CLIMATE ACTION TEMPLATE FOR BC RURAL MUNICIPALITIES 2023

Sooke Climate Action Committee 2021-22

This document's author(s) live in the unceded traditional territories of the T'Sou-ke (pronounced: tsa-awk) First Nation and Sc'ianew (pronounced: CHEA-nuh) First Nations.

In the SENĆOŦEN (pronounced: sen-chaw-thin) language, T'Sou-ke refers to a species of Stickleback fish which live in the mouth of the territory's major river (T'Sou-ke Nation, 2021). Early settlers anglicized T'Sou-ke to Sooke, which is now the name of the municipality, main road, river, and river basin.

The Sc'ianew (Beecher Bay) First Nations' ancestors spoke multiple languages, and their name means the "place of big fish" in the Klallam language (Sc'ianew First Nation, 2021). The settler Canadian government used residential schools and other colonial policies to eradicate Indigenous culture, and as such, the Klallam language is no longer spoken.

Since Time Immemorial, the lands comprising the District of Sooke have been connected to the health, wellness, traditions, languages, culture, and self-determination of the T'Sou-ke and Sc'ianew Nations. Their ancestors stewarded these lands and waters in relation with and an eye to future generations that we can only aspire to now, given the challenges of settler-society-induced climate change, pollution, and biodiversity loss.

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The Sooke Climate Action Committee spent three years trying to compose a climate action plan (CAP) at the request of the municipal council. Not that we didn't already have a climate plan. The first CAP was adopted in the early twenty-teens and was a visionary document, you know, for 1970. It was adopted and subsequent councils either forgot about it or simply ignored its existence. Which is the typical fate of such plans (a topic I'll return to. Again and again and again...).

What we submitted to council was an attempt to unify what the council was doing (*i.e.*, extending the trail system, producing an OCP (official community plan)) with what we felt needed to be done (*i.e.*, a full-time climate action coordinator, restrictions on development). We felt that the "OMG! We're all going to die!" way of addressing climate collapse didn't seem to be working, so we brought in a consultant to help us craft a new and different way to address the issue. What we came up with was an attempt to re-frame the response to climate collapse in a new narrative structure. Creating a new narrative, a new way to approach the topic, would allow us to make the CAP a series of steps on the road towards a richer, deeper life which, in turn, would lead to a more resilient, disaster-ready town.

This change in the narrative changed the ultimate shape of the plan. The CAP becomes less prescriptive and more aspirational document when viewed this way. When we talk about "how we move", for example, the issue becomes "what if we didn't have to move as much?" What if we had more jobs in our town and we were treated less as a bedroom and more as a community? What if we had a telecommuting hub, so people didn't have to leave town just to go to a meeting? What if the town was more centrally dense and our multi-use trail system expanded from dog walkers to a system that actually *went somewhere people wanted to go*?

Changing the narrative in this way broadens its scope, bringing in other actors to contribute to a better future. The Chamber of Commerce can be onside with our call for more local retail and commercial businesses—after all, the number of home-based businesses in Sooke number in the low hundreds, and many of them would greatly benefit from being able to scale up their operations. The provincial government is on-board with telecommuting, and business centres have a strong track record. Suggesting the town pursue the establishment of one seemed to fit with the CAP. And a compact and busy town core means the trail system could become a lot more important, and at less cost than roads.

So, who are we to be telling you what to do? Well, we're not telling you what to do. Whenever I needed to write a report, back when I did such things, I always wanted to see another report that had been submitted earlier in order to understand the presentation that was wanted. Different places, different people, want their information dressed up in specific ways. We are offering up three years of work to you in order that you can save a lot of time and grief in composing a CAP for your locale because all the necessary work has been done—you can copy our format, substitute our information with your own (or not), and our goals with yours. And I've tried to include as many of the supporting documents as I could in this package. Our CAP is a way of formatting your CAP. It's a way of thinking about the issues. And we hope it's offering something other than "OMG! OMG! We're all going to die!" What we want it to be is an offering of hope.

PREFACE: THE STORIES WE TELL

Make no mistake, the goal behind the Sooke Climate Action Plan is to start a long-overdue revolution where we are, where you are, and where everyone else is. When the second iteration of the climate committee was formed in 2021 (the one I chaired), we all understood that we are in trouble. Meaning our town, province, country, and planet. But it was calculated early on that if we dropped our tCO_2e (tonnes carbon dioxide equivalents—all greenhouse gases expressed in equivalent tonnes of carbon dioxide) by 7% a year, we could reduce our carbon footprint across the municipal district by 50% by 2030 in line with international, IPCC (Intergovernmental Panel on Climate Change), and BC provincial goals. That was a couple of years ago, and the "seven percent solution," while adopted by council, hasn't made much headway yet. The result is we are stuck with the need for a higher number or more distant target. The phrase, however, has been adopted as shorthand for talking about our staged tCO_2e reduction plans. The problem is, as ever, how to kick-start this reduction.

As it turned out, our committee had a number of highly qualified members from widely varied backgrounds. But when we sat down together (well, video-conferenced during COVID) the question was always the same: "Gosh, with fifty years of this problem, why has nothing been done?" (To be honest, the language was a lot stronger than that, the delivery more forceful). Seth Klein's book *A Good War: Mobilizing Canada for a Climate Emergency* had just been published, and by chance several on our team had read it. Klein was suggesting that Canadians have risen to a similarly daunting challenge, World War II, and they can use the same strategies to tackle the climate crisis. Klein wanted to stop us saying "there's nothing I can do," and start saying (in the words of the great US propaganda poster) "we can do it!" An idea that sparked a lot of discussion and thought on the committee.

The committee began to wonder; what would happen if we left the "end of the world" rhetoric out, and instead began talking about the world we wanted to see. This question of narrative, and of how to communicate it, resulted in a sub-committee being struck to try and translate these ideas into practice.

Understand that, when I speak of "the narrative," it's not me trying to mislead or fuzz up the issue in front of us. We communicate with stories. When I ask "how was your day?" you tell me a story. Most of our complex thoughts are distilled into stories. If I ask what you think about the events in the Ukraine, your answer tells me what stories you've been exposed to. Invasion? Probably Western media. Necessary incursion? Probably Eastern/Russian media. And when you tell me your thoughts, you are telling me the story you have put together. When I talk about changing the narrative, the changed narrative is to help us think about an issue in a different way because we have a different story.

One of the problems with the "OMG, it's the end of the world!" story is that if it is the end of the world, there's nothing to be done. If I quit driving, it's not going to make any difference. If I install a heat pump, it won't make a difference. That's what the end of the world means: it's over. We can't change things.

But what if we can? If that's the case, it means that it's not the end of the world and there *is* something we can do about the climate crisis. There are our individual actions—using mass transit, or installing a heat pump. And there are our collective actions—like designing our towns differently, or taking the ten corporations that have led us here and hold them to account[1]. *There are things we can do.*

And because there are things we can do, it's not the end of the world. Not unless we want it to be. And I don't want it to be. So let me tell you a story about villains and heroes, small victories and grand gestures. Let me tell you how reducing our emissions by just 7% each year will gain us a new world. That's the narrative, that's what I want to tell you.

In order to build this narrative, the sub-committee began doing on-street interviews, trying to discover if climate change was even an issue in town. It turns out that it is, and the information we gathered in this way informed the development of our final story. The CAP includes several quotes from these interviewees, and it is clear that our neighbours are thinking seriously about the climate emergency.

Our committee turned to practical, on-the-ground ideas that could help us reach our goal of an annual 7% reduction in the district's emissions. We looked at programs, zoning, water usage, and more. You can see the results of our deliberations in the final report. We wanted low-effort, high result actions. A ban on future natural gas hook-ups, for example. Natural gas releases carbon in the production, transport, and final use of the product. And, living as we do in an earthquake-prone area that is expecting an eventual Tohoku-sized quake (that's the 2011, 9+ earthquake in Japan which changed the axial spin of our planet. Yes, the island I'm living on is expecting one of these), it was thought that perhaps lining the ground with buried pipes of a flammable, explosive, and toxic gas might not be in our best interests. Your mileage may vary, as they say on the internet. But recent research does suggest that there are also significant health issues with gas appliances in the home, lending weight to this proposal.[2]

We also tried to work on immediate action items in order to present them to council for consideration. Our goal was one action each month. We didn't quite achieve that goal, and I believe

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1 *See* By The Numbers section
2 UCLA Center for Occupational and Environmental Health pdf accessed 14 March 2023 See attached.

that by the end, council may have become a little tired of hearing from us so frequently. Maybe we should have tried every second month….

The great thing was that district staff were on board. The Action on Climate Team (ACT) from Simon Fraser University (SFU) had, between 2018 and 2021, developed the Integrated Climate Action for B.C. Communities Initiative (ICABCCI), putting forward the idea of a “green lens.” This is the idea of viewing plans from a climate-first perspective. District staff had adopted the program and were starting to implement it.

Other community groups were also on board. When we wanted to re-visit the topic of food security, the Sooke Region Community Health Network (SRCHN) released their Sooke Region Food Security Report 2021. We couldn’t have asked for better timing. (The report is appended to this document. You can do with it what we want you to do with the CAP: use it as a template, a plug-and-play document.)

When we wanted to look into telecommuting centres, WorkBC told us they were planning to include one in their new building in Sooke. The CAP was not the only game in town. Local groups, simply by pursuing their own agendas, were bringing forward proposals and plans that fit nicely under the plan.

Work has also been done on how to best pursue higher density in the centre of town, how to design a trail system, why you keep big box stores out, and how 1950s style suburban development can lead a town into bankruptcy. What works and what’s better is pretty much known, even from and particularly from a climate action perspective. Wherever possible, I’ve appended the best practices guides and other supporting documents so you don’t have to search for them.

So, with the research in hand, and concerns expressed by citizens in on-street interviews, we began to craft our narrative and the report. We received tremendous support from Maia Carolsfeld at the district office who translated our work into a council-ready document. Being council-ready, though, did change the way in which the information could be presented. For example, when I re-wrote a section introduction (How We Relate: Our Deepest Connections) as a much more radical call for change, it was reduced to a quote box.[3] This was probably the right thing to do, but my personal goal was (and remains) to have the CAP to be seen as a more radical call to try and grasp a new world.

[3] Imagine how happy I was when *The Dawn of Everything* came out and extensively discussed the same thoughts I’d tried to include.

LCR: LOW CARBON RESILIENCE

LCR. It's a set of initials we used often. That I'm using often. So, I really should try to explain what low carbon resilience means. So, to quote the Simon Fraser University website:

> *Integrated climate action, or low-carbon resilience (LCR), minimizes climate risk, reduces emissions, and advances multiple social, environmental and economic sustainability goals—including across all 17 United Nations Sustainable Development Goals (SDGs). By using an LCR approach we aim to advance systemic sustainable development opportunities such as equity, biodiversity, clean economic development and healthy and sustainable communities. On the flip-side, by applying a climate lens—reduction of climate risks and emissions—across each of the SDGs, we are able to build more effective, resilient and sustainable solutions.*

Nice, isn't it? Glossy, precise, and just on the border of being unintelligible. But there is meaning here. We have to look at our day-to-day actions, from committee work to building permitting to passing bylaws, and view them with a long term, climate-centred view. An example would be something like if you are working out development setbacks from streams or wetlands, what are the climate implications of filling in a wetland and allowing houses to be built? Is the wetland a carbon sequestering peat bog? Are there fish in the stream? Then what happens when the stream warms through global heating, and how would encroachment affect local drainage? Would you have to replace a bog that is filtering and slowing drainage water flow with a system that would dump silt and toxins directly into running surface water?

The goal is the long-term sustainability of your town/municipality/district. The 2022 atmospheric river that slammed our province set a new benchmark for what to expect with a collapsing climate. Towns cut off. Highways washed away. Residents of a drained lake bed seemed surprised when their long-neglected dike system failed and the lake came back. And yet we're still better off than California over 2022/23.

The destruction left by the atmospheric river cost the province billions of dollars. And that means each one of us pays. We pay in dollars, we pay in stress and worry, and some of us pay with our homes and even lives. As the collapse deepens, climate collapse intensified disasters are going to get more damaging and more expensive. We will end up being forced to pick and choose what to fix.

When New Orleans was hit by hurricane Katrina (a hurricane intensified by climate collapse) in 2005, we saw that large sections of the city were laid waste when the levee broke. The city still isn't repaired. The toll and cost—1,392 fatalities and damage estimated between $97.4 billion and $145.5 billion was enormous. So enormous that decisions were made to essentially write-off some of the city's primarily black and poor wards and neighbourhoods as too costly to repair and making them "sacrifice zones"[4]. Katrina displaced somewhere between eight hundred thousand and one million people from the central Gulf coast to elsewhere across the US, and became the largest diaspora in the history of the

4 https://www.theguardian.com

United States. These were climate refugees—people forced to relocate by climate collapse related issues.

Your town should not become a sacrifice zone. Nor should mine. So, the goal is to be resilient, focused, and prepared. When planning resilience in your locale, plan for extremes, expect the worst to be worse than you think. Strong systems perform well under normal circumstances, but normal systems do not perform well under extreme circumstances.

Think about our health system. For decades, politicians have been using the system as a fiscal whipping boy. “Cut the fat!” was the rallying cry they used. Well, they cut the “fat.” And the flesh. And they’ve been working on the bones. So, what happened? The medical services sector actually needs a certain amount of fat on it. That’s what is used when there’s an emergency and service delivery must be ramped up. Cut to the bone, there was no excess capacity that could be brought into play. And then the pandemic hit.

We knew the pandemic was coming. Maybe not exactly when or what it would be, but governments had been warned for decades that there would be another one. We knew the kind of preparatory work that needed to be done. We even had a dry run with the SARS scare in 2003. We knew that the medical system had to be designed to be resilient. It had to be a strong system performing well under normal circumstances.

Instead, we had a normal system. A system that was already showing stress cracks. When the pandemic came, the medical system didn’t have enough doctors, nurses, facilities to properly cope. Did the system collapse? No, but parts failed in different locations across the country. Now the same people who cut the system down are telling us that the public system has clearly failed, and private medical delivery will save us all. It’s a great example of what Naomi Klein calls “disaster capitalism.” Disaster capitalism centres on the exploitation of major crises (disasters or upheavals) to establish controversial and questionable policies, while citizens are too distracted (emotionally and physically) to engage and develop an adequate response, in order to resist effectively.

Climate-collapse-fuelled disasters will be subject to the same exploitation, the same dismantling of the public sphere. There will be the same push-back and cries of “You can’t do that! It’ll cost us money!” when we try to enact policies to make our towns more resilient and full collapse less likely. It’s short-term thinking, and what we need now is century-long-term thinking.

I know, this sounds very much “OMG, we’re all going to die”. But we move forward in hope while remaining aware of the challenges. We just have to make decisions that look forward instead of backwards. The goal is a better life that is sustainable and resilient. Many climate-forward sustainability policies have the added benefit of making where you live a nicer place to live. Making your town more walkable while also increasing the available commercial or retail space for small businesses can help reduce the number of personal vehicle trips. Trails and sidewalks are cheaper to build than roads, so making the town more walking and bicycle friendly helps keep the tax bill down—and can increase a town’s cumulative tax income from new businesses opening up[5].

[5] *See* “the Numbers Are In” section.

Expect this push-back. Change is often perceived as a threat—particularly by people who are operating on outdated and obsolete information. Business groups, for example, are very change adverse no matter how much they adopt the rhetoric of neoliberalism and "creative destruction". The development community thinking is particularly conservative; concepts of how and what to build trace back to the 1950s, and any change is perceived as a serious threat to their historical right to maximum profits. Plus, many members of the development community seem to have an ingrained feeling of "Just let us do what we want. We know what's best to build." (Actually, they don't. Look at any town where developers have been, or have controlled, the local government.)

You can watch this playing out in the provincial housing crisis. The solution is claimed to be building more of the same—and how's that been working out? Housing getting cheaper? More available? More important might be how to handle the 20+ % of housing being purchased by investors[6], who have as their primary motivation the security of capital, rather than the housing or social good of our population. Governments, who are supposed to have the greater good as a goal, were warned that there would be a housing crisis when they stopped supporting public housing, just as they were warned that cuts to income support and mental health services would lead to a homelessness crisis and a rise in dependence on food banks[7]. The story of governments ignoring climate collapse is a familiar one.

The failure of our provincial governments to find solutions or approaches to deal with the housing crisis, the climate crisis and more, stem from this capture of the imagination by the neoliberal story we've been hearing since the Reagan, Mulroney, and Thatcher governments in the 1980s.

Most of us recognize the existential threat posed by climate collapse. What we want, and what we need, is a sense of mutual assistance, of community, in beginning to implement the changes needed to cope with the threat. And this an important point: climate action does not necessarily mean hardship. There are many changes we can make that will actively make our lives better. And the changes are almost always cumulative. A denser town core makes trails more valuable, and can be reflected in lowered costs for roads. But more cycling and walking also will be reflected in lowering local healthcare demand. A district home economist can help food producers create value added products for local consumption as well as creating demand for those products. The synchronistic benefits keep piling up and then spark their own spin-off benefits.

To help identify co-benefits from low carbon resilience, the SFU Climate Action Team developed a chart to assist you:

[6] "Recent Statistics Canada numbers show investors own a big share of the country's condo market, as much as 42 per cent in some parts of Ontario, adding another hurdle for first-time home buyers trying to enter the market." CBC 2023

[7] *Food Banks and the Welfare Crisis*, Riches, Graham. Ottawa : Canadian Council on Social Development, 1986 available online at https://archive.org/details/foodbankswelfare0000rich

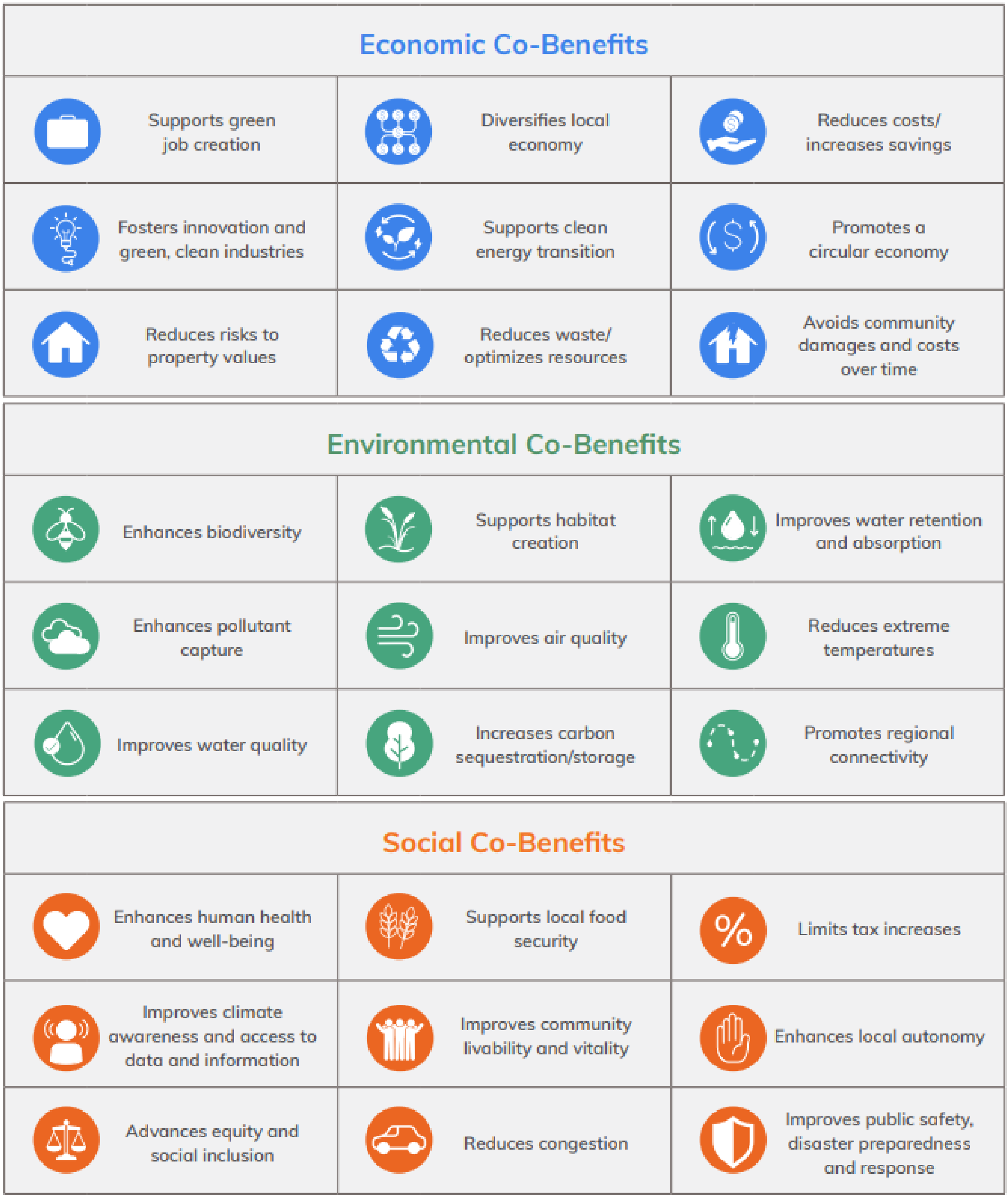

Figure 1From SFU Climate Action Team website[: https://www.sfu.ca/act.html](https://www.sfu.ca/act.html)

The goal of this chart is to help you understand how policy generates change in places you might not expect. The listed co-benefits aren't the only ones that can occur. You should find that you need to add your own into the chart.

You want policies to hit as many of these co-benefits as possible. And while economic benefits may be at the top of the page, the policy goals in all three categories should be seen as being on an equal footing. Putting economic policies first is what got us into this in the first place.

Initiatives put forward by climate action committees should also reference these goals. How can your initiative—or climate action report—be seen through this lens? Are you paying attention to economic co-benefits? Does it promote community livability? Will this initiative also help reduce the effects of extreme temperatures?

When you're talking about climate action, it's a good idea to have consulted a chart like this. It helps when trying to communicate the value of the initiative to different groups. Your Chamber of Commerce would want to know more about the economic side-benefits the change would bring. Your neighbour might be more interested in keeping property taxes down. Because climate action is not only about producing elegant reports. You also have to be able to explain the plan and show how it will benefit different groups. Oh, and if your town is ever planning for Infrastructure Canada funding, the "green lens" is a basic requirement.

Creating a climate plan is only the first step. Then you have to start bringing people on-side. You, and members of your committee, have to talk to people. Informally with your neighbours, and more formally at meetings of the Lion's Club, Chamber of Commerce, the Legion, the high school. Draw attention to news events like the California floods, explaining how the additional heat the ocean soaked up from climate heating helped turn a minor storm into a major one, and a major one into a catastrophic one. That the drought was climate intensified, that climate collapse first takes on the form of making normal events more intense, more frequent, longer lasting. That the floods weren't just because of massive rainfall, but also because drought-damaged soil can no longer take up water[8] and it takes forever to reconstitute itself as proper dirt again.

And then tell them that there is a plan. Already in front of council, it just has to be implemented. Tell your story, reference your climate plan for your town. Have a conversation about how the perfect can't be the enemy of the good. Will this solve all the problems? No. But it will be better than the nothing being currently done. And when we look back at how our lives improved after we started, then we can do the bigger, more difficult things.

Nicholas Bagley has pointed to something called "The Procedure Fetish," which impairs the speed at which we can accomplish things. To quote the abstract from his paper:

> "*The strict procedural rules that characterize modern administrative law are said to be necessary to sustain the fragile legitimacy of a powerful and constitutionally suspect administrative state. We are likewise told that they are essential to public accountability because they prevent factional interests from capturing agencies. Yet the legitimacy-and-accountability narrative at the heart of administrative law is both overdrawn and harmful. Procedural rules have a role to play in preserving legitimacy and discouraging capture, but*

8 *See* "Yes, drought can make it harder for soil to absorb water" at verifythis.com The video they reference can be found on Gfycat

they advance those goals more obliquely than is commonly assumed and may exacerbate the very problems they aim to fix. This Article aims to draw into question the administrative lawyer's instinctive faith in procedure, to reorient discussion to the trade-offs at the heart of any system designed to structure government action, and to soften resistance to a reform agenda that would undo counterproductive procedural rules. Administrative law could achieve more by doing less ."[9]

What he's saying is that the procedure we use for change is probably flawed. Idea, draft, citizen consultation, redraft, citizen consultation, repeat until consensus or exhaustion is achieved, might not be the best way to approach policy implementation. When he talks about "discouraging capture," he is talking about policy capture by special interest groups. And no matter how noble our goals, how important our policy, we will be considered a special interest group bent on taking over the "suspect administrative state." This suspicion is again a call-back to the eighties capture of the administrative state by the Milton Freidman-led Chicago School economists who, through the Reagan/Thatcher/Mulroney governments, proceeded to dismantle it. To quote again:

"It is nonetheless wrong to assume that an agency procedure will discourage capture simply because it aims to foster deliberation, transparency, and rationality. The reverse will often be true. The reason is simple. To avoid getting drawn into contentious debates over political power, administrative law has a penchant for formal procedural equality: everyone is afforded an equal opportunity to advance the values of deliberation, transparency, and rationality. <u>So industry associations participate on the same footing in the administrative process as environmental groups, and every poverty-stricken member of the public has the same right to have her voice heard as the wealthiest banker.</u> If procedural equality does not do enough to mitigate capture, administrative law scholars are prone to call for still more procedures that afford still more opportunities to participate, monitor, and push back. Maybe then the public's voice will finally cut through the interest-group din."[10] (emphasis mine)

Or, as Anatole France is claimed to have said: "In its majestic equality, the law forbids rich and poor alike to sleep under bridges, beg in the streets and steal loaves of bread."[11]

We need to think differently. Shifter, a urban cycling advocate with a channel on youtube, recently posted a video on ways to explore different approaches to policy and the urban environment.

9 Nicholas Bagley, The Procedure Fetish, 118 MICH. L. REV. 345 (2019).
Available at: https://repository.law.umich.edu/mlr/vol118/iss3/2

10 ibid

11 I've also heard it claimed that G.B. Shaw said this. Of all the information I'm trying to include for you, who said this is the one piece I don't care enough about to track down. Whomever said it, the sentiment is still accurate.

In the case of bike lanes, this can mean installing a *temporary* bike lane, and only *then* seeking public input, and modifying where necessary because of that input.

Allow me to apply this to bike lanes and active commutes. If, when you mention bike lanes, the response is “sure. We’ll get some paint and mark some in,” you know you are dealing with someone or someones whom have almost never ridden a bike, and certainly never tried to commute by bike. People use alternative active transportation when they feel it is safe. And a bike gutter marked with magic paint to protect cyclists aren’t safe. But there is something you can try if you already have bike gutters; temporary physical separation. This helps deal with the problem of separation and also the “procedure fetish”. There is a lot of detail in Shifter’s video on the topic, but what it boils down to is by using things like plastic bollards and concrete parking bumpers (both relatively inexpensive—particularly compared to a fully retrofitted roadway), you can trial separated bikeways, and once in place and after some time for all concerned to adapt, then you can solicit public feedback. This can avoid the “devise, consult, revise, consult” black hole. Because you are not adopting a permanent policy, just introducing a temporary trial, implementation can be immediate. After some time has passed with the temporary measures in place, then you can consult the affected public and revise the trial. When most everyone has stopped complaining, you know you have it right and can move to adopt a permanent policy measure. This helps avoid the whole “It’s new and different and therefore wrong” feeling most of us experience. Trial and consult lowers barriers to adoption while better defining policy and still remaining transparent.

Cities Begin In the mind: The question of Narrative

How we see the world is in a large part dependent on the stories we tell. Our current story is one of inequity, isolation, and unavoidable collapse. Those of us with houses and retirement plans have acquired them at the cost of the future. Inequality and authoritarianism are just the way things are. Of course, our governments are non-responsive; as Evans and Giroux write:

> "Our reading [...] understands that a critique of power is a theoretical and political necessity, since it is committed to exposing and challenging the normalization of subjugation in all its forms. Confronting this bleak and often disavowed reality unsettles the normalized conditions of our lives in such a way that we can begin to grasp the operations of power evident in the increasing use of violence by the state as it divests from social welfare in favor [sic] of corporate welfare and embraces its role as an increasingly oppressive state funded by, beholden to, and in the service of a small financial elite."[12]

Political analysis of this kind is necessary for understanding why our democracies are failing us on the climate crisis. Such political analysis can underpin, but does not have to be a part of the climate narrative we are developing. Our climate strategies must offer hope and community. Think of the approach of our governments during WWII. The domestic propaganda emphasized the power of hope, community, and mutual assistance rather than the power of the Nazi war machine.

What if we tell ourselves a new story? As *Dawn of Everything* says,

> "Cities begin in the mind.
>
> Or so proposed Elias Canetti, a novelist and social philosopher often written off as one of those offbeat mid-century central European thinkers no one knows quite what to do with. Canetti speculated that Paleolithic hunter-gatherers living in small communities must, inevitably have spent time wondering what larger ones would be like. […] These 'invisible crowds', Canetti proposed, were in a sense the first human cities, even if they only existed in the imagination."[13]

This is important. In order to build cities, we have to imagine cities. In order to have a better future, we need to imagine a better future.

How do we transition from the current vision of ourselves and our living arrangements into a vision of a better world? We change how we think of the world. After all, as a society we've transitioned from the view that the wilderness was home, to a source of horror and nightmares, and then into one where we preserve wilderness in order to enjoy its benefits. Changing our minds is not only possible, but necessary.

The question then becomes "what do we see when we talk of a climate-resilient, more localized community"? Is it simply transitioning to electric everything and leaving the rest of our society the same? Does it involve a four-day work week? Maybe you love or hate the "mincome," or basic annual

12 p.47 *Disposable Futures: The seduction of violence in the age of spectacle* Evans, B. And Giroux, H.A.
13 p. 276 *The Dawn of Everything: A New History of Humanity* Graeber, D. & Wengrow, D.

income. Re-planting forests? Continuing to log, but using heat pumps? Prioritizing tourism over extractive industry, or the other way round?

The purpose of this package is not to tell you what to think or do, but rather to give you the necessary tools with which to plan. The background work has been done. You plug in your local conditions and concerns to compose your own new story.

So, what was our story? Pretty straightforward, really: "We only have to reduce our emissions by 7% a year in order to meet the goal of a 50% reduction by 2030. And we know the steps we have to take to achieve this reduction. There are changes involved, but they are not major disruptive ones. Each step is reasonable, straightforward, and ends up making your life safer, better, easier, or more relaxed."

That's the narrative arcing over everything else. The reductions have to come from everywhere but do not have to bring privation. Making changes can bring us a cleaner, quieter, healthier, and more equitable world. It can be as simple as not having to make an hours-long commute every day in miserable, heavy traffic, or by getting cars off the road to make your commute easier. Perhaps it's lowering your hydro costs by installing solar and a heat pump so you find it easy to work one day a week less and every weekend is a three-day weekend. And, as a co-benefit, your fridge and freezer don't fail when there's a power outage. There's a lot of low-hanging fruit. Our job is to pick it. The zero emissions in 2050 decisions are for longer-term planning (and, yes, I am aware we should have started the long-term planning fifty years ago).

These are changes we can make in our lives, in our towns, and in our province. They have to be adapted to your local conditions, but *you can figure that out*. If your town is too reliant on produce flown in from California or Mexico, maybe building a local food system should be a priority. Want to move the transition away from gasoline engines along? Think about mass transit, or rolling out a system of municipal car-charge points. Or think of something better. I have faith in you, I know that you've got this! Remember:

Whatever plans you have in the CAP, remember that the narrative, the story, is paramount. The story is the thing that people respond to, the thing people remember. That you want to install a hundred heat pumps a year will not resonate as well as “your family life will improve.” “An easier commute” is better than “a 7% reduction in car traffic.” I, for one, am convinced that story will get us to a better future, because story can resonate differently with different listeners. Rural conservatives will respond better to a focus on how this will restore and improve small towns, and will re-introduce the value of self-sufficiency. Progressives will perk up with discussion of climate justice and a post-consumerist society. Young people will respond to just about anything that suggests that they might have a future.

So, you’re not telling different stories, you’re just choosing which parts to emphasize when you’re talking to a specific audience. Commuting with commuters. Strengthening local business with the Chamber of Commerce. Better services with homeowners. Tailoring your narrative to your listener is not wrong. Rather, you are focusing on your listener’s concerns.

With all that being said, let me emphasize one point: go talk to your neighbours. There’s no traction without connection.

The Sections

How We Move

Our *How We Move* goals from the CAP:

1. *Residents walk, cycle, use electric mobility devices, take transit, or drive an EV for 75% of trips to and from Sooke by 2030*
   - *Move from 11% in 2020 to 75% in 2030.*
2. *Residents walk, cycle, use electric mobility devices, take transit, or drive an EV for 30% of trips within and around Sooke by 2030*
   - *Move from 10% in 2020 to 30% in 2030.*
3. *30% of passenger vehicles, and 10% of commercial vehicles are electric by 2030.*
   - *In 2018, there were 134 electric and 104 hybrid passenger vehicles registered in Sooke (out of 10,209 total vehicles).*
   - *In 2020, there were 248 electric and 120 hybrid vehicles registered in Sooke (out of 10,132 total vehicles).*
   - *As of 2020, there are no electric or hybrid commercial vehicles registered in Sooke.*
   - *In 2030, this would mean over 3,000 vehicles would be electric.*
4. *95% of all construction and demolition waste material is diverted from landfill and reused in new construction and other projects by 2030.*
5. *100% of organic material is diverted from landfill and used to create compost and other products by 2030*

How we move is based in why we move. We move because we live in one place and do stuff in another. Work, school, shopping recreation, all these and more don’t happen where we live—at least in the contemporary world. There are two types of movement: active and passive—with mass transit tending to straddle the definitions.

Active transportation is walking, biking, horse-back riding and similar methods which use the human body. Passive is your fossil-fuelled transportation: flying, driving a fossil-fuelled vehicle, boarding a cruise ship and the like. Biologically driven versus fossil fuel driven.

Our goal should be to maximize the active and minimize the passive. That means prioritizing walking, biking, and mass transit over driving. Making active transportation the default holds so many spin-off benefits: health, reduced costs, better air quality, improves urban livability, and can even increase disaster preparedness. And it takes us back to where we began. There’s a reason our traffic laws usually take the view that the pedestrian has the right-of-way. Pedestrians came first.

How we move now is intimately connected with how we grew, so how we are going to move is connected to how we are planning to grow. How we move is the defining element of development. If you imagine virgin farmland about to be turned into suburbia, well, first there has to be a road. But this gives us the opportunity to define what communities are going to look like in advance of them being built. Put in roads, you get cars. Put in mass transit, like trolleys or buses, and you get a community focused more on active transportation.

Putting in car-dependent transportation with underground utilities is also expensive. It's the reason your town finds itself in fiscal difficulty: your taxes will not cover upkeep and eventual replacement of infrastructure. And those who allowed this state of affairs will be long gone by the time the bill comes due. So your council will have to go begging to "senior" levels of government for grants to do the work—just like every other town and city. Mostly at the same time.

Studies[14] indicate that areas designated "poor" often pay more in taxes (and receive fewer services) than suburban areas, and that dense mixed-use city centres contribute more than big-box stores, or any stores with extensive parking.

To reduce fossil fuel dependent transportation means planning our growth around being a walkable urban environment. But how can we tell if the policies we adopt are having an impact?

The short answer? Monitoring. The long answer? Well, monitoring. There are times when having numbers is instructive, and times when having them is essential. If you have multi-use trails, establish traffic counters at various places along the trails. This immediately establishes both where people are using the trails and how many people are using the trails. Establishing permanent active and passive transportation counters provides real-time commuter data which can be extrapolated into hourly, daily, weekly tCO2e emission numbers. When you enact a policy or design change, you can get prompt, current feedback on how that policy or change is affecting active and passive transportation.

The data generated by this monitoring can be used in a number of ways. Municipal staff can use it in reporting to your local government as well as for grant applications to senior levels of government. It can be provided to the public at large so that everyone knows the policy outcomes and citizen scientists have the opportunity to pursue research projects (say, the impact of traffic counts on fish-bearing streams). And it can even be gamified, tapping into the competitive urge to change the numbers in one direction or another. Imagine a sign board in a high traffic zone with a continuously updated car count and tCO2e emissions count coupled with a publicity campaign to "Make Lower Better!" We really seem to like games, contests, and lotteries, so why not take advantage of that to motivate ourselves and our neighbours?

Somehow, this is the section that got the "*100% of organic waste diverted from the landfill*" and "*95% of all construction and demolition waste material is diverted from landfill"* resolutions in it. One of the reasons these are in the document at all is because Sooke has a small but active and effective Zero Waste group. Members of Zero Waste Sooke (ZWS) just don't understand why we send our organic waste across the Strait for composting. Or send it anywhere for that matter. We live on ground that needs a continual application of composted organic matter, so why can't we get it here without all the transport carbon? Local collection, local composting, local reuse. And as long as we're still bringing food from away, we would be getting nutrients for our soil from another place's soil.

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14 Here I point you towards Strong Cities and [their website](). And they are more North American focused rather than US-centric.

The same can be said of other resources. Metals, plastics, pretty much anything in the recycle stream should be treated as a business possibility. I've been talking up the idea of a local recycle yard with an integrated resale shop and attached business incubator. Let people try out ideas for turning recycle into resource.

Jane Jacobs took the view that cities grow by replacing imports[15] with local production. If living through the 2020s is teaching us anything, it's that you can't rely on come from away. Our global supply chains are shaky at the best of times, so maybe we should be looking towards home. If we adopted local food production for local food consumption, along with local composting, we would go a long way towards supporting local farmers and eating better food. This would have the added benefit of growing the local economy, and works with almost any import replacement you can manage. Import replacement can be an economic and carbon win.

Another of the issues we don't often think about is embodied carbon. When we look at an electric car, we think of how using it releases no appreciable tCO2e. What we often don't think about is how much tCO2e was released in the acquisition and production of the material used to create the car in front of us. This is the embodied carbon, and everything we manufacture embodies carbon in this way. A proper carbon accounting takes this embodied carbon into account. So when it comes to electric cars, honestly, we would be better off converting existing cars to electric power, rather than building new ones. It's the economic cost that prevents us from considering this: converting an existing vehicle from one containing ~4000 parts to one that contains ~400 would crash new car production, drastically reduce maintenance requirements, and cripple emerging electric car production. Would it be better for consumers? Well, it would be a lot cheaper to convert rather than produce. It would significantly reduce ongoing costs. And it would require a lot less resource extraction.

At the other end, we often don't think about the disposal of our stuff either. One of the issues facing landfills, for example, is methane release from mixed waste. And each tonne of methane is the equivalent of about twenty tonnes of carbon dioxide. Landfills often have flare stacks to burn the released methane, converting it into carbon dioxide. This is a win, but not a really big one. In 2003, the Capital Regional District (CRD) built a landfill gas-to-electricity plant next to the flare station in order to utilize the methane in the landfill gas to produce electricity. The facility contains a reciprocating engine which works very much like a car engine, except instead of gasoline, methane is the fuel. Mechanical energy is turned into electrical energy. The electricity produced is fed into the existing BC Hydro distribution system on-site. The facility produces close to 1.6 megawatts of green power – enough electricity to supply about 1,600 homes.

Another source of waste—and of tCO2e—is demolition and construction waste. In demolition, many materials, such as asphalt roofing tiles, can be recycled or reused. At a friend's church, recently, they wanted to remove an old, near-unusable building. In the end, the contractor (who specialized in deconstructing old buildings) ended up paying the church real money for the right to take the building down. That's how valuable many of the building components were.

Deconstructing buildings, rather than demolishing them, can yield value. Even if it's just keeping waste out of the landfill. And keeping waste out of the landfill reduces the cost of the landfill (which

[15] Jacobs, J. (1984). *Cities and the wealth of nations : principles of economic life* (1st ed.). Random House.

we pay for), reduces the material available for decomposition, and consequently reduces methane production (as well as other contamination of land and water).

How We Grow

The *How We Grow* goals from the CAP:

1. *Achieve a walkability score of 75 for Town Centre and Town Centre Waterfront areas of the community.*
2. *Increase urban tree canopy by 20% by 2030.*
3. *Increase protected acres of parkland by 15% by 2030.*
4. *Increase to 20% food self-sufficiency by 2030 by creating favourable conditions for food production using regenerative practices, food education, and reskilling opportunities.*

Vancouver, in the eighties, faced the knowledge that the city wasn't the best place to live. After much discussion, the planning department came up with the basic principles that have led Vancouver into being one of the world's "best" cities (I say "best" because the groups that publicize such ranking rarely include all the criteria and weighting they used to get to this conclusion). The principles are called Vancouverism. Vancouverism is characterized by a large residential population living in the city centre with mixed-use developments, typically with a medium-height, commercial base and narrow, high-rise residential towers, significant reliance on mass public transit, creation and maintenance of green park spaces, and preserving view corridors. The architect Bing Thom described Vancouverism this way:

> *It's a spirit about public space. I think Vancouverites are very, very proud that we built a city that really has a tremendous amount of space on the waterfront for people to recreate and to enjoy. At the same time, False Creek and Coal Harbour were previously industrial lands that were very polluted and desecrated. We've refreshed all of this with new development, and people have access to the water and the views. So, to me, it's this idea of having a lot people living very close together, mixing the uses. So, we have apartments on top of stores. In Surrey we have a university on top of a shopping centre. This mixing of uses reflects Vancouver in terms of our culture and how we live together.*[16]

Larry Beasley was one of this group of planners (ultimately, he became Vancouver's Co-Director of Planning), and in his book on the process called, oddly enough, Vancouverism, he detailed the six principles of modern city design:

- The neighbourhood is the basic building block
- Broaden transportation choices—particularly mass transit
- Incorporate diversity in new areas from the beginning
- Rely on urban design
- Commit to environmental responsibility

[16] Sharma, Ian Alexander Narasimha (2012). "On the Edge: Redevelopment Projects at the Urban-Marine Interface in Vancouver, BC". University of Washington.

- Foster collaboration among all forces and agents of city building[17]

How does this affect you, living in a small town or rural municipality? Well, this probably needs to be the basis for your Official Community Plan (OCP). You are supposed to have one—but then, our councillors have struggled with ours for almost four years. Then they decided not to pass it, saying that it should be left to the new post-election council to consider. So, yours may be mired in the same kind of issues.

You have to embed your values in the OCP. Do you want a community dedicated to becoming net-zero? You have to make sure that your current and future council understands that. And the place for that is the OCP. The climate action plan is for describing how to get to the future you want to see.

But what can be done? Well, I'd answer, but my answer would be worse than having an expert answer. The best at defining what can be done (with particular information for small BC communities) is *Toward Sustainable Communities: Solutions for Citizens and Their Governments* by Mark Roseland and currently in its fourth edition. The book is available from New Society Publishers and is a great reference book for any citizen action group. Mark Roseland is Director of the Centre for Sustainable Community Development at Simon Fraser University and Professor in SFU's School of Resource and Environmental Management. He lectures internationally and advises communities and governments on sustainable development policy and planning. And most importantly, he's available to talk to your group. For a small honorarium, he spoke for well over an hour with the Sooke Life-Long Learners group, detailing what BC rural communities can do. The talk was also recorded and made available to our municipal councillors.

Managing growth will define your community. If you are seeing current growth, or are expecting future growth, get out in front. Do you want to reduce car dependency, and by extension car tCO_2e? Then restrict suburbs of single-family homes. Densify, particularly your town core. Get transit in place first—development follows transit, not the other way around, as counter-intuitive as that seems to be. And transit doesn't necessarily mean mass transit. It can be as simple as pre-planning where your multi-use trails are going to go. Or planning to only have best-practice sidewalks.

You don't even have to do the research on best-practices. For example, the BC government has produced the Active Transportation Guide to assist communities in building walkable towns. I've appended it to this document.

Here's the example for urban sidewalks:

[17] Beasley, L. Vancouverism 2019

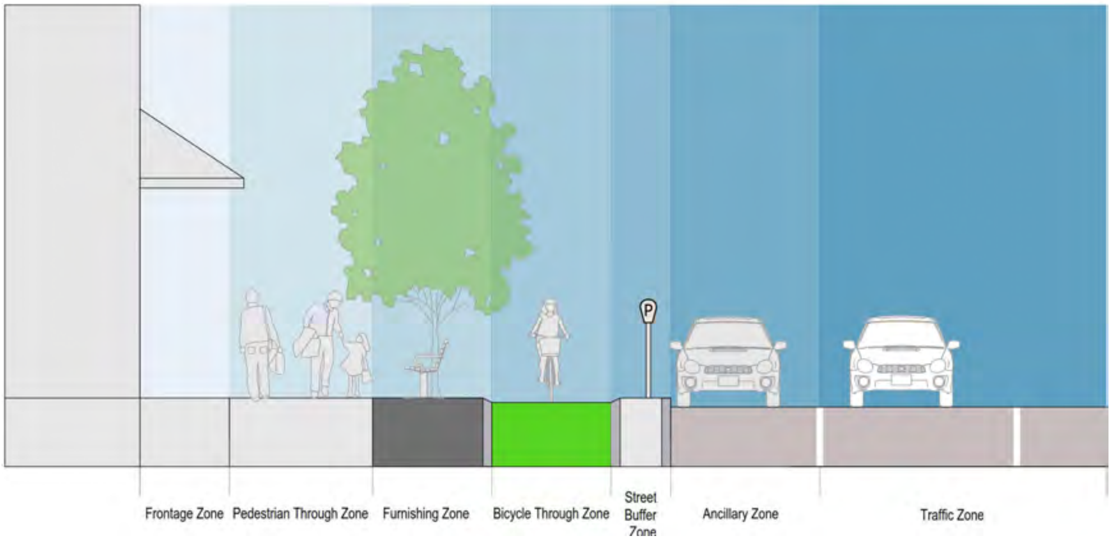
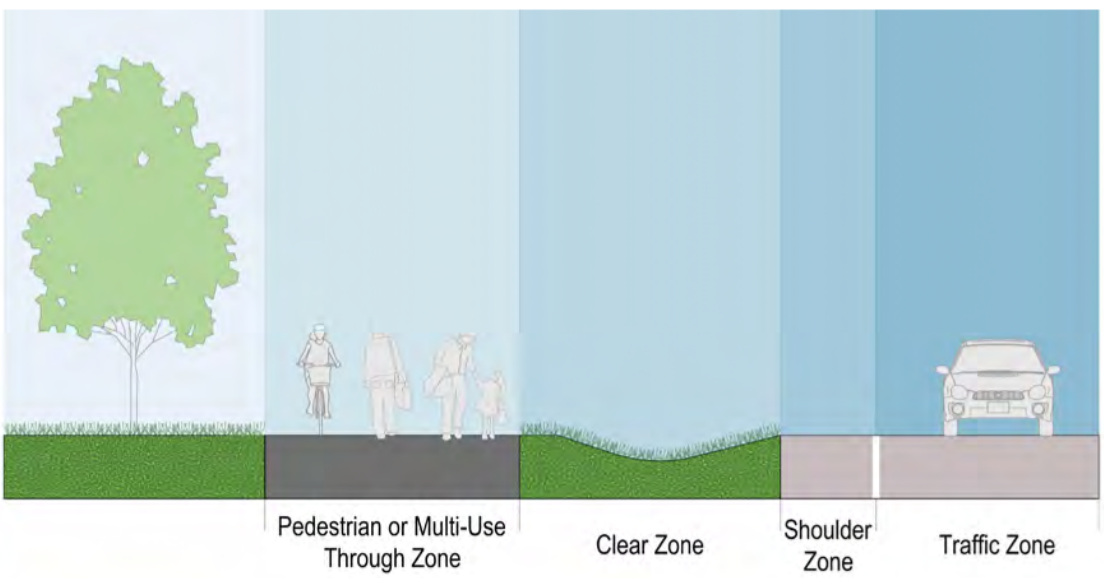


Figure B-2 // Urban Street Zones

And for rural zones:



What, then, are we looking at? Well, look at how wide the sidewalk is. There's room for businesses to put out displays, small café tables, or produce bins in front of their stores without impeding wheelchairs or child strollers. And there's all that room for people. There's room to stop and chat, room for both slow and fast walkers, kids, and space to look at the businesses without disrupting pedestrian flow.

Then there is a street furnishing zone, with a space to put benches, planter boxes, trees. This decorates the street while separating people from cyclists and traffic. It can also reduce street noise—keep in mind that cities aren't loud. Cars are.

The street furnishings separate pedestrians from cyclists, while giving cyclists a place to dismount and join the pedestrian flow. And the cycling lane is physically separated from traffic. Not with that magic paint that's supposed to keep cyclists safe, creating what's called a bicycle gutter. There is instead a physical separation: a curb, parking, more street furnishings. Design elements which make cyclists feel safe riding in town. Europe has proven time and again that building cycling infrastructure creates bike riders. This should be no surprise; Jane Jacobs taught us that creating traffic infrastructure creates traffic.[18]

This lesson from Jacobs is important. If you build it, they will come. Build roads, cars will drive on them. Build infrastructure to relieve congestion and the relief is short-lived. Ease of use creates more traffic to overwhelm the ease of use.

Often this traffic is created by development. Seeing a road, housing will be built to take advantage of it. The only way to reduce traffic is to make driving more difficult and the alternatives much easier. Mass transit relieves congestion by taking cars off the road. Vehicular traffic and accessible mass transit will achieve a dynamic equilibrium[19].

So, when you build bike and pedestrian infrastructure the same thing happens: people use it. Densify the core, and you have people deciding that maybe they only need a car occasionally, and perhaps they can make do with a car share co-op membership (think Modo or Evo). This is what happened in Vancouver.

Again, the European experience is instructive. By prioritizing human-powered commuting or active transportation (with concessions to mobility devices like powered wheelchairs), Amsterdam now builds bike garages near their train stations. Garages that can hold upwards of five thousand bikes. I'm not kidding. Check out the youtube channel Not Just Bikes. Created by a Canadian who grew up in Ontario, lived in Houston, and now resides in Amsterdam, NJB will astound you with his discussion of transportation, urban design, and Dutch bicycling (such as why helmets should be optional).

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[18] Jacobs, Jane *The Death and Life of Great American Cities* 1961 see also By The Numbers section

[19] The idea that more roads don't equal better traffic flow has a lot of other ideas around it. Start with the Downs-Thomson Paradox, which is the number-backed version of Jane Jacobs.

When looking at commute times, there seems to be Marchetti's Constant. We all figure that a half-hour is about the right commute time—regardless of the transportation choice. So, bikes and foot traffic, cars and mass transit, all should take about half an hour to get you where you're going. Commute times over the magic half-hour create growing frustration—and usually the call for more/better roads.

Braess's Paradox is about how adding a road can slow traffic. Often, removing a road will speed traffic. Not the least reason is that some driver's may then find mass transit more efficient for their commute.

That building a road might increase traffic is called "induced demand," or "induced traffic." This also follows the Lewis-Mogridge Position, where you find you're just shifting congestion around. There are better descriptions of these concepts in the "By The Numbers" section of this preface.

Rural best practices are generally the same: instead of the sidewalk/sidewalk furnishings/bike path, there's a multi-use trail. But it too is separated from traffic—in this rendering, by a ditch.

And let me take a moment to praise ditches. A ditch may not be the most efficient way to drain water from an area, but that's it's superpower. Ditches can act as mini-bogs. Water can be encouraged to move more slowly through ditches, particularly if sod has been used to create a herringbone pattern along the bottom. The turbulence created in such a ditch serves to help clean the water passing through it. If it has been planted with cattails, the cattails will take up heavy metal contamination in their roots, locking it away and preventing it entering a fish-bearing stream. Ditches also can support life such as amphibians, can be designed to pool to let turbidity settle out, and just generally be great. While it's always better and cheaper to use natural features rather than mimicking the feature with a built environment, the closer you get to the original natural system, the better it will function. Natural drainage first, nature-based built environments like a ditch second, and buried pipes or other technologically-based solutions are a far distant third.

When we looked at the numbers, the sheer volume of cars commuting out of, and back into, Sooke every day was both appalling and very disheartening. It made it clear that development had turned our small town into nothing more than a bedroom community for Victoria—an hour or so commute away. When it came to the numbers, they were out of date by a couple of years because the province only monitors every few years. In case you didn't know, not measuring is a tactic to cover non-action. Until you measure it, the problem doesn't exist. Not measuring frequently means that it's clear the numbers will be horrific, and that in this case there's no real plan to deal with tCO2e emissions. The committee disagreed with this approach, and felt that we should have real-time monitoring of traffic. Traffic counters are reasonably cheap, can be permanently installed, and now come with wireless data transmission capability.

The same is true of active transportation monitoring: not as cheap, but can be permanently installed, and can transmit the data over a wireless connection. So real-time, publicly accessible data is easily available. But how to use it?

One possibility could be data transmitted to a live notice board. How many cars on the road each day, estimated amount of tCO_2e emitted per day, and number of people using active transportation. And data like this can even be gamified. The idea behind turning actions into a game is about making something potentially tedious into something fun. Gamification is effective because it taps into people's natural desires for fun, competition and achievement. Particularly if you can compete against a nearby town.

With the availability of micro-computers like the Arduino and Raspberry Pi, it is very easy to design monitoring stations for just about anything. Pollutants, water levels, anything you can think of really. So real-time data collection has become cheap and (relatively) easy. There are manuals available to simplify the process even more. You should consider taking advantage of this. What happens when citizen scientists can and do measure just about anything? It makes issues exist. High school students can build and deploy monitoring stations for, say, water pollution, and those numbers can be used to demand action. Regular updates to your town's social media page(s) can generate public pressure around issues like this.

And you need public pressure to back-up issues brought before council. Our council has adopted the seven percent solution, accepted the CAP, but is still mired in arguments around how (and now *if*) to proceed. Without continued public pressure, contentious issues can be moved from being front and centre, to being pushed over to the edge of the desk, and eventually may be (accidentally) knocked off into the garbage (which I hope will be the most I'll extend a metaphor). Thankfully, we have had such continued public pressure, so the issue is still being debated in Sooke, rather than being forgotten.

How We Build

The *How We Build* goals from the CAP:

- *All new residential and commercial buildings are net-zero energy ready based on the BC Energy Step Code (using 80% less energy) by 2028.*
- *All new residential and commercial buildings use heat pumps or other forms of zero-emissions heating and hot water systems.*
- *No new residential or commercial natural gas connections are made after 2024.*
- *80% of existing residential fossil fuel heating and hot water systems are replaced with zero emission systems by 2030.*
- *100% of existing commercial fossil fuel heating and hot water systems are replaced with zero emission systems by 2030*

How we build is a difficult one. Construction uses a lot of concrete, and you can figure that approximately one tonne of concrete means approximately one tonne of tCO2e (Princeton University figures 0.93 pounds per pound of concrete). That's how carbon intensive the cement-making process is. And while there are alternatives, like hemp-crete and carbon-sequestered cement, these have their own issues.

So, if we are to continue using concrete, we have to figure out how to sequester a lot more carbon. Current carbon capture systems are far from being a mature technology and don't currently capture anywhere near what they claim. While it is possible that a magic bullet will appear, counting on it appearing is a recipe for failure.

One idea brought up by our committee was to make every proposed project contain an approximation of how many tCO2e will be emitted and a plan for mitigating that release. We experienced immediate and strong push-back. Nobody wants to know the numbers. And again, not measuring is a tactic to cover non-action. Until you measure it, the problem doesn't exist. I remain convinced that this policy of estimation and mitigation is foundational to countering the climate crisis. But we're still working to get this policy enacted.

And you can require this for private projects as well as municipal ones. Even without a plan for mitigation, at least you can estimate annual tCO2e. And estimation is pretty straightforward: Environment Canada, as well as many other websites, offer carbon calculators where plugging in numbers like "how many cubic metres of concrete are you planning to pour?" generates the tCO2e number. The numbers you will see on projects isn't exact, but will let you make decisions based on best estimate numbers.

And when it comes to mitigation, be cautious of practices that will take extended periods of time. Yes, planting a hundred trees will draw down all the carbon from a proposed project, but may take a thousand or more years to achieve that draw-down. And yes, there are also on-line calculators for how much carbon a given species of tree will remove per-year based on its diameter. Until the tree reaches old-growth status, it's not that much. Mitigation is not going to be a simple problem to solve.

One approach is to become more open to alternative housing concepts. Tiny homes can be one choice, as can yurts, straw bale buildings, stack walls, and many others. Many of these techniques have been used for decades if not centuries, proving their viability.

The push-back is that "they don't meet code and can't be insured." And owners worry about re-sale value. It means that there is a lot of work still to be done on updating the building code to allow for more experimental builds.

Yet there are currently ways to build that will reduce emissions long-term. Garden or green roofs are designed to be planted in order to help reduce summer heating, moderate rain run-off, and even provide edible plants. They can be flat roofs, lined with planters, or canted roofs solidly planted with sod, or anything in between. Here in Sooke, we have a yurt-style building with a circular canted roof planted with grasses that has been functioning for decades.

Sooke has also adopted the provincial STEP building code. The BC Energy Step Code[20] is an optional compliance path in the BC Building Code that local governments may use, if they wish, to incentivize or require a level of energy efficiency in new construction that goes above and beyond the requirements of the BC Building Code. Builders may voluntarily use the BC Energy Step Code as a new compliance path for meeting the energy-efficiency requirements of the BC Building Code. The BC Energy Step Code puts British Columbia on a path to meet the province's target that all new buildings must be "net-zero energy ready" by 2032.

Notice that they are shooting for "net-zero ready," not net-zero. And the program is not yet mandatory, but voluntary. So, there's a lot of wiggle room left in order that developers won't have to meet that "net-zero ready" standard for quite a while. Yet I would say that adopting the STEP code is marginally better than not adopting it in your municipality. Expect push-back. Developers are often facing the future with ideas dating from the 1950s, and hate change.

There are benefits to replacing as many roads a possible with multi-use trails. One major one is that pretty much any non-asphalt construction will help reduce the heat island effect. Built environments seem to work exactly the opposite of what we want; they concentrate environmental heat while generating their own. This results in a built environment being degrees hotter than the surrounding environment. Not a good thing during a heat-dome event.

Again, there are ways to mitigate heat-islands and built-environment heating. One way is to simply require white, "green (or planted)," or solar roofs. Unlike black asphalt roofs, each of these reduce heating by reflection, absorption, or conversion.

One of the down-sides of converting to heat pumps is that they enable one to use, and actually encourage, air conditioning. During a heat-dome event, running the air conditioner generates heat

[20] BC Energy Step Code accessed 14 March 2023

outside to supply cooling inside, and by doing so contributes to the heat island effect. White, green, and solar roofs all help to prevent heating in the first place, and can lower air conditioning needs.

How We Lead

The *How We Lead* goals from the CAP:

1. *Reduce transportation emissions from municipal operations by 50% by 2030 by implementing fleet electrification and providing e-bikes as an option for short staff trips.*
2. *Achieve green business certification through Vancouver Island Green Business Collective66 by increasing operational and building efficiency by 2027.*
3. *Increase efficiency of outdoor lighting by transitioning all remaining outdoor lights to LEDs by 2024.*
4. *Participate in a verified carbon offsetting program for remaining emissions resulting from municipal operations.*

How we lead refers to how the District of Sooke can be seen doing what is being recommended to the community. To quote the CAP: “How We Lead invites us to rethink how we lead by example, communicate internally and with the public, and prioritize low carbon resilience in all municipal operations.” This whole “lead by example” thing has been kept really straightforward in order to be achievable by local government. “Reduce transportation emissions [with] fleet electrification and providing e-bikes” doesn’t take a lot of thought. When retiring a vehicle from the municipal fleet, replace it with an electric car. Have a bike or two around so quick trips can be made by electric-assist bike rather than car.

Frustratingly, Sooke still has a distance to cover in order to achieve these goals. Currently there’s not even bike parking at the municipal hall, so non-car active transportation isn’t really top-of-mind. But we can count one success. I asked staff about how the town’s electric bill was paid and was told “Hydro sends a bill, we pay it.” Now we don’t have all that many streetlights, but the ones that we had were not what you would call “energy efficient”. I cornered one of the council members and pointed out that if we’re paying for streetlights, we have the right to insist that they be transitioned to the most energy efficient ones available. (Yup, that’s exactly how I said it. I didn’t get worked up at all. No, really!) Since then (Not out of fear. Why would you think that?) the town is transitioning all municipally-paid lights over to energy efficient fixtures. It’s a small win, true. But it’s a win. And honestly, we need to celebrate every win, no matter how small. Because small wins can add up to noticeable steps along the road to resiliency.

One of the things to watch out for would be when you get items like number four (page 27):

4. Participate in a verified carbon offsetting program for remaining emissions resulting from municipal operations.

It’s easy to find carbon offset programs. But a good one that is actually doing what it claims? Much, much harder to find. One alternative is to start your own. As an example, a forestry company is clear-cutting forest in our district, and then selling the stripped blocks in approximately 40 hectare (100 acre) chunks for development. The acquisition of one or more of these could allow the municipality to begin its own carbon offset program. One of the big benefits would be that when the council chooses to brag about how well they’re doing, the claims can be quickly checked up on. It’s not exactly the same with a commercial operation. They’re often a lot less forthcoming on how things are going.

I know that I, if not everyone, accepted several blurry goals in the CAP because they act as placeholders. When we reach the placeholder, we can develop projects, plans, and programs which can be brought in front of council to push forward in these areas. All in service of the one overarching goal: 50% tCO_2e emissions reduction by 2030.

How We Relate

The *How We Relate* goals from the CAP:

- *Review of all district policies and bylaws using a climate justice framework .*
- *Virtual and in-person learning opportunities hosted by the District and its partners on a regular basis to improve community knowledge of ecosystems, climate change, Just Transition, and FireSmart.*
- *Focused education opportunities on mobility shift, heat pumps, and other individual level opportunities for behaviour change that impacts carbon reduction.*
- *Development and full implementation of a community wellness matrix*

This is a big one, but there is help. Appended to this document is the Climate Justice Toolkit for Municipalities: Best Practices for Centring Equity and Justice in Local Climate Action. Once again, the hard initial work has been done and you can take advantage of that. The toolkit lists some action areas: integrate climate justice into planning and policy, conduct meaningful and inclusive engagement, embed climate justice and build capacity internally, and suchlike.

Climate justice is not only about reconciliation issues, but also about ensuring that all historically marginalized groups are given the opportunity to participate. The phrase I often use is "Lift the bottom. Lower the top. Spread the middle." Poor, marginalized, and racialized communities are usually the first to feel the effects of climate change, and those who suffer the most from it. Again, the way the poor, black communities were treated post Katrina is an excellent example. Special needs of the community were not taken into account (such as needing transportation out of town), they were least prepared (because of an historical reluctance to spend public money on the poorest wards and poorest people), and then warehoused in ill-prepared facilities. Hysterical, and flat-out incorrect reporting of rumour and hearsay about looting and violence in the community was just the icing on the racist cake.

Marginalized communities don't just jump on board the climate collapse preparedness train. Historically othered folks know damn well when they are not wanted. So, it is incumbent on you to start the dialogue. Reach out and ask. Don't tell. People know what the problems in their community are. They also have ideas about solutions—solutions based in their knowledge of their own community. You don't have that knowledge, so the number one most important thing you can do is listen.

There is also the need to relate to our neighbours. This is where programmes like FireSmart can help. Talking to you neighbours about, say, the possibility of a nearby forest fire causing the destruction of your neighbourhood or even town can lead to productive conversations on how climate collapse is worsening these events and how your town might become more climate resilient.

One of the adaptive measures slowly being phased in here is the "neighbourhood pod." Designed for emergency situations, these are shipping containers holding emergency supplies and maintained by and for a given neighbourhood. They are also a great way to open communication and build solidarity.

By The Numbers

The 10 Biggest Carbon-Dioxide Emitting Firms In The World

Rank	Firm	Billion tonnes of carbon dioxide equivalent produced (1965 to 2017)
1	Saudi Aramco	59.26
2	Chevron	43.35
3	Gazprom	43.23
4	ExxonMobil	41.90
5	National Iranian Oil Co	35.66
6	BP	34.02
7	Royal Dutch Shell	31.95
8	Coal India	23.12
9	Pemex	22.65
10	Petroeos de Venezuela	15.75

Source: The 10 Biggest Carbon-dioxide Emitting Firms In The World January 2020. Retrieved March 2023

The Traffic Congestion Paradox (from page 18)

Yes, I've used the Wikipedia articles. They are succinct, well-written, and most certainly better than anything I could come up with.

Downs-Thomson Paradox

The Downs-Thomson paradox (named after Anthony Downs and John Michael Thomson), also known as the Pigou-Knight-Downs paradox (after Arthur Cecil Pigou and Frank Knight), states that the equilibrium speed of car traffic on a road network is determined by the average door-to-door speed of equivalent journeys taken by public transport.

It is a paradox in that improvements in the road network will not reduce traffic congestion. Improvements in the road network can make congestion worse if the improvements make public transport more inconvenient or if they shift investment, causing disinvestment in the public transport system.

The general conclusion, if the paradox applies, is that expanding a road system as a remedy to congestion is ineffective and often even counterproductive. That is known as Lewis-Mogridge position and was extensively documented by Martin Mogridge in the case study of London on his 1990 book Travel in towns: jam yesterday, jam today and jam tomorrow?

There is interest in the study of this phenomenon since the same may happen in computer networks as well as transport networks. Increasing the size of the network is characterized by behaviors of users similar to that of travelers on road networks, who act independently and in a decentralized manner in choosing optimal routes between origin and destination is an extension of the induced demand theory and consistent with Downs' 1992 theory of "triple convergence", formulated to explain the difficulty of removing peak congestion from highways. In response to a capacity addition three immediate effects occur: drivers using alternative routes begin to use the expanded highway; those previously traveling at off-peak times (either immediately before or after the peak) shift to the peak (rescheduling behavior as defined previously) and public transport users shift to driving.

Source: Downs-Thomson paradox - https://en.wikipedia.org

Marchetti's constant

"Marchetti's constant is the average time spent by a person for commuting each day. Its value is approximately one hour, or half an hour for a one-way trip. It is named after Italian physicist Cesare Marchetti, though Marchetti himself attributed the "one hour" finding to transportation analyst and engineer Yacov Zahavi.

Marchetti posits that although forms of urban planning and transport may change, and although some live in villages and others in cities, people gradually adjust their lives to their conditions (including location of their homes relative to their workplace) such that the average travel time stays approximately constant. Ever since Neolithic times, people have kept the average time spent per day for travel the same, even though the distance may increase due to the advancements in the means of transportation. In his 1934 book *Technics and Civilization*, Lewis Mumford attributes this observation to Bertrand Russell:

Mr. Bertrand Russell has noted that each improvement in locomotion has increased the area over which people are compelled to move: so that a person who would have had to spend half an hour to walk to *work a century ago must still spend half an hour to reach his destination, because the contrivance that would have enabled him to save time had he remained in his original situation now—by driving him to a more distant residential area—effectually cancels out the gain.*

A related concept is that of Zahavi, who also noticed that people seem to have a constant "travel time budget", that is, "a stable daily amount of time that people make available for travel." David Metz, former chief scientist at the Department of Transport, UK, cites data of average travel time in Britain drawn from the British National Travel Survey in support of Marchetti's and Zahavi's conclusions. The work casts doubt on the contention that investment in infrastructure saves travel time. Instead, it appears from Metz's figures that people invest travel time saved in travelling a longer distance, a particular example of Jevons paradox described by the Lewis–Mogridge position. Because of the constancy of travel times as well as induced travel, Robert Cervero has argued that the World Bank and other international aid agencies evaluate transportation investment proposals in developing and rapidly motorizing cities less on the basis of potential travel-time savings and more on the accessibility benefits they confer."
Source: Marchetti's constant - https://en.wikipedia.org

Braess's paradox

"Braess's paradox is the observation that adding one or more roads to a road network can slow down overall traffic flow through it. The paradox was first discovered by Arthur Pigou in 1920, and later named after the German mathematician Dietrich Braess in 1968.

The paradox may have analogies in electrical power grids and biological systems. It has been suggested that, in theory, the improvement of a malfunctioning network could be accomplished by removing certain parts of it. The paradox has been used to explain instances of improved traffic flow when existing major roads are closed."
Discovery and definition

Dietrich Braess, a mathematician at Ruhr University, Germany, noticed the flow in a road network could be impeded by adding a new road, when he was working on traffic modelling. His idea was that if each driver is making the optimal self-interested decision as to which route is quickest, a shortcut could be chosen too often for drivers to have the shortest travel times possible.
Source: Braess's paradox - https://en.wikipedia.org

Induced Demand

"In economics, induced demand – related to latent demand and generated demand – is the phenomenon whereby an increase in supply results in a decline in price and an increase in consumption. In other words, as a good or service becomes more readily available and mass produced, its price goes down and consumers are more likely to buy it, meaning that quantity demanded subsequently increases. This is consistent with the economic theory of supply and demand."

"In transportation planning, induced demand, also called "induced traffic" or consumption of road capacity, has become important in the debate over the expansion of transportation systems, and is often used as an argument against increasing roadway traffic capacity as a cure for congestion. Induced traffic may be a contributing factor to urban sprawl. City planner Jeff Speck has called induced demand "the great intellectual black hole in city planning, the one professional certainty that every thoughtful person seems to acknowledge, yet almost no one is willing to act upon.""

Source: induced demand - https://en.wikipedia.org

Welcome to Overload: The Supporting Documents

Included below are:

1. Sooke2030 Climate Action Plan
2. BC Active Transportation Design Guide
3. Climate Justice Toolkit for Municipalities
4. Effect of Residential Gas Appliances on Indoor and Outdoor Air Quality
5. Sooke Region Food Security Report
6. Low Carbon Resilience Handbook 2022
7. Urban Heat: Can White Roofs Help Cool Warming Cities?
8. Updates to *Limits to Growth*
9. Food Waste Reduction Guides
10. Zero Waste Reports/Guides

2: Active Transportation Design Guide - Province of British Columbia Seriously, this guide is 78mb in size, and makes the entire document unwieldy. I tried making it part of this .pdf, but it crashed too many systems (gmail, for example), so you can get your own copy from the above link.

CLIMATE JUSTICE

TOOLKIT FOR **MUNICIPALITIES**

Best Practices for Centring Equity and Justice in Local Climate Action

2021

Climate Justice Toolkit for Municipalities

June 2021 | Toolkit

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The **British Columbia Council for International Cooperation (BCCIC)** is a network of civil society organizations and individuals moving toward a better world based in British Columbia, Canada. Its youth-led climate change branch focuses on providing sound and evidence-based policy recommendations to all levels of governments while representing the interests of Canadian youth at climate negotiations worldwide.

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Positionality

The authors would like to acknowledge our positionality as settlers and uninvited guests living and learning on the stolen lands of the xʷməθkʷəy̓əm, Stz'uminus, S'ólh Téméxw (Stó:lō), Skwxwú7mesh-ulh Temíx̱w (Squamish), sə̓lilwəta□ɬ təməxʷ (Tsleil-Waututh), and Coast Salish nations. We also identify as women, youth, and students. Our backgrounds, worldviews, intersectional identities, and experiences shaped this report, which has been developed from a place of privilege. We hope it can serve to uplift the work on climate justice that has been led by racialized, underserved and marginalized communities.

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Preface

Climate justice is a framework for climate action that centres social justice and equity in our understanding of climate change, including its causes and impacts, as well as in climate mitigation and adaptation efforts. Governments must respond to the calls of communities leading the climate justice movement and empower those who have been historically excluded from the policy process to be at the forefront of climate change decision-making. By recognizing climate change as an issue that disproportionately impacts certain populations over others, climate policy is better equipped to account for the plethora of ways in which climate change can exacerbate social inequalities.

Municipalities must recognize the intersectional impact of climate change and the crucial importance of climate justice to ensure that policy at the local level of governance is equitable. As the closest jurisdiction to the ground, municipalities have great potential to ensure that climate action centres the voices and leadership of marginalized populations across British Columbia (BC) moving forward.

Purpose of the Toolkit

This Toolkit illustrates the nature of climate justice across BC's municipalities to gain an understanding of what is currently being done to implement climate justice in local governance structures, identify opportunities for improvement, and outline challenges moving forward. The findings of this project have been informed by interviews conducted with local government officials and climate-focused organizations, yet remain non-exhaustive. The Toolkit is not intended to be hierarchical, although some synergies between steps are necessary. Climate justice is a multifaceted issue, and these are only some of many meaningful approaches to pursue.

How to use and who should use this Toolkit?

This Toolkit should be used to critically examine and reflect on current municipal practices (both in and out of climate policy) and guide municipalities in the continual and evolving process of climate justice. This report first outlines the concept of climate justice at international and local scales, followed by an overview of the current state of climate justice action by local governments throughout BC. It then outlines a set of action items for local governments to either address the issue or amplify existing efforts. The listed action items within the Toolkit are meant to provide municipal decision-makers with steps to operationalize climate justice in a meaningful, equitable, and holistic way

Climate Justice in Practice

Key Term

Marginalized Communities

The term “marginalized communities” is used here to refer to powerful groups subjected to systematic oppression. While recognizing that this label has been applied to a diverse range of individuals with complex experiences of oppression, the term “marginalized” reflects their shared experiences of discrimination, marginalization, and oppression on the basis of identity factors.

International Climate Justice

The experience of climate change is highly unequal, with negative impacts experienced most acutely by those in the Global South and **marginalized communities** across the world.[3] Nations in the Global South are significantly less responsible for the emissions that have fueled climate change, yet they face a disproportionate burden of its impact due to factors such as physical geography and level of industrial development.[4] For example, low-lying islands or arid regions are more vulnerable to sea-level rise and drought, respectively.[5] Many of these nations have limited access to resources and technology, lowering their capacity to implement climate adaptation measures.[6] These barriers are closely linked to colonization and its continuing expression in today’s global economy.[7] Climate justice activists have called on wealthier and historically responsible countries to shoulder greater responsibility for decreasing greenhouse gas emissions and support less-developed nations in their adaptation and mitigation efforts.[8]

[3] “A Feminist Approach to Climate Justice” (AQOCI and the Inter-Council Network, May 31, 2019), https://www.ocic.on.ca/wp-content/uploads/2019/06/WD_A-Feminist-Approach-to-Climate-Justice_Final_2019-05-31.pdf.

[4] Mary Robinson Foundation. “The Geography of Climate Justice,” 2011. accessed April 23, 2021, https://www.mrfcj.org/resources/the-geography-of-climate-justice-an-introductory-resource/.

[5] Mary Robinson Foundation. “The Geography of Climate Justice.”

[6] Mary Robinson Foundation. “The Geography of Climate Justice.”

[7] Brandon Kendhammer, “A Controversial Article Praises Colonialism. But Colonialism’s Real Legacy Was Ugly.,” *Washington Post*, accessed June 10, 2021, https://www.washingtonpost.com/news/monkey-cage/wp/2017/09/19/colonialism-left-behind-a-long-legacy-most-of-it-bad/.

[8] Charveriat Celine et al., “United for Climate Justice” (Institute for European Environmental Policy, April 2019), https://ieep.eu/uploads/articles/attachments/83ba9663-eb7b-40df-b886-d6be6c19ec54/Climate%20justice%20background%20paper.pdf?v=63736027852.

Key Term

Equity

The quality of being just, impartial, and fair. Equity is often confused with equality, though they refer to different things. For example, equal (i.e. the same) treatment of all populations in the face of climate change would result in an unjust distribution of impacts. Climate action grounded in equity provides differential treatment based on specific needs, in order to achieve a fair, just, and equal outcome.

Intergenerational Equity

The right of each generation to experience the same amount of well-being, often applied to environmental and climate policy to ensure future generations do not have to shoulder the burden of the environmental degradation occurring in the present.

[9] Edith Brown Weiss, "Climate Change, Intergenerational Equity, and International Law," *Georgetown University Law Center*, 2008, 615–27.

[10] "Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs," accessed June 10, 2021, https://sdgs.un.org/2030agenda.

[11] "Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs."

[12] P S Reddy, "Localising the Sustainable Development Goals: The Role of Local Government in Context," *University of KwaZulu-Natal* 9, no. 2 (June 2016), https://www.local2030.org/library/307/Localising-the-SDGs-The-role-of-Local-Government-in-context.pdf.

[13] "UNSDG: Leave No One Behind," accessed June 2, 2021, https://unsdg.un.org/2030-agenda/universal-values/leave-no-one-behind.

Intergenerational equity is another critical consideration for international decision-making on climate change due to the long-term timescale of climate change impacts. Today's actions have severe implications for the well-being of future generations who will experience the brunt of climate change impacts. Intergenerational climate justice recognizes that present generations have a duty towards future generations to minimize present and future climate change and pass on an Earth of equal condition to what we experienced.[9]

In 2015, all 193 Member States of the United Nations adopted the 2030 Agenda for Sustainable Development, which states the overarching goals of eradicating poverty, strengthening peace, and achieving sustainable trajectories for people and nature by 2030.[10] The 2030 Agenda is a critical global policy framework for climate justice, emphasizing equity, responsibility to future generations, and an intersectional approach to policy and government action. It includes 17 Sustainable Development Goals (SDGs) and centres climate action as a global priority through Goal 13, "take urgent action to combat climate change and its impacts."[11] Municipal governments play a key role in achieving the Agenda, as work for climate action and other interdependent SDGs will require transformative change at the local level.[12] The "Leave No One Behind" pledge of UN member nations to actively eradicate poverty, discrimination, and inequalities, and "endeavor to reach the furthest behind first" also significantly applies to the issue of climate justice and the work of municipalities.[13]

Local and City Level
Climate Justice

Key Term

LGBTQIA2S+

An acronym that represents the Lesbian, Gay, Bisexual, Transgender, Questioning, Intersex, Asexual and Two-Spirit communities.

In addition to the international and intergenerational distribution of climate change impacts, climate justice is integral to local-level governance. Climate change perpetuates inequalities between and within nations as marginalized populations bear a disproportionate burden of its impacts. This includes - but is by no means limited to - Black, Indigenous, and People of Colour; immigrant and refugee populations; women and girls; individuals identifying as part of the LGBTQIA2S+ community; people with disabilities; those experiencing homelessness; low-income populations; rural communities; the elderly; and their intersecting identities.[14] In addition, youth and future generations are of particular concern given that they will be burdened with the consequences of our actions. The intersection of diverse identity factors in different socioeconomic contexts means that some individuals and groups face more significant systemic barriers than others and are more at risk of experiencing the harmful effects of climate change. Climate action can either reinforce such

[14] Jennifer Dobai, Manuel Riemer, and Bianca Dreyer, "Sustainability Justice in the Context of Municipal Climate Action Planning: Key Consideration" (Viessman Centre for Engagement and Research in Sustainability, September 3, 2020). OHCHR, "The Rights of Those Disproportionately Impacted by Climate Change," *United Nations*, September 20, 2016, https://www.ohchr.org/Documents/Issues/ClimateChange/EM2016/DisproportionateImpacts.pdf.

inequalities or work to dismantle them towards an equitable, just future.

Municipal governments play a critical role in the production of justice issues. Their policies and work in urban development can influence social, political, and economic inequality within their community and contribute to the production of greenhouse emissions that reproduce these inequalities.[15] Governments can support resilience in the face of climate change by addressing socioeconomic inequalities,[16] as well as ensuring that policies do not direct resources away from critical social supports, displace poor or marginalized communities, or negatively affect them in other ways.[17] Additionally, municipalities must work to avoid the injustices known as "acts of omission," wherein elite groups are both protected and prioritized in climate action plans at the burden of low-income communities.[18]

Moving forward, BC's municipalities must recognize that climate justice means Indigenous Justice. Specifically, this will require decolonizing climate policy and addressing the structural inequalities perpetuated by ongoing colonial relations in BC and across Canada.[19] We see Indigenous communities worldwide defending their lands and leading movements for environmental and climate justice. Municipal governments must not violate the rights of Indigenous peoples, including their right to manage land in their territories, and should meaningfully include their voices, knowledge, and approaches in climate action.[20] This does not mean merely stating the intention to do so but working in genuine partnership with First Nations. This is pertinent to begin to address the oppression faced by Indigenous communities and Nations and to ensure that climate action does not come at their expense. BC municipalities need to learn and understand the realities faced by local First Nations communities. One place they could start is reviewing and integrating recommendations from critical analyses of Canada's Climate Action Plans by Indigenous peoples.[21]

[15] Harriet Bulkeley, Gareth A. S. Edwards, and Sara Fuller, "Contesting Climate Justice in the City: Examining Politics and Practice in Urban Climate Change Experiments," *Global Environmental Change* 25 (March 1, 2014): 31–40, https://doi.org/10.1016/j.gloenvcha.2014.01.009.

[16] Martin, "Report: Inequalities Exacerbate Climate Impacts on Poor," *United Nations Sustainable Development* (blog), accessed April 23, 2021, https://www.un.org/sustainabledevelopment/blog/2016/10/report-inequalities-exacerbate-climate-impacts-on-poor/.

[17] OHCHR, "The Rights of Those Disproportionately Impacted by Climate Change," *United Nations*, September 20, 2016.

[18] "Equity Impacts of Urban Land Use Planning for Climate Adaptation: Critical Perspectives from the Global North and South - Isabelle Anguelovski, Linda Shi, Eric Chu, Daniel Gallagher, Kian Goh, Zachary Lamb, Kara Reeve, Hannah Teicher, 2016," accessed June 10, 2021, https://journals.sagepub.com/doi/10.1177/0739456X16645166.

[19] "Decolonizing Climate Policy in Canada" (PhiLab, March 31, 2021), https://static1.squarespace.com/static/5e8e4b5ae8628564ab4bc44c/t/6061cb700fbea64d81d4a2e6/1617021810952/pcf_critique_FINAL_executive_summary.pdf.

[20] "Decolonizing Climate Policy in Canada."

[21] Indigenous Climate Action, "Amplifying Voices," https://www.indigenousclimateaction.com/amplifying-voices.

Key Term

Resilience

Resilience is the ability to adapt and thrive no matter the chronic stresses and acute shocks, such as slower climate change impacts to more severe weather events.[2]

Intersectionality

An analytical approach that seeks to investigate and establish the ways that different inequalities intersect with one another and to change societal norms that "hold other oppressive systems in place"[1] by accounting for factors such as age, ability, gender, race, region, socioeconomic status.

In BC, there is a far-reaching commitment to climate action across municipal governments, with 187 out of 190 municipalities as signatories to the BC Climate Action Charter stating a commitment to climate action.[22] However, climate justice as a term and guiding framework is not widely seen across BC municipal governments' climate policies or plans. The City of Vancouver has taken a substantial step towards climate justice within its recent Climate Emergency Action Plan released in 2020.[23] As well, the District of Saanich has taken action to integrate equity into its recent Climate Plan.[24] Although direct mention of justice or climate justice is absent, the plan acknowledges the disproportionate burden of climate impacts on marginalized populations. It states that an equity lens will inform city planning for resilience, and includes strategies to work towards equitable climate action.

Opportunities exist across municipalities for commitment and efforts towards meaningful and equitable climate action. Through interviews with city councillors in BC and leaders in environmental- and justice-based work, this research has highlighted several key steps municipalities can take towards this goal. However, the scope of this project is limited given the absence of direct consultations with marginalized communities. We sought to reduce this limitation by conducting interviews with individuals in organizations that work with these communities and who understand the complexities of the issues they face.

[1] "In the Words of Marai Larasi: 'If We Are to End Violence against Women and Girls, We Need to Create Seismic Shifts across Our Social Norms.,'" UN Women, accessed June 7, 2021, https://www.unwomen.org/news/stories/2018/1/in-the-words-of-marai-larasi.

[2] "Urban Resilience," *Resilient Cities Network* (blog), accessed June 12, 2021, https://resilientcitiesnetwork.org/urban-resilience/.

[22] The Province of BC and UBCM, "The BC Climate Action Charter," 2007, https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/local-governments/planning-land-use/bc_climate_action_charter.pdf.

[23] City of Vancouver, "Climate Emergency Action Plan," October 22, 2020, https://council.vancouver.ca/20201103/documents/p1.pdf.

[24] District of Saanich, "Climate Plan: 100% Renewable and Resilient Saanich," 2020, https://

6 ACTION AREAS

The following section outlines a list of key action items organized into six action areas that can inform and guide municipal governments towards climate justice.

INTEGRATE CLIMATE JUSTICE INTO PLANNING AND POLICY

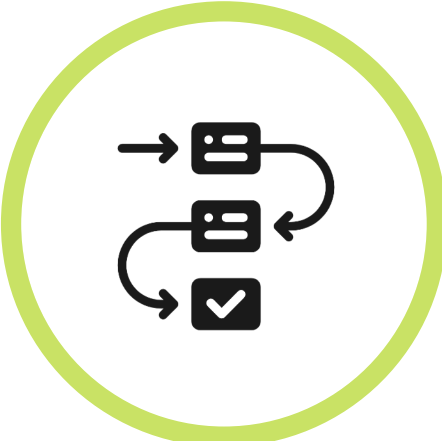
CONDUCT MEANINGFUL AND INCLUSIVE ENGAGEMENT

EMBED CLIMATE JUSTICE AND BUILD CAPACITY INTERNALLY

PARTNER AND COLLABORATE

ENSURE ACCESS TO BASIC GOODS AND SERVICES

RAISE AWARENESS AND AMPLIFY



Integrate Climate Justice into PLANNING AND POLICY

Overview

Climate justice should be moved from a secondary consideration to a central goal and should be integrated throughout all municipal work. This requires recognition and understanding of the justice implications of both climate change and climate policy.

ACTION ITEMS

1.1 Recognize climate change as a justice issue.

Publicly acknowledge that climate change and climate policy impacts fall disproportionately on marginalized communities such as Indigenous peoples, racialized groups, women, and girls.

1.2 Develop a climate justice strategy.

Aim to come to an understanding of key concepts and share resources through widespread consultation and collaboration. Such efforts should include diverse sets of stakeholders across different sectors so that no voices are left behind.

1.3 Implement an intersectional climate justice lens.

Form a working definition for climate justice, actively use the term in policy-making, and provide information on how it will be applied across municipal work. Develop climate action plans with climate justice at the core, rather than as an added consideration. Work to understand who is currently or could become vulnerable in your municipality, in terms of spatial risks to climate impacts and other determinants of vulnerability such as gender, a limited support network, or low income.[25]

1.4 Actively integrate anti-racism, gender equity, and intergenerational equity into work.

Begin by investigating how these inequities are currently built into the practices, policy, and operations of the municipality. Having open discussions with co-workers, capacity-building workshops, and inclusive hiring practices are places to start. Examples of actions include creating spaces or working groups to discuss and learn about racism, providing staff training on anti-racism and encouraging staff to attend conferences on the topic, and supporting diverse programming and events within your community, among many other actions that can be taken.[26] It's important to remember that equity advocacy needs to be sustained throughout all climate justice actions.

[25] Rachel Brisley et al., "Socially Just Adaptation to Climate Change" (Joseph Rowntree Foundation, July 2012).

[26] "Anti-Racism and Anti-Discrimination for Municipalities: Introductory Manual," accessed June 7, 2021, http://www.ohrc.on.ca/en/book/export/html/2495.

1.5 Center reconciliation with Indigenous peoples in all climate action.

There is no climate justice without justice for Indigenous communities in Canada. Climate action needs to actively dismantle colonial practices and policies that disproportionately impact Indigenous communities. Climate justice should work together with Indigenous voices and should support Indigenous leadership towards environmental resiliency.

1.6 Represent climate justice action in financial commitments.

Demonstrate how climate justice is incorporated into the municipal budget to demonstrate how it has been prioritized and have this information publicly available.

1.7 Create Key Performance Indicators.

Employ a concrete set of metrics to quantify and track climate justice strategies currently implemented at a municipal level. This will ensure assessment of the impacts of the policy and make the results known to the public to hold local governments accountable. Set short-term goals that are achievable, dynamic, and trackable in line with long-term objectives. This can include social vulnerability mapping using weighted indicators that consider the intersection of several factors such as gender, food access, disability, age,[27] or local community resilience metrics.[28]

[27] California's Fourth Climate Change Assessment, "Climate Justice Report" (State of California, n.d.), https://resourceslegacyfund.org/wp-content/uploads/2018/09/Climate-Justice-Report-4CCCA-v.4-00455673xA1C15.pdf.

[28] "Community Resilience Toolkit" Bay Localize, BayArea2020, 2020, https://baylocalize.files.wordpress.com/2018/12/Community_Resilience_Toolkit_v1.0.pdf.

1.8 Conduct environmental monitoring and impact assessments.

Incorporate intersectional impact analyses of distributional inequalities. Such assessments should assess inequalities found in stakeholder consultation and in the implementation of compensation mechanisms for marginalized groups. Impact assessments should use both qualitative and quantitative methods. Such analyses should also utilize storytelling and Indigenous ways of sharing knowledge to better understand the inequitable distribution of environmental impacts.

1.9 Identify and mitigate unforeseen outcomes.

Anticipate, plan, and have appropriate adaptation measures in place for potential negative effects of climate policy on the population to anticipate unintended consequences that harm vulnerable communities.

CASE STUDY

The City of New Westminster[29]

New Westminster has developed a social equity policy as part of Envision 2032, a framework that informs and guides the City's work. The City's social equity policy informs the design, implementation and evaluation of their work - including policies, projects, programs and services - in order to identify and remove systemic barriers in the community. The policy does not specify exactly which systemic barriers they are referring to, thus providing an example of a need for more precise language within policy. New Westminster has applied a social equity lens to identify and improve the disparity of health outcomes between populations resulting from social determinants of health. In addition, the City undertook initiatives to support the development of safe, affordable housing for single mothers leaving situations of domestic violence. The Social Equity Policy is a key pillar for climate justice, promoting gender equality from an intersectional lens, supporting community resilience, and informing equitable climate actions plans.

[29] "'A city without barriers': New Westminster aims for social equity with new policy" PlanH. https://planh.ca/success-stories/city-without-barriers-new-westminster-aims-social-equity-new-policy?fbclid=IwAR2bmUNQyHkj_j6xqhC_AGy99xjIwNGJc8cFIhkDsiiPfkbakBx_ORYVY6g

CASE STUDY

The City of Vancouver

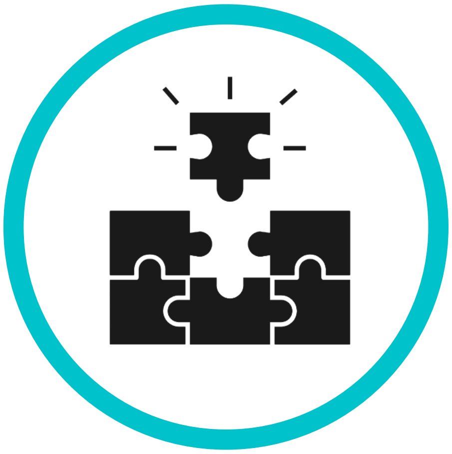
Vancouver's Climate Emergency Action Plan (approved November 2020) has integrated action for climate justice at multiple levels and was informed by equity analysis conducted by an Equity Working Group.[30] The working group aimed to include the voices of marginalized groups such as "Indigenous communities, communities of colour, low-income populations, or other disproportionately impacted communities the City typically fails to involve in policy development."[31] The plan includes a commitment to establishing a Climate Justice Charter, which will be developed in coordination with disproportionately impacted communities to "identify how City staff creating climate policy and programs can better address and integrate equity and racial justice." The Charter will incorporate equity indicators that can measure progress, outline methods for budget analysis with an equity lens, and direct economic benefits of policies towards marginalized communities or businesses in need.

"Meaningfully integrating equity into our work will take time, to allow staff to examine and change internal practices, build new relationships with impacted and systemically excluded communities, and to co-create solutions with those communities."[32]

[30] City of Vancouver, "Climate Emergency Action Plan."

[31] City of Vancouver, "Climate Emergency Action Plan," **1**

[32] City of Vancouver, "Climate Emergency Action Plan," **15**



CONDUCT MEANINGFUL AND INCLUSIVE ENGAGEMENT

Overview

Voices of those most affected by climate change need to be centred and uplifted in climate conversations. To establish a foundation for meaningful engagement, trust must be built and repaired with marginalized populations. Also, efforts must be made to ensure that citizens have equitable access to participatory events and other avenues of engagement that shape a municipality's climate change adaptation and mitigation actions.

ACTION ITEMS

2.1 Centre reconciliation across municipal work and establish trust-based relationships with Indigenous communities.

Municipal climate action must respect the self-determination of Indigenous Peoples and work to implement the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).[33] See the resource list in the Toolkit's appendices for further information on reconciliation in municipalities.

2.2 Engage diverse and unrepresented stakeholders.

Re-evaluate what groups are involved in city-level consultations to increase the scope of voices included and move towards more comprehensive engagement that centres the concerns of marginalized groups.

2.3 Recognize the agency and valuable expertise of marginalized communities.

Take the initiative to listen to and meaningfully engage with local communities in discussions on the barriers they face and what policy actions would be most useful.

[33] United Nations, "United Nations Declaration on the Rights of Indigenous Peoples," June 5, 2015, https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html/.

Discussions should also seek to learn from the important climate action efforts that these groups, such as Indigenous communities, are already leading. Participation should be accessible, and participants in engagement processes should be fairly compensated for their contribution and input in the policy design process.

2.4 Engage with citizens on climate policy using creative and accessible methods.

Seek to obtain feedback from people whose voices are not included in conventional engagement processes. Examples include conducting engagement at transit lines and other public hubs and establishing a permanent system of engagement within day-to-day municipal operations instead of taking an ad-hoc approach. Consider appointing a staff member liaison or engagement committee to conduct public engagement on a regular basis.

2.5 Provide accessible discussions of climate justice.

Spark community discussion surrounding the importance of climate justice and your municipality's climate justice action plan. Tailor climate justice communications to be approachable, engaging, and inclusive to a diverse range of individuals and groups. In addition to digital materials, develop in-person initiatives such as public art spaces and neighbourhood block festivals that foster an understanding of climate justice and build community connections.

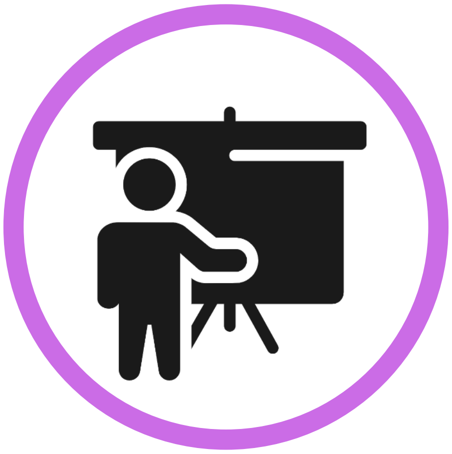
2.6 Develop collaborative, co-designed approaches to engagement.

Engage communities in collaborative, co-designed engagement to gain insight into both social and physical climate risks faced across the municipality. Design these initiatives to foster cross-sectoral engagement between local government, academia, the private and non-profit sectors, local cultural institutions and the general public. Examples include a diverse task force on climate justice, focus groups or social innovation labs that include a mix of expert and non-expert opinions, with a focus on BIPOC voices.

2.7 Establish a diverse climate justice advisory committee or working group.

Create a specialized, interdisciplinary working group that allows interested citizens from all backgrounds to have their concerns and ideas heard. This will foster ongoing, meaningful engagement rather than a tokenistic solution.[34]

[34] Apolitical, "How to Break down Silos on Climate Change," December 19, 2019, https://apolitical.co/en/solution_article/how-to-break-down-silos-on-climate-change.



EMBED CLIMATE JUSTICE AND BUILD CAPACITY INTERNALLY

Overview

There is a need to improve understanding of what actions fall within municipal jurisdiction, how municipal powers can be harnessed towards the achievement of climate justice, and how municipal governments' internal structures and practices contribute to and perpetuate both inequality and environmental degradation. Climate justice must be integrated across municipal operations.

ACTION ITEMS

3.1 Commit to internal diversity, equity & inclusion[35]

Establish a comprehensive approach to analyzing and establishing gender and racial diversity, equity, and inclusion within the municipal government workforce, policies, programs, and community engagement strategies. Ensure adequate representation of women, BIPOC, and equity-deserving individuals within the municipality's planning commissions and decision-making bodies.

3.2 Predict, measure and respond to unintended consequences.

To preemptively evaluate potential negative and unintended outcomes of climate policy, consult with stakeholders and marginalized populations, refer to literature reviews on related policies and their evaluations, and connect with other municipalities to learn from their experiences. Restructure policies as needed and implement measures to mitigate predicted adverse outcomes. Post-implementation, collect data from repeated long-term observations and have a mechanism in place for receiving feedback to learn about impacts as they occur. Finally, apply an adaptive management cycle to integrate learnings.

[35] "Justice Equity Diversity and Inclusion," US Climate Action Network, accessed April 23, 2021, https://www.usclimatenetwork.org/justice_equity_diversity_and_inclusion.

3.3 Stay up to date on climate justice research and activism

Actively seek out and listen to calls to action from organizations working on climate justice advocacy or supporting and representing oppressed peoples (e.g. Indigenous Climate Action). These platforms may host valuable resources about experiences of inequity and climate-related impacts and concerns of specific groups or individuals. Though not a replacement for direct engagement processes with local communities, efforts towards this action item can help alleviate participation fatigue of marginalized populations and improve access to the plethora of available, up-to-date information on such issues.

3.4 Employ staff across municipal departments responsible for guiding equity and climate justice action

These employees would serve as a knowledge source on climate justice and equity, actively inform the policy-making process, and reduce silos between departments for a coordinated approach.

3.5 Implement mandatory staff and elected official training on climate justice

Workshops and professional development seminars on key issues such as anti-racism, equity and inclusion, and climate justice are critical to understanding individual roles and responsibilities in perpetuating social and environmental injustice.

CASE STUDY

The City of Ottawa

The City of Ottawa created the Aboriginal Working Committee in 2007 to further reconciliation within their municipality.[36] The Committee operates with a direction "focused on building trust, relationships, and awareness through concrete actions" and comprises the municipality, various local service providers (libraries, school boards, police forces), and the indigenous organizations that make up the Ottawa Aboriginal Coalition.[37] The Committee attempts to further reconciliation in urban settings by using a "cultural working model" for municipal action that can "reflect the priorities of urban aboriginal communities."[38] By establishing internal channels such as this as mechanisms for partnership and collaboration with Indigenous communities, climate action can better centre reconciliation within its efforts.

[36] Community and Social Services Dept, "City of Ottawa Reconciliation Action Plan," February 23, 2021, https://ottawa.ca/en/city-hall/creating-equal-inclusive-and-diverse-city/city-ottawa-reconciliation-action-plan.

[37] Community and Social Services Dept, "City of Ottawa Reconciliation Action Plan,".

[38] Community and Social Services Dept, "City of Ottawa Reconciliation Action Plan,"

PARTNER AND COLLABORATE

Overview

Silos need to be broken down both within government institutions and between other sectors of society. Multilateral action, therefore, must be taken to meaningfully engage with other municipalities and sectors of society to address climate justice successfully. In addressing climate justice, municipalities should take a whole-of-society approach to support the implementation of the 2030 Agenda for Sustainable Development, which emphasizes the contribution and partnership of stakeholders in all sectors and collaboration with local communities to develop vital synergies. A whole-of-society approach is needed to ensure no voices are excluded from action on climate change and climate justice.

ACTION ITEMS

4.1 Connect with diverse organizations & community groups that represent or work with marginalized populations

Some organizations have working knowledge about the urgent needs of these communities and how they can be supported. Build trust and relationships with these groups, actively work to understand the barriers and climate risks their members face, and prioritize their calls to action.

4.2 Amplify and utilize the resources of community organizations

For example, build off the knowledge and work of community climate hubs,[39] which serve to connect and coordinate local climate initiatives, engage with the community to develop grassroots support, and advocate for government action on climate change.

4.3 Collaborate with other municipalities

For example, establish a participatory forum that operates as a space for dialogue between municipalities on their respective experiences, challenges and achievements. The forum should streamline knowledge-building and increase understanding of how climate change has impacted different communities across BC and internationally. Examples could include a series of discussion sessions, webinars, or establishing a task force to facilitate dialogue across municipalities.

4.4 Collaborate with universities[40] and other academic institutions

This work can help bridge the gap between policy and academic research being conducted on climate justice. Collaborating with this sector can also help encourage students to innovate and develop experimental projects to advance climate justice, while promoting their involvement in the policy-making process to further intergenerational equity.

[39] "Community Climate Hub - FAQ," accessed June 13, 2021, https://docs.google.com/document/d/1h_Jam7lagQLjzQicHnrTIFNV5XpUwW-DzHasTwOeTAw/preview.

[40] "Connecting Vancouver to Build a Better City," CityStudio Vancouver, accessed June 13, 2021, https://citystudiovancouver.com/.

Global and Local Urban Networks

Examples of different coalitions of cities and municipalities that are advancing efforts to ensure climate justice and urban resilience:

C40 Cities

C40 is a network of 97 global cities that are driving forward sustainable action on climate change. C40's mission aims to reduce half of the collective carbon emissions from its member cities while also centering equity and community resilience. C40 supports cities to implement community-focused urban regeneration and climate adaptation projects.

Rockefeller 100 Resilient Cities

The 100 Resilient Cities (100RC) was a program pioneered by The Rockefeller Foundation in 2013 to connect cities and build a network to drive transformational change and support urban resilience. Each city hired a Chief Resilience Officer to catalyze this agenda. The Resilient Cities Network expands upon 100RC to support the Chief Resilience Officers of each city to 'future-proof' their communities.

Federation of Canadian Municipalities (FCM)

The FCM is a convening force of local governments across Canada, and its membership includes more than 2000 municipalities representing 90% of Canadian citizens. The FCM advocates for citizen needs at the federal level. The FCM also offers a Green Municipal Fund to help municipalities adopt sustainable practices in the energy, land use, transportation, waste, and water sectors.

Climate Caucus

The Climate Caucus is a non-partisan network of 300+ local councillors, mayors, and regional directors across Canada working towards science-based, socially-just climate action. The Caucus is a meeting place for elected representatives to connect, collectively define problems and design solutions, and advocate at the provincial, territorial and federal levels of government.

ENSURE ACCESS TO BASIC GOODS AND SERVICES

Overview

The most marginalized communities need secure access to those goods and services which meet their basic needs and, thereby, improve resiliency in the face of climate impacts. Recognize what powers are at your disposal as a municipality to address climate justice across different sectors. Opportunities for more climate-conscious action are abundant in areas such as affordable housing, green and active transportation, women's empowerment, sustainable land use/development, and access to affordable food, clean energy, and social services within communities.

ACTION ITEMS

5.1 Implement redistributive policies at the community level to build community resilience.

This can involve defunding regressive city expenditures or taxing specific land and properties to capture developers' profit for reinvestment into public infrastructure.

5.2 Support a just transition to a low-carbon society.

Develop retrofit programs that support the implementation of energy efficiency and conservation measures and the generation and use of renewable energy sources. Prioritize low-income households facing energy poverty. Support a just transition by funding retraining programs, providing buffers to transitioning workers, advocating for provincial and federal governments to attract low-carbon jobs with comparable wages and benefits for affected workers, and implementing policies that encourage high-quality job programs for women, BIPOC and marginalized communities.

5.3 Strengthen local food security

Increase urban food production, strengthen key food system infrastructure, support access to healthy foods, and support the recycling and re-use of organic waste.[41] Support local projects, such as farmers' markets and community gardens. Work with developers to encourage the integration of community gardens into new multi-family developments.

5.4 Center public urban design around community resilience

Create public spaces that tie in to all the social determinants of health. For instance, community farms could complement green spaces, promote food resilience, support community centres providing social services, commission public art installations, and create spaces for the public to interact with and combat social isolation.[42]

5.5 Center equity in adaptation measures

Design adaptation measures to address vulnerabilities and advance equity. Some examples include: create equitable green spaces and shade access in preparation for heatwaves; integrate the prioritization of vulnerable communities into disaster response strategies; assess and respond to the intersectional gendered needs of women, girls and gender diverse people in emergency situations (e.g. concerning water, health and sanitation); and design long-term development plans such that lower-income populations are not most at risk of flood, rising sea levels, or landslides, and that the burden of care in these situations does not fall solely on the shoulders of women. Conduct equity analysis of proposed measures to avoid potential negative policy implications, such as green spaces impacts on gentrification.

[41] PlanH, "How Do Local Governments Improve Health and Community Well-Being?" (BC Healthy Communities Society and Healthy Families BC, September 2013), https://squamish.ca/assets/planH/d0e40f740e/planh-local-government-guide-web.pdf. Linda Shi et al., "Roadmap towards Justice in Urban Climate Adaptation Research," *Nature Climate Change* 6, no. 2 (February 2016): 131–37, https://doi.org/10.1038/nclimate2841.

[42] Diane Archer and David Dodman, "Making Capacity Building Critical: Power and Justice in Building Urban Climate Resilience in Indonesia and Thailand," *Urban Climate* 14 (July 1, 2015), https://doi.org/10.1016/j.uclim.2015.06.007.

CASE STUDY

The City of Victoria

The City of Victoria's Climate Leadership Plan includes an outline of projected climate impacts the city will face in upcoming years and points to the risk of rising food insecurity for low-income groups as climate change increases food prices.[43] Although not explored within the Climate Leadership Plan, Victoria's 2012 Official Community Plan (OCP) provides an analysis and plan of action for addressing food insecurity, with respect to future cost and stability of the food supply.[44] Equity considerations are integrated into outlined actions to address food insecurity within the community.

"The plan policies support a shift towards a more sustainable food system, one that considers and integrates food production, processing, distribution, consumption and waste recovery to support the nutritional, social, environmental and economic health of the community."[45]

[43] City of Victoria, "Climate Leadership Plan," 2018, https://www.victoria.ca/assets/Departments/Sustainability/Documents/City%20of%20Victoria%20Climate%20Action%20Plan.pdf.

[44] City of Victoria, "Official Community Plan," July 2012.

[45] City of Victoria. **120**

RAISE AWARENESS AND AMPLIFY

Overview

It is crucial that the distribution of education and knowledge resources is equal amongst communities and that citizens have equitable and accessible spaces where they can come together to co-produce knowledge.

ACTION ITEMS

6.1 Increase accessibility of information

Provide accessible and clear communication of local climate change risks and municipal action plans. For example, distribute information in more languages, improve readability by creating brief and comprehendible reports for the public, use other mediums to communicate information such as audio, and consider other culturally appropriate ways of sharing knowledge and information, such as storytelling.

6.2 Raise awareness of climate risks and potential adaptation measures

Empower communities to make informed decisions in the face of climate-related risks by disseminating information on anticipated local climate impacts, planned adaptation measures, and available support.[46]

6.3 Communicate current municipal plans and reports on climate justice

Improve transparency of climate justice initiatives and related key performance indicators to allow citizens to more readily hold local governments accountable. Carefully consider the value of community-driven data.

[46] Brisley et al., "Socially Just Adaptation to Climate Change."

6.4 Pursue public education and outreach programs to support climate justice

Educate the local public about how the transition to a zero-carbon economy can be just and beneficial to people's livelihoods. Include climate justice resources and information in regular public communications materials and consider innovative ways to reach local communities by consulting and co-creating campaigns with those who have lived experience.

6.5 Advocate for climate justice at other levels of government

A whole-of-government approach is needed to advance climate justice meaningfully. Municipalities should voice the critical need for climate justice, share knowledge on best practices, and synergize action with provincial and federal levels of government.

TIPS for Addressing Climate Justice from Interviewees

1. Actively **listen** to the experiences and concerns of **marginalized communities**

2. Strive for **place-based solutions** that address the needs of your specific community

3. Continuously ask the following questions: who is this policy **accessible** to, who is included in this conversation, and how are we including them?

4. Try to **share** experiences and information regarding climate action and justice efforts with other municipalities to increase **engagement** and **co-learning**

5. When engaging with the public, **go** to where they are instead of making them come to you

6. **Frame** policy directions on climate and climate justice in terms of how it can benefit communities to galvanize support both internally within the municipality and the general public

7. **Think outside of the box** to address this issue in an **intersectional** and **intergenerational** manner

8. Turn to citizens to help push for climate justice at the local level and apply a bottom-up approach to decision-making, in which diverse citizen participaion helps drive the planning and implementation process for climate justice

Conclusion

Municipalities today are facing increasingly pressing problems at the intersection of social justice and climate change. The growing field of climate justice calls for local governments to take action by preparing not just physical infrastructure to protect against climate effects, but also its citizens with the tools and resources needed to build resilience within their neighbourhoods, particularly for marginalized communities experiencing the disproportionate effects of climate change. Climate action must break down inequalities, be grounded in reconciliation and anti-racism, and move towards a more equitable future for all communities.

Municipalities across BC face different barriers in their recognition and integration of climate justice. This Toolkit aims to bring local governments to a common ground and provide actionable items to support meaningful action.

This inquiry has identified several examples of BC municipalities taking action to bolster climate justice and integrate a climate justice lens in their work. However, there remains considerable room for improvement. Municipalities should strive to ensure that climate justice is embedded within their climate action plans, beyond an acknowledgement of disproportionately affected communities, and towards actions that can empower and amplify the voices of these communities, address systemic inequalities, and ensure that society's transition to a climate-resilient future is just and equitable.

Additional Resources

Municipalities are encouraged to further their research on climate justice using the resources provided below

Key Concepts of Climate Justice

Climate Change and Social Justice

Climate Justice and Its Intersectionality with Gender

Just Transition

Climate Change, Intersectionality, and GBA+ in British Columbia

Reconciliation with Indigenous Peoples

Decolonizing Climate Policy in Canada

Indigenous Climate Action: Youth Needs Assessment

Gender Equality and Sustainable Development

A People's Orientation to a Regenerative Economy

Building Equity Using Nature-based solutions

Other Useful Tools for Municipalities

Anti-Racism and Anti-Discrimination for Municipalities

Equity and Inclusion for Municipalities

Adaptation Strategies and Vulnerability Assessments

Climate Active Neighborhoods

King County's Climate Action Toolkit

Climate Compass' Analytical Tool for Municipal Climate Action

Canadian Coalition of Municipalities Against Racism and Discrimination

Appendices

Appendix A - Approach

In our investigation of the nature of climate justice within BC's municipalities, we first analyzed the surrounding literature on the term and its implications in the Canadian context. By looking at peer-reviewed and grey literature, we were able to define both what climate justice is and how it has affected the municipalities of BC.

To support our literature review on the topic and get a better idea of the nature of its influence in this context, we conducted interviews with both climate justice-centred organizations and local government officials. Individuals were asked the following set of questions:

- What does climate justice mean to you? Would you consider climate justice an important issue for municipalities to address? Why or why not?
- How has your municipality responded to the call for climate justice? What future plans does your municipality have to implement climate justice?
- To your knowledge, what are other municipalities doing to respond to the call for climate justice?
- Generally speaking, where do you see municipal climate justice going in the future?
- What advice do you have for municipalities to effectively implement/advance municipal climate justice?

From the responses we received, we were able to understand the nature of the issue within the organizations and local governments that these individuals were working in and were able to craft a set of recommendations and best practices to include within our Toolkit. Overall we conducted 15 interviews, the results of which are explained below.

Appendix B - Interviews

What is Climate Justice?

Overall, there was strong consensus from interviewees that climate justice is paramount to addressing climate change. Most individuals chose to define the concept in terms of making sure that groups who are disproportionately impacted and excluded from conversations surrounding climate change are built into the focus of climate change policy moving forward. Interviewees often reiterated that climate justice acknowledges that climate change has direct ties to injustice and that climate policy should actively work to dismantle such injustice. A definition was concisely put by an interviewee who defined the concept as “looking at alleviating inequality, from income to racial and more, in the ways we shape climate action and policies, because we’ve seen the impacts of climate change are not being equally felt across demographics.” Those interviewed provided consensus that climate justice is important to incorporate in city policy and planning and often reiterated the intersectionality of equity with other municipal issues such as affordability and green investments.

Municipalities and their Experience

According to the local government officials, there was consensus over the importance of incorporating climate justice within municipal policy work, yet there were varying degrees to which individuals thought that the term was familiarized within local governance. Many officials mentioned that although they were familiar with the term and its importance, it was not yet within the vernacular of city-level governance. Other words such as climate emergency, climate crisis, and climate action were much more common within the local policy communities despite an awareness of climate justice and its importance at the local level. Despite the discrepancy in terminology, there has been actions undertaken across BC’s municipalities to address the issue with varying degrees of comprehensiveness in strategies to do so.

Cities such as the City of Vancouver (COV) were often cited as an example to which other municipalities often look to as a change maker in terms of municipal climate policy. Most recently, the COV committed to climate justice within their Climate Emergency Action Plan. The Cities of North Vancouver, New Westminster, and Victoria in BC were also cited as other positive climate policy models. These examples were highlighted due to their ability to not only frame climate issues through the lens of climate justice, but their ability to action their rhetoric surrounding climate change through policy. Some interviewees stated that many municipalities were on the trajectory to addressing climate justice in terms of acknowledging it as an emergency, yet had work to do regarding the equity piece of climate justice.

All local government officials acknowledged the significant challenges that addressing the issue from the local level of policy-making poses. From a governance perspective, some officials expressed that there was some level of confusion among city staff as to what they had the authority and jurisdiction to address concerning climate change at the local level and that this may hinder the types of solutions available for municipalities. Reliance on technical perspectives was also cited as an obstacle to achieving equity in climate planning, as, oftentimes, experiential testimony and community engagement are relied upon less than expert testimony. In addition, a significant obstacle to achieving policy change in relation to climate justice is the lack of policy transference and learning across municipalities in BC, resulting in city staff reinventing the wheel in isolation from one another instead of learning and engaging with one another.

Climate Justice Organisations

The organizations we interviewed that actively address climate justice within their mandate and operations offered commentary on the nature of climate justice in municipalities and the challenges and opportunities these settings possess. They often reiterated that climate justice involves actively centering BIPOC voices in the conversation and policy surrounding climate justice and that the principal mechanism to do so is storytelling and fostering dialogue so that marginalized voices have the space to engage within community policy accessible to them.

Indeed it was the act of meaningful listening and engagement that many organizations interviewed reiterated as the key to addressing climate justice in municipalities. As it is widely understood that municipalities are constrained through resources and jurisdiction in addressing the issue, a key argument of climate justice advocates was that cities need to implement solutions rooted in their communities and tailored to the needs of area-specific BIPOC and marginalized groups. It was also argued that there is work to be done to build trust between such marginalized groups and colonial institutions such as city governments. Thus, cities should consider what framing shifts are necessary within their institutions to make sure that engagement is meaningful and that these groups have adequate representation in City level planning and policy bodies that hold decision-making power.

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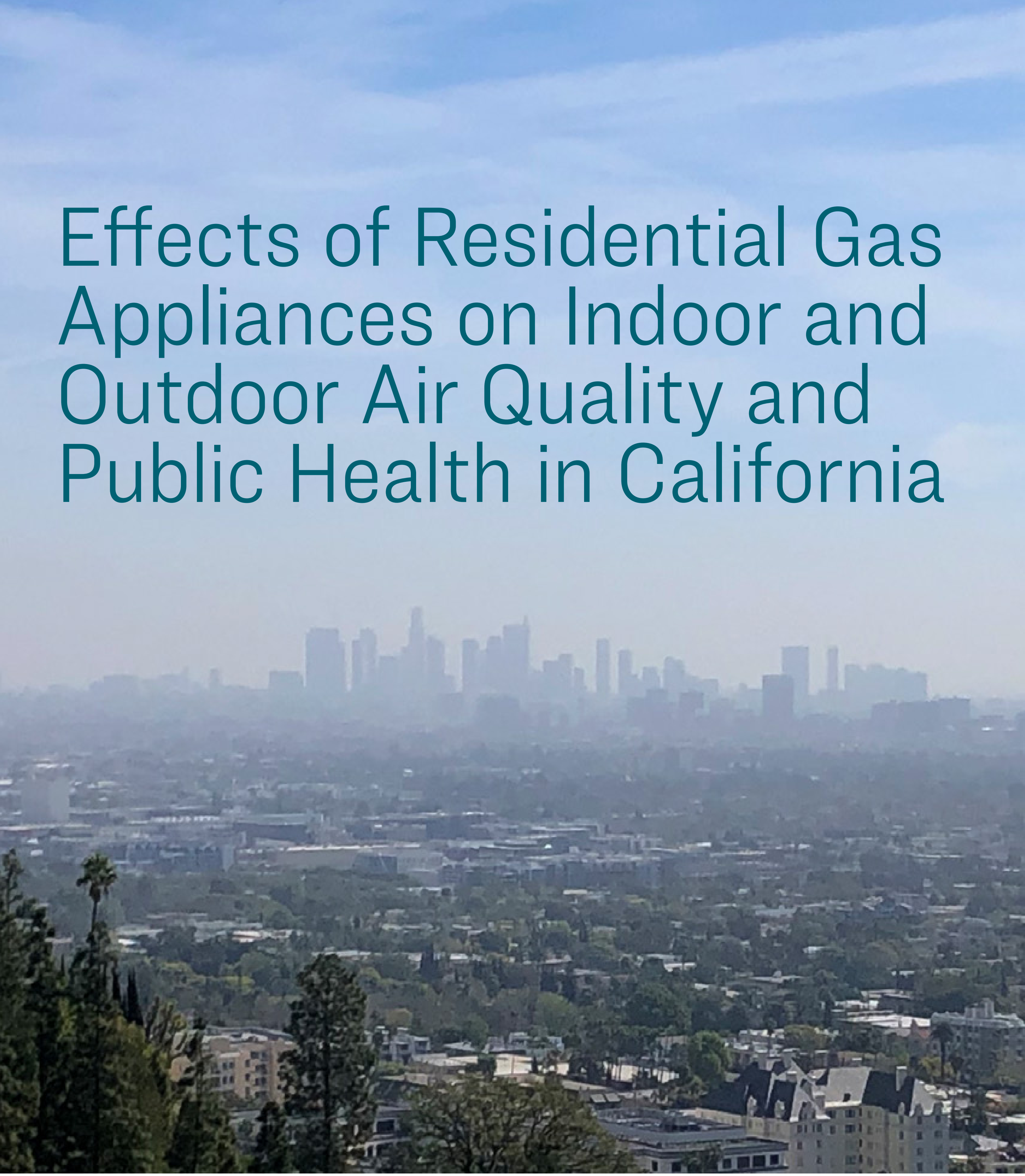
Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California



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Cover: A view of downtown Los Angeles from Hollywood Hills, blanketed in smog the afternoon of March 5th, 2020. Photo by Kristiana Faddoul, Sierra Club

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ABBREVIATIONS AND UNITS LIST

ABBREVIATIONS/ ACRONYMS	DESCRIPTIONS*
AB	Assembly Bill
ACS	American Community Survey
AER	Air exchange rate
AHS	American Housing Survey
BenMAP	U.S. EPA's Benefits Mapping and Analysis tool
BTU	British thermal unit
CAAQS	California Ambient Air Quality Standards
CARB	California Air Resources Board
CDC	Centers for Disease Control and Prevention
CEC	California Energy Commission
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
DTSC	California Department of Toxic Substances Control
E3	Energy and Environmental Economics, Inc.
EF	Emission factor
EPRI	Electric Power Research Institute
GHG	Greenhouse gas
h	Hour
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
I/O	Indoor/outdoor ratio
IARC	International Agency for Research on Cancer
ISA	Integrated Science Assessment
J	Joule
LBNL	Lawrence Berkeley National Laboratory

ABBREVIATIONS/ ACRONYMS	DESCRIPTIONS*
MBR	Mass burning rate
mg	Milligram
ng	Nanogram
NAAQS	National Ambient Air Quality Standards
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
µg	Microgram
OEHHA	Office of Environmental Health Hazard Assessment
ppb	parts per billion
ppm	parts per million
PAH	Polycyclic aromatic hydrocarbon
PERE	Program for Environmental and Regional Equity
PM	Particulate matter
$PM_{2.5}$	Fine particulate matter
PN	Particle number
RASS	Residential Appliance Saturation Study
REL	Reference Exposure Level
SB	Senate Bill
SFH	Single-family home
SO_2	Sulfur dioxide
UCI	University of California, Irvine
USC	University of Southern California
UFP	Ultrafine particle
US EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
VSL	Value of a statistical life
WHO	World Health Organization
WTP	Willingness to pay

** Links to the associated databases are embedded wherever applicable.*

EXECUTIVE SUMMARY

The electrification of residential buildings refers to the transition from fossil-fuel-powered appliances to electric technologies. Dozens of cities in California have already passed electrification policies to ensure new constructions within their jurisdictions are built all-electric. State regulatory agencies and utilities are pursuing programs and policies to support residential and commercial building electrification as part of meeting the state's climate and energy goals.

There has been considerable focus on building electrification's potential to reduce greenhouse gas emissions, and less focus on how electrification can also yield significant air quality and public health benefits.

California currently faces a global pandemic in which a rapidly spreading coronavirus disease, COVID-19, can cause severe respiratory illness and even death. New evidence suggests that a small increase in long-term exposure to fine particulate matter ($PM_{2.5}$) leads to a large increase in the COVID-19 death rate; this further establishes the substantial value in protecting the population from the respiratory vulnerability caused by widespread air pollution.

Exposure to the pollutants produced from gas appliances can be detrimental to human health; thus, one significant benefit of replacing natural gas (hereafter referred to as "gas") appliances with electric appliances would be the elimination of indoor air pollution that comes from burning gas indoors. This report aims to better understand the health concerns associated with gas appliance use, as well as the health benefits of phasing out residential gas appliances in California.

To systematically evaluate the impact of gas appliances on indoor air quality (Section 2), we developed an emission factor (EF) database, provided an estimate of indoor air pollutant concentrations due to gas appliance usage, and characterized the associated health impacts. Next, we evaluated the potential health co-benefits resulting from changes to ambient (outdoor) air quality related to residential gas appliance electrification (Section 3). This was accomplished by estimating the total emission of outdoor air pollutants in California due to the use of household gas appliances, the reduction in emissions due to residential building electrification under a modeled transition scenario, the resulting reduction of premature deaths and cases of acute and chronic bronchitis in California, and monetization of those health benefits. A detailed description of the data and methods can be found in Appendix A.

Key Findings

INDOOR AIR QUALITY

- Gas appliances emit a wide range of air pollutants, such as carbon monoxide (CO), nitrogen oxides (NO_x, including nitrogen dioxide (NO_2)), particulate matter (PM), and formaldehyde, which have been linked to various acute and chronic health effects, including respiratory illness, cardiovascular disease, and premature death.
- Under a hypothetical cooking scenario where a stove and oven are used simultaneously for 1 hour, peak concentrations of NO_2 from cooking with gas appliances exceed the levels of acute national and California-based ambient air quality thresholds in more than 90% of modeled emission scenarios.
- Concentrations of CO and NO_2 resulting from gas cooking are the highest for apartments, due to a smaller residence size. This presents an additional risk for renters, who are often low-income.
- Increases in indoor air pollutant concentrations can be driven by insufficient ventilation. Surveys show that less than 35% of California residents use range hoods when cooking — and many homes in the U.S. are lacking range hoods or ventilation altogether.
- The use of kitchen appliances for supplemental heating can increase exposure risks, and there is evidence this disproportionately affects low-income households, though more data on the frequency of use is needed to quantify the risk to various populations.

- Environmental justice communities disproportionately experience poor housing conditions which can be detrimental to health. Concerns related to gas appliance use include: the presence of old and unmaintained appliances in households, smaller and overcrowded residences where air pollution can reach higher concentrations, and challenges faced by renters to control appliance choices or afford maintenance. These populations already face cumulative effects associated with health and environmental injustices more broadly, and gas appliance issues can compound this. There are significant data gaps regarding equity and the health effects of gas combustion on low-income and minority populations, which should be further explored to facilitate a just transition to a low-carbon future.
- Better regulations and safeguards are needed to protect residents from exposure to indoor air pollution from gas appliances. Along with replacing gas kitchen appliances with electric alternatives, increasing the frequency of range hood use and improving the efficacy of ventilation technology would also reduce exposure and protect public health.

OUTDOOR AIR QUALITY

- Gas appliances are also a source of outdoor air pollution, and literature shows that the pollutants released by combustion can lead to illness and premature death.
- Using the EFs developed in this study's indoor air quality analysis, and assuming all indoor emissions are transported to the outdoor environment, we find that approximately 12,000 tons of CO and 15,900 tons of NO_X (see Figure 3-1 in Section 3.2.1) were emitted to outdoor air from the use of residential gas appliances in California in 2018.
- If all residential gas appliances were immediately replaced with clean electric alternatives, the reduction of outdoor NO_X and $PM_{2.5}$ would result in 354 fewer deaths, as well as 596 fewer cases of acute bronchitis and 304 fewer cases of chronic bronchitis annually in California (Table 3-1). This is equivalent to approximately $3.5 billion in monetized health benefits over the course of one year. These numbers only account for exposures from outdoor air as a result of residential electrification; a full exposure assessment accounting for indoor exposures would increase the total health benefits and the associated economic benefits of residential electrification.

In summary, this report contributes to a growing body of research quantifying the air quality and health impacts from the use of gas appliances in households, and highlights several potential benefits, both health-related and economic, of residential electrification throughout the state of California. While this report provides an estimate of emissions, and resulting emission reductions from discontinuing the use of gas appliances in residences, it does not consider the full spectrum of costs and benefits associated with residential building electrification. Policymakers and stakeholders are encouraged to use this report, alongside existing research on building decarbonization, electrification, and other related topics, as a tool to develop stronger regulations and protections that limit indoor and outdoor air pollution from gas appliances, and to support new policy development to improve public health, particularly for communities disproportionately burdened by pollution from fossil fuels.

1 INTRODUCTION

1.1. CALIFORNIA'S GAS CONSUMPTION AND TRANSITION TO CLEAN ENERGY

Natural gas (hereafter referred to as "gas") is one of California's primary energy sources.[1] It is a fossil fuel consisting of mostly hydrocarbons, the majority of which is methane (CH_4) - a potent greenhouse gas (GHG). In 2018, more than 2.1 trillion cubic feet of gas were consumed in California, which accounts for 7.1% of gas consumption within the entire United States.[1]

In California, gas is used to fuel power plants and certain industrial processes, and in buildings for heating and cooking. In residences, common gas-powered appliances include stoves, ovens, furnaces, water heaters, clothes dryers, and fireplaces. Results from the American Housing Survey (AHS) indicate that more than 90% of California households use gas for at least one purpose, and almost 70% of households use gas for cooking.[2]

While demand for gas in the power sector is expected to drop dramatically as the state implements Senate Bill (SB) 100, which calls for 100% carbon-free electricity, there is no current statewide policy to address the gas that is burned inside California's buildings, even though consumption by residential and commercial buildings accounts for 31% of gas use within the state.[1] The residential sector alone accounts for more than 20% of the state's gas use.[1] Research also indicates that residential appliances alone constitute 15% of California's CH_4 emissions from gas,[3] and overall, buildings are responsible for an estimated 25% of all GHG emissions in California.[4,5] Two-thirds of these are caused by onsite combustion of fuel, including gas.[5] While this report focuses on California, it is worth noting that the climate effects of gas use in buildings are of national significance. The United States Environmental Protection Agency (US EPA) reported that in 2017, gas consumption comprised 89% of direct, fossil-fuel carbon dioxide (CO_2) emissions from the residential and commercial sectors.[6]

California is a national leader in clean energy and climate policy, and has mainly pursued new policies and programs to promote building electrification (i.e., the transition from fossil-fuel-powered appliances to electric technologies) as a climate mitigation strategy.[4,7,8] State and local agencies have not, for the most part, regulated gas appliances or promoted electrification to explicitly improve air quality and public health, although agencies and reports have noted cleaner air and improved health outcomes as a co-benefit of building decarbonization.[9]

This research was commissioned to inform the potential air quality and health benefits of stricter regulation of gas appliances with a goal of improving the state's air quality and population health, and to better understand the co-benefits of building decarbonization.

Much recent research surrounding the use of gas as an energy source focuses on emissions of GHGs, such as carbon dioxide (CO_2) as a result of combustion, as well as the leakage[i] of CH_4.[3,14] Organizations such as Energy and Environmental Economics, Inc. (E3) and the Electric Power Research Institute (EPRI) have conducted comprehensive research for the California Energy Commission (CEC) and utility companies on decarbonization and building electrification. Findings indicate that California residential building electrification is a cost-effective GHG mitigation tool under many circumstances, and would often result in reduced consumer household energy costs.[4,7]

i. Though gas has been considered a transitional fuel because it emits less GHGs than other fossil fuels[10], evidence indicates that the leakage of methane negates the climate benefits of burning gas.[11] In addition, the use of fracking for the extraction of gas results in methane leaks and incurs severe environmental and health costs; the chemical additives involved in fracking are highly toxic.[11–13]

1.2. GAS APPLIANCE USE AND ASSOCIATED AIR QUALITY AND HEALTH OUTCOMES

Another key area in the literature explores the extent of criteria pollutants, such as carbon monoxide (CO), nitrogen dioxide (NO_2), and particulate matter (PM) produced from gas combustion, and the health co-benefits from GHG reduction tactics due to the reduction of these criteria air pollutants, which have a more localized and substantial impact on public health than GHGs.[15] Gas has been marketed as a relatively clean fuel because it emits less criteria pollutants compared to other fossil fuels, such as coal and oil,[16,17] as well as the burning of biomass.[18,19] However, there are significant risks associated with the burning of gas in residences, due to the indoor emission of pollutants, such as CO and formaldehyde (from incomplete combustion), as well as nitrogen oxides (NO_X) such as NO_2 (caused by the oxidation of nitrogen during combustion). Other hazardous compounds emitted from the burning of gas inside homes include volatile organic compounds (VOCs), sulfur oxides, and PM.[20] The resulting indoor air pollution can have adverse effects on human health, as Americans spend almost 90% of their time indoors,[21] and a substantial body of literature has established that both indoor and outdoor air pollution are notable threats to human health.[22–24] While many studies have been published on the various sources and effects of indoor air pollution, the extent of the effects of residential exposure to combusted gas on human health merits additional analysis.

Many studies have measured emissions and concentration levels of NO_2, NO_X, PM, formaldehyde, and other compounds while appliances were in use. Overall, studies have reported higher concentrations of CO and NO_2 in homes that use gas rather than all-electric appliances. Although electric appliances do not generate emissions from combustion, they can produce emissions from other sources, such as the cooking of food, or dust on the heating surface.[23,25–28] There are also numerous studies on cooking activities, which also provide evidence of emissions from gas stove and oven use, although some emissions are related to the cooking style and type of food being cooked, and not the fuel that is being used.[26,28,29] Additionally, studies on the association between gas appliance use and health have mixed results, in part due to study design limitations, but also due to a lack of data on quantified exposures.[30,31] The nature of this uncertainty is described in further detail in Section 2.1. Studies have also demonstrated associations between gas stove use and increased respiratory symptoms for household

residents, particularly children.[32–34] Notably, children had lower odds of suffering from asthma and bronchitis in households where adults used ventilation when operating gas stoves.[35] The California Department of Public Health recommends increasing outdoor ventilation and using exhaust fans when cooking with gas stoves, and avoiding the use of illegal, fuel-burning, unvented gas space heaters.[36]

Environmental health burdens associated with gas appliance use can disproportionately affect low-income individuals, who are often renters with less control over appliance installation and maintenance,[37–39] and typically living in smaller units, which can result in elevated pollutant concentrations.[40,41] These issues compound the cumulative health effects in environmental justice communities, populations which currently — and historically — have borne a disproportionate burden of environmental health risks.

1.3. SCOPE OF RESEARCH

Considering existing knowledge, as well as specific knowledge gaps, this research builds upon work from other organizations, including the Lawrence Berkeley National Laboratory (LBNL), the California Air Resources Board (CARB), the CEC, E3, and EPRI, to conduct a wide-ranging evaluation of the effects of gas appliance use on both indoor and outdoor air quality, the associated health effects and susceptibility of populations, and the potential benefits of electrifying residential gas appliances throughout the state. We endeavor to consider how these issues impact low-income and environmental justice communities throughout the report.

This report is a synthesis of relevant literature and data, incorporating literature primarily focused on the 21st century in California, and including new secondary analyses and modeling to the extent possible. Our work is novel in its combination of varying approaches of evaluating gas appliances, including: (1) modeling a variety of gas cooking exposure scenarios and conducting sensitivity analyses accounting for pollutant spillage into the indoor environment from four types of appliances; (2) an evaluation of exposure and vulnerability considerations, including equity-related concerns associated with gas appliance use; (3) an in-depth aggregation of current data on the health impacts of pollutants associated with gas combustion; (4) a quantitative assessment of outdoor emissions resulting from gas appliance use; and (5) a health impact and monetary valuation assessment of exposure to those outdoor emissions. This assessment aims to help the general public and policymakers to better understand the potential health impacts associated with gas appliance use, as well as the health benefits of phasing out residential gas appliances in California.

In the rest of the report, we separate our analysis into two main sections: indoor air quality and health effects, and outdoor air quality and health effects. We start with a detailed background section, then present results and discussion for each section. We conclude with a summary of our findings. The data and methodology can be found in Appendix A.

2 INDOOR AIR QUALITY AND HEALTH EFFECTS

Section 2 is focused on indoor air quality and health effects. Section 2.1 provides background information from a literature review, and Section 2.2 contains the results and discussion. The objectives of this section are to:

- quantify emission factors of CO, NO_2, and NO_X from gas appliances in California;
- evaluate the impact of gas appliance usage on indoor levels of CO, NO_2, and NO_X, as well as their associated health effects; and
- qualitatively assess the vulnerability of specific populations to indoor air pollution exposures from gas appliance usage, through an equity lens.

In this section of the report, we quantitatively focus on three pollutants: CO, NO_2, and NO_X. We do not include other pollutants, such as formaldehyde and PM [including ultrafine particles (UFP, particles less than 0.1 micrometer in size), and fine PM with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$)], due to data paucity and feasibility. However, to the extent possible, we do qualitatively assess the emissions and associated health effects of these additional pollutants. Therefore, formaldehyde and PM are mentioned throughout the background (Section 2.1), and exposure is assessed in various portions of the Results & Discussion (Section 2.2).

2.1. BACKGROUND

This section provides general background information from the literature, and further findings based on modeling are presented in the results section. In this literature review section, we:

- **explore** the relationship between gas appliance use and indoor air quality by describing findings from relevant research studies and reports (2.1.1);
- **define** factors associated with pollutant emissions (2.1.2) and resulting indoor air concentrations (2.1.3), such as appliance ventilation and maintenance, and house volume and air exchange rate (AER);
- **clarify** the significance of the relationship between indoor air pollution and human health, particularly with respect to environmental justice communities (2.1.4); and
- **identify** current knowledge gaps and the contribution of this report (2.1.5).

2.1.1. THE RELATIONSHIP BETWEEN GAS APPLIANCE USE AND INDOOR AIR QUALITY

Formation of combustion pollutants

Combustion pollutants are produced from the use of gas appliances, including water heaters, stoves, ovens, furnaces and other indoor heating devices, such as gas fireplaces. Notable pollutants include CO, NO_2, NO_X, formaldehyde, and PM, including UFP and $PM_{2.5}$, though there are several other pollutants associated with residential gas combustion (see Table B-1 in Appendix B regarding pollutants emitted from gas combustion and their associated concentrations in the indoor environment). Although we were unable to quantitatively analyze all the pollutants emitted by combustion appliances, Table B-1 illustrates the wide range of pollutants produced. It excludes the pollutants subjected to subsequent quantitative analysis in this report — CO, NO_2, and NO_X — pollutants with known health effects that also have enough publicly available combustion emission data to conduct analysis.

Combustion-related pollutants are primarily formed by the processes of incomplete combustion or oxidation. Incomplete combustion occurs when there is insufficient oxygen available to complete the combustion of fuel, resulting in byproducts such as CO and formaldehyde. In order to facilitate "complete" combustion, the proper amount of gas and air must be supplied at the correct pressure. However, incomplete combustion and its associated byproducts are unavoidable, even under ideal conditions.[42] Regarding oxidation, a prevalent example resulting in combustion pollution formation is the oxidation of nitric oxide (NO) to NO_2. At high temperatures, NO is formed by the combination of nitrogen with oxygen then oxidized to become NO_2.

Overview of types of gas appliances

Out of all commonly used gas appliances, water heaters and home heating devices such as furnaces are responsible for the majority of gas use in households, and thus, emit a larger proportion of combustion pollutants than gas kitchen appliances (stoves and ovens).[3,15,42–44] However, kitchen appliance emissions have a more significant effect on indoor air quality, as the heating appliances are vented outdoors and those emissions are generally considered to be outside the building envelope. Depending on the type of appliance and associated features, pollutants are either emitted directly into the living space, mitigated with ventilation technology such as range hoods, or directly vented outdoors (typically water heaters and furnaces). Ventilation effectiveness, which usually depends on appliance quality and maintenance, is discussed further in Section 2.1.2. There are regulations surrounding the use of gas appliances in households, including requirements for heating devices and water heaters to be vented outdoors, and prohibiting the sale of unvented gas space heaters. We discuss these regulations further in Section 2.1.2.

Pollutant emissions and indoor air concentrations associated with gas appliance use

Organizations such as LBNL and CARB have conducted research on the topic of gas appliance emissions in California specifically. They have studied the effectiveness of ventilation technology (including the use of range hoods), issues such as backdrafting (the backward movement of exhausted gases through the venting system) into residences from ventilation ducts and pollutant spillage (described in more detail in Section 2.1.2), and increasing the energy efficiency of appliances, and have modeled indoor air quality and population exposures resulting from the use of these appliances. [27,44–53] Additionally, researchers from other institutions have conducted various studies on these topics over the last several decades, from measurement of indoor air concentrations to simulating concentrations from gas appliance use, both in California and in other regions.[25,26,54–60] Studies measuring pollutant emissions or indoor air concentrations have consistently found that the use of gas appliances can result in concentrations of pollutants — particularly NO_2 — at concentrations above the level of ambient (outdoor) air quality standards.

Specifically, studies of California residential buildings have examined the association between gas appliances and measured indoor levels of air pollutants, including CO, NO_2, NO_X, $PM_{2.5}$, UFP, polycyclic aromatic hydrocarbons (PAHs), and formaldehyde.[44–46,48–50,52] While the majority of research focuses on cooking appliances, such as stoves and ovens, studies have also measured pollutant emissions or resulting indoor air pollutant concentrations from the use of heating appliances, such as furnaces, space heaters, water heaters, and fireplaces.[44,54,56,58,60–63] Furthermore, although many studies have measured $PM_{2.5}$ and UFP emissions from cooking with various types of food and cooking oil, these particulate emissions were often attributed to the food and cooking method rather than the operation of gas appliances.[55,57,64]

Several studies have found gas stove usage results in both peak and weekly average NO_2 concentrations exceeding the level set by both the chronic California Ambient Air Quality Standards (CAAQS) ambient annual average limit of 57 micrograms per cubic meter ($\mu g/m^3$), and the acute National Ambient Air Quality Standards (NAAQS, set by the US EPA) 1-hour limit of 188 $\mu g/m^3$ or 100 parts per billion (ppb). Please refer to Section 2.2.2 for relevant considerations regarding the use of outdoor air quality standards to assess exposure to indoor air quality.[27,45,46,49,52] Studies of California residential buildings have reported NO_2 levels in excess of these standards in kitchens and bedrooms, suggesting elevated concentrations throughout the entirety of the home during a single instance of gas cooking, especially in homes using gas stoves with pilot lights, or without venting range hoods.[49,50,52] Research from earlier decades on unvented gas space heaters measured NO_2 and $PM_{2.5}$ concentrations above standards, but these types of heating devices are no longer legally sold in California.[58,60,65,66]

Research has found that CO is a lesser potential health concern than NO_2 if appliances are operating properly. Gas stoves have been associated with increased levels of indoor CO in California homes, but these increases in concentrations are generally negligible,[27,49,51,52] with only a small portion of homes exhibiting CO concentrations above the CAAQS 1-hour standard of 23 milligrams per cubic meter (mg/m^3).[45,46] However, CO concentrations above the CAAQS 8-hour standard of 10 mg/m^3 have been reported during preparation of a full meal and under broiling conditions, without range hood use (though these were peak values and these concentrations did not persist for an entire 8-hour period).[27] Furthermore, CO emissions may rise to higher concentrations under conditions where appliance ventilation mechanisms fail or are not used, or the stove is misused for heating residences, and we address the former in Section 2.1.2. CARB reports that CO is responsible for 13 to 36 deaths from non-fire-related CO poisoning in California each year since 2000.[67]

As mentioned at the beginning of Section 2, although we do not include PM or formaldehyde in our quantitative assessment, it is important not to overlook these pollutants when considering the effect of gas appliances on air quality. Similarly to CO, studies measuring $PM_{2.5}$ emissions found that increases attributed solely to gas kitchen appliances (with no cooking of food involved, though sometimes a pot of water was heated) were negligible.[49,52] One caveat mentioned previously is that cooking can be a significant source of exposure to $PM_{2.5}$ due to heating and combustion of food and cooking oil, resulting in indoor concentrations far in excess of the NAAQS 24-hour threshold of 35 μg/m^3.[27,55,57] Furthermore, studies have measured substantial peak UFP concentrations during gas stove cooking, both with and without food.[28,30,44,48,57,68,69] All studies including tests of gas stoves used without food demonstrated elevated UFP concentrations.[28,44,68] Emissions from episodic sources such as cooking, with either gas or electric stoves, constitute a majority of indoor UFP concentrations.[30,48,68,70–72] UFP concentrations during episodes of cooking without a range hood are comparable to those found outdoors on high pollution days.[28] Since no government standards for UFP concentrations currently exist, and the health effects of UFPs are not yet fully characterized, it is challenging to regulate these smaller particles. Though we do not quantitatively evaluate UFP in this report, we discuss the health effects of UFP exposure in Section 2.2.4. Studies have also estimated particle emissions from other types of gas appliances, such as water heaters and home heating devices, but most assess particle emissions in the units of particle number (PN, which better reflects UFP levels) and not $PM_{2.5}$. Based on CARB's annual projections of county-level, estimated total emissions for $PM_{2.5}$ from residential gas combustion, and as seen for other pollutants as well, water heaters and home heating appliances have significantly higher overall emissions than gas cooking appliances. However, water heaters and home heating appliances are vented outdoors (outside the building envelope), as mandated by regulations.[73]

Gas appliances also emit formaldehyde,[27,44,62] but some studies did not find a statistically significant association between gas appliance use and indoor formaldehyde concentrations.[45,46,74] A CARB analysis reported formaldehyde concentrations far above the acute Reference Exposure Level (REL) of 55 μg/m^3

set by the California Office of Environmental Health Hazard Assessment (OEHHA) during gas cooking, both with and without food.[27] An REL is the maximum concentration at which not to expect any adverse, non-cancer health effects at each given exposure duration (acute, 8-hour, or chronic). However, an LBNL study of California homes found that although 95% of homes tested had formaldehyde concentrations above the OEHHA chronic REL, these levels were not statistically significantly associated with gas appliances.[45] In addition, gas appliances emit acetaldehyde,[27,44] a highly toxic and carcinogenic VOC similar to formaldehyde, with recent research indicating low levels emitted from gas stove burners.[44] Due to the lack of emission data and statistically significant evidence reported in the primary literature, we did not include formaldehyde or acetaldehyde in our quantitative analysis.

Besides experimental research, several simulation studies have modeled gas appliance emissions and reported exposures to indoor pollutants, including CO, NO_2, and formaldehyde.[47,53,59] Simulation studies specific to California residential buildings found that gas stove emissions comprise up to a third of total weekly average concentrations of indoor CO and NO_2, and even conservative estimates of indoor CO and NO_2 concentrations may frequently be in excess of the 1-hour and 8-hour CAAQS standards for CO and the 1-hour NAAQS standard for NO_2. [47,53] One study estimated that in a typical winter week, 12 million and 1.7 million Californians may be exposed to NO_2 and CO levels (respectively) in exceedance of acute, ambient air quality standards.[47] Furthermore, the study estimated that formaldehyde emissions from gas cooking appliances alone would lead to exposures exceeding the OEHHA acute RELs (for approximately 50% of homes) and chronic RELs (for less than 10% of homes), depending on the season.[47]

2.1.2. FACTORS INFLUENCING EMISSIONS TO THE INDOOR ENVIRONMENT

Apart from the frequency of appliance use, as well as trends toward reduced heating (and increased cooling) demand for California buildings, there are several important factors influencing the quantity of emissions to indoor residences.

Appliance ventilation conditions

The effective removal of combustion products generated by gas appliances is a core element of health and safety in buildings. Home heating devices and water heaters must have their exhausted gases moved through the appliance, out of the venting apparatus, and into the outdoors.[75] The National Fire Protection Association 54: National Fuel Gas Code provides safety requirements for the ventilation of gas appliances and requires that gas space heaters and water heaters be vented to the outdoors, while the California Health and Safety Code prohibits the sale of unvented gas space heaters, and mandates the existence of ventilation equipment above stoves and ovens.[76,77] Even with such legislation in place, unvented or inadequately vented gas cooking appliances are present in some California homes.[78,79]

One significant concern regarding appliance ventilation failure is pollutant backdraft and resulting spillage, which put residents at greater risk of CO poisoning. Backdraft refers to the backward movement of exhausted gases through the venting system, and spillage refers to the resulting leakage of exhausted gases from the appliance into the indoor environment, which leads to the buildup of pollutants inside the home.[80] Although the frequency of backdrafting and spillage events is not well-established, this has led to excessive CO exposure, which has severe consequences: The Centers for Disease Control and Prevention (CDC) estimated 393 deaths in the United States from unintentional, non-fire-related CO poisoning associated with consumer products in 2015.[81] In California specifically, the Tracking California program (previously known as the California Environmental Health Tracking Program) estimated 643 emergency department visits due to non-fire-related CO poisoning in 2016.[82]

One main cause of backdraft and spillage is depressurization, which happens when air removed from the house by weather-related forces, open doors and windows, or mechanical appliances such as exhaust fans and furnaces, results in a lower air pressure indoors as compared to the outdoor environment.[80,83] Depressurization interferes with the mechanisms of combustion appliances, resulting in backdrafting and spillage. Depressurization is usually periodic rather than continuous,[83] although research has observed instances of continuous depressurization.[84] A literature review conducted by LBNL found that while up to 50% of appliances tested were at risk of backdrafting, few instances of “sustained” backdrafting or spillage were recorded.[80] There are several challenges associated with monitoring for backdrafting and spillage in homes.[80] Due to the existing limitations, questions regarding the frequency, duration, and severity of backdrafting and spillage events remain to be answered.

Low-income and elderly residents may face increased risk of CO poisoning from gas combustion appliances. A 2016 LBNL report on wall furnaces in apartments did find that backdrafting can occur frequently in small residences when kitchen and bathroom exhaust fans are

on a high setting, though this study had a relatively small sample size (16 apartments) and highlighted the need for additional research.[85] Nonetheless, this points to the potential for added risk for residents, including elderly populations, who live in smaller rental apartments, are often low-income, and face existing challenges with the burdens of appliance maintenance.[86,87]

Considering the uncertainty surrounding improper ventilation, one of our two sensitivity analyses (See Section 2.2.2 and Appendix A.1.2 for details) involved a scenario to account for the potential of indoor emissions from appliances, such as water heaters and home heating devices, that are designed to solely emit combustion pollutants outdoors. Of course, the location of the appliances, which can vary from wall furnaces in living rooms to water heaters in designated mechanical closets, are not aspects we were able to control for, but are important considerations for future research.

Appliance maintenance considerations

Maintenance issues can have a pronounced impact on the emissions produced by combustion appliances, as well as on ventilation efficiency. Old appliances that have not been maintained are at risk of ventilation failure, resulting in potentially dangerous levels of pollutants being emitted into the indoor environment.[44,61,80] Other problems requiring maintenance include heat exchanger failures and blocked flues in furnaces.

Appliance tuning, which refers to various aspects of appliance maintenance, can also have a substantial impact on emissions. Well-tuned appliances often emit substantially less CO than poorly tuned appliances, sometimes differing by an order of magnitude.[80,83,88–91] However, there are only limited studies on appliance maintenance and safety mechanisms, and these topics warrant further research.

2.1.3. FACTORS INFLUENCING COMBUSTION POLLUTANT CONCENTRATIONS IN AN INDOOR ENVIRONMENT

There are several factors that significantly affect the indoor air pollutant concentrations resulting from combustion.

Range hoods and capture efficiency

Gas stoves often lack adequate exhaust ventilation. The low-rise residential building ventilation code ASHRAE 62.2 requires the installation of range hoods in kitchens, with minimum airflow and maximum noise levels, but it is estimated that only half of new homes in the United States comply with this standard.[78] Furthermore, a study of California homes, using data from a real estate website, approximated that 47% of homes had combination microwave/range hoods, which do not meet the airflow and noise level requirements of ASHRAE 62.2, while 7% of homes had no range hoods at all.[79] A 2014 LBNL report highlighted a specific need for the development of over-the-range microwaves that meet the ASHRAE 62.2 requirements.[92] The body of research on the use and effectiveness of range hoods is growing.

Research on kitchen range hoods has demonstrated their potential to reduce exposure to pollutants emitted by combustion appliances, as well as evaluated noise levels, since sound is one reason why people often elect not to use range hoods.[45,52,57,68,92–97] Range hoods differ considerably in their ability to remove pollutants from the indoor environment and can be assessed using capture efficiency as a measure of overall effectiveness. Capture efficiency refers to the proportion of pollutants emitted from an appliance that are removed by the range hood before they enter the indoor environment.[52,93] The capture efficiency of range hoods is often above 50%, though it varies widely depending on the cooktop burner used (typically lower for front burners), as well as coverage and quality of the hood.[52,57,68,93,95] In one study of California residences, the use of range hoods resulted in significant reductions in air pollutant concentrations within the home.[52]

While studies have shown that range hoods can significantly reduce exposure, they are infrequently used and not always available or appropriately sized or installed.[78,79,92] Small-scale survey results show that less than 35% of California residents use range hoods when cooking,[98] while a CARB study of California homes found that 54% of participants did not use their range hood.[96] As mentioned previously, studies have shown that the excessive noise produced by many range hoods and fans is a primary reason for the lack of range hood use.[92,96,97] It is important to note that increased awareness of the need for ventilation during cooking and encouragement of range hood use may reduce exposures to pollutants emitted by combustion appliances for those with properly sized, installed, and maintained hoods. However, renters sometimes do not have range hoods installed, or existing hoods are not vented outdoors and may not meet standards, therefore putting renters at heightened vulnerability to exposure to air pollutants from gas cooking appliances.[99] Due to the infrequency of range hood use, our analysis assumed that there is no significant range hood use as a health-protective conservative assessment, though it is still useful to consider our estimates in the context of conditions involving range hoods as well, with varying levels of capture efficiency.

Residence size and ventilation

The size and ventilation of an indoor space are primary determinants of indoor air quality. In smaller residences, indoor air pollutants are distributed across a smaller space and thus, are more concentrated.[100–102] The volume of an indoor space is also a major factor in the determination of AER, which is expressed as the number of indoor air volumes replaced with outdoor air per hour.[102]

Ventilation (and AER) significantly influence indoor air quality. Inadequate ventilation has been associated with higher concentrations of indoor air pollutants, including NO_2, $PM_{2.5}$, and VOCs, as well as adverse health outcomes.[103–106] In fact, a recent study of commercial buildings in California determined that such buildings rarely meet ventilation standards.[107] There are reported challenges associated with meeting ventilation standards in multifamily housing as well.[108] A dilemma that has emerged in recent years, particularly with climate change considerations, is the dichotomy between promoting energy efficiency and improving indoor air quality. The tightening of building envelopes — essentially, residential air-sealing — has the potential to save billions in energy bills and reduce infiltration of outdoor air pollutants,[109] but it also decreases ventilation, degrading indoor air quality.[110] More energy-efficient buildings with tightened envelopes have, in some cases, been associated with adverse health outcomes due to worsened indoor air quality,[111,112] though a recent study on green buildings found several health benefits for individuals who moved from conventional housing to green-renovated housing.[106] Due to the crucial role of ventilation in determining indoor air quality, developments in building energy efficiency should be balanced with the preservation of indoor air quality.

2.1.4. WHY THIS ISSUE MATTERS: INDOOR AIR QUALITY, HUMAN HEALTH, AND ENVIRONMENTAL JUSTICE

As mentioned in the introduction, considering that people in the U.S. spend almost 90% of their time indoors, indoor air quality and human health are closely linked.[21] Many studies have assessed the health impacts of various indoor air pollutants.[30,113,114] We discuss each primary combustion pollutant (CO, NO_2/NO_X), as well as the pollutants we do not quantitatively evaluate (PM and formaldehyde) and their associated relationships with human health in detail in Section 2.2.4.

In the context of household gas appliances, the potential transition from gas to all-electric home appliances could benefit low-income households and environmental justice communities by improving both indoor and outdoor air quality. These communities face disproportionate air-pollution burdens[115] and limited access to clean energy resources.

While many issues related to gas appliance use and vulnerable populations are challenging to quantify without primary data collection, we aim to aggregate

as much of the relevant quantitative and qualitative information as possible on this topic as it connects to environmental justice and equity. A few key equity considerations related to gas appliance use, which we explore further in Sections 2.2.2 and 2.2.3, are as follows:

- SUPPLEMENTAL USE OF COOKING APPLIANCES FOR HEATING RESIDENCES. Though the frequency is not well-established, some research indicates that low-income and minority residents may disproportionately use kitchen appliances for the purpose of heating their residences (instead of using designated heating devices).
- HOUSING CHARACTERISTICS: TENURE, QUALITY, RESIDENCE SIZE, AND APPLIANCE MAINTENANCE. Residences occupied by low-income populations are often older, and use older, less efficient, and unmaintained appliances. These older appliances may not be regularly maintained due to the cost required and a lack of available funds to repair them, or lack of landlord attention.[37–39] Low-income residences are also likely to be smaller in size and have inadequate ventilation, resulting in higher indoor pollutant concentrations.[40,41]
- TIME-ACTIVITY PATTERNS. Time-activity patterns, or the amounts of time spent performing various activities throughout the day, substantially affect exposure to pollutants in various environments. Notably, children in low-income families may spend a greater amount of time at home and indoors than other populations.
- CUMULATIVE EFFECTS: HEALTH AND ENVIRONMENTAL JUSTICE IN CALIFORNIA. Residents in environmental justice or “disadvantaged” communities [defined by SB 535 as the top 25% scoring tracts in OEHHA’s CalEnviroScreen tool, used for assessing environmental justice vulnerability] face some of the worst air quality in the state. Gas appliance emissions add to the persistent outdoor air pollution and can compound existing environmental burdens, placing low-income residents and people of color at even greater risk of adverse health effects from air pollution.

2.1.5. KNOWLEDGE GAP AND CONTRIBUTIONS TO THE LITERATURE

Based on the literature review, there is a clear need to: (1) aggregate information on related studies of gas appliances, indoor air quality, equity, and health; and (2) conduct data analysis to provide additional clarity on these issues through quantitative estimations.

While there is clear evidence of a relationship between indoor air quality and health, and combustion falls under that domain, there is some inconclusive literature related to gas appliance use and specific health effects. The broader relationship between NO_2 and adverse health effects is well-established,[116] but a recurrent theme in the literature is the uncertainty regarding the link between indoor NO_2 exposures from gas combustion and respiratory illness.[30,31,113,117] Challenges to the clarification of this relationship include the variabilities between appliances, use activity patterns, and home size and ventilation.[118] Studies have also highlighted the uncertainty regarding the relationship between residential indoor concentrations and personal exposure.[119] While several studies investigating gas appliances and asthma exacerbation produced mixed results, evidence supports a clearer association between gas appliances and asthma and respiratory symptoms in children,[33,120,121] with one meta-analysis reporting that children living in homes using gas for cooking have a 42% higher risk of having asthma.[33] While we did not estimate the association between specific health symptoms and use of gas appliances, our literature review and analysis aim to clarify the relationship between pollutants associated with gas appliance use and human health.

As described earlier, there are a limited number of recent studies that simulate and measure indoor air pollutant concentrations resulting from the use of gas appliances, and many are focused entirely on gas stovetop ranges. We used similar methods and data as some of those studies to conduct our analysis, but we included multiple types of appliances and conducted a detailed literature review on the use of gas appliances, related pollutants, and human health.

We modeled pollutant emissions, concentrations, and exposures resulting from gas appliance use in different housing types in California and linked these exposures to potential health effects via comparison to state and national standards. To our knowledge, there are no existing literature review and secondary analysis studies that tie together indoor air quality modeling for various pollutants, housing types, and low-income vulnerability in California.

2.2. RESULTS AND DISCUSSION

2.2.1. EMISSION FACTOR DATABASE

Results of statistical analyses

To model the effects of gas appliances on indoor air quality, we first created an emission factors (EF) database for residential gas appliances (see Appendix A, Section A.1.1 for details). Our regression models, designed to predict EFs in units of ng/J (nanogram/Joule), found that there are significant differences in EFs among gas appliance types.

Unsurprisingly, the EFs of gas appliances have declined over time, likely due to the technological advances of appliances and pollutant capture technology, which reduce emissions. Consistently, as the year of the publication from which EFs were gathered became more recent, the ng/J emissions decreased (e.g., a paper in 1995 would report higher emissions than a paper published in 2009, with a statistically significant difference); this indicates that emissions have reduced over time. For NO_X, there is a statistically significant increase in EFs for appliances designed to be vented outdoors (e.g., water heaters and home heating devices).

EF and emission rate estimations

As described in Appendix A, the EFs of gas appliances in a unit such as ng/J do not reflect the amount of pollutants released during the consumption without accounting for the mass burning rate (MBR, in J per time period) of different gas appliances. The emission rate in µg/hour (µg/h), or the amount of pollutants released in a specific time period during the usage of different gas appliances, is the product of the EF in ng/J and the MBR in J/h, since both factors affect the rate that combustion byproducts are released into the air.

EFs in ng/J, and emission rates in µg/h (the amount of pollutants released in a specific time period during the usage of different gas appliances) for each appliance category and pollutant were calculated as described in Appendix A.

Table 2-1: Mean emission factors (EF) and emission rates (ER) for each appliance type.

Appliance Type	CO (mean)		NO_2 (mean)		NO_X (mean)	
	EF (ng/J)	ER (µg/h)	EF (ng/J)	ER (µg/h)	EF (ng/J)	ER (µg/h)
Gas Stove	52	670,000	10	130,000	38	440,000
Gas Oven[ii]	92	1,700,000	8.3	150,000	36	640,000
Gas Water Heater[iii]	18	3,200,000	3.4	490,000	25	2,300,000
Gas Heater	16	1,300,000	5.3	320,000	37	1,600,000

Note: Values correspond to total emission factors and rates when the appliance is turned on, regardless of whether an appliance is vented outdoors (meaning not all these emissions travel indoors).

ii. Separate EFs were calculated for stoves and ovens, but throughout this report we combined the two for most analyses (using a sum of emission rates), due to the nature of existing data (e.g. the RASS and CARB State Implementation Plan data). More specifics available upon request.

iii. This analysis incorporates both tankless and storage water heaters, which do have significantly different emissions for CO; tankless water heaters have higher emissions of CO. We did not control for these differences in our analysis. These higher emissions also occur for formaldehyde, which we did not quantitatively assess in this report.[44]

Table 2-2: Average indoor air concentrations by appliance – peak (highest concentration) vs. time-averaged 15-minute cooking, 1-hour cooking, and 2-hour cooking scenarios.

Appliances	Pollutant	Average Peak Concentration (µg/m³)	Average Time-weighted Concentration (µg/m³)	Average Time-weighted Concentration (µg/m³)	Average Time-weighted Concentration (µg/m³)
Duration		Peak	15-minute cooking	1-hour cooking	2-hour cooking
Location		Kitchen	Entire Residence	Entire Residence	Entire Residence
Stoves and ovens	CO	18,000 *(16 ppm)*	950 *(0.83 ppm)*	2,600 *(2.3 ppm)*	4,900 *(4.2 ppm)*
	NO_2	1,600 *(860 ppb)**	16 *(9 ppb)*	37 *(19 ppb)*	64 *(34 ppb)**
	NO_X	6,700 *(3,600 ppb)*	43 *(23 ppb)*	130 *(69 ppb)*	250 *(130 ppb)*
Stoves only	CO	5,600 *(4.9 ppm)*	550 *(0.48 ppm)*	1,000 *(0.9 ppm)*	1,700 *(1.5 ppm)*
	NO_2	750 *(400 ppb)**	12 *(6.4 ppb)*	22 *(11 ppb)*	34 *(18 ppb)*
	NO_X	2,800 *(1,500 ppb)*	26 *(14 ppb)*	62 *(33 ppb)*	110 *(58 ppb)*

*Note: Values marked with * exceed acute CAAQS (for average peak concentration) for CO and NO_2, or 8-hour CAAQS for CO/chronic CAAQS for NO_2 (for time-weighted concentrations).*

Descriptive statistics from the results of our EF calculations are listed in Table 2-1. Kitchen appliances have higher EFs in ng/J for all pollutants, as compared with other gas appliances, but energy usage for water heaters and home heating devices is much higher (see Figure B-2 in Appendix B), which is why resulting emissions are higher for water heaters and home heating devices.[3,15,42,44,45] This is consistent with previous studies that have observed higher emissions from water heaters and home heating devices. Residential water heating results in the highest level of emissions of each of these pollutants.

2.2.2. INDOOR AIR QUALITY IMPACTS AND SUSCEPTIBILITY

Indoor air quality model results

As described in Appendix A, a mass-balance model[122] was used to estimate indoor air concentrations of CO, NO_2, and NO_X under various scenarios of kitchen appliance use, including peak concentrations in the kitchen and time-weighted concentrations throughout the entire home (considering that cooking only occurs for a small portion of the day). This is described further in Appendix A (Section A.1.2), but the model produced an output with the highest concentration value, representing the emissions while cooking; we averaged these to establish the peak concentration levels presented in Table 2-2. For peak concentration levels, we used kitchen-specific volumes, and for values weighted by appliance usage time, we used entire residence volumes, under the assumption that pollutants would mix into the residential space over time. We are conservatively assuming there is no range hood use, and that all kitchen appliances are unvented.

Table 2-2 provides an overview of the average concentrations calculated using the model. We used a range of 15 minutes of cooking to 2 hours of cooking to represent a spectrum of potential cooking patterns.

Defining exceedances of air quality thresholds

Throughout this section, we used California (CAAQS) and U.S. EPA (NAAQS) ambient (outdoor) air quality **standards** as a metric for health effects from exposure.[iv] These standards are the maximum allowable concentration of a pollutant present in outdoor air that will not have a known, adverse impact on human health and are developed to apply to long-term, ambient outdoor air quality, averaged over time periods. It is not possible to actually exceed these outdoor standards in an indoor environment due to the technical definition.

Therefore, we apply target **thresholds** using the standards as a guide to provide context for indoor air quality. We refer to three different types of thresholds based on the standards: 1) acute (1-hour for NO_2 and CO), 2) 8-hour (for CO), and 3) chronic (annual mean for NO_2 — there is no annual mean standard for CO). When we use the term "acute," we are referring to 1-hour standards. For CO, we refer to 8-hour standards directly as such. For NO_2, when we use the term "chronic," we are referring to the annual mean standards.

When an exceedance is referenced in this report, it means that the modeled indoor air concentration is higher than the threshold levels based on the standards in Table B-7. When we refer to the percentage of exceedances, we are discussing the percent of our modeled indoor air quality estimates that exceed thresholds (please see Appendix A for additional details). We evaluate the indoor air quality exceedances of the

iv. An underlying assumption is that concentrations and exposures are directly proportional.

Table 2-3: Concentration and exposure scenarios.

Pollutant	Scenario(s)	Time-Averaging	Location	Comparison
CO	Peak (assuming 1 hour of elevated concentration for exceedance to apply)	None	Kitchen	*Acute:* 1-hour thresholds
NO_2	Peak (assuming 1 hour of elevated concentration for exceedance to apply)	None	Kitchen	*Acute:* 1-hour thresholds
CO	15-minutes, 1-hour, and 2-hours of cooking	8-hour	Entire residence	*8-hour* thresholds
NO_2	15-minutes, 1-hour, and 2-hours of cooking	24-hour	Entire residence	*Chronic:* annual mean thresholds

CAAQS and NAAQS thresholds, overall and for separate residence types, for CO and NO_2 (there are no applicable standards for NO_X).

We compare the peak concentrations (which are direct model outputs without any time-averaging, reflecting kitchen concentrations) from our indoor air quality model to the acute NO_2 and CO thresholds, under the assumption that exceedances of the thresholds for our estimated peak concentrations only apply under a scenario where cooking occurs for an extended period of time and the air quality levels in the kitchen remain elevated for an entire hour (considering the ambient air quality acute 1-hour threshold described above). We compare the modeled 8-hour time-averaged CO concentrations to the 8-hour CO thresholds, and the 24-hour time-averaged NO_2 concentrations to the chronic NO_2 thresholds, under three cooking-time scenarios (15 minutes of cooking, 1 hour of cooking, and 2 hours of cooking. This is laid out in Table 2-3.

We focus on the California CAAQS and U.S. NAAQS in this report, but we also note that Canada has existing indoor residential air quality guidelines for NO_2 that are more stringent than the U.S. thresholds we discuss throughout the report (i.e., 170 $\mu g/m^3$ for 1-hour, and 20 $\mu g/m^3$ for 24-hour).[123] Thus, the NO_2 results we present here can also be considered through the more health-protective lens of the Canadian standards. The Canadian CO standards are similar to the CAAQS and NAAQS thresholds. All of these standards can be found in Table B-7 in Appendix B.

Findings: exceedances of air quality thresholds

As shown in Table 2-2, for the use of both stoves and ovens simultaneously, the 2-hour use of kitchen appliances results in an average of the time-weighted NO concentrations of 64 $\mu g/m^3$, exceeding the chronic (annual mean) NO_2 CAAQS threshold of 57 $\mu g/m^3$. For 2 hours or less of stove use alone, the average household does not exceed any chronic thresholds.

Exceedances resulting from the use of both kitchen appliances simultaneously, as well as from stoves individually, are summarized in Table 2-4, with percent exceedances for both the CAAQS and NAAQS (see Appendix B, Table B-7 for each threshold level). As mentioned previously and in Appendix A, the kitchen peak concentrations are compared with the acute thresholds, and the modeled 15-minute, 1-hour, and 2-hour cooking, entire home concentration estimates have been time-averaged (over 24 hours for NO_2 and 8 hours for CO), and are compared with the chronic threshold for NO_2 and 8-hour threshold for CO.

When both stoves and ovens are used simultaneously, 18.7% of peak CO concentrations inside the kitchen exceed acute CAAQS, and 11% of 2-hour and 4.5% of 1-hour cooking averages throughout the home exceed 8-hour CAAQS. For CO, less than 1% of 8-hour concentrations based on a 15-minute cooking scenario results exceed the 8-hour CAAQS.

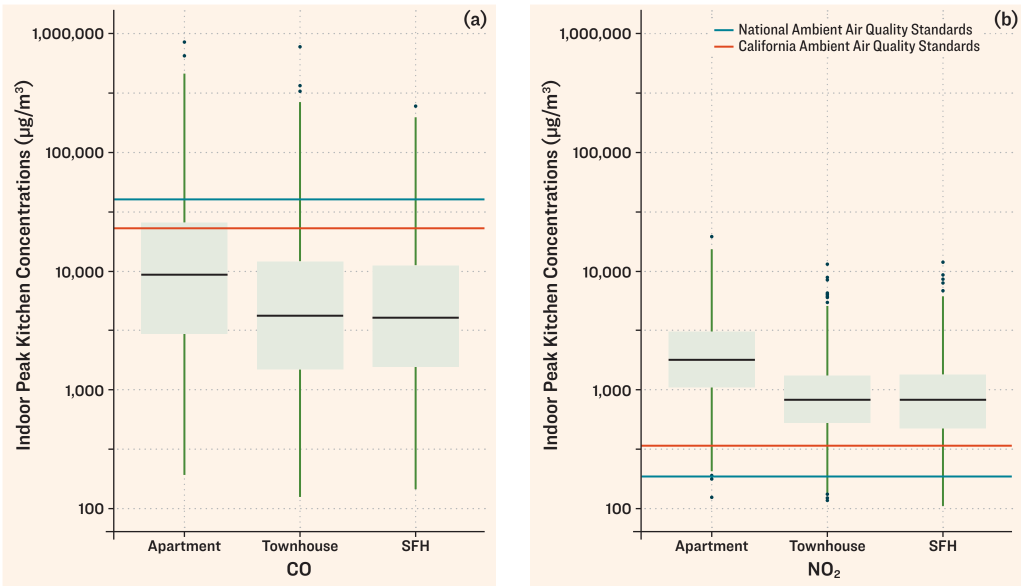
Results for NO_2 are even more noteworthy, particularly for peak concentrations. Again, when both stoves and ovens are used at the same time, more than 90% of

Table 2-4: Percent exceedances of air quality thresholds by appliances used and cooking time intervals.

Appliance	Pollutant	Acute		8-hour for CO and Chronic for NO_2					
		% of Peak Exceeding CAAQS	%of Peak Exceeding NAAQS	% of 15-minute Use Exceeding CAAQS	% of 15-minute Use Exceeding NAAQS	% of 1-hour Use Exceeding CAAQS	% of 1-hour Use Exceeding NAAQS	% of 2-hour Use Exceeding CAAQS	% of 2-hour Use Exceeding NAAQS
Stoves and ovens	CO	19%	11%	0.4%	0.4%	4.5%	4.5%	11%	11%
	NO_2	93%	99%	2.0%	0.1%	15%	2.5%	45%	15%
Stoves only	CO	4.4%	2.6%	0.1%	0.1%	1.0%	1.0%	2.7%	2.7%
	NO_2	61%	81%	1.7%	0.4%	5.0%	1.1%	15%	4.1%

Note: In the peak scenarios, when comparing concentrations to air quality thresholds and acute exposures, we assume cooking time occurred for the entire 1-hour period that the acute threshold applies.

Figure 2-1: Peak concentrations in the kitchen resulting from usage of stoves and ovens simultaneously, by pollutant [(a) CO and (b) NO_2] and housing type.



peak NO_2 concentrations inside the kitchen exceed acute CAAQS. Additionally, 45% of 2-hour and 15% of 1-hour cooking averages throughout the home exceed chronic CAAQS, though only 2% of 15-minute cooking concentrations exceed chronic CAAQS.

When stoves are used independently, and resulting emissions and concentrations are lower, CO exceedances are again much less significant, while for NO_2, exceedances of acute NAAQS occur up to 80% of the time for peak concentrations, and exceedances of chronic CAAQS occur up to 15% of the time for the longest cooking time (2 hours), both based on the most stringent thresholds.

Keeping in mind the air quality thresholds, these percentages represent the frequency that air quality can no longer be considered safe (i.e., having no known, adverse impact on human health).

Figure 2-1 and Tables 2-5 and 2-6 provide housing-type-specific assessments. Figure 2-1 depicts average peak concentrations inside kitchens for each housing type, along with acute, ambient air quality standards for CO and NO_2. Variations in peak concentrations shown in Figure 2-1 are a result of variations in residence volume and associated ventilation rates. Our findings for apartments, townhouses, and single-family homes (SFHs) in Tables 2-5 and 2-6 are a disaggregation of the data in Table 2-4 and serve to inform the public about the variations in indoor air concentrations by building type. It must be noted that these findings are based on averages of housing volume and ventilation found in the literature, and may not represent all homes; therefore, these should only be used as general indicators. While Table 2-2 and Table 2-4 include a 15-minute cooking scenario, we did not include this particular scenario in the housing-specific tables (2-5 and 2-6) for simplicity. If the 15-minute cooking scenario is of further interest, Tables 2-2 and 2-4 can be used to extrapolate the data.

To appropriately interpret these tables and figures, we refer to housing estimates in California. Throughout the state, approximately 58% of residences are SFHs, 30% are apartments, and 9% are attached homes, such as townhouses.[2] The remainder (~3%) are primarily mobile homes, but because those make up such a small percentage of the California housing stock, we

Table 2-5: Average peak (kitchen) and time-weighted, 8-hour average (entire home) CO concentrations from use of gas kitchen appliances in various residence types, and percentage of scenarios in which concentrations exceed air quality thresholds.

Residence Type	Acute - Peak		8-hour			
	Peak Conc. in Kitchen (µg/m3)	% of Cases Above 1-hour Standards	8-hour Conc. 1-hour Cooking Entire Home (µg/m3)	% of Cases Above 8-hour CAAQS 1-hour Cooking	8-hour Conc. 2-hour Cooking Entire Home (µg/m3)	% of Cases Above 8-hour CAAQS 2-hour Cooking
Apartment	28,000	27.6%	3,900	8.2%	7,400	18.2%
Townhouse	13,000	12.8%	2,000	2.5%	3,500	6.9%
SFH	12,000	12.2%	1,800	1.8%	3,300	5.8%

Table 2-6: Average peak (kitchen) and time-weighted 24-hour average (entire home) NO_2 concentrations from use of gas kitchen appliances in various residence types, and percentage of scenarios in which concentrations exceed air quality thresholds.

Residence Type	Acute - Peak		Chronic			
	Peak Conc. in Kitchen (μg/m3)	% of Cases Above Acute Standards	Time-weighted Conc. 1-hour Cooking Entire Home (μg/m3)	% of Cases Above Chronic CAAQS 1-hour Cooking	Time-weighted Conc. 2-hour Cooking Entire Home (μg/m3)	% of Cases Above Chronic CAAQS 2-hour Cooking
Apartment	2,400	98.3%	46	27.2%	85	65.8%
Townhouse	1,100	90.8%	31	8.4%	52	31.9%
SFH	1,100	87.0%	33	12.5%	56	33.9%

do not include them in this analysis. However, this is an important area for additional study. There are existing challenges with the provision of utilities in mobile home parks; the California Public Utilities Commission approved a Mobile Home Park Utility Upgrade Program in 2014, which is still operating.[124]

These concentrations and exceedances are comparable to the findings in previous studies, both modeled and measured, many of which are discussed in Section 2.1.1. One notable finding is that exceedances are all higher for apartments, primarily due to smaller residence sizes.

A 2012 analysis conducted by LBNL measured pollutant levels in 155 California homes and found that approximately 10% of residences studied had chronic (6-day, in the case of this study — typical passive monitoring methods only capture multiday NO_2 averages) indoor air concentrations of NO_2 exceeding chronic CAAQS, which are comparable to our 1-hour cooking results of 15% exceedances for stoves and ovens used simultaneously, and 5% for just stove use (Table 2-4).[45] They had a low number of exceedances for CO, which aligns with our findings (Tables 2-4 and 2-5) that CO exceedances are much less frequent than NO_2. A modeling analysis of Southern California homes found a similar pattern between CO and NO_2 exposures.[53]

We did find a high percentage of peak exceedances of acute (1-hour) thresholds for NO_2 when both stoves and ovens are used (Table 2-4 and 2-6), and associated exposures apply, assuming the household cooked for the entire hour, but this is not necessarily a typical exposure scenario; it depends on cooking habits in the home. When only stoves are used (Table 2-4), the risk assessment more closely matches existing literature on emissions from stovetop ranges. A simulation-based study of California residences, which incorporated seasonality, found that among homes using gas stoves with no ventilation (the same conditions as our analysis), 55-70% exceeded NAAQS NO_2 standards.[47] Though we found that almost all of our estimated concentrations exceeded the 1-hour NO_2 NAAQS threshold for concurrent stove and oven use, we found 80% exceedances when solely stoves are used (Table 2-4), which is comparable.

Overall, our analysis echoes the assertions of many existing studies that exceedances of regulatory standards for NO_2 may be frequent and are a cause for concern. Additional information on the pollutant levels measured and simulated in the literature is provided in Section 2.1.1.

Sensitivity analysis: using kitchen appliances for heating residential spaces and the impact of improper ventilation

In situations where designated heating devices are insufficient in a residence, kitchen appliances are sometimes used as heating devices. Additionally, as discussed in Section 2.1.2, ventilation technology does not always work exactly as designed. Due to the lack of existing data sources, we were unable to quantify the frequency of occurrences of the use of kitchen appliances for heating residential spaces, or the frequency of improper ventilation that results in pollutant spillage to the indoor environment. We have provided a brief analysis of existing knowledge to cover the spectrum of this potential issue.

Again, while it is challenging to quantify the frequency of these types of occurrences, there are many circumstances under which backdrafting and spillage of combustion pollutants can occur, and evidence suggests this may happen in homes across the United States (see Section 2.1.2). Under these various scenarios where appliances designed to be vented outdoors are improperly vented and combustion gases spill into the interior, peak exposures rise significantly, particularly because when used, these types of appliances have higher hourly emissions than kitchen appliances (see Table 2-1). One key assumption for this portion of the analysis is that the pollutant spillage is occurring for the entire time the appliance is operating. Due to the conservative nature of this assumption, we included several capture efficiency scenarios; we have provided this range of scenarios to account for various percentages of combustion pollutants traveling indoors instead of out through ventilation. These concentrations are for each appliance used individually, as opposed to concurrently.

Compared to the average peak concentrations presented in Tables 2-2, 2-5, and 2-6, the concentrations resulting from improper ventilation presented in Table 2-7 are elevated in several cases. For water heaters, these concentrations commonly exceed the acute CAAQS threshold for CO (two out of four capture efficiency scenarios) and NO_2 (all four scenarios). For NO_2, concentrations for home heating device use also exceed the acute CAAQS threshold for all but the highest capture efficiency scenario. These represent peak concentrations throughout the entire home, not just the kitchen (since there is not a specific, designated room for these other appliances); therefore, these are modeled on a larger volume than peak concentrations in the other tables. It is important to note that if the appliance of concern is in a small room, concentrations in that room will be significantly higher than what is recorded in Table 2-7.

There is limited information on the supplemental use of cooking appliances (stoves and ovens) for heating residences (meaning appliances not designed for heating are used to heat spaces in the home). When gas cooking appliances are used for heating, there are two particularly important considerations: the greatly increased duration of use, compared to when they are used for cooking, and that they constitute an unvented heating source. These factors elevate indoor combustion pollutant levels. A study investigating the relationship between respiratory illness in children, gas stove use, and ventilation found that in homes where adults used the stoves for both cooking and heating, as opposed to solely for cooking, children had significantly higher odds of being diagnosed with asthma and experiencing other respiratory symptoms.[35]

Under a scenario where kitchen appliances are used for supplemental heating for approximately 4 hours, time-weighted exposures in the entire home rise by a factor of 4.8 for NO_2 as compared to 1 hour of cooking, and the chronic CAAQS threshold is exceeded in 90% of instances. The 8-hour CO concentrations would rise by 2.8 times in this scenario. If only the stove is used for both cooking and supplemental heating, time-weighted exposures for NO_2 rise by a factor of 4.0 and exceed the CAAQS threshold 51% of the time when supplemental heating occurs. On average, the 8-hour CO concentrations would rise by 2 times when compared to 1 hour of cooking.

Though frequency of use for these purposes is not well established, particularly in recent literature and datasets, there are reasons for equity-related concern. A report based on the National Health and Nutrition Examination Survey (NHANES) III (1988-1994) found that use of a gas stove or oven for heating was highest among adults in the Southern U.S., with lower-income households engaging in such use of combustion appliances approximately twice as often as higher-income households.[125] In recent years, the U.S. Census Bureau's American Community Survey (ACS) started collecting data on supplemental heating devices, but found no clear income- or race-based trends. In each income group, 2.6-5.4% of households reported using cooking stoves for supplemental heating. Significantly fewer households use gas ovens with the oven door open for heating, as opposed to cooking stoves.

There have been a few articles written on the use of gas stoves for supplemental heating, though several date to the early 1980s. This behavior has been identified as a contributor to elevated indoor NO_2 levels in low-income housing — particularly in combination with poor ventilation and small apartment size[30] — and the use of gas stoves for heating is linked with childhood asthma.[118] In the previously mentioned NHANES III of more than 8,000 children, those who lived in homes where a gas stove or oven was used for heat were more likely to have

Table 2-7: Mean peak CO and NO_2 exposures in the entire home associated with pollutant backdrafting/spillage and various capture efficiencies.

Appliance	Pollutant	Concentration with 0% Capture Efficiency (µg/m³)	Concentration with 25% Capture Efficiency (µg/m³)	Concentration with 50% Capture Efficiency (µg/m³)	Concentration with 75% Capture Efficiency (µg/m³)
Heating devices	CO	11,000	8,200	5,600	3,000
	NO_2	730*	550*	370*	190
	NO_x	3,900	2,900	2,000	990
Water heaters	CO	31,000*	24,000*	16,000	8,100
	NO_2	1,400*	1,100*	710*	360*
	NO_x	6,400	4,800	3,200	1,600

*Note: Values marked with * exceed acute CAAQS for CO and NO_2.*

clinically diagnosed asthma.[118,121] In a 1980s study of 700,000 residents in New York City, approximately 50% of those with gas stoves, but no gas heating appliances, were found to use gas stoves for supplemental heating.[126] A study of patients with symptoms of CO exposure found that use of gas stoves for heating was a significant predictor of high carboxyhemoglobin levels, indicating CO poisoning.[127] In a sample of residences in the United Kingdom, use of gas ovens for heating was significantly related to NO_2 concentrations in both kitchens and bedrooms.[128] However, in a study of low-income public housing in Boston, supplemental heating with stoves was not a significant predictor of indoor NO_2 concentrations, though gas stove heating behavior was only assessed via an initial survey and not during the environmental sampling period.[129] Researchers have called for further research and education on the impact of supplemental heating with gas stoves, and have identified the improvement of heating technology as a means of limiting the use of gas stoves for heating.

2.2.3. ADDITIONAL EXPOSURE AND VULNERABILITY CONSIDERATIONS

This section includes a brief, qualitative discussion of other factors associated with exposure and associated risk.

Synergistic effects of multiple air pollutants

There is potential for synergistic effects of exposure to multiple pollutants, including our pollutants of interest — CO, NO_2, and NO_X — meaning that exposure to multiple pollutants at one time may not be a direct sum of the individual health impact of exposure to each pollutant.[130] The health effects of pollutants such as $PM_{2.5}$, NO_X/NO_2, and CO are evaluated separately in our report and others, but these exposures occur simultaneously, and concurrently with other pollutants not included in our analysis, such as heavy metals, PAHs, and VOCs (both during cooking, and due to other sources of indoor exposures).[27,119] We are not able to account for this in our analysis, but it is an important consideration.

Body weight, inhalation rates, and gender

Body weight and inhalation rates play a major role in determining the effects of personal exposure to airborne contaminants. Higher inhalation rates result in greater exposures, and lower body weights increase the effects of exposure, due to a higher dose per unit of body weight. Body weight and inhalation rate are also correlated, and thus, the two factors should be considered in conjunction.[131] Inhalation rates increase with body weight, with substantial increases found when comparing people of normal weight and people who are overweight; additionally, males have slightly higher inhalation rates than females.

Body weight and inhalation rate considerations are most important in regard to children, who are particularly susceptible to the adverse health effects of air pollution. Children perform a substantially higher level of daily physical activity than adults, which culminates in a far greater intake of air into the lungs.[132] Furthermore, children breathe 50% more air per unit of body weight than adults, due to having a greater lung surface area to body weight ratio.[133]

We did not incorporate body weight and inhalation rates into our quantitative assessment, but the California Department of Toxic Substances Control (DTSC) releases and regularly updates a set of Human Health Risk Assessment (HHRA) notes[134] focused on different aspects of risk assessment, and HHRA Note 1 is entirely focused on default exposure factors, including body weight and inhalation rate. Additionally, the 2011 US EPA Exposure Factors Handbook offers a comprehensive overview of inhalation rates for children and adults according to age, gender, body weight, and activity level.[131] According to this handbook, domestic tasks such as cooking are considered light intensity activities.

In terms of gender, the variations between men and women related to body weight and inhalation rate apply, but in regard to gas appliances, there is an additional consideration regarding which gender spends more time cooking and thus, is in closer proximity to gas appliances being used in the kitchen. Surveys have indicated that women do spend more time preparing meals than men[v], resulting in additional exposure to combustion pollutants in households with gas appliances.[137,138] A 1991 CARB study of children's activity patterns also found the prevalence of potential exposure to fumes from a gas-powered oven to be consistently elevated for children of all ages and genders.[139]

Housing characteristics: tenure, quality, residence size, and appliance maintenance

Disadvantaged populations disproportionately experience poor housing conditions that can be detrimental to health.[140] A recent State of the Nation's Housing report from Harvard University found that more than half of the nation's low-income population

v. We do not expand upon it in this report, but it is important to note that the gender disparities in cooking frequency as well as associated exposures for children are international issues, particularly in countries where traditional cookstoves are used to burn solid fuels, leading to significant environmental health concerns.[135,136]

live in high-poverty neighborhoods.[141] Housing quality related to safety is substandard in many low-income residences,[142,143] and is inextricably linked with public health concerns; also, appliance age and maintenance fall under this umbrella of housing safety considerations.[40,144] Lower-income families are often renters: The median income for renters in California is $50,000 annually, while the median income for home owners is $90,070 annually.[2] Lower-income families often do not have control over, or incentive to engage in, appliance replacement and maintenance; additionally, these families have less disposable income to spend on resolving maintenance issues. We can refer to the sensitivity analyses in 2.2.2, which highlight a potential health concern associated with old and unmaintained appliances: improper ventilation resulting in spillage of combustion pollutants into the living space. Lack of maintenance may result in improper ventilation occurring for extended periods of time. Thus, there is a need for future research on the sociodemographic trends in households with appliance maintenance and ventilation concerns.

Housing size variations are accounted for within the indoor air quality model; a smaller home with the same ventilation rate as a larger home will have higher concentrations of pollutants due to having lower volume. Our findings from Section 2.2.2 demonstrate that exceedances for CO and NO_2 are all higher for apartments, primarily due to smaller residence sizes.

Additionally, individuals in the kitchen and other rooms will be in closer proximity to gas-burning devices. This may have air quality and health implications for low-income populations living in smaller homes. Furthermore, low-income residences are more likely to be overcrowded,[145] which may affect cooking frequency. “Overcrowding” is defined as occurring when there is more than one person living in a residence as there are rooms in the residence (including rooms such as the living room and kitchen). According to the California Department of Housing and Community Development, California’s overcrowding rate is 8.4%, which is more than double the U.S. average of 3.4%.[145]

Time-activity patterns

Research has shown that children in low-income families spend more time in the home,[146] and are thus exposed to indoor air quality issues in the home more often than children from families with a higher socioeconomic status. Limited literature indicates that this may be particularly due to lower participation in after-school programs, resulting in greater exposure to indoor air pollutants in the home.[147,148] This is an area for future study.

Cumulative impacts: health and environmental justice in California

As we briefly touched upon in the background section, low-income and environmental justice communities are often disproportionately affected by adverse environmental conditions, and historically, have less access to clean water and air, as well as to clean energy resources. Many environmental issues in disadvantaged communities are externalities that these communities do not have control over, and these issues contribute to health disparities.

Existing research has explored the cumulative effects faced by vulnerable communities, finding that there are many complex, nuanced relationships between environmental and social factors that can result in significant (and potentially nonlinear) health effects on the population.[115,149] This includes the exacerbation of the effects of harmful environmental exposures — such as air or water pollution — and the enhancement of psychosocial stress experienced in impoverished neighborhoods. There are also potential synergistic effects from exposure to multiple pollutants, and multiple stressors, that need to be explored further to be fully understood.[115,149]

Research suggests that regulatory interventions must consider different elements of cumulative effects to reduce environmental inequities and associated health disparities.[115] It is critical to note that any air quality impact from the use of gas appliances compounds upon preexisting, complex, and adverse environmental and health burdens in these communities.

2.2.4. HEALTH EFFECTS OF AIR POLLUTION

In this section, we present the existing evidence surrounding each pollutant's relationship with gas appliance use, and describe the specific acute and chronic health impacts associated with exposure. We address indoor exposures specifically, but this section is also generally applicable to outdoor, ambient exposures to these pollutants. Table 2-8 summarizes the health effects described in this section.

2.2.4.1. Nitrogen oxides

NO_X, predominantly consisting of NO and NO_2, are widespread gaseous pollutants. NO_2 is primarily formed from the oxidation of NO.[155] Existing research evaluates the human health impacts of both NO_X and NO_2, but much of recent literature focuses on NO_2, particularly since a growing body of evidence indicates that it leads to premature mortality. Therefore, we focus specifically on NO_2 in this section. The 2016 US EPA Integrated Science Assessment (ISA) on the health effects of NO_X found the literature to be suggestive of a causal relationship between chronic NO_2 exposure and respiratory effects, cardiovascular effects, cancer, and mortality, though it did not make an absolute determination.[116]

As mentioned in Section 2.1.1, combustion appliances — specifically, gas cooking appliances — have been found to increase indoor NO_2 levels above acute CAAQS and NAAQS thresholds.[119] Studies have observed higher NO_2 exposures in homes with gas stoves compared to those with electric stoves.[27,221] When cooking with gas, peak concentrations of NO_2 in the kitchen can reach levels far in excess of the CAAQS 1-hour NO_2 threshold.[34] Individuals who cook with gas can be exposed to high levels of NO_2 due to close proximity to the stove. These peak concentrations of NO_2 are comparable to those reported in Section 2.2.2.

Though exposure to NO_2 has been linked to adverse health outcomes, there is some mixed evidence regarding the association between indoor NO_2 exposure from combustion appliances and specific respiratory health impacts.[31,33] Studies from the last several decades have found a robust association between NO_2 from gas cooking and increased risk of respiratory illness

Table 2-8: Overview of health effects of main studied pollutants.

Pollutant	Health Effects	
	Acute	Chronic
Nitrogen oxides (NO_x)	Decreased lung function, asthma exacerbation, respiratory infection,[118,120,150–153] stroke[154]	Premature mortality,[155–158] lung and breast cancer,[156,159] cough, shortness of breath, asthma, wheezing, respiratory illness in children[33,33,91,117,120,160–163]
Carbon monoxide (CO)	Death, brain damage, seizures, memory loss, dementia, headaches, dizziness, nausea[164–168]	Brain and heart toxicity,[164,169–173] heart failure and cardiovascular disease,[167,174–176] low birth weight[177]
Fine particulate matter ($PM_{2.5}$)	Stroke, increased blood pressure[154,178–180]	Premature mortality,[22,181] bronchitis, asthma onset and exacerbation,[185–189] low birth weight and preterm birth[190–194]
Ultrafine particles (UFP)	Increased blood pressure[179,195]	Cardiovascular disease,[196,197] neurological disorders[198,199]
Formaldehyde	Respiratory/eye/skin irritation, sneezing, coughing, nasal congestion,[103,200,201] drowsiness, chest tightness, shortness of breath,[103,200,202] asthma exacerbation,[203,204] death (higher doses)[205]	Cancer,[103,172,206–210] asthma and bronchitis in children,[200,211,212] damage to respiratory system,[205,211,213–219] headaches, sleep disorders, memory loss,[202,205] birth defects, low birth weight, spontaneous abortion[205,213,218,220]

in children, such as asthma, wheezing, and other respiratory symptoms.[33,91,120,162,163] NO_2 exposure from gas appliances is implicated in many other respiratory symptoms, including cough, lung obstruction, and shortness of breath.[33,117,160,161] Women may be at higher health risk from NO_2 exposure, due to greater susceptibility and higher frequency of cooking compared to men.[117,138,160] Research suggests that due to the widespread use of gas for cooking, NO_2 exposure from gas appliances has a substantial public health impact, particularly in children, as described in Section 2.2.3.[33]

The respiratory effects of acute NO_2 exposure more broadly include decreased lung function, asthma exacerbation, and increased risk of respiratory infection.[118,120] Children are at the highest risk of health effects from NO_2 exposure.[118,120,222] Short-term NO_2 exposures above the CAAQS 1-hour standard are associated with lung inflammation, particularly in individuals with asthma or chronic obstructive pulmonary disease (COPD).[150–153] Acute NO_2 exposure is also associated with increased risk of hospital admission and mortality from stroke.[154]

Chronic NO_2 exposure is suspected to be a driver of air-pollution-related mortality and is associated with premature death.[156,222] Studies have observed a relationship between chronic NO_2 exposure and all-cause, cardiovascular, respiratory, and lung cancer mortalities, with greater risks among populations with preexisting diseases.[155–158] Chronic NO_2 exposure also increases the risk of lung and breast cancers,[156,159] and evidence also suggests impact to pregnancy outcomes, such as low birth weight.[223–225] A substantial body of evidence supports an independent effect of NO_2 on mortality, and epidemiological research on this burgeoning topic is accumulating quickly.[155–158] Because NO_2 is ubiquitous and large populations are exposed, even small increases in NO_2 may have extensive public health consequences.[155–158,222]

2.2.4.2. Carbon monoxide

Although exposure to dangerous levels of CO is preventable, many instances of CO poisoning still occur in homes,[226] resulting in estimated expenses of $1.3 billion annually in the United States.[227,228] As mentioned previously, the Tracking California program estimated 643 emergency department visits due to non-fire-related CO poisoning in 2016,[82] and CARB estimates there have been 13-36 non-fire-related CO poisoning deaths in California annually since 2000.[67] Although CO emissions from gas appliances can be negligible,[27,49,51,52] and most of the CO concentrations presented in our results in Section 2.2.2 are below the state and national 8-hour standards of 10,000 μg/m^3, dangerously high CO exposures from gas appliances may occur due to mechanical and ventilation failures.[164,229] Excessive CO exposures, often associated with gas appliances, have been found to cause severe damage to brain tissue,[164–168] and can result in long-term or permanent neurological symptoms such as seizures, memory loss, and dementia.[228–232]

CO exposure has diverse, acute human health effects, with symptoms ranging from headaches, dizziness, and nausea at low concentrations, to neurological damage and death at high concentrations.[165,168] CO is an insidious pollutant; because it is tasteless, odorless, and induces nonspecific symptoms, CO exposures often remain undetected by both victims and medical professionals.[233]

While the health effects of acute exposure are well-established, the long-term impact is not as well-studied or understood. Chronic exposure to low concentrations of CO was found to be associated with adverse health effects on multiple organ systems, with substantial evidence demonstrating toxic effects on the brain and heart.[164,169–173] The World Health Organization (WHO) suggests potential toxic effects of chronic CO concentrations above 6.9 mg/m^3.[172] Increases of 11.5 mg/m^3 in ambient CO levels are associated with increased risk of hospital admission for congestive heart failure, particularly in the elderly,[167,174,175] whereas increases of slightly more than 1 mg/m^3 in 1-hour maximum CO concentrations are associated with increased risk of cardiovascular-disease-related hospitalizations.[176] In addition, children are especially vulnerable to CO exposure due to their developing nervous systems and high metabolic rates,[229] and exposure to ambient CO levels close to those of the WHO threshold listed previously in this report is associated with an increased risk of low birth weight.[177] There are other risks associated with CO exposure during pregnancy as well.[234]

2.2.4.3. Particulate matter

PM is a leading cause of worldwide mortality and morbidity, and there is evidence that $PM_{2.5}$ pollution adversely affects cardiovascular and respiratory health through a myriad of pathways.[22,181] Recent research, based on the Global Burden of Disease project, found that $PM_{2.5}$ led to approximately 8.9 million deaths in 2015, which is higher than previous estimates.[24] PM concentrations are often higher indoors than outdoors and come from a variety of sources, including cooking, household aerosol products, office equipment, and transportation of outdoor pollution into the indoor environment.[182]

Cooking with combustion appliances can be a significant source of $PM_{2.5}$ and UFP exposure,[26,27,64,235] though studies of $PM_{2.5}$ exposure from these types of appliances have shown a decrease over the last several decades, likely due to technological advances resulting in reduced emissions. Although both gas and electric stoves generate particle emissions, gas stoves have been found to produce greater particle exposures.[26,28] Cooking methods, and the type of food being cooked, can also have a substantial impact on $PM_{2.5}$ emissions, and the use of cooking oils with higher smoke temperatures has been identified as a means of reducing $PM_{2.5}$ emissions.[236] As mentioned previously, many of these experimental tests involved food, and the $PM_{2.5}$ concentrations observed cannot solely be attributed to the appliances. Additionally, as mentioned in Section 2.1, PM emissions from gas water heaters and home heating devices are significantly higher than PM emissions from kitchen appliances.

Short-term exposure to $PM_{2.5}$ is associated with cardiovascular and cerebrovascular disease, including strokes and increases in blood pressure.[154,178–180] An increased risk of hospital admissions and mortality for stroke has been observed per 10 μg/m^3 short-term increase in ambient $PM_{2.5}$.[154]

$PM_{2.5}$ also has well-established, chronic health effects.[182] An extensive body of evidence supports a significant association between $PM_{2.5}$ and all-cause mortality.[22] $PM_{2.5}$ exposure is associated with an increased risk of cardiovascular and respiratory mortality, with a greater increase in risk than seen for NO_2.[156–158] The impact of $PM_{2.5}$ pollution also includes increased emergency room visits and general hospital admissions,[182–184] and chronic $PM_{2.5}$ exposure is linked to certain cardiovascular diseases and chronic respiratory conditions as well, such as bronchitis and asthma onset and exacerbation.[185–189] Chronic $PM_{2.5}$ exposure is particularly harmful to pregnant women and children. Long-term $PM_{2.5}$ exposure during pregnancy is associated with increased risk of low birth weight and preterm birth per 10 μg/m^3 increase in $PM_{2.5}$.[190–194] A study of more than 600,000 births in California over a 7-year period revealed a significant association between $PM_{2.5}$ exposure and low birth weight.[237] One recent study found that the dose-response relationship between preterm birth and $PM_{2.5}$ is linear at lower pollution levels, suggesting increased risk even at low concentrations.[190]

Evidence indicates that combustion processes produce large amounts of UFPs.[48,57,236] UFPs can also be formed by nucleation, where low volatile gas phase species are converted to aerosol phases. Nucleation events can be provoked by the operation of gas appliances, where combustion processes produce gaseous emissions such as CO and NO_2.[44,238,239] In an LBNL study of combustion appliance emissions, the vast majority of particles emitted by gas stoves were found to be in the ultrafine range,[44] and a study of residences in Northern California found cooking to be the greatest source of indoor UFPs.[48] A chamber study demonstrated substantial UFP number concentrations of more than 300,000 particles/cm^3 emitted by both gas and electric stoves,[240] while a residential study of gas stoves in Taiwan recorded $PM_{2.5}$ concentrations of up to 100 μg/m^3 and UFP emissions of up to 1,400,000 particles/cm^3.[241]

Burgeoning research indicates that UFPs significantly affect human health, though regulatory intervention to control emissions of these particles is particularly challenging, due to their small size.[198] Emerging evidence posits UFPs are potentially more toxic and harmful than $PM_{2.5}$ on a per unit mass basis.[179,242]

Chronic exposure to UFPs is associated with increases in markers related to cardiovascular disease risk.[196,197] Both ambient UFP concentrations and UFP emissions from indoor sources have been found to increase blood pressure in adults and children.[179,195] UFP exposure also has pronounced respiratory effects: A study of five European cities over a 10-year period found an association between UFP and respiratory hospitalizations during warm periods, with the strongest effects seen among children 0-14 years old.[243] Researchers suggest that UFPs may contribute to neurological disorders as well.[198,199]

Exposure to PM has well-established acute and chronic health effects, and though we were not able to quantify indoor residential exposures to $PM_{2.5}$ and UFPs in this report, due to limited available data, PM exposure due to indoor gas appliance operation should be considered in future air pollution and health effect studies.

2.2.4.4. Formaldehyde

Formaldehyde is a part of a larger family of VOCs, which are common indoor pollutants with sources including building materials, carpeting, paint, furniture, personal care products, and combustion.[30,244,245] Newer residential buildings have been found to produce greater formaldehyde and VOC emissions than older buildings.[200,244] Additionally, recent evidence suggests that infiltration of outdoor formaldehyde contributes substantially to indoor concentrations.[246,247] Formaldehyde is an extremely prevalent pollutant, and a study of California homes found that 95% had formaldehyde levels above the OEHHA chronic REL.[45]

Formaldehyde has been formally established as a human carcinogen by regulatory agencies such as the WHO and the International Agency for Research on Cancer (IARC), and noted potentially carcinogenic by other agencies, with evidence of it causing nasopharyngeal cancer and, to a lesser extent, leukemia.[103,172,206–210] Apart from its carcinogenic effects, formaldehyde is a sensory and respiratory irritant with both acute and chronic non-cancer health effects.[103,200,201] However, formaldehyde exposures often occur in conjunction with large numbers of other VOCs and indoor air pollutants; thus, identifying the direct health effects of formaldehyde has proven challenging.[200,213,248]

Formaldehyde can be formed as a byproduct of combustion processes, due to incomplete combustion.[103,247] Although most existing literature focuses on formaldehyde emissions as a result of cigarette smoking, wood combustion, and off-gassing from building materials, a number of studies have investigated the effects of formaldehyde formation due to gas appliances and residential cooking activities.[27,44–46,74] Although the operation of gas appliances has been found to result in formaldehyde emissions, the concentrations measured in such studies were often below the OEHHA chronic REL of 9 μg/m^3.[27,44] Additionally, several studies did not indicate any significant contribution of gas appliance use to indoor formaldehyde concentrations.[45,46,74] These results are consistent with research showing that building materials are the primary sources of indoor formaldehyde emissions.[30,244,245] Preliminary evidence in mice suggests intermittent exposures to higher concentrations of formaldehyde are more damaging than constant low-level exposures, as the dose-response relationship between formaldehyde and its impact on human health is not linear.[214] This may be of importance when considering formaldehyde emissions from gas appliances, as these exposures are acute and unpredictable, as opposed to chronic and stable (as in the case of formaldehyde emitted from building materials).

Respiratory irritation is the most common, acute effect of formaldehyde exposure, along with related symptoms such as dry skin, sneezing, coughing, eye irritation, and nasal congestion.[200,202,205,207,211,249] Formaldehyde exposure is also associated with a range of nonspecific symptoms, including drowsiness, chest tightness, and shortness of breath.[103,200,202] Relatively low formaldehyde concentrations are associated with increased risk of asthma and chronic bronchitis in children.[200,211,212] Formaldehyde also increases sensitivity to allergens in asthmatics, even at the WHO-recommended maximum, 30-minute average concentration.[203,204] Acute formaldehyde poisoning at higher doses is associated with severe symptoms, including fever, vomiting, abdominal pain, and in extreme circumstances, death.[205]

Chronic formaldehyde exposure is an issue of concern as well, as effects have been found to increase over time. In addition to increasing cancer risk, chronic exposure to formaldehyde results in a multitude of symptoms, including reduced lung function, tremors, and damage to the nasal passages.[205,211,213–219] The relationship between chronic formaldehyde exposure and poor respiratory health may be particularly important for children.[250] Additionally, chronic formaldehyde exposure has neurotoxic effects, causing symptoms such as headaches, sleep disorders, and memory loss.[202,205] Formaldehyde is also a reproductive and developmental toxicant associated with birth defects, low birth weights, and spontaneous abortion.[205,213,218,220]

While exposure to formaldehyde can result in life-threatening, adverse health conditions, it remains unclear whether formaldehyde is a significant concern related to gas appliance use. Since formaldehyde is a known carcinogen, this topic demands further research.

2.2.5. ASSUMPTIONS AND LIMITATIONS

Due to the limited scope of this project, we did not conduct any primary data collection; we only analyzed existing literature and datasets. While we used as many relevant data sources as we could access, data paucity was a major limitation for this report. Particularly for conducting future quantitative analyses with regard to equity, the development of additional, publicly available databases to include more detailed and higher spatial resolution data would be a significant asset.

There are other factors associated with exposure that we were unable to control for, including the location of appliances throughout the home (water heaters and home heating devices), and seasonality (which affects ventilation, as well as the ambient pollutant concentrations used in the indoor air model).[29,47] There were also challenges associated with determining a standard residence volume and ventilation rate for each residence type, so these values are based on estimates from primary literature, and public data and reports.

Details on our calculations of volumes and ventilation rates are included in Appendix A. We also did not assess any exposures or other dangers associated with electrification, as we focus on combustion pollutants in this report.

There are also limitations associated with the use of an indoor air quality model. This model assumes the pollutant of interest reaches a steady state, which is more appropriate for emissions occurring over a consistent period, not for analyzing short-term emissions. Our analyses also operated under various assumptions about the time spent using kitchen appliances. We approximated applicable time periods, but we also wanted to provide varying assessments considering different amounts of time using the appliances, so that readers of this report can gain a better understanding of the implications of their own appliance-use habits. Additionally, as mentioned previously, the 1-hour (acute) thresholds compared to our peak kitchen pollutant concentrations only apply to exposures under a scenario where air quality levels remain elevated for an entire hour.

Finally, there are indoor air quality issues associated with the use of gas cooking appliances that will remain despite the implementation of electrification, and we do not account for this. Some PM emissions are associated with cooking oils and foods, and there are no mitigation methods for this, other than the use of ventilation devices such as range hoods. We do not claim that the transition to electric appliances would make a substantial difference in terms of emissions from cooking oils and food.

This report does not compare the benefits and costs of electrification versus improving range hood use and efficiency in terms of reducing indoor air pollution. This is an important consideration that needs to be included in any full-scale assessment of indoor air pollution mitigation techniques. We touched briefly upon range hoods in Section 2.1.3.

3 OUTDOOR AIR QUALITY AND HEALTH EFFECTS

Section 2 discussed the indoor air quality issues and resulting health effects associated with the use of residential gas appliances. This portion of the report covers an equally relevant realm: how the use of these appliances affects outdoor (ambient) air quality, the extent to which residential building electrification would reduce ambient exposures to the pollutants of concern, and the resulting premature mortality and morbidity reductions throughout the state. Section 3.1 provides background information from a literature review, and Section 3.2 contains the results and discussion. The objectives of this section are to:

- quantify the total emissions of CO, NO_2, and NO_X due to gas appliances across California;
- model changes in ambient $PM_{2.5}$ due to reduced emissions of NO_X and $PM_{2.5}$ from a hypothetical, residential building electrification scenario; and
- estimate the potential reduction in mortality associated with the modeled scenario.

In the results and discussion portion of this outdoor air quality section of the report, as described in these objectives, we included various quantitative assessments of four pollutants: CO, NO_2, NO_X, and $PM_{2.5}$. In Section 3.2.1, we assessed the total emissions of CO, NO_2, and NO_X based on our EFs calculated in Section 2. In Sections 3.2.2 and 3.2.3, we considered only two pollutants: NO_X and $PM_{2.5}$. We first estimated reductions in secondary $PM_{2.5}$ levels due to a calculated reduction in NO_X and resulting nitrate $PM_{2.5}$. We then incorporated CARB data on $PM_{2.5}$ emissions from residential gas appliances to estimate the total reduction in $PM_{2.5}$ from the replacement of gas appliances, representing changes in primary and secondary (nitrate) $PM_{2.5}$ from gas use. We then assessed health impacts from reductions in those estimated ambient $PM_{2.5}$ levels. This is described in detail in Appendix A.

3.1. BACKGROUND

In this literature review section, we discuss the following relevant topics:

- current electrification research as it relates to criteria air pollutants, and related policy and implications of electrification more generally (3.1.1);
- the relationship between gas appliances and outdoor air quality (3.1.2);
- resulting outdoor air quality, health, and environmental justice implications (3.1.3); and
- the identified knowledge gap we aim to fill (3.1.4).

3.1.1. CALIFORNIA'S ELECTRICITY LANDSCAPE

Electricity and criteria air pollutant emissions

Residential building electrification has multiple potential co-benefits, spanning the domains of air quality, health, and climate change mitigation.[251,252] Reducing air pollutant emissions through electrification would improve air quality and promote public health while also limiting production of GHGs. The coupling of electrification with decarbonizing electricity generation represents an ideal scenario, producing these associated co-benefits. Of course, even without complete, wide-scale decarbonization of electricity generation, decreasing the carbon-generating proportion of the power mix will be conducive to climate change mitigation.[253]

There are several existing research studies on air quality and health co-benefits from electrification.[254–256] A recent modeling study predicted that achieving the California Executive Order S-3-05 target of reducing GHG emissions to 80% below 1990 levels by 2050 through a focus on electrification would result in significant public health benefits.[256] A comprehensive decarbonization approach, prioritizing electrification and clean, renewable energy sources, with 85% electrification in commercial and residential sectors, would reduce 2050 emissions of NO_X by 34% and $PM_{2.5}$ by 33%.[256] Furthermore, the pollutant reductions would result in the avoidance of an estimated 12,100 premature deaths annually by 2050, due to changes in ambient ozone and $PM_{2.5}$, with a monetized estimated value of $109 billion.[256] This particular scenario, focused on the implementation of clean, renewable energy and high levels of electrification, had significantly more health co-benefits than a scenario focused on combustible, "renewable" fuels. Similarly, a study modeling the air quality impact of Assembly Bill (AB) 32[257] (The Global Warming Solutions Act of 2006, which facilitated the enactment of the Cap-and-Trade Program), predicted cumulative emissions reductions of approximately 15% for NO_X and 1% for $PM_{2.5}$ throughout California.[254] Air quality improvements due to AB 32 were predicted to avoid approximately 880 premature deaths per year by 2030, with an estimated monetized value of $5.4 billion.[254] Another California-focused study on reaching the 2050 GHG emissions targets predicted air-pollution-associated premature mortality reductions of up to 2,760 deaths per year by 2050, with an estimated monetized value of up to $20 billion annually.[255]

A 2018 CEC report investigating future decarbonization scenarios reported high levels of building electrification to be an effective, relatively low-risk, and low-cost GHG mitigation strategy as compared to other mitigation measures, and a key factor in reducing gas consumption.[7] On a related project in 2019 for the CEC, the E3 group and the Advanced Power & Energy Program at University of California, Irvine (UCI) evaluated the air quality and health effects of electrification; they evaluated multiple scenarios to reduce GHG emissions from 1990 levels by 80% by the year 2050, including a high building-electrification scenario, and a no building-electrification scenario.[258] Similar to the CEC report, they also found that building electrification has the potential to be low risk and low cost, in this case compared to the

widespread use of renewable gas.[258] One portion of this project involved using the U.S. EPA's Benefits Mapping and Analysis tool (BenMAP) to conduct a health-impact analysis for a high building-electrification scenario. Building electrification was projected to result in lower $PM_{2.5}$ concentrations, particularly in winter, and the BenMAP analysis reported health savings of approximately $200 million over 10-day episodes in summer and winter, due to mitigation of ozone and $PM_{2.5}$ from the high building-electrification scenario.[258] Reductions in secondary $PM_{2.5}$ formation from lower NO_x emissions from gas appliances were found to have a major impact on health savings.[258] The building-electrification scenarios modeled by UCI indicate substantial co-benefits to air quality and human health as a result of reductions in NO_x, $PM_{2.5}$, and ozone. However, these scenarios were designed to reduce GHG emissions rather than target criteria pollutant reductions.[258]

EPRI prepared a 2019 report, commissioned by the CEC, investigating the air quality implications of electrification in California across multiple sectors.[15] It estimated that electrification would result in substantial reductions of $PM_{2.5}$ and ozone across California, with monetized health benefits estimated to be $108 billion per year in 2050.[15] It also found that electrification of residential and commercial stationary sources resulted in the majority of $PM_{2.5}$ reductions (61%), with significant impacts from the reduction of residential wood combustion.[15]

One aspect to keep in mind throughout this analysis, which will be mentioned again in the Results and Discussion section, is that electricity generation at gas power plants emits both GHGs and criteria air pollutants. Even if all residential gas appliances were transitioned to electric appliances, the electricity required to power these appliances must still be generated by some form of fuel, and gas power plants currently produce almost half of the electricity generation in the state. Therefore, in order to avoid increased emissions from gas power plants, building electrification must be based on the preface that the electric power system will continue to decarbonize and shift to clean energy. As California increasingly builds and relies upon zero-carbon electricity sources such as wind and solar energy, which is state-mandated by the 100% Clean Energy Act of 2018, or SB 100, the overall GHG and air quality benefits of electrification will increase (This law enacted the Renewables Portfolio Standard (RPS), which mandates that 100% of electricity sold must be generated from zero-carbon energy sources by 2045[259]. This is discussed further in Section 3.2.2.

Overall, GHG emissions reductions and in particular, electrification, offer immense co-benefits with regard to air quality, health, and economic value, with the largest benefits predicted in densely populated, metropolitan areas.[7,15,254–256]

Building electrification in California: policy and economic implications

California is a national leader in clean energy and climate policy. Though local emissions of criteria pollutants are a byproduct of combustion processes (the focus of this report), there is a substantial body of research on the relationships between energy sources and climate change mitigation,[3,42,251,260–262] and climate change mitigation continues to be a main driver of policy that affects electrification status throughout the state. Together, SB 32 (which extends AB 32), SB 100, California's B-55-18 Executive Order to achieve carbon neutrality by 2045, and other forthcoming bills provide a strong legislative framework for mitigating climate change, with aggressive targets for reducing GHG emissions.[257,263] Research has identified wide-scale electrification of multiple energy-consumption sectors, including residential buildings, as an important requisite for achieving California's GHG emissions goals; [4,7,8] this transition will require policy support.[264]

Unlike the national landscape, where approximately 25% of all homes in the United States are all-electric,[265] roughly 90% of California's homes consume gas for various fueling purposes. The majority of California homes use gas for heating and cooking: Recent AHS surveys estimated that 64% of California homes used gas as their primary heating fuel, and that 67% of homes used gas as their primary cooking fuel.[2] One example of a scenario with high rates of building electrification, as described in the recent report by E3, finds that more than 7 million existing California residences will need to be retrofitted with electric technologies.[4] A different report posed another scenario showing that if gas were entirely phased out at an accelerated pace, there would be more than 13 million residential buildings in California retrofitted by 2045.[266]

In July 2019, Berkeley became the first city in California to introduce legislation to phase out the use of gas piping in new buildings, with limited exceptions.[267] Since then, roughly 30 cities and counties have adopted ordinances supporting or requiring the construction of all-electric buildings.[268]

A study modeling the impact of future building electrification found that all-electric homes performed better than mixed-fuel buildings, in terms of both GHG emissions reductions and abatement costs associated with the construction of buildings compliant with the Title 24 California Building Standards.[269] In particular, the electrification of space and water heating appliances presents an opportunity for substantial GHG emissions reductions, which aligns with our results from Section 2 regarding criteria pollutant emissions.[260,270,271]

Additionally, a recent study investigating the consequences of residential building electrification in California predicted several load-distribution effects to the electrical grid.[4] Building electrification would result in more efficient utilization of the power grid as characterized by an improved load factor, which is the ratio of average- to peak- electricity demand. The report forecasted changes in seasonal electricity demand, with higher overall winter electricity loads and slightly lower peak summer electricity loads.

Transitioning to electric heat pumps would provide effective heating and cooling in buildings, and the recent maturation of heat pump technologies has been identified as an efficient and beneficial component of future electrification.[4,272,273] This is all particularly relevant as California temperatures are rising. Projected increases in the intensity, frequency, and duration of heat waves[274] could result in higher air conditioning adoption, increased cooling demands, and decreased heating demands.

There are several economic considerations related to a transition from gas to electricity. Fugitive CH_4 emissions produced when gas appliances are not operating (e.g., emissions from pipe leaks) are estimated to incur an economic cost to consumers of approximately $30 million annually.[3] Research has also found that building all-electric reduces construction costs considerably, and lowers energy bills overall.[275] One research group projected consumer energy bill savings for a range of appliances, and found that despite higher capital costs in certain scenarios, the majority of households will have both bill and life-cycle savings as a result of building electrification.[4] However, one consideration identified by a recent report is that as demand for gas falls, cost for gas customers increases significantly.[258] In a wide-scale electrification scenario, this may result in low-income gas consumers requiring rate protection or financial assistance for transition. This report also predicted higher utility bills for mixed-fuel homes than for all-electric homes after year 2030.[258] This may have multifaceted effects that constitute equity concerns; higher utility bills for gas-using homes will further encourage electrification, but low-income consumers who rent their homes and do not own their gas appliances, or are unable to afford purchasing electric appliances, may bear a disproportionate burden of transition costs. One report addressed other barriers to residential electrification throughout the state, highlighting that, despite the fact that all-electric homes have lower maintenance costs (and other considerable benefits, including no direct emissions), the up-front costs of purchasing high-efficiency, electric appliances are higher.[15] Savings were highest for homes with the greatest heating and cooling demands, such as larger SFHs.

Policy intervention providing incentives for replacing gas appliances with electric appliances may make the transition to electrification in California more equitable. For example, tariffs for all-electric homes offer lower rates for electricity to offset their higher electricity consumption.[276] Financing programs providing low- or no-interest loans for electric appliances could provide a means for making electrification economically feasible, especially in disadvantaged communities.[276]

3.1.2. RESIDENTIAL GAS APPLIANCES AND OUTDOOR AIR QUALITY

Relationship between indoor and outdoor air quality

While much of scientific literature focuses on the transport of outdoor pollutants into indoor environments, emissions from residential gas appliances also transport outdoors, through the ventilation system or through open windows and other pathways.[277] The relationship between indoor and outdoor air can be characterized by the indoor/outdoor (I/O) ratio. The I/O ratio is influenced by factors such as natural and mechanical ventilation and the tightness of the building envelope: Generally, closed windows lead to low I/O ratios, while well-ventilated environments have higher I/O ratios.[277]

Pollutant chemistry

Atmospheric chemistry is important when considering certain criteria pollutants. NO_X is heavily involved in the formation of ground-level ozone.[278] Ozone is a secondary pollutant produced by a complex chemical reaction between NO_X, VOCs, and sunlight.[278] Ozone is a risk factor for all-cause, cardiovascular, and respiratory mortality,[279,280] and the global burden of ozone exposure is estimated at almost half a million deaths per year,[281] although a recent study estimates that this number could actually be as high as 1.2 million.[282] Contributions to ozone associated with NO_X emissions from gas appliance use are outside the scope of this study.

3.1.3. WHY THIS ISSUE MATTERS: OUTDOOR AIR QUALITY, HEALTH, BUILDING ELECTRIFICATION, AND ENVIRONMENTAL JUSTICE

In Section 2, this report discussed indoor air quality effects from the use of gas appliances in residences;

however, air pollution from residential gas combustion affects outdoor air quality as well. The relationship between outdoor air quality and public health is an important equity issue that merits greater public awareness and policy development. As introduced in Section 2.1.4, low-income communities and communities of color often have poor air quality and are burdened with associated negative health effects. More than 40% of all fossil-fuel power plants in California are disproportionately concentrated near disadvantaged communities, including in the San Francisco East Bay, the Sacramento area, Bakersfield, and the Los Angeles South Bay.[283] Furthermore, data from the exposure mapping tool CalEnviroScreen demonstrate that the most socially vulnerable communities, such as those with high poverty, unemployment, and poor health status, also suffer the highest cumulative burden of pollution exposure.[283,284] These communities often have less access to healthcare and may only seek out medical professionals when in dire need, further exacerbating the mortality and morbidity effects experienced due to increased pollutant exposure.[15]

Apart from these important considerations regarding outdoor air quality, health, and environmental justice as they relate to gas appliances and electrification, there are numerous other equity considerations related to the potential transition to electrification. These equity considerations are not a focus of this report but must not be overlooked.

The University of Southern California (USC) Program for Environmental and Regional Equity (PERE) prepared a 2019 report for the Climate Equity Network offering guiding principles for a just and equitable transition to a low-carbon future.[283] The report drew attention to the need to protect and prioritize disadvantaged communities throughout the process of alleviating the effects of climate change. EPRI's electrification report (discussed previously) also highlights equity considerations.[15] EPRI conducted interviews and hosted stakeholder meetings with environmental justice groups to discuss the results of their electrification analysis, receiving input from the communities affected.[15] Beyond simply acknowledging injustices of the past, both the USC PERE and EPRI emphasize the need for disadvantaged communities to play a role in the transition to electrification and renewable energy, stating that these marginalized populations should be included in the decision-making process as a means of advancing equity.[15,283]

A 2019 Greenlining Institute report focused on equitable building electrification, developing a five-step framework for California to ensure that environmental and social justice communities are at the forefront of this transition.[285] The steps outlined in this report include working closely with communities to identify needs and make community-driven decisions, identifying methods and metrics for data tracking, ensuring allocation of necessary funding, and successfully influencing outcomes.[285] As mentioned previously, policy intervention, such as providing incentives for replacing gas appliances with electric appliances, can help make the transition to electrification in California more equitable.[276] While there are existing low-income

energy programs throughout the state, Greenlining's report identifies that there are significant distributive justice shortcomings in terms of benefit allocation; for several reasons outlined in more detail in their report, program benefits are not maximized for households in need.[285] These reports and many others have highlighted the importance of equity in decision-making regarding California's energy future.

3.1.4. KNOWLEDGE GAP AND CONTRIBUTIONS TO THE LITERATURE

Our study contributes to a growing body of recent research on the potential impact of expanding electrification throughout the state. Large-scale research projects modeling the future of electrification in California have considered the impact across economic sectors.[15,254–256] These studies reported significant reductions in criteria air pollutant emissions, and associated health and monetary benefits, in addition to reduced GHG emissions. Our approach is novel in that it isolates the emissions and health effects of gas appliances in the residential sector, providing estimates of criteria pollutant emissions and their resulting effects on outdoor air quality and health.

Our focus on the emissions associated with residential gas appliances may serve as a benchmark to be used by future models of a potential switch to electrification. This report offers a quantitative approximation of the contribution of residential gas appliances to overall air pollutant levels in California. We anticipate that this analysis will contribute to a more developed understanding of how residential activity impacts air quality on a larger, statewide scale.

3.2. RESULTS AND DISCUSSION

3.2.1. CONTRIBUTION OF GAS APPLIANCES TO OUTDOOR AIR POLLUTION IN CALIFORNIA

Total emissions of pollutants from gas appliances throughout the state

Using our calculated EFs and CEC data on gas consumption, we estimated total annual emissions of NO_X (which includes NO_2) and CO for 2018 (See Appendix A, Section A.2.1 for additional details). We found that residential gas appliances emitted approximately 15,900 tons of NO_X (with a confidence interval of 15,500 to 16,300) and 12,000 tons of CO (with a confidence interval of 10,800 to 13,100) in 2018. In comparison, CARB's annual estimates for residential gas appliance use were approximately 16,000 tons for NO_X and 9,000 tons for CO for 2018. There is no specific estimate for NO_2 provided by CARB for comparison here, but we do present NO_2 results separately in Figures 3-1 and 3-2. Since the numbers are similar in magnitude, indicating consistency between our estimates and CARB's estimates, we chose to extract $PM_{2.5}$ gas combustion emission estimates from CARB, and use them for the remainder of the outdoor air quality and health analysis in this section to develop more comprehensive estimates for total pollutant reductions and mortality impacts. This is discussed in Appendix A in more detail. Figure B-4 in Appendix B depicts total emissions of the three studied pollutants by county from gas appliance use, calculated using the EFs reported in Section 2.

This report's findings indicate that emissions from residential gas appliances account for approximately 3% of total NO_X emissions in California (Figure B-5 in

Figure 3-1: Estimated state-wide emissions of pollutants (a) CO, (b) NO_2, and (c) NO_X by gas appliance type.

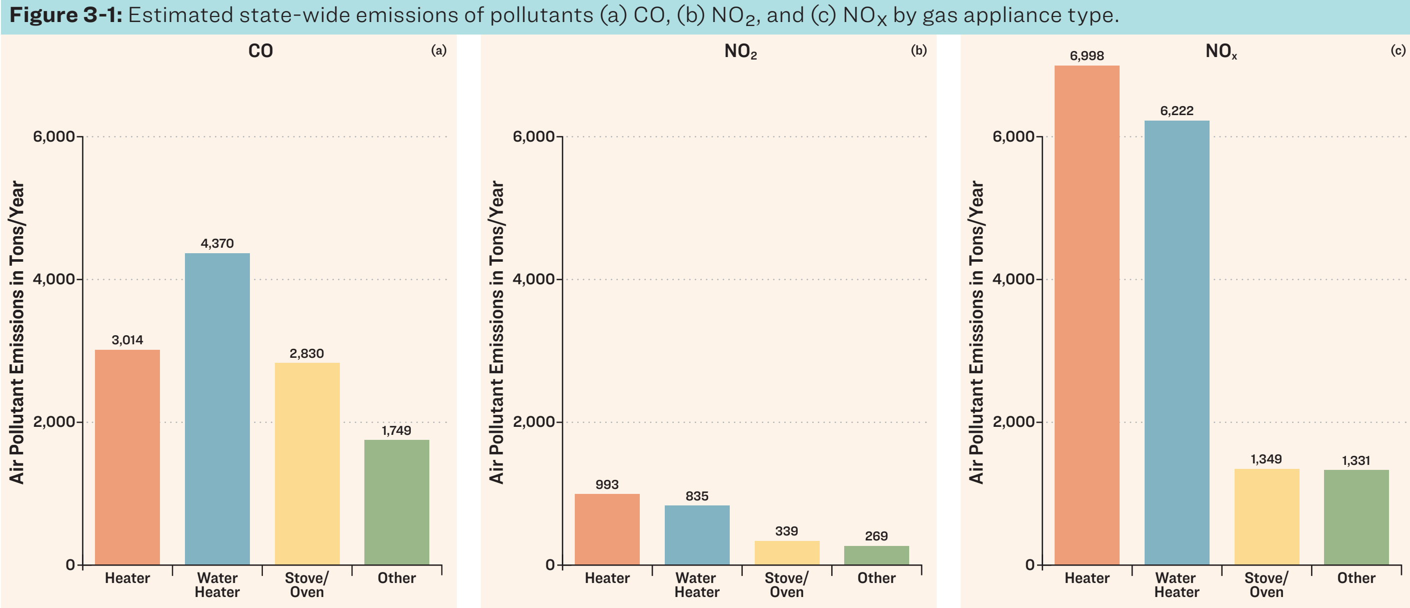
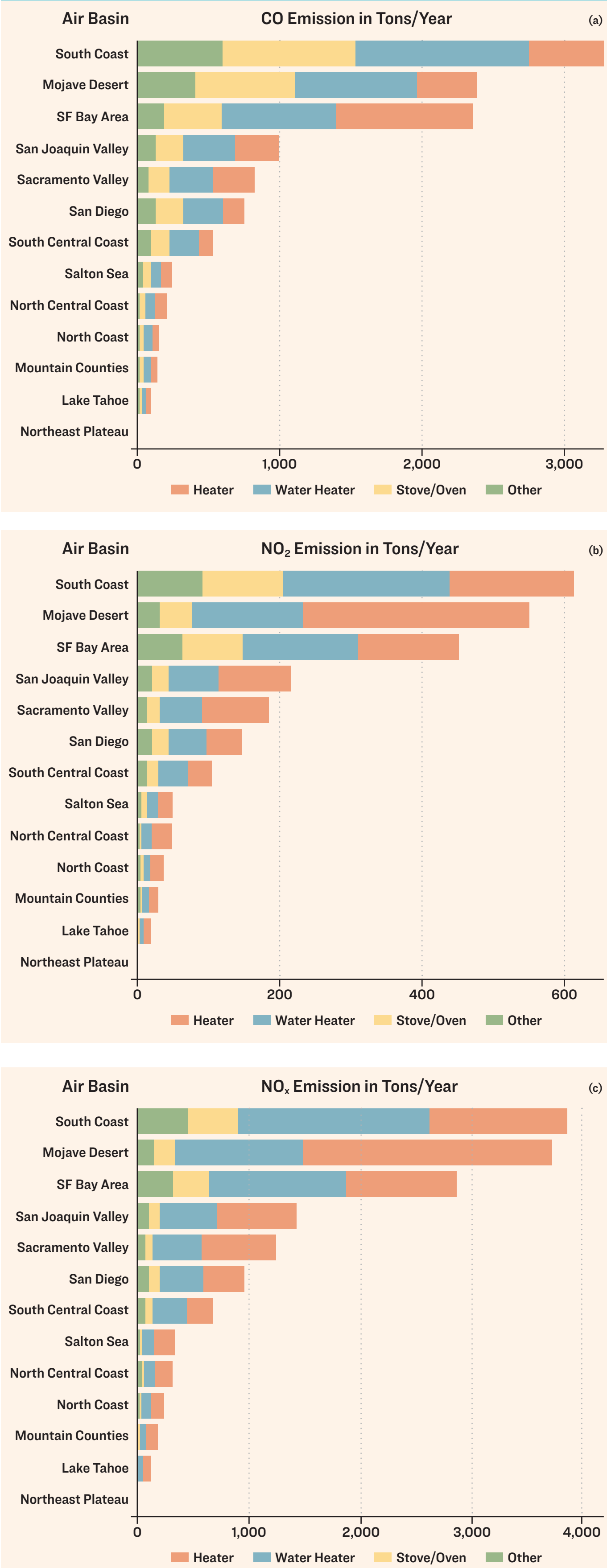


Figure 3-2: Estimated emissions of (a) CO, (b) NO_2, and (c) NO_X in air basins from gas appliances by type.



Appendix B shows NO_X emissions from gas appliances by county, as compared to NO_X emissions from all sources).[73] Among all counties in California, Los Angeles County has the highest total NO_X emissions, as well as the highest NO_X emissions from gas appliances (3,900 tons/year). As of 2019, 34 million Californians live in counties that are not in compliance with state or federal ambient air quality standards for ozone and/or $PM_{2.5}$.[286] Considering NO_X contributes to ambient $PM_{2.5}$, gas appliances have the potential to add to this pollution burden.

Comparison of emissions from various types of appliances

Our analysis indicates that gas water heaters and home heating devices, such as furnaces, are responsible for the bulk of outdoor air pollution from gas appliances. Gas water heaters contribute the most to CO emissions (36.5% of all CO emissions come from residential gas appliances) when compared with other types of gas appliances, while gas heating appliances emitted the most NO_X (44% of all NO_X emissions from residential gas appliances) in California for 2018 (Figure 3-1). This is associated with the relative EFs in ng/J of each pollutant for each appliance type, as well as the percent distribution of use of these appliances, extracted from the Residential Appliance Saturation Study (RASS).[287]

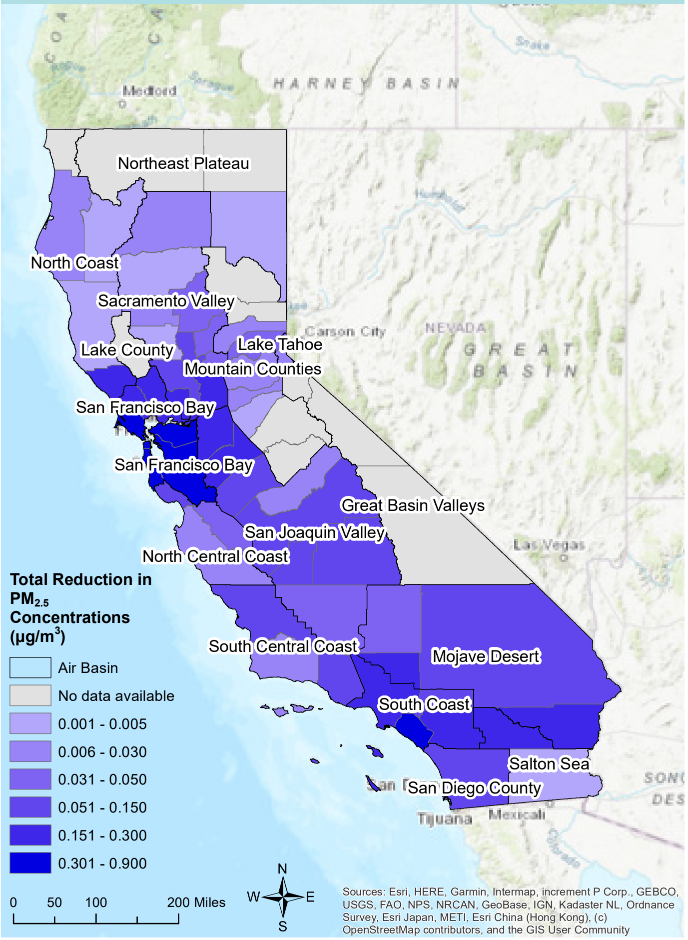
This section also shows the estimated apportionment of emissions for each gas appliance type by air basin, as depicted in Figure 3-2. Variations by air basin result from different usage profiles for the climate zones designated in the RASS (see Appendix A, Section A.2.1 for details). The two air basins not included in this figure (Great Basin Valleys and Lake County) did not have any available gas consumption data.

Moving forward, this report only discusses NO_X, as ambient CO is not used in the health-impact calculations and NO_2 is a component of NO_X. As described previously, we assess the contribution of NO_X to $PM_{2.5}$ using our calculated EFs. We also assess the independent contribution from $PM_{2.5}$ emissions from residential fuel combustion to ambient $PM_{2.5}$, using data extracted from a CARB database. We did not develop EFs for $PM_{2.5}$ in Section 2 due to data paucity.

3.2.2. EMISSION REDUCTION DUE TO RESIDENTIAL BUILDING ELECTRIFICATION

We simulated an electrification scenario in which 100% of gas appliances were replaced with clean-energy electric appliances, under the assumption that all emissions described in Section 3.2.1 are eliminated. As mentioned in the beginning of Section 3, we first

Figure 3-3: Total reduction in ambient $PM_{2.5}$ concentrations in California from elimination of gas appliances, by county in 2018.



estimated reductions in secondary $PM_{2.5}$ levels, based on our calculated reduction in NO_X (Section 3.2.1) and resulting nitrate $PM_{2.5}$. We then incorporated CARB data on $PM_{2.5}$ emissions from residential gas appliances to estimate the total reduction in $PM_{2.5}$ from replacement of gas appliances, representing changes in primary and secondary (nitrate) $PM_{2.5}$ from gas appliance use. This scenario is described in detail in Appendix A. Overall, this scenario suggests a reduction in the ambient $PM_{2.5}$ concentration by an average of 0.11 µg/m^3 per county (see Appendix A.2.3 for details).

Appendix B shows county data for total $PM_{2.5}$ and NO_X emissions, and the estimated emission reductions with building electrification per county. Figure 3-3 shows the geographic distribution of emission reductions due to residential building electrification.

As discussed in Section 3.1.1, there are existing emissions from power plants due to electricity generation.[73] Gas accounts for approximately half of all electricity generation in California,[288] and thus, if the fuel sources of electricity generation were to remain the same, gas usage would increase (and associated emissions from power plants would increase) if the new electric load is not powered by renewable energy resources. However, utilities are making progress to ramp down electricity production from gas and deploy clean energy on the grid, in accordance with the state's zero-carbon requirements. Additionally, taking into consideration California law SB 100 — which requires all of the state's electricity to be generated by zero-carbon resources by 2045 — there will be increasingly less dependence on nonrenewable resources from power plants, and an increased clean energy portfolio that contributes to reduced emissions from power plants.[259] Our analysis does not account for any increases in gas used for electricity generation as a means of looking beyond the transition period to zero-carbon resources.

3.2.3. REDUCED MORTALITY (DEATH) AND MORBIDITY (DISEASE) DUE TO ELECTRIFICATION

In this section, we assess the human health impact from emission reductions in the ambient $PM_{2.5}$ levels due to building electrification described in Section 3.2.2. Using the U.S. EPA's BenMAP community edition tool (BenMAP-CE), we estimated all-cause mortality impacts, acute bronchitis impacts, and chronic bronchitis impacts[vi] due to the reduction in $PM_{2.5}$ from the modeled electrification scenario for the year 2018, as described in Section 3.2.2. As described in the Data and Methods section (Appendix A, Section A.2.3), we incorporated impacts from the reduction of both primary and secondary (nitrate) $PM_{2.5}$ from the conversion of NO_X to secondary $PM_{2.5}$.

For the year 2018 (as described in Section 3.2.2), the improvement in outdoor air quality from residential building electrification alone would reduce approximately 354 deaths (all-cause mortality), 304 cases of chronic bronchitis, and 596 cases of acute bronchitis in California (see Table B-5 for confidence intervals for mortality). The most affected counties are the higher-population areas, i.e., Los Angeles County and Orange County, due to the nature of the concentration-response function.

To estimate the monetized benefits of reduced all-cause mortality, we used a Value of a Statistical Life (VSL) estimation in BenMAP, which is commonly used in health impact assessment. For acute and chronic bronchitis, we used a Willingness to Pay (WTP) function, explained in more detail in Appendix A. The mortality reductions

vi. Mortality impact applies to the population aged 30-99; acute bronchitis impact applies to the population aged 8-12; and chronic bronchitis impact applies to the population aged 27-99.

result in estimated monetized benefits of almost $3.3 billion. For reductions of acute bronchitis and chronic bronchitis cases respectively, benefits were estimated at $310,000 and $150 million respectively, in 2019 dollar-values. The total estimated, monetized benefits for all health effects addressed (i.e., all-cause mortality, acute bronchitis, and chronic bronchitis) were estimated to be close to $3.5 billion dollars (see Table B-6 for confidence intervals for mortality).

A summary of all health impact and valuation results is shown in Table 3-1, and annual monetary values for the five California air basins with the highest monetary benefits are shown in Table 3-2. There are additional tables in Appendix B describing health effects and resulting monetary benefits by county and by air basin. Tables B-3 and B-4 [vii] in the appendix include an approximation of mortality and valuation results by air basin for nitrate $PM_{2.5}$ alone and all $PM_{2.5}$. For morbidity and the remainder of this discussion, this report only refers to impacts from total $PM_{2.5}$.

Table 3-1: Annual health impacts and monetized benefits from outdoor air quality improvements in a residential electrification scenario.

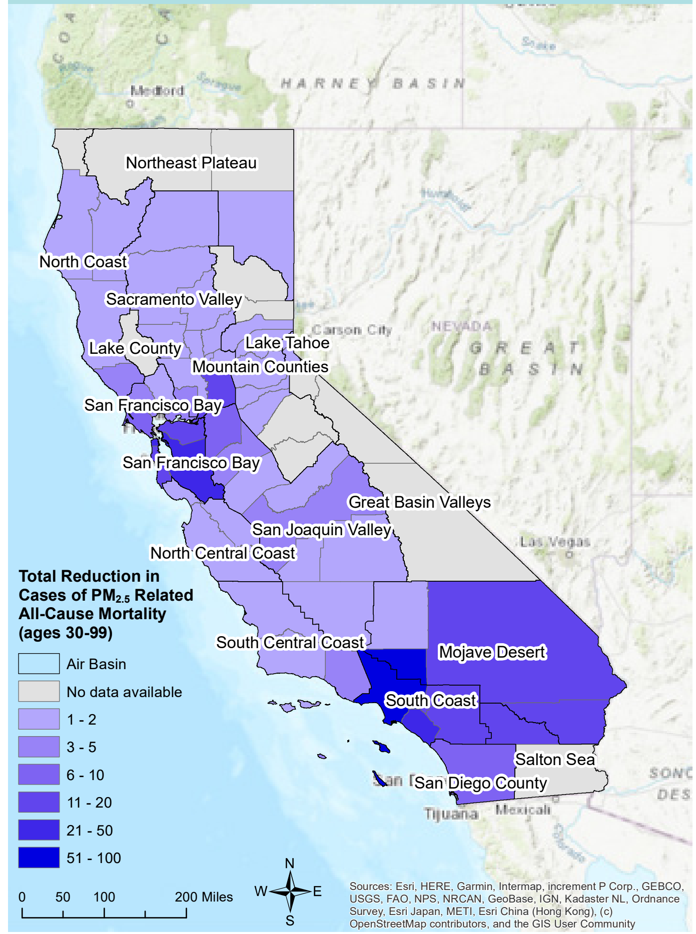
Health Impact	Avoided Mortality and Morbidity Cases (Annual)	Monetized Benefits (Annual)
All-Cause Mortality (ages 30 - 99)	354	$3.3 billion
Acute Bronchitis (children ages 8-12)	596	$0.3 million
Chronic Bronchitis (ages 27-99)	304	$150 million
Totals	—	**$3.5 billion**

Table 3-2: Estimated annual monetization of health benefits from the electrification scenario by air basin for the five air basins with the highest benefits throughout the state.[viii]

Air Basin	All $PM_{2.5}$: Mortality Valuation (Annual)	Acute Bronchitis Valuation (Annual)	Chronic Bronchitis Valuation (Annual)
San Francisco Bay Area	$1.2 billion	$100,000	$58 million
South Coast	$1.0 billion	97,000	$46 million
Mojave Desert	$0.6 billion	57,000	$26 million
Sacramento Valley	$0.2 billion	16,000	$7 million
San Joaquin Valley	$0.2 billion	18,000	$6 million

A geographic depiction of mortality reductions by county is provided in Figure 3-4.

Figure 3-4: Total reduction in annual cases of $PM_{2.5}$ related all-cause mortality by county in 2018.



We can compare our findings with other recently released reports. As previously mentioned, EPRI released an analysis for the CEC on the air quality and health impacts of a high electrification scenario in California. In their analysis, EPRI found that electrification of multiple sectors in 2050 would result in $108 billion in annual health benefits for California from reductions in $PM_{2.5}$ and ozone.[15] They also found significant, unexpected impacts from the reduction of residential wood combustion — reductions in winter $PM_{2.5}$ from wood-burning are equivalent to reductions from all other sources combined. More than half of EPRI's reported benefits would occur in the South Coast Air Basin. The analysis involved developing a reference and electrification scenario for 2050 based on emission inventories for non-road, stationary, on-road, and power-sector sources, pulled from multiple databases and models. Though there are other challenges in comparison

vii. We separated an air pollution impact of a county evenly across different air basins, in cases where the county is spread over different air basin areas.

viii. The values in this table are rounded to two significant digits. Please see Table B-4 for detailed results.

here as well, considering EPRI's analysis is for 2050 and ours is for 2018, and our analysis only incorporates $PM_{2.5}$ and residential building electrification, and is only including the effects of gas, it is reasonable to assume that our estimated benefits are a small percentage of EPRI's. Another general point of comparison is CARB's GHG inventory cited by the EPRI report, which suggests that the residential sector was responsible for approximately 6% of GHG emissions in 2017, most of which resulted from gas combustion.[289] This can be compared to our residential sector findings of 3% ($3.4 billion) of the monetized benefits EPRI estimated for high electrification of multiple sectors; however, again, our analysis only accounted for $PM_{2.5}$, and not ozone. Thus, they are even more comparable.

A Massachusetts Institute of Technology study published in early 2020 assessed premature mortality from cross-state air pollution in the U.S., accounting for $PM_{2.5}$ and ozone emissions and resulting health effects from exposure.[290] This analysis found that the residential and commercial sectors, which included residential combustion of all fuels as well as other sources (such as waste treatment), were responsible for more than 6,000 premature deaths in California in 2018.[290] Our analysis accounts for a small subset of these mortality rates. We only assess $PM_{2.5}$ and residential gas consumption in our analysis; we do not include other fuels or emission sources, as the 2020 study did. Our findings account for approximately 6% of these premature deaths attributable to the residential and commercial sectors. Another key finding from that particular study: The premature deaths caused by those two sectors is double the number caused by electric power generation processes. The authors of that study clarify that this is a direct result of significant emission reductions in electric power generation processes since 2005.[290]

We were not able to assess outdoor air quality and resulting health effects at the census tract level due to data paucity, but conducting future analyses at that spatial level would enable us to draw quantitative conclusions about the relationship between gas appliance use, electrification, and environmental justice.

3.2.4. ASSUMPTIONS AND LIMITATIONS

There are several limitations associated with the analysis presented in Section 3. Data limitations restricted the geographical scale for this analysis, as much data (e.g., on energy use) are only available at the county level and higher. The RASS data we used to estimate total emissions is from 2009, and therefore may not be entirely representative of current usage proportions of different appliances. Due to the limited scope of this project, we were not able to conduct dispersion or photochemical modeling for the distribution of $PM_{2.5}$ emissions and resulting ambient changes, and instead used a back-of-the-envelope calculation for estimating changes in $PM_{2.5}$ at the county level that would result from eliminating residential gas appliances. We also assumed all indoor emissions from gas appliances eventually traveled outdoors, which is a health-protective, conservative assessment. We also did not account for heating demand trends or seasonality in this analysis, although prior studies have separately evaluated winter and summer seasons. Considering these factors, this is a simplified analysis and should be considered a conservative approximation.

Regarding the health impact analysis, it is important to note that the BenMAP software accounts for ambient outdoor $PM_{2.5}$ changes and does not assess population time-activity patterns or personal exposures, which also significantly contribute to health effects.

Finally, there are several facets of electrification that we were unable to include in this report due to the scope of this project. There are some pollutant emissions from the use of residential electric appliances, though not to the same extent as those produced by combustion of gas appliances; we did not account for these electric appliance emissions in this analysis. This report only focuses on residential buildings and does not include an assessment of the health and monetary impacts from the electrification of commercial buildings. Also, it does not assess the costs and potential adverse impacts of residential electrification as some other reports do, such as EPRI's report (on electrification of multiple sectors), which we have discussed and cited.[15]

4 CONCLUSION

While California is a leader in clean energy and climate policy, many regions of the state have poor air quality, particularly in state-identified disadvantaged communities. As part of the state's strategy to improve air quality and public health, one area of focus can be reducing emissions from gas appliances through methods such as building electrification. This report presents the adverse health effects resulting from the residential use of gas appliances and outlines the potential benefits of transitioning residential gas appliances to all-electric appliances. These benefits are not only related to GHG emission reductions, but also are related to improving indoor and outdoor air quality, as well as subsequent health and economic effects from pollutant reductions.

The indoor air quality analysis for this report found that concentrations of CO and NO_2 during cooking events can exceed the levels set by national and California-based ambient air quality standards, occurring much more often for NO_2 than CO. Under a cooking scenario where the stove and oven are used simultaneously for an hour, acute exposures to NO_2 from cooking with gas appliances exceed the levels of national and California-based ambient air quality thresholds in more than 90% of modeled emission scenarios. Concentrations of CO and NO_2 resulting from gas cooking are the highest for apartments, due to smaller residence sizes. This presents an additional risk for renters, who are often lower income than homeowners. Considering the well-known dangers of CO poisoning, and that acute and chronic exposures to NO_2 are associated with respiratory illness and mortality, this is a serious concern that should not be overlooked. We echo other researchers in this space with the recommendation that proper ventilation technology, such as effective, low-noise range hoods, be implemented to reduce exposure and protect public health.

Regarding outdoor air quality, this report indicates that under a 2018 scenario where all residential gas appliances were transitioned to electric, the reduction of secondary nitrate $PM_{2.5}$ (from NO_X) and primary $PM_{2.5}$ would result in 354 fewer deaths, and 596 and 304 fewer cases of acute and chronic bronchitis, respectively. The reduction in associated negative health effects is equivalent to approximately $3.5 billion in monetized health benefits for just one year.

However, these health and monetary benefits will not be realized at the pace or scale needed without policymaker support. Decision-makers at state and local agencies that regulate air quality all have important roles to play in determining the best course of action for reducing pollution from gas appliances, and doing so in a way that prioritizes and protects those most burdened by air pollution — namely, low-income and environmental justice communities. Implemented strategically, new policies to reduce air pollution from residential buildings will yield significant health benefits, improve the quality of life for Californians, and reduce greenhouse gas emissions.

APPENDICES

Appendix A: Data and Methods

A.1. INDOOR AIR QUALITY & HEALTH EFFECTS (SECTION 2 IN THE REPORT)

A.1.1. EMISSION FACTOR DATABASE

We developed an EF database of CO, NO_2, and NO_X for different gas appliances, including stoves and ovens, heating devices, and water heaters. In cases where EFs were not available for some pollutants (due to data paucity and/or feasibility), such as $PM_{2.5}$, UFP, and formaldehyde, a qualitative analysis of related emissions and associated health impacts was conducted.

Aggregating appliance characteristics from online resources

First, we summarized real-world (measured) EFs of gas appliances from existing peer-reviewed or grey literature. While most previous studies reported the EF of gas appliances in a unit such as ng/J, those values do not reflect the amount of pollutants released during the consumption without accounting for the MBR in J/h of different gas appliances. Hence, we also summarized the MBR of various gas and electric appliances from approximately 15 main appliance brands using online resources, including websites for companies such as Home Depot, Lowe's, Amazon, etc. Our internet search terms to select brands and extract information included, "gas and electric ovens," "cooktops," "popular gas appliances," "range," "gas range," "electric range," "furnace," "water heater," and "fireplace." We gathered information regarding different models for each brand, including price(s), heat output in British thermal units (BTUs — which were converted to J/h), and specification characteristics.

Extracting emission rates from primary literature and determining significant explanatory variables

We acknowledge that the EF (ng/J) can be influenced by many factors, such as appliance age, location, and ventilation conditions. Thus, we collected information on these parameters in conjunction with EFs from the aforementioned literature. We performed a multiple linear regression analysis to quantify the contribution of different factors to the EFs of CO, NO_2, and NO_X, with EFs and various factors as dependent and independent variables, respectively. We ran three models using RStudio software, with emission rates of CO, NO_2, and NO_X as the outcome variable.

$$Log\ (Emission\ Factor) = \beta_0 + \beta_1\alpha + \beta_2\chi + \beta_3\delta + \beta_4\phi + \beta_5\eta + \beta_6\lambda \quad (1)$$

where, α = appliance directly vented (yes/no), χ = energy use (J/h), δ = appliance age, ϕ = appliance type, η = laboratory or residence setting, and λ = year of study.

The EFs from literature used as the outcome variable in the regression analysis, along with the associated covariates, were primarily extracted from a 2009 report produced by LBNL in California, which was ideal since it provided very detailed information on sampling methods and results.[44] Since this dataset is the most recent source and specific to our study area, this was our primary data source for the quantitative analysis. We also gathered emission rates from other papers, some of which dated to the 1970s (so, covering the last 50 years); we gathered as much data as was feasible during the timeframe. We only used data from the United States, and most data used was California-based, but we needed to use several other studies as well, to optimize the regression models. Of course, there have been technological advances that have reduced emission rates over time, and this was factored into the regression model. Appliance ages spanned from 1-20 years old. Most of the data used fit the regression line well.

Based on the results of normality tests, we log-transformed the data. We ran the model with multiple specifications, including with and without the oldest data points, and with various appliance groupings, to ensure our model was optimally fitted. The final sample sizes (emission rates with values for each covariate in the regression equation), including all appliance types, were approximately 55 for each pollutant.

The regression models all had R^2 values of ≥ 0.6 (see Figure B-1 in Appendix B), which indicates that the models fit well, and the dependent variables of pollutant EFs in ng/J are highly predictable from the data. Three supplemental figures with the regression lines, J/second distribution (prior to conversion to J/h) and predicted emission rates are included in Appendix B (Figures B-1, B-2, and B-3).

We identified factors that are significantly associated with EFs. Then, by reviewing existing literature and databases, we obtained or assigned appropriate values for those factors to better reflect the real-world scenario in California, and used bootstrapping statistics to simulate the distribution of each factor — and thus, EFs in California, accordingly, with 1000 bootstraps for each factor. This nonparametric technique involved resampling data to estimate data distributions and is widely used. The MBR values, in J/h, were gathered from online resources and converted from BTU/h. The ventilation characteristics we used for stoves and ovens were based on the general assumptions that stoves and ovens are not vented, and heating devices and water heaters are vented [44] (assumed due to existing regulations). According to California Health and Safety Code, gas-fueled, unvented space heaters cannot be sold,[76] the CEC mandates direct venting of water heaters to outside spaces,[291] and the California Mechanical Code regulates the venting of other fuel-burning devices as well (additional information on these types of regulations is provided in Section 2.1.2 of the report).[292] The age of appliances was gathered from the RASS. We calculated EFs for stoves and ovens separately, but combined them for much of this analysis under the assumption that the devices were operating at the same time and were entirely vented into the kitchen, though we do include some separate considerations for stove use only. We did not adjust for variable range hood use, due to survey results showing low rates of range hood use in California.[98] Therefore, this aspect of the analysis is more conservative.

Developing emission rate database

With available data on EFs (ng/J) and MBR (J/h), we derived a new emission rate database for NO_2, NO_X, and CO in a unit of ng/h, which we converted to µg/h, which reflects the emission rate, or the amount of pollutants released in a specific time period during the usage of different gas appliances. To validate our results, we compared our calculated emission rates to the WHO's household fuel combustion emission rate targets[293] as well as primary literature. We used Microsoft Excel to conduct the bootstrapping and initial model setup. The equations used for calculating EFs and emission rates are listed here:

$$\begin{gathered}EF\text{ (in a unit of ng/J)} = f(\alpha, \chi, \delta, \phi, \lambda) * \text{prediction uncertainty}\\ \text{Emission rate (in a unit of ng/h)} = BTU^* f(\alpha, \chi, \delta, \phi, \lambda) * \text{prediction uncertainty}\end{gathered} \tag{2}$$

where, α = appliance directly vented (yes/no), χ = energy use (J/h), δ = appliance age, ϕ = appliance type, and λ = year of study.

A.1.2. INDOOR AIR QUALITY IMPACTS AND SUSCEPTIBILITY

We estimated the impact of the gas appliances that are not vented to the outdoors (stoves and ovens) on indoor air quality using our developed EF database and a mass balance model:[122]

$$C = p\left(\frac{Q}{Q+kV}\right)C_O + \frac{S}{Q+kV} \tag{3}$$

where, V = volume of the indoor space (m^3), Q = ventilation rate (m^3/h), S = emission rate (µg/h), C_0 = outdoor concentration (µg/m^3), C = indoor concentration (µg/m^3), k = deposition rate (h^{-1}), and p = penetration factor (unitless).

We used values for deposition rate and penetration factor from recent journal articles.[47,52] For outdoor concentrations, we used average California values from the EPA's Air Data portal for 2018.[294] The methods for determining volume and ventilation rate, which varied for different housing types, are described later in this section.

For this analysis, we defined two indoor environments, one with the use of gas appliances and one without, to determine the contribution of gas appliances to indoor air pollution, the latter of which represents an electrification scenario; we assumed there were no emissions of combustion pollutants with the use of electric appliances. Under the assumption of a steady state, we calculated the increment of indoor levels of CO, NO_2, and NO_X due to gas appliance use by comparing C in models with or without emissions (S) from gas appliance usage. The elevation of pollutants' concentrations due to gas appliances was weighted by the time of their usage (e.g., time-activity patterns) over 24 hours to estimate the contribution to chronic exposures. We modeled the use of kitchen appliances under three cooking scenarios: 15 minutes, 1 hour, and 2 hours per day.[ix] These timeframes

ix. We took this approach because we believe it is valuable to compare cooking times of 15 minutes, 1 hour, and 2 hours, since one objective of this report is to help the public understand these concerns, and considering that some households may cook more or less than others, we wanted to provide this range.

were chosen based on a cooking appliance use survey indicating a total daily cooking time of around 1 hour for breakfast, lunch, dinner, and other meals, for both stoves and ovens, though we included multiple timeframes to account for a wide range of cooking patterns.[98] For CO, we also weighted the elevated concentrations over 8 hours for comparison with the national 8-hour standard of 10 mg/m^3 for both California and the EPA.[295,296] The model also produced an output with the highest concentration value, representing the emissions while cooking; we used this to establish peak concentration levels. For peak concentration levels, we used kitchen-specific volumes, and for values weighted by usage time, we used entire residence volumes under the assumption that pollutants would mix into the residential space over time.

We modeled the increments of CO, NO_2, and NO_X due to gas appliance use in three common residential building types: SFHs, apartment buildings, and townhouses. As shown in Equation (3), the relationship between C and S is dependent on other building parameters associated with indoor air quality, suggesting differential impacts of gas appliances in different building types. Therefore, we collected data on building design parameters (e.g., air exchange rate and ventilation, residence volume) by housing type in California from regulatory standards, AHS, primary literature, and various other reports on building ventilation and other factors. To estimate kitchen volume, we assumed kitchens occupied 10% of the house volume. This is near the lower end of the range found in our literature review, and hence, another conservative assumption. We used bootstrapping to simulate the distributions of the various housing parameters, and incorporated them into Equation (3) to finalize our indoor air quality estimates. These findings were simplified into three boxplots, by pollutant (Figure 2-1).

For assessing the impact these concentrations and associated exposures may have on health, we stopped evaluating NO_X separately, since NO_2 is established to be the primary health concern out of the nitrogen oxides, as well as a main combustion pollutant with established ambient air quality standards.

As noted in Section 2.2.2, we used California (CAAQS) and U.S. EPA ambient (outdoor - NAAQS) air quality standards as a metric for health effects from exposure. These standards are the maximum allowable concentration of a pollutant present in outdoor air that will not have a known, adverse impact on human health and are developed to apply to long-term, ambient outdoor air quality, averaged over time periods. It is not possible to actually exceed these outdoor standards in an indoor environment due to the technical definition. Therefore, we apply target thresholds using the standards as a guide to provide context for indoor air quality. We refer to three different types of thresholds based on the standards: 1) Acute (1-hour for NO_2 and CO), 2) 8-hour (for CO), and 3) chronic (annual mean for NO_2; there is no annual mean standard for CO). When we use the term "acute," we are referring to 1-hour standards. For CO, we refer to 8-hour standards directly as such. For NO_2, when we use the term "chronic," we are referring to the annual mean standards.

When an exceedance is referenced in this report, it means that the modeled indoor air concentration is higher than the threshold levels based on the standards in Table B-7. When we refer to the percentage of exceedances, we are discussing the percent of our modeled indoor air quality estimates that exceed thresholds. We evaluated the indoor air quality exceedances of the CAAQS and NAAQS thresholds, overall and for separate residence types, for CO and NO_2 (there are no applicable standards for NO_X).

To assess acute exposures of these two pollutants, we compared peak concentrations to acute (1-hour) CAAQS and NAAQS. This is like calculating a hazard quotient (HQ) as is done in risk assessment, which would be a ratio of the concentrations to the established standards. If the HQ is less than 1 (essentially, if the maximum concentration does not exceed the standard), adverse health impacts are not expected. We compared the peak concentrations to 1-hour CAAQS of 339 μg/m^3 (180 ppb) for NO_2 and 23 mg/m^3 (20 ppm) for CO and 1-hour NAAQS (US EPA standards) of 188 μg/m^3 (100 ppb) for NO_2 and 40 mg/m^3 (35 ppm) for CO.[295] Exceedances of the thresholds for our estimated peak concentrations (based on 1-hour standards) only apply under a scenario where cooking occurs for the entire hour and the air quality levels remain elevated.

To assess chronic exposures, we compared chronic exposure concentrations for NO_2 to the annual mean CAAQS (57 μg/m^3 or 30 ppb) and NAAQS (100 μg/m^3 or 53 ppb) as well.[295,296] For CO, we compared our 8-hour averages to the 8-hour threshold of 10 mg/m^3 (9.0 ppm) for both CAAQS and the NAAQS.[295] All acute, chronic, and 8-hour standards are listed in Table B-7. We also qualitatively discussed long-term health impacts of the pollutants (Section 2.2.4) as described in the literature, since chronic impacts are less well-established for NO_2 and CO (though the epidemiological literature on NO_2 and mortality is expanding, which we discuss in detail in the results section). More information on this is provided in Section A.1.3.

We conducted two sensitivity analyses: we estimated indoor air concentrations due to potential use of kitchen appliances for supplemental heating, and we estimated concentrations resulting from improper ventilation systems for appliances required to be vented outdoors (within the results, we discuss peak concentrations in the entire home due to the ventilation issues).

We evaluated exposure susceptibility qualitatively to the extent possible (Section 2.2.3), including equity considerations. There is insufficient data to quantitatively estimate exposure disparities in different groups. It is important to note that risk is highly dependent on exposure parameters (e.g., inhalation rate and body weight). Additionally, different populations' exposures are affected by their activity patterns as well as by the environmental concentrations of pollutants. We qualitatively discussed the exposure levels of populations with different characteristics.

A.1.3. HEALTH EFFECTS OF AIR POLLUTION

We reviewed previous human research studies focusing on pollutants that could be emitted by gas appliances. Specifically, controlled-exposure experimental and time-series epidemiologic studies were reviewed to evaluate the adverse health effects of short-term exposures, while cross-sectional studies were reviewed for long-term effects. In Section 2.2.4, we summarized potential outcomes associated with CO, NO_2, and NO_X at all levels, including those comparable to our modeled concentrations. Additionally, we summarized the current literature on the health impacts of exposure to PM and formaldehyde.

A.2. OUTDOOR AIR QUALITY & HEALTH EFFECTS (SECTION 3 IN THE REPORT)

A.2.1. CONTRIBUTION TO TOTAL EMISSIONS OF OUTDOOR AIR POLLUTANTS IN CALIFORNIA

We estimated the total emissions of outdoor air pollutants from gas appliances in California, at the county and state-wide levels. To do this, we used the EF database created in Section 2 in combination with total gas consumption (from the CEC) to calculate the total emissions of CO, NO_2, and NO_X in tons/year.[297] Since consumption patterns related to appliances vary by region (e.g., in some regions 40% of the energy may be used by water heaters, but in a different area, more energy is designated to heating devices than water heaters), we used the RASS relative appliance energy usage splits by climate zones to estimate emissions in each county by assigning counties to each climate zone. Total emissions of each pollutant by county are depicted in Figure B-4. We compared the contributions from gas appliances to NO_X emissions with other sources in California, which is shown in Figure B-5. With the data of energy consumption by different gas appliances in California,[287] we also estimated the emissions by appliance type, and the result is depicted in Figure 3-1.

It is also important to note that for this second section, we incorporated emissions from all types of appliances, while for the indoor air quality evaluation, we primarily considered emissions from appliances that are not vented to the outdoors (e.g., stoves and ovens), and also conducted a sensitivity analysis, incorporating scenarios in which venting technology for water heaters and home heating devices failed to transport all combustion pollutants outdoors. For this section, we operated under the conservative assumption that all indoor emissions are transporting outside.

A.2.2. EMISSION REDUCTION DUE TO ELECTRIFICATION

We simulated NO_X emissions (which include NO_2) under the assumption that all the energy generated by gas appliance usage is replaced by clean electricity. We modeled and evaluated an all-electrification scenario, as compared to the "business as usual" scenario with no replacement of appliances (though this scenario is unrealistic, as normal replacement rates are a part of "business as usual"). This simulates 100% replacement of gas appliances with electric appliances.

Our modeled scenario, which is for the year 2018, was based on the assumption of adoption of entirely clean electric technologies. We discussed the limitations associated with this, with consideration to the emissions from electricity generation at power plants,[298] and the reduction in EFs over time.

A.2.3. REDUCED AMBIENT $PM_{2.5}$ CONCENTRATIONS AND RESULTING MORTALITY AND MORBIDITY IMPACTS DUE TO ELECTRIFICATION

Using the same scenario listed in Section A.2.2 and the previously calculated reduction in total outdoor emissions, we estimated the potential mortality and morbidity impacts (only for acute and chronic bronchitis) in California due to residential building electrification and the resulting reduction in ambient outdoor concentrations of $PM_{2.5}$. This analysis was entirely separate from the indoor air exposure analysis in Section 2. Again, we operated under the conservative assumption that all indoor emissions are transported outdoors.

Approximately 40% of NO_X converts into nitrate-$PM_{2.5}$ after emission. Thus, we first estimated reductions in secondary $PM_{2.5}$ levels by county (later aggregated to air basin) due to reduction in NO_X and resulting nitrate $PM_{2.5}$, using methods described in a recently published paper.[299]

$$\Delta PM_{2.5\ ij} = PM_{2.5\ (ambient)ij} * \ k \ * \frac{\Delta NOx_{ij}}{NOx_{ij}} \qquad (4)$$

In Equation 4, i represents the year, j represents the area of analysis (county), and k is the conversion rate for NO_x to nitrate (0.4).[300] $\Delta NO_x ij$ is the reduction in NO_x emissions in that particular county and year, and $NO_x ij$ is the total NO_X emissions in county j in that year, extracted from CARB's State Implementation Plan Standard Emission Tool database.[73] $PM_{2.5} ij$ is the nitrate $PM_{2.5}$ level in each county, and was calculated by averaging nitrate $PM_{2.5}$ data from the US EPA Air Data portal.[294]

We did not develop EFs for primary $PM_{2.5}$ in our study, due to data paucity and uncertainty regarding how much gas combustion contributes to $PM_{2.5}$ (our literature review provided sufficient evidence of a relationship between UFPs and gas combustion, but not solely $PM_{2.5}$ in papers published in recent decades, particularly for kitchen appliances). Since we were not able to calculate EFs for $PM_{2.5}$ for reasons stated previously, we extracted CARB estimates of emissions for $PM_{2.5}$ from residential gas appliances. We used Equation 5 shown here to calculate changes in ambient $PM_{2.5}$ levels; the baseline $PM_{2.5}$ levels were extracted from the US EPA Air Data portal:

$$\Delta PM_{2.5\ ij} = PM_{2.5\ (ambient)ij} * \frac{\Delta PM2.5_{ij}}{PM2.5} \qquad (5)$$

We then summed the two changes in $PM_{2.5}$, with the final $PM_{2.5}$ increase representing both changes in primary and secondary (nitrate) $PM_{2.5}$ from gas use.

We used the EPA's BenMAP tool to estimate the mortality and morbidity (acute and chronic bronchitis) impacts for the scenario as compared to "business as usual," using the standard U.S. EPA preloaded selections when possible. BenMAP uses established concentration-response functions to quantify mortality from increased $PM_{2.5}$ pollution. Inputs included: the change in $PM_{2.5}$ calculated in Equation 5, population rates,[301] incidence rates,[302] and a β value,[156,303] which represents the health impact per unit change of pollution and is drawn from epidemiologic literature. We used California-specific input values.

Additionally, we used our BenMAP mortality and morbidity outputs to monetize the benefits of electrification. This process was done using the BenMAP software (it has VSL calculations and other specific morbidity valuation functions as well), except for chronic bronchitis, which has a functionality issue within BenMAP that we confirmed with U.S. EPA staff. We calculated valuation for chronic bronchitis manually. As stated in Section 3.2.3, we used VSL estimates for monetizing mortality benefits, which is standard in health impact assessment literature. For acute and chronic bronchitis, we used the WTP metric for valuing illness. The U.S. EPA BenMAP manual defines WTP as "the willingness of individuals to pay for a good or service, such as a reduction in the risk of illness," and it is considered conservative.[304] We adjusted all of the monetary outputs for inflation by converting them to 2019 dollars, using the Bureau of Labor Statistics' CPI Inflation Calculator.

The mortality and valuation results are presented in Tables 3-1 and 3-2 in the report, and Tables B-3 to B-6 in Appendix B.

Appendix B: Supplemental Figures and Tables

Figure B-1: Relationship between predicted and measured EFs of (a) CO, (b) NO_2, and (c) NO_X. (Blue line = correlation between predicted EFs and measured EFs.)

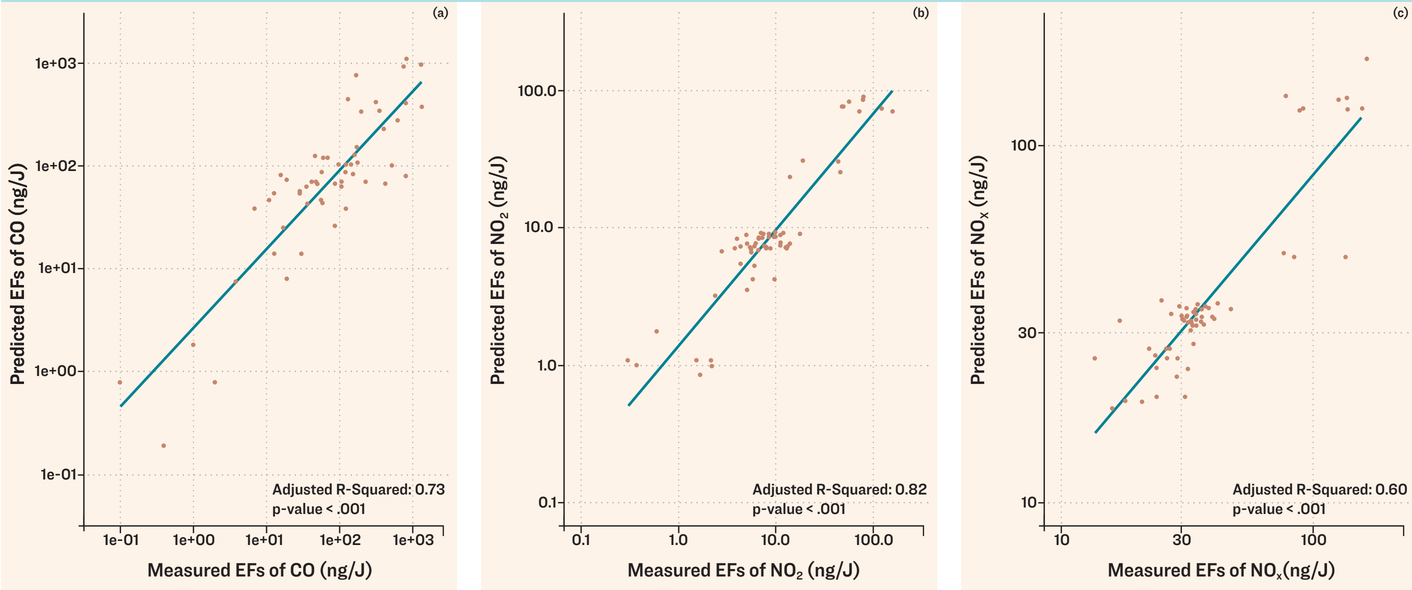


Figure B-2: Energy use histogram of (a) heating devices, (b) water heaters, (c) ovens, and (d) stoves, gathered from online resources.

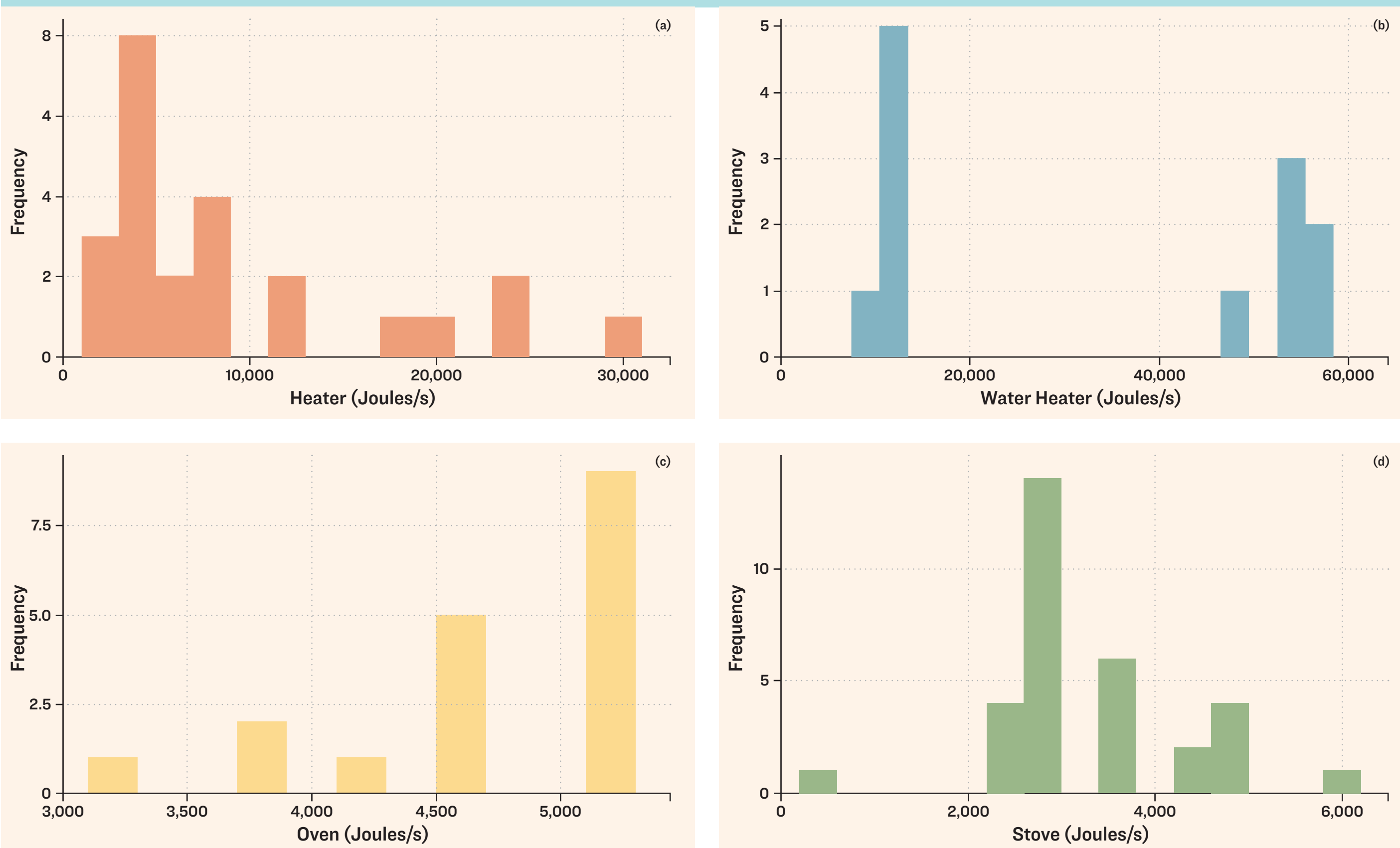


Figure B-3: Predicted emission rates of (a) CO, (b) NO_2, and (c) NO_X in μg/h for various gas appliances.

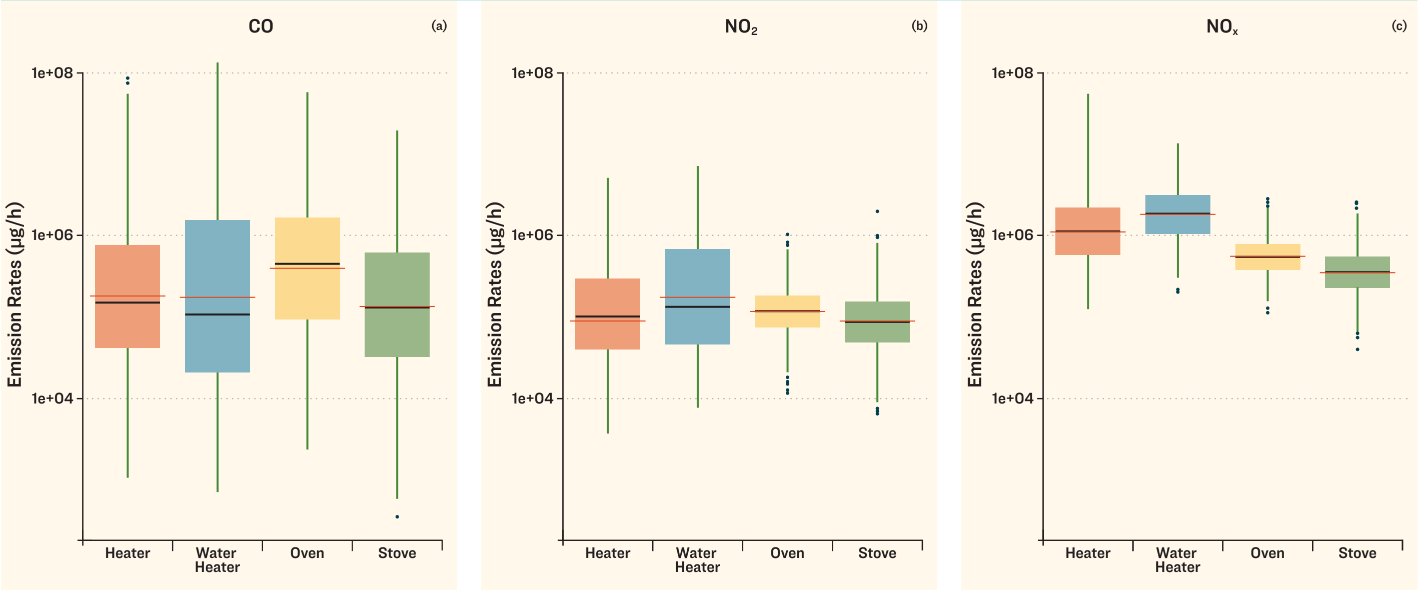


Figure B-4: Total emissions of air pollutants (a) CO, (b) NO_2, and (c) NO_x by county (gray outlines) in 2018.

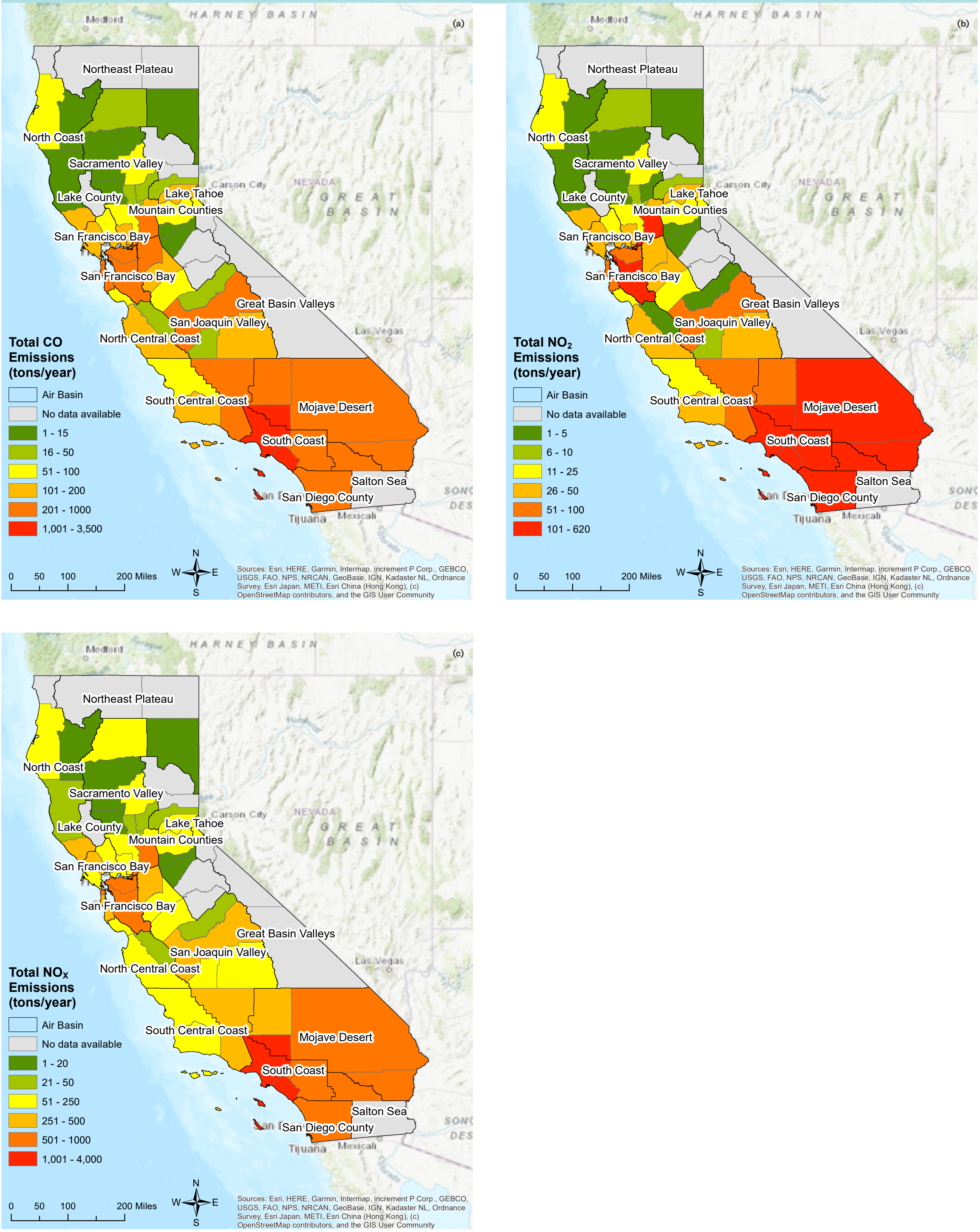


Figure B-5: NO_X emissions from residential gas appliances as compared to NO_X emissions from all sources (all California counties).

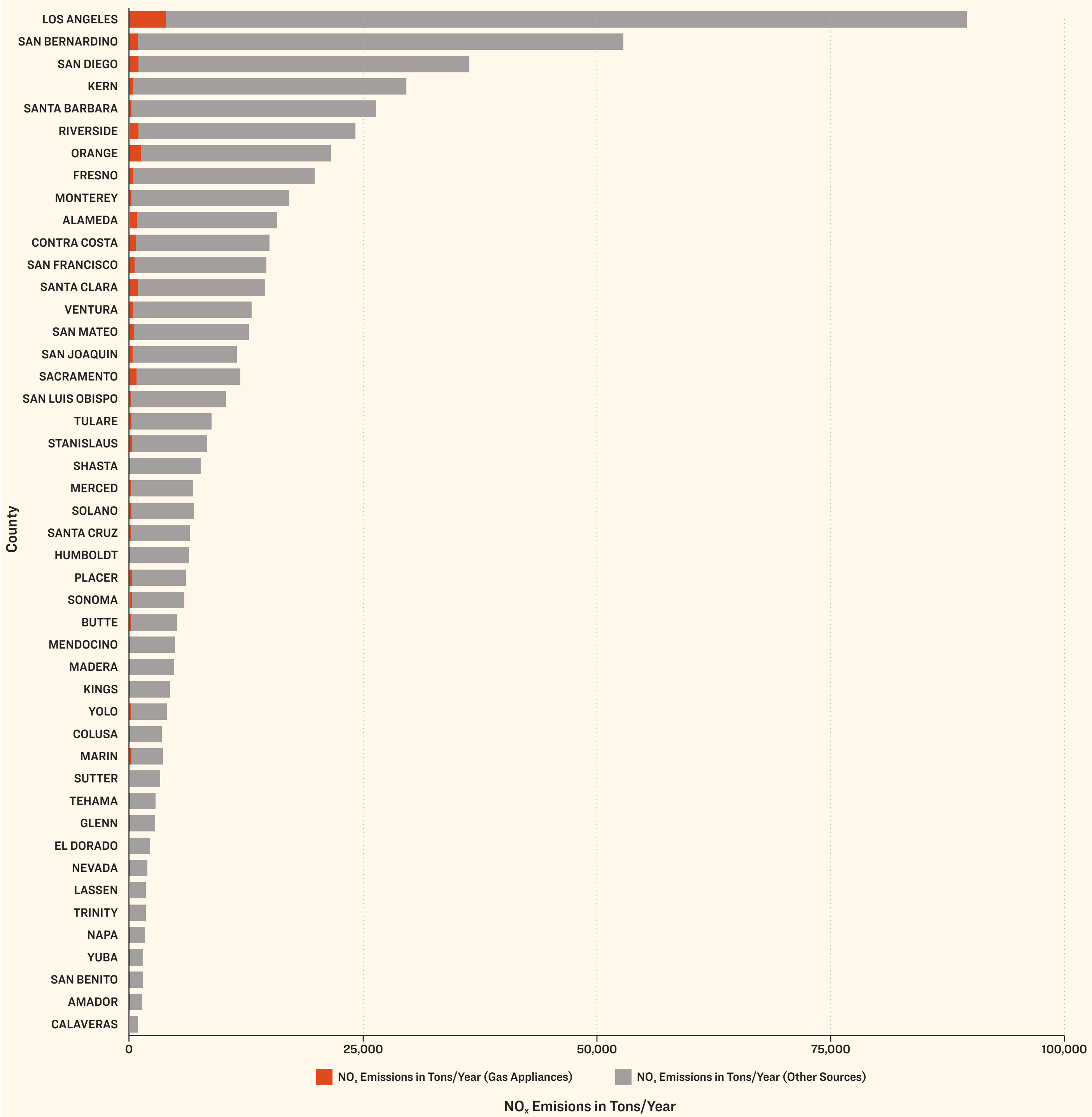


Table B-1: Pollutants other than CO, NO_2, and NO_x emitted during gas appliance use as identified in various studies and reports, and a summary of associated key findings and health outcomes.

Pollutant	Source	Description of Study	Key Findings Related to Pollutant	Example of Health Impacts of Exposure to Pollutant
Acetaldehyde	Fortmann, R., Kariher, P. & Clayton, R. 2001[27]	Assessed emissions of multiple pollutants during typical stove and oven use activities in a California home (both gas and electric ranges).	Acetaldehyde is present in air samples collected during fish broiling, oven self-cleaning, and pork roast tests. These findings, though limited, provide evidence that cooking may have a substantial effect on aldehyde levels more broadly.	Carcinogenic, sensory irritant, and affects the respiratory system.[305,306]
	Mullen, N. A., Li, J. & Singer, B. C. 2012[45]	Concentrations of CO, NO_x, NO_2, formaldehyde, and acetaldehyde were measured over 6-day periods in 155 California homes to assess associations of pollutant concentrations with natural gas appliances.	The geometric mean of acetaldehyde concentrations in both kitchens and bedrooms was 9 ppb, which was much higher than outdoor concentrations. However, acetaldehyde concentrations were not significantly affected by gas appliance use.	Carcinogenic, sensory irritant, and affects the respiratory system.[305,306]
	Mullen, N. A. et al. 2016[46]	To assess the indoor air quality impacts of gas appliance use, collected indoor and outdoor measurements of pollutants at 352 California homes with natural gas appliances, and conducted interviews with residents.	This study did not find statistically significant changes in acetaldehyde levels due to gas appliance use.	Carcinogenic, sensory irritant, and affects the respiratory system.[305,306]
	Singer, B. C. et al. 2009[44]	Measured emission rates of multiple pollutants from natural gas combustion in various types of stoves, ovens, broilers, water heaters, and furnaces. This was a large study with multiple objectives.	Acetaldehyde emission rates were low for all burners.	Carcinogenic, sensory irritant, and affects the respiratory system.[305,306]
Formaldehyde	Fortmann, R., Kariher, P. & Clayton, R. 2001[27]	Assessed emissions of multiple pollutants during typical stove and oven use activities in a California home (both gas and electric ranges).	Formaldehyde was present in air samples collected during fish broiling, oven self-cleaning, and pork roast tests. This study reported formaldehyde concentrations far above the acute Reference Exposure Level set by OEHHA during gas cooking, both with and without food. These findings, though limited, provide evidence that cooking may have a substantial effect on aldehyde levels more broadly.	Carcinogenic, sensory and respiratory irritant, causes nausea and headache.[103,200,201,206,307,308]
	Mullen, N. A., Li, J. & Singer, B. C. 2012[45]	Concentrations of CO, NO_x, NO_2, formaldehyde, and acetaldehyde were measured over 6-day periods in 155 California homes to assess associations of pollutant concentrations with natural gas appliances.	The geometric mean of formaldehyde concentrations in both kitchens and bedrooms was 15 ppb, which was much higher than outdoor concentrations. About 95% of homes had indoor formaldehyde levels above the Chronic Reference Exposure Level set by OEHHA. However, formaldehyde concentrations were not significantly affected by gas appliance use.	Carcinogenic, sensory and respiratory irritant, causes nausea and headache.[103,200,201,206,307,308]
	Mullen, N. A. et al. 2016[46]	To assess the indoor air quality impacts of gas appliance use, collected indoor and outdoor measurements of pollutants at 352 California homes with natural gas appliances, and conducted interviews with residents.	This study did not find statistically significant changes in formaldehyde levels due to gas appliance use.	Carcinogenic, sensory and respiratory irritant, causes nausea and headache.[103,200,201,206,307,308]
	Singer, B. C. et al. 2009[44]	Measured emission rates of multiple pollutants from natural gas combustion in various types of stoves, ovens, broilers, water heaters, and furnaces. This was a large study with multiple objectives.	Formaldehyde emission rates showed high variability across all burners, but were particularly low in storage water heaters and high in tankless water heaters.	Carcinogenic, sensory and respiratory irritant, causes nausea and headache.[103,200,201,206,307,308]

Table B-1: Pollutants other than CO, NO_2, and NO_x emitted during gas appliance use as identified in various studies and reports, and a summary of associated key findings and health outcomes, cont.

Pollutant	Source	Description of Study	Key Findings Related to Pollutant	Example of Health Impacts of Exposure to Pollutant
Polycyclic Aromatic Hydrocarbons (PAHs)	Fortmann, R., Kariher, P. & Clayton, R. 200[127]	Assessed emissions of multiple pollutants during typical stove and oven use activities in a California home (both gas and electric ranges).	PAHs were found in cooking oils used, though PAH air concentrations were low; the study concluded that additional research on PAHs is necessary in order to fully assess the impact of cooking on PAH concentrations.	Varies by PAH. Examples are carcinogenic and teratogenic effects, and various impacts from oxidative stress.[311,312]
	Ruiz, P. A. et al. 2010[66]	Conducted indoor and outdoor sampling of 16 homes with unvented space heaters using different energy sources (electric/central heating, compressed natural gas, liquified petroleum gas, and kerosene) in Chile.	This study found high levels of PAHs in homes with kerosene space heaters. The impacts of gas space heaters were less significant.	Varies by PAH. Examples are carcinogenic and teratogenic effects, and various impacts from oxidative stress.[311,312]
	Yu, K.-P. et al. 2015[241]	Sampled particle concentrations and PAHs in five gas cooking kitchens of non-smoking families in Taiwan and conducted a health risk assessment.	This study found that PAH concentrations were correlated with PM concentrations, and PAH cooking exposures could result in cancer risks exceeding the well-established threshold of 10^{-6}.	Varies by PAH. Examples are carcinogenic and teratogenic effects, and various impacts from oxidative stress.[311,312]
	Dutton, S. J., Hannigan, M. P. & Miller, S. L. 2001[90]	Monitored emissions of NO_2, CO, and PAHs from unvented natural gas fireplaces in two Colorado residences.	The concentrations measured here were more than an order of magnitude larger than ambient measurements in urban areas. This study highlights the need for research to assess the effects of PAH exposure further.	Varies by PAH. Examples are carcinogenic and teratogenic effects, and various impacts from oxidative stress.[312,313]
Sulfur Dioxide (SO_2)	Jones, A. P. 1999[23]	This review paper assessed indoor air quality and health.	This review identifies that indoor SO_2 concentrations can be high in homes with poorly vented gas appliances and kerosene space heaters, citing studies (before 2000) that have sampled homes with both types of appliances.	Respiratory symptoms and disease, premature mortality.[313,314]
	Triche, E. W. et al. 2005[315]	Assessed respiratory symptoms and exposures of almost 900 women who used secondary heating devices, including gas space heaters, during winter.	A 10-ppb increase in SO_2 was associated with an increase in respiratory symptoms (wheezing and chest tightness), though kerosene heaters evaluated in this study were the primary source of SO_2.	Respiratory symptoms and disease, premature mortality.[313,314]

Table B-1: Pollutants other than CO, NO_2, and NO_x emitted during gas appliance use as identified in various studies and reports, and a summary of associated key findings and health outcomes, cont.

Pollutant	Source	Description of Study	Key Findings Related to Pollutant	Example of Health Impacts of Exposure to Pollutant
Ultrafine Particles (UFP)/Particle Number (PN)	Dennekamp, M. et al. 2001[28]	Measured UFP and nitrogen oxide emissions from gas and electric stoves and ovens in a laboratory chamber with no ventilation.	Gas combustion alone and with boiling water produced UFP in a peak size range of 15-40 nm. Electric stove coils also generate UFP. The authors suggested that cooking in kitchens with inadequate ventilation could produce toxic particle number concentrations.	Respiratory impacts, cardiovascular disease, various impacts from oxidative stress, neurological impacts.[199,316–318]
	Minutolo, P. et al. 2008[319]	Measured UFP emissions from 3 heater burners and 1 stove burner in an experimental chamber.	UFP in the size range of 1 nm-10 nm formed under all examined conditions, but at very low mass concentrations. Larger UFP (soot particles) are not formed under the conditions studied. A larger amount of particles were ultimately emitted from the stove top burner than heater burners.	Respiratory impacts, cardiovascular disease, various impacts from oxidative stress, neurological impacts.[199,316–318]
	Ruiz, P. A. et al. 2010[66]	Conducted indoor and outdoor sampling of 16 homes with unvented space heaters using different energy sources (electric/central heating, compressed natural gas, liquified petroleum gas, and kerosene) in Chile.	Found higher levels of UFP in homes with combustion heaters (including gas heaters) than in homes with electric heaters or central heating.	Respiratory impacts, cardiovascular disease, various impacts from oxidative stress, neurological impacts.[199,316–318]
	Wallace, L., Wang, F., Howard-Reed, C. & Persily, A. 2008[320]	Measured UFP emissions of a gas stove, electric stove, and electric toaster oven in a test house. 150 tests were conducted.	Found larger particle number concentrations than reported in previous studies assessing larger particles >10 nm, with the highest concentrations occurring at a 5 nm particle size. The study concludes that gas and electric stoves produce these small particles in significant quantities.	Respiratory impacts, cardiovascular disease, various impacts from oxidative stress, neurological impacts.[199,316–318]
	Zhang, Q., Gangupomu, R. H., Ramirez, D. & Zhu, Y. 2010[57]	Measured UFP, $PM_{2.5}$, and black carbon concentrations from cooking in residences.	Cooking increased UFP concentrations in the kitchen significantly. This study found that the highest UFP concentrations occurred when gas stoves were turned on high and range hoods were not on.	Respiratory impacts, cardiovascular disease, various impacts from oxidative stress, neurological impacts.[199,316–318]
Other Volatile Organic Compounds (VOCs)	Stocco, C. et al. 2008[323]	Measured personal, indoor and outdoor 24-hour levels of 188 VOCs (though analysis focused on 18) in 48 homes for 8 weeks during winter and summer in Canada. Created an exposure model using predictions based on indoor concentrations.	Indoor concentrations of VOCs are predictive of personal exposures. Having a gas stove in the home was a significant predictor of acrolein exposure.	Varies by VOC. Examples are headaches, fatigue, respiratory issues.[321,322]

Table B-2: Emissions of $PM_{2.5}$ and NO_X from residential gas appliance use and estimated primary, nitrate, and total $PM_{2.5}$ reductions under an electrification scenario in which all residential gas appliances are replaced with electric appliances.

County	$PM_{2.5}$ Emissions from Gas Appliances (tons/year)[73]	Primary $PM_{2.5}$ Reduction (μg/m³)	NO_x Emissions from Gas Appliances (tons/year)	Nitrate $PM_{2.5}$ Reduction (μg/m³)	Total $PM_{2.5}$ Reduction (μg/m³)
Alameda	101	0.47	793	0.021	0.49
Alpine	0	0	0	0	0
Amador	0.77	0.0072	7.5	0.00081	0.0081
Butte	12	0.029	91	0.0031	0.032
Calaveras	0.22	0.0017	1.4	0.00023	0.0020
Colusa	0.80	0.0036	7.5	0.00051	0.0042
Contra Costa	77	0.29	634	0.018	0.30
Del Norte	0	0	0	0	0
El Dorado	1.2	0.0027	84	0.0025	0.0052
Fresno	44	0.045	368	0.018	0.062
Glenn	1.0	0.013	8.2	0.00070	0.014
Humboldt	7.0	0.0091	71	0.00071	0.0098
Imperial	1.9	0.0015	0	0	0.0015
Inyo	0	0	0	0	0
Kern	39	0.030	343	0.0133	0.043
Kings	6.7	0.067	53	0.0114	0.078
Lake	0	0	0	0	0
Lassen	0	0	3.9	0.00018	0.00018
Los Angeles	368	0.22	3883	0.041	0.26
Madera	3.1	0.018	29	0.0055	0.024
Marin	23	0.41	192	0.0086	0.41
Mariposa	0	0	0	0	0
Mendocino	2.7	0.0036	21	0.00027	0.0038
Merced	10	0.072	90	0.012	0.085
Modoc	0	0	0	0	0
Mono	0	0	0	0	0
Monterey	22	0.0086	181	0.0017	0.010
Napa	9.2	0.19	75	0.019	0.20
Nevada	2.1	0.013	48	0.0037	0.017
Orange	120	0.33	1178	0.041	0.37
Placer	18	0.025	229	0.0057	0.031
Plumas	0	0	0	0	0
Riverside	72	0.12	960	0.043	0.16

Table B-2: Emissions of $PM_{2.5}$ and NO_X from residential gas appliance use and estimated primary, nitrate, and total $PM_{2.5}$ reductions under an electrification scenario in which all residential gas appliances are replaced with electric appliances, cont.

County	$PM_{2.5}$ Emissions from Gas Appliances (tons/year)[73]	Primary $PM_{2.5}$ Reduction (μg/m³)	NO_x Emissions from Gas Appliances (tons/year)	Nitrate $PM_{2.5}$ Reduction (μg/m³)	Total $PM_{2.5}$ Reduction (μg/m³)
Sacramento	73	0.21	716	0.028	0.24
San Benito	2.2	0.032	23	0.0027	0.035
San Bernardino	80	0.062	857	0.0039	0.066
San Diego	62	0.057	942	0.016	0.073
San Francisco	65	0.84	512	0.015	0.85
San Joaquin	35	0.22	316	0.026	0.24
San Luis Obispo	14	0.051	132	0.0025	0.053
San Mateo	56	0.53	446	0.015	0.55
Santa Barbara	25	0.028	194	0.0014	0.029
Santa Clara	112	0.37	851	0.040	0.41
Santa Cruz	14	0.062	122	0.0031	0.065
Shasta	6.6	0.0064	61	0.00057	0.0070
Sierra	0	0	0	0	0
Siskiyou	0	0	0	0	0
Solano	27	0.22	205	0.0098	0.23
Sonoma	30	0.15	252	0.011	0.16
Stanislaus	26	0.16	220	0.022	0.19
Sutter	5.4	0.051	43	0.0031	0.054
Tehama	1.3	0.0023	13	0.0011	0.0034
Trinity	0	0	0.080	0.0000032	0.0000032
Tulare	21	0.043	181	0.016	0.060
Tuolumne	0	0	0	0	0
Ventura	41	0.12	344	0.0050	0.13
Yolo	10	0.064	91	0.0053	0.070
Yuba	2.6	0.044	26	0.0042	0.048

Table B-3: Estimated mortality and morbidity reductions from the electrification scenario by air basin, in 2018.

Air Basin	Nitrate $PM_{2.5}$: Reduced Mortality	All $PM_{2.5}$: Reduced Mortality	Acute Bronchitis (Cases Avoided)	Chronic Bronchitis (Cases Avoided)
Great Basin Valleys	0	0	0	0
Lake County	0	0	0	0
Lake Tahoe	0.061	0.29	0.35	0.19
Mojave Desert	9.7	61	109	52
Mountain Counties	0.088	0.43	0.45	0.27
North Central Coast	0.063	0.91	1.5	0.76
North Coast	0.14	2.2	2.5	1.5
Northeast Plateau	0.0021	0.0024	0.0031	0.0017
Sacramento Valley	2.1	20	31	14
Salton Sea	1.4	5.4	9.9	4.1
San Diego	2.1	9.5	15	7.8
San Francisco Bay Area	6.0	125	196	115
San Joaquin Valley	2.8	18	35	13
South Central Coast	0.24	5.7	9.3	4.4
South Coast	14	105	185	91
Total	**39**	**354**	**596**	**304**

Table B-4: Estimated monetization of the health benefits from the electrification scenario by air basin, in 2018.

Air Basin	Nitrate $PM_{2.5}$: Mortality Valuation	All $PM_{2.5}$: Mortality Valuation	Acute Bronchitis Valuation	Chronic Bronchitis Valuation
Great Basin Valleys	$0	$0	$0	$0
Lake County	$0	$0	$0	$0
Lake Tahoe	$565,809	$2,707,573	$185	$95,561
Mojave Desert	$90,280,523	$570,844,734	$57,048	$26,344,390
Mountain Counties	$818,583	$3,972,574	$239	$134,691
North Central Coast	$592,105	$8,528,831	$808	$380,196
North Coast	$1,332,509	$20,137,675	$1,331	$729,931
Northeast Plateau	$20,055	$22,050	$2	$831
Sacramento Valley	$19,919,241	$187,863,502	$16,487	$7,182,284
Salton Sea	$13,247,571	$50,566,952	$5,187	$2,069,330
San Diego	$19,447,260	$88,384,743	$8,138	$3,932,141
San Francisco Bay Area	$56,225,767	$1,168,481,307	$103,155	$57,664,334
San Joaquin Valley	$26,072,110	$168,161,417	$18,422	$6,390,438
South Central Coast	$2,226,449	$53,269,838	$4,888	$2,206,735
South Coast	$134,721,840	$983,223,898	$97,343	$45,569,735
Total	**$365 million**	**$3.31 billion**	**$0.31 million**	**$153 million**

Table B-5: BenMAP outputs for estimated mortality reductions from the electrification scenario by county, in 2018.

County	All $PM_{2.5}$: Reduced Mortality (95% Confidence Interval)
Alameda	29.4 (19.85, 38.93)
Alpine	0 (0, 0)
Amador	0.02 (0.02, 0.03)
Butte	0.43 (0.29, 0.57)
Calaveras	0.01 (0, 0.01)
Colusa	0.003 (0.002, 0.004)
Contra Costa	14.58 (9.84, 19.29)
Del Norte	0 (0, 0)
El Dorado	0.05 (0.03, 0.07)
Fresno	2.5 (1.69, 3.31)
Glenn	0.02 (0.01, 0.03)
Humboldt	0.08 (0.05, 0.1)
Imperial	0.02 (0.02, 0.03)
Inyo	0 (0, 0)
Kern	1.5 (1.02, 1.99)
Kings	0.38 (0.26, 0.51)
Lake	0 (0, 0)
Lassen	0 (0, 0)
Los Angeles	96.88 (65.42, 128.22)
Madera	0.16 (0.11, 0.21)
Marin	5.17 (3.49, 6.85)
Mariposa	0 (0, 0)
Mendocino	0.02 (0.01, 0.03)
Merced	0.85 (0.58, 1.13)
Modoc	0 (0, 0)
Mono	0 (0, 0)
Monterey	0.15 (0.1, 0.2)
Napa	1.55 (1.04, 2.05)
Nevada	0.11 (0.07, 0.14)
Orange	44.89 (30.31, 59.42)
Placer	0.79 (0.53, 1.05)
Plumas	0 (0, 0)
Riverside	16.16 (10.91, 21.39)
Sacramento	16.04 (10.83, 21.23)
San Benito	0.07 (0.05, 0.09)
San Bernardino	13.03 (8.8, 17.25)
San Diego	9.46 (6.39, 12.52)
San Francisco	28.64 (19.33, 37.93)
San Joaquin	7.79 (5.26, 10.31)
San Luis Obispo	0.79 (0.53, 1.05)
San Mateo	16.03 (10.82, 21.23)
Santa Barbara	0.54 (0.36, 0.71)
Santa Clara	25.35 (17.12, 33.56)
Santa Cruz	0.69 (0.47, 0.91)
Shasta	0.1 (0.06, 0.13)
Sierra	0 (0, 0)
Siskiyou	0 (0, 0)
Solano	4.54 (3.07, 6.01)
Sonoma	4.11 (2.78, 5.44)
Stanislaus	4.51 (3.05, 5.97)
Sutter	0.24 (0.16, 0.32)
Tehama	0.01 (0.01, 0.02)
Trinity	0 (0, 0)
Tulare	1.05 (0.71, 1.39)
Tuolumne	0 (0, 0)
Ventura	4.37 (2.95, 5.78)
Yolo	0.56 (0.38, 0.74)
Yuba	0.16 (0.11, 0.21)

Table B-6: BenMAP outputs for estimated monetization of mortality reductions from the electrification scenario by county, in 2018 (shown in 2015 dollars, pre-inflation adjustments).

County	All $PM_{2.5}$: Mortality Valuation & 95% Confidence Interval		
	Estimate	Lower Bound	Upper Bound
Alameda	$255,972,880	$23,741,228	$694,285,440
Alpine	$0	$0	$0
Amador	$202,040	$18,743	$547,983
Butte	$3,774,240	$350,120	$10,236,708
Calaveras	$54,529	$5,058	$147,895
Colusa	$28,817	$2,673	$78,159
Contra Costa	$126,885,312	$11,769,362	$344,151,744
Del Norte	$0	$0	$0
El Dorado	$448,354	$41,592	$1,216,049
Fresno	$21,789,786	$2,021,323	$59,099,608
Glenn	$174,319	$16,171	$472,799
Humboldt	$687,856	$63,810	$1,865,639
Imperial	$217,224	$20,151	$589,166
Inyo	$0	$0	$0
Kern	$13,099,088	$1,215,142	$35,528,120
Kings	$3,329,755	$308,882	$9,031,176
Lake	$0	$0	$0
Lassen	$20,543	$1,906	$55,719
Los Angeles	$843,326,528	$78,224,896	$2,287,352,832
Madera	$1,362,471	$126,391	$3,695,370
Marin	$45,046,368	$4,178,137	$122,180,416
Mariposa	$0	$0	$0
Mendocino	$180,162	$16,713	$488,643
Merced	$7,440,247	$690,186	$20,179,928
Modoc	$0	$0	$0
Mono	$0	$0	$0
Monterey	$1,315,226	$122,009	$3,567,224
Napa	$13,453,159	$1,247,909	$36,488,836
Nevada	$921,981	$85,529	$2,500,646
Orange	$390,746,336	$36,243,116	$1,059,827,968
Placer	$6,895,075	$639,627	$18,701,210
Plumas	$0	$0	$0
Riverside	$140,681,808	$13,049,800	$381,568,448
Sacramento	$139,650,096	$12,953,712	$378,772,032
San Benito	$613,641	$56,925	$1,664,352
San Bernardino	$113,451,872	$10,524,312	$307,711,232
San Diego	$82,344,448	$7,638,627	$223,339,872
San Francisco	$249,324,048	$23,121,320	$676,267,520
San Joaquin	$67,795,992	$6,288,626	$183,882,720
San Luis Obispo	$6,890,559	$639,203	$18,688,990
San Mateo	$139,580,336	$12,945,681	$378,590,528
Santa Barbara	$4,701,954	$436,181	$12,752,904
Santa Clara	$220,699,600	$20,470,320	$598,609,024
Santa Cruz	$6,017,096	$558,174	$16,319,943
Shasta	$835,539	$77,510	$2,266,194
Sierra	$0	$0	$0
Siskiyou	$0	$0	$0
Solano	$39,542,172	$3,667,874	$107,249,936
Sonoma	$35,786,860	$3,319,630	$97,063,968
Stanislaus	$39,271,068	$3,642,793	$106,514,288
Sutter	$2,117,348	$196,416	$5,742,799
Tehama	$110,212	$10,224	$298,922
Trinity	$0	$0	$0
Tulare	$9,130,249	$846,966	$24,763,624
Tuolumne	$0	$0	$0
Ventura	$38,036,816	$3,528,387	$103,166,240
Yolo	$4,857,377	$450,592	$13,174,484
Yuba	$1,407,345	$130,553	$3,817,086

Table B-7: List of air quality standards

Air Pollutant	Standard	Averaging Time	Concentration
CO	CAAQS	1-hour	23,000 µg/m³ (20 ppm)
		8-hour	10,000 µg/m³ (9 ppm)
	NAAQS	1-hour	40,000 µg/m³ (35 ppm)
		8-hour	10,000 µg/m³ (9 ppm)
	Health Canada Residential Indoor Air Quality Guideline	1-hour	28,600 µg/m³ (25 ppm)
	Health Canada Residential Indoor Air Quality Guideline	24-hour	11,500 µg/m³ (10 ppm)
NO_2	CAAQS	1-hour	339 µg/m³ (180 ppb)
		Annual mean	57 µg/m³ (30 ppb)
	NAAQS	1-hour	188 µg/m³ (100 ppb)
		Annual mean	100 µg/m³ (53 ppb)
	Health Canada Residential Indoor Air Quality Guideline	1-hour	170 µg/m³ (90 ppb)
	Health Canada Residential Indoor Air Quality Guideline	24-hour	20 µg/m³ (11 ppb)

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Putting Healthy Food on Our Tables

Sooke Region Food Security Report

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Executive Summary

Subject Matter

The report addressed food security under the federal and provincial poverty reduction strategies. Funded through a grant from Union of BC Municipalities, the aim is to provide a report on the present food security situation in the Sooke Region, which in turn will contribute to a strategic plan to tackle this important issue. The content of this report is to benefit stakeholders in different sectors, as poverty touches upon all aspects of community living.

Methods of Analysis

Tools developed were online public surveys with the same survey provided in paper form for individuals that might not access the internet, and some individuals of varying food insecurity and life situations participated through individual interviews online or by phone. The data collected provided the main core of the results of this report, which was supported by academic literature and factual information. As food security is inter-linked with many aspects of poverty, their impacts needed to be explored further in our local context.

Findings

The lack of availability to food, including fresh produce, was not seen as an issue, but firstly the lack of disposable income and secondly transportation. Once the main bills were paid, of which housing was the main expense, food was the variable variable in a low-income household. Food service providers, the Sooke Food Bank in particular, were de facto supplementing necessary income for many to survive in our community. Around 15% of the households in Sooke and the Sooke Region in general are of low-income, many of which consist of children and seniors. The necessary household income to manage with the cost of living in a BC community of a population under 30,000 is $42,408.00.

Income and employment are not the only factors in managing financially, but also a range of physical, psychological and socio-economic factors. An individual experiencing poverty

has a myriad of complexities that may hinder one from securing a liveable income and getting food on the table. The feeling of shame or mental health issues may hinder individuals in difficult situations to seek help. At times they are not aware of the supports that exist that could potentially assist them.
The pandemic has only exacerbated the whole poverty situation, which demands more reliable income streams and support services.

Recommendations

- Efforts should be made to ensure as much money in people's pockets as possible in order to cover more than the cost of living, but to assist them to come to a level where they feel secure and are able to plan for the future (employment, income tax, benefits, child care etc).
- Local and regional authorities need to find creative ways to make life easier for its population whether it be amending by-laws through a food security and equity lens, leading discussions that are outside of their normal mandate and scope, or through advocacy with the provincial and federal government.
- Address the impact of discrimination on individual and group circumstances through safety practice, intersectional practices, representation in community development and decision-making processes, including efforts towards reconciliation.
- Increase existing and encourage other relevant services to support low-income households in a motivating manner to reduce stigma, while not adding onto the burden that is already being experienced by these individuals and families.
- Housing is an important contributor to poverty in the region. Densification of the town core with affordable rental housing units would allow for better accessibility to amenities, services and transportation. Explore alternative housing arrangements such as cooperatives, co-housing, makerhoods etc.

- Create an environment where it is possible to easily physically access healthy food provision and services, as well as deter unhealthy food options in the community in order to uphold equitable community values.
- Develop a healthy food culture where healthy products are promoted, communal food gatherings facilitated, cooking and food preservation sessions continued and sensitization of nutritional and traditional food culture to encourage healthy eating habits and community spirit.
- Efforts need to be made to become more self-reliant by increasing local food production through increased farming on existing space, using unused farm lots, increasing greenhouse growth on industrial land, and coordinating neighbourhood growth initiatives, while reducing climate change through a sustainable circular economy.
- A regional coordinating body such as a Food Policy Council including both beneficiaries and food producers/providers should be established in the region, in order to provide a more holistic approach to food and economic growth, self-reliance and healthy living.
- A regional food hub could increase the growth of food production and processing locally, while providing employment opportunities.

Acknowledgement

Scia'New, T'Sou-ke and Pacheedaht First Nations upon which unseated territories the Sooke Region exists and thrives

District of Sooke, including the members of the Land Use, Climate Action and Community Economic Development Committees

Capital Regional District

Sooke Food Bank

Meals on Wheels

Sooke Farmers' Market

Sooke Family Resource Society

Sooke Holy Trinity Anglican Church - Vital Vittles

Sooke School District (SD62)

Sooke Region Chamber of Commerce

Sooke Region Food CHI

Sooke Region Communities Health Network

Worklink Employment Society

A special debt of gratitude to:

All community members who contributed to this consultation

All Sooke Region Farms who have contributed to all of the consultation processes and strategic plans in the past including this one

Resident Food Experts with important experiences from near and afar

Union of BC Municipalities for funding this project

Introduction

Under the auspices of Poverty Reduction, a grant was applied for and attained through the Union of BC Municipalities to conduct a local literature review on food security, facilitate a public consultation with documentation that in turn would support a community strategic plan accordingly.

The purpose of this report is to provide the District of Sooke and the rest of the Sooke Region's authorities, various sectors and community members with representative data that will provide insight on how to support such an important issue as food insecurity in a holistic manner.

This report relied heavily on the "Community Food Systems Assessment - A Companion Tool for the Guide"[1] in order to be able to document the necessary empirical information to support practical solutions by building upon the past efforts in food and service provision development leading to sustainability and accessibility.

The definition of Food Security and its association to poverty will be stated, as well as exploring regional environmental and health-related indicators. Next, the report will map social/cultural and local food indicators including elements of food procurement. Finally, food policy indicators will be addressed, with the report concluding with its recommendations.

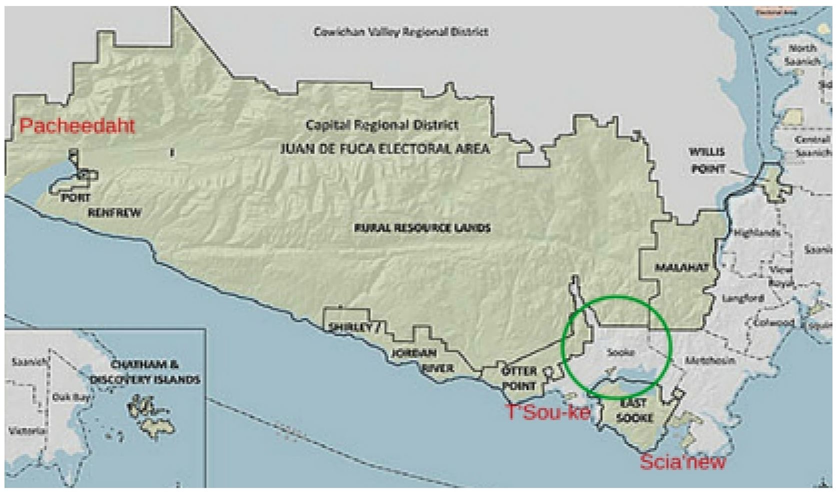
Geography

The Sooke Region is on the South Western corner of Vancouver Island, British Columbia. The area along the Juan de Fuca Strait includes from left to right on map 1: Pacheedaht First Nation, Port Renfrew, Jordan River, Shirley, Otter Point, District of Sooke, T'Sou-ke First Nation, Scia'new First Nation and East Sooke. The District of Sooke is a municipality, while

[1] Community Food Assessment Guide for Regional Health Authorities in British Columbia

the other communities with the exception of the First Nations are under the Capital Regional District (CRD).

A community previously consisting of forestry and fishing, is developing into a bedroom community for people working in the Westshore or the City of Victoria, while also attracting young families and retired seniors.



Map 1: Sooke Region

Consultative Approach

A food security consultation took place during January and February 2021, almost a year after the Covid-19 pandemic started. A *survey* was shared online, where all community members within the Sooke Region were invited to take part and 157 from all adult age ranges and income levels participated. A hard copy version of the same survey was distributed at the Sooke Food Bank and Sooke Shelter and 40 and 12 surveys were completed respectively. Questions addressed food and financial needs, how their situation could be improved if desired, and their willingness to produce, prepare and preserve food.

In addition, 15 *individual interviews* took place by phone and zoom adhering to pandemic restrictions. Interviewees were aged 22 to 72, with a predominance of women over 50. These qualitative data interviews provided necessary substance to the quantitative data from the surveys. Questions were more open-ended providing the interviewees the freedom to express their concerns about their own situation or that of their family members.

Equally important was the *input of food service providers and producers*. An online survey with 12 food service agencies and food producers, followed by a few discussions took place to offer insight on realities before and after the pandemic, as well as their opinions as to possible improvements.

Before proceeding with the survey results, first a clarification of terms and circumstances.

What is Food Security?

According to the provincial Food Security Evidence Review (2013), Food Security means that all people at all times have physical and economic access to adequate amounts of nutritious, safe, and culturally appropriate foods, which are produced in an environmentally sustainable and socially just manner, and that people are able to make informed decisions about their food choices.

Community food security, the major focus of this paper, exists "when all citizens obtain a safe, personally acceptable, nutritious diet through a sustainable food system that maximizes healthy choices, community self-reliance and equal access for everyone."[2]

Household/ individual food insecurity is defined as "the inability to acquire or consume an adequate diet quality or a sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so."[3]

Food security is a complex issue that recognizes the importance of human health and social equity, environmental health and sustainable food production, and economic vitality for both producers and consumers. Health is determined by complex interactions between

[2] Food Security - Evidence Review (2013) - p. 1
[3] Food Security - Evidence Review (2013) - p. 2

social and economic factors, the physical environment, and individual behavior. This requires a focus on partnerships and inter-sectoral cooperation, finding flexible and multidimensional solutions for complex problems, and public involvement and community participation.[4]

This is reinforced by both federal[5] and provincial[6] respective Poverty Reduction strategies. In 2010, the Provincial Health Services Authority (PHSA) noted that, based on the evidence of the relationship between food security and health, food security is a key public health priority in British Columbia.[7]

Low income, especially among vulnerable people (e.g., families headed by single females, indigenous peoples, homeless individuals and new immigrants) is one of the key contributing factors to the lack of individual and household food security. In the larger context of community food security, many additional factors impact the population as a whole, including food quality, food availability and accessibility, and multiple issues that impact the sustainability of the food system itself.

Because of the broad and complex range of these factors, a collaborative, multi-factorial approach is necessary not only at the regional and local levels but also at the provincial, national and international levels. The overall goal of the core public health program on food security is to increase food security for the population of British Columbia.

Social Determinants of Health

Social Determinants of health[8] are the broad range of personal, social, economic and environmental factors that determine individual and population health. The main determinants of health include:

[4] Food Security - Evidence Review (2013) - p. 17
[5] Canadian Poverty Reduction Strategy
[6] TogetherBC, British Columbia's first-ever poverty reduction strategy
[7] Food Security - Evidence Review (2013) - p. 7
[8] Social determinants of health and health inequalities - Canada.ca

1. Income and social status
2. Employment and working conditions
3. Education and literacy
4. Childhood experiences
5. Physical environments
6. Social supports and coping skills
7. Healthy behaviours
8. Access to health services
9. Biology and genetic endowment
10. Gender
11. Culture
12. Race / Racism

Social Determinants of Health[9] refer to a specific group of social and economic factors within the broader determinants of health. These relate to an individual's place in society, such as income, education or employment. Experiences of discrimination, racism and historical trauma are important social determinants of health for certain groups such as Indigenous Peoples, LGBTQ and Black Canadians. It has been scientifically proven that racism and discrimination actually takes years off one's life, due to the constant stress involved.[10]

Sooke Community Health Statistics

Provincial health authority figures follow geographical areas of responsibility. The Sooke Region falls under Sooke and Esquimalt, therefore numbers for the various parts of the Sooke Region were not attainable without including the much larger Westshore and Esquimalt communities. However, there was a subsection for Sooke proper, which will be used here[11].

Overall, Sooke's numbers around education, employment, life expectancy, chronic disease, maternal health, students fresh produce consumption and childhood vulnerability were

[9] Social determinants of health and health inequalities - Canada.ca
[10] Health inequalities are 'direct result of institutional racism'
[11] Island Health Community Health Profiles
communityhealth.phsa.ca/healthprofiles/healthreportcomparisontobc/sooke

similar to the provincial average. Sooke had some percentage points in its favour with teenage smoking, while being at a disadvantage with regards to affordable housing.

Though hovering around the average may seem reassuring, the numbers are not necessarily positive overall and there is always room for improvement with regards to health and wellbeing.

Direct information from the three First Nations regarding these areas were not available. However, the First Nations Health Status Report (2015)[12] revealed that indigenous of Vancouver Island are three times more likely to have diabetes and osteoarthritis and two times more likely to have hypertension than their peers aged 50-64. Asthma and hypertension saw an increase in females.

With the opioid epidemic, there is a common understanding that the entire population, no matter of origin, has seen an increase in overdoses and deaths, especially during the pandemic.[13]

Vulnerable Populations

The groups who are most vulnerable to food insecurity are: female headed single families, indigenous peoples, marginally housed and homeless, and new immigrants.[14] There is a clear linkage between income levels and food security, with the prevalence of food security rising to almost 50% in the lowest income group.[15] Among low-income groups, food insecurity is experienced disproportionately by some population sub-groups. The 2007-2008 Canadian Community Health Survey found that:

· People in the lowest income decile had quadruple the rate of food insecurity compared to the national average (of 7.7%); 56% of those receiving social assistance and 25% of those receiving workers' compensation/employment insurance were food insecure.

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[12] First Nations Health Status & Health Services Utilization
[13] Overdose Deaths Accelerating During COVID-19 | CDC Online Newsroom
[14] Food Security - Evidence Review (2013) - p. 6-7
[15] Food Security - Evidence Review (2013) - p. 3

· Approximately 21% of indigenous people living off-reserve experienced food insecurity.

· Some 13% of recent immigrants experienced food insecurity.

· More households with children reported food insecurity compared to the average household (9.7% versus 7.7%). Those with young children and greater than three children at home were most affected (11% and 14% respectively). Core Public Health Functions for BC: Evidence Review Food Security Population and Public Health, Ministry of Health.[16]

· Some 25% of households led by female lone parents were food insecure, which was twice the rate of households led by male lone parents (11.2%) and four times the rate of households led by couples (6.3%)

Federal Statistics

According to the Statistics Canada Health Fact Sheets on Household Food Insecurity, in 2017/2018, 8.8% of Canadian households - approximately 1.2 million - experienced some moderate or severe food insecurity due to financial constraints.[17] Food insecurity exists when household members report having issues with the quality or quantity of food consumed (moderate food insecurity) or having experienced reduced food intake or disrupted eating patterns (severe food insecurity). These kinds of household food insecurity have been associated with a range of poor physical and mental health outcomes, for example, multiple chronic conditions, distress, and depression.

Moderate and severe household food insecurity varied by family type. The proportion of households that experienced food insecurity was over twice as high for lone-parent families with children than for couples with children. Among households with children, female lone-parent families were the most likely to experience food insecurity (25.1%), followed by male lone-parent families (16.3%) and couples with children (7.3%)[18]

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[16] Food Security - Evidence Review (2013) - p. 11

[17] Health Fact Sheets Household food insecurity, 2017/2018

[18] Health Fact Sheets Household food insecurity, 2017/2018

Households in Canada consisting of a couple living alone were the least likely to experience food insecurity (3.4%). Among single-person households, females and males experienced a similar rate of moderate or severe food insecurity (about 12%, chart 1).

Households who were renting their home had higher rates of moderate or severe food insecurity than those that owned their home. In 2017/2018, 19.1% of households who were renting experienced food insecurity compared to 4.2% of households who owned their home.

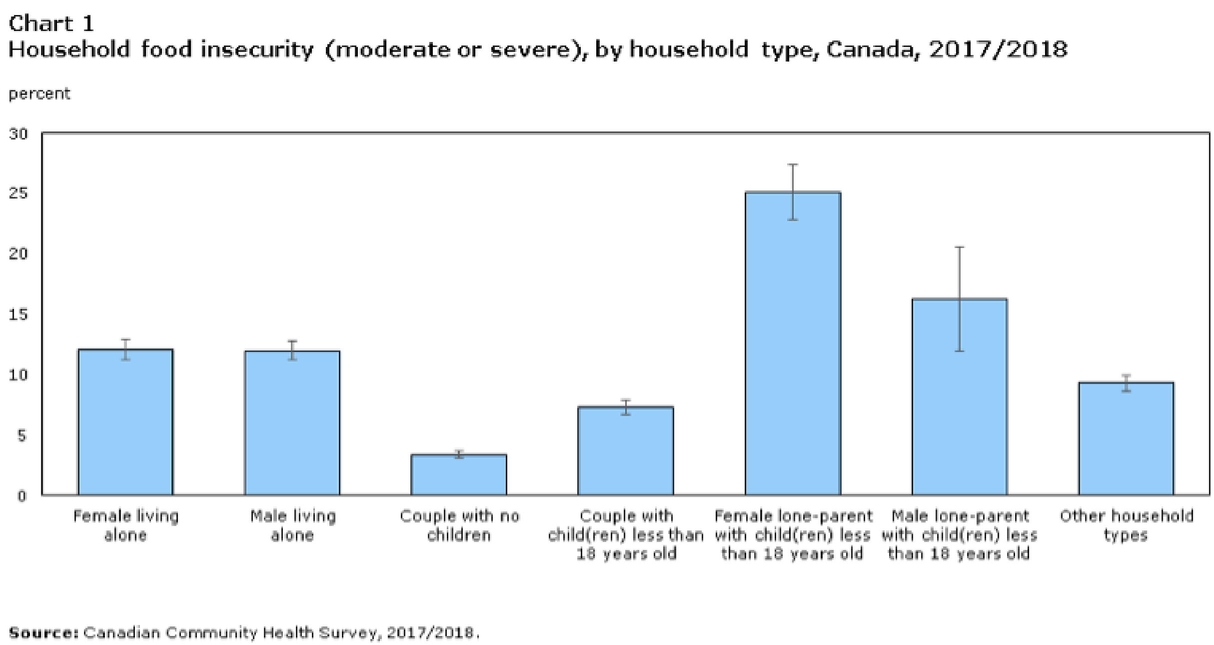

Chart 1: Household Food Insecurity Canada (2017/2018)

Household food insecurity (moderate or severe) differs between provinces and territories. Food insecurity was highest among households in Nunavut with 49.4% experiencing food insecurity (about 25.8% moderate and 23.7% severe food insecurity). Of the 5,800 households with children in Nunavut, 62.4% reported food insecurity among the adults and 42.7% reported food insecurity among the children.

Rates of food insecurity (moderate and severe) were also higher than the national average (8.8%) in Nova Scotia (10.9%), Manitoba (10.2%), Yukon (12.6%), and Northwest Territories

(15.9%). Quebec (7.4%) was the only province/territory with a lower proportion of households experiencing food insecurity than the average. All other provinces including BC had rates of food insecurity similar to the national average.

In addition to the moderate and severe food insecurity, 4.0 % are marginally food insecure on the national level, which means that a total of 12.7% are in a food insecure situation.

12.4 % of British Columbians are food insecure in 2018 (marginal 3.7%, moderate 5.5% and severe 3.2%).

In 2017/2018, around 1.6 million out of 14.3 million households (11.9%) in Canada relied on government benefits as their main source of income.[19] Just over one in five (22.5%) of these households were food insecure. For households that relied on other sources of income (such as wages and salaries, job-related pensions, etc.), the rate of food insecurity was much lower, at 6.8%.[20]

Sooke Region Demographic Statistics

As Sooke is the main hub in the region for services and amenities, but most of the agricultural land surrounds it, it was deemed essential to include the entire Sooke Region in this analysis.

According to the 2016 census, "Juan de Fuca 1" depicts East Sooke, Otter Point, Shirley and Jordan River only. There was no option to identify these communities separately. Port Renfrew and the District of Sooke were distinct, as well as the three First Nations in the region, namely Scia'new (Beecher Bay), T'Sou-ke and Pacheedaht ("Gordon River 2" in census) .

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[19] Health Fact Sheets Household food insecurity, 2017/2018 - Stats Canada

[20] Health Fact Sheets Household food insecurity, 2017/2018 - Stats Canada

Dem. Indicators (2016)	Scia'new FN	T'Sou-ke FN	District of Sooke	Juan de Fuca 1	Pacheedaht FN	Port Renfrew	Total
Population	129	225	13,001	4,670	111	144	18,280
Pop. % growth/ decline	-60.20%	0.027	0.137	0.102	0.156	0.036	N/A
Pop. density km2	49	301.5	229.6	21.1	116.3	16.6	N/A
Single parent household	10	15	550	130	5	0	710
Seniors	15	15	2,150	905	10	30	3,125
indigenous	125	215	865	370	85	105	2,765
No certificate or degree	40	45	1,765	555	25	10	2,440
Recent immigrants	0	0	125	15	0	0	140
School-aged children (5-19)	35	55	2,355	650	15	10	3,120

Table 1: Demographic Indicators Sooke Region

With the exception of Scia'new FN, all of the communities experienced population growth. Sooke has a relatively high growth rate of young families and seniors in BC contributing with people of resources but also the potential for further vulnerability through the emergence of more single parent households and elderly aging in place.

Recent immigrants to the District of Sooke are from developed countries with English as either their first or second language.

Interesting to note the population density on the First Nation reserves.

Sooke Region Income Statistics

The numbers included are also found through Statistics Canada, but from 2015. It will be very interesting to receive the new numbers expected this year, 2021, especially with the inclusion of numbers from the pandemic.

The Low Income Cut-Off (LICO) is when a family spends 20 percent more of its income on necessities (food, shelter and clothing) than the average family does.

Econ. Indicators (2015)	Scia'new FN	T'Sou-ke FN	District of Sooke	Juan de Fuca 1	Pacheedaht FN	Port Renfrew
Median total household income	$36,224	$41,088	$71,796	$76,288	$40,640	$61,760
Median after-tax total household income	$35,200	$39,168	$62,359	$66,400	$39,424	$53,120
% Ind. low income after-tax (LIM-AT%)	N/A	N/A	14.40%	15.30%	N/A	N/A
% Minors low income (0-5)	N/A	N/A	19.20%	19.60%	N/A	N/A
% Minors low income (0-17)	N/A	N/A	18.30%	20.30%	N/A	N/A
% Seniors low-income	N/A	N/A	11.30%	11.10%	N/A	N/A

Table 2: Economic Indicators Sooke Region

It is interesting to note that both the District of Sooke and Juan de Fuca 1 have similar numbers across the board. Sadly, large percentages (14.4% for DoS and 15.3% for JdF) of the population are deemed to be low income, but even higher numbers among the most vulnerable of the population, firstly children (18.3% and 20.3%) and then seniors (11.3% and 11.1%).

Consultation Survey Income Statistics

Among the 157 survey respondents in the community, household make-up and income sources were revealed.

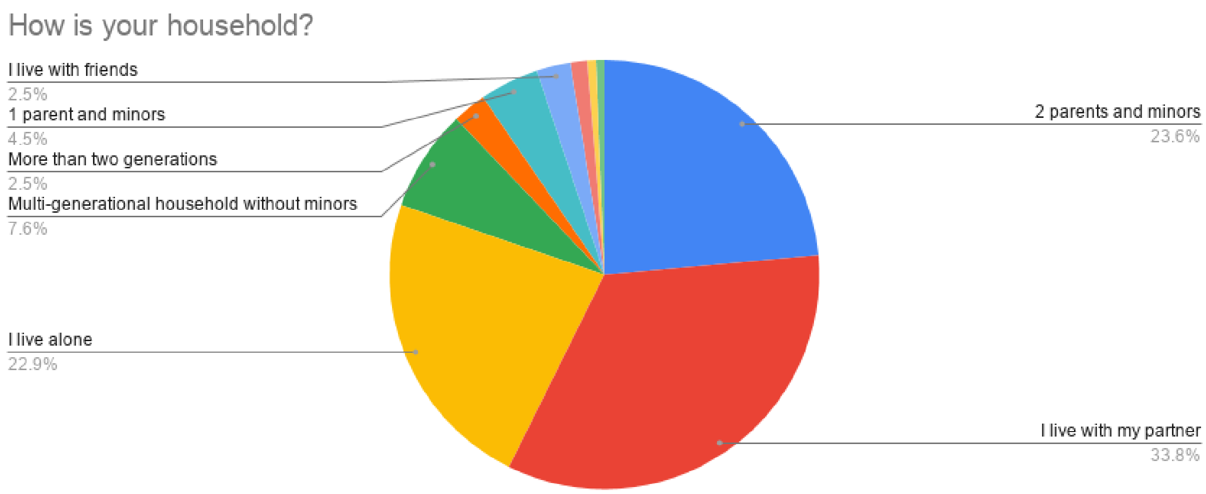

Chart 2: Household

The majority of respondents were living in households with 2 parent families with children, couples and individuals living alone. The remainder were either in multi-generational families, single parents or living with friends. Two respondents answered Sooke Shelter. It is unfortunate that more from these latter groups did not take part in the survey, as these are the individuals pre-identified as most vulnerable.

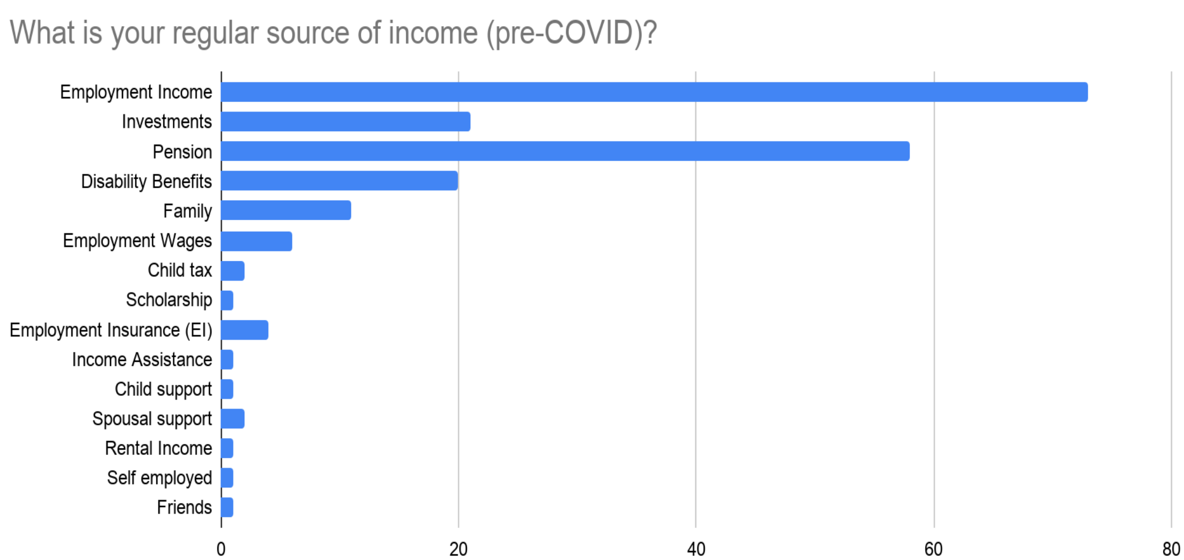

Chart 3: Income Source

Among those who responded to the survey, most gain their income from employment whether wages or self-employment. The seniors benefit from pensions and quite a few from investments. This is the generation that perhaps could afford to make investments, while the younger generation have not had that luxury.[21] Increased university fees and debts of one's own and then the future of one's children's post-secondary fees can be daunting and may not permit much saving, let alone managing daily life. It could also be that there is no longer a saving culture due to low interest rates and refinancing solutions.

There were around 15% that relied on family for assistance. It was commented in the interviews that people in difficulty need to stay in the area where they live even if it is unaffordable because of their reliance on social networks. This statistic would support the statement that the family link is still somewhat strong. A few individuals consulted explained how they as seniors were paying for medication and treatment for chronic illnesses of their adult children, or that there was mental illness in the family and needed care. Missed credit card payments due to reduced employment led to loss of housing. There are many life situations that could lead to downward mobility, and some members of our community were fortunate enough to be able to rely on their families.

Among those interviewed were some who had previously lived in Victoria but moved to Sooke due to its relative housing affordability. Cities are pricing out the urban poor, who then move to the suburbs or in this case a rural community. The safety nets in rural areas are not as secure as in urban centres, which may cause further issues for these individuals, a loss of their social network and an extra burden on the already service poor communities themselves.

[21] It may take millennials 29 years to save enough to afford a home in Canada's biggest cities - Financial Post

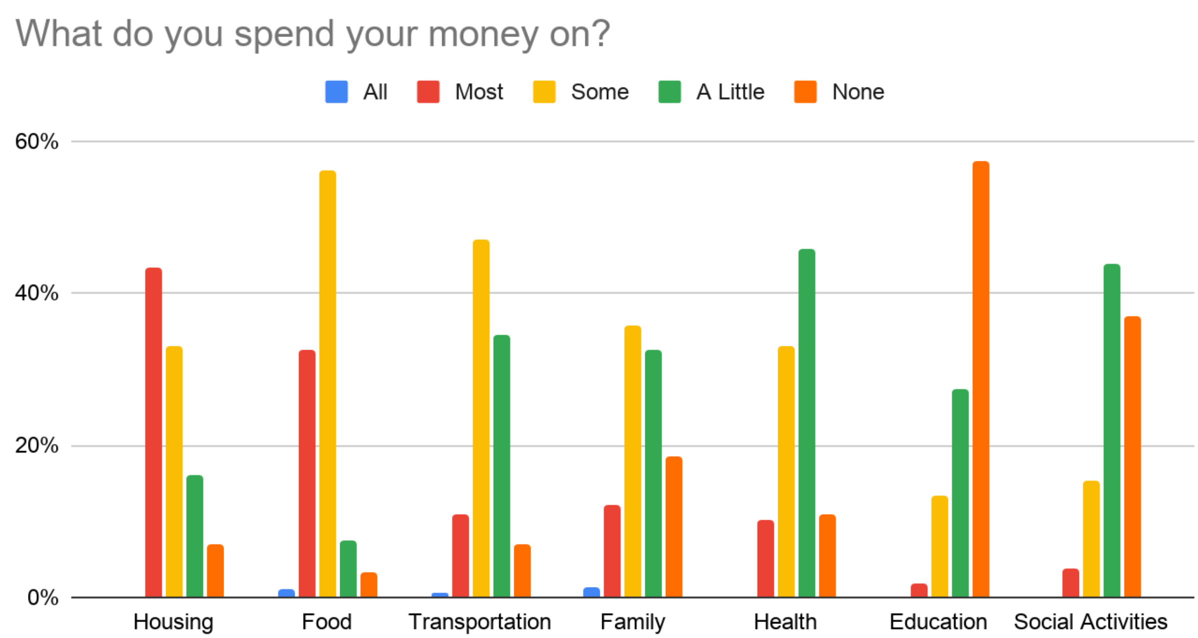

Chart 4: Income Expenditure

Obviously because of the nature of housing expenses, it would amount to the greatest deduction in one's income. However, it is important to note how there are a number of people who spend much of their income on food, transportation and health. In discussions with some seniors who had already paid off their mortgage, they would spend most of their money on food after utilities. It was a way to treat themselves as they did not take part in many activities outside of the home. This may explain the discrepancy with the established theory that food is the last necessity to be covered. Social activities are a luxury that not many can afford, or the lack of spending can also be due to the lovely nature that can be explored for free in our region.

When consulting with the Sooke Family Resource Society, it was acknowledged that their clients, who were low-income households with young children either with two parents or one only, were living from month to month. They lived for the child tax that would come every 20th of the month. They live upon what is in the account that day. Transportation and child care are major concerns with regards to getting around to find cheaper food than what can be found in Sooke, let alone medical appointments etc. Due to their financial situation, they are normally not in possession of credit cards, which limits online purchases and deliveries from box stores located in Langford that are more economical. Food is seen as a variable after the bills are paid, which is devastating especially with growing children requiring nutrients regularly. These individuals rely heavily on the Sooke Food Bank, Cobb's Bread donations, the BC Farmers' Market coupon program[22] - an initiative that creates a mutual benefit for low income families (fresh produce) and farmers (receive full price for their food) and the Sooke Country Market (promotion of its members to the community), Give Food Get Food program[23] , Farm Bucks (50% subsidized of local farm produce through the South Island Farm Hub) and the Good Food Box[24]. The latter four provide fresh food produce, where the Food Bank has a tendency to have more tinned goods with occasional fresh greens though efforts are made to improve upon that situation. The Sooke Baptist Church's Grace Gardens and the Sooke Region Food CHI Sunriver Garden donate regularly to the Food Bank when in season. It was added that the need for fresh produce outweighed the availability. It was urged that these programs increase capacity as only few families have access to these programs to date.

Social Assistance

To provide some better understanding as to what kind of benefits are available and how much one may receive, one may refer to the Social Assistance Rate Table found on the BC government website.[25]

Everyone who is on a "fixed income" of some sort, feels the constraints of added expenses. In talking with various community members, it was evident that there was much suffering taking place in private despite getting financial assistance. One had problems making ends meet. There was not always awareness of benefits available or dissuaded by the bureaucratic hoops one had to jump. Having several issues to

[22] How It Works - Nutrition Coupon Program - BC Farmers' Market
[23] Givefoodgetfood.ca
[24] The Good Food Box
[25] B.C. Income Assistance Rate Table

address that happened to fall across several ministries, created serious complexities and frustrations. The lack of affordable and appropriate housing was also a major complaint, especially among this group, as this was the biggest expense. The Sooke Family Resource Society confirmed that many young families needing assistance hesitate to reach out as they fear judgement and their parental skills questioned. Many individuals do not want to be perceived as weak or seeking handouts, as this is highly stigmatized.

During the Accessibility consultation held in Sooke in November 2019, it was stated that it was a struggle for individuals with disabilities to earn money because as soon as they earned more than the cap, their disability payments were reduced. As living with disabilities is a costly affair, every dollar counts. To quote Dr. Roy Brown[26] : "Almost all of us will experience a disability issue sooner or later in our lives".

So, people are in need of more money to survive, and if they try to find additional funds through employment, then they feel they are penalized. However, the employment they might gain in their present predicament is not enough to cover the cost of living. What is even more discouraging is seeing seniors, who are supposed to enjoy their "golden years", having to work again so they can support themselves or their families (grandchildren), often in low-paying jobs previously reserved for youth.

In addition, if one does not have a physical address, one cannot attain benefits, penalizing an extremely vulnerable population, namely the homeless.

Employment opportunities vary and with the gig economy, where it is more difficult to make ends meet on a regular basis. Worklink in Sooke has confirmed that as a result of the pandemic more people are considering working from home as entrepreneurs in the hope of creating better job security for themselves. Fortunately, Worklink[27] has various support

[26] Dr. Roy Brown is Emeritus Professor of the University of Calgary, and Emeritus Professor of Flinders University, Australia. He also holds the position of Adjunct Professor at the School of Child and Youth Care, University of Victoria and SRCHN Board Director
[27] http://www.worklink.bc.ca/

programs for those who are unemployed, underemployed, precariously employed or need to (re-)enter the workforce. It provides self-employment services (50-52 weeks covered living expenses as well as business coaching), skill enhancement and assistive technology. It also has employer services and employer-community partnerships to create jobs. Worklink is presently considering the prospect of a business hub in conjunction with its future new office building, where meeting space could be made available for home businesses and entrepreneurs.

Pandemic Benefits

Doing a consultation during a pandemic has its challenges, not to mention not being able to meet with the community members being consulted. Also, the data becomes somewhat exceptional and it is difficult to estimate how relevant that information will be once the pandemic is over. There was some curiosity about how the benefits provided by the government would affect the daily lives of Canadians.

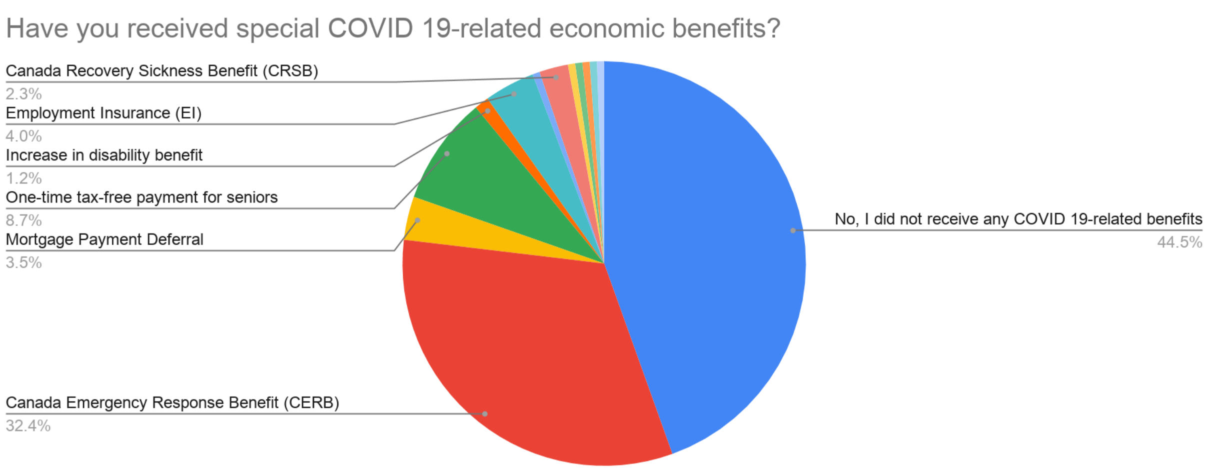

Chart 5: Covid-19 Benefits Reception

Indeed, there were numerous Sooke Region residents that received Covid-19 subsidies in one form or another, though 44.5% of those did not.

When asked if their situation changed as a result of the extraordinary benefit, 45.9% claimed that their circumstance did not change and almost 20% were worse off. Almost 10% claimed to be better off, which was interesting. It begs the question as to how poorly they were doing financially before the pandemic.

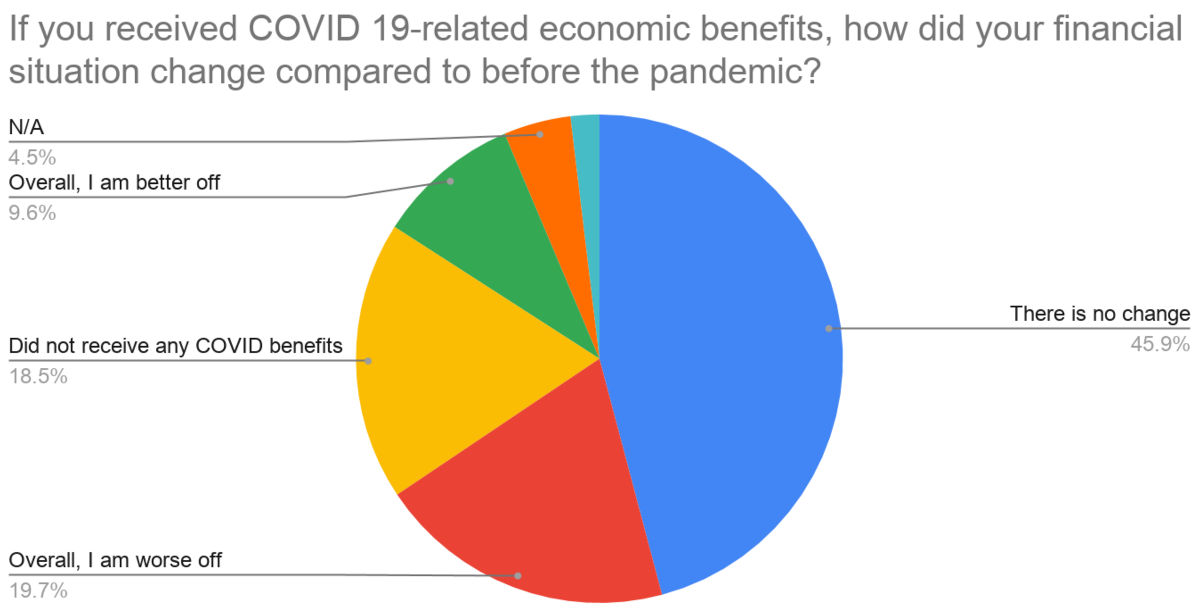

Chart 6: Financial Situation Change Due to Covid-19 benefits

Among those who responded, there was one that mentioned how the extra benefit actually bumped the family into a higher tax bracket and were now no longer eligible for stipends for their children's activities. In that situation, the respondent stated they were worse off though they had more funds.

Housing Stress

As housing is a major expense and this expense affects food security, it is only appropriate to evaluate what housing costs are in the region. Unfortunately, there is no data for the First Nations, but the other information will provide some indication of cost.

Housing (2016)	Scia'new FN	T'Sou-ke FN	District of Sooke	Juan de Fuca 1	Pacheedaht FN	Port Renfrew
Median monthly cost of owned dwelling	N/A	N/A	$1,428	$1,257	N/A	$501.00
Owner households paying more than 30% of income	N/A	N/A	22.30%	21.90%	N/A	N/A
Median monthly shelter cost for rented dwelling	N/A	N/A	$1,061	$994	N/A	N/A
Tenants paying more than 30% of income	N/A	N/A	47.60%	38.50%	N/A	N/A

Table 3: Sooke Region Housing (2016)

Again, these numbers are from 2016. Though housing affordability was already an issue back then, it has become increasingly desperate.

It is evident by the amounts that the closer one lives to the services and amenities, the higher the cost of housing. The median dwelling price in Port Renfrew is a third to that of Sooke proper.

Over one fifth of all house owners spend more than a third of their income on housing. Though mortgage costs exceed rental costs, it is clear that the high percentage rate of renters who are using more than 30% of their income on just rent is alarming, especially District of Sooke at almost 50%, with Juan de Fuca 1 at almost 40%.

Real estate is generally thought to be an investment out of the lower class through wealth accumulation, as the equity will be handed on to the next generation to provide them with a better starting point in life. However, with such high housing prices despite a low interest rate, there is the possibility of becoming house-poor, where all is invested into the house and not saved for retirement.[28]

[28] No, it is not OK to be 'house poor' - The Globe and Mail

The District of Sooke Housing Needs report (2019) confirmed that the majority of the population could not afford to own a house, a townhouse nor an apartment. Therefore putting a lot of pressure on the rental market.[29] The report's findings were as follows:

1. Address market-rate housing needs for all age cohorts
2. Address non-market housing needs
3. Enhance supply of rental housing
4. Enhance housing affordability
5. Facilitate development of vacant land
6. Prepare for anticipated growth in population aged 65 years and older[30]

Alternative Housing Options

Cooperative housing is nothing new, but by joining forces individuals may get the opportunity to get more for their limited income through pooling and sharing resources. Monthly housing charges are set by the members to cover the costs of running the co-op. A member's right to live in the co-op is protected as long as they're following all of the rules. Community. There is a strong sense of community because members actively participate in all aspects of running the co-op[31].

Adapting present builds and single family houses to accommodate inter-generational or peer **Co-Housing** could lower individual housing costs through this shared model, while reducing isolation. The **Co-Caring** models practiced at Sooke Harbourside and West Winds, where seniors support each other, are not particularly affordable but may be seen as an investment to enable aging in place. The future Sooke Region Elders' Complex with 79 affordable rentals and a seniors activities and resource centre will provide support for the

[29] Sooke HOUSING NEEDS REPORT - p. 71
[30] HOUSING NEEDS REPORT - p. 75
[31] https://www.cmhc-schl.gc.ca/en/professionals/industry-innovation-and-leadership/industry-expertise/affordable-housing/co-operative-housing-guide

tenants and the general seniors' population. It is through subsidies that the rentals are made affordable. Other pending affordable housing buildings funded by the CRD, including 45 shelter rate units, are scheduled for Sooke in the next few years.

An interesting option of combining housing, employment, amenities and perhaps even child care in one location, namely **Makerhoods**. Makerhoods integrates affordable living, space for light manufacturing, the creative explosion of the "maker movement," business support and a shared digital platform in support of a completely new paradigm to catalyze economic development.[32] One Makerhood could be on a regular one family home lot and have the same footprint. In these smaller living spaces, incorporated with work space, shops to sell the wares and other amenities, this creates an affordable living arrangement, lower transportation and carbon emissions and an attractive town addition. As the Sooke Region has numerous small enterprises, many of which cannot afford the present commercial space, this could become a vibrant colony of like-minded individuals that could collaborate, share resources and inspire each other.

Though affordable housing is important to contribute to disposable income, **renters' rights** cannot be understated. Landlord and renter relationships can be either positive or disruptive for a myriad of reasons. However, in conversations with service providers, some landlords are abusing the vulnerability of some tenants leading to insecure housing contributing to anxiety about one's future. RentSmart[33] is a non-profit that provides educational sessions for renters and landlords to reduce the risk of homelessness through rights and obligations sensitization.

Number of Homeless

As stated in the recent Sooke Region Homelessness Report as defined by the Government of Canada[34]

[32] https://www.makerhoods.com/
[33] Rent Smart | Housing Education | Homelessness Prevention
[34] Sooke Region Homelessness Report | srchn

Chronic homelessness - refers to individuals who are currently experiencing homelessness and who meet at least one of the following criteria:

- They have a total of at least six months of homelessness over the past year
- They have a recurrent experience of homelessness over the past 3 years, with a cumulative duration of at least 18 months.

Various typologies of homelessness that are referred are:

Unsheltered - absolutely homeless and living on the streets or in places not intended for human habitation.

Emergency Sheltered - including those staying in overnight shelters for people who are homeless, as well as shelters for those impacted by family violence.

Provisionally Accommodated - referring to those whose accommodation is temporary or lacks security of tenure.[35]

In rural areas, homelessness is less visible and harder to identify, as many find spots to camp out in the forest etc. A local primary school teacher observed too often how parents would have to choose between housing and food, leading to families temporarily living in cars.

On March 11, 2020, Sooke Shelter Society facilitated a homeless Point in Time count, where 37 individuals were identified[36].

- 18 spent the night of someone else's place
- 9 slept outdoors unsheltered
- 6 slept in vehicles
- The remainder (under 6) slept in other locations.

[35] Canadian Observatory of Homelessness, 2017
[36] Sooke Region Homelessness Report | srchn - pages 18-19

Among them, 64% were male, 27% were female and 11% identified as LQBTQS2+. From the same population, 17% were youth, 55.6% adults and 28% seniors. With regards to illness, 78% were using substances, 65% had mental health issues, 43% had other ailments and 46% had physical disabilities.

Sooke Shelter Society[37], a local grass-roots volunteer support group for individuals experiencing homelessness, had 73 clients from January - July 2020 (p. 16). Among the 73 clients:

- Youth represented around 13%, adults 74% and seniors 13%
- 74% were living rough, in a car, camper and/or staying temporarily with others, A little over half were male and the rest female
- 29% were experiencing hardship, lower income or living in poverty, among them 74% were male and 26% female

Hidden Homelessness[38]

For the homelessness report, a survey was conducted online and a visit to the Food Bank where 46 respondents contributed. Most identified as White Caucasian, where 35% of the total were male while 65% were female. It is known that many youth, especially those transitioning out of foster care, tend to couch surf. With low youth representation (3.6%) in this survey, adults dominated with 89% and elderly at 7.27%.

When asked where they slept the previous night, the answers were:

- 2% slept in nature
- 9% stayed with relatives
- 41% had a private rental
- 39% had own accommodation
- 9% "other" included motorhome, boat, friends

[37] Sooke Shelter Society - https://www.sookeshelter.org/
[38] Sooke Region Homelessness Report | srchn - page 19

Though the grand majority of respondents were housed, they felt that they were one pay cheque away or a crisis away from eviction.

The Sooke COVID Shelter was established in June 2020 as a response to the pandemic. It was seen as important to house homeless individuals to reduce community spread and simultaneously provide much needed support for this population. In March 2020, 38 individuals were identified, 24 of whom completed the intake for service, 5 were referred to a motel in Victoria and 19 accessed the emergency shelter at Seaparc Leisure Centre. In July, the location was moved to Otter Point Road. As of September 2020, there were 15 clients, 60% male and 40% female. Five residents identified as indigenous and one was a veteran. As of April 2021, the shelter will become a more permanent fixture on West Coast Road at the Hope Centre, where there is more much needed capacity and support.

The Complexity of Being Vulnerable

As can be seen in this section, there are many life situations that can lead to a situation of poverty. Such circumstances may happen to anyone. What was made very clear through the individual interviews was the distress such situations brought on, leading to depression and other mental health issues. One feels trapped. One is not able to plan the day, let alone one's future. Mobility issues due to injury or other ailments adds to the isolation. Also, not eating nutritious meals regularly, especially if one is taking medication, may lead to a continuation of a downward spiral.

Though all those consulted started out by saying that they did not need help, admittedly partially due to not wanting hand-outs, it was gradually concluded that they all would have appreciated some guidance to navigate the system, including those who considered themselves to be strong personalities. Examples of guidance would be to have someone who could advocate to help gain benefits, get appropriate medical attention, attain affordable housing, get assistance with income tax returns[39], gain employment and help

[39] See the Sooke Region Volunteer Centre for its annual free tax clinic

identify their rights. A navigator to find ways to get more money in the pockets of individuals, as well as facilitate necessary support. To be able to help such individuals, who might be "hiding", is difficult and may be achieved through trust-building through present support services.

Attempts must be made to create an equitable playing field, i.e. what is right, just and fair. Provincial Equity Guides exist and should be utilized in all community planning, including socio-economic and indigenous policies and practices.[40]

Population That is Food Insecure

In Canada, 4 million people are food insecure.

1 in 6 Canadian children under the age of 18 is affected by household food insecurity. Households with children led by female lone parents are especially vulnerable to food insecurity; one-third of these households are food-insecure.[41]

44% of Canadians say it would be difficult to meet their obligations if their pay was delayed by one week.[42]

12% or British Columbians are food insecure.[43]

Market Basket Measure

Statistics Canada uses the cost of the Nutritious Food Basket, aka the Market Basket Measure (MBM), to determine the low income thresholds of poverty based upon the cost of a basket of food, clothing, shelter, transportation, and other items for individuals and families representing a modest basic standard of living. A family with disposable income

[40] Supporting Equity in Planning and Policy Action Guide. - Plan H
[41] Household Food Insecurity in Canada – PROOF
[42] Survey Finds Employed Canadians Failing to Take Advantage of Improved Financial Picture to Reduce Debt or Save More for Retirement).
[43] Household Food Insecurity in Canada – PROOF

less than the poverty threshold appropriate for their family's size and region would live in poverty. According to the MBM (2018) for a rural community in BC is **$41,463.00**, and a BC community with a population under 30,000 is **$42,408.00**. This is similar to an equally sized community in Saskatchewan and the Maritime provinces, and interestingly to that of the City of Toronto.

During our consultation for this report we asked about community members' food consumption frequency and potential sacrifices towards having a "satisfying meal".

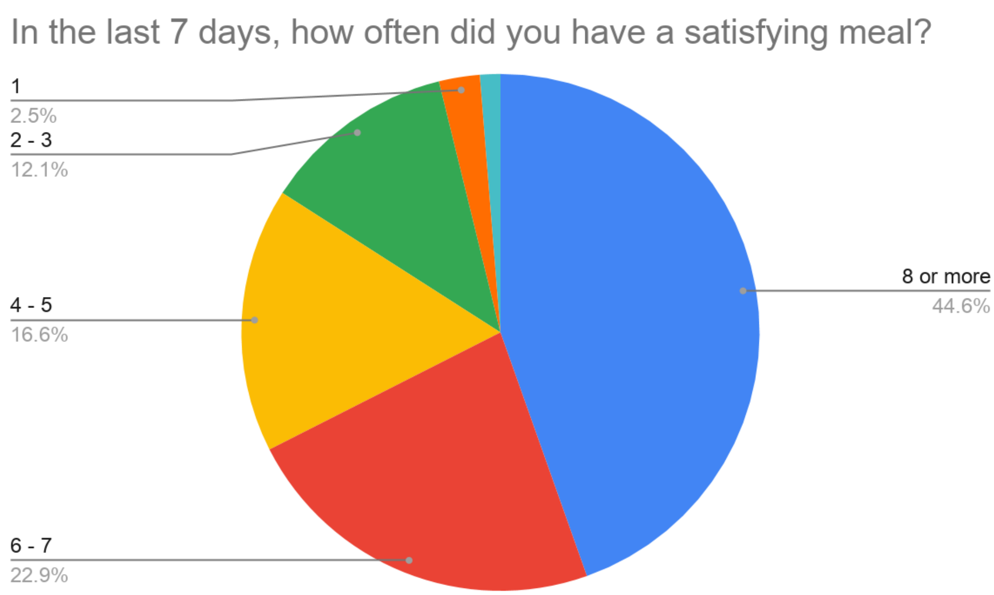

Chart 7: Meal Intake

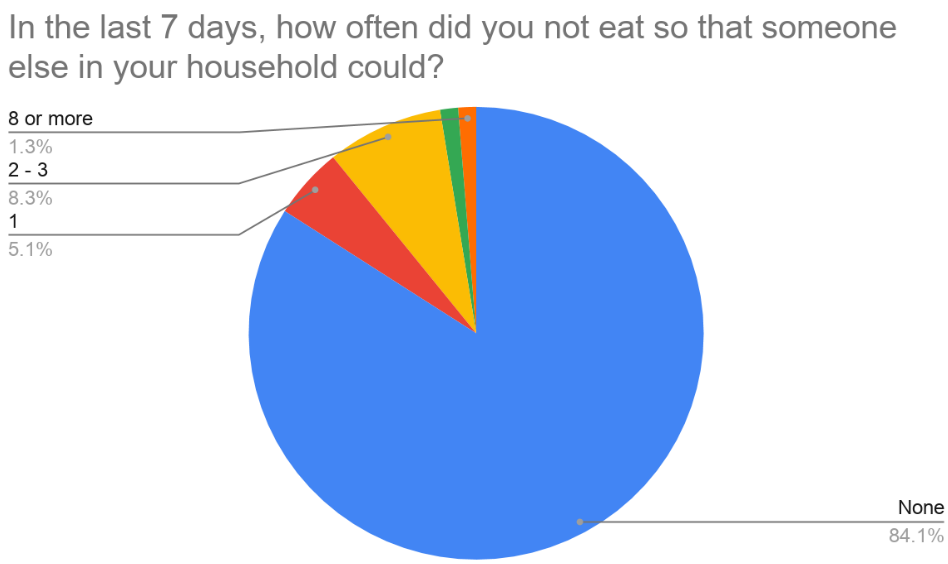

Chart 8: Meal Sacrifice

Sadly, there were community members who had to sacrifice their own meals so that others in their household could eat. Though this consultation did manage to have a wide range of age groups, it would be the population with families that would most likely find themselves in this situation or a partner with an ailment that needed to be prioritized. Understanding that single family households led by women are of the most vulnerable families, and not well represented in this survey, it can be estimated that this issue is an alarming one that needs to be addressed more than at present.

When asked about how their situation could be improved, the answers were mostly on the financial conditions.

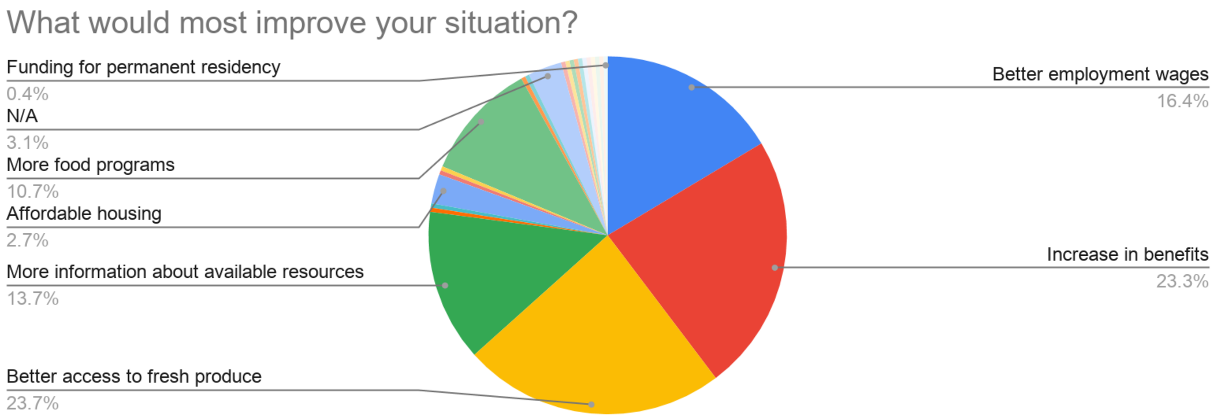

Chart 9: Situation Improvement Conditions

An increase in financial standing was the dominating influence totalling almost 40%, followed by better access to fresh produce at nearly 24%. Interestingly, affordable housing was only at 3%, while more food programs were at nearly 11%. Having more affordable housing would put more money in one's pocket for disposable income.

Returning to the Market Basket Measure, a Sooke household with less than $42,408.00 and a Juan de Fuca resident with a household income less than $41,463.00, would then be considered food insecure.

Econ. Indicators (2015)	Scia'new FN	T'Sou-ke FN	District of Sooke	Juan de Fuca 1	Pacheedaht FN	Port Renfrew
Median total household income	$36,224	$41,088	$71,796	$76,288	$40,640	$61,760

Table 4: Median Household Income (2015)

It's About Income Not Food Supply

Graham Riches, Emeritus Professor of Social Work, University of British Columbia[44], exclaimed how governments must own and act on the national public health data that food insecurity is an income problem, not a food problem. Covid-19 made this abundantly clear.

[44] Canada must eliminate food banks and provide a basic income after COVID-19

Nationwide, Covid-19 has produced a spike from 10.5% to 14.6% of the number of Canadian households reporting they are food insecure. Unsurprisingly, the key public policy pandemic response is income-based. The Canada Emergency Response Benefit (CERB) has to date gone to 8.7 million people at a cost of $72.5 billion. An additional $37 billion has been allocated to the CERB transition plan for the establishment of new sickness and care benefits.

The adequacy of workplace benefits will be critical given that pre-pandemic, 65% of food-insecure households relied on employment income, according to federal food insecurity data[45].

Those who face the biggest challenges, however, are Canadians ineligible for the new EI/CERB benefits, including the two million currently dependent on provincial social assistance. National data also shows even before the pandemic struck, 60% of social assistance households were already food insecure[46].

“Beyond COVID-19,” he explains, “we should no longer tolerate the inequities of corporate charity and the stigma associated with relying on society’s leftovers for those in need. It’s long past time to reframe food insecurity as a matter of income security, and to ensure public policy is developed with human rights in mind.”

Riches concludes, the pandemic is not the ideal time to propose exiting food banks as a response to widespread food insecurity. Food bank use after all is surging[47].

The Sooke Food Bank has indeed seen a surge during the pandemic, including the working poor dropping by on their lunch break to pick up food or individuals finding themselves for the first time in a Food Bank queue, which corresponds with observations from across the country.[48]

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[45] Household Food Insecurity in Canada – PROOF
[46] Social assistance5 - Proof
[47] Canada must eliminate food banks and provide a basic income after COVID-19
[48] The Working Poor in the Toronto Region: A closer look at the increasing numbers | Metcalf Foundation

Anecdotally, while the survey was being conducted at a Food Bank day, it was noted that there were so few clients (40) that particular day when there was normally a line up around the block. The explanation was that it was family allowance day, meaning that when the cheques were received the families went to the stores to purchase goods. It was further confirmed through individual interviews that the Food Bank had become an income supplement as food was the last of the necessities to be addressed when all the bills had been paid. If the money was in hand, food banks would not be visited and therefore no longer necessary. Unfortunately, our society still desperately needs food banks and other food support services as a plaster on a deep wound that society still needs to remedy.

To note, Old Age Security and Guaranteed Income Supplement were identified as a key driver of substantial decreases in food insecurity among the poorest seniors in Canada.[49] On the other end of the generational spectrum, the rate of severe food insecurity dropped by one-third among low-income families after the introduction of the Canada Child Benefit (CCB) in 2016.[50] If one is raised in poverty, then one is most likely to remain in poverty.[51] Providing the necessary support in life, especially early on, is an investment in society.

Universal Basic Income

Basic Income Guarantee[52] ensures everyone an income sufficient to meet basic needs and live with dignity, regardless of work status.

A form of BIG was established in 1967 with income guarantees for seniors. Shortly afterwards, in 1971, the idea of a wider basic or guaranteed annual income was the key recommendation in a Senate report on poverty (the "Croll report")[53]. Also in the 1970s, both Canada and the United States ran extensive pilot programs, including a unique site in

[49] Food Insecurity in Poor Canadian Seniors is Greatly Reduced when Guaranteed Annual Income Kicks in

[50] Canada Child Benefit helped reduce severe food insecurity, U of T study finds.

[51] Just the Facts - Poverty in Canada

[52] About Basic Income

[53] http://www.albertasenator.ca/flashblocks/data/BT%20Poverty/Croll%20Report%201971.pdf

Dauphin, Manitoba[54]. A Senate Committee in 2009[55], noting growing inequality and persistent poverty in Canada, said it was time to put a guaranteed income back on the public agenda.

The current BC government studied basic income. A report from January 2021 concluded that there are better options available, namely a reform of the existing support programs. "The needs of people in this are too diverse to be effectively answered by a cheque from the government.", but rather social support needs to be fortified.[56]

Living Wage

Currently, the minimum wage in BC is $14.60/hour. With such wages, families often have to make choices between necessities, including food. In 2019, a living wage for Greater Victoria was calculated to be $19.39/hr.[57] The pandemic reaffirmed how unsteady retail and restaurant employment is and how women were the ones to suffer the most from this. The increasingly non-committal employment practices of irregular hours, part-time and contract work and not paying employment benefits across the board, have led to precarious living conditions. There is still much to be achieved with regards to increasing living costs but not equally rising wages.

It could also be argued that underemployment, as well as poor pay, is a factor leading to downward mobility.

Affordable Care

The pandemic also reinforced the need for affordable quality **childcare**. Women were often the ones to stay at home with children who were learning remotely. The scenario of single parent households under such circumstances or of family illness, is a frightening

[54] A Canadian City Once Eliminated Poverty And Nearly Everyone Forgot
[55] IN FROM THE MARGINS: A CALL TO ACTION ON POVERTY, HOUSING AND HOMELESSNESS
[56] Guaranteed basic income in BC not the best way to a more just society, expert panel finds
[57] http://livingwagecanada.ca/index.php/living-wage-communities/british-columbia/

one. If one wants to work near home and not have the luxury of a home office situation, chances are one has to take an ill-paying job in Sooke or commute to Westshore and Victoria.[58] However, without decent wages women are not attracted to (re-)joining the workforce, unless they desperately need to and then may become vulnerable to unsteady contracts, leading to food insecure households. For a positive model, one could look to the Nordic countries that have been frequently ranked the "best places to have children" for their parental leave and highly subsidized childcare system, which has been a great equalizer with regards to gender and socio-economic equality and child development.[59]

Care is not only childcare. There are many individuals and families who are dependent upon **individual care** to function, whether they be people with born or acquired illness or simply aging. This can become a very costly affair if one does not have a family network one can rely upon. Services in the region are few. It has been complained that agencies that actually send home help tend to send different individuals each time due to scheduling, which leads to additional anxiety among clients.

Charitable Services

The charitable services listed below include the Food Bank, warm meal services and other services that are connected with food for clients in one way or another in the Sooke Region.

Food Banks

Though it was argued earlier that food banks are an indication of our society not meeting the financial challenges of its citizens, it must be clearly stressed how important the food banks are while systemic change is brought about.

Sooke Food Bank

- *Number of members per month:* 700+ (⅓ of clients are seniors, increase in working poor and young families)

[58] B.C.'s working poor: Affordable child care key to lifting families out of poverty
[59] Why Nordic nations are the best places to have children

- *Availability:* 3 days a month but available 24/7, also during COVID. Delivery is provided twice a month. Estimated value of food is $290,000. Milk money, Back Buddies, $50.00 Walmart gift cards for school kid shoes and Christmas programs are additional projects. Clients may access some household goods, clothing and books, as well as important resource information, a gentle ear to listen and potential referrals to services and benefits.
- *Demographics:* Accommodates demographics of all types, with a noticeable recent increase of working poor and young families. It is acknowledged that there is a stigma attached to visiting the Food Bank, but it is a trusted agency with many vulnerable individuals
- *Origin and quality of food:* Donations from the public and local stores, fresh produce from community gardens and during covid local farmers, purchases from grants and donation funds. There is a predominance of non-perishable items, but fresh produce is procured. A recipe sheet accompanies fresh food boxes to inform those who are not familiar with certain fresh produce.

The Sooke Food Bank saw a surge in clients already before the pandemic, which was only exacerbated by Covid-19. The present location in the Sooke Community Hall is no longer appropriate for the high demand in food distribution. There have been calls for a new location with more space, as well as a paid staff member to run the operations, which is presently on a volunteer basis.

Community Hot Meals

Meals On Wheels

- *Number of members per month:* 30 each time, 45 in the summer
- *Availability:* Warm meals prepared and delivered three times a week (Mon., Wed. and Fri.)
- *Demographics:* Seniors and vulnerable individuals
- *Origin and quality of food:* Meals prepared in the community hall kitchen. Food by donation, through the Food Bank and small fee $6/meal.

Vital Vittles - Anglican Church

- *Number of members per month:* 51-75
- *Availability:* 4 times a month - Fridays
- *Demographics:* General public, families, homeless, individuals with disabilities, seniors
- *Origin and quality of food:* Warm meals prepared in the church kitchen. During Covid people could pick up meals at a designated window. Provides informational resources.

Big House Community Breakfasts - Sooke Baptist Church
- *Number of members per month:* 80
- *Availability:* Not during Covid, otherwise on Monday and Wednesday mornings
- *Demographics:* General public, families, homeless, individuals with disabilities, seniors
- *Origin and quality of food:* Warm meals are prepared in the communal kitchen

T'Sou-ke First Nation
- *Number of members per month:* Open to nation members and guests
- *Availability:* Weekly on Wednesdays
- *Demographics:* First Nation members and guests
- *Origin and quality of food:* Warm meals are prepared in the communal kitchen

Pacheedaht First Nation
- *Number of members per month:* Open to nation members and guests
- *Availability:* Weekly
- *Demographics:* First Nation members and guests
- *Origin and quality of food:* Warm meals are prepared in the communal kitchen.

Scia'new First Nation
Information was not attained for this report, but it is presumed that this nation follows a similar practice.

Shelter With Meals

Sooke Shelter

- *Number of clients per month:* Fluctuates around 20
- *Demographics:* Adult homeless population in Sooke, both genders.
- *Origin and quality of food:* Catering from local restaurants and donations from the Food Bank, provides service information

Other Agencies

Sooke School District

- *Number of members per month:* 100+
- *Demographics:* school children and youth
- *Origin and quality of food:* Meal programs, gardening programs, food garden plots, weekly supplement informal service "Backpack Buddies". Some elementary schools: Sandwiches, snacks etc for those without breakfast or lunch. Select schools have daily lunch meals provided to some students; monthly fruit and vegetable program for schools, weekly supplement services (e.g., Backpack Buddies), as needed food provision to those needing some

extra nutrition. Information services provided. Grocery store gift cards are provided to some families. The local high school has a culinary arts program and two of the schools have vegetable garden plots.

Sooke Shelter Society

- *Number of members per month:* 76-100
- *Demographics:* adults experiencing homelessness or near homelessness
- *Origin and quality of food:* Upon demand provides gift cards, provides service information

Sooke Family Resource Society (SFRS)

Number of clients per month: 100+
Demographics: Indigenous, families, children and youth
Origin and quality of food: Food program, meal program, food gardening support, good food box to Sooke and Pacheedaht (twice a month), provides service information

Better at Home under Sooke Region Communities Health Network

- *Number of members per month:* 70
- *Availability:* Weekly during Covid
- *Demographics:* Seniors registered with the Better at Home program
- *Origin and quality of food:* Purchases are done at the local grocery stores

Sooke Embrace Facebook Group

If one is looking for immediate and quick assistance, Sooke Embrace has revealed itself to be a trusted source for many who do not have time to go through hoops, bureaucracy or are intimidated by service providers. Requests can be made by the needy. In turn, the generous and philanthropic advertise meals, clothing etc. for quick and easy pick-up. This Facebook group is an important addition to the Sooke support scene, having carved out a niche where it has a broad outreach. This has revealed itself through its membership, activity and local research[60] .

[60] Living on the Edge - Homelessness in the Sooke Region - Feb. 2021 https://www.sookeregionchn.org/sooke-region-homelessness-report

Food Procurement

In the survey, respondents were requested to provide details about how/where they got their food, many respondents did have multiple food sources.

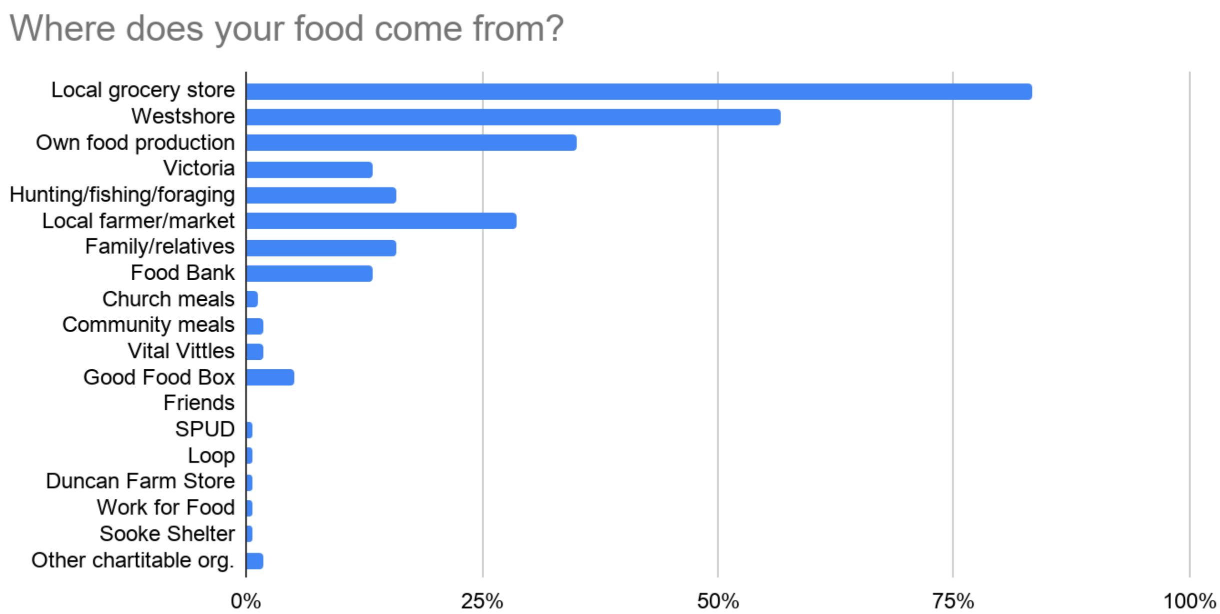


Chart 10: Origin of Food Procurement

Among the top three were the local grocery stores, Westshore (where the box stores are located) and gardening. The local farmer or farmers' market along with hunting, fishing and foraging were next in frequency. A variety of charitable food and meal distributors were in small numbers. It is assumed that if the surveyor had visited the Food Bank on a busier day, those numbers might have been higher.

Returning to the gardening aspect of food procurement, the survey sought to understand gardening practices in the community.

When asked regarding any barriers that were encountered when procuring healthy food, the majority of respondents replied that they did not experience any barriers. However, almost 30% stated that they could not afford it and almost 10% stated that they could not find it.

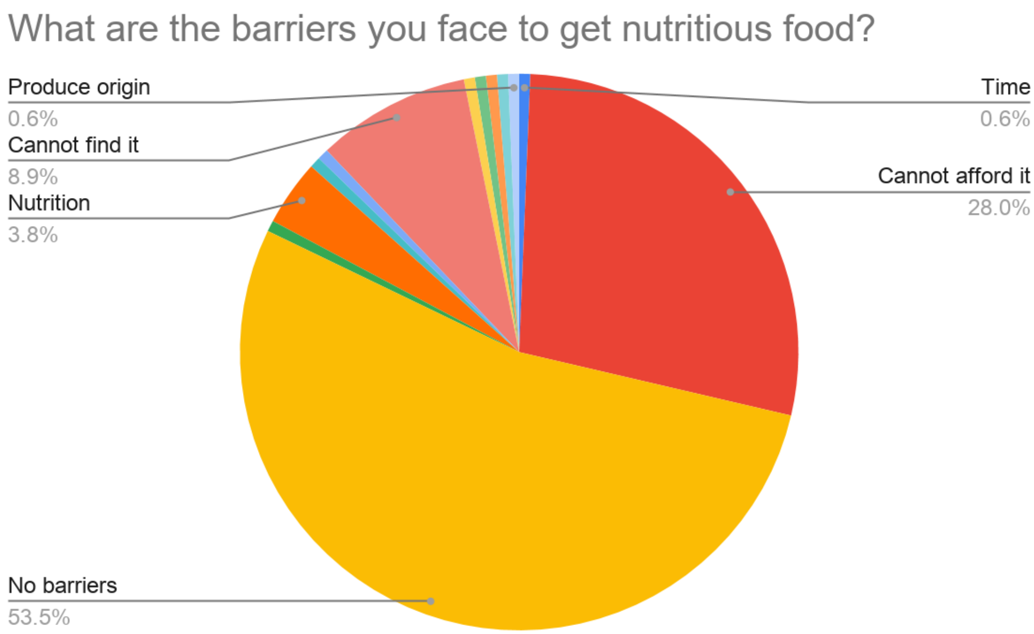


Chart 11: Barriers to Healthy Food

This data would confirm that affordability is a major issue to attaining nutritious food. If finances are lacking, it could be suggested that gardening could be an alternative.

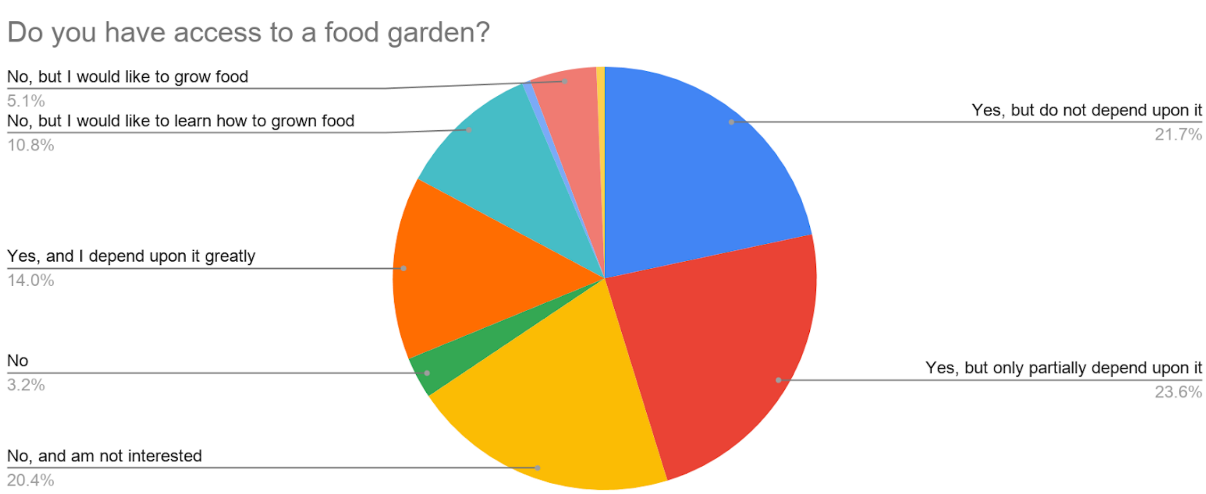


Chart 12: Food Garden Accessibility

With regards to gardening, 14% depend upon gardening greatly and almost 24% partially depend upon it. 20% were not interested at all. It should be stated that some respondents expressed their inability to garden due to lack of time or restricted mobility issues. Over 10% stated that they did not have access to a garden and would like to learn. 5% stated that they did not have access to a garden but would like to. Perhaps some garden matches could be arranged through the Young Agrarians[61] to have the able-bodied garden on the not-so-able-bodies' gardens and a share in the crops.

It was suggested by Sooke Family Resource Society that individuals and families that are feeling overburdened, should not be pressured to garden unless they really wanted to. The fear of failure in “one more thing” when their life situation is so complex should be understood and not judged. Gardening may contribute to alleviate food insecurity to a certain degree, but perhaps not sufficiently to balance out other personal concerns.

Once the crops are harvested, then comes preparation and preservation.

Food Safe Community Kitchens

There are several food safe community kitchens available in the community, but most are reserved for the associated members, and often insurance formalities and custodial requirements may be a barrier for those requesting to use the facilities.

1. Sooke Community Hall
2. Sooke Baptist Church
3. Anglican Church
4. Sooke Child, Youth and Family Centre
5. St. Rose of Lima Catholic Church
6. Edward Milne Community School
7. T’Sou-ke First Nation
8. Pacheedaht First Nation
9. Scia'new First Nation
10. Shirley Hall
11. Knox Church
12. East Sooke Community Hall

[61] Young Agrarians - https://youngagrarians.org/

13. East Sooke Fire Hall
14. Sooke Region Museum

The regional hotels, restaurants and the two main grocery stores are naturally included in this selection.

The question as to interest around accessing such kitchens was put to community members.

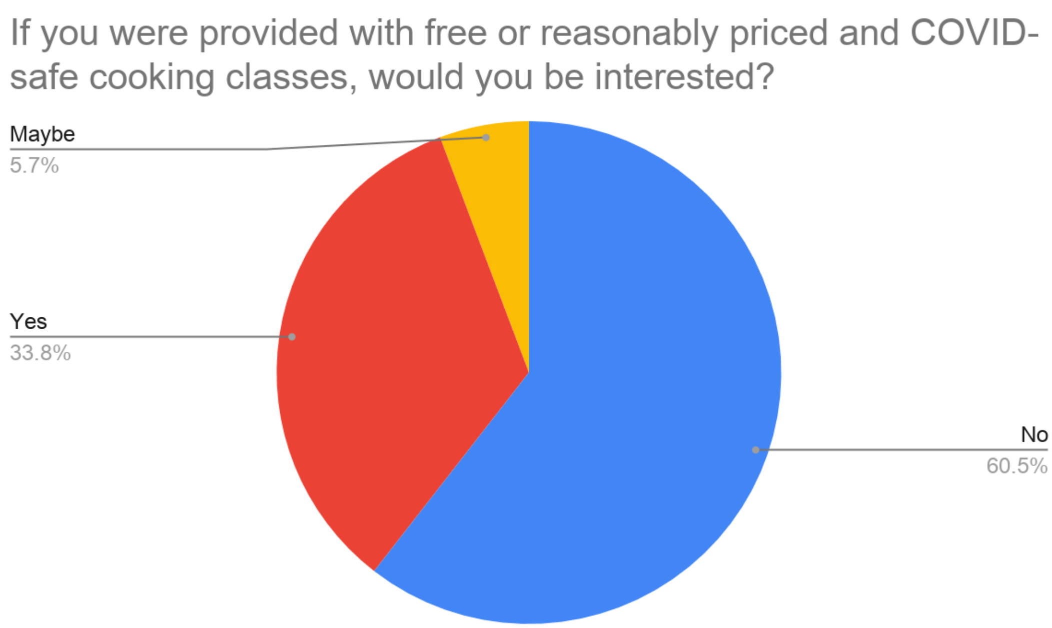


Chart 13: Cooking Class Interest

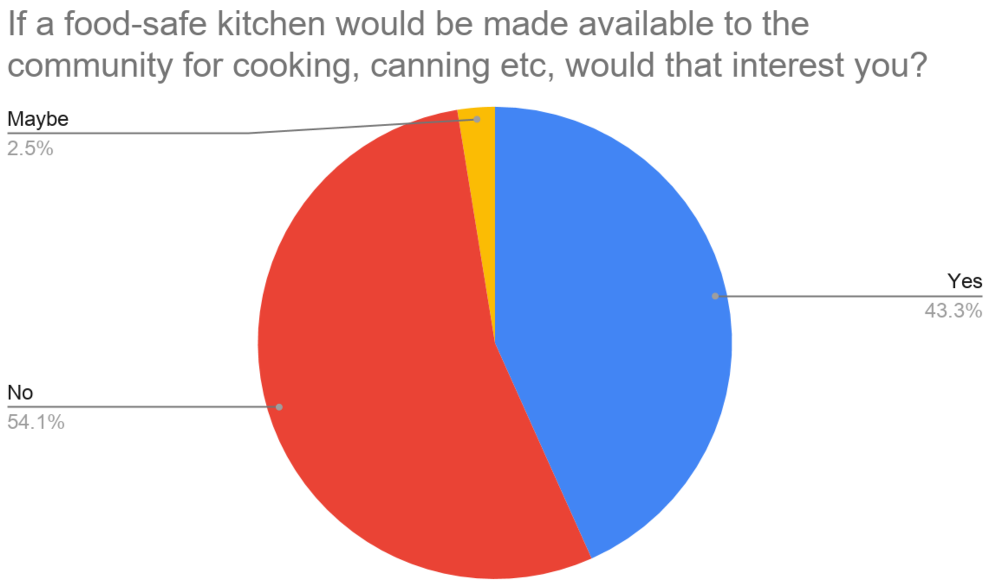


Chart 14: Access to Food Safe Community Kitchen

When formulating the question, it was hoped that the survey participants would comprehend that social gatherings were not meant for during the pandemic. Unfortunately, it was not understood as such by all. Despite this mishap, almost half expressed an interest in cooking classes and access to a food safe kitchen for making preserves etc. There were a couple of suggestions to facilitate cooking classes online so that everyone could cook from their own kitchens using their own utensils. An excellent option, albeit with limited community connection. Interestingly enough, some youth surveyed in the recent Youth Activities Consultation (2021)[62] expressed an interest in participating in family cooking class sessions so that they could connect more with their families and learn at the same time.

[62] https://www.sookeregionchn.org/youth-activities-consultation

Social/Cultural Indicators

Indigenous Peoples' cultural practices and traditional food systems are mutually supportive and both are vital for their food security and overall well-being, yet these systems are being degraded or destroyed for a number of reasons.[63] It also could be argued that through modernity and convenience all of our health and food systems do require improvement.

Availability, Accessibility and Acceptability of Food Resources

Vancouver Island is known for its more alternative lifestyle choices, where there are certainly many people that embrace organic foods and the natural environment. There are also those who simply do not have the time or energy to assemble wholesome meals or even afford the raw produce to prepare with. In any case, the items are available in Sooke. It is more a question of preparation time and skills and affordability.

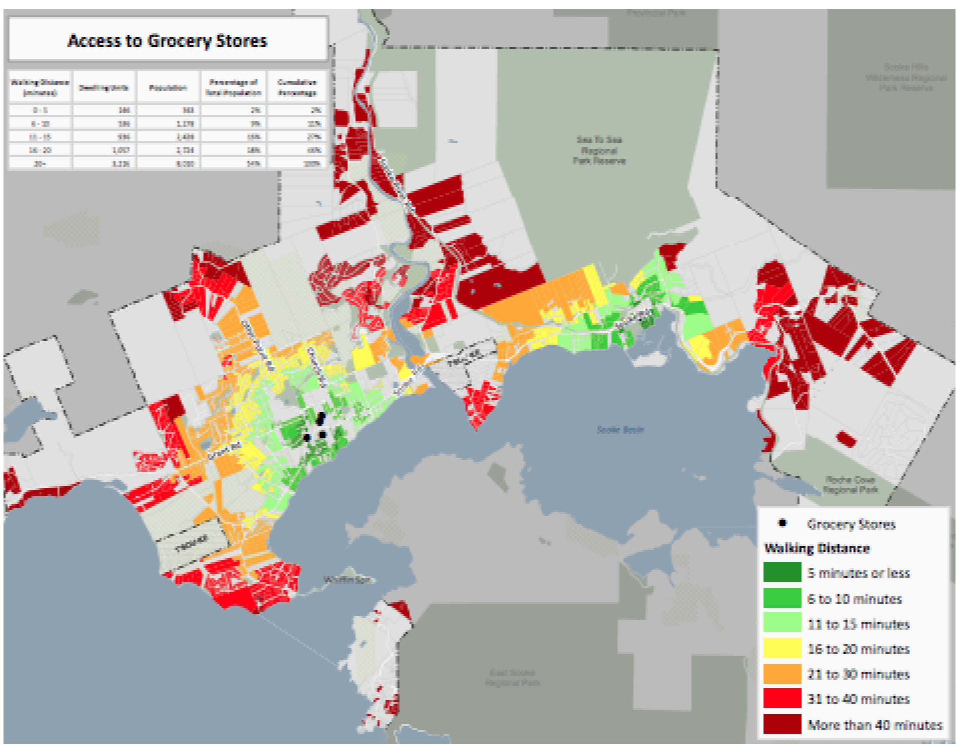
Interpreting the numbers for foraging, fishing and hunting in chart 9, there seems to be some activity in the community on that score. So it can be assumed that there are no particular barriers for those with an interest and knowledge of that type of food procurement. To note, in several provinces the food banks accept meat from hunters. The Fair Chase Food – GOABC's Meat Donation Program hunters in BC share bounty with local food charities.[64] A guide for food banks is also available on how to accept these donations.[65]

With regards to fishing, in years past the local community could buy locally fished fish at the wharf from the local fishing boats coming in. Currently it has to be sold to middle men and then is bought back and sold in the community at an inflated cost. It is understood that this is due to licensing from the province. However, it is an ongoing sorrow to many that local fish is not readily available to the community.

[63] Cultural indicators of Indigenous Peoples' food and agro-ecological systems*
[64] Responsible Food - Wild Harvest Initiative - GOABC in BC Canada
[65] https://www.foodbankscanada.ca/Safe-Food-Handling/Be-Prepared-to-Handle-Hunted-Game.aspx

Once outside of Sooke proper, there are no all year round food stores, with the exception of East Sooke. Delivery options exist through Western Foods, but one has to go to the store first and pick out the items. Thrifty's, located in the Westshore, delivers to Sooke only. During the pandemic, the local Seniors Better at Home program[66] and Sooke Family Resource Society were doing grocery shopping for their respective clients. The Sooke Food Bank started door-to-door delivery during the pandemic for its clients, adding Port Renfrew to its route.

Residents in rural areas usually have a garden and preserve their produce, if they are able-bodied. There is the tendency for some to stock up on food through big purchases in Langford at the box stores there, where prices are lower. One would need a vehicle and strong arms to push the shopping cart through long aisles to manage those trips.



Map 2: Access to Grocery Stores in Sooke (OCP 2010)

[66] https://www.sookeregionvolunteers.org/sooke-region-better-home-program-0

As one can see by the map above, green indicates proximity to the grocery stores cluster in the Sooke core (the green core to the left), while red shows a much longer walk. It should be mentioned that due to lack of sidewalk continuity, distances are not the only obstacle here. The green cluster to the right on the map does have a fresh produce market store next to a gas station sweet shop. The inner core of Sooke hardly has any housing. Taking those elements into account, most of the inhabitants in Sooke are either in the orange or red zones, which creates a car dependency and a barrier.

Those living in the rural areas are car dependent in any case, due to lack of bicycle paths and the distance from Sooke core.

Three public bus routes go to the Sooke core with bus stops across from both grocery stores, arriving from Victoria/Westshore (driving a circular route around the older residential area), East Sooke and Otter Point. In a past study done with senior citizens[67], concerns were raised about ascending and descending the bus with grocery bags. Families with young children in tow might also find using the bus to grocery shop challenging. At times bus stops were next to a ditch with no sidewalk, making it difficult to walk. The East Sooke and Otter Point routes operate only twice on weekdays during the day, so this is not always convenient for everyone, but the option is welcome.

Values placed on healthy eating, food and nutrition buying habits

When looking at Sooke's image, it could be argued that its appearance provides some contradicting value statements around health. The region promotes itself as a natural outdoors paradise, which indeed it is. However, with the numerous fast food and commercial chain stores lined up along the main road when one drives through the town, the signal is another. Grocery stores have healthier items on the outer rim of the establishment, while all the "cheaply" priced processed items cover all of the aisles in between. Sweets and snacks surround every shop till, and vending machines are equally

[67] Published Reports - Seniors Managing at Home (2016)

stocked with processed foods. Sporting events serve hot dogs and hamburgers along with soda pop.

Parents are encouraged to provide their children with homemade nutritious lunches, but time and again messages are sent home about disposing of plastic wrappers from processed food items or reminders not to bring sweets to school.

There is one natural food store.

The *Sooke Farmers' Market* was for years located on the side of a road in an inhospitable lot. Fortunately, it has been moved to a more accommodating location at John Phillips Memorial park next to the town hall. However, there are calls for a roofed all-year round market, which could further promote farmers and fresh produce consumption, as well as provide some community spirit during rainy days.

The Influence of Retail and Restaurant Chains

When driving along the highways of North America, one cannot avoid the clusters of retail and restaurant chains in cities and towns, Sooke included. Brand is the factor which has an impact on the consumer purchase decision-making process. Brands provide information about products and create associations that affect the mind of the consumer in purchase process[68]. The predominance of such entities have a negative influence on our eating habits and may lead to chronic diseases, in addition to contributing to community poverty in general .

Public policy has played a major role, particularly through tax incentives and other development subsidies that give national chains a significant advantage. To note, local businesses do have more of a tendency to invest locally, provide more employment and keep the money locally than chains would[69]. Some would state that the nature of corporate retail and restaurant chains, where funds are not re-invested locally but rather return to

[68] Henrieta Hrablik Chovanová et al. / Procedia Economics and Finance 34 (2015) 615 – 621 - p. 618
[69] https://ced.msu.edu/upload/reports/why%20buy%20local.pdf

headquarters is an "extraction economy"[70]. Picturesque and quaint communities like Chemainus, BC have older town cores that incorporate smaller retail spaces that do not accommodate the bigger box stores, yet encourage local businesses and walkability. Meanwhile, a growing number of communities are adopting land use rules that deter chain stores and actively encourage local ownership[71] to promote the local economy. Commissioned by the British Columbia division of the Canadian Union of Public Employees, a study[72] analyzes the economic impact and market share of the province's independent retailers and restaurants. With regard to economic impact, the study finds that, for every $1,000,000 in sales, independent retail stores generate $450,000 in local economic activity, compared to just $170,000 for chains. Among restaurants, the figures are $650,000 for independents and $300,000 for chains. Across both sectors, this translates into about 2.6 times as many local jobs created when spending is directed to independent businesses instead of chains. The study concludes that a shift of just 10 percent of the market from chains to independents would produce 31,000 jobs paying $940 million in annual wages to BC workers. With regard to market share, the study finds that while BC's independent retailers captured just over half of all retail sales as recently as 2003, they have since lost ground. By 2010, independents accounted for 45 percent of BC's overall retail sales and only 34 percent of the market with automobile and gasoline sales excluded. Although BC has a reputation for innovative planning initiatives, on this measure it lags the rest of Canada, where independents account for 42 percent of retail spending. Among restaurants, BC's independent sector accounts for 72 percent of full-service dining and 19 percent of limited-service dining.

In discussion with the Sooke Region Chamber of Commerce, it was explained how the high rents for retail space was actually leading to the inability of local shop owners to manage, let alone hire staff at minimum wage. Some accounts of local shop owners report a living below the poverty line.

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[70] The End of the Extraction Economy - Strong Towns
[71] The Impact of Chain Stores on Community – Institute for Local Self-Reliance
[72] "Independent BC: Small Business and the British Columbia Economy" [PDF]. *Civic Economics*, Feb. 2013.

There are larger communities in the U.S. that have banned chains of all types, but that has proven to be costly for low-income families that rely on the low prices that chains offer.[73] Indeed, our survey and consultations have shown that the need for cheaper food options is vital for low-income families in our community, as the present Sooke prices are too high despite having chains. If transportation was not an obstacle, busing being too cumbersome with multiple shopping bags, Sooke Region low-income families would prefer driving to the box stores in Langford where they get more for their money as confirmed by Sooke Family Resource Society.

Fast food restaurants have been highly scrutinized for serving high fat and energy-dense foods, which are low in nutritional value and have been linked to overconsumption and weight gain[74] [75]. In addition, fast food drive-through services provide a convenient and easily accessible way for individuals to purchase and consume foods without exiting their vehicle, also contributing to physical inactivity and distracted driving[76] [77]. In the last several years, fast food related bylaws, restrictions, and/or policies have emerged as a topic of interest in Canada, specifically pertaining to the adoption of municipal bylaws banning fast food drive-through services. However, little is known regarding the extent and spread of these bylaws among Canadian municipalities.[78] The simplicity of drive-thrus are well-known. Perhaps healthier ready-made and affordable meal services with pick-up, delivery or home preparation options could be developed as a local enterprise.

With regards to the visibility of large corporate signs, especially when the store occupies the whole width of a block can be perceived as an eyesore, but also a direct/indirect influence of shopping habits. In some areas of Toronto, they have started to place the

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[73] Retail revolution: should cities ban chain stores? | Cities - The Guardian
[74] Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. Annu Rev Public Health. 2008;29:253–72.
[75] U.S. Department of Health and Human Services. The surgeon General's vision for a healthy and fit nation. 2010.
[76] Feldstein LM. Zoning and land use controls: beyond agriculture. Maine Law Review. 2013;65:467–90.
[77] Sallis JF, Glanz K. The role of built environments in physical activity, eating, and obesity in childhood. Futur Child. 2006;16:89–108.
[78] https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-5061-1

larger store above smaller retail and restaurant spaces, in order to reduce dominating signage at the ground level as well as provide a less alienating facade. It would be recommended that signage by-laws be applied to limit exposure and provide equal signage space to local amenities and provide proper connecting sidewalk interface to allow for accessibility. By making the larger stores have equal visible storefront space by having the main area of larger stores removed from the ground floor or the larger stores operate more in depth of the structure, there will be a more aesthetically pleasing appearance through smaller scale and physician accessibility as there will not be such great distances between vendors[79].

When entering most of the retail chain stores in Sooke, one is surrounded by unhealthy consumables also when the stores in question are not related to food products at all. Addressing the retail food environment begins with checkout, where the vast majority of purchases are unplanned. By rethinking checkout, retailers could support their customers' health, rather than pushing the consumption of extra—and often unwanted—calories from candy, soda, and other junk food and sugary drinks.high rates of obesity, diabetes, and heart disease, the retail environment should be shaped not only by economic drivers but also by public health considerations[80]. It would be recommended to place sweets and snacks away from tills to prevent last minute impulse buys and exposure to children.

Nutritional Initiatives

In consultation with Sooke Family Resource Society, it was confirmed that low-income households were indeed aware of nutritional practices, but fresh produce affordability was their main obstacle. The processed foods are cheaper and filling; staving off hunger. Increasing existing fresh produce programs would be an important community value statement. The cost included in subsidized programming is still an obstacle for many in the low-income category.

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79 Retail Design Manual - City of Toronto (2019) - p. 21
80 Temptation at Checkout - Center for Science in the Public Interest

In the past, Island Health Public Health Nutrition Program tried to address the snacks and vending machines at the tills as well as in the schools. They did not have much success but might be willing to engage on this after the pandemic. There was a very detailed policy about food and Island Health worked with the schools to decrease the amount of unhealthy foods being consumed as well as sold for fundraising. There was a really successful snack program at Ecole Poirier but when the teacher who coordinated it left it was discontinued.

The "Healthy Schools, Healthy Communities" roundtable facilitated by SD62 and Island Health work together with partners to improve the health of the children through educational and food programming.

Seaparc Leisure Centre does aim towards a healthier environment for recreation facilities through the "Stay Active Eat Healthy" *healthy food and beverage approach*.[81] Perhaps something to be adopted throughout the region including the district.

Creating food sharing opportunities

Creating **social eating spaces** in public places and restaurants would encourage friends and families to eat together. There are picnic benches in some public parks and park benches at scenic spots. During the pandemic, restaurants were provided with some flexibility with regards to outdoor dining seating, which created an endearing ambiance that invited more restaurant dining. However, as most of the restaurants are along the main highway, noise and fumes from passing cars were off-putting. Shrubbery to create a barrier might be a temporary solution, but a more well-planned approach for future establishments would be advisable. The key is to make social eating spaces inviting and visible for frequency of use for meal sharing opportunities.

In the survey, people were asked if they were interested in **communal eating gatherings**. Some were a bit confused about this activity - "If I have a kitchen, why should I go to

[81] Everything Else - Stay Active Eat Healthy - BCRPA

another one?" appeared more than once. On the other side of the coin, there were many participating in the survey who would like to facilitate such sessions.

For a few years the Military Family Resource Centre had a monthly meeting in Sooke that took place over a supper. It was very popular but was cut for reasons not understood here. Pre-pandemic, Sooke Family Resource Society gathered the parents of their preschool children for common meals and cooking classes. This was also an opportunity to inform families about resources and make a connection between peers.

Creating such opportunities can teach about nutritional meals and be introduced to other food cultures. With three First Nations in the region, there is a richness of culture and gastronomy that most non-indigenous have not experienced. Use of nature in ways that have been for generations are being passed on. Their regular communal meals encourage conversations among generations to run freely and connections are strengthened. Also, simply learning to appreciate fresh produce and the amount of work and resources that go into it, provides a more mindful approach towards agriculture and food waste.

The District of Sooke Climate Action Committee's Education Working Group is working on Engagement and Social Mobilization, which support this approach.

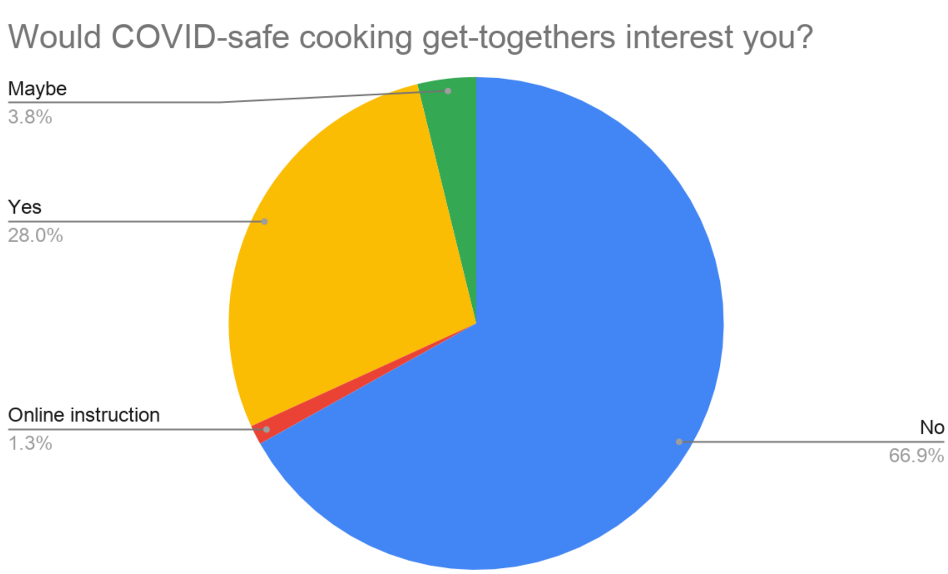

Chart 15: Cooking Get-Togethers

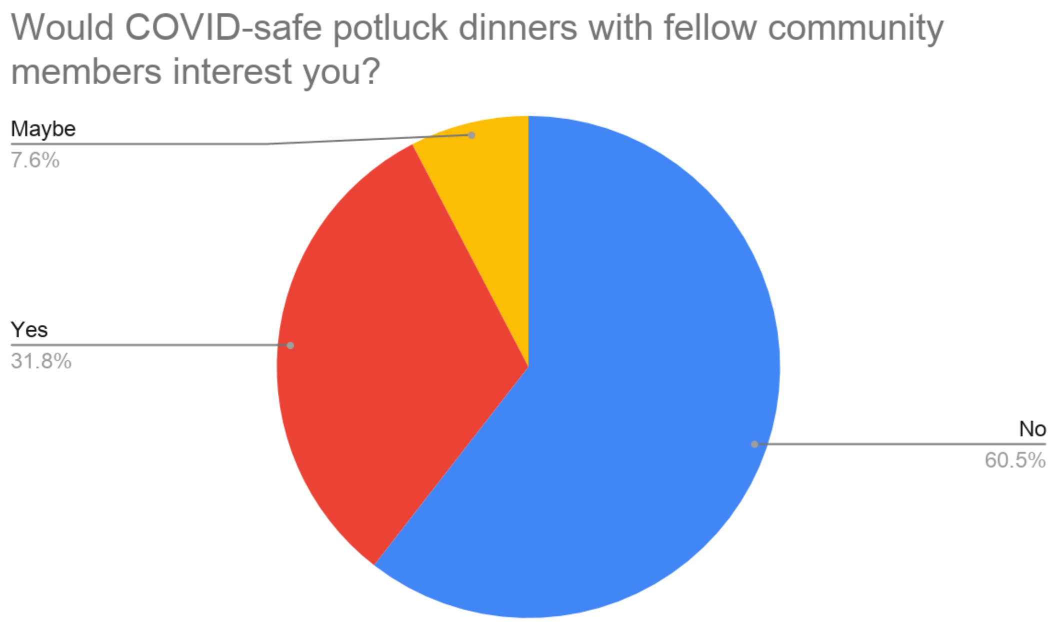

Chart 16: Potluck Dinners

Almost a third were willing to meet for communal meals, either for cooking sessions or potlucks. Referring back to Indigenous food culture, the rest of the community will have a better understanding of rituals, practices and community connection, and perhaps even improve upon eating habits as well.

Availability of culturally relevant and/or traditional food

Indigenous Food Culture

First Nations have deep traditions in hunting, fishing and foraging. The Sooke Region is fortunate to be located by the sea and surrounded by forest. Some traditions, stories and language have been lost due to residential schooling and past federal policies. However, a resurgence in interest from not only the Indigenous themselves but also others in the region, can help strengthen and grow the old practices.

The T'Sou-ke First Nation has presently one community greenhouse, the Ladybug Garden[82], where elders are provided with produce directly while some is used for the weekly Wednesday community meals. There are an additional three larger greenhouses, previously used for wasabi cultivation[83], that will be transformed for community food production. To note, the wasabi crop included 15,000 entities harvested annually.

This nation also has a fisheries program that coordinates activities and advises on fisheries, seafood and habitat throughout the territory.[84]

The T'Sou-ke First Nation engaged consultants from the University of Victoria to do a feasibility study on aquaculture. The study indicated that oyster and clam cultivation in the Sooke Basin was ideal for ecological, economical and cultural reasons. Presently, there are 8 hectares of oyster and clam cultivation taking place. With some external investment, this project is entirely owned and operated by the T'Sou-ke Nation. There are four million oysters per harvest with the capacity to grow 32 million.

It was discovered that the well-sought after abalone clams grew naturally in the basin, but these could not be harvested due to natural protection. It would be suggested that actual cultivation could be an enterprise worth pursuing. The same feasibility study showed that the Sooke Basin was not favourable for seaweed cultivation, but rather in sheltered areas in the Juan de Fuca Strait.

THe T'Sou-ke host initiatives such as the "Zero Mile Diet" and the "10 Mile Diet", where ingredients of meals are either collected around one's home or within a 10 mile radius. Banquets are held to celebrate what is locally harvested.

The T'Sou-ke Nation, working with three other First Nations in BC, is starting a three-year assessment of how to build Food Resiliency in the face of climate change looking at traditional resources. This project is funded by a grant from ECCC Federal Department of

[82] Ladybug Garden & Greenhouse - T'Sou-ke Nation
[83] T'Sou-ke Going Green… Really Green
[84] Fisheries - T'Sou-ke Nation

Environment and Climate Change Canada. Workshops are taking place addressing how to live off the land. It would seem that only one generation ago, the T'Sou-ke were doing just that. A three-year plan is being formulated. Here is a program they are working on for the coming year around building resiliency around food security:

1. Digging the clam beaches between docks in the basin and inner harbour and do a clam survey and work towards making it a yearly event with membership, perhaps even paddling to the clam digging sites.

2. Measure the health of the community by introducing traditional foods, clams, oysters, crab, stick-shoes, goose-neck barnacles, salmon, cod halibut.

3. Do some community work on their territory seasonally harvesting in the food forest with the seasons like the roots, shoots, berries and medicines.

4. Look into how this project can play a role in bringing down adverse effects of diabetes, measure future health concerns and increase health from hiking in our territory.

5. This project could strengthen them in their territorial rights in title and their Douglas treaty rights.

6. Advocate for the environmental health of their territory in a good way.

7. Over time a routine with the seasons in the harvest within their territory would be established.

8. Growing food at home plays a role in a lightfoot print approach towards the zero mile diet and over time hopefully routine.

To understand Indigenous food practices, the best way is to actively engage with the three First Nations in the region. In addition, reports such as "T'Sou-ke Traditional Food Resource Study - … and that's the way we did that"[85], "Cultivating Food Sovereignty - Indigenous Food Systems on Vancouver Island" [86] and "Traditional Foods: Are they Safe for First Nations

[85] "T'Sou-ke Traditional Food Resource Study … and that's the way we did that", by Melinda Jolley in collaboration with Quaqua-yuk (Frank Planes) and Gordie Planes (April 2000)
[86] Indigenous Food systems on Vancouver Island

Consumption?”[87] can be an educational opportunity for those who wish to understand more.

Indigenous Tourism BC[88]promotes an initiative called “Living Legends: Experiencing Culture Through Food”, which states that “each living plant and creature requires nourishment. The experience of gathering together to enjoy a meal is a celebration of success and survival. When we explore the food of another culture, we learn about available ingredients, seasonal practices, and local preparation techniques.” This is not only a learning opportunity for the region to understand and use the bounty that surrounds us throughout the year, but also a niche tourism activity involving culture and nature interpreters that is worthy of coordinating efforts in the Sooke Region to achieve.

Ethnic Food Culture

With regards to ethnic food needs, there are few immigrants in the Sooke Region. However, Sooke does have several Asian restaurants that are frequented often by the local community. The City of Victoria does have a larger and more diverse population, where there are shops and restaurants accommodating all tastes. Various cooking sessions have been conducted by Sooke Region Lifelong Learning[89]. “A Taste for India” was particularly popular.

Though the region is not culturally diverse as compared with other parts of Canada, healthy food cultures could still be adopted. Of particular interest might be from cultures with similar climate and conditions, in order to use or cultivate relevant locally found produce. Japan has a very similar setting to ours and has used millenia to perfect their fished and foraged cuisine, which has proven itself to be very healthy indeed. Sooke having a sister city

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[87] Traditional Foods: Are they Safe for First Nations Consumption?

[88] https://www.indigenousbc.com/stories/experiencing-culture-through-food?gclid=CjwKCAjwxuuCBhATEiwAIIIz0RblZsjmulwsluSPXt2c-O9tvwwXOwAoktGOHCNAys6MsNROgmCglhoC-78QAvD_BwE

[89] https://www.sookeregionchn.org/sooke-region-lifelong-learning

in Japan may seize upon this as an opportunity. Other eating cultures may be equally identified and explored with further community discussion.

Local Food Indicators

Food waste

In this report, it has been stated that food availability is not the issue, but rather finances. With food waste, it is argued that hunger is not a scarcity problem, but rather a logistical problem.

It is understood that the local grocery stores donate fresh produce to the Sooke Food Bank. It is doubtful that all of the food waste is being donated, as it is deemed too foul or there is a lack of capacity to distribute. A suggestion would be to sell unbunched items (“singles”) for a lower price to get rid of them before expiry.
Another suggestion would be to have a depot to sell “unwanted goods” that are still edible but discarded for whatever reason by distributors or stores at a cheaper rate. There is an app called Flashfood[90] that works directly with Loblaws chain to offer food discounts of up to 50% on a daily basis. A similar app in Toronto, called Feedback[91], lets restaurants post about discounted meals after peak times.

Or turn it the other way around, where stores replace all its quantity discounts [like buy two get the third free] with single item discounts to minimise food waste.[92] People can also be encouraged to write shopping lists or take pictures of the content of their fridge before heading to the store to avoid impulsive purchases.

The Loaves and Fishes Food Bank in Nanaimo accepts absolutely all donations from all over. They refuse nothing. They proceed to sort out the goods, whereupon some are

[90] Flashfood | Save money and reduce food waste
[91] FeedBack App | Diverting excess food by offering discounts
[92] How did Denmark become a leader in the food waste revolution? - The Guardian

distributed to food bank clients, then next are the farmers that take what they can for animal feed and composting. Apparently the animals do not appreciate citrus and onions. Items that are packaged end up in the landfill. However, this process has reduced the amount of food waste that ends up in the landfill.

Food Share Network[93] was developed by the Mustard Seed in Victoria and is an interface between food suppliers and agencies that require food for distribution to clients through the Give Food Get Food project. The Food Rescue project of perishable items from food producers and sellers was originally designed for emergency food needs, but has developed beyond that. All rescued food is repackaged through a packaging centre under Food Safe guidelines. 40 agencies benefit from this program.

At certain universities and workplaces, there is a system to post pictures of leftover food from events that are immediately picked-up for consumption by colleagues. A similar approach is being followed by Sooke's own facebook group, **Sooke Embrace.** Meals are prepared and followers needing a meal answer the call. Perhaps local restaurants and food stored could do the same, especially since such philanthropic gestures are exempt from liability.

Distance that food travels from farm to fork

The issue of food waste once the product has entered the food store and is no longer deemed a desirable product, has now become well-known. However, it is worth noting that over one third of food produced across the whole food chain is wasted; with 51% of this waste occurring before it reaches the consumer.[94] The more the produce travels to get to our tables, the more spoilage there is. If the origin of the fresh produce found in the local grocery stores were tracked, as most of them are imported from the United States, Mexico, and even further afield, there would be plenty of air or land miles to be reckoned with.

[93] Givefoodgetfood.ca
[94] Innovation for a circular economy - Agri-TechE

Having a bigger and more varied local produce production would save on CO2 gas emissions and provide tastier meals as the fruits and vegetables are harvested closer to readiness. Unfortunately, the success of large scale transportation encourages import over self-sustaining.

Food flow analysis

As most of the produce, fresh or otherwise, do not originate nor are processed in the region, a food flow analysis from farm to processor to store is rather complex and very much outside of this scope. It should also be stated that even if produce in major farming areas are headed *per se* directly to the store, there is still a stop at the packaging plant, where further waste is produced. The nutritive value drops the longer the trip and the more stops it makes towards its final destination - our tables.

Ability of local agriculture to meet nutritional needs of residents

Through round-table discussions with local farmers, it was acknowledged that the commercial farmers are not able to meet demand. They are producing at full capacity and still they are constantly being approached by community members to buy their produce.

Food grown on local farms go to either Victoria or local markets, local restaurants and hotels. Some are sold at food stalls on farm property. With Covid and the increased interest in buying locally, residents have been able to order from the individual farmer through referring to the online Food CHI Farm Guide[95], where pick-up and delivery options were made available.

The Sooke Country Market has online ordering through the Local Line website[96]

[95] http://sookefoodchi.ca/farm-guide/
[96] https://localline.ca/sooke-country-market

When referring to the Agricultural Census 2016, the Sooke Region is grouped with Saanich excluding the Saanich Peninsula (Juan de Fuca 2).[97] It is therefore not easy to discern the actual farm numbers, crops etc from that data, other than the fact that there are increasingly fewer farms. When referring to the Sooke Region Food CHI Farm Guide,[98] understanding that this does not include all farms, there is a predominance of greenhouse and green produce and very little farm animal production.

Percentage of food consumed in the region that is grown and processed in the region

There is no real data on this point. It is suggested by the content of the grocery store shelves, namely processed goods, come from Eastern Canada and the United States. In peak growth season, the stores may have fresh produce from the Okanagan Valley and other parts of BC, in addition to import produce.

Availability of local compared to conventional produce in retail stores

As local farmers are at capacity and sell either to markets, restaurants, hotels and some community members, there is often no produce to provide to the supermarkets even if there was a willingness to sell them. From a retail point of view, there might also be some concerns around regularity and sustainability throughout the year due to the short growing season, and upholding regular supply chains to keep prices down.

Price of local produce compared to imported food

Local produce is much more expensive than imported produce. An imported head of lettuce in season is $1.50 in the grocery store, while a farm stand equivalent would be between $3.00-$7.00. However, it will be argued that the taste of the local lettuce will be

[97] Statistics Canada. Table 32-10-0403-01 Farms classified by farm type
[98] http://sookefoodchi.ca/farm-guide/

more delicious and contain more nutrients as it was harvested more recently and at peak maturity and grown organically.

In the Sooke Region, local farmers' goods are generally considered niche producers for those who can afford to spend more for quality. Though it is understood that it is expensive to farm in the Sooke Region and the high produce prices cannot compete with imports, the fact remains that most people in our community do not have the disposable income to buy locally grown produce at the existing prices.

Farmers have voiced their concerns over restrictive by-laws that limit operations whether it be water taxes, the option to have tiny homes and modular units on Agricultural Land Reserve land to reduce start-up costs, the cost of farm hands or the lack of encouragement for young farmers to earn a living off the land in an area where property prices are so high, and yet many settled farmers on of retirement age not using their land at capacity and lack succession planning.

Indeed, the wide procurement of local foods for the masses is a conundrum. Though there might not be any silver bullet, through local coordination and ingenuity some measures may be found that could at least increase local food production that could benefit customers of also lesser means through subsidies, a voucher system etc. See section under "Potential Initiatives" for some suggestions.

Food Policy Indicators

Food Policies

District of Sooke

Identified agricultural strategies and policies for the District of Sooke are identified below:

- District of Sooke Agricultural Plan "Community Roots" (2009)[99]

[99] Agricultural Plan - District of Sooke

- District of Sooke Official Community Plan (OCP) (2010)[100]
- Ongoing consultations by the District of Sooke OCP including "Picture Sooke" campaign (2021)[101]

Food Security is addressed in Section 4.5 of the current OCP about Agriculture and Food Security Official Community Plan (OCP) Bylaw.[102] Gardening and growing of food is a permitted use in all zones. In single family, multi-family (the more urban areas) prohibits livestock and male poultry is prohibited on lots less than 2000m2, but the keeping of 6 female poultry is permitted on lots over 600m2 (provided conditions are met).

Agricultural plans were made over a decade ago and unfortunately there does not seem to be much progress in advancing the recommended strategies for the district. The conclusions and recommendations remain very sound, albeit some data requires updating. There is hope that with this OCP that there will be some empirical progress on that score.

Local initiatives to increase food production

- *Sooke Farmers' Market*[103] at Memorial Park - a seasonal weekly food and artisan market
- Community Gardens: *Sunriver Garden* and *Grace Garden* (Sooke Baptist Church) which surplus produce go to the Sooke Food Bank
- *Sooke Food CHI*[104]- working to create vibrant, sustainable food systems for the area including a Farm Guide, Apple Fest, Food Tree program, Seedy Saturday and the FED Garden[105] grow bag project.

Capital Regional District (CRD)

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[100] District of Sooke Bylaw No. 400 Official Community Plan, 2010 Page 1 of 212
[101] Official Community Plan (OCP) Review
[102] www.civicweb.net
[103] Sooke Country Market
[104] Sooke Region Food CHI Society | Food Community Health Initiative
[105] My FED Farm Garden (Backyard or Patio)

- Capital Regional District Food and Agricultural Strategy - "Setting Our Table" (2016)[106]
- Regional Foodlands Access Program - Feasibility Study (Executive Summary)[107]

As the CRD is mostly rural, agriculture is of priority and has therefore provided policies on indigenous interests, land protection, securing the agricultural base and economic development, while including climate change and ecological aspects to their strategic plans.

The Sooke Region Farmland Trust's objectives are to save local farmland from development and to return it to productive use by seeding the possibilities for a new generation of farmers.

Food Round Tables

School District 62 has actively promoted Healthy Eating[108] policies as well has co-established with Island Health the "Healthy Schools Healthy Communities" network, where food security is discussed.

Island Health promotes food security through the provincial Community Food Action Initiative[109], which aims to increase community food security for all British Columbians. The primary objectives are to increase awareness of food security, improve access to local and healthy food, promote food knowledge and skills, increase community capacity to address local food security, and develop policy to support community food security. Through this initiative, Food Security Hubs[110] have been established to develop community partnerships for the purposes of building community food security on Vancouver Island. Examples are the Capital Region, the Cowichan Valley, the Nanaimo region and the Comox Valley.

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[106] Setting Our Table - CRD
[107] Regional Foodlands Access Program Feasibility Study and Business Case
[108] http://healthyschools.sd62.bc.ca/#healthy-eating
[109] Community Food Security - Island Health
[110] Food Security HUBS

Capital Region Food and Agricultural Roundtable (CRFAIR)[111] brought together diverse organizations which were involved in the food system in different ways. The first ten years of our work focused on learning and networking, and undertaking public education to make food systems and food security issues a public priority. As the roundtable grew, CRFAIR established the Food Access Working Group, the Food Policy Working Group, the Farmlands Working Group, and the Food Literacy Working Group. Each of these working groups was made up of key stakeholders and experts who identified priorities and undertook research, education and action based projects to address key issues. It has now developed into a Food Security Hub and is supported financially by Island Health, as cited above.

The Capital Regional District has built numerous water fountains to deter pop drink consumption and plastic water bottle waste. In addition, the CRD facilitates the Regional Outcomes Monitoring (ROM) Collaborative, and; the development of an online mapping resource to identify inequities in the region through the visualization of local data and community assets. It promotes community health and wellbeing.[112]

A similar health initiative exists in the Sooke Region, namely the Sooke Region Communities Health Network[113], but the aspect of food security is being addressed only now. The Sooke Food CHI[114] , mentioned earlier in this report, has promoted the agricultural and gardening aspect in the region.

Two unofficial food security gatherings between food producers and consumers took place in 2015 and 2016 as a result of lack of activity on that front in the region. It was ascertained that the existing farmers were already at capacity and that it would be in everyone's interest to increase local food production, to promote commercial industry in this sector

[111] CRFAIR
[112] Community Health & Wellbeing | CRD
[113] www.sookeregionchn.org
[114] Sooke Region Food CHI Society | Food Community Health Initiative

through agritourism, but also to diversify our food through understanding our environment, our Foodshed.

Foodshed

Food self-sufficiency seems like a dream due to our short growing seasons and dependency upon imported goods for more of our food consumption. The City of Campbell River's Sustainable Official Community Plan[115] has a chapter committed to food security and food self-sufficiency. By 2031, Campbell River will be at least 10% self-sufficient in food, a community garden will exist in every neighbourhood and the local farmers' market will be an important direct marketing opportunity for local producers. By 2060, it will have 50% food self-sufficiency with a largely self-reliant agriculture and food system, and food stores with healthy food within a 10-minute walk of nearly all homes. There are communities on the island that are dedicating themselves to his concept.

In order to take these steps in the Sooke Region, an overview of our Foodshed is required. A Foodshed is a catchment area for our food, which is geographical, financial and cultural. It's both natural and human-built, and its food source is from both land and water by traditional and conventional means. It is the entirety of a system that moves from the source to the consumer.

A Foodshed working group consisting of farmers and interested parties, gathered in 2015 came with the following.

Problem analysis:

1. The demand for local product is exceeding supply
2. Consumers are detached from agriculture, lack of awareness
3. No organized produce sales organization in the region
    - a Farmers' Market has been established since then
4. High cost of small farmers' input due to low quantity purchase
5. Lack of infrastructure to facilitate production at a lower cost

[115] https://www.campbellriver.ca/docs/default-source/Document-Library/plans/scr-framework-integrated-community-sustainability-plan.pdf?sfvrsn=8bf58d09_1 - p. 59

6. Strict regulations and legal structures inhibit growth and entrepreneurship
7. No succession planning
8. Lack of possibilities for young potential farmers to start in agriculture due to extremely high start-up costs
9. Traditional food gathering practices are not understood by most

Strategic priorities identified by the same group:

1. Understand what is challenging the abilities of the Sooke Region to produce enough food
2. Create a coordinated and managed Foodshed
3. Promote local produce
4. Get consumer buy-in
5. Create opportunities for local businesses and tourism sector
6. Create other beneficial opportunities in the region
7. Regional sales of local food, i.e. a community food store or cooperative
8. Reduce cost for farmers
9. Access locally grown seedlings
10. Increase availability of service of mechanics, bailing etc
11. Reduce cost of infrastructure, i.e. a cooperative machinery pool, abattoir
12. Food processing facilities
13. Understand legalities to facilitate growth
14. Establish succession in farming as an occupation
15. Increase interest in farming as an occupation
16. Maintain/increase agricultural land percentage in the region
17. Promote cooperative farming
18. Promote tenure
19. Research financial incentives
20. Find non-intrusive/non-destructive ways to benefit more from the natural bounty in the region
21. Promote agri-tourism

In turn, community members had an opportunity to chime in. In 2016, the Sooke Region Health Summit was organized where community members addressed four main topics, namely physical and mental health, age-friendly community, socialization and food security.

The five key findings from the Foodshed working group were:

1. Significant concern exists over the high cost of healthy food (including organic), especially for low income families in the Sooke Region

2. Service agencies, including the Sooke Food Bank and churches, are straining to meet the demand for healthy food

3. Many families lack the opportunity and/or skills to grow or prepare healthy food

4. The limited availability of locally produced healthy food is linked to restrictive or prohibitive regulations and the high costs of production (land, labour, inputs)

5. Potentially productive land is underutilized in the Sooke Region.

We could also include regenerative farming as a way to capture CO2.

These align with most recommendations made in District and CRD strategies, with some room for holistic visioning. The ideas and willingness are present in the community. It is time to move forward with practical implementation.

Food Policy Councils

In 2019, the Federal Government, through Agriculture and Agri-food Canada, published a "Food Policy for Canada"[116] where a roadmap for 2019-2024 is laid out to improve upon the six following points:

1. Vibrant communities: Improved community capacity and resilience to food-related challenges. Innovative community-led and community-based initiatives contribute to vibrant and resilient communities that support individuals and households facing immediate and long term food-related challenges by providing culturally diverse solutions in an inclusive manner.

2. Increased connections within food systems: Increased governance spaces and partnerships that connect multiple sectors and actors across the food system. Increased collaboration on food-related issues across sectors of government, society, fields of work, and academic disciplines is a central component of food policy. Increased connections across the Canadian food system will strengthen our ability to make progress together on food-related issues and adapt to emerging needs.

[116] Agriculture and Agri-food Canada: Food Policy for Canada - Everyone at the Table

3. Improved food-related health outcomes: Improved health status of Canadians related to food consumption and reduced burden of diet-related disease, particularly among groups at higher risk of food insecurity. The food that Canadians eat is a key determinant of their health and wellbeing. Everyone involved in the food system can work together to make it easier for people living in Canada to have sufficient access to safe and nutritious food, maintain a healthy diet that is culturally diverse, and reduce the burden of diet-related disease.

4. Strong Indigenous food systems: To be co-developed in partnership with Indigenous communities and organizations. The Food Policy for Canada will help advance the Government of Canada's commitment to Reconciliation with Indigenous Peoples, build new relationships based on respect and partnership, and support strong and prosperous First Nations, Inuit and Métis food systems – as defined by communities themselves.

5. Sustainable food practices: Improvements in the state of the Canadian environment through the use of practices along the food value chain that reduce environmental impact and that improve the climate resilience of the Canadian food system. It is essential to maintain the health of our natural resources so that we can continue to provide food for future generations. Greater efforts to develop and maintain sustainable food practices will help make better use of natural resources, lower greenhouse gas emissions, and create efficiencies and financial savings across the food system.

6. Inclusive economic growth: Improved access to opportunities in the agriculture and food sector for all Canadians within a diversified, economically viable, and sustainable food system. There is tremendous potential for economic growth within Canada's food system given the growing global demand for high-quality food that is nutritious and sustainably-produced. Canada is well-positioned to supply this demand while maintaining an increasingly diversified and inclusive food and agriculture sector.

By having a coordinated body such as a Food Policy Council to look at our food systems holistically and not only from the provider or beneficiary perspective, a more comprehensive food provision could be established.

Food CHI members met with several other non-profits in early 2020 and the group had identified the creation of a Sooke Region Food Policy Council. At that time, the District of Sooke was not in the position to act on this initiative. Now with the new financial incentives from the province and grant funders, this would be an ideal time to establish such a council for the region. It is recommended that the Sooke Region Food Policy Council either fall under the District of Sooke's Community Economic Development Committee with representation from the CRD or a separate entity with strong representation by the District of Sooke and the CRD.

Food Hubs

In 2021, the province of BC invested $2.1 million in the development of an island-wide food hub network.[117] This is to establish the economic stability and growth of small and middle-sized businesses and farms in the hope to reduce food insecurity. Port Alberni is showing some success already with seafood processing and access to a commercial kitchen where food processors may refine and develop new products.[118] The new additions Cowichan Valley and Victoria (South Island) will support farming and food processing, while Bowser will focus much like Port Alberni on seafood processing. In Cariboo, their food hub includes rental opportunities for the food safe kitchen, while also benefiting from workshops and training.[119]

There are many independent entrepreneurs, agricultural, artisanal and others, in the Sooke Region that would greatly benefit from such occasional rentals as this would reduce investment costs. Such activities could also provide the community exposure to ocean and

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[117] Province invests $2M in three Vancouver Island food hubs – Sooke News Mirror
[118] Port Alberni food hub opens commercial kitchen space – BC Local News
[119] B.C.'s newest 'food hub' opens in Cariboo region to support food entrepreneurs - CBC News

land produce, and hopefully provide an affordable and healthy food option. As identified earlier in this report, there are numerous food safe kitchens in the Sooke region of varying sizes, which could be potentially utilized with the understanding that there are liability and availability issues to be resolved for such use.

As the South Island Food Hub in Victoria is partners with the Capital Region Food and Agriculture Initiatives Roundtable (CRFAIR) and the Foodshare Network to promote a healthy and sustainable food system in the Capital Region with a focus on land agriculture, it might be suggested that the Sooke Region could be sidelined due to the Sooke curve geographical divide, as has happened in the past with other Western Community collaborations. A couple of Sooke farmers are already actively participating in the South Island Food Hub, and in April 2021 delivery of produce along aggregation points on distribution routes were being considered.

It would depend upon this region's commitment and leadership representation on how this would be organized. A choice would have to be made whether to actively join this group or to have a separate Sooke Region Food Hub or a "sub-hub" in order to allow for larger collaboration opportunities, while developing local solutions with both land and sea. The latter is being highly promoted by the federal government through their Federal Blue Economy Strategy (2021).[120]

Sooke Region Food CHI also reached the understanding that the Food Hub may not be ready for a full scale processing of foods yet, but it is agreed that the concept of a Food Hub is timely with the funds from provincial and federal governments. There is a community willingness to work together to help pull some of these items together and implement them now. Like many many initiatives in our community, it is through interaction and smaller successes the hub will be strengthened in capacity to be able address the bigger items with time.

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[120] Fisheries and Oceans Canada - Canada's Blue Economy Strategy

Potential Initiatives

There are many exciting and feasible agricultural models that could be implemented in the Sooke Region, including the District of Sooke. The following are just a few that could be considered. Some are already taking place on Vancouver Island or elsewhere in Canada. The approaches are feasible through clear goal setting and community collaboration, including the various authorities.

Community Supported Agriculture

For over 25 years, Community Supported Agriculture (CSA)[121] has become a popular way for consumers to buy local, seasonal food directly from a farmer.

Here are the basics: a farmer offers a certain number of "shares" to the public. Typically the share consists of a box of vegetables, but other farm products may be included. Interested consumers purchase a share (aka a "membership" or a "subscription") and in return receive a box (bag, basket) of seasonal produce each week throughout the farming season.

There are several CSAs in the Sooke Region already. To note, CSAs can also benefit from the sea as well as land. A CSA fishing boat would bring fish from the Juan de Fuca Strait back to Sooke Region tables.

Cooperative Farming

Farming and agricultural co-ops[122] were among the first co-operatives in Canada. Today, this sector is a key player in Canada's cooperative and mutuals movement, and is undeniably a heavy weight in this sector of the Canadian economy. This well-developed sector offers established co-op models that fall into three groups: processing and marketing co-ops (384), such as dairy co-operatives; farm-supply co-ops (182), such as seed

[121] Community Supported Agriculture - LocalHarvest
[122] AGRICULTURE AND AGRI-FOOD $6 billion $15 billion - Cooperatives and Mutuals Canada

co-ops; and farm support co-ops (693), such as farm equipment co-ops. Particular to this sector, a majority of agri-food co-operatives are constituted as producer co-ops.

Farm cooperatives could be arrangements between fellow farmers to farm a piece of land that they could not afford to purchase on their own. An example of which can be found in Sooke where several families joined together.

Cooperative Food Purchasing

Through buying in bulk, the prices could be reduced for members, including low-income earners. **Bulk buying clubs** are often smaller, more informal groups of friends or neighbours that come together to buy food in bulk to save money. **Community Food Smart** is a bulk food buying club organized as a partnership of organizations, working together to provide their members with the opportunity to obtain nutritious fruits and vegetables at the lowest price[123].

Cooperative Businesses

A **Business Cooperatives**, also known as a co-op, is a type of organization that is both owned and controlled by its members, who also happen to use the services and products of the cooperative. These businesses are different from other types of companies, because they are formed and operate for the benefit of their members[124]. **Workers Cooperatives** have proven to be an effective tool for creating and maintaining sustainable, dignified jobs; generating wealth; improving the quality of life of workers; and promoting community and local economic development, particularly for people who lack access to business ownership or even sustainable work options[125]. **Newer cooperatives** often have different goals than their predecessors. They want to go beyond serving their members to do good in the broader world. They can adopt complex, multi-stakeholder ownership structures to address complex challenges[126]. The cooperative business model could apply to food related operations, service provision, banking etc.

[123] Start Your Own - Community Food Smart
[124] The Advantages of a Cooperative Business - Small Business Chron
[125] The Benefits of Worker Cooperatives | Democracy at Work Institute
[126] How to Adopt a Cooperative Business Model — NBS.

Ecovillages (Farm Villages)

An *ecovillage* is an intentional, traditional or urban community that is consciously designed through locally owned participatory processes in all four dimensions of sustainability (social, culture, ecology and economy) to regenerate social and natural environments.[127]

Ecovillage projects can be educational centres, green schools, permaculture centres and agro-ecological farms, transition initiatives, social and community enterprises, online communities, etc. There are 42 ecovillages in Canada, with several in BC.

Rainwater Catchment

Rainwater harvesting is the collection and storage of rainwater for potable and nonpotable uses. With the right controls in place, harvested rainwater can be used for irrigation, outdoor cleaning, flushing toilets, washing clothes, and even drinking water.[128]

As for farm utility, there are 8 different methods:[129]

1. Swales
2. Rain barrel system
3. Keyline design
4. Vallerani system
5. Imprinting
6. Trincheras
7. Gabions
8. Water retention landscapes

Depending upon the property, the easiest way is probably the rain barrel system as they can be filled up quickly in our climate zone during the long rainy season, and a micro-drip irrigation system.

One good property of rainwater is that it is a soft form of water and does not impact plants negatively. Unlike hard water, that adds calcium carbonate to crop plants, forming a

[127] What is an Ecovillage - https://ecovillage.org/projects/what-is-an-ecovillage/
[128] Rainwater Harvesting
[129] Rainwater Harvesting: 8 Methods

coating on the roots/leaves. Also, rainwater is a preferable source of drinking water for livestock compared to chlorinated water.[130]

The Regional District of Nanaimo developed a rainwater catchment guide for homeowners.[131]

Pollinator Hedgerows

Establish hedgerows, buffer stips and other meadows for native bees and pollinators.

Aquaculture

Aquaculture is the farming of aquatic organisms, e.g. fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, e.g. regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. The T'Sou-ke Nation have been harvesting from clam and mussel farms for years, along with other traditional ocean harvesting activities.[132]

Seaweed Farming and Processing[133]

Kelp captures carbon dioxide, and then they actually help bury it in a place from where it's very difficult for it to come back into the atmosphere.[134] Not only is seaweed used as food for human consumption, but is also used as fertilizer, animal feed, fish feed, biomass for fuel, cosmetics, integrated aquaculture and wastewater treatment.[135] Interestingly, livestock fed with some seaweed in their feed (80g) had reduced methane levels by 82%.[136] If the region wants to develop beyond a primary resource sector, a seaweed processing plant

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130 Rainwater Harvesting for Sustainable Agriculture - The Permaculture Research Institute.
131 Rainwater Harvesting
132 Fisheries - T'Sou-ke Nation
133 'Regenerative ocean farming' could be coming soon to a coast near you - CBC News
134 Why seaweed might be the next key asset in the fight against climate change - CBC Radio
135 OTHER USES OF SEAWEEDS - FAO
136 Feeding Cattle Seaweed Reduces Their Greenhouse Gas Emissions 82 Percent - Uni. of Calif. Davis

would cost around $1.2 million dollars. This plant would dry and make flakes out of the seaweed to facilitate transport.

The biggest obstacle hindering the expansion of seaweed aquaculture is the length of time it takes to secure licences from the federal and provincial governments and agencies.[137]

Vertical Farming[138]

There is the option to attain more land for agricultural purposes. If farming activities are to increase, then that might be the way to move forward. However, it is possible to increase the amount of produce with high-density farming on land that is not necessarily agricultural land. This project can be established in an industrial zone, waste land or even mall rooftops.

Vertical farming is a new form of urban agriculture that can be grown in industrial zones or building rooftops. A vertical farm is able to use 95% less water, because it is recycled. Because production is indoors, there virtually is no need for herbicides and pesticides. Vertical Farming makes the year-round cultivation of food possible and adaptable to a variety of crops. The primary focus of all functions in and around vertical farming is on optimal plant growth while maximizing the use of natural resources, such as the sunlight. This is why vertical farm production is no longer dependent on using fossil resources.

Hydroponics is when a plant is fed using a water and nutrient mix and is not supported in soil. Sometimes the roots of the plants will be suspended in an inert substance like volcanic glass or coconut husk mixtures that retain water and structure to support the plant roots.

Aeroponics is similar to, and often sub-categorized under hydroponics. Plants are fed using water and nutrient mixtures, but it is applied via mist or vapour on the exposed roots of the plant.

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[137] Should Canada be hungry to farm seaweed? - National Observer

[138] VERTICAL FARMING. - Vertical Farm Institute

Aquaponics integrates aquaculture and hydroponics into one production system. Aquaponics relies on the food introduced for fish, which works as the system's input. As fish eat this food and process it, they transform it into urine and fecal matter, both rich in ammonia, which in sufficient quantities can be toxic to plants and fish. Afterward, the water (now ammonia-rich) flows, together with uneaten food and decaying plant matter, from the fish tank into a biofilter. Afterward, inside this biofilter, bacteria break everything down into organic nutrient solutions (nitrogen-rich) for growing vegetables.[139]

The two recirculating systems in which fish and plants are produced in separate units. Smart software and sensors continuously take measurements and interconnect the two cycles, whenever needed, to make optimum use of synergies, whilst still creating the best growth conditions for both units. The aquaponics approach is profitable if facilities are sufficiently large. The main obstacles for commercial aquaponics are the high investment costs.[140]

Using soil and substrate mixtures for planting is a method well known to any farmer. In vertical farming however, instead of requiring large surface areas exposed to the sun, plants are grown on shelves using high-efficiency LED lights and hydrated using a water recycling system.[141]

Mushroom Farming and Processing[142]

BC is the second largest producer of mushrooms in Canada after Ontario, but there are hardly any mushroom farms on Vancouver Island despite its favourable conditions. Mushrooms are very diverse in not only species but also in uses.[143]

1. Ethanol fuel
2. Crop companionship

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[139] What Is The Aquaponics System? Definition, Benefits, Weaknesses
[140] Combined production of fish and vegetables can be profitable - Science Daily
[141] Vertical Farming: Growing Up? - Crop Tracker
[142] Six Steps To Mushroom Farming | How To Do Mushroom Farming - Mushroom Council
[143] 9 mushroom uses: Surprising uses for the fungus that improve your life - Inverse

3. Skin care
4. Tea
5. Vegan leather
6. Fight cancer
7. Hair loss
8. Building materials
9. Burial suit
10. Styrofoam substitute.[144]

Though the health and hair benefits may be debatable, there are definitely some processing and commercial opportunities to explore, in addition to primary resource production.

Solar Greenhouse[145]

The core LUMO technology is a light-altering dye that converts green light to red light. Red light has the highest efficiency for photosynthesis in plants. The absorbance of chlorophyll a and b, two pigments found in plants that are critical to photosynthesis, highlights the fact that plants absorb in the blue and red portion of the spectrum, and not in the green. In extensive plant trials, crops under LUMO have experienced positive growth responses, including increased yield, faster time to maturation, and disease resistance. The greenhouse structure is leveraged as the LUMO solar panel racking system, which reduces installation and material costs and creates eligibility for up to 30% in ITC solar energy incentives, MACRS solar depreciation and an additional 25% USDA REAP grants. The LUMO allows commercial growers or investors to produce more revenue with 20% to 30% less capital input on new greenhouse construction, and LUMO solar panels come for FREE.

[144] Company Uses Mushrooms to Grow Plastic Alternatives - JStor
[145] Solar greenhouses Soliculture

South Island Abattoir

Transportation to Nanaimo is a trial for animals before slaughter. Stress is known to affect the quality of the meat, in addition to unnecessary cruelty to the animal. A mobile abattoir was suggested in the past, but apparently this was not deemed food safe. A second best option would be to have an abattoir on the South Island.

Young Agrarians[146]

A spin-off from L'art terre in Quebec, Young Agrarians developed in BC as a landsharing or lease agreement between an established farmer perhaps wanting to retire and a young potential farmer. Retiring farmers often need to sell the farm in order to retire. However the younger generation is not able to afford to buy larger properties, especially on Vancouver Island with its high property costs.

Young farmers are recommended to work on someone else's farm for a few years first and then develop a business plan.

Young Agrarians match established and new farmers. Through the match, the established farmer may mentor the aspiring farmer. It developed a "Transition Tool Kit", a "Land Listing" and a "Land Access Guide". Legal assistance when drawing up contracts is provided. The website also offers garden space sharing, where owners not able to cultivate can benefit from the bounty of someone else's efforts on the owner's plot.

[146] Young Agrarians - Growing the next generation of farmers and food lovers in Canada!

Circular Economy Applied to Agriculture[147]

Farming is energy intensive and a major pollutant, especially where animal production is concerned. As livestock production has been decreasing in the region, that does minimize the adverse effects such activity has on the environment.

1. Water reuse (recycling irrigation water) and/or water re-catchment
2. Precision agriculture
3. Bio-fertilizer
4. Biofuel

Within the agricultural realm, the circular economy approach suggests that the industry can achieve greater sustainability simply by keeping more resources and materials in use for as long as possible. This can be achieved in a number of different ways, including increased product durability, reuse and recycling.[148]

Fondaction[149]

This is an investment fund dedicated to the circular economy, including sustainable agribusiness. Developed in Quebec and for Quebecers, this is a model that should be encouraged in BC. More than 177,000 Québecers invest with Fondaction. Various instalment options make retirement savings accessible to everyone.

Available in close to 2,500 workplaces, Fondaction offers retirement savings by payroll deduction to about 50,000 unionized and non-unionized workers. These people save with every pay without upsetting their budget. They enjoy immediate tax savings, reducing the impact on their take-home pay.

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[147] Circular Economy: Waste-to-Resource & COVID-19 | Land & Water | Food and Agriculture Organization of the United Nations | Land & Water

[148] Agriculture and its contribution to circular economy – Cleanfarms.

[149] Affordable retirement savings for everyone (RRSP) - Fondaction

By investing in Fondaction, shareholders improve their financial situation at retirement. They accumulate shares and enjoy tax credits from the governments of Canada and Québec, in addition to the tax benefits of a registered retirement savings plan (RRSP).

Recommendations

This report is for the community as a whole or to be used by independent entities for their respective purposes. Some recommendations seem self-evident as to who should address them, while others will require some more thought and task allocation between different community entities. They may require advocacy at higher levels than the Sooke Region, while others will be related to by-laws and regulations or even grass-root initiatives. It is advised that through a community impact approach[150] a patchwork of political authorities, businesses, service providers and community members contribute through coordinated activities to reach community established goals with this report and others that already exist and are readily available. With the exception of proposed infrastructure, building and industrial projects, the **grand majority of the recommendations are short-term activities with long-lasting rewards**. The platforms to address these issues have been suggested in the body of this report as well as in the recommendations listed below.

Poverty Reduction and Food Security

- When undertaking a review of the zoning bylaw following OCP adoption, consider revisions to the zoning bylaw in the context of poverty reduction or equity lens.
- Address the impact of discrimination on individual and group circumstances through safety practice, intersectional practices, representation in community development and decision-making processes, including efforts towards reconciliation[151].
- Advocate for policies that would entail a living wage and fair working conditions.
- Support and grow services that support low-income households, providing programming that is motivating rather than stigmatizing the different affected groups, and not over-burdening already weary households. Holistic support should be guided by social determinants of health.

[150] What is Collective Impact? - Collective Impact Forum
[151] Racism Consultation Survey Report - ICA Victoria

- Build affordable housing rental units that are close to the town core or public transportation route. From an ecological and social services aspect, apartment blocks are preferable.
- Create a community service navigator system where community members, especially the most vulnerable, can consult to attain appropriate benefits, advice and services, including housing, income tax and mental health, to support them in their individual circumstances compassionately while increasing in-pocket funds.
- Improve physical accessibility to healthy food sites through sidewalk and bike connectivity and public transport.
- Promote food vouchers for the most vulnerable to purchase produce with local farmers and farmers' markets.
- Advocate for affordable but also appropriate housing where renter and landlord rights are equally upheld.
- Promote option to have a common online platform where food providers including restaurants and producers can advertise food that is still consumable but no longer sellable.

Community Spaces

- Encourage "healthier" local businesses that keep the region's money in the region.
- Continued promotion of healthy food at vending machines, meals served at various institutions and food stands at public and sporting events.
- Encourage sales and use of products that are transformed from locally grown or "abandoned" produce to avoid waste and stimulate local commerce.
- Create inviting social eating spaces in public places and at restaurants, including options for coverage for those rainy days.
- Address the possibility of a covered Farmers' Market so that local fresh produce could be sold all year round, as well as providing a venue for local entrepreneurs to sell their wares.

- Adopt and promote healthy food and beverage consumption and sales' policies for public buildings, recreation centres and social/sporting events.
- Pass or amend policies restricting food and beverage marketing in all settings frequented by children (e.g. libraries, recreation centres, parks.)[152] .
- Influence shops that sell unhealthy snacks to place these items in one location away from the till to reduce impulse buying and overexposure to children.
- Adopt and promote healthy workplace and organizational eating policies (e.g.serve healthy foods at local government meetings and events using the Eat Smart, Meet Smart guidelines)
- Increase access to and beautify water fountains/hydration stations.
- Promote permits and incentives for healthy food retailers, especially in underserved neighbourhoods.
- Promote a farm to school and farm to cafeteria program.
- Promote use of food safe community kitchens, including this item in the zoning by-law. At present, small-scale processing of craft or artisan items are permitted with restricted floor areas of 200m2.

Agriculture

- Follow recommendations from Sooke Agricultural Plan 2012 and DoS OCP 2010.
- Inventory of farms - number, types, dormant farmland, brown fields etc., and explore ways to utilize them to the benefit of the community or to increase employment in a sustainable manner
- Enable green houses including vertical agriculture and hydroponics in industrial zones and on buildings (rooftop agriculture). To determine if this can be supported.
- Stimulate ideas around how new farmers may reduce starting costs through housing and equipment storage on ALR land.

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[152] Healthy Eating & Food Security - Plan H (p. 3)

- Create infrastructure (i.e. water and sewage) to facilitate greenhouses and similar food producing and processing operations at the industrial zone.
- Establish aquaculture farming and processing.
- Promote and facilitate farming mentorship programs including the Young Agrarians Program.
- Promote cooperative farming and fishing, where farmers and fishermen can get capital up front and community members have a more steady supply of local produce.
- Establish rainwater catchment infrastructure to reduce water use for gardens and agriculture.
- Increase property taxes on agricultural land not used for agricultural purposes, if no valid reason can be provided, to avoid brown fields and encourage land leasing to young farmers, or have a two-tier system for example $3,500 vs $10,000 income threshold where there is a bigger tax break to encourage farmers to produce even more on their land.[153]
- Support local agriculture by protecting existing Agricultural Land Reserve and adding land to this reserve where appropriate (see Sooke Region Farmland Trust).

Food Gardens

- Promote and facilitate gardening mentorship programs, including the FED program and the Sooke Garden Club.
- Promote and coordinate neighbourhood fruit tree cultivation and produce sharing programs.
- Promote neighbourhood garden surplus exchanges.
- Subsidize, promote and coordinate gardening programs where those who are able bodied and willing without gardens can cultivate gardens of those who do not have time or are not able to garden, with a share of the crop.
- Designate areas for urban community gardens, edible landscapes and local food markets and offer access to underutilized local government properties

[153] Encouraging Agriculture Production through Farm Property Tax Reform in Metro Vancouver (2016) - Metro Vancouver (p. 15)

- Tax reduction for having sizable gardens (size to be determined) over lawns
- Promote food skills programs such as food preparation, preservation and appreciation, and budgeting for food expenses facilitated through Food Safety courses[154], Indigenous workshops and social programs.
- Include neighbourhood fruit tree schemes with a potential tree management by-law in coordination with FoodCHI's fruit gleaning project to reduce human-wildlife interaction.

Collaborations

- Establish a **Sooke Region Food Policy Council** - facilitated by both the District of Sooke and the CRD partnering with food producers and providers, businesses, health authorities and service agencies.
    - Engage a regional Food Security Coordinator to holistically coordinate activities from the beneficiary and producer/provider angle.
    - Improve food systems, including indigenous communities
    - Sustainable food practices
    - Viable local food systems
    - Address regional food waste
    - Trainings in private food production, preparation and preservation
    - Working group under the Food Policy Council - work with First Nations, Farmers and local businesses to promote agri-tourism on land and water.

Potential partners: Sooke Food Bank, Sooke Region Food CHI, District of Sooke, CRD, T'Sou-ke First Nation, Scia-new First Nation, Pacheedaht First Nation, School District 62, Transition Sooke, Island Health, Local churches, Sooke Family Resource Society, Sooke Region Communities Health Network

[154] Food Safety Courses - Province of BC

- Create a **Sooke Region Food Hub** where food safe kitchens and larger industrial processing can handle what is harvested from land and sea, to stimulate local food production and entrepreneurship, as well as local food consumption, taking advantage of federal and provincial funding streams. This hub might be placed under the Sooke Region Food Policy Council.
    - Evaluate the need of a centralized refrigeration facility for temporary storage.
    - Establish a cooperative machines and tool park for farmers and entrepreneurs.
    - Develop a network food safe kitchens for entrepreneurial use

Potential partners: Sooke Food Bank, Sooke Region Food CHI, District of Sooke, CRD, T'Sou-ke First Nation, Scia-new First Nation, Pacheedaht First Nation, Sooke Region Chamber of Commerce, Worklink Employment Society

- Create a **Business Hub** where independent entrepreneurs and students can come and share information resources, get training and mentorship, have access to meeting space and hi-speed internet and to share ideas to grow new and existing businesses.

Potential partners: Worklink Employment Society, District of Sooke, CRD, T'Sou-ke First Nation, Scia-new First Nation, Pacheedaht First Nation, Sooke Region Chamber of Commerce

- Through the **Community Economic Development Committee** address:
    - Poverty reduction lens to improve upon the general well-being of the population.
    - Promote various economic business models to enrich the community's financial and social well-being.
    - Circular economy initiatives in conjunction with relevant sector actors in an environmentally sustainable manner.
    - Blue economy initiatives in conjunction with relevant sector actors in an environmentally sustainable manner.

  - Encourage a BC equivalent foundation activity such as “Fondaction” in Quebec that funds circular agri-economy in local communities.
  - Advocate with Statistics Canada, Island Health and other similar data collecting entities to provide data that reflect the same and smaller communities to simplify data analysis at the local level.
- Through the **Land Use Committee** (continue) to address
  - Densification of housing in the town core, better sidewalks, bike paths and solid bus stops to enable easier access to amenities and necessary services, especially for those with mobility issues.
  - Exploring smart ways of adapting present builds for inter-generational or peer co-housing leading to lower individual rents and reduction of social isolation.
  - Promote Makerhoods where affordable housing, light manufacturing with amenities may be combined to encourage entrepreneurship.
  - To increase the amount of affordable commercial space for much needed commercial and support services.
  - Keep a poverty reduction and good food practices lens with regards to land use in the commercial as well as the agricultural sector.
  - To actively take part in the Food Hub and Food Policy Council.
  - To activate spaces to congregate as a community.
  - Explore extensive water catchment infrastructure
- Through the **Climate Action Committee** (continue) to address
  - Distance food travels from farm to fork, food waste etc.
  - Explore collaborating with T’Sou-ke First Nations on their food resiliency project in the face of climate change.
  - Explore initiatives to improve food culture, along with food security.
  - Encourage more local transit and rideshare to increase access to amenities and services.

- Encourage fruit trees to contribute to neighbourhood food security as well as the carbon sink.

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Again, this is a hefty document, so I'm again asking you to download your own copy from the above link.

From Yale 360

Urban Heat: Can White Roofs Help Cool World’s Warming Cities?

New York City has painted about 7 million square feet of tar rooftops white to lower temperatures.
NASA

It has long been known that installing white roofs helps reduce heat buildup in cities. But new research indicates that making surfaces more light-reflecting can have a significant impact on lowering extreme temperatures – not just in cities, but in rural areas as well.

BY FRED PEARCE • MARCH 7, 2018

Summers in the city can be extremely hot — several degrees hotter than in the surrounding countryside. But recent research indicates that it may not have to be that way. The systematic replacement of dark surfaces with white could lower heat wave maximum temperatures by 2 degrees Celsius or more. And with climate change and continued urbanization set to intensify “urban heat islands,” the case for such aggressive local geoengineering to maintain our cool grows.

The meteorological phenomenon of the urban heat island has been well known since giant cities began to emerge in the 19th century. The materials that comprise most city buildings and roads reflect much less solar radiation – and absorb more – than the vegetation they have replaced. They radiate some of that energy in the form of heat into the surrounding air. The darker the surface, the more the heating. Fresh asphalt reflects only 4 percent of sunlight compared to as much as 25 percent for natural grassland and up to 90 percent for a white surface such as fresh snow.

Most of the roughly 2 percent of the earth’s land surface covered in urban development suffers from some level of urban heating. New York City averages 1-3 degrees C warmer than the surrounding countryside, according to the U.S. Environmental Protection Agency – and as much as 12 degrees warmer during some evenings. The effect is so pervasive that some climate skeptics have seriously claimed that global warming is merely an illusion created by thousands of once-rural meteorological stations becoming surrounded by urban development.

Climate change researchers adjust for such measurement bias, so that claim does not stand up. Nonetheless, the effect is real and pervasive. So, argues a recent study published in the journal *Nature Geoscience*, if dark heat-absorbing surfaces are warming our cities, why not negate the effect by installing white roofs and other light-colored surfaces to reflect back the sun's rays?

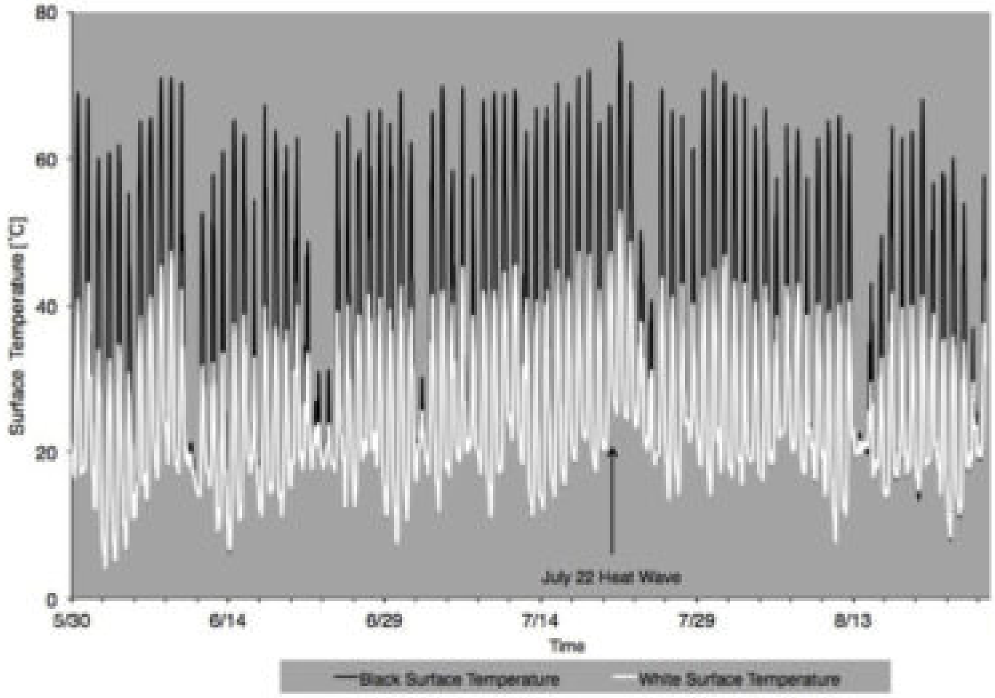
Lighter land surfaces "could help to lower extreme temperatures by up to 2 or 3 degrees Celsius," says one researcher.

During summer heat waves, when the sun beats down from unclouded skies, the creation of lighter land surfaces "could help to lower extreme temperatures… by up to 2 or 3 degrees Celsius" in much of Europe, North America, and Asia, says Sonia Seneviratne, who studies land-climate dynamics at the Swiss Federal Institute of Technology (ETH) in Zurich, and is co-author of the new study. It could save lives, she argues, and the hotter it becomes, the stronger the effect.

Seneviratne is not alone in making the case for boosting reflectivity. There are many small-scale initiatives in cities to make roof surfaces more reflective. New York, for instance, introduced rules on white roofs into its building codes as long ago as 2012. Volunteers have taken white paint to nearly 7 million square feet of tar roofs in the city, though that is still only about 1 percent of the potential roof area.

Chicago is trying something similar, and last year Los Angeles began a program to paint asphalt road surfaces with light gray paint. Outside the United States, cool-roof initiatives in cities such as Melbourne, Australia are largely limited to encouraging owners to cool individual buildings for the benefit of their occupants, rather than trying to cool cities or neighborhoods. The evidence of such small-scale programs remains anecdotal. But now studies around the world are accumulating evidence that the benefits of turning those 1 percents into 100 percents could be transformative and could save many lives every year.

Keith Oleson of the National Center for Atmospheric Research in Boulder, Colorado looked at what might happen if every roof in large cities around the world were painted white, raising their reflectivity — known to climate scientists as albedo — from a typical 32 percent today to 90 percent. He found that it would decrease the urban heat island effect by a third — enough to reduce the maximum daytime temperatures by an average of 0.6 degrees C, and more in hot sunny regions such as the Arabian Peninsula and Brazil.



White test plots on the roof of the Museum of Modern Art in Queens, New York, measured 40 degrees Fahrenheit cooler than those painted black throughout the summer of 2011. GAFFIN ET AL.

Other studies suggest even greater benefits in the U.S. In a 2014 paper, Matei Georgescu of Arizona State University found that "cool roofs" could cut temperatures by up to 1.5 degrees C in California and 1.8 degrees in cities such as Washington, D.C.

But it may not just be urban areas that could benefit from a whitewashing. Seneviratne and her team proposed that farmers could cool rural areas, too, by altering farming methods. Different methods might work in different regions with different farming systems. And while the percentage changes in reflectivity that are possible might be less than in urban settings, if applied over large areas, she argues that they could have significant effects.

In Europe, grain fields are almost always plowed soon after harvesting, leaving a dark surface of soil to absorb the sun's rays throughout the winter. But if the land remained unplowed, the lightly colored stubble left on the fields after harvesting would reflect about 30 percent of sunlight, compared to only 20 percent from a cleared field. It sounds like a relatively trivial difference, but over large areas of cropland could reduce temperatures in some rural areas on sunny days by as much as 2 degrees C, Seneviratne's colleague Edouard Davin has calculated.

In North America, early plowing is much less common. But Peter Irvine, a climate and geoengineering researcher at Harvard University, has suggested that crops themselves could be chosen for their ability to reflect sunlight. For instance, in Europe, a grain like barley, which reflects 23 percent of sunlight, could be replaced by sugar beet, an economically comparable crop, which reflects 26 percent. Sometimes, farmers could simply choose more reflective varieties of their preferred crops.

Again, the difference sounds marginal. But since croplands cover more than 10 percent of the earth's land surface, roughly five times more than urban areas, the potential may be considerable.

Reducing local temperatures would limit evaporation, and so potentially could reduce rainfall downwind.

On the face of it, such initiatives make good sense as countries struggle to cope with the impacts of climate change. But there are concerns that if large parts of the world adopted such policies to relieve local heat waves, there could be noticeable and perhaps disagreeable impacts on temperature and rainfall in adjacent regions. Sometimes the engineers would only be returning reflectivity to the conditions before urbanization, but even so, it could end up looking like back-door geoengineering.

Proponents of local projects such as suppressing urban heat islands say they are only trying to reverse past impacts of inadvertent geoengineering through urbanization and the spread of croplands. Moreover, they argue that local engineering will have only local effects. "If all French farmers were to stop plowing up their fields in summer, the impact on temperatures in Germany would be negligible," Seneviratne says. "Local radiative management differs from global geoengineering in that it does not aim at effecting global temperatures [and] global effects would be negligible," she says. It is "a measure of adaptation."

But things might not always be quite so simple. Reducing local temperatures would, for instance, limit evaporation, and so potentially could reduce rainfall downwind. A modeling study by Irvine found that messing with the reflectivity of larger areas such as deserts could cause a "large reduction in the intensity of the Indian and African monsoons in particular." But the same study concluded that changing albedo in cities or on farmland would be unlikely to have significant wider effects.

Los Angeles has coated several streets in a light gray paint to reduce road-top temperatures by as much as 10 degrees Fahrenheit. CITY OF LOS ANGELES BUREAU OF STREET SERVICES

What is clear is that tackling urban heat islands by increasing reflectivity would not be enough to ward off climate change. Oleson found that even if every city building roof and stretch of urban pavement in the world were painted white, it would only delay global warming by 11 years. But its potential value in ameliorating the most severe consequences of excess heat in cities could be life-saving.

The urban heat island can be a killer. Counter-intuitively, the biggest effects are often at night. Vulnerable people such as the old who are stressed by heat during the day badly need the chance to cool down at night. Without that chance, they can succumb to heat stroke and dehydration. New research published this week underlines that temperature peaks can cause a spike in heart attacks. This appears to be what happened during the great European heat wave of 2003, during which some 70,000 people died, mostly in homes without air conditioning. Doctors said the killer was not so much the 40-degree C daytime temperatures (104 degrees F), but the fact that nights stayed at or above 30 degrees (86 degrees F). Such urban nightmares are likely to happen ever more frequently in the future, both because of the expansion of urban areas and because of climate change.

Predicted urban expansion in the U.S. this century "can be expected to raise near-surface temperatures 1-2 degrees C… over large regional swathes of the country," according to Georgescu's 2014 paper. Similar threats face other fast-urbanizingparts of the world, including China, India, and Africa, which is expected to increase its urban land area six-fold from 1970 to 2030, "potentially exposing highly vulnerable populations to land use-driven climate change."

Several studies suggest that climate change could itself crank up the urban heat island effect. Richard Betts at Britain's Met Office Hadley Centre forecasts that it will increase the difference between urban and rural temperatures by up to 30 percent in some places, notable in the Middle East and South Asia, where deaths during heat waves are already widespread.

A combination of rising temperatures and high humidity is already predicted to make parts of the Persian Gulf region the first in the world to become uninhabitable due to climate change. And a study published in February predicted temperatures as much as 10 degrees C hotter in most European cities by century's end.

No wonder the calls to cool cities are growing.

A city-wide array of solar panels could reduce summer maximum temperatures in some cities by up to 1 degree C.

Another option is not to whitewash roofs, but to green them with foliage. This is already being adopted in many cities. In 2016, San Francisco became the first American city to make green roofs compulsory on some new buildings. New York last year announced a $100-million program for cooling neighborhoods with trees. So which is better, a white roof or a "green" roof?

Evidence here is fragmentary. But Georgescu found a bigger direct cooling effect from white roofs. Vincenzo Costanzo, now of the University of Reading in England, has reached a similar conclusion for Italian cities. But green roofs may have other benefits. A study in Adelaide, Australia, found that besides delivering cooling in summer, they also act as an insulating layer to keep buildings warmer in winter.

There is a third option competing for roof space to take the heat out of cities — covering them in photovoltaic cells. PV cells are dark, and so do not reflect much solar radiation into space. But that is because their business is to capture that energy and convert it into low-carbon electricity.

Solar panels "cool daytime temperatures in a way similar to increasing albedo via white roofs," according to a study by scientists at the University of New South Wales. The research, published in the journal *Scientific Reports* last year, found that in a city like Sydney, Australia, a city-wide array of solar panels could reduce summer maximum temperatures by up to 1 degree C.

That is the theory, but there are concerns about whether it will always work in practice. Studies into the impact on local temperatures of large solar farms in deserts have produced some contradictory findings. For while they prevent solar rays from reaching the desert surface, they also act as an insulating blanket at night, preventing the desert sands from losing heat. The net warming effect has been dubbed a "solar heat island."

The lesson then is that light, reflective surfaces can have a dramatic impact in cooling the surrounding air – in cities, but in the countryside too. Whitewashed walls, arrays of photovoltaic cells, and stubble-filled fields can all provide local relief during the sweltering decades ahead. But policymakers beware. It doesn’t always work like that. There can be unintended consequences, both on temperature and other aspects of climate, like rainfall. Even local geoengineering needs to be handled with care.

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Update to Limits to Growth: Comparing the World3 Model With Empirical Data

Update to Limits to Growth: Comparing the World3 Model with Empirical Data

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A Thesis in the Field of Sustainability

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Harvard University

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Abstract

For more than three decades, the authors of the bestseller *Limits to Growth* (LtG) warned that a pursuit of continuous growth would result in a sharp decline (i.e., collapse) of global human welfare levels within the 21st century. The authors published three LtG books between 1972 and 2004, in each of which they studied interactions between global variables of a model called World3. With World3, which was updated for each book, the authors generated different scenarios for global developments by varying assumptions about technological development, amounts of natural resources, and societal priorities. Their "business as usual" (BAU) scenario contained no assumptions on top of historical averages. BAU showed a halt in the increase of global welfare levels around 2020, and a collapse starting around 2030. Not all scenarios led to collapse; the LtG team identified a set of assumptions that produced a "stabilized world" (SW) scenario in which decline was avoided and welfare remained high. But independent empirical data comparisons since then, most recently from 2014, indicated that the world was still following BAU.

The objective of my research was to examine whether this still was the case based on data available in 2019, and whether there was opportunity left for society to align with the SW scenario. My research objectives were to i) conduct a data comparison between the current global state and scenarios made with the latest version of World3, and ii) determine how close each scenario compared with observed data. I hypothesized that BAU would align more with the data than other scenarios, and do so closely for most or all variables. I collected data for real-world indicators of the World3 variables population,

fertility, mortality, pollution, industrial output, food, services, non-renewable natural resources, human welfare, and ecological footprint. This data came from academia, (non-)government agencies, United Nations entities, and the World Bank. I used four LtG scenarios with underlying assumptions that span a range of technological, social, and resource conditions: BAU, SW, "comprehensive technology" (CT), and "business as usual 2" (BAU2). CT represents the technologist's belief in humanity's ability to innovate out of environmental constraints. BAU2 assumes double the resources as in BAU and depicts a pollution collapse, including from CO_2 (i.e., climate change). Both scenarios indicate a halt in growth within the next few decades, but BAU2 shows a sharp decline while CT shows a moderate one. To measure alignment of empirical data with scenarios I used: value difference, rate of change difference, and normalized root mean square error.

My research revealed an overall close alignment of empirical data with each of the four scenarios, which is a testament to the accuracy of World3. SW was followed least closely, then BAU, and both BAU2 and CT aligned closest. My hypothesis was rejected, but this could change with an update of the comparison because for several variables the scenarios only diverge significantly after 2020. This is especially so for BAU2 and CT, which is why it was not possible to differentiate between them. It's thus unclear whether a future decline can be expected to be moderate or sharp, but both scenarios indicate society will run into limits in the medium term. The close alignment of scenarios and their lack of divergence means that the identification of BAU2 and CT as closest fits could be nullified or even reversed with a few years' extra data points. It also means that it is not too late to change course. Although SW tracks least closely, a deliberate trajectory change is still possible. That window of opportunity is closing fast.

Dedication

To Donella Meadows, whose wonderfully written insights sparked my research and to my mother, who sparked everything.

Acknowledgements

I'm grateful to Graham Turner for his support, insights, and engagement throughout this process. I could not have wished for a better Thesis Director. It was a pleasure and honor to work with him.

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Definitions of Terms

BAU scenario	Business as usual scenario
BAU2 scenario	Business as usual 2 scenario
BP	British Petroleum
CT scenario	Comprehensive technology scenario
EF	Ecological footprint
EI	Education index
FAO	Food and Agriculture Organization
GDP	Gross domestic product
GFCF	Gross fixed capital formation
GFN	Global Footprint Network
GP	Geochemical Perspective
HDI	Human Development Index
IIP	Index of industrial production
IMF	International Monetary Fund
LtG	Limits to Growth
MIT	Massachusetts Institute of Technology
NOAA	National Oceanic & Atmospheric Administration
NRMSD	Normalized root mean square deviation
OECD	Organisation for Economic Co-operation and Development
p.c.	per capita

RMSD	Root mean square deviation
ROC	Rate of change
SW scenario	Stabilized world scenario
USGS	US Geological Survey
UN DESA	UN Department of Economic & Social Affairs
UN DESA PD	UN DESA Population Division
UN DESA SD	UN DESA Statistical Division
UN DP	UN Development Programme
UN EP	UN Environment Programme
UNIDO	UN Industrial Development Organization
WB	World Bank
WHO	World Health Organization

Chapter I

Introduction

In this thesis I describe my research on the principle and model of the Club of Rome's *The Limits to Growth* (LtG). I conducted a comparison between empirical world data and scenarios described in the LtG books, analyzed deviations and corroborations, and drew conclusions on what these might imply for future global developments. Part of this work I plan to submit to a journal, and to that end one chapter in this document was written as a full article that can be read on its own.

This thesis' structure is as follows. The rest of this chapter, Chapter I, provides a background on LtG, updates to LtG from other researchers, and my research objectives, question, and hypothesis. Chapter II consists of my article, which means it follows its own organizational structure conforming with the journal submission guidelines. Chapter III, the last chapter, contains further discussion of my research results, followed by the final conclusions.

Background

The essence of the LtG message is that a continued pursuit of growth on a finite planet will inevitably lead to an "overshoot and collapse" pattern (Meadows, Meadows, & Randers, 2004). The term overshoot and collapse originates from ecology and describes a three-phase pattern. In the first phase a population is growing until it reaches the number that can be sustained by its environment, i.e., its "carrying capacity" (e.g., Schmitz, 2007). The population can grow beyond its carrying capacity, but it can only remain there temporarily. Because there aren't enough resources to sustain that population size, population growth slows down and subsequently ends altogether as the mortality rate rises. This is the second phase, at which the population is said to be in overshoot. In the third phase, the mortality rate has surpassed the birth rate and the population starts to decline, at a higher speed than it was growing in the first phase. This third phase is called a collapse because of the steepness that typically marks the decline.

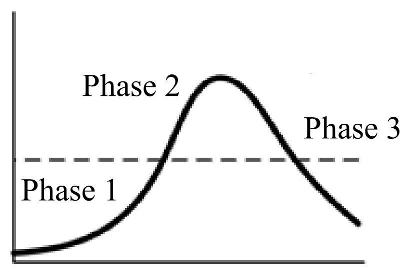

Figure 1. Stylized version of an overshoot and collapse pattern (Thwink.org, n.d.).

The principle that an expansive growth will be brought to a halt by some limiting factor, followed by a collapse or not, can be generalized beyond population to any real-world growth process (Chichakly, 2009). Any adult is, most often tacitly, familiar with limits to growth. For example, we have learned that coffee works at first to increase our focus, but that in the long run it stops working and can become a limiting factor if it keeps us from getting the sleep we need (Meadows, 2012). In system thinking, this dynamic of changing and often delayed diminishing forces that counteract an expansive force is known as the Limits to Growth principle (Senge, 1994). Another example of this dynamic is that of continuous use of natural resources in pursuit of economic growth. If these natural resources are finite and non-renewable, continuous use will render them scarce over time, however abundant they might have been historically. At some point the resources will become so scarce that they stop to function as the contributing factor to economic growth that they had been, and instead become a limiting factor in standards of living (or: welfare levels, the two terms are used interchangeably throughout this document). Figure 2 shows the systems depiction of the Limits to Growth principle as it pertains to this last example.

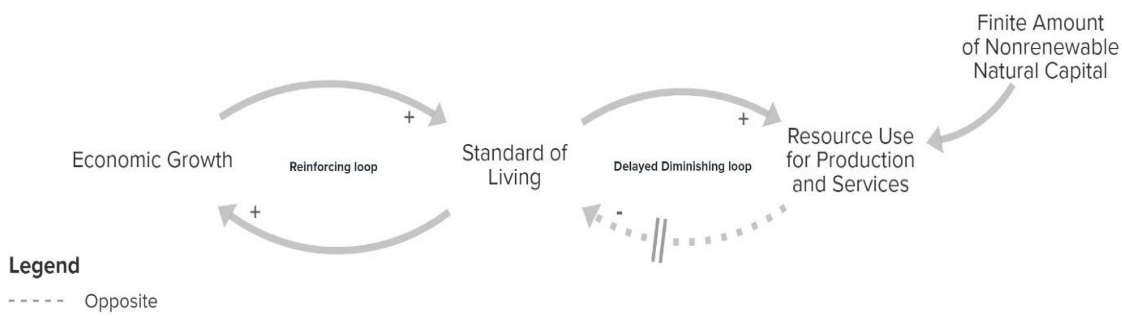

Figure 2. Systems depiction of the Limits to Growth principle (by author).

Sustained economic growth has been a recent achievement from a historical perspective (Maddison, 2006; Piketty, 2014), although one would not be able to tell from the dominance of the growth imperative in modern day debates, amongst economists, business leaders, and politicians alike. There are those that have felt it necessary to warn about the dangers in society's striving for continuous growth, amongst them a team of scientists from the Massachusetts Institute of Technology (MIT). Over the past four decades, these MIT scientists published three LtG books: in 1972 (Meadows, Meadows, Randers, & Behrens), 1992 (Meadows, Meadows, & Randers), and 2004 (Meadows et al.). Each book described the LtG message illustrated with scenario runs of the system dynamics model World3, which was updated for each book. World3 is based on the work of former MIT professor Forrester (1971; 1975), generally considered the founder of system dynamics modelling. The basis of system dynamics modelling is the recognition that to understand a system's behavior one cannot just study the behavior of its individual parts in isolation; the structure of the system, the total of relationships between its parts, is often just as important.

The World3 Model

The World3 model consists of many interacting stocks, flows, and rates. Examples are industrial capital (a stock), industrial output (a flow), and industrial capital depreciation (a rate). Other examples are the total surface of arable land (stock), deaths per year (flow), and the service capital investment rate. The key characteristics of World3, as in any dynamic systems model, are the causal links between the variables. These enable one to analyze global society as a system, i.e., as a world where the influence of policies and major environmental, financial, social, technological, and other trends are not always linearly proportional in impact, nor always felt and responded to immediately, and do not neatly stay within industry, sector, or country boundaries.

The global societal system is analyzed by using the World3 model to run scenarios. By varying World3's parameters, for example a pollution impact factor or available resources at the start of the run, one can begin to understand how variables could interact over time to form the general behavior of the global system. The general behavior that World3 runs revealed was a halt in industrial capital growth at some point in the 21st century, followed by a sharp decline (i.e., collapse). The most discussed scenario was the “business as usual” (BAU) scenario, which ran on historic averages without any additional assumption. This BAU scenario ended in collapse. There were scenarios in which collapse was avoided, but assumptions in those runs were markedly different from prevailing real-world priorities at the time.

There are five subsystems in World3: population, industrial output, agricultural production, non-renewable natural resources, and pollution. Figure 3 shows a stylized rendering, i.e., a causal loop diagram, of some of the interactions in World3.

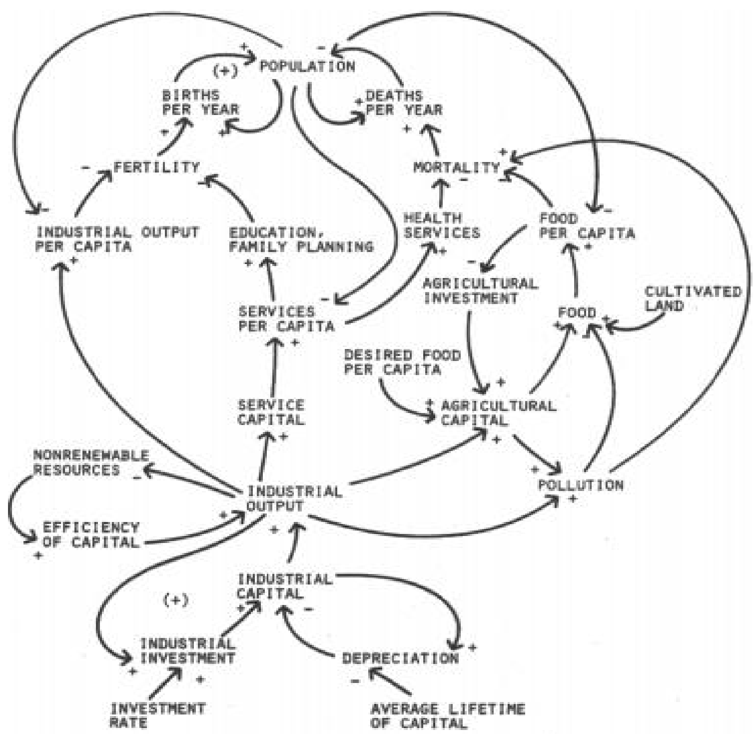

Figure 3. Causal loop diagram of World3 (Sverdrup, Koca, & Ragnarsdóttir, 2015).

Note that Figure 3 does not depict the actual dynamic systems model, which is more complex and contains many more variables. See Appendix 1 for an overview of all the variables and their interactions as modelled in World3 from the original book. A more detailed and technical analysis of how the model behaves was published shortly after the first LtG book (Meadows, 1974).

World3 Variables

Many descriptions of World3 still mention the subsystems— population, industrial output, agricultural production, resources, and pollution—as the five LtG variables. However, the graphs of the 1972 LtG book depicted eight variables in one graph: population, fertility, mortality, industrial output per capita (p.c.), food p.c., services p.c., fraction of non-renewable resources remaining, and persistent pollution (e.g., Figure 7 in Chapter II).

In their 2004 update, the LtG team showed three graphs instead of one and changed some of the variables depicted. The five macro variables are in the first "State of the World" graph: population, industrial output, agricultural production, non-renewable resources, and pollution (Figure 4).

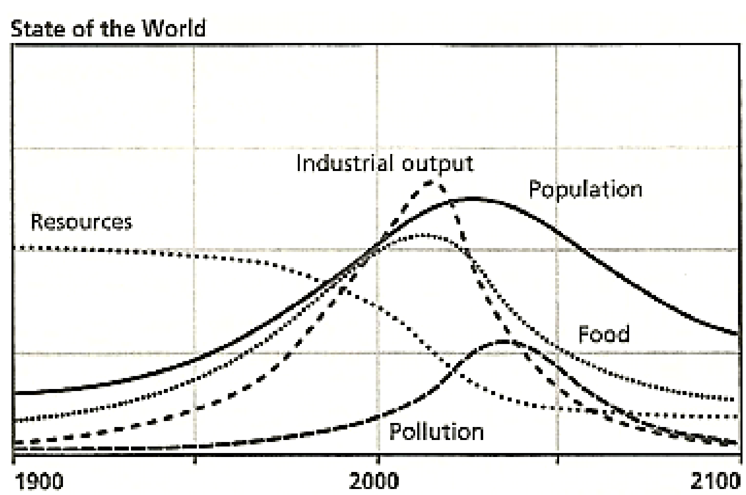

Figure 4. First graph of scenario 1 or BAU scenario, State of the World (Meadows et al., 2004).

The second graph in the update, “Material Standards of Living” (Figure 5), showed four more variables: life expectancy (replacing fertility and mortality rates), food p.c., services p.c., and consumer goods p.c.. This last variable is calculated as a constant consumption fraction times industrial output p.c. (i.e., industrial output divided by the population).

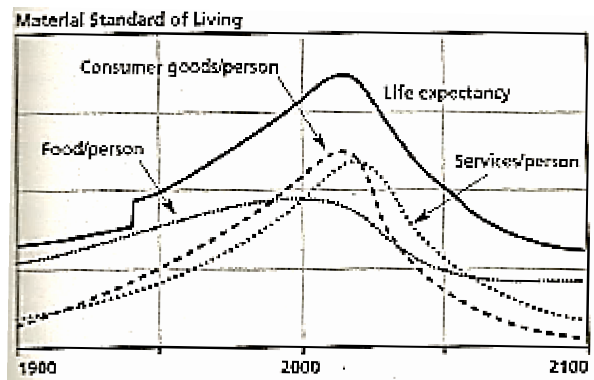

Figure 5. Second graph of scenario 1 or BAU scenario, Material Standard of Living (Meadows et al., 2004).

The third “Human Welfare and Footprint” graph showed two new variables: human welfare levels and ecological footprint (Figure 6).

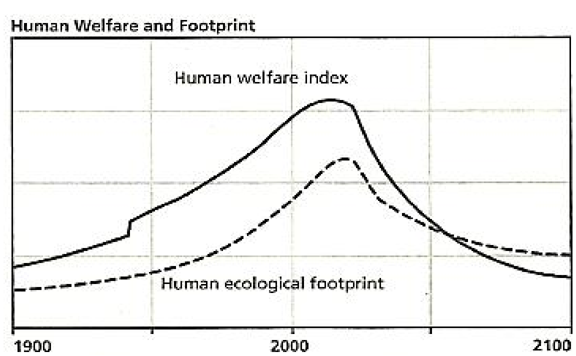

Figure 6. Third graph scenario 1 or BAU scenario, Human Welfare and Footprint (Meadows et al., 2004).

Thus, in the last LtG book there are eleven variables to compare with real-world data. It should be noted however, that only two of the added variables were not directly derived from or linked to other 1972 variables: human welfare levels and ecological footprint (EF), the variables of the third graph (Figure 6). As mentioned, life expectancy replaced fertility and mortality rates to convey the same concept of longevity. And the two variables, global agricultural production and industrial output, do not add a whole new dimension to a set of variables already containing food p.c., industrial output p.c., and population. Table 1 contains an overview of depicted variables in both books.

Table 1. Variables depicted in scenario runs of first and last LtG books.

	First book (1972)	**Last book (2004)**
Depicted variables	population non-renewable resources pollution industrial output per capita food per capita services per capita fertility mortality	population non-renewable resources pollution industrial output per capita food per capita services per capita life expectancy industrial output agricultural production human welfare levels (*new*) ecological footprint (*new*)

Technical Modelling Criticisms of World3

There were many critics of the LtG. I discuss the criticisms on the LtG message and the economic and technological assumptions underlying the World3 model in the article in Chapter II (see also Bardi (2011) for another account of criticism and counterarguments). Here I discuss the technical criticism of World3. Some critics focused on the working of World3 specifically, others critiqued the new modeling technique (system dynamics) itself as non-rigorous or even non-scientific.

The World3 model can be sensitive; relatively small parameter changes will in some cases significantly alter a scenario's trajectory (Castro, 2012; de Jongh, 1978; Vermeulen & de Jongh, 1976). This is a valid critique, however it seems insufficient to refute the general validity of World3's outcomes. Sensitivity is problematic in predictive models because it reduces the confidence one can have in a prediction. The LtG authors did not intend World3 to be a predictive model, but a tool to understand world dynamics. The accuracy of general dynamics that occur once global limits are approached and breached, is not necessarily nullified by the fact that the timing of such events cannot be robustly predicted within a few years' precision (Lyneis, 2000; Sterman, 1994). Indeed, recreation of runs with the same parameter changes as in these critical studies confirmed that World3 can be sensitive to parameter changes, but also showed that these changes did not avoid an overshoot and collapse pattern (Turner, 2013).

Other technical modelling criticism, from acclaimed academics in their field, seemed to be based on a lack of understanding of the essence of system dynamics modelling. A 1973 critique contained a technical review of World3 and the conclusion that it was inadequate from the perspective of linear modeling (Cole, Freeman, Jahoda, &

Pavitt, 1973), which is not the right criterion for a system dynamics model (Sterman, 2000). Yale economist Nordhaus (1973; 1992), who was awarded a Nobel Prize in Economics in 2018, focused on isolated equations of World3 in a response to the first and second LtG books, thereby neglecting feedbacks between system variables in his analysis (Forrester, Low, & Mass, 1974; Turner, 2012). Nordhaus (1973) also stated that "not a single relationship or variable is drawn from actual data or empirical studies" (p. 1157). This is incorrect; although historical data is not fitted to a model using econometrics, it is used for setting numerical values for the assumptions underlying World3 (Forrester et al., 1974).

No Critical Data Comparisons

None of the LtG critics mentioned above or in Chapter II have gone on to publish a study in which World3 scenarios are compared against recent data, even though that seems an obvious and convincing way to make claims about the model's inadequacy. The only empirical test along that line of thinking was a famous bet between ecologist Ehrlich and economist Simon about the price of a basket of five commodities (Sabin, 2013; Worstall, 2013). Ehrlich bet that the price would rise between 1980 and 1990 as a result from increased scarcity; he lost. Many have pointed out that Ehrlich would have won the bet had it been for a different ten-year period (Sabin, 2013; Worstall, 2013). More importantly, none of the LtG team members made this bet and the World3 model does not run scenarios for specific commodities. In fact, some scenarios assumed perfect substitutability of resources and even an endless supply of non-renewable natural resources (this does not avoid collapse, but merely changes its cause from resource depletion to a pollution crisis). Still, Erlich losing the bet was interpreted by many as proof that LtG has been wrong.

Qualitative and Partial Empirical Updates of LtG

There have been some qualitative updates on LtG. A report to a United Kingdom Interparliamentary group concluded that there was “unsettling evidence that society is still following” the BAU run of the first LtG book (Jackson & Weber, 2016, p.3). A report to the Club of Rome by Bardi (2014) that focused on non-renewable natural resources concluded the same. Bardi, based on his own research and contributions from senior scientists across relevant disciplines, concluded that industrial civilization is likely to deplete its low-cost (i.e., high quality and in sizeable and concentrated quantity available) mineral, metal, and fossil resources with debilitating impacts for the global economy and key infrastructures within the coming decade. This message was repeated in a *Geochemical Perspective* article that same year (Sverdrup & Ragnarsdóttir, 2014). Less likely ally Simmons (2000), an investment banker, former energy adviser to United States (US) President Bush, and member of the National Petroleum Council, stated: “The most amazing aspect of the book is how accurate many of the basic trend extrapolation[s] […] still are, some 30 years later” (p. 15).

There have been many studies on variations on the World3 model (e.g., Saeed, 2014), and/or partial validation such as those into peak oil (e.g., Hall & Day, 2009) and peak supply of other non-renewable resources like minerals and metals (e.g., Sverdrup & Ragnarsdóttir, 2014). Although they cannot serve as a validation of the complete World3 model, the conclusions of these studies align with the LtG message.

Turner's Quantitative Empirical Updates of LtG

The only quantitative comparisons of real-world data with the original output of World3 have been published by Turner (2008, 2012, 2014). Turner compared empirical data with three of the twelve scenarios from the first LtG book:

1. BAU, the "no assumptions" scenario based on historical values from between 1900-1970 (Meadows et al., 1972, p. 129).
2. "Comprehensive technology" (CT), which assumes a broad range of technological solutions (Meadows et al., 1972, p. 147).
3. "Stabilized world" (SW), the scenario that assumes both technological solutions and social changes (Meadows et al., 1972, p. 147).

Turner chose these scenarios because they "effectively span the extremes of technological and social responses as investigated in the LtG" (Turner, 2008, p. 400). These 1972 LtG scenarios are described in more detail in Chapter II.

Based on quantitative comparisons for all variables, Turner concluded that overall, world data compared favorably to key features of the BAU, and much more so than for the other two scenarios.

Research Objectives, Question, and Hypothesis

Given the outcomes so far of LtG updates, most notably those from Turner, I thought it useful to perform a quantitative update of the LtG comparison. My research objectives were to:

- conduct an empirical update with the latest data available in 2019, i.e., a data comparison between the current global state and World3 scenarios, including the BAU one.
- determine how close each World3 scenario compares with empirical data, and draw conclusions about what these results means for potential future developments of global trends.

I used the variables and scenarios of the 2004 book. One exception on the variables was for life expectancy; I used fertility and mortality rates because the World3 version that I used for running the LtG scenarios did not provide life expectancy as an output. I focused on four scenarios: the 2004 versions of the scenarios that Turner used in his work, plus "business as usual 2" (BAU2), where the effect of increased non-renewable resources is explored. BAU2 and the other three scenarios are described in Chapter II and in Appendix 2.

Given that Turner found a close track to BAU (of 1972) and that society hadn't made revolutionary global changes in policies and priorities since 2014, I expected to find that observed data would indicate global society following the 2004 BAU scenario most closely. This then translated into the following research question and hypothesis:

- Research question: To what extent do real-world indicators of population, fertility, mortality, pollution, industrial output p.c., food p.c., services p.c., non-renewable natural resources, global human welfare, and ecological footprint over the past four decades track their respective variables in the BAU, BAU2, SW, and CT scenarios of the latest World3 version?

- Hypothesis: Of the four scenarios, the BAU scenario approximates the most recent empirical data the best, and does so relatively closely for most or all variables.

Chapter II

Update to Limits to Growth: Comparing the Word3 Model with Empirical Data

This chapter is written as an article that can stand on its own. Its organizational structure follows the guidelines of the journal targeted for submission, which is as follows: Introduction, Background, Results, Discussion, Conclusions, and a separate Methods section. Because the article is co-authored with Turner, it's written in first person plural, instead of first person singular like the rest of the thesis.

Abstract

We conducted a data comparison between scenarios from the 2004 Limits to Growth (LtG) book and empirical data. The scenarios ran on the latest version of the system dynamics model World3-03, which had not before been evaluated in this way. Our research benefitted from improved data availability, and included a scenario and two variables that had not been part of previous quantitative LtG analysis. Sourcing data from various organizations, including the World Bank and the United Nations, we plotted observed data along with four LtG scenarios spanning a range of assumptions on technological developments, the amount of natural resources, and societal priorities. From these graphs and two quantitative accuracy measures we constructed, we found that the four World3-03 scenarios align closely with observed global data. The two scenarios that showed the closest alignment indicate a decline in food productivity, industrial capital, and human welfare levels within three decades. Our results are inconclusive as to

whether this decline would necessarily constitute a collapse, because such a pattern is present in only one of the two scenarios. Because the scenarios diverge significantly after 2020, an update of this comparison in another few years might be able to identify one specific closest fit to empirical data. Without major changes in societal priorities, this is unlikely to be the scenario showing a sustainable path; the one scenario in which any decline in human welfare within this century is avoided, aligned with the data the least.

Introduction

In the bestseller *Limits to Growth* (LtG) (Meadows et al., 1972), the authors concluded that if humanity kept pursuing economic growth without regard for environmental and social costs, global society would experience a sharp decline (i.e., collapse) in economic, social, and environmental conditions within this century. They used a model called World3 to study key interactions between variables for global population, birth rate, mortality, industrial output, food production, health and education services, non-renewable natural resources, and pollution. The LtG team generated different World3 scenarios by varying assumptions about technological development, amounts of non-renewable resources, and societal priorities. The few comparisons of empirical data with the scenarios since then, most recently from 2014, indicated that the world was still following the "business as usual" (BAU) scenario. BAU showed a halt in the hitherto continuous increase in welfare indicators around present day, and a sharp decline starting around 2030.

Given the unappealing prospect of collapse, we considered whether humanity was still following BAU or had changed course and aligned more with another LtG scenario, perhaps one in which collapse was avoided. This article describes our research to answer that question. We quantitatively compared World3 scenarios with empirical data. Our research thus constitutes a 2019 update to previous comparisons, but it also adds to them in several ways. Earlier data comparisons used scenarios from the 1972 LtG book. We used the latest, revised and recalibrated, World3 version. Our comparison also included a scenario and two variables that had not before been part of such research, and benefitted from better empirical proxies thanks to improved data availability.

Background

The LtG message was that continuous growth cannot be sustained indefinitely (Meadows et al, 1972). Effectively, humanity can either choose its own limit or at some point reach an imposed limit, at which time a decline in human welfare will have become unavoidable. An often missed, but key point in the LtG message is the plural of "limits" (Meadows et al., 2004; Meadows & Meadows, 2007). In an interconnected system like our global society, a solution to one limit inevitably causes interactions with other parts of the system, giving rise to a new limit which now becomes the binding constraint to growth (Meadows & Meadows, 2007). To illustrate this point, the LtG authors had created various scenarios with World3. World3 was based on the work of Forrester (1971; 1975), the founder of system dynamics: a modeling approach for interactions between objects in a system, often characterized by non-linear behavior like delays, feedback loops, and exponential growth or decline. The LtG scenarios were thus not meant to produce point predictions, but rather to help us understand the behavior of systems in the world over time.

LtG Publications

The first book (Meadows et al., 1972) was commissioned by the Club of Rome and introduced World3 together with twelve scenarios. The most widely discussed scenario has been the BAU. It maintained parameters at historic levels from the latter part of the 20th century, without imposing any additional assumptions. In BAU, standards of living would at some point stop rising along with industrial growth once the accompanying depletion of non-renewable resources had started to render these a limiting factor in industrial and agricultural production. Continuation of standard economic operation without adapting to the constraint of growing resource scarcity would then require increasingly more industrial capital to be diverted towards extracting non-renewable resources. This would leave less for food production, citizen services and industrial re-investment, causing declines in these factors and, subsequently, in population (Meadows et al., 1972).

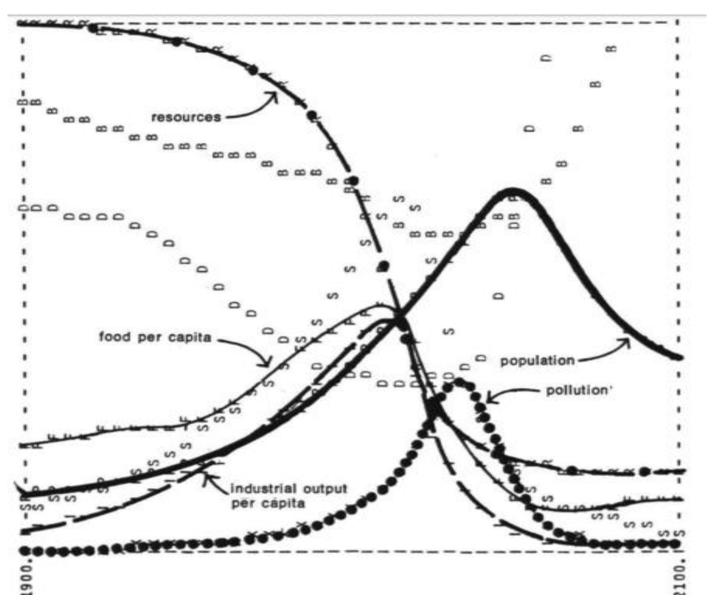

Figure 7. The BAU scenario from the first LtG book (Meadows et al., 1972).

There were eleven other scenarios in the first book, including “comprehensive technology” (CT) and “stabilized world” (SW). CT assumes a range of technological solutions, including reductions in pollution generation, increases in agricultural land yields, and resource efficiency improvements that are significantly above historic averages (Meadows et al., 1972, p. 147). The SW scenario assumes that in addition to the technological solutions, global societal priorities changed from a certain year onwards (Meadows et al, 1972). A change in values and policies translate into, amongst other things, low desired family size, perfect birth control availability, and a deliberate choice to limit industrial output and prioritize health and education services. SW was the only scenario in which declines were avoided.

The second book, *Beyond the Limits*, was published in 1992 (Meadows et al.). The LtG team had recalibrated World3 to two decades of additional data. The authors concluded that while humankind had had the opportunity to act during the twenty years after the first LtG book, humanity had now reached overshoot (i.e., transgression above earth’s carrying capacity).

The third and last book, *Limits to Growth: The 30-Year Update*, dates from 2004 (Meadows et al.). It described ten new scenarios which were similar to those from the first two books in assumptions, but made with a revised World3 model: World3-03. The model revisions included incorporation of two new variables: the human ecological footprint and human welfare. The assumptions regarding technological progress were also intensified, going above historic rates even further, making the CT scenario more optimistic compared to its 1972 version.

Criticism

The LtG books and World3 received much criticism (e.g., Norgard, Peet, & Ragnarsdóttir, 2010), most of which was unsubstantiated (Bardi, 2011). Some critics misinterpreted the scenarios and key message of the books, others critiqued World3's modeling assumptions.

Despite obviously being false, some misconceptions have proven persistent and influential in the public debate. An example is the claim that the first book predicted resource depletion by 1990 (Passell, Robert, & Ross, 1972). This misconception promulgated to the point of being repeated even by organizations like the United Nations Environment Programme (UN EP, 2002). It was actively revived by analysts (Bailey, 1989; Lomborg & Olivier, 2009; "Plenty of Gloom", 1997), who subsequently dismissed LtG because depletion and collapse had not taken place. However, what the authors had claimed was that without major change in the global system, growth will halt before 2100. It is clear from the scenario graphs that reversal points lie beyond 2000.

Modelling criticism focused mostly on the assumptions concerning technological progress and market correction. Some argued that World3 did not give enough credence to humanity's ability to invent technological solutions to environmental challenges (Cole et al., 1973; Kaysen, 1972). These critics ignored that the LtG book contained several scenarios with very optimistic assumptions about technological innovation and adoption, given historic averages. Even the very optimistic assumptions on humankind's ingenuity and willingness to share solutions (also with those that cannot pay for it) did not prevent declines in a scenario, unless it was paired with societal value and policy changes. Others regarded the absence of a corrective price mechanism as a fatal flaw, contending that increased prices would spur substitutions between resources and other technological solutions (Kaysen, 1972; Solow, 1973). For example, Nobel prize winning economist Solow (1973) argued that price pressures would increase public demand in the future for higher taxes on scarce resources. This has not occurred. Research by the International Monetary Fund (IMF, 2014) and the Organisation for Economic Co-operation and Development (2017; 2018), amongst others, suggests that the social costs of pollution and non-renewable resource depletion are currently nowhere fully reflected in taxes. Fossil fuels alone still carry large government subsidies (Coady, Parry, Sears, & Shang, 2017), totaling 6.5% of global gross domestic product (GDP).

Updates to LtG

Several qualitative reviews of the LtG publications have described how dynamics in World3 could be observed in the real world (Bardi, 2014; Jackson & Weber, 2016; Simmons, 2000). One such review was from LtG author Randers (2000). Randers did admit that non-renewable resources, particularly fossil fuels, had turned out to be more plentiful than assumed in the 1972 BAU scenario. He therefore postulated that not resource scarcity but pollution, especially from greenhouse gases, would cause the halt in growth. This aligns with the second scenario in the LtG books. This scenario has the same assumptions as the BAU, except that it assumes double the non-renewable resources. We refer to this scenario as BAU2. More resources do not avoid collapse in World3; the cause changes from resource depletion to a pollution crisis.

BAU2 was quantitively assessed in a 2015 recalibration study of World3-03 (Pasqualino, Jones, Monasterolo, & Phillips). Results indicated that society had invested more to abate pollution, increase food productivity, and invest in services compared to BAU2. However, the authors did not compare their calibration with SW, nor did they use their recalibrated version of World3 to run the scenario beyond the present to see if collapse was avoided.

Quantitative comparisons between LtG scenarios and empirical data were conducted by Turner (2008; 2012; 2014). He compared global observed data for the LtG variables with three of the twelve scenarios from the first book: BAU, CT, and SW. Turner concluded that world data compares favorably to key features of BAU, and much more so than for the other two scenarios.

We examined whether a comparison for data available in 2019 with the recalibrated World3-03 produced the same outcomes as Turner had found. Because he used the 1972 variables, Turner did not include the two that were added in 2004, human welfare and ecological footprint (EF). Another open question therefore was to what extent these variables aligned with their real-world counterparts. Lastly, given the attention that BAU2 had gotten and that its pollution crisis can be interpreted as depicting climate change (i.e., collapse from greenhouse gas pollution), this scenario ought to be included in a comparison.

Research

Our goal was to determine to what extent empirical data aligned with scenarios of World3-03 (henceforth called "World3"). We compiled data from various databases, including the United Nations and World Bank. These data were indicators for what the following ten variables represented: population, fertility (birth rate), mortality (death rate), industrial output per capita (p.c.), food p.c., services p.c., non-renewable resources, persistent pollution, human welfare, and EF. We plotted this data along with four World3 scenarios: BAU, BAU2, CT, and SW. These were the 2004 LtG book equivalents of the three scenarios in Turner's earlier work, plus BAU2.

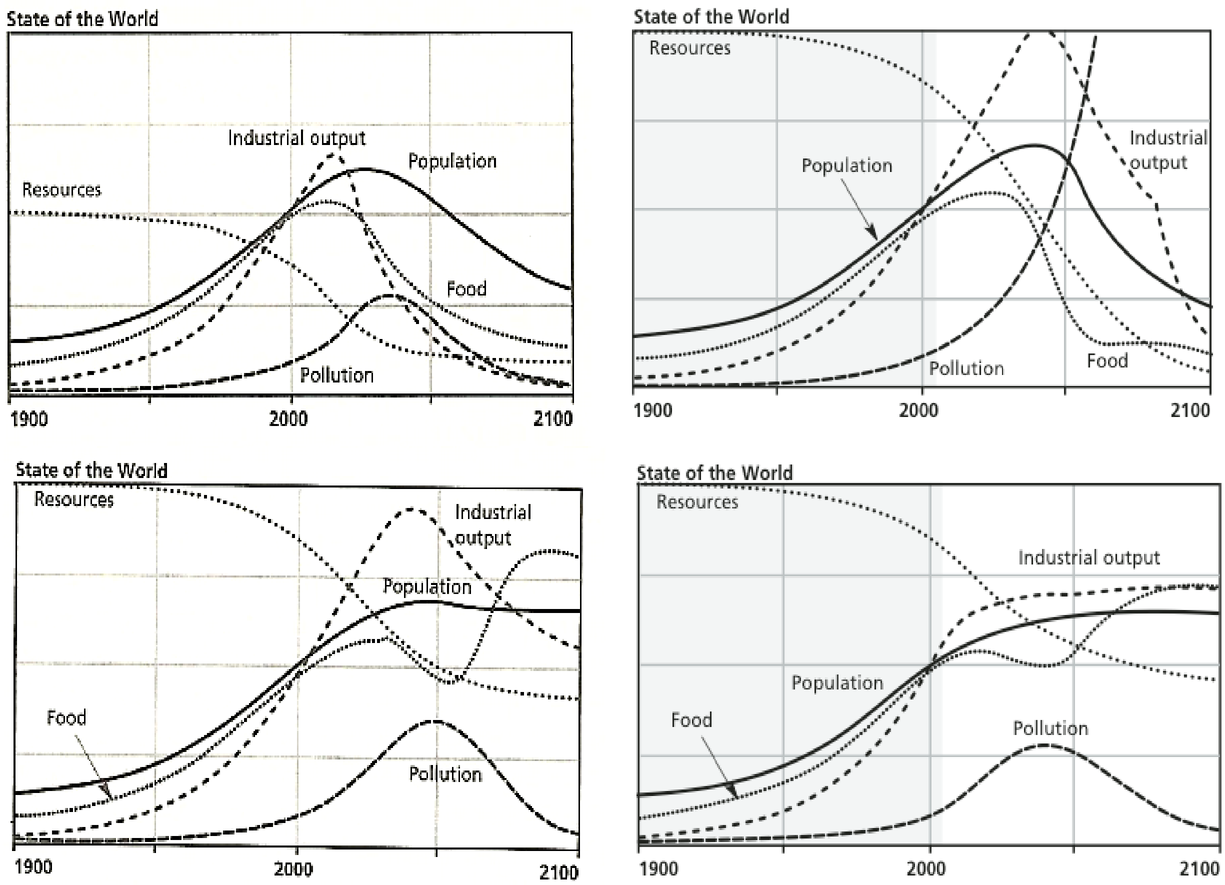

Figure 8. BAU (upper left), BAU2 (upper right), CT (lower left), and SW (lower right) scenarios (Meadows et al., 2004; n.d.).

The assumptions underlying each scenario differ in technological, social, or resource conditions. The cause of decline, varying from a temporary dip to societal collapse, also differs for each scenario (Table 2)

Table 2. Description and cause of halt in growth and/or decline per scenario.

Scenario	**Description**	**Cause**
BAU	No assumptions added to historic averages.	Collapse due to natural resource depletion.
BAU2	Double the natural resources of BAU.	Collapse due to pollution (climate change equivalent).
CT	BAU2 + exceptionally high technological development and adoption rates.	Rising costs for technology eventually cause declines, but no collapse.
SW	CT + changes in societal values and priorities.	Population stabilizes in the 21st century, as does human welfare on a high level.

To quantify how closely the LtG scenarios compare with observed data, we used the same measures as in Turner (2008):

1) the combination of

- the value difference (between the model output and empirical data), and
- the difference (between the model output and empirical data) in rate of change (ROC)

—both applied at the time point of most recent empirical data,

2) the normalized root mean square difference (NRMSD).

It was necessary to establish suitable uncertainty ranges for each of these measures, given World3's low precision and the error margins we can expect in the empirical data. We chose uncertainty ranges of 20%, 50% and 20% for the value difference, ROC and NRMSD, respectively. This recognizes that global data is unlikely to have higher than 10% accuracy due to measurement difficulties, and many variables are combinations of factors. At the same time the uncertainty ranges are still narrow enough to be a meaningful indication of agreement between observed and simulated data. We do not suggest interpreting the 20% and 50% as strictly as say, one would use α as a cut-off point in statistical analysis. The accuracy measures complement a visual inspection of the graphs by quantifying the alignment error.

See Methods for data sources, formulas of the accuracy measures, and other specifics.

Results

Below we show graphs of the LtG scenarios and empirical data plotted for the ten variables, and discuss to what extent they aligned. An overview of the outcomes per variable for each of the two accuracy measures are provided subsequently.

The graphs are in 5-year intervals, which means that in some cases the most recent data point is not depicted. All the accuracy measures are calculated using the most recently available data. For example, for variables where the data series extended to 2017, the accuracy measures were calculated with the 2017 figures, but 2015 is the last empirical data point plotted in the graph.

Population

The SW scenario was the farthest off, BAU2 and CT were the closest. The BAU also still fell within the ranges we had set for the accuracy measures.

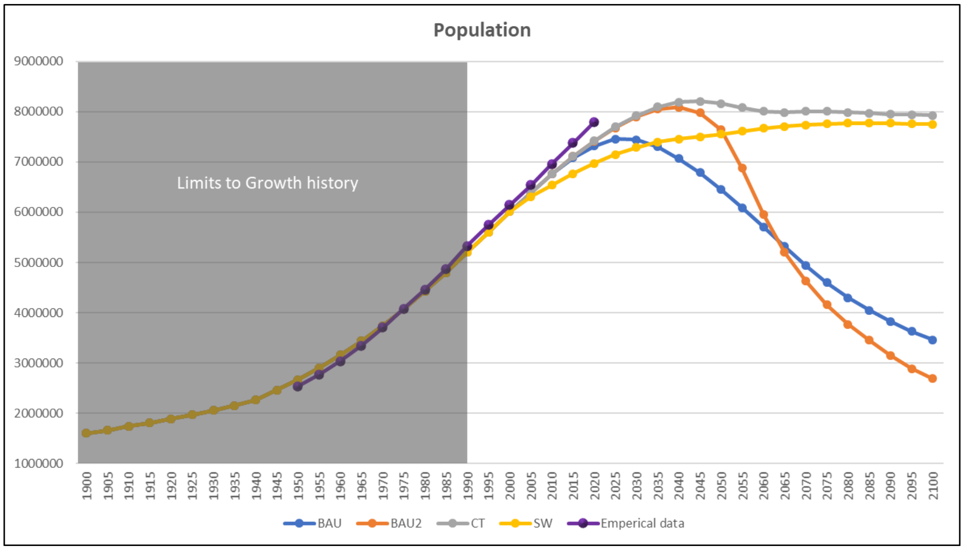

Figure 9. Scenarios and empirical data for population (in thousands of people).

Fertility

The birth rate was higher than in any scenario. The SW scenario fell outside of the uncertainty ranges for all measures. BAU was closer in value but fell outside the 50% range for the ROC. Both BAU2 and CT were in range for all accuracy measures.

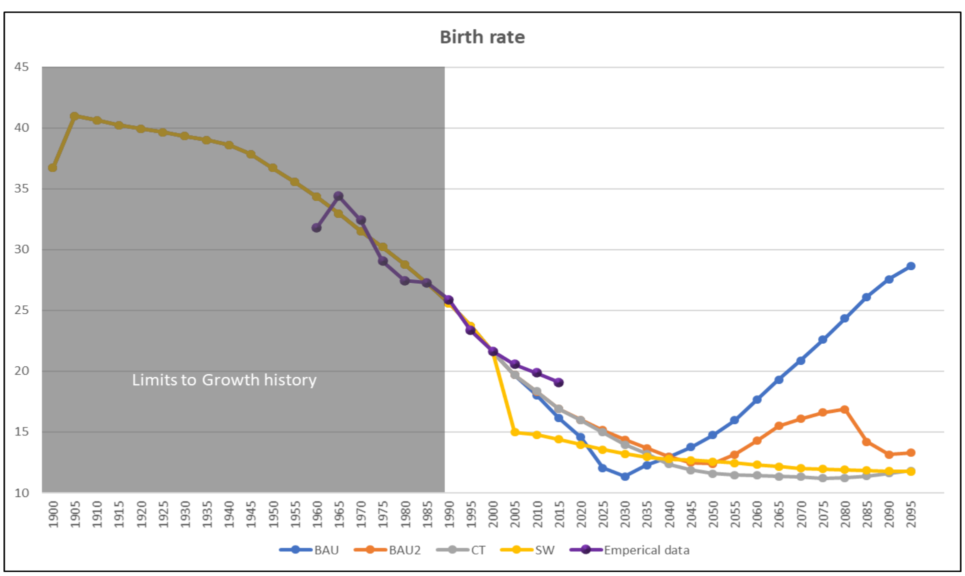

Figure 10. Scenarios and empirical data for fertility (births per thousand people).

Mortality

All scenarios aligned closely with the crude death rate in value and NRMSD. Each scenario was well out of the uncertainty range for the ROC, because contrary to the scenarios the empirical data shows no increase in mortality at this point.

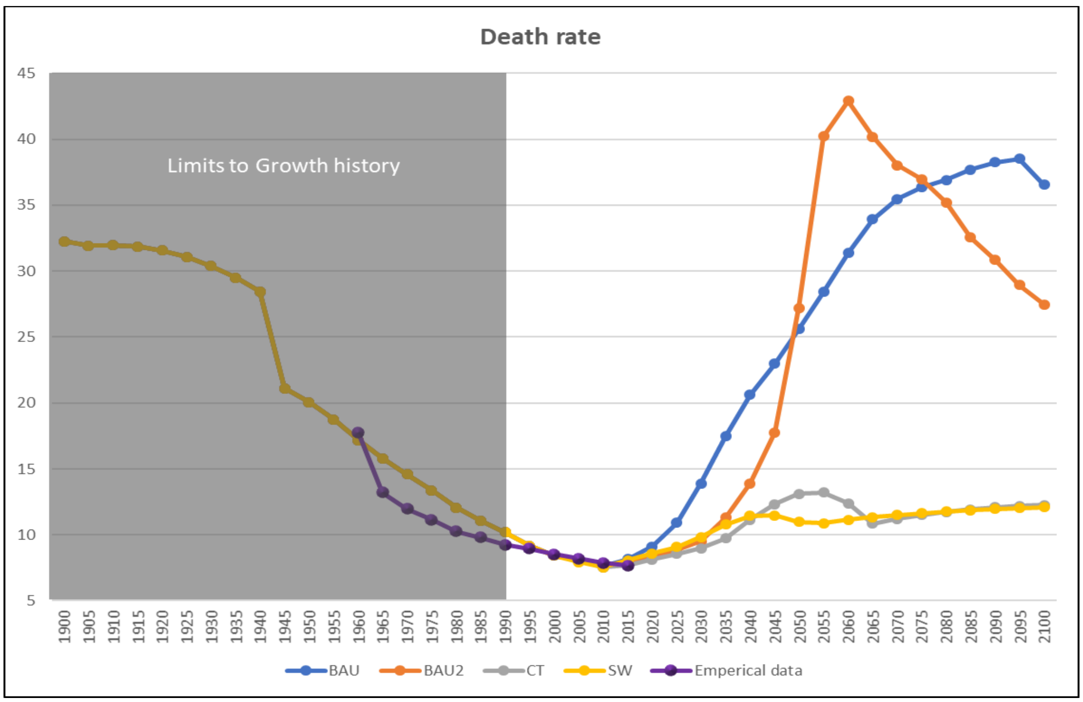

Figure 11. Scenarios and empirical data for mortality (deaths per thousand people).

Food Per Capita

Food p. c. was higher than in any scenario. All scenarios compared favorably in value and NRMSD, with SW being the closest. However, all scenarios were well outside of the 50% range when it came to ROC.

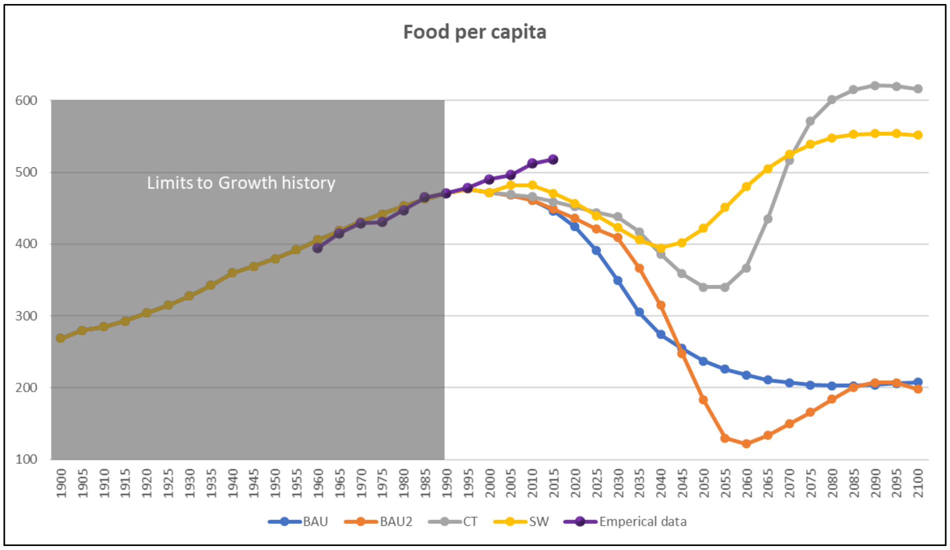

Figure 12. Scenarios and empirical data for food per person (in kilocalories per day).

Pollution

We used two proxies, CO_2 and plastics. Scenarios have not started to diverge yet, so all show the same comparison. Both accuracy measures were outside the uncertainty ranges for the CO_2 series. For the plastics proxy, measure 1 was within range for each scenario, measure 2 was right on the uncertainty range and therefore inconclusive.

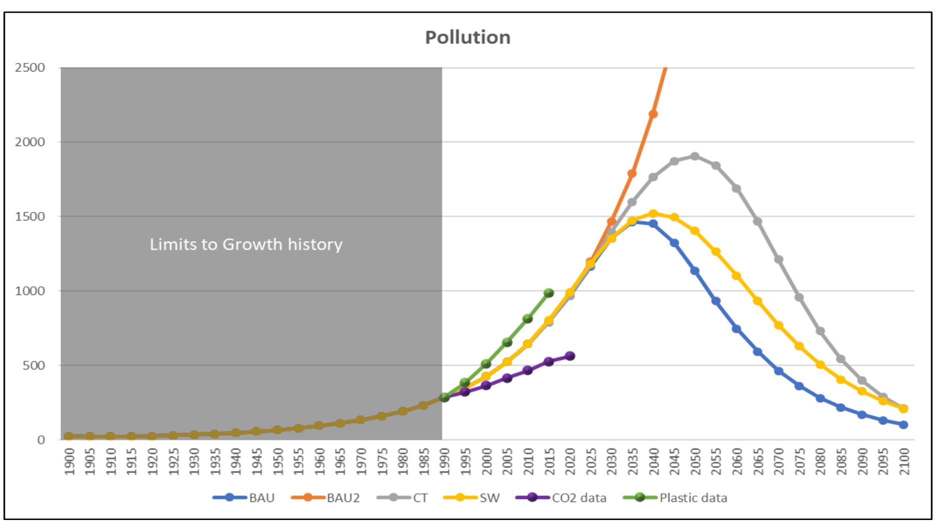

Figure 13. Scenarios and empirical data for pollution (plastic and CO_2).

Services Per Capita

Three proxies were used for this variable: health expenditure, education expenditure, and the education index (EI). Health expenditure showed a close agreement in value and NRMSD for all scenarios, but none were below 50% with regards to the ROC. Education expenditure showed a close agreement for both measures for all scenarios, with BAU clearly showing the closest alignment. The EI gave the same results: accuracy measures were within range for each scenario, with the BAU closest.

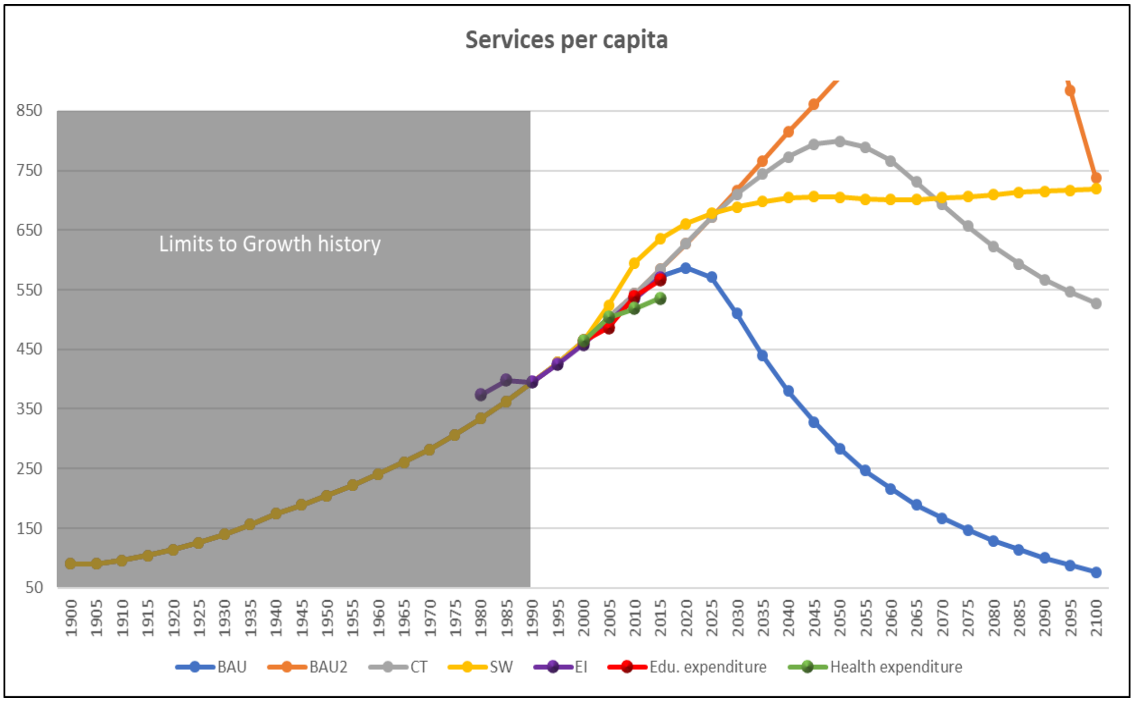

Figure 14. Scenarios and empirical data for services (health or education expenditure and education index).

Industrial Output Per Capita

We used two proxies for this variable, the index of industrial production (IIP) and gross fixed capital formation (GFCF). The GFCF series compared closely in value and

NRMSD for all scenarios, but only BAU2 and CT also showed a close enough comparison to the ROC. The IIP proxy also compared closely in value and NRMSD, but none of the scenarios were below 50% for the ROC.

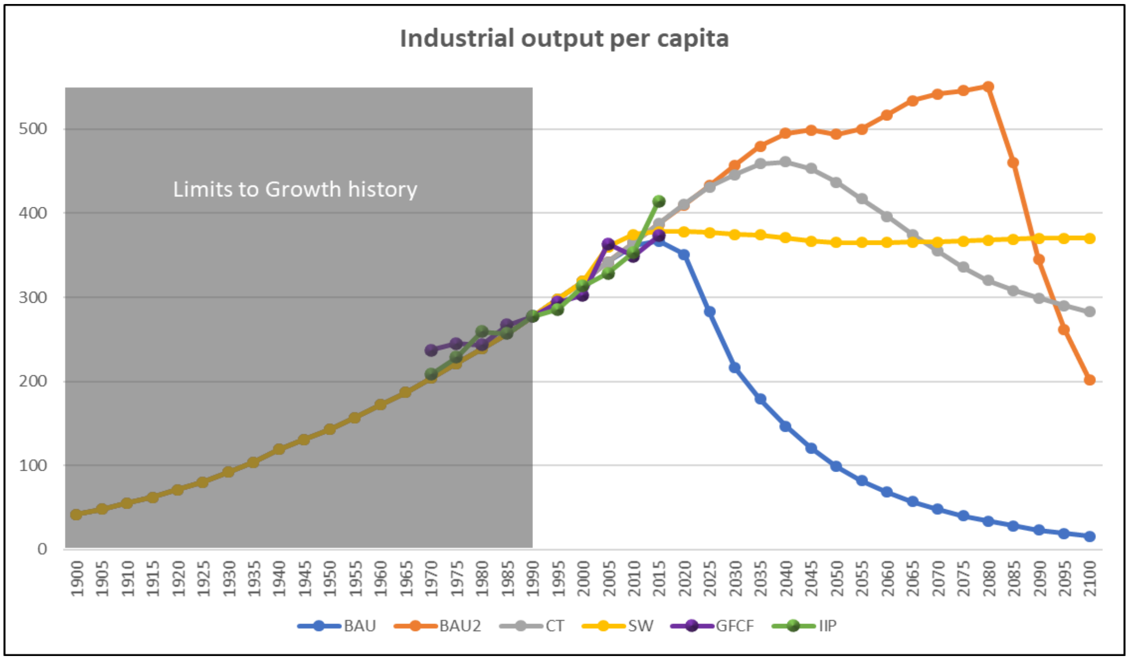

Figure 15. Scenarios and empirical data for industrial output (gross fixed capital formation and index of industrial production).

Non-renewable Natural Resources Per Capita

We used three proxies: two for fossil energy and one for metals. We also used upper and lower bounds for each fossil energy proxy, based on various expert estimates of ultimately recoverable resources. Because the scenarios have not diverged yet, all exhibited similar comparisons. Accuracy measures of the metals proxy were in range for all scenarios. Both fossil energy proxies showed all alignment errors below 20% with regards to value and NRMSD. The proxies' lower bounds for the most part were also relatively close for the ROC. However, the two upper bounds of both fossil energy proxies fell outside of range for the ROC.

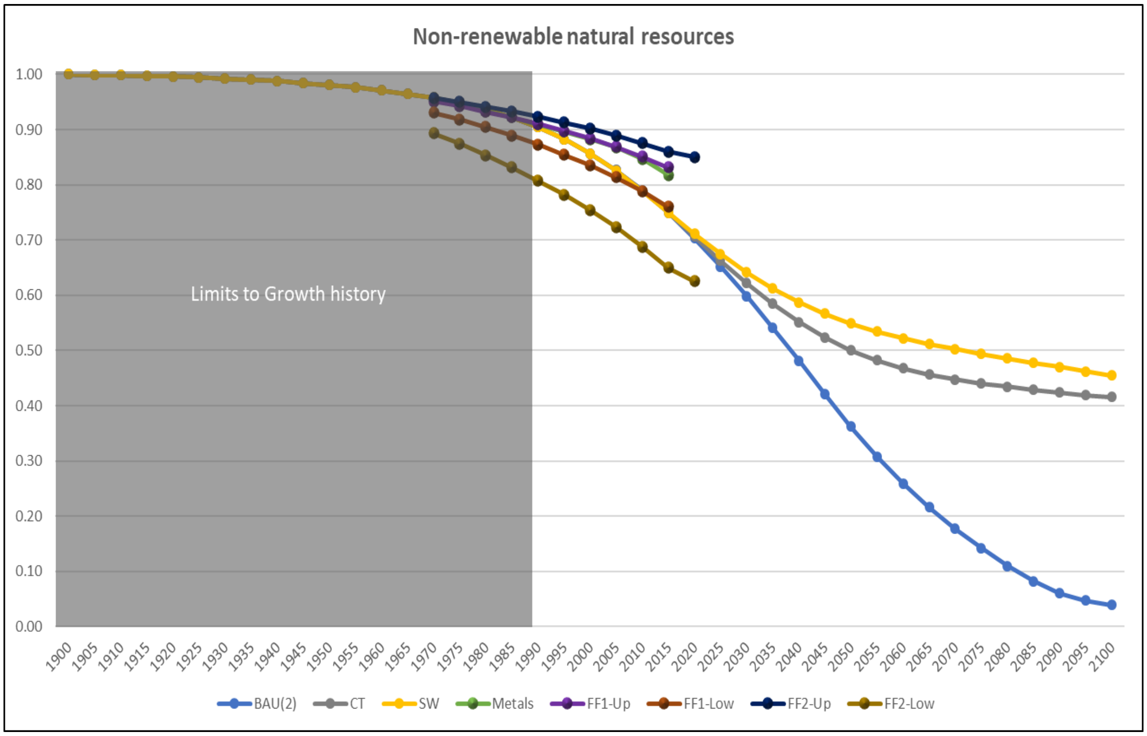

Figure 16. Scenarios and empirical data for non-renewable resources (metals and two fossil fuel expert estimates, both with high and low estimates).

Human Welfare

The LtG team (Meadows et al., 2004) created this variable to represent the UN Human Development Index (HDI). The HDI showed a close agreement in value and NRMSD for all scenarios. The CT scenario was the only one within range for the ROC.

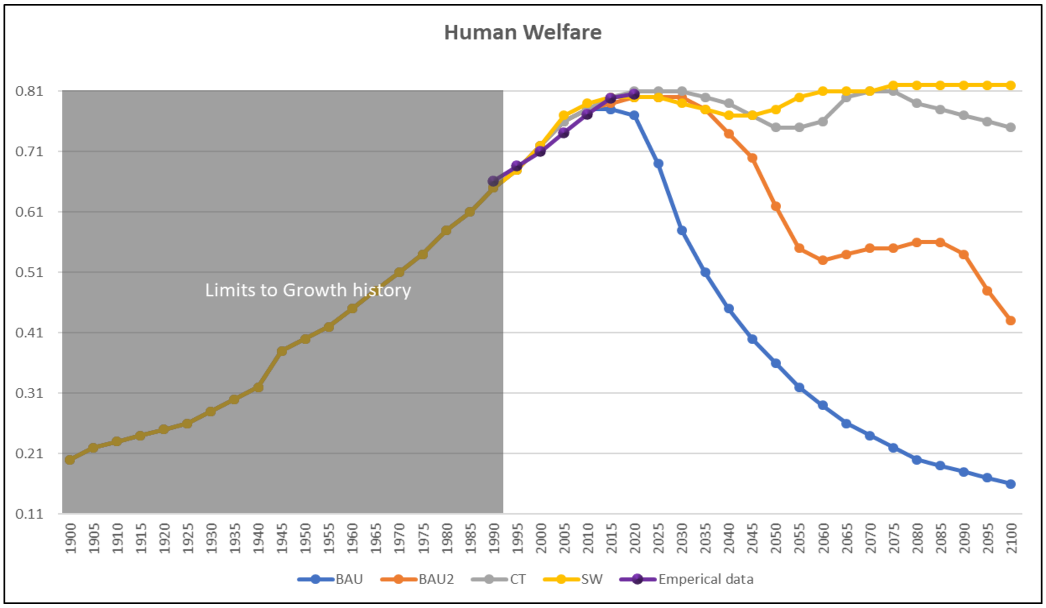

Figure 17. Scenarios and empirical data for welfare (UN Human Development Index).

Ecological Footprint (EF)

This variable represents Wackernagels' ecological footprint (Meadows et al., 2004). The EF was below 20% for all scenarios for value and NRMSD. However, each scenario was significantly outside the 50% range for the ROC.

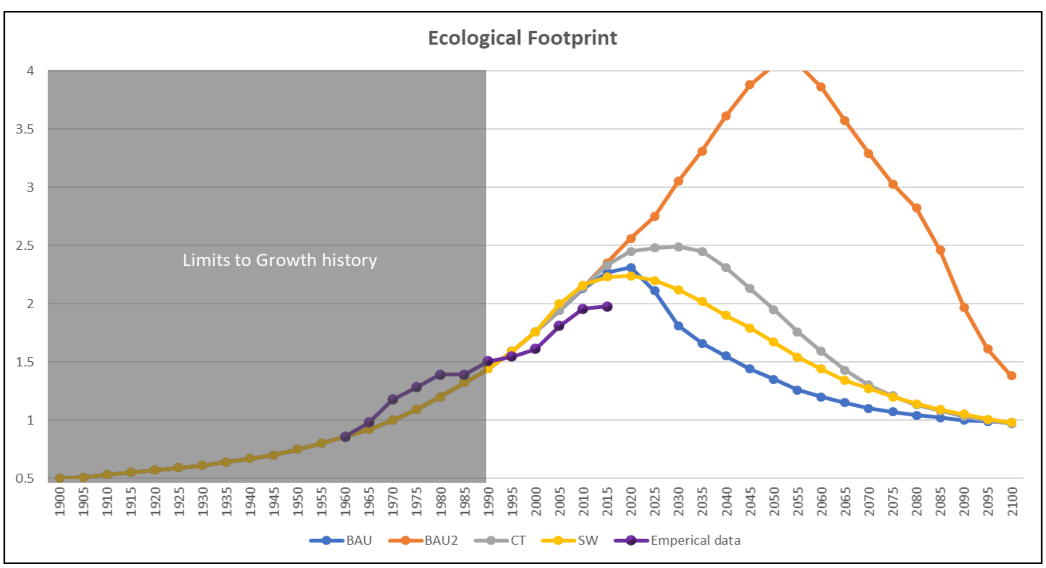

Figure 18. Scenarios and empirical data for the human ecological footprint.

Accuracy Measures

The below table and graph provide an overview of the two accuracy measures for each variable and scenario. Table 3 shows the results for accuracy measure 1, the graph in Figure 19 shows accuracy measure 2. Some variables had more than one data series for comparison with the scenario (i.e., more than one proxy). These data are listed in one cell per variable in the table and displayed separately in the graph.

The numbers in Table 3 that were within the uncertainty ranges (20% for the value difference and 50% for the ROC) are printed in green, the ones outside the range in red. The uncertainty boundaries were left in black. The 20% line is easily identified in Figure 19.

Table 3. Accuracy measure 1: value difference and rate of change difference (in %) for World3-03.

Scenario		Popula-tion	Fertility	Mortality	Food p.c.	Services p.c.	Industrial output p.c.	Pollution	Natural cap.p.c.	Welfare	EF
BAU	Δ value	-6	-18	12	-13	1; 1; 7	-1; -11	-20; 59	-15; -11; -8; -2; 15	-3	15
	ΔROC	-42	118	-109	-230	1; 12; 76	-123; -90	-14; 169	12; 43; 55; 121; 179	-125	593
BAU2	Δ value	-5	-12	5	-12	3; 4; 9	-7; 9	-20; 59	-15; -11; -8; -2; 15	-1	19
	ΔROC	-28	41	-105	-213	53; 70; 140	-64; 240	-14; 173	12; 43; 55; 121; 179	-66	940
CT	Δ value	-5	-12	3	-11	3; 5; 9	-6; 9	-20; 59	-15; -11; -8; -2; 16	0	18
	ΔROC	-25	43	-104	-162	53; 71; 140	-62; 250	-14; 170	7; 41; 50; 113; 166	-42	841
SW	Δ value	-11	-24	9	-8	12; 13; 19	-9; -2	-19; 62	-15; -11; -8; -2; 16	0	13
	ΔROC	-52	-50	-107	-173	33; 49; 134	-127; -95	-8; 190	-3; 36; 39; 97; 143	-70	247

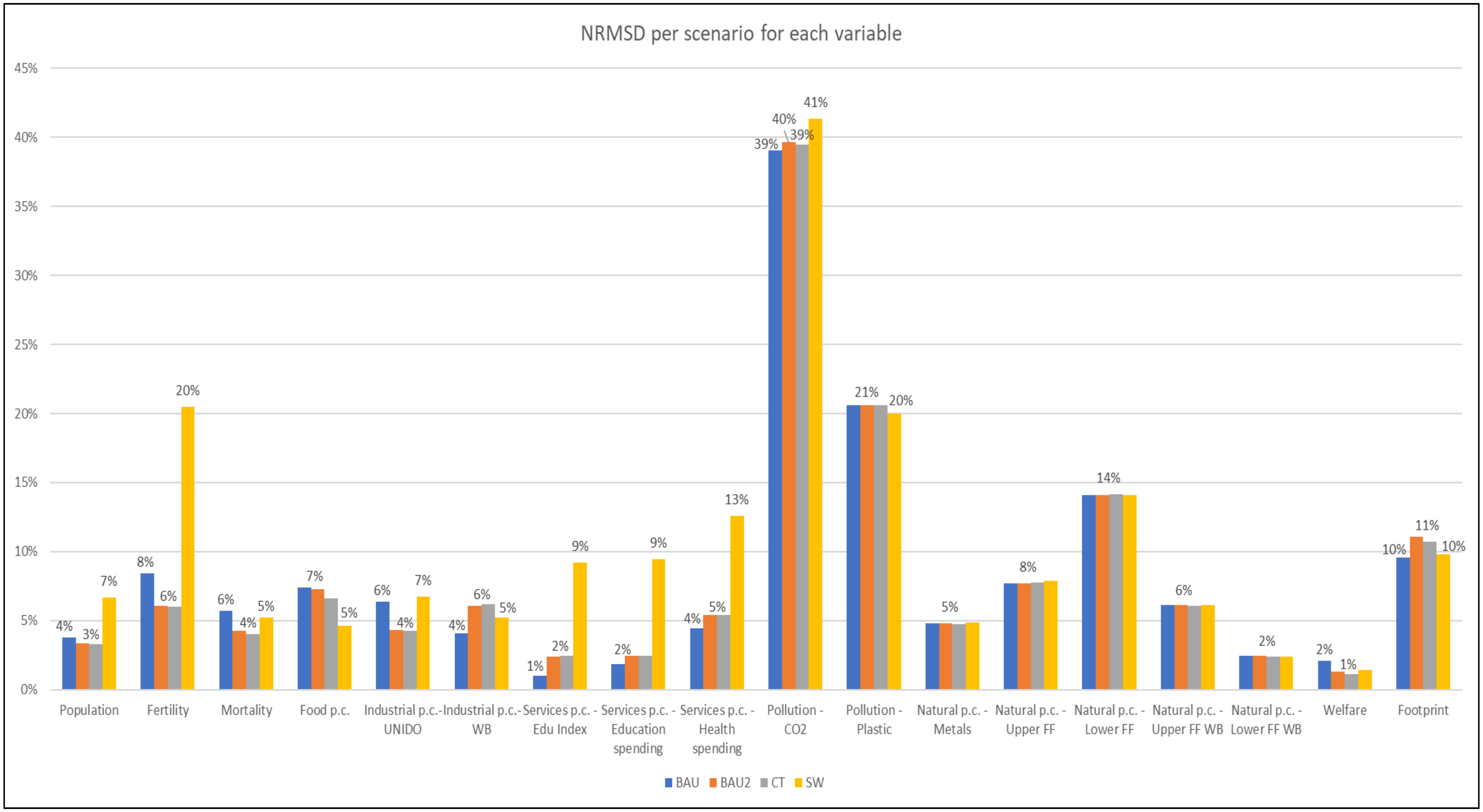

Figure 19. Accuracy measure 2: NRMSD. Plotted for each World3-03 scenario and variable.

Discussion

The LtG scenarios overall aligned closely with empirical data in value. Measure 2 (the NRMSD) was not greater than 20% for all variables (Figure 19), except for pollution. Table 3 shows that most differences in value were also within the 20% range, except for pollution and for fertility in SW. The ROC showed more and larger deviations between scenarios and empirical data.

Table 4 contains a count per scenario for each time it was the closest fit. A scenario was counted as a closest fit when it aligned more closely than other scenarios and at least one proxy was within the uncertainty bounds for both accuracy measures. This last criterium is a stringent, we could also have used the requirement of only one accuracy measure being within uncertainty bounds. (As is clear from Figure 19, accuracy measure 2 is within bounds for at least one proxy for every variable.) We chose both measures instead of either one, because scenarios show a reversal around present time for several LtG variables. Therefore, alignment in ROC is an important part of the accuracy assessment. As a second derivative, however, ROC is also the most sensitive part of the measure. In one case, industrial output p.c., we decided to balance the ROCs sensitivity with its importance by counting the scenario that showed close alignment in value (both difference and NRMSD) and the ROC slightly over the 50% bound (i.e., 62% and 64%). When all scenarios were outside of uncertainty bounds for at least one measure, they were counted as inconclusive (the last column in Table 4). For the cases where two or more scenarios aligned to the same extent, they were all counted. This is why Table 4 shows 22 counts total over ten variables. The use of more than one proxy for some variables did not lead to double counting. Although different proxies for the same variable sometimes had different numerical results, they often led to the same outcomes in terms of alignment (or not) to a certain scenario.

Table 4. Count per scenario of closest agreement with empirical data.

Scenario	BAU	BAU2	CT	SW	None
Count of closest alignment with data	4	6	7	3	2

Unlike previous comparisons, this research did not reveal one particular scenario aligning with empirical data more closely than the others. This is because scenarios start to deviate later in World3-03 than was the case in the 1972 version of World3. Even when scenarios showed close alignment, in some cases choosing a closest fit scenario was not possible because they all aligned to a similar extent. This was the case with the non-renewable resources, for example, and with the plastics proxy for the pollution variable. Especially the BAU2 and the CT scenarios don't deviate significantly before 2020, resulting in both being closest fits for several variables. Because scenarios often aligned closely in value, a decisive factor in determining the closest fit was the difference in ROC. This means that even in cases where one scenario could be picked as a closest fit, this outcome could change in future updates because additional datapoints can change a ROC significantly. For example, the accuracy measures for the welfare variable indicated CT as the closest fit, but this is only because its ROC difference was below the 50% uncertainty range. The other scenarios agree closely in value too, and mathematically speaking it's entirely possible that even next year's datapoint will cause their rates of change (now 66% and 70%) to dip below 50%. This should be kept in mind with Table 4.

The lowest count for closest fit is for SW, the scenario that would indicate a sustainable path. When it was possible to distinguish between scenarios, the CT and BAU2 aligned closest most often. One cannot simply "take the midway" between two scenarios produced by a complex, nonlinear model like World3. However, both BAU2 and CT indicate that continuing business as usual, even when paired with unprecedented technological development and adoption, is not possible. Trying to do so would inevitably lead to declines in industrial capital, agricultural output, and welfare levels within this century. Our results are inconclusive as to whether such declines could be labeled collapse, because the two scenarios show a distinctly different decline pattern. Although the steepness of a scenario's collapse pattern cannot be used for predictive purposes (Meadows et al., 2004), the fact that CT has the highest count in close alignments might suggest the possibility of future declines being relatively soft landings, at least for humanity in general. This would align with the global forecast that Randers made in 2012 with a different model than World3. Randers' forecast described a high-tech world of changing weather patterns, a shrinking population, and a natural environment diminished in size and biodiversity. It included consumption and GDP stagnation around the middle of the century, but the subsequent decline was not forecasted as an overshoot and collapse pattern.

Conclusion

We compared empirical data with the most recent version of the LtG model, World3-03. The scenarios overall align closely with global data, indicating that World3's dynamics can still be observed in the real world. The four LtG scenarios in this comparison, BAU, BAU2, CT, and SW, diverge significantly after 2020. For this reason, it was often not possible yet to distinguish between scenarios, and an update of this comparison in another few years will likely yield more pronounced outcomes. It also means that our results should be interpreted as preliminary, because the closeness of scenarios as well as the uncertainty within the empirical data theoretically allows for any scenario to still become a closest fit even in the short term. At this point, our results indicate that humanity is not following a sustainable path as laid out by SW. When divergence between scenarios allowed to make such distinctions, observed data aligned most closely with BAU2 and CT. Although this result does not necessarily indicate an impending collapse, both scenarios display a halt in growth and subsequent decline in industrial capital, agricultural output, and welfare within three decades. This suggests that humanity is on a path to having limits imposed on itself, rather than consciously choosing its own.

Methods

BAU, BAU2, CT, and SW, correspond to scenarios 1, 2, 6, and 9 in the 2004 LtG book. This means that for the SW scenario, we assumed policy changes starting in 2002.

To create the scenarios, we used the original CD-ROM that came with the 2004 book. (We obtained a mint condition with CD-ROM still attached.) The CD-ROM contains simulations of the scenarios, numerical output of the variables, and the code to run simulations in STELLA, a dynamic systems modelling program (ISEE Systems, 2019). A zip file of World3-03 is also available from MetaSD (2019) and it can be run on free software from Vensim (2019).

The CD-ROM provides World3 output in 5-year intervals, this is also what we used in our plots and calculation of accuracy measures.

Data Sources

Below we list for each variable the source of empirical data that we used for the comparison, and briefly discuss reliability. Some variables required proxies because the variable in World3-03 (henceforth called "World3") is not directly observable or quantifiable in the real world. We often used the same data sources as Turner in his earlier work, however, in several cases we were able to improve on those thanks to new or recently enhanced indices and databases. When empirical data was expressed in different units than the LtG scenarios, we normalized them to the 1990 scenario value, because that is the year that World3 was recalibrated to last (Meadows et al., 1992).

Population. We used figures from the Population Division of the United Nations Department of Economic & Social Affairs (UN DESA PD, 2019). Their population series includes estimates for 2020, which we used to compare against the LtG 2020 values. Annual population figures can also be found on the World Bank Open Data website (WB, 2019a). Both sites mention national agencies and international organizations as their sources, such as Eurostat, the US Census Bureau, and census publications from national statistical offices.

Global population will likely be one of the more accurate data used in this research. Although censuses in some countries will be less frequent and/or of lower quality than in others (WB, 2019a), variances in the data should be within the precision that we worked with. Estimates for next year can be made with enough accuracy for our purpose too. The WB population data differs slightly from the UN figures, but the errors are around 0.5%, which is negligible compared to the precision level of World3.

Fertility & mortality. We used the data series from the WB Open Data site (2019b; 2019c). The WB mentions as its sources the same organizations and publications as for its population series.

These two series' reliability should be similarly high as for population. Uncertainties around data on deaths and births can be higher in some developing countries (2019c). However, the WB notes that its data "are generally considered reliable measures of fertility in the recent past" (2019b), and for the precision level we were working with we can assume the same for mortality.

Food per capita. We used total energy available per person per day to approximate this variable. The daily caloric value per capita can be found in the Food Balance Sheets on FAOSTAT (2019a), the database of the Food and Agriculture Organization (FAO).

The FAO states that "there is a substantial amount of estimated or imputed data points", leading it to conclude that "the accuracy for certain products, countries and regions is not that good" (FAOSTAT, 2019b). Because the FAO does not quantify the inaccuracy, we cannot say to what extent it impacted our research outcomes. An additional source of error was the fact the series has not been updated in several years; it extends to 2013. Because we worked with 5-year periods, we used the 2013 observed value to compare with the 2015 LtG scenario values. This is unlikely to have significantly impacted the accuracy measures based on value, because global values will not change that much in absolute terms over two years. However, it is possible that it made a significant difference in the calculated rate of change.

Industrial output per capita. We divided both proxy series, index of industrial production (IIP) and gross fixed capital formation (GFCF), by population to arrive at per capita numbers. The industrial output p.c. variable represented citizens' material and technological standard of living, and was a factor in the World3 society's ability to grow food and deliver services (Meadows et al., 2004).

IIP is a standardized macroeconomic indicator of an economy's real output in manufacturing, mining, and energy (e.g., Moles & Terry, 1997). Unlike gross domestic product (GDP), IIP excludes retail and professional services, making it an obvious proxy for industrial output. The IIP series can be retrieved as "INSTAT2" on the data portal of the UN Industrial Development Organization (UNIDO, 2019a). UNIDO does not provide a global IIP, so we created one with a weighted average of country IIPs. As weights we chose national manufacturing value added, also sourced from UNIDO (2019b).

The WB (2019d) provides a global GFCF series. GFCF includes land improvements (e.g., fences and drains), infrastructure (e.g., roads), building construction plants (e.g., schools, offices, hospitals, and industrial buildings), machinery, and equipment purchases. This aligns closely with the definition of the industrial output variable in World3, especially as it relates to a society's ability to deliver services and grow food.

Reliability of both proxies should be adequate for our purpose. Given the mandates of UNIDO (2019c) and the WB (2019e), we can assume they source from industry associations and government agencies. These are credible institutions, who in turn collect the data through regular censuses and firm surveys (Moles & Terry, 1997). Although data quality on fixed capital formation can be weak in some cases (WB, 2019f), the series should be accurate enough because we normalized the data for this variable. Rather than comparing absolute numbers, in this case we were comparing the trend in industrial capital growth. Therefore, consistency in the underlying data collection is more important than precision, especially at the level of aggregation that we worked with. The GFCF series is based on the System of National Accounts 1993 standards (WB, 2019d), which ensures some standardization in reporting across national accounts (UN DESA Statistical Division, 2019). The INDSTAT2 series is the only one that provides "data by a single classification standard for more than 40 years, which makes it particularly valuable for long-term structural analysis" (UNIDO, 2019d).

Services per capita. In World3, services p.c. represents education and health services (Meadows et al., 2004). We used the Education Index (EI), spending on health, and spending on education as proxies.

The EI is constructed by the UN Development Programme (UN DP, 2019a). It's calculated using mean years of schooling and expected years of schooling (UN DP, 2019b). These two figures can be quite different especially in developing countries, and combined thus provide a good indication of currently available education services (UN

DP, 2019c). UN DP does not provide a global EI, so we created one by weighing each country's EI by its population fraction.

The reliability of the EI proxy should be adequate for our purpose. The EI consists of census/survey information compiled by various official government agencies, which are widely considered reliable (Barro & Lee, 2019; UN DP, 2019b). The EI had some missing data points, and we filled in the gaps with the value from the first year that data became available (again). For six small countries the EI was unavailable completely, so we left those countries out of the proxy. Because these missing data points or series were only for a handful of countries with a relatively small population, these adjustments will not have affected the aggregate significantly, especially not because we normalized the data series.

The WB provides global figures for both government spending on education (2019g) and health expenditure (2019h). The two series are expressed as a percentage of GDP. The LtG authors described many collapse patterns as resources being diverted away from services to industrial capital in order to keep extracting natural resources, abate pollution, and/or produce food. Faction of GDP is an indication of how resources are allocated towards something on a macro level, as expressed by the WB's statement that a "high percentage to GDP suggests a high priority for education" (2019g). Therefore, tracking the fraction of global GDP spent on education or health can help reveal whether the mechanism described by LtG is indeed observable.

Both GDP and government expenditure on education and health are widely and frequently recorded figures. The health spending series is sourced from the World Health Organization (WHO) and consist of "all health spending in a given country (…)

regardless of the entity or institution that financed and managed that spending" (WB, 2019h). The WHO (2019) collets data from "government budgets and health accounts studies", which, given that our research does not require high-precision data, should be sufficiently reliable. This is underlined by the WB comment that the series "generates consistent and comprehensive data on health spending (…), which in turn can contribute to evidence-based policy-making" (2019h).

Pollution. World3 assumes pollution to be globally distributed, persistent, and damaging to human health and agricultural production. We used CO_2 concentrations and plastic production as proxies.

Atmospheric CO_2 data (Tans & Keeling, 2019) were obtained from the National Oceanic & Atmospheric Administration (NOAA). We subtracted the 1900 CO_2 level of 297 parts per million (Etheridge et al., 1996), because the LtG scenarios put pollution at 0 in 1900. Although CO_2 it not the only persistent pollutant —NO_x, SO_x, heavy metals, and ozone-depleting substances are other examples— it is a good proxy because of the global impacts that climate change brings for human health, the environment, and our ability to grow food, and because there is accurate time series data.

CO_2 data from credible organizations like NOAA are widely considered reliable. NOAA (2019) uses air samples taken from remote sea level locations, which it claims, "results in a low-noise representation of the global trend". The NOAA CO_2 series differs little from global CO_2 averages published by other organizations that use different methods (NOAA, 2019).

Global plastic production data was sourced from Geyer, Jambeck, & Law (2017). We adjusted the data downwards by the share of plastic that gets discarded, which reportedly went from 100% in 1980 to 55% in 2015 (Geyer et al., 2017). Not all plastic is considered pollution, however, we felt it an appropriate proxy given that plastic is persistent and ubiquitous in today's society. Various kinds of plastics can be found throughout the entire consumer product and food supply chain, from oceans and marine wildlife (van Sebille et al, 2015; Smillie, 2017) to tap water (Kosuth, Wattenberg, Mason, Tyree, & Morrison, 2017), from agricultural land (Nizzetto, Langaas, & Futterto, 2016) to dietary components and the air we breathe (Wright & Kelly, 2017a), prompting a growing body of scientific literature on a wide range of possible negative human health effects (Halden, 2010; Wright & Kelly, 2017b).

The models used to create the plastics data series contained multiple assumptions and simplifications, introducing considerable uncertainty for the estimates (Geyer et al., 2017). For this reason, the authors rounded cumulative results to the nearest 100 metric ton and conducted sensitivity analyses around mean product lifetimes and waste management rates. In these analyses, plastic estimates changed by between 4% to 8%. This is well below the 20% uncertainty range we used, so we can assume the plastics data accurate enough for our research.

Non-renewable resources. We used two fossil fuel proxies and one metal proxy. We assumed full substitution between energy or metal resources, which is conservative given the current state of technology (Brathwaite, Horst, & Iacobucci, 2010; Driessen, Henckens, van Ierland, & Worrell, 2016; Graedel, Harper, Nassar, & Reck, 2015). The proxy data series that we created were not normalized to 1990 values because they represent fractions (i.e., they run on a scale from 1 to 0) and so scaling them would distort the comparison. Because BAU and BAU2 differed only in amount of resources and these were set to 1 at 1900, the two scenarios show the same curve.

Both fossil energy proxies consisted of estimates of remaining coal, natural gas, and oil. The first fossil fuel proxy was the same as in Turner's earlier work. His 2008 paper lists all the sources he used to determine high and low expert estimates for fossil energy resources in 1900. Annual production of each resource was sourced from the World Watch Institute, which in turn had compiled the data from organizations including the UN, British Petroleum (BP), and the US Energy Information Administration. We updated Turner's series with production data from BP's *Statistical Review of World Energy* (2019), and summed over the three fossil resources to arrive at the total annual production series. These production data were cumulatively subtracted from the total high and low resource estimates, resulting in an upper and lower bound for the fraction of non-renewable resources remaining over time. The second fossil energy proxy was constructed using the same method, but with resource estimates from a *Geochemical Perspective* (GP) publication (Sverdrup & Ragnarsdóttir, 2014), and production data from the WB (2019i).

Although both proxies are based on data from credible organizations, non-renewable natural resources data are amongst the more uncertain compared to other variables in this research. Consequently, we worked with upper and lower bounds of expert estimates, which should mitigate the inherent uncertainty in fossil resource data sufficiently for a meaningful comparison. Turner (2008) deliberately created bounds for the fossil energy proxy that lay on extreme ends of the spectrum. High and low expert estimates from the GP publication for the second fossil energy proxy were closer together. We took some assurance from the fact that the second fossil fuel proxy falls in between the upper and lower bounds of the first one.

The metals proxy consisted of resource estimates of 21 metals: Aluminum, Antimony, Bismuth, Chromium, Cobalt, Copper, Gold, Indium, Iron, Lead, Lithium, Manganese, Nickel, Niobium, Palladium, Platinum, Silver, Tantalum, Tin, Vanadium, and Zinc. Resources estimates of the metals available in 1900 were based on the GP publication also used for the second fossil energy proxy (Sverdrup & Ragnarsdóttir, 2014). Production of each metal was obtained from the US Geological Survey (USGS, 2019). GP provided remaining recoverable amounts for each metal as of 2010, so we summed USGS production over 1900 to 2009 and added this sum to the metal resource GP estimate to arrive at the 1900 resource figure. Production and resource data were subsequently summed over the 21 metals, and the total annual production was subtracted from the 1900 total resource over time.

The USGS production series were comprehensive overall. There were some missing data points, but sensitivity analysis showed that neither the most conservative nor extreme choice for the missing data points significantly impacted research outcomes. (We interpolated with the mean of the last and next known year when possible, and otherwise conservatively assumed zero production.) We took assurance from the fact that the metals proxy too falls in between the upper and lower bounds of Turner's fossil energy proxy.

Human welfare. The HDI data series can be found on the website of UN DP (2019a). The HDI has undergone methodological changes over the years (UN DP, 2019d), which have led to significant retroactive adjustment to the series. The 2004 LtG book (Meadows et al.) tells that the World3 welfare variable was very close to the UN DP value of 1999, but this was no longer the case for the latest version of the HDI data series. The UN DP (2019d) states: "The difference between HDI values (…) published in HD Reports for different years represents a combined effect of data revision, change in methodology, and the real change in achievements in indicators". UN DP (2019d) therefore advises not to source HDI numbers from Reports, but to use the "data series available in the on-line database". Therefore, we scaled the current HDI data with a factor 1.106 to line up with the World3 scenarios value of 2000.

The extent to which revisions to the HDI may have impacted our comparison beyond a scaling issue is unknown. The HDI series also had two missing data points, which we filled through linear interpolation. The inaccuracy that this introduced is unlikely to be significant, given firstly our research's level of precision and secondly that with the scaling of the series the most important aspect becomes the rate of change.

Human ecological footprint. The Global Footprint Network (GFN, 2019a) publishes the ecological footprint (EF) on its website. We scaled the EF series to scenario values between 1990 and 2000 (with a factor 1.17), because the LtG team would have calibrated World3 to line up with EF figures at the time. The reason that today's EF data did not exactly line up is most likely the several revisions to the EF calculation over the past two decades (GFN, 2019b), similarly to the HDI.

The GFN states that the “Ecological Footprint accounts provide a robust, aggregate estimate of human demand on the biosphere as compared to the biosphere’s productive capacity” (2019b). Revisions to the calculation may have impacted our comparison beyond what can be solved with scaling, but to what extent is not known.

Determination of Accuracy

We used the same statistical measures as in Turner (2008) to determine relative closeness between a scenario variable and observed data:

1) the combination of the value difference and the rate of change difference,
2) the normalized root mean square deviation (NRMSD).

The calculations of the two measures are done for 5-year intervals ending in the final year of the data series. In the below equations, we assume that ending year to be 2015 to make the formulas easier to interpret. It is straightforward to adjust the equations for data series ending in another year.

Measure 1*: value change and rate of change*

$$\Delta Value = \frac{Variable_{2015} - ObservedData_{2015}}{ObservedData_{2015}}$$

$$\Delta RateOfChange = \frac{(Variable_{2015} - Variable_{2010}) - (ObservedData_{2015} - ObservedData_{2010})}{ObservedData_{2015} - ObservedData_{2010}}$$

Measure 2: NRMSD

In the formula below we assume the start of the sum to be 1990. This is what we used for each variable where this was possible, however, some series did not go back as far, in which case below equation would have to be adapted accordingly.

$$NRMSD_{2015} = \frac{\sqrt{\frac{\sum_{t=0}^{5}(Variable_{1990+5t} - ObservedData_{1990+5t})^2}{6}}}{\left(\frac{\sum_{t=0}^{5} ObservedData_{1990+5t}}{6}\right)}$$

These two measures of accuracy do not provide the level of precision of some statistical tests. As discussed in the article, the accuracy measures are appropriate when combined with visual inspection given World3's global scope and aggregation. Precision does not always correspond to accuracy. The precision of linear regression and other econometric methods are based on assumptions of constancy like linearity, homoscedasticity, or normality, which cannot be assumed outside controlled experiments or other unusually stable environments (Branderhorst, 2018; Sterman, 1994). As such, they are inadequate for analyzing the dynamics of a system like our society (Forrester, 1971; Meadows, 2012). The accuracy measures are useful to determine World3' merit, not for point predictions, but as an analysis tool for general global dynamics.

Chapter III

Further Discussion and Final Conclusion

In this final chapter I elaborate on my research results, including a data comparison for the 1972 version of World3, and interpret what the deviations between observed data and LtG scenarios might indicate about the model's assumptions and validity. As mentioned in Chapter II, overall alignment with empirical data was close for all scenarios. Data series typically extended to 2016, 2017, or 2018, and in one case to 2013 (food per capita). New data points could change which scenario(s) align(s) closest in a future update of this research, especially because by then scenarios will have diverged more. With that caveat, I close this chapter and thesis with what my results could mean for world trend developments in the upcoming few decades.

Comparison with the 1972 World3 Version

Because Turner's comparisons were more conclusive than my research, I repeated the exercise for the 1972 World3 version. Thus, I also conducted an update to Turner's work. I used the same scenarios and variables as he did, thereby leaving the BAU2 scenario and the EF and welfare variables out. Although the BAU compared favorably with empirical data more often than in the comparison with the World3-03 scenarios, in the update reported here it no longer showed a conclusively closer alignment over other scenarios (Table 5). In Turner's last paper (2014), the count of the BAU was twice that of the second closest fit, the CT scenario. This is no longer the case.

Table 5. Count per scenario of closest alignment for 1972 version of World3 from this research and from the last comparison by Turner (2014).

Scenario	BAU	CT	SW	None
Count of closest alignment with data in 2019	3	4	1	2
Count of closest alignment with data in Turner (2014)	6	3	1	2

Appendix 3 contains the results of the 1972 World3 comparison. These show that overall, empirical data followed the three 1972 scenarios less closely than the scenarios created with World3-03. Deviations were higher in frequency and size than in the results in Chapter II. Although the BAU was the closest fit for more variables in the 1972 comparison, empirical data aligned more closely with the World3-03 version of the BAU scenario. The reason that BAU was less often counted a closest fit in this research was not because of less alignment with empirical data, but because the CT and BAU2 aligned even closer (Table 3 and Figure 19). The overall closer alignment with observed data available in 2019 of the World3-03 scenarios makes sense given that they were based on the most recent version of the model, while the 1972 version was calibrated on historical data that is by now almost half a century old. It does seem then, that any future LtG data comparisons should be conducted with the World3-03 scenarios, although there certainly are still lessons to be learned from comparative studies between the World3 scenario versions and their underlying assumptions.

What a Global Model Will Miss: Distribution

It's an interesting contrast that on one hand empirical data for the food p.c. variable did not show signs of the decline in food production that the scenarios indicate

(Figure 12), while on the other hand according to the UN Food and Agriculture Organization (FAO) the number of undernourished people in the world has been on the rise again since 2015 (FAO, 2019a). (I should note that the food p.c. data series only goes to 2013, see the Methods section of Chapter II). At the same time of growing undernourishment, a third of the food produced in the world for human consumption still gets lost or wasted every year (FAO, 2019b). This points at a distribution issue. Likewise, economic and other inequalities have been increasing in the world since the 70s, certainly so in advanced economies and to more varied extents in developing and emerging countries (Piketty, 2014; Dabla-Norris, Kochhar, Suphaphiphat, Ricka, & Tsounta, 2015; World Inequality Database, 2018). As the IMF put it (Dabla-Norris et al., 2015): "Widening income inequality is the defining challenge of our time".

Perhaps the lack of a distributional factor in the World3 model could be one possible explanation that not one specific scenario was followed anymore based on data available in 2019 (Table 4). In this light, it is also worth noting that the one variable for which the BAU was still most closely followed, including in terms of ROC, was services p.c (Figure 14). Although industrial capital and welfare aligned closest to CT (Figure 15 and Figure 17), this was not paired by quality education and health services to the point, and especially not at the rate of increase, that one would expect based on those scenarios. This would suggest that resources are not divided as evenly as is modelled in World3, and rather are diverted to other priorities such as resource extraction and/or are used to service a smaller fraction of the population only. This too would be in line with Randers (2012), which included forecasts of increased inequalities between countries and regions.

SW Followed Least

For those variables where the scenarios had started to diverge at the end point of the data series, SW was followed the least closely (Table 3 and Figure 19). This indicates that the world is not on a sustainable path. The reason for the relatively larger deviations is simply that the assumptions in SW, especially regarding societal priorities, are not and have never been fully present in the real world.

Population and birth rate were both higher than in SW because this scenario assumes low desired family size and perfect birth control availability, which had not been the situation globally so far (UN Population Fund, 2018). The SW scenario also assumes deliberate efforts to redirect resources away from industrial capital accumulation towards education and health services. This results in stagnation in industrial capital p.c. around present time (without a subsequent decline) and a short growth spurt around 2010 in services p.c. (Figure 14 and Figure 15). The empirical data of the respective proxies, however, did not show either of these movements. This could also be derived from accuracy measure 1 (Table 3). For services p.c., there was a positive ROC difference between SW and empirical data, indicating that the increase in the variable in the real world was not as high as in the scenario. The SW also showed the largest positive value difference amongst the four scenarios, because the absence of the growth spurt in the real world resulted in a lower value than the scenario one. For industrial output p.c. on the other hand, accuracy measure 1 showed a negative ROC difference out of the uncertainty bound, because industrial growth was higher in the real world than in SW (and in the other scenarios).

BAU Not Followed Closest

My hypothesis was rejected, as the BAU was not a best fit scenario in this comparison (Table 4). This does not mean that the BAU scenario is eliminated; new data points could change the outcomes in a future comparison. The population variable, for example, was within uncertainty bounds for both accuracy measures for BAU (Table 3 and Figure 19). It was not the closest alignment because BAU2 and CT were significantly closer in ROC in this comparison, but a slowdown in population growth over the next few years could change that outcome.

Another example is the industrial output p.c. variable. Both proxies aligned closely in value with BAU but were out of bounds for the ROC at -90% and -123% (Table 3 and Figure 19). As mentioned in the section above, historical industrial output growth has been higher than in the scenarios, however, a future slowdown in observed industrial output growth is not just a theoretical possibility. As the head of the IMF, Kristalina Georgieva, recently mentioned, the global economy is experiencing a "synchronized slowdown" (Lawder, 2019). The most recent empirical data has been heavily influenced by China's performance, but with the country hitting a 30-year low in GDP growth this year (Crossley & Yao, 2019) it might not be able to keep holding the industrial production figures up at these levels (Qui & Yao, 2019; "China's Economy Slows on Weak Investment", 2019).

The Meaning of BAU2 and CT as Closest Fits

Based on data available in 2019, both the CT and BAU2 scenarios were the closest fits. The two scenarios can't effectively be distinguished because they hadn't diverged sufficiently yet. However, these scenarios do show significantly different developments in about five years from now (Figure 8 and Figure 20).

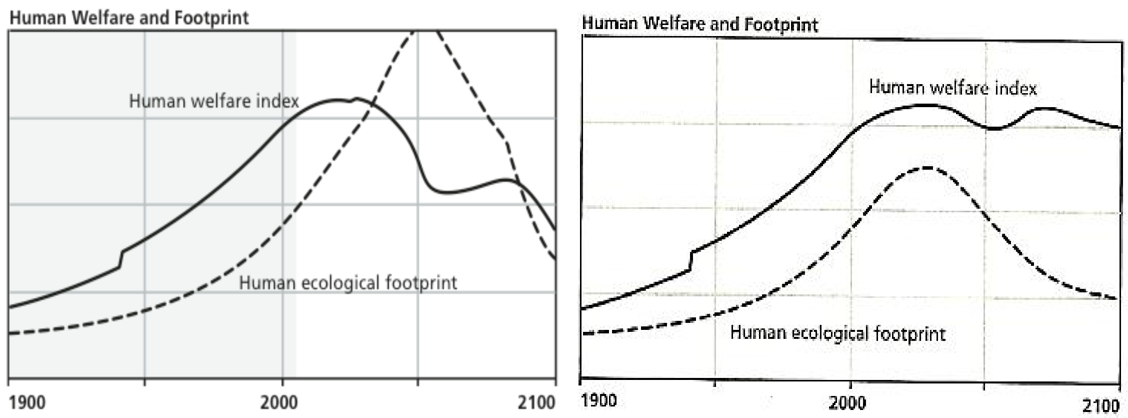

Figure 20. Welfare and EF developments for BAU2 (left) and CT (right) (Meadows et al., 2004).

The BAU2 depicts a scenario where pollution will cause societal collapse, while the CT shows only a moderate decline in welfare levels. So, what do we make of these two scenarios both being the best fit? The short answer is that at the moment we do not know whether we are following either scenario or a mix of both. Available data is inconclusive, and no one knows the future with certainty.

The question of whether we are following CT or BAU2 seems to come down to whether we believe society could be facing impending collapse, as depicted in BAU2, or whether technological innovation can stretch earth's carrying capacity to a point where collapse is largely avoided, as CT seems to indicate. It's important to note however that even if we followed CT, this would not necessarily mean declines can be assumed to be as moderate as in Figure 8 and Figure 20. The LtG authors were careful to point out that the behavior of World3 after collapse is not informational (Meadows et al., 2004). This is partly because of the modelling limitations. As with any model, World3 is a simplified version of the real world. As mentioned, lack of distribution is one major simplification. The rich and the poor are not represented separately in World3. Many pervasive social issues, such as discrimination, oppression, violence, and corruption, are not explicitly modelled. World3 does not distinguish between geographic parts of the world. Local natural disasters, e.g., floods or earthquakes, are absent. There is no military capital in the model. As the LtG authors stated (Meadows, Meadows, & Randers, n.d.), these limitations probably make World3 “highly optimistic”. For example, it is hard to imagine how domestic and international resource conflicts would not have significant impact on the course of a decline once set in. The implication is that one must be extremely careful with drawing detailed, quantitative conclusions from a collapse pattern. My results indicate that global society can expect a halt in growth in the medium term, because this is what happens in both scenarios. We can expect declines in CT to not constitute a collapse and thus to be less dramatic than under BAU2, but we cannot be more precise than that. If I assumed the world is following CT, I could not use the scenario patterns to quantify the declines. For example, one cannot look at Figure 20 and draw the assuring conclusion that the decline in our standard of living will be less than a non-threatening 10% on a global level.

The fact that both the BAU2 and CT were the best fits could also suggest a mix of the two scenarios; humanity has carried on business as usual while putting its faith in innovating itself out of any environmental crisis it would encounter along the way, as many LtG critics promised we could. This would be in line with findings of Pasqualino et al. (2015) that humanity had invested more to abate pollution and increase food productivity compared to BAU2. Society may successfully innovative itself out of some constraints. Indeed, one reason that natural capital turned out to be more abundant that most experts expected in the 70s is that technological developments made it possible to extract from deeper and more dispersed resources (e.g., Helm, 2011; Faucon, 2013; The University of Texas at Austin, 2019). But a new limit emerged once the constraint from non-renewable natural resources was relaxed, just as the Limits to Growth principle predicts. Pollution, notably but not only in the form of CO_2, became the new constraint on carrying on business as usual (e.g., Woody, 2013; Jakob & Hilaire, 2015). This illustrates one of the major reasons that humanity cannot be expected to technologically innovate itself out of an environmental crisis: as long as the goal of the economic system is perpetual growth, technological developments will mostly serve to sustain growth, not life (Meadows, 2012). And as long as growth continues, new limits will be met.

BAU2 forecasts that the new limit will come from pollution, including from greenhouse gasses. The pollution variable did not show a close fit with empirical CO_2 data, but the impact factor in World3 (both versions) is too low given the myriad and complex ways that climate change impacts life. In BAU2, pollution levels have to literally get off the scale of the graph for it to cause collapse (Figure 8). But it is well established that increases in CO_2 levels much smaller than those depicted in the BAU2 graph would cause a crisis in the next few decades (e.g., Intergovernmental Panel on Climate Change, 2018). At the current impact factor in World3, other forms of pollution may be a better approximation. Many localized chemical pollution, e.g., water, land, and air contamination, by now has a persistent occurrence in locations around the globe. However, there is no global data repository of any kind for these contaminations. Plastics are another example of a localized pollution with global occurrence, and that proxy did show a close fit with LtG scenarios.

My Future Scenario

Based on my results, I would indeed synthesize a future scenario that is a mix of CT and BAU2. In this scenario, society will stay on the current path that conflates progress with expansion, albeit with the best intentions behind the concept of “green growth”. Natural non-renewable resources will be depleted further, and pollution in all its manifestations of contamination, toxicity, and climate change will become an increasing problem. Pressing problems present opportunities to those who are able to capitalize on them (which are not necessarily the ones most affected). Therefore, we will see unprecedented innovation in fields like renewable energy, pollution abatement, resource efficiency, agricultural practices, and disaster resiliency, although not as much as in the assumptions underlying CT. These technologies will come at major costs. It is these costs that cause declines in CT, but because World3 lacks a distributional factor, in the scenario they are borne equally by every person. I do not think this will happen in the real world. Amidst major income and wealth inequality, a mix of CT and BAU2 will mean that negative impacts from pollution on water and food supply, human health, and weather patterns, will be largely spared from those that can afford the technological solutions, and borne mostly by those that cannot. Basically, when I say that I expect a mix of the two scenarios I mean that some of us will experience a CT future while others will experience the BAU2 one.

What If We Are Following CT?

Some might postulate that there is no mix between the BAU2 and the CT at all, and argue that we are following the CT, which will become apparent in the upcoming years when new data shows the closest alignment to CT instead of BAU2. They might look at Figure 20 and say: "We will all be fine with only a temporary dip in welfare levels around 2050." I could point out that the assumptions underlying the CT scenario are highly optimistic given historic figures. For example, CT assumes technological progress rates of 4% a year which, amongst other things, should lead to reductions in pollution emissions of 10% from their 2000 values by 2020 and 48% by 2040 (Meadows et al., 2004). Compared to our performance record of reducing global CO_2 emissions, the CT assumptions seem unrealistic to me. However, the technologist might argue that technological developments are ever accelerating, and the solar technology boom or nuclear fusion breakthrough are around the corner to completely change our trajectory. We could keep going back and forth for a long time with our arguments, none of which would change the fact that ultimately the future is uncertain.

Much more important, whether we are following the CT is not the right discussion to have. Is the only thing that can motivate society an impending collapse? I would argue not, in fact, I would argue the opposite. One just needs to look at the climate change debate and realize: if impending doom was enough motivation for humanity to make the necessary changes, we would have made them by now. The overwhelming threats of climate change and other sustainability challenges seem to not scare people into action so much as they scare them into the arms of economists, technology gurus, and spiritual leaders who promise that some force, be it the invisible hand, human ingenuity, or surrender to a higher power will solve our systemic problems for us (Vargish, 1980). I intentionally avoided delving into all the details of why I think the CT is unrealistic, because it would obscure the question we really should be asking: do we want to be following the CT scenario in the first place? Why would we use our innovative powers to invent robot pollinators to replace the bees, if we also have the choice to invent agricultural practices that do not have the side effect of insecticide? Why use drones to plant new trees, when we could also restructure our economic priorities so that existing rainforest is not cut and burned down? Now that humanity has attained truly global reach, now that we have an unprecedented power to shape our own destiny, limits to growth force upon us the question: who do we want to be and what world do we want to live in?

Conclusion

I compared empirical world data available in 2019 against scenarios from both the first and last LtG books, which were created by an earlier and recalibrated version of the World3 model. The data comparison with the latest World3 version included four scenarios: BAU, BAU2, CT, and SW. Empirical data showed a relatively close fit for most of the variables. This was true to some extent for all scenarios, because in several cases the scenarios don't significantly diverge until 2020. The overall close track with empirical data of the latest World3 version is a testament to the accomplishment of the LtG team, when they created and recalibrated a model which has been able to generate global interacting trends accurately three decades into the future.

When scenarios had started to diverge, the ones that showed a closest fit with empirical data most often were BAU2 and CT. I thus rejected my hypothesis that society was still following BAU, which had been the conclusions of comparisons that used the earlier World3 version. The BAU not being the closest fit scenario does not imply that societal collapse can be ruled out. The scenario that depicts the smallest declines, SW, is also the one that aligned least closely with empirical data. Furthermore, one of the best fit scenarios, BAU2, shows a collapse pattern. The other best fit scenario however, CT, shows only a moderate decline. At this point, therefore, results indicate a halt in growth within the next three decades, but leaves open whether the subsequent decline will constitute a collapse.

This outcome does not mean that human suffering will likely or even possibly be avoided. In fact, my results show services p.c., a variable directly related to wellbeing, following the scenario that puts a collapse nearest in the future (BAU). This suggests that, contrary to what is assumed in World3, resources are not distributed equally amongst people. It may be worth researching whether incorporation of a distribution effect improves the model. Given the major income and wealth inequality in the world, I have interpreted both CT and BAU2 being the closest fits, as that both scenarios will play out in the upcoming few decades; the high-tech solutions and moderate welfare decline of CT will befall on the rich, while the effects of the pollution crisis and collapse in living standards of the BAU2 will be borne mostly by the poor.

Lastly, the close alignment to empirical data and the fact that the scenarios had not diverged yet, together form a call to action. Hidden behind a seemingly ambiguous outcome of two best fit scenarios that marginally aligned closer than the other two, hails the message that it's not yet too late for humankind to change course and alter the trajectory of future data points. Global society does not have to settle for CT as a best-case scenario. We have another choice.

This thesis has mostly focused on the hard data analysis, but there is a value aspect around LtG and it would be a shortcoming to ignore this other, non-quantifiable dimension. As the LtG books and many other experts have stated: humanity needs a change in values and priorities in order to reach a global equilibrium. But changing our societal priorities does not need to be a capitulation to grim necessity. A world in which human activity is regenerative instead of rapacious is not just one in which collapse is avoided, it is a world where our natural surroundings are full of life. The LtG graphs show how society would be more stable in the SW scenario, but not how much more its citizens would be thriving. World3's equations do not capture human's innate love for nature in all its abundance and diversity, and how we hurt when we lose parts of it forever. By the time the next data comparison may be able to show one best fit, more will be lost and a course change will be more difficult or even impossible. Now is the time to deliberately choose global equilibrium with nature in all its forms, including fellow humans. Not because we cannot survive without parts of nature, although we very well may not, but because we love life more than growth.

Appendix 1

Dynamic Systems Depiction of World3

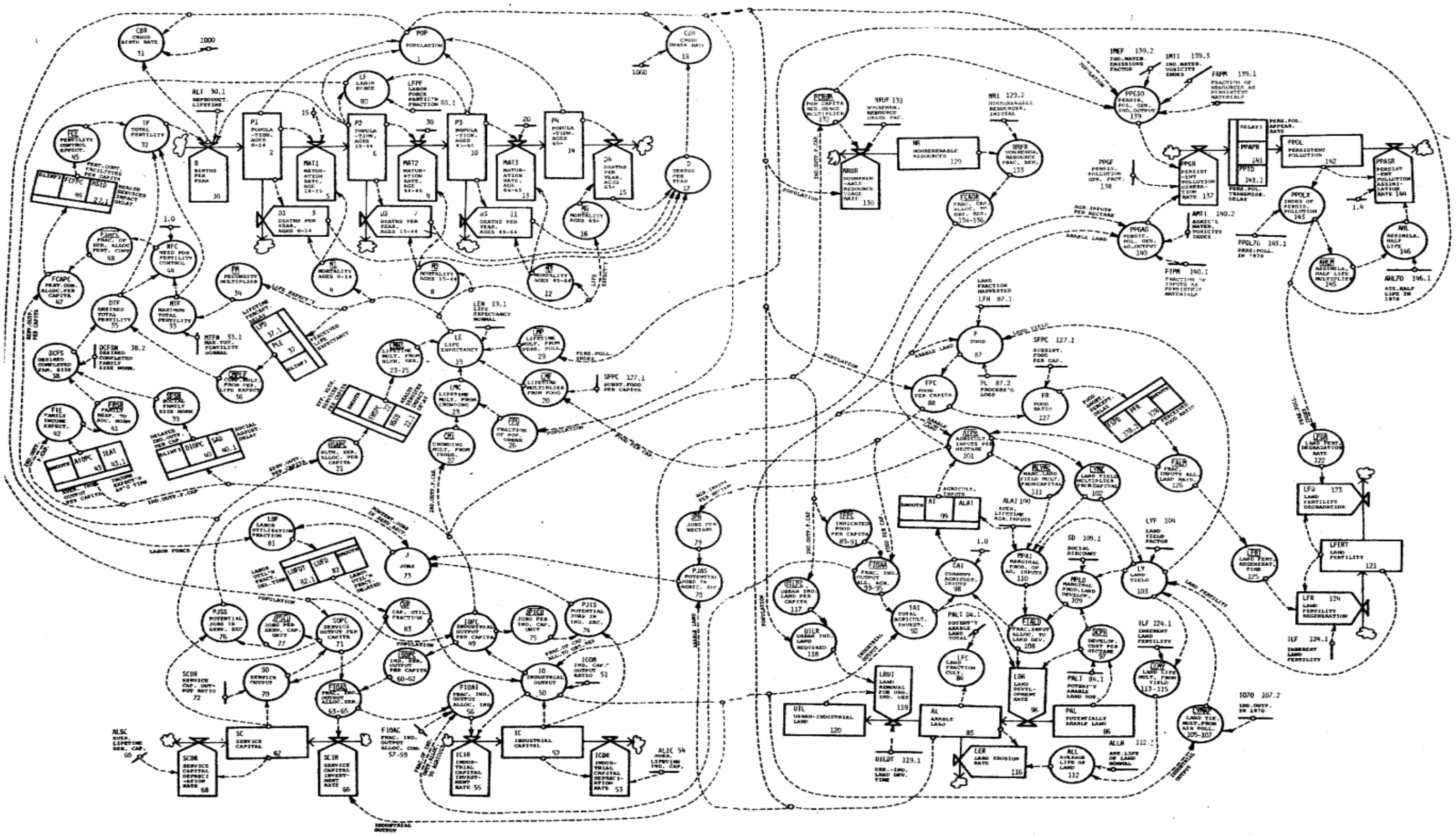

Figure 21. Depiction of the interactions in the World3 model (Pasqualino, et al., 2015).

Appendix 2

The Four LtG Scenarios Used in the Research

Scenario 1 (BAU).

Scenario 1 represents a global society that proceeds as long as possible without major structural policy changes. Meadows et al. (n.d.) describe this scenario as follows:

> As natural resources become harder to obtain, capital is diverted to extracting more of them. This leaves less capital for investment in industrial output. The result is industrial decline, which forces declines in the service and agricultural sectors. About the year 2030, population peaks and begins to decrease as the death rate is driven upward by lack of food and health services.

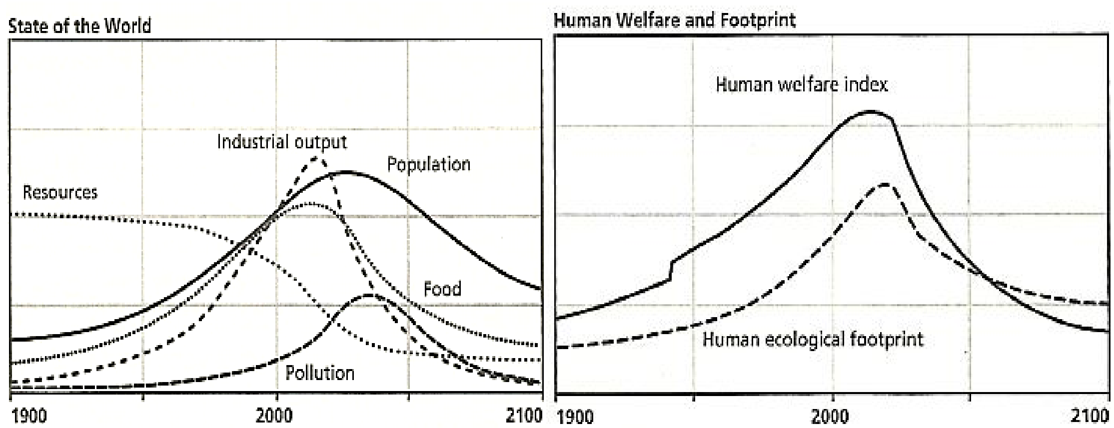

Figure 22. Scenario 1, or the BAU scenario (Meadows et al., 2004).

Scenario 2 (BAU2)

Scenario 2 assumes that the world's non-renewable natural resources double, and further assumes that resource extraction technologies will postpone the onset of increasing extraction costs. Meadows et al. describe scenario 2 as follows (n.d.):

> Under this scenario industry can grow 20 years longer. But pollution levels soar, depressing land yields and requiring huge investments in agricultural recovery. The population finally declines because of food shortages and negative health effects from pollution.

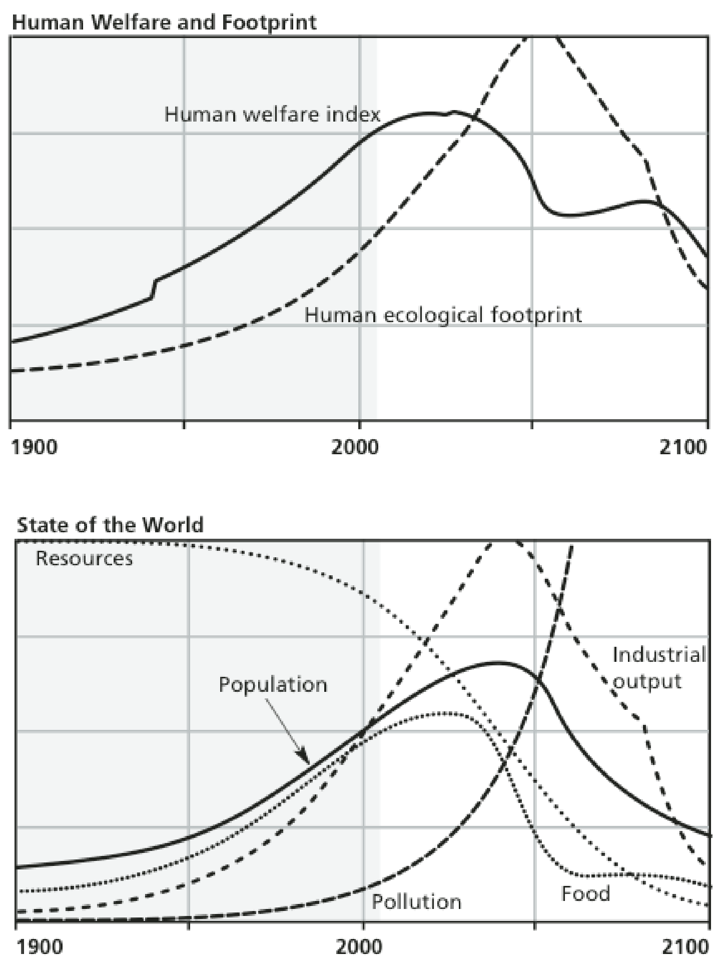

Figure 23. Scenario 2, or the BAU2 scenario (Meadows et al., n.d.).

Scenario 6 (CT)

This simulated world focusses on technological advancements to solve natural resources scarcity and pollution problems. Powerful technologies that abate pollution, increase land yields, counter land erosion, and boost resource conservation are assumed to take place. The technological innovation and implementation is assumed to involve financial costs, and the delay between discovery and full implementation of innovations is assumed to be 20 years. Technology does in fact seem to avoid a decline as steep as in some other scenarios in CT, however, standards of living still show a moderate decline around 2030 as a result from the costs that the high rate of technological innovation requires.

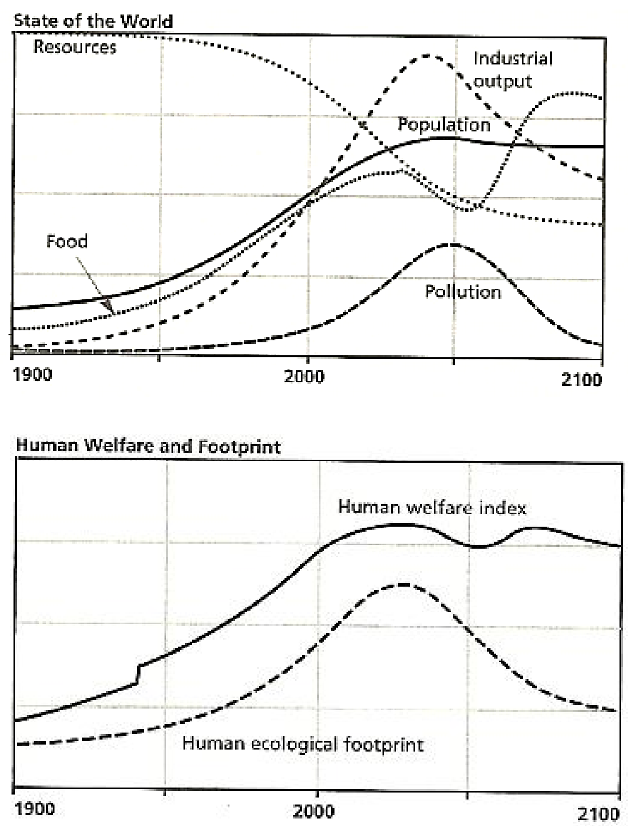

Figure 24. Scenario 6, or the CT scenario (Meadows, et al., 2004).

Scenario 9 (SW)

In this scenario, global society deliberately seeks stable population by perfect birth control availability and average desired family size of two children per family. It also caps industrial output per person, and prioritizes investments in pollution control, resource conservation, and agricultural technologies. The effectiveness in avoiding collapse depend on when these changes are assumed to take place. In the below graph, this was 2002.

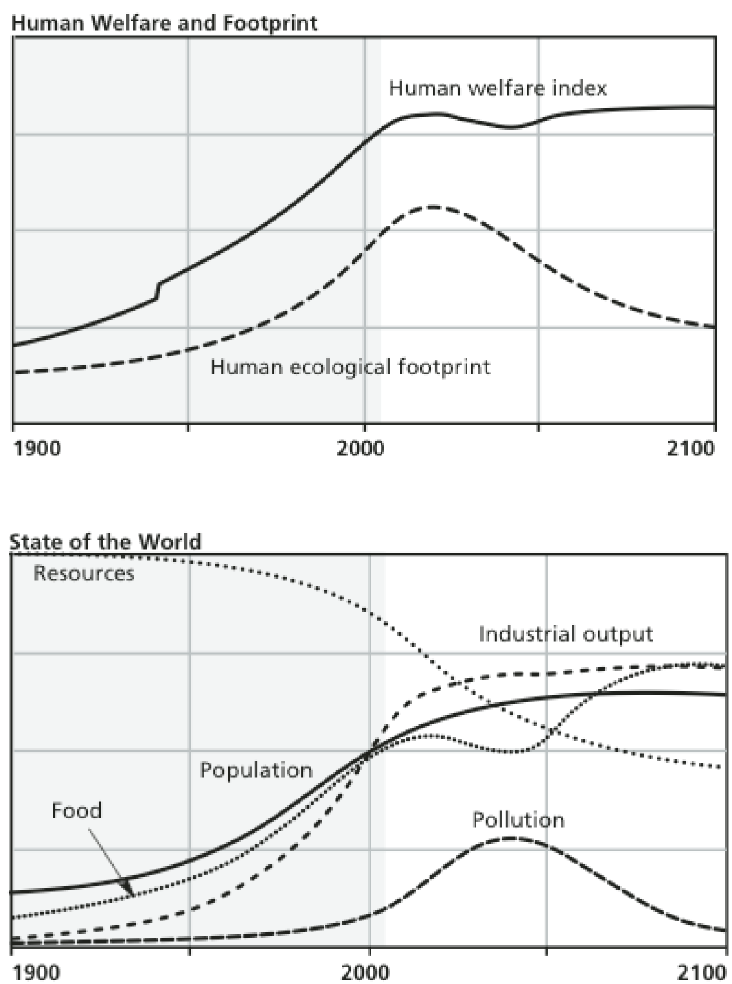

Figure 25. Scenario 9, or the SW scenario (Meadows, et al., n.d.).

Appendix 3

Results From the 1972 World3 Data Comparison

Table 6. Accuracy measure 1: value difference and rate of change difference (in %) for 1972 World3 version.

Scenario		Population	Fertility	Mortality	Food p.c.	Services p.c.	Industrial output p.c.	Pollution	Natural cap.p.c.
BAU	Δ value	-7	1	27	-9	-18 ; -13 ; 8	-12 ; 10	-21 ; 78	-45 ; -42 ; -43 ; -38 ; -27
	ΔROC	-41	180	128	-86	-49; -49 ; -21	-94 ; -87	-36 ; 432	115 ; 189 ; 198 ; 323 ; 436
CT	Δ value	-1	-3	-21	67	60 ; 69 ; 111	66 ; 107	-70 ; -44	0 ; 4 ; 5 ; 13 ; 33
	ΔROC	26	-55	-13	337	647 ; 654 ; 1072	16 ; 138	-77 ; -73	-53 ; -37 ; -35 ;-8 ; 16
SW	Δ value	-36	-33	9	16	0 ; 6 ; 33	-24 ; -5	-87 ; -74	-6 ; -2 ; -1 ; 7 ; 25
	ΔROC	-81	-72	-100	-176	-166 ;-143 ;-142	-142 ; -120	-77 ; -102	-66 ; -55 ; -53 ; -34 ;-16

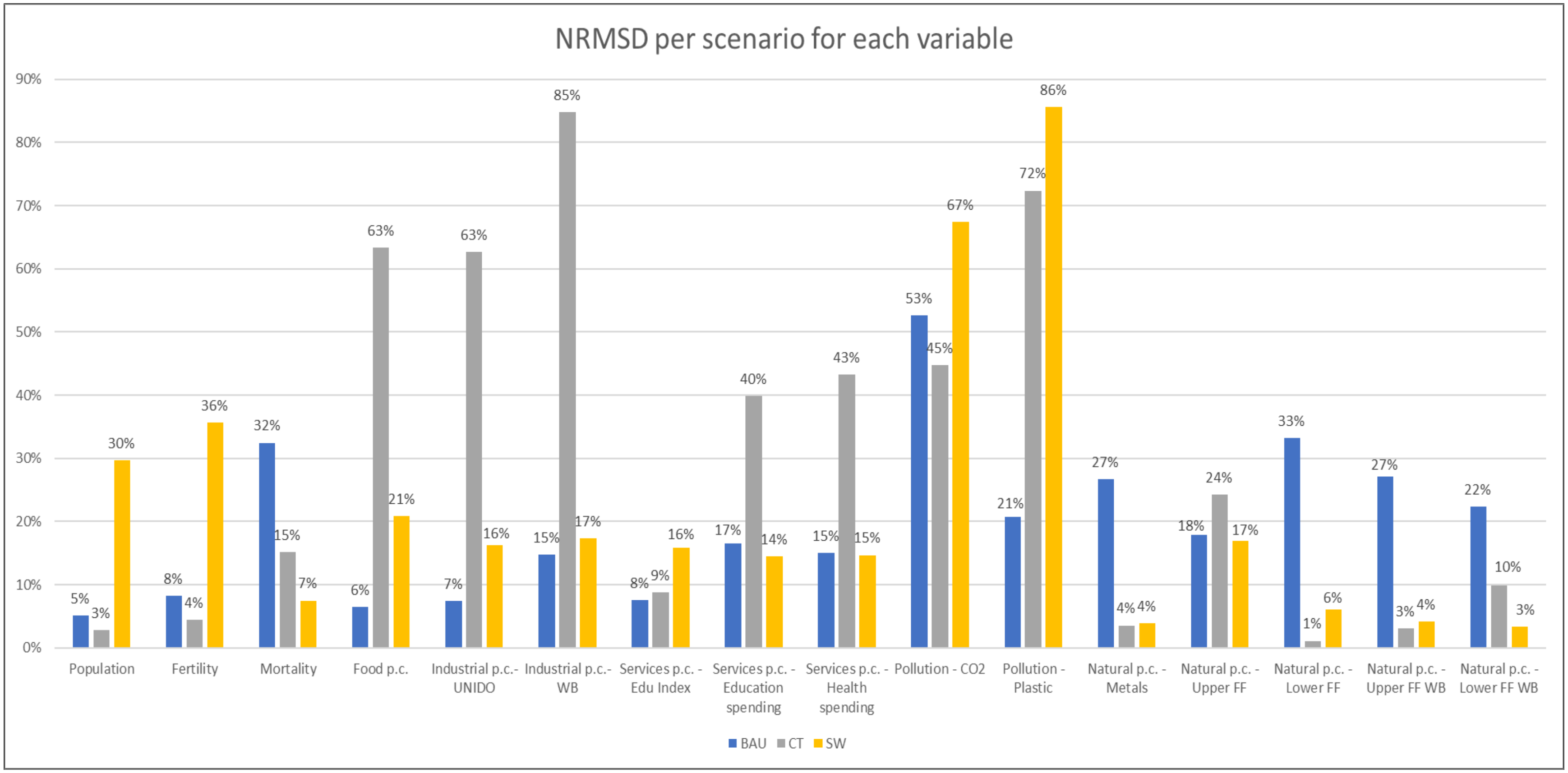

Figure 26. Accuracy measure 2: NRMSD. Plotted for each 1972 World3 scenario and variable.

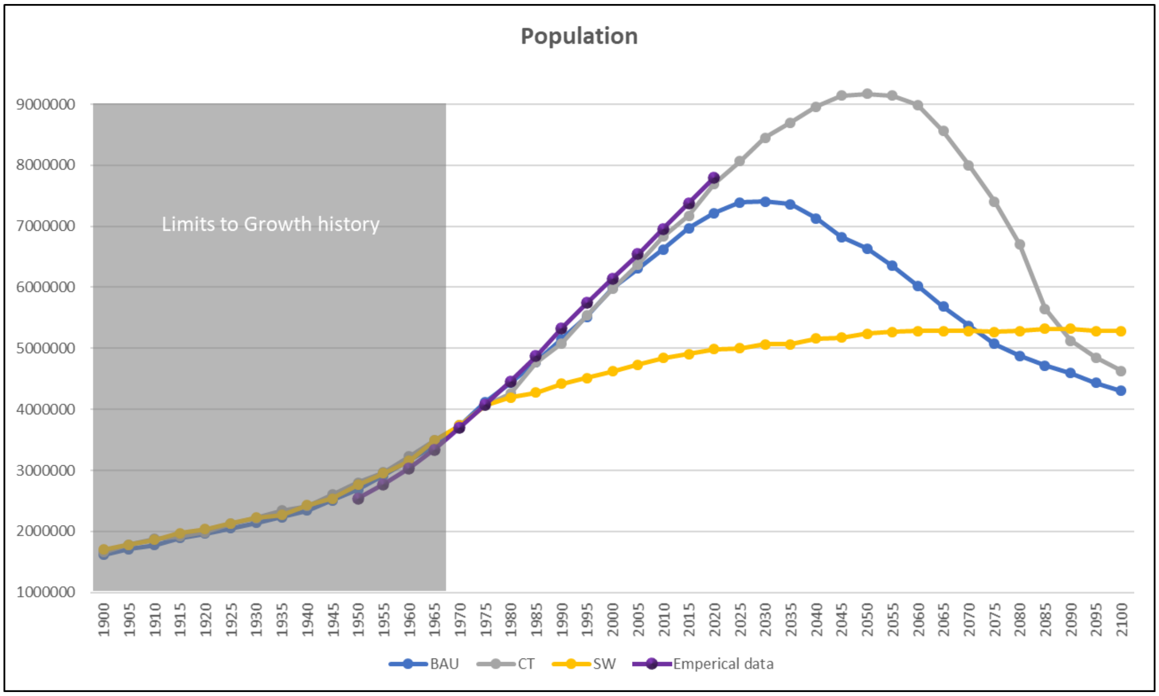

Figure 27. 1972 World3 scenarios and empirical data for population (in thousands of people).

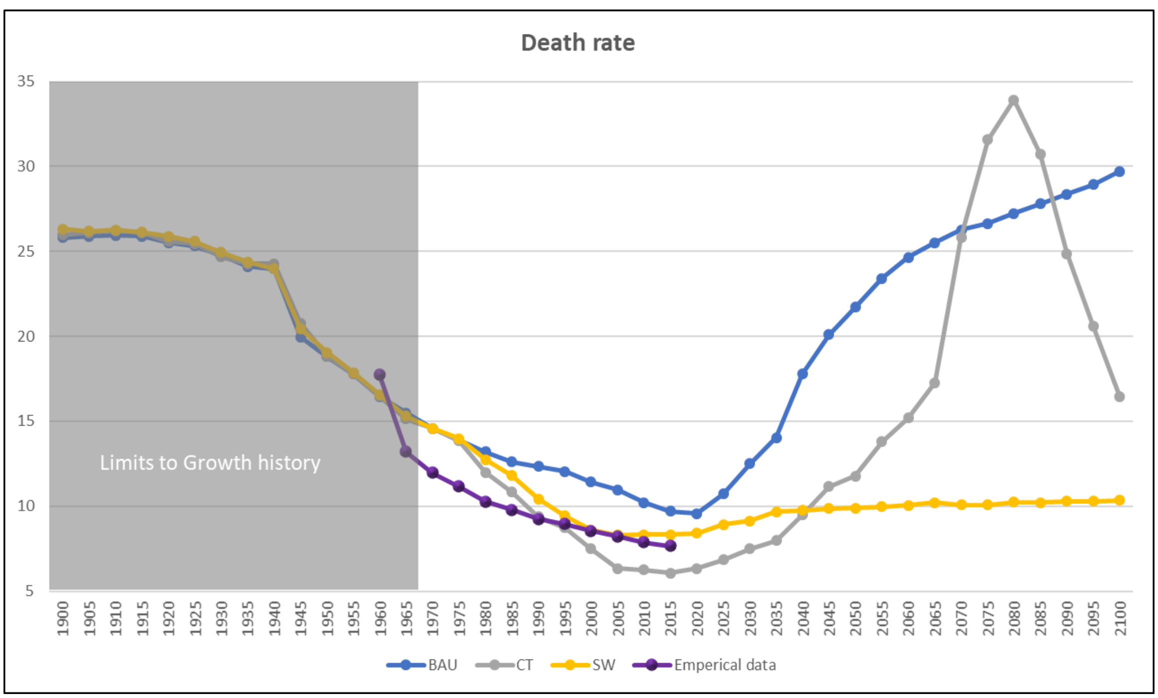

Figure 28. 1972 World3 scenarios and empirical data for mortality (deaths per thousand people).

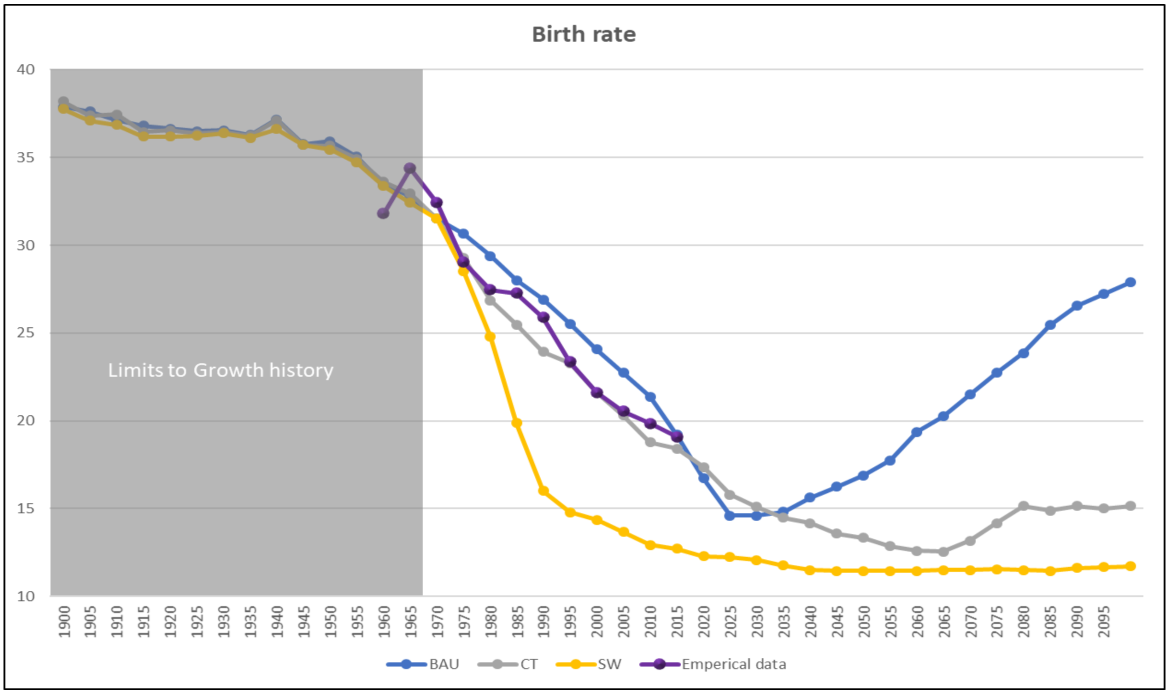

Figure 29. 1972 World3 scenarios and empirical data for fertility (births per thousand people).

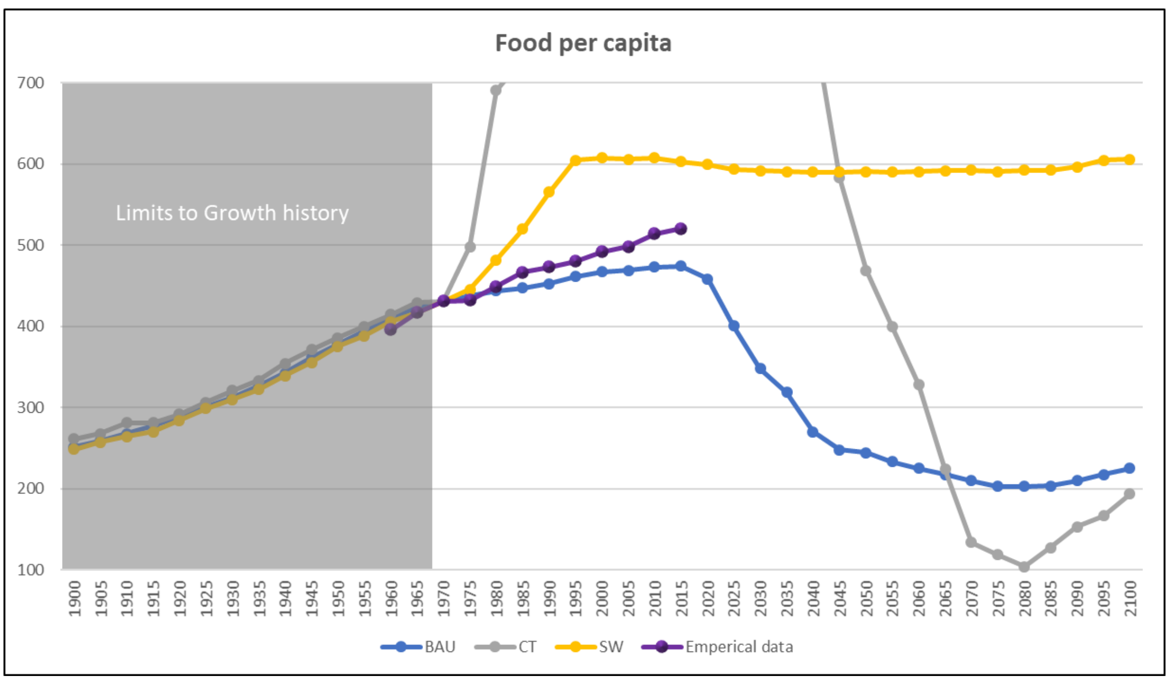

Figure 30. 1972 World3 scenarios and empirical data for food per capita (in kilocalories per day).

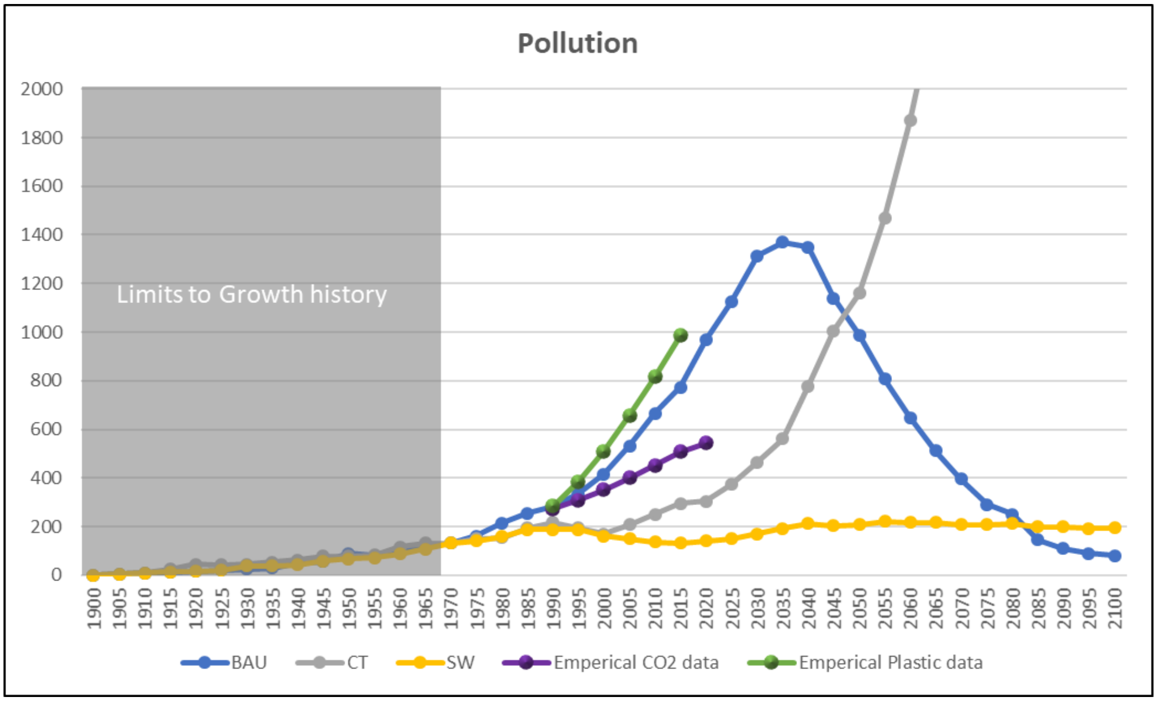

Figure 31. 1972 World3 scenarios and empirical data for pollution (plastic and CO_2).

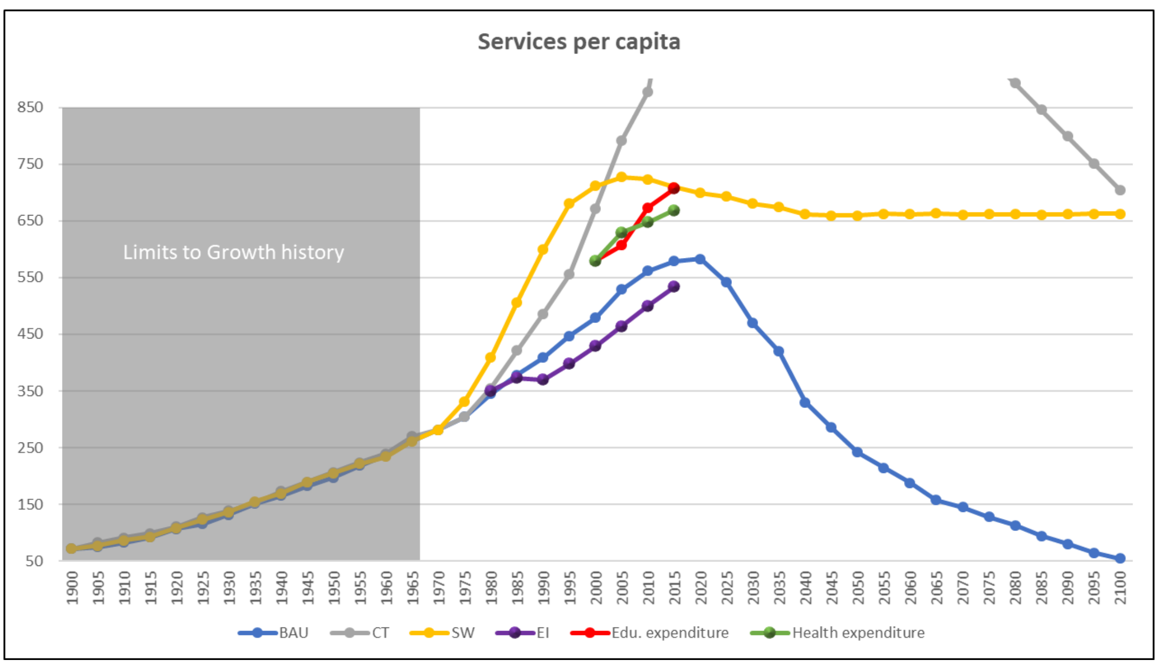

Figure 32. 1972 World3 scenarios and empirical data for services (health or education expenditure and education index). In this case the EI is probably the best proxy, because expenditure data does not go back beyond 2000 and the LtG scenarios have diverged already by then. We chose to scale expenditure data to somewhere in between the scenarios.

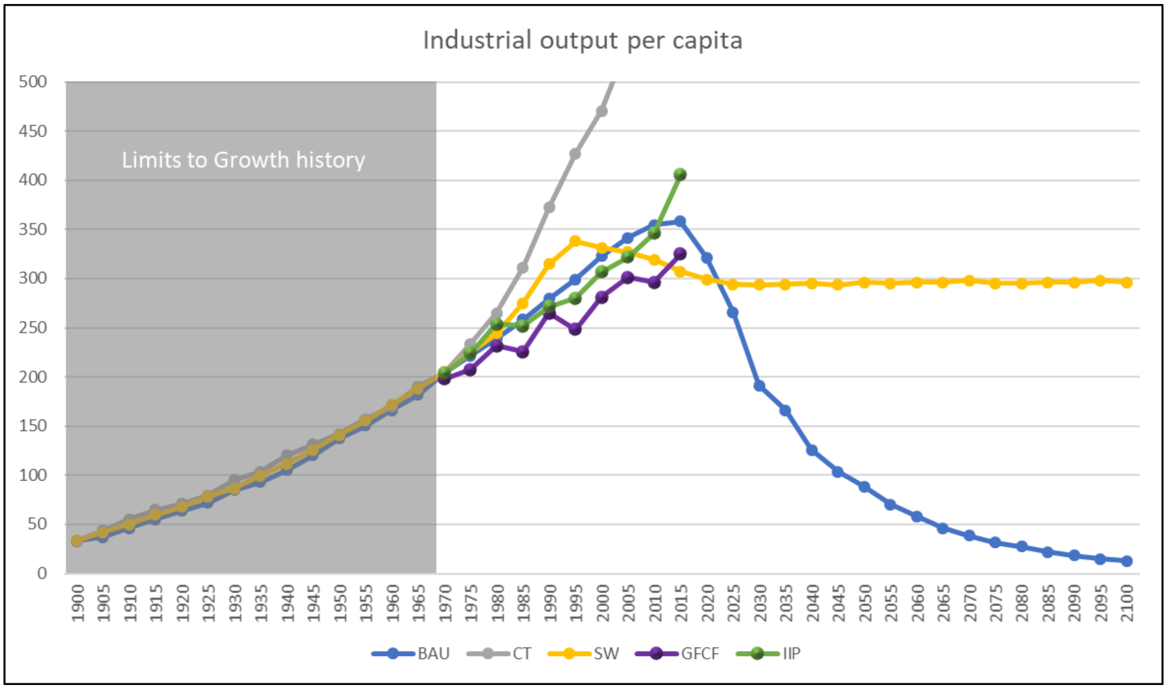

Figure 33. 1972 World3 scenarios and empirical data for industrial output per capita (gross fixed capital formation and index of industrial production).

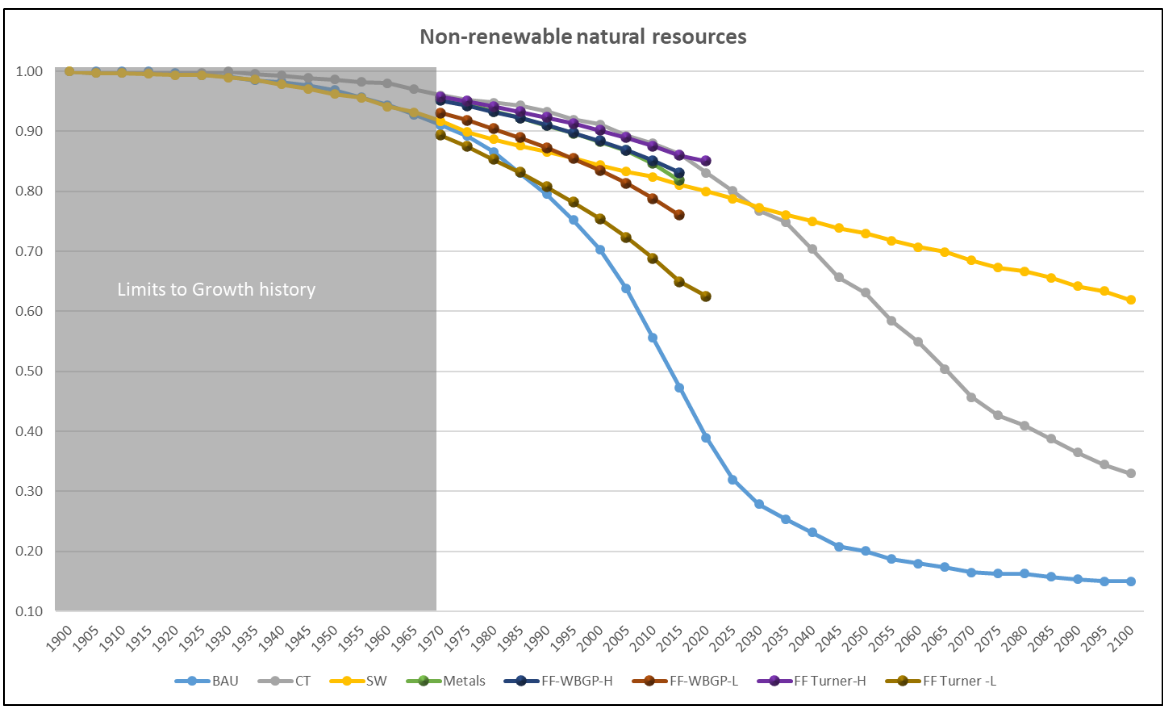

Figure 34. 1972 World3 scenarios and empirical data for non-renewable natural resources (metals and two fossil fuel expert estimates, both with high and low estimates).

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How to Measure Food Waste:

A Guide for Measuring Food Waste from Households in Canada

JUNE 2018

zeroWASTE
NATIONAL ZERO WASTE COUNCIL

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How to Measure Food Waste: Executive Summary

"If you can't measure it, you can't improve it."

– Peter Drucker, business author

Introduction

Reducing food waste in Canada offers economic and environmental benefits. But tackling this issue demands a good understanding of the sources and causes of food waste, the ways in which it can be quantified, and the background knowledge to apply the best approach for your particular circumstances.

This document provides a basic overview of all three aspects, so you can implement a food waste study that delivers good data – pointing the way to intelligent choices for action.

Why Measure Food Waste?

Measuring food waste give delivers a better understanding of the volume and nature of the food being thrown away. With that baseline data in hand, municipalities and other orders of government can measure their efforts to reduce waste, determine which methods deliver the most success, and improve their waste prevention strategies. Further, as consistent methodologies are adopted across the country, the aggregated data provides a valuable national perspective. With a better understanding of food waste issues across Canada, it becomes easier to work toward national-level approaches and solutions.

Food Waste Terminology and Definitions

Tackling a problem like food waste systematically requires establishing consistent terminology for what is being measured. The following definitions are adapted from the internationally recognized *Food Loss and Waste Accounting and Reporting Standard.*[1]

- **Food:** Substances (including drinks) intended for human consumption. Also includes spoiled material no longer fit for consumption and substances used in the making of the food. Does not include water or other processing agents.
- **Inedible Parts:** Material associated with a food, but is not generally consumed in some markets. Examples include pits, rinds, and bones. Does not include packaging.
- **Food Loss:** Food and associated inedible parts removed from the food supply chain to be recovered, recycled or disposed. Food loss generally applies to the production and distribution stages of the supply chain.
- **Food Waste:** Food that is not consumed at the retail, food service and consumer stages of the food supply chain.

Food Waste Quantification Methodologies

It's not the most glamorous task, but sometimes addressing food waste means literally digging deeper into the waste stream to understand what and how much is being thrown away. To figure out what's in our food waste, kitchen diaries and waste composition studies are the two most common forms of data collection. Waste composition studies can be conducted through an aggregated sampling method (bulk or small area-based) or individual sampling. Recruitment of participants in a kitchen diary study can use a stratified random selection or open recruitment method. The different forms of data collection and the associated sampling methodology are described more fully in this document.

Which Study Method is Right for You?

All of the study methods listed above have positives and negatives to consider. For many decision-makers, cost is likely top-of-mind. Nonetheless, if a particular approach cannot deliver the information necessary to make good waste prevention decisions, even a low-cost study may be money wasted.

Determining the right approach for your food waste study also means determining what it is you are trying to find out. With a clear sense of your end goal in mind, you can decide whether you need the detailed and specific information of a kitchen diary, or if the general information provided by a bulk sample study is sufficient data.

This document contains detailed information, a decision tree, and comparison charts to help you choose what would best align with your needs.

Conclusion

The massive amount of food waste in Canada impacts our nation's environment, health, and financial resources. Successful approaches to reduce wasted food will require a greater understanding of the factors at play. That's why measuring food waste must become a priority for Canadian policy-makers. With good data in hand, collected using similar methodologies across the country, we can gain a better understanding of the strengths and weaknesses inherent in current food management and waste systems, the motivating factors behind household choices surrounding food waste, and the solutions offering the best return on our investments.

[1] https://www.wri.org/sites/default/files/REP_FLW_Standard.pdf


LOVE
FOOD
HATE WASTE


DON'T
LET GREAT
TASTE GO TO
WASTE

Contents

1. Canada's National Zero Waste Council and Love Food Hate Waste Canada Campaign

The National Zero Waste Council was founded by Metro Vancouver in collaboration with Federation of Canadian Municipalities (FCM) as a leadership initiative bringing together governments, businesses and non-governmental organizations to advance a waste prevention agenda in Canada. Making progress in preventing waste by local governments taking action alone is not possible. Through a collaborative approach that involves important stakeholders, the Council promotes better alignment with global initiatives in design change, policy innovation, and behaviour change that will be successful in preventing waste in global markets.

The Council has identified reducing food waste in Canada as a strategic priority and the opportunity for making progress is enhanced by concern that government, media and the public has expressed about the size of the problem. The economic impact of food waste in Canada is conservatively estimated at $31 billion annually but if the cost of resources and energy wasted throughout the food value chain in producing, processing and distributing food that is eventually wasted is included, the cost spirals to more than $100 billion per year.[2] Reducing food waste in Canada therefore would result in cost savings for most stakeholders but will also create new economic opportunities for businesses looking to expand their markets and product types. There would also be community benefits associated with better use and distribution of surplus foods while reducing the amount of food waste going to landfills could make a contribution to Canada's commitment to reduce its greenhouse gas emissions.

Since waste occurs along all elements of the supply chain – from food production through to retail and post-consumer disposal as garbage – solving food waste requires a collaborative effort. Important initiatives are already underway in Canada to reduce food waste, including some initiatives involving strategic collaborations. However, most actions are implemented in a fragmented fashion and lack coordination and collaboration. What is lacking is a systems-based analysis to support a vision for change and inform strategy and tactic development and implementation.

In response, the National Zero Waste Council has developed *A Food Loss and Waste Strategy for Canada*.[3] The Strategy was informed by actions already underway by businesses, community organizations and governments in Canada, as well as from the US and Europe. It is hoped that this Strategy offers a rallying point for numerous and diverse stakeholders; that it provides tangible solutions that leverage action emerging in Canada and other parts of the world; and that it offers a clear way forward.

Love Food Hate Waste Canada

An essential component of reducing food waste in Canada is engaging Canadians to make better decisions about how to shop, store and prepare food. Some very simple but mindful changes can lead to substantial reductions in food waste generated by households. Love Food Hate Waste is a public education campaign developed by the Waste and Resources Action Programme (WRAP) in the U.K. to reduce food waste. It is now a globally recognized and proven campaign active around the world. Canada's National Zero Waste Council initiated the Love Food Hate Waste Canada campaign as a key deliverable of its Strategy to reduce food waste across Canada.

Love Food Hate Waste Canada is a multi-year, collaborative campaign bringing together governments, retailers and others to help consumers rethink their relationship with food. The campaign, launched in 2018, by the National Zero Waste Council in collaboration with its campaign partners will provide consumers across Canada tips and ideas to effectively prevent food waste.

Love Food Hate Waste Canada engages Canadians to think about how households generate food waste and how by making different decisions when buying and storing food and in preparing meals, they can reduce this waste of resources. The advantage of a national campaign is the common messaging coming from a variety of partners from local and provincial governments to food retailers and other stakeholders using multiple platforms (e.g., via social media, in-store promotions, bus shelters).

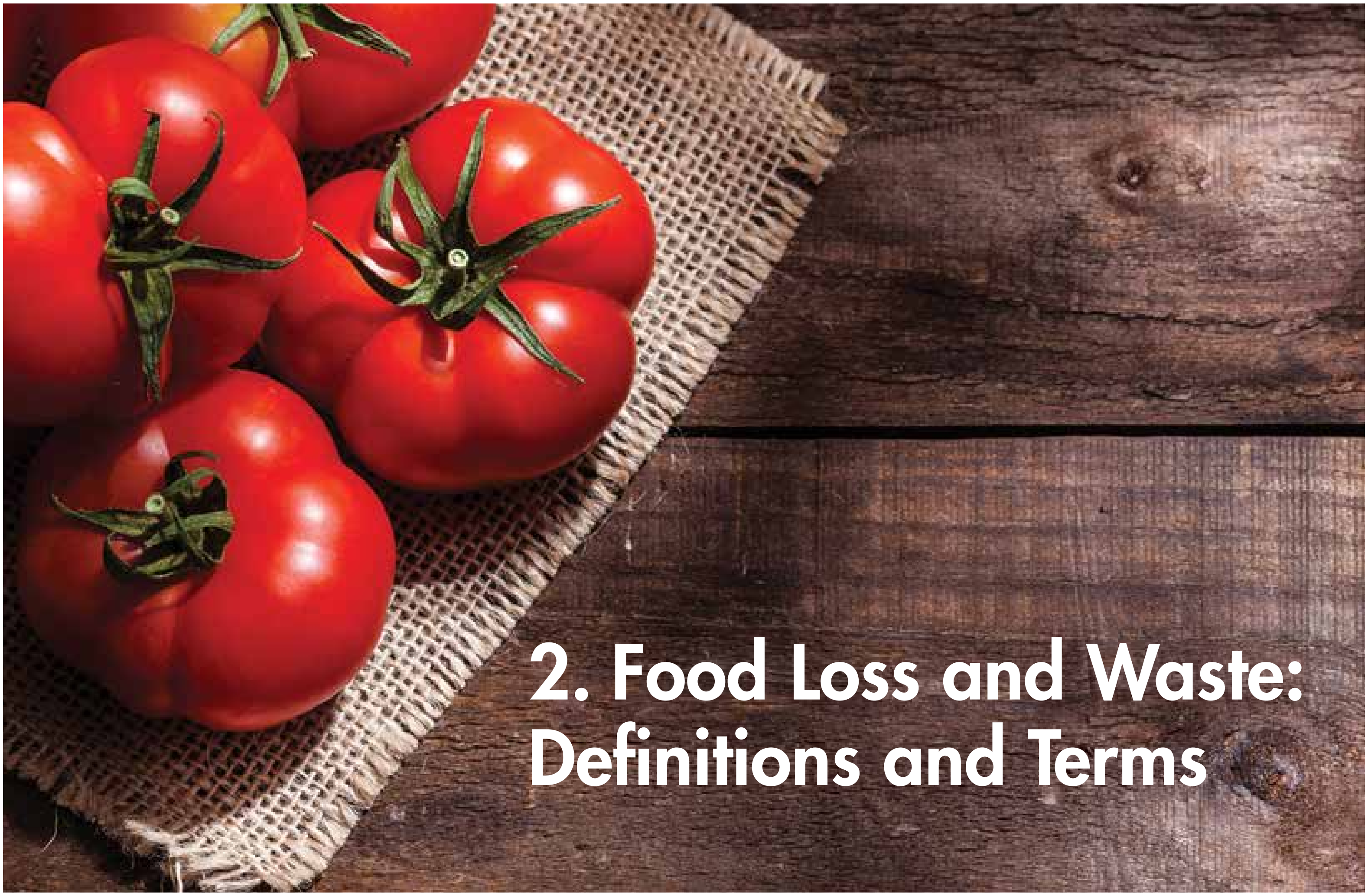
The objective of Love Food Hate Waste Canada is to prevent household food waste from occurring in the first place. The benefits of becoming a campaign partner are specific:

- For local governments, preventing wasted food reduces the amount of organics that needs to be managed. The campaign also provides local governments opportunities to inform and engage residents on a topical issue.
- For grocers, the campaign provides a way to engage directly with consumers on an issue of mutual concern and in a manner consistent with increasing brand recognition and customer loyalty.

Working across Canada using common, effective messaging should result in less food waste and therefore a food system with a smaller carbon footprint that uses less natural resources. At the same time, families and individuals may reduce their food costs.

[2] Value Chain Management International, 2014. "The Cost of Canada's Annual Food Waste". Available at: vcm-international.com/wp-content/uploads/2014/12/Food-Waste-in-Canada-27-Billion-Revisited-Dec-10-2014.pdf

[3] http://www.nzwc.ca/focus/food/national-food-waste-strategy/Documents/NZWC-FoodLossWasteStrategy.pdf



2. Food Loss and Waste: Definitions and Terms

Tackling a problem like food waste requires establishing standards for quantifying it. This is important for tracking food waste over time as well as in comparing or amalgamating data across jurisdictions. The Food Loss and Waste Accounting and Reporting Standard (FLW Standard) was established as a voluntary global standard for quantifying and reporting food loss and waste (FLW). By aligning with this standard, definitions and terminology are consistent, which allows for better comparability between different studies.

The FLW Standard provides a modular framework that enables entities to use a common set of terms to define what they include when referring to FLW or any similar term. The FLW Standard defines the possible material types, as well as the possible destinations of the material that is removed from the food supply chain.

The distinction between food and inedible parts was adapted from the FLW Standard as follows:[4]

Food: Any substance – whether processed, semi-processed, or raw – that is intended for human consumption. Food includes drink, and any substance that has been used in the manufacture, preparation, or treatment of food. Food also includes material that has spoiled and is therefore no longer fit for human consumption. It does not include cosmetics, tobacco, or substances used only as drugs. It does not include processing agents used along the food supply chain, for example, water to clean or cook raw materials in factories or at home.

Inedible Parts: Components associated with a food that, in some markets, are not intended to be consumed by humans. Examples of inedible parts associated with food could include bones, rinds, and pits/stones. Inedible parts do not include packaging. The distinction between food and inedible parts varies among users (e.g., there is a market for chicken feet but not as large of a market for other chicken parts), changes over time, and is influenced by a range of variables including culture, socio-economic factors, availability, price,

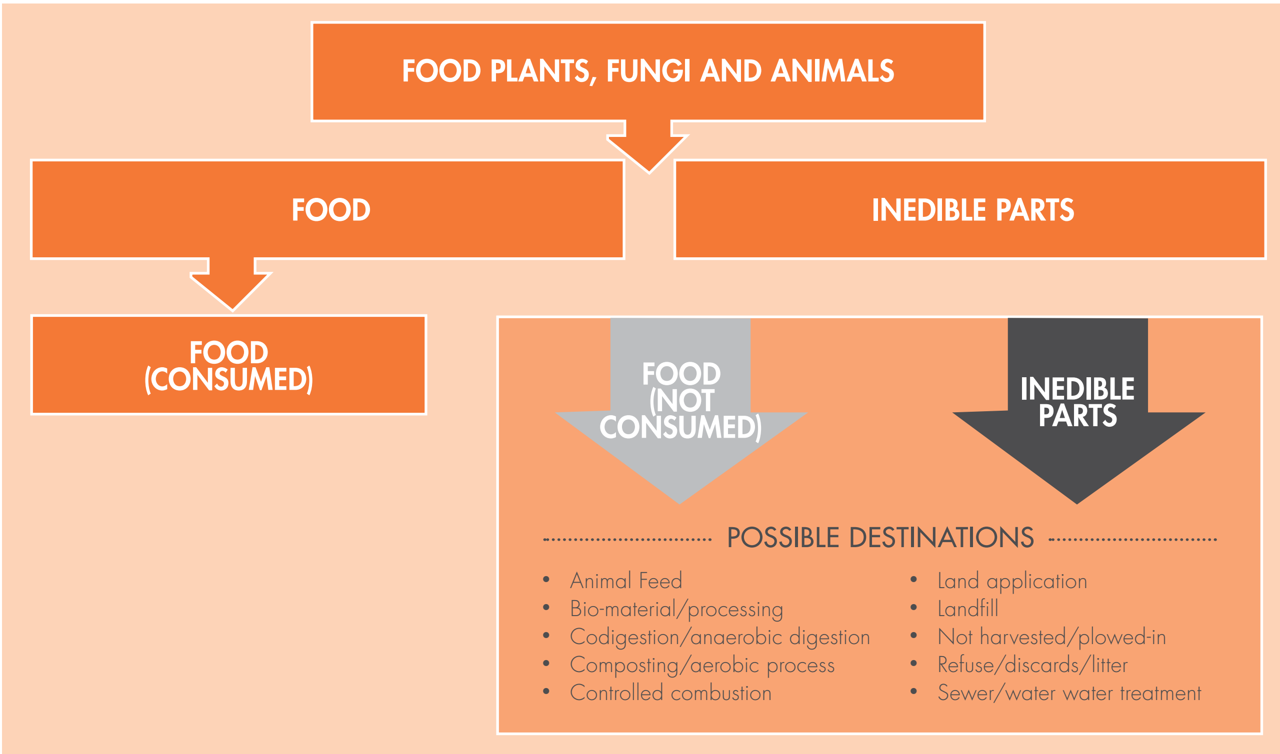


Figure 1: Possible Destinations of Food Loss and Waste (FLW Protocol Steering Committee 2016)

technological advances, international trade, and geography.

Possible destinations for FLW defined by the FLW Standard are presented on *Figure 1*. Food is only considered to have been lost or wasted if it is not consumed by humans. In other words, rescued food is not FLW as long as it is ultimately consumed by humans. However, if food is rescued but not consumed (e.g. spoiled donations), then it is FLW.

Food loss: Food and associated inedible parts removed from the food supply chain to be recovered, recycled or disposed (i.e., all ten destinations included in the FLW Standard). Food loss encompasses food waste and spans all stages of the food supply chain (from production to consumption) but generally refers to loss experienced from production through distribution.

Food waste: Food that is not consumed at the retail, food service and consumer stages of the food supply chain.

In this report, definitions of FLW have been taken from the Commission for Environmental Cooperation's (CEC) Characterization and Management of Food Loss and Waste in North America report.[5] Since the Love Food Hate Waste Canada benchmarking methodology only applies to households, food waste is the most appropriate term.

4 FLW Protocol Steering Committee. 2016a. Food Loss and Waste Accounting and Reporting Standard. http://flwprotocol.org/wp-content/uploads/2017/05/FLW_Standard_final_2016.pdf

5 http://www3.cec.org/islandora/en/item/11774-characterization-and-management-food-waste-in-north-america-foundational-report-en.pdf

3. Why Measure Food Waste?

United Nations General Assembly adopted a set of 17 Sustainable Development Goals (SDGs) in 2015. SDG 12 seeks to "ensure sustainable consumption and production patterns" and the third target (Target 12.3) calls for halving per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains (including post-harvest losses) by 2030.[6]

On a global scale, progress on this target is important. Each year, an estimated one third of all food produced – equivalent to 1.3 billion tonnes worth around $1 trillion – ends up rotting in the bins of consumers and retailers, or spoiling due to poor transportation and harvesting practices. Food waste represents a waste of resources and contributes to climate change. Reducing food waste creates new economic opportunities, redirects healthy and safe foods to worthwhile community initiatives, and contributes to more sustainable environmental conditions.

In Canada, as in other middle and high-income regions, the majority of food waste occurs in the post-harvest stages of the food chain – in processing, wholesaling, retailing and final consumption. This is important because as the Food and Agricultural Organization (FAO) indicates, when food is wasted further down the food supply chain, the environmental consequences per tonne of food wasted grows. Food waste occurring at the end of the supply chain includes the embedded resources, energy, and labour involved in processing, packaging, transport, storage, and preparing of food.

Champions 12.3 is a coalition of executives from governments, businesses, international organizations, research institutions, farmer groups, and civil society dedicated to inspiring ambition, mobilizing action, and accelerating progress toward achieving SDG Target 12.3 by 2030. Champions 12.3 articulates a three-step approach for reducing food loss and waste: target, measure, and act.[8] While what ultimately matters is taking action, for local governments setting targets are important. Targets provide a focus and motivates action. A basic tenet in business is "what gets measured gets managed" so by quantifying food loss and waste, decision-makers can better understand the problem in their communities and can evaluate the impact of changing policies and other actions.

As most policies and targets for solid waste are set by provincial and local governments, measurement of FLW increases accountability toward meeting FLW reduction commitments or requirements. FLW data can also provide inputs to environmental indicators for other targets such as avoiding greenhouse gas emissions from food waste in landfills. Other benefits of FLW measurement for provincial and local governments include:

- Improving projections of capacity needs for organics processing and disposal facilities as food waste is one of the largest components of municipal solid waste (by weight);
- Understanding major causes and sources of FLW to tailor policies and program design to optimize the level of impact; and
- Identifying sources of surplus food or edible byproducts that could be rescued for secondary markets or donation.

[6] https://sustainabledevelopment.un.org/sdg12

[7] http://www.fao.org/save-food/resources/keyfindings/en/

[8] https://champions123.org/2017-progress-report/

4. How to Plan and Implement a Food Waste Measurement Study

The most common methodologies used by leading organizations working on quantifying food waste from single and multi-unit residential households are waste composition studies and kitchen diaries. General descriptions of these methodologies are presented in this section. More detailed descriptions of both methodologies can be found in the FLW Standard's Guidance on Quantification Methods for Waste Composition Analysis[9] and Diaries.[10]

Waste Composition Studies

A waste composition study involves physically separating, weighing, and categorizing food waste. Compared to visual audits, which generally uses volumetric estimates or item counts, this method is also considered to be more accurate since measurement by volume requires conversion to weight through assumed densities or material sizes. By collecting weight data directly, it eliminates the additional error associated with conversions.

Waste composition studies are best suited for collecting detailed information about food waste and overcome under-reporting issues or participant biases associated with surveys and kitchen diaries. However, they only account for food waste destinations associated with municipal solid waste (e.g., compost/aerobic processes, anaerobic digestion, controlled combustion, landfill). Food waste fed to animals, disposed down the drain, or in backyard compost are not captured. Another challenge with this method is separating materials in compacted loads (more applicable when collected in compactor trucks), since food waste may become indistinguishable or water weights are lost (e.g., leaked out or transferred onto drier items such as paper).

The categories used for waste composition studies can range from basic categories (e.g., food, inedible parts) to primary food categories (e.g., meat, vegetables) and detailed categories (e.g., apples, bananas).

9 http://flwprotocol.org/wp-content/uploads/2016/06/FLW_Guidance_Chapter4_Waste_Composition_Analysis.pdf

10 http://flwprotocol.org/wp-content/uploads/2016/06/FLW_Guidance_Chapter6_Diaries.pdf

Waste composition studies can be conducted through an aggregated (bulk or small area-based) or individual sampling method, as described below.

Waste composition data can be extrapolated based on tonnages from solid waste management facilities or population data.

More detailed information about food waste collection studies can be accessed in a separate document of technical appendices.

Bulk Sampling

Bulk sampling typically occurs at a transfer station or disposal/processing location (e.g., landfill, compost facility) where collection vehicles unload materials. Each load represents one collection route, which represents approximately 500 to 1,000 households, depending on the size of the truck, compaction, and waste disposal habits in the area. Single family households normally have designated vehicles for collection and therefore loads are not mixed with other sectors. Multi-unit households may be collected with samples from the industrial, commercial, and institutional (ICI) sector, and therefore is more challenging to segregate. In some cases, arrangements are made with the hauler to only collect from multi-unit households (described further under small area-based sampling). Waste generators are not aware that their waste is being sampled using this method.

Samples are selected from loads by selecting a section of the load for sorting using a random number generator system. Sample sizes typically range from 90 kg to 135 kg.[11]

Small Area-Based Sampling

Small area-based sampling involves collecting waste from a specific physical area. The waste is collected in aggregate, similar to bulk sampling, but the generators are targeted. For example, the designated area may be a particular street or neighbourhood, or a select number of multi-unit residential buildings. Normally, the waste generators are not made aware that their waste is being sampled using this method. In some cases, households are informed of the waste composition study taking place, or are provided information upon inquiry, and have the option to opt-out of having their waste collected.

Depending on the size of the load collected, either all the materials are sorted or 100 kg is sampled from a randomly selected section of the load.

Individual Sampling

Waste samples are collected from individual households. These households can be recruited through stratified random selection or open recruitment. For single family homes or multi-unit homes with individual collection containers, samples are collected from curbside set outs. For multi-unit residential buildings with shared containers, additional coordination is required to have residents place garbage (or other material streams) in separate bags, tagged with a unique identifier that refers to their household. Sampling is conducted anonymously (i.e., homes are only identified by a sample code, not by their address).

When sampling from curbside set outs, households do not necessarily need to know that their waste is being collected; however, it is common practice to provide notification so that there is an option to opt-out. In some cases, informed consent is required, particularly when the waste composition study is linked with a survey or kitchen diary. For multi-unit residential buildings, informed consent is necessary since residents need to take the extra step of placing their waste in tagged or labelled bags.

11 Recommended Waste Characterization Methodology for Direct Waste Analysis Studies in Canada. (1999) CCME http://www.ccme.ca/files/Resources/waste/packaging/pn_1497_waste_char.rpt_final_e.pdf

Food Diaries

Kitchen diaries involve having individuals or group of individuals (e.g. all members of a household) maintain a daily log of food waste and other information. Participants are recruited to complete a self-reported kitchen diary, normally for a one week duration. Participants record the weight, volume, or item counts of their food waste before it is disposed along with information such as the time, disposal destination, state of the food, and reason for disposal. Participants may also complete a survey before and/or after the diary to provide data on demographics and household food practices.

Kitchen diaries are a useful tool to identify behaviours linked to food waste and quantify food waste that is not collected through municipal waste collection systems. However, the self-reporting nature of the diary may lead to some data inaccuracies. Sources of inaccuracy include under-reporting through intentional or unintentional omissions of occurrences of food waste, changes in behaviour that result from the act of completing a diary (e.g., participants want to show they don't waste food and alter their food consumption patterns for that week), and recruitment bias (e.g., only participants that are interested in food waste issues sign up or less-interested participants drop out).

While the data collected may be offset from true values, this type of error would be systemic between repeated studies and therefore any difference between the two studies represents a valid difference. Furthermore, a variety of methods can be employed to improve data accuracy. Methods to adjust for under-reporting in kitchen diaries include conducting a waste composition study on participating households or comparing kitchen diary data to waste composition studies conducted in the same or similar jurisdictions. Methods to reduce recruitment bias include offering honouraria or other incentives to participate in order to attract participants that are not as interested in food waste issues or using stratified random selection versus open recruitment.

Kitchen diary data can be extrapolated using population and household composition data.

Stratified Random Selection

The target population (e.g., all residents of a municipality) are divided into key groups (strata) based on factors such as housing type, neighbourhood, income level, age, or other demographic variables. Targets or quotas for each of these strata are set such that the kitchen diary participants represent the population as a whole. Participants are then randomly recruited within each strata through in-person (e.g., door-to-door) recruitment, panels, or telephone calls. Only households targeted for recruitment are able to sign up for the study.

Open Recruitment

An open call for participation in a kitchen diary is advertised to the entire target population in a variety of communication methods such as traditional media, social media, email lists, or word-of-mouth. Anyone who responds can sign up, regardless of their demographic group.

Factors in Selecting Appropriate Study Type

For the purposes of comparison, the quantification methodologies described in this section are divided into three study types: waste composition study (bulk or small area-based sampling), waste composition study (individual sampling), and kitchen diaries.

The reason for subdividing waste composition studies between bulk and individual sampling is that the methodological differences in sample selection are large enough to affect multiple decision-making factors. The study types are defined as follows:

- Waste composition study (bulk or small area-based sampling): Waste samples are collected on a regular or targeted collection route from multiple households in a collection vehicle. Loads are randomly subsampled, manually sorted into different food waste categories and weighed to determine composition.

- Waste composition study (individual sampling): Waste samples are collected from individual households, then manually sorted into different food waste categories and weighed to determine composition.
- Kitchen diaries: Participants are recruited to complete a self-reported kitchen diary whereby all food waste is logged over a designated time frame.

A comparison table of the three study types with consideration for decision-making factors that may be faced by an entity undertaking food waste quantification is presented in *Table 1*.

Definitions of decision-making factors are as follows:

- Cost/resources required: Financial, material, and human resources to undertake the study.
- Understanding of drivers of food wastage: Obtaining insights on attitudes and behaviours related to food waste from a study.
- Differentiation of food categories in waste: Ability to distinguish different types of food waste.
- Understanding of demographics: Obtaining demographic information on the generators of food waste.
- Level of data objectivity: Certainty that data represents typical food wasting behaviours.
- Food waste destinations captured: Number of possible destinations of food waste included in the scope of the study.

TABLE 1: **COMPARISON OF FOOD WASTE QUANTIFICATION STUDIES BASED ON KEY DECISION-MAKING FACTORS**

DECISION-MAKING FACTOR	**STUDY TYPE**		
	WASTE COMPOSITION STUDY (AGGREGATED SAMPLING)	**WASTE COMPOSITION STUDY (INDIVIDUAL SAMPLING)**	**KITCHEN DIARIES**
COST/RESOURCES REQUIRED	**LOW** • Lowest cost on a per-sample basis as the main resource requirement is for sorting and data analysis • If waste composition studies are already conducted on a regular basis, they can be adapted to include food waste categories with minimal cost implications	**MEDIUM** • Samples need to be collected by a designated team and cannot be conducted using a collection vehicle on a regular route • If informed consent is required, additional resources are needed for participant recruitment • Requires a larger number of samples for statistical significance due to smaller sample weights which increases resource needs for collection, sorting, data entry and analysis	**HIGH** • Participant recruitment requires a large amount of resources to ensure representation • Each participant requires several points of contact and ongoing support • An incentive ($50 to $150) is typically offered to each participant for study completion, as well as a kitchen scale • Requires the most amount of time for data entry, compilation, and analysis
UNDERSTANDING OF DRIVERS OF FOOD WASTAGE	**LOW** • Participants do not know that they are participating in a study and thus cannot be asked to complete a survey • A general survey can be conducted, but is not linked to waste sample generators	**MEDIUM** • A survey may be conducted to obtain data on attitudes and behaviours related to food waste	**HIGH** • Participants can be asked why they wasted food each time data is recorded • A pre- and/or post-survey is typically conducted to obtain data on attitudes and behaviours related to food waste; however, lengthy surveys may result in lower completion rates
DIFFERENTIATION OF FOOD CATEGORIES IN WASTE	**MEDIUM** • Items may be harder to separate from other materials due to compaction in trucks but are generally still distinguishable	**HIGH** • Samples are typically collected directly from household containers or bags and not compacted, therefore items are more intact and easier to separate	**HIGH** • Food waste is recorded as detailed descriptions by item

TABLE 1: **COMPARISON OF FOOD WASTE QUANTIFICATION STUDIES BASED ON KEY DECISION-MAKING FACTORS** *(CONT.)*

DECISION-MAKING FACTOR	STUDY TYPE		
	WASTE COMPOSITION STUDY (AGGREGATED SAMPLING)	WASTE COMPOSITION STUDY (INDIVIDUAL SAMPLING)	KITCHEN DIARIES
UNDERSTANDING OF DEMOGRAPHICS	**LOW** • Only broad geographies of study participants can be known, so demographics are limited to general information (e.g., census data) • More coordination or cost may be needed to isolate multi-unit sector samples • More challenging to determine per household or per capita food waste generation	**MEDIUM** • A survey may be conducted to acquire demographic information specific to the generators	**HIGH** • Participants typically complete a survey that includes demographic information
LEVEL OF DATA OBJECTIVITY	**HIGH** • Study participants are not aware of their participation	**MEDIUM** • Study participants are typically aware of their participation, but not asked to do anything outside of their usual routines	**LOW** • Participants may change their behavior as they monitor it or complete the diary based on what they consider socially desirable • Due to self-reported nature of kitchen diaries, participants may not record all food wasted • With additional resources, kitchen diaries may be conducted in concert with waste composition studies to ground-truth data
FOOD WASTE DESTINATIONS CAPTURED	**MEDIUM** • Only includes destinations for municipal solid waste, but the majority of food waste is disposed in that stream • Cannot capture food waste that is fed to animals, disposed down the drain, or backyard-composted	**MEDIUM** • Only includes destinations for municipal solid waste, but the majority of food waste is disposed in that stream • Cannot capture food waste that is fed to animals, disposed down the drain, or backyard-composted	**HIGH** • Participants are typically instructed to record all food wasted, including amounts fed to animals, disposed down the drain, or backyard-composted • Allows for quantification of beverage waste, as the majority is disposed down the drain

5. Proposed Methodology

Selecting the Type of Study: Decision Tree

The primary factor faced by the majority of entities working on food waste quantification is the amount of resources available. Often, resource limitations dictate what type of study is feasible. The decision tree presented in *Figure 2* **can help with study selection. The decision tree is meant to provide a general guideline for selecting the type of study. Ultimately when collecting data to establish a baseline and track progress, it is important for the methodology to stay consistent between measurement events. Another tool that can be used to assist with selecting the type of study is the FLW Quantification Method Ranking Tool.** [12]

Sample Selection

Availability of resources normally dictates the number of samples for a study. Where resources are available, the minimum number of samples to obtain statistically valid results can be calculated using a power calculation:

$$n = \left(\frac{Z\sigma}{E}\right)^2$$

Where n is the size of the sample, Z is the standard score of a normal distribution of the selected confidence interval, σ is the estimated standard deviation of the outcome variable (amount of food waste) for the population, and E is the desired margin of error.

[12] http://flwprotocol.org/wp-content/uploads/2016/06/FLW-Quantification-Method-Ranking-Tool_As-of-June-2016.xlsm

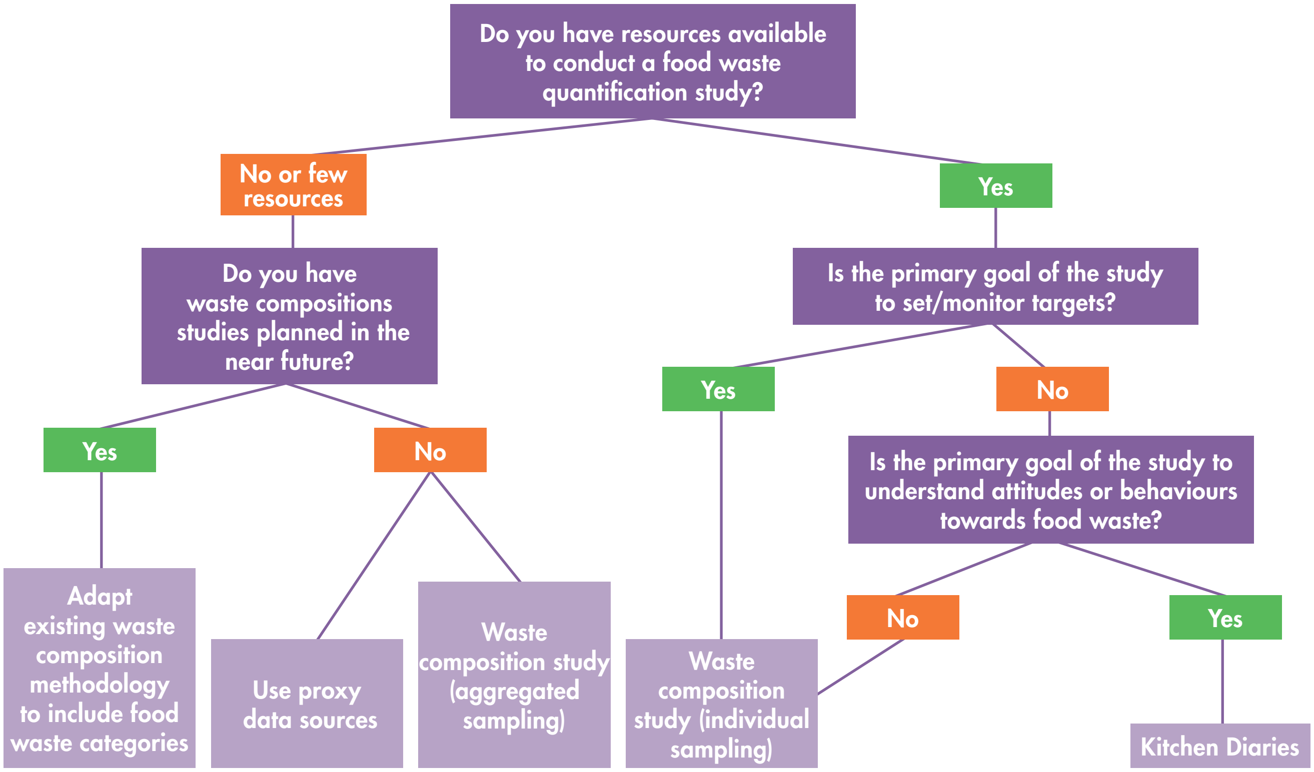


Figure 2: Decision Tree for Selection of Study Type

The standard deviation can be taken from a previous study with a comparable method and population (e.g., residential food waste measurement in another Canadian city). The desired margin of error can be calculated by applying a percentage to the estimated mean. Below is an example calculation assuming a 95% confidence level (a = 0.05) and 10% margin of error using an estimated mean of 150 kg/household/year and standard deviation of 130 kg/household/year:

$$n = \left(\frac{Z\sigma}{E}\right)^2 = \left(\frac{1.96 * 130}{150 * 0.10}\right)^2 = 288$$

Waste Composition Studies

Samples can be selected for waste composition studies in one of three ways: bulk sampling, small area sampling, and individual sampling. Individual sampling is recommended over bulk or small area sampling to reduce compaction of materials and allows for collection of data on a per-household basis. However, bulk and small area sampling can be used as lower-cost options. Regardless of the sampling strategy, both the garbage and organics (if food waste is collected) should be sampled to capture both food waste destined for disposal and diversion. The quantity of food waste in recycling is typically nominal compared to garbage and organics.

The following subsections describe general procedures for sampling. Background information on sampling methodologies can be found in the Recommended Waste Characterization Methodology for Direct Waste Analysis Studies in Canada report [13] (CCME 1999).

[13] CCME. 1999. Recommended Waste Characterization Methodology for Direct Waste Analysis Studies in Canada. http://www.ccme.ca/files/Resources/waste/packaging/pn_1497_waste_char.rpt_final_e.pdf

A combination of sampling strategies may be used in one waste composition study. For example, bulk sampling may be used for single family homes and small area sampling may be used to segregate garbage from multi-unit homes.

Bulk Sampling

At a transfer station or disposal/processing location, coordinate with operations staff on procedures to identify collection vehicles containing garbage and other materials from the target population and set aside a location for the load to be emptied where the full load can be seen.

After the collection vehicle has emptied the load, divide the load evenly into segments (e.g., a 3x3 grid) and number each segment. Randomly choose one segment (e.g., using a random number generator) to sample from. Collect approximately 100 kg (+/- 10 kg) of material from the selected segment for sorting. Large bulky objects should not be collected as part of the sample.

Small Area Sampling

When a collection vehicle reaches a transfer or disposal/processing location, the procedure for sampling a load for small area sampling is the same as bulk sampling. The only difference is in the planning process for how the load is obtained. Coordinate with municipal operations staff or private haulers to designate specific vehicles to collect materials for the waste composition study from representative routes. Collection should take place on the same day as the regular collection schedule so residents do not need to be notified of the study and follow their regular habits. Representation may be based on geography, demographics (e.g., income level or housing type), or a combination of the two variables. Geographical representation is the easiest to coordinate, as it typically can be organized based on existing collection routes. For example, one route from each of the northern, southern, eastern, and western parts of a city can be selected and the license plates of the targeted vehicles can be relayed to waste sorting team.

Individual Sampling

It is assumed that informed consent is not required for individual sampling. However, it is highly recommended that copies of a letter from the participating jurisdiction describing the study be carried by staff while collecting samples. That way, information can be provided if requested by residents. If informed consent is required, then households need to be recruited first using stratified random selection.

The selection of households for sampling is similar to the approach used for small area sampling, which is to ensure representation of the population in the collected samples. Samples are collected by a designated team instead of a regular collection vehicle, so there can be more flexibility in route selection. A cargo van or cube truck is used for sample collection, depending on the target number of samples and anticipated volume per sample based on residents' disposal habits.

For homes with curbside collection services, sample collection takes place on the regular collection day at a time after most residents have set out materials for collection, and before collection vehicles arrive in the area. Where possible, coordinate with the hauler on route timing to ensure collection vehicles do not start their routes in the target area before samples have been collected. When collecting samples from curbside setouts, collect all materials set out in garbage and organics (if applicable) except for large bulky objects and segregated yard and garden debris (e.g., leaf bags, branch bundles). Samples from each household should be bagged and labelled to keep materials from individual households separate.

Individual sampling for multi-unit homes is not recommended because it is very cumbersome and therefore difficult to coordinate. A recommended alternative to individual sampling for multi-unit residential buildings is to collect all the garbage generated by the building on the regularly scheduled collection day(s) over a one week period and divide the weight of the materials by the number of units. This method requires less coordination, reduces the risk of participation and social desirability bias, and still allows for a per household generation rate to be calculated. When sampling is conducted in this way, all materials should be weighed. If the sample is greater than 100 kg, then randomly subsample 100 kg for sorting.

Kitchen Diaries

To ensure representation of data collected, it is recommended to recruit participants for kitchen diaries using stratified random selection. Do not use open recruitment as it can increase bias in the dataset. Similar to small area-based and individual sampling, the strata used for stratified random selection can be determined based on a combination of geographic and demographic representation.

Participants can be recruited via one of three methods:

- **In-Person:** Recruitment staff go door-to-door in selected neighbourhoods or lobbies of multi-unit residential buildings to recruit participants.
- **Phone:** Phone numbers are randomly selected within geographic areas (e.g., postal codes) and called to recruit participants.
- **Panels:** Members of existing survey panels are contacted. Panelists that fit within the target geographic or demographic parameters are randomly selected to participate.

To encourage more representative participation, an incentive should be offered (e.g., a $100 gift card). Otherwise, participation will likely be biased towards civic-minded people who are interested in food waste or environmental issues.

Food Waste Categories

The minimum level of food waste categorization is differentiating food from inedible parts. There is a substantial level of subjectivity involved in determining which components of food products are considered to be inedible parts. This can be managed through setting clear protocols and how corresponding training is implemented.

For some items (e.g., egg with shell, fish with bones, and peach with pit), the food and associated inedible part(s) are discarded as one intact item. Generally, it is recommended to categorize these items based on the component that has the majority (approximately more than 40%) of the weight. For example, a whole egg in a shell or whole peach with a pit inside would be considered food while a mostly eaten fish with a few pieces of flesh remaining on the bones would be considered inedible parts.

When sorting food waste for waste composition studies or classifying items during the data entry process for kitchen diaries, classification into primary food categories is highly recommended. This level of categorization provides insights as to which types of food are wasted and can help determine strategies for food waste reduction interventions or measure their effectiveness. Inedible parts could be further classified into primary food categories if that level of detail is desired. However, there are generally fewer opportunities to reduce the generation of inedible parts and the focus of most food waste reduction campaigns are on the edible food portion.

Descriptions of primary food categories are presented in *Table 2* based on the categories used to estimate the baseline for Metro Vancouver's Love Food Hate Waste campaign in 2014. Common items found in each of the categories are also included to serve as a guide to help with the sorting process. During the training and supervision of sorting or data entry staff, it is very important to have consistency for how items are categorized. Sorted waste composition bins or kitchen data entry sheets should be periodically reviewed, especially at the beginning of a study to check that staff are categorizing items correctly.

TABLE 2: **FOOD WASTE CATEGORIES**

CATEGORY	DESCRIPTION	EXAMPLES – FOOD	EXAMPLES – INEDIBLE PARTS
VEGETABLES AND SALAD	Vegetables according to culinary definition. Includes mushrooms and fungi, roots and tubers, pulses and legumes, and seaweeds.	Eggplant, bean, broccoli, cabbage, carrot (including peel), cauliflower, celery, zucchini, cucumber, lettuce, mushroom, onion, pea, pepper, potato (including peel), spinach, sprouts, squash, corn, tomato, salad mix, mixed vegetables.	Tops of root vegetables (e.g., carrots), onion skin, hard stalks (e.g., pepper, lettuce, squash), hard vegetable peels (e.g., winter squash).
FRUIT	Fruit according to culinary definition.	Apple (including peel), banana, kiwi, melon, orange, pear (including peel), pineapple, mango, grapes, berries, stone fruits, citrus fruits, avocado, mixed fruits.	Apple core, banana peel, hard/waxy fruit peels (e.g., melon, mango), vines (e.g., grape or berries), citrus peel, stone fruit pits, avocado peel and seed.
MEAT AND FISH	All types of meat, poultry, and game products, in pieces and cuts or comminuted, fresh, and processed. Includes fresh fish and various processed fish products. Includes aquatic vertebrates (fish and aquatic mammals), aquatic invertebrates, and shellfish.	Pork, ham, bacon, beef, lamb, chicken, turkey, duck, game meat, deli meats, processed meats, fish, jellyfish, clams, snails, shrimp, crab, lobster, sea urchins, sea cucumbers.	Bones, shells, tendon, fat from cuts of meat.
BAKERY	All savory baked goods and breads. Includes uncooked dough or batter. Does not include sweet bakery items and processed snack foods.	Bread, bagels, scones, soft pretzels, croissants, pancakes, naan, filo, tortilla, breadsticks, dough, pancake batter, croutons, crisp breads, breadsticks, breadcrumbs.	None.
DAIRY/EGGS	Dairy products that are derived from the milk of any milking animal (e.g., cow, sheep, goat, buffalo). Fresh in-shell eggs, products that may substitute for fresh eggs, and other egg products. Does not include ice cream.	Milk, cheese, cream, yogurt, kefir, sour cream.	Egg shell, wax coating on cheese.
HOMEMADE/ PRE-PREPARED	Foods prepared as meals or components of meals that are mixtures of multiple categories of food. These include pre-prepared foods which require minimal preparation by the consumer (e.g., heating, thawing, rehydrating). Includes products composed primarily of protein that are derived from soybeans or from other sources.	Soup, canned soup, stew, sandwich, pasta with sauce, stir fry with meat and vegetables, salad with dressing, instant noodles, savory pie, burrito, casserole, soy burger patty, frozen dinner.	None.

TABLE 2: **FOOD WASTE CATEGORIES** *(CONT.)*

CATEGORY	DESCRIPTION	EXAMPLES – FOOD	EXAMPLES – INEDIBLE PARTS
DESSERTS	All sweet items that could be consumed at the end of a meal or a snack. Includes sweet bakery items.	Cake, cheesecake, pudding, jelly, donut, sweet pastries, sweet pies, strudel, fruit crumble, ice cream, mousse.	None.
STAPLES	Unprocessed and various processed forms of cereal and cereal-based products. Includes cooked cereal-based products if they have not been mixed with other types of food.	Breakfast cereal, flour, pasta, rice, corn flour, noodles, couscous.	Husks from milling.
CONDIMENTS/ SAUCES/SPICES	Substances added to food to enhance its aroma and taste. Includes certain prepared foods that act as sauces or condiments.	Salt and salt substitutes, soy sauce, herbs, spices, seasonings, vinegar, mustard, ketchup, salsa, mayonnaise, gravy, dips, pickles, olives, sugar, honey, jam, peanut butter.	None.
OIL/FAT	All fat-based products that are derived from vegetable, animal or marine sources, or their mixtures. Does not include fat from cuts of meat.	Butter, margarine, lard, suet, vegetable oils, flavoured oils.	None.
CANDY AND SNACKS	All cocoa and chocolate products, other candy products, chewing gum, and decorations and icings. All types of savory snack foods, nuts, and seeds.	Chocolate, candy, chewing gum, cereal bar, cookies, nuts, seeds, trail mix, popcorn, chips, crackers.	Nut and seed shells.
DRINKS	Alcoholic and non-alcoholic beverages, excluding dairy products.	Bottled water, soft drinks, coffee, fruit juice, tea, alcohol, smoothies.	Coffee grounds, tea bags.
OTHER	Items that do not fit into other categories or serve a special purpose. Includes items that are indistinguishable.	Baby food, baby formula, mixed semi-solid food, draining from canned and bottled food.	None.

The categories in *Table 2* can be aggregated or disaggregated based on the objectives and resources available for the measurement exercise. Examples of possible adaptations include:

- Aggregating inedible parts as one category and sorting edible food into detailed categories;
- Combining similar foods such as fruits and vegetables or bakery and dessert;
- Disaggregating homemade/pre-prepared meals into packaged and unpackaged; and
- Adding sub-categories for food to differentiate between whole/untouched items and leftover items.

Handling Food Waste in Packaging

Packaging with trace amounts of food waste are frequently encountered during waste audits. If there are small amounts of food waste found in packaging, do not categorize it as food waste. Generally, if the packaging represents the majority of the total weight of the item (e.g. a bread bag with a few crumbs at the bottom, peanut butter stuck to the bottom of the jar), classify the item as packaging and not as food.

To optimize sorting efficiency, if food waste is contained in lightweight packaging, it does not need to be removed during the sorting process. Typically the weight of food inside the package greatly exceeds the weight of the packaging, and therefore the packaging is negligible. Furthermore, when food is removed from lightweight packaging, some of the food may remain on the packaging and therefore result in lower weights of food waste. Examples of lightweight packaging include:

- Plastic film;
- Aluminum foil;
- Polystyrene;
- Lightweight plastic containers (e.g., clamshells, PET bottles); and
- Paper wrapping.

When food waste is contained in heavier packaging, the food items should be separated. Some discretion can be used to retain the packaging if it is difficult to remove the food items from the packaging (e.g., wet foods soaked onto a paper plate) or if the quantity of food greatly exceeds the amount of packaging (e.g., a full jar of pasta sauce). Examples of heavier packaging include:

- Glass containers;
- Metal cans;
- Durable rigid plastic containers (e.g., reusable lunch containers); and
- Fibre-based take-out containers.

Overall, between the small amounts of food that are classified as non-food (stuck on packaging) and the small amounts of packaging that are included with food waste categories, the weights generally equal out and greatly improve the efficiency of sorting.

Additional Considerations for Kitchen Diaries

The format of kitchen diaries should allow participants to record descriptions of food items that they discard along with their weights. Participants should be instructed to record separate weights for each type of food item (e.g., weigh potato peels separate from onion skins).

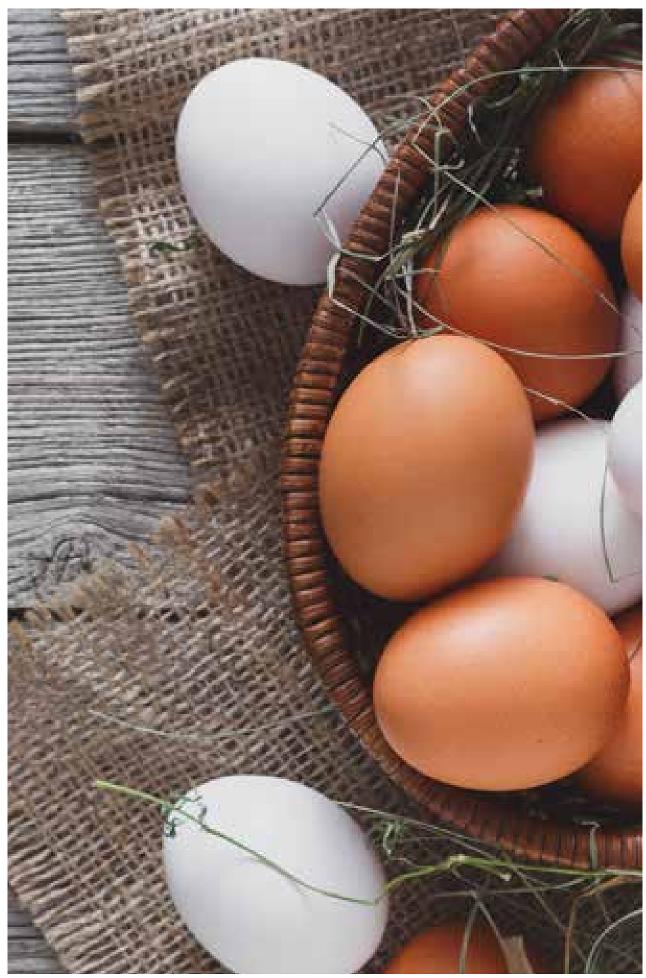
Participants should not be asked to categorize food items themselves, as it is an additional step in the diary recording process and categorization will likely be inconsistent due to different interpretations of what each food category means. An example of a diary page is included on *Figure 3*.

If no food or drink waste, please say why: All food consumed ☐ Meal not eaten at home ☐ Other (write in) ____________

Type of Food? Please give a full description of the food or drink waste including brand. (If you run out of space you can use the overflow pages at the back of the diary.)	State? Was it cooked, prepared or served before being thrown away?		How much was diagnosed? What was the weight, volume number or amount?	Where? Please tick where it was thrown away							Why? Please give reason for disposal. Some possible answers may be:					
	Original state	Cooked/ prepared/ served		Food scraps & garden waste bin	Garbage bin	Backyard/home compost	Sink	Garburator	Toilet	Fed to animal	Bought too much	Cooked/served too much	Past use before date/food spoiled	Didn't like the taste	Peeling, cores, shells	Other – Please specify:
	x	x		x	x	x	x	x	x	x	x	x	x	x	x	
	x	x		x	x	x	x	x	x	x	x	x	x	x	x	

Figure 3: Example Kitchen Diary Template

Coding of food descriptions into categories should be conducted by trained staff at the data entry stage. To allow for analysis of data by detailed food types (e.g., apples versus bananas), kitchen diary data should be entered with a standardized word list so it can be compiled in a consistent way. For example, participants may write 'Granny Smith apple', 'apple', 'red apple', or 'apples' in their diary. These entries should all be coded as 'apple'.



Weight Based Measurement Method

Regardless of the study type, food waste is to be measured by weight in metric units to avoid inaccuracies associated with volume or item count conversions. Weight-based measurement also increases comparability of results between jurisdictions. For waste composition studies, weights should be recorded in kilograms to the nearest 0.05 kg. For kitchen diaries, weights should be recorded in grams to the nearest 1 gram.

If weight based measurement isn't possible, then the next best option is volumetric measurement or a visual audit. Going this route means that the accuracy of the food waste data is compromised and this will require notation or a disclaimer.

Extrapolation

Extrapolation of food waste quantification study results to estimates for a jurisdiction can be conducted in multiple ways depending on the availability of data. Methods for extrapolation based on the study conducted and available data are presented in *Table 3*.

TABLE 3: **EXTRAPOLATION METHODS**

STUDY TYPE	DATA COLLECTED	AVAILABLE DATA	EXTRAPOLATION METHOD
WASTE COMPOSITION STUDY (BULK OR SMALL AREA SAMPLING)	% of food waste.	Tonnage from solid waste management facilities.	Multiply % of food waste by tonnage to estimate food waste by jurisdiction.
WASTE COMPOSITION STUDY (INDIVIDUAL SAMPLING)	% of food waste.	Tonnage from solid waste management facilities.	Multiply % of food waste by tonnage to estimate food waste by jurisdiction.
	Kg of food waste per household.	Number of households.	Multiply kg of food waste per household by number of households to estimate food waste by jurisdiction.
KITCHEN DIARY	Kg of food waste per household.	Number of households.	Multiply kg of food waste per household by number of households to estimate food waste by jurisdiction.
PROXY DATA (IF UNABLE TO DO DIRECT DATA COLLECTION)	% of food waste from waste composition study in similar jurisdiction.	Tonnage from solid waste management facilities.	Multiply % of food waste by tonnage to estimate food waste by jurisdiction.
	Kg of food waste from waste composition study or kitchen diary in similar jurisdiction.	Number of households.	Multiply kg of food waste per household by number of households to estimate food waste by jurisdiction.


DON'T
LET GREAT
TASTE GO TO
WASTE

Technical Appendices can be provided upon request

- Appendix A: Measurement Methods
- Appendix B: Food Waste Categories
- Appendix C: Sample Selection
- Appendix D: Extrapolation Methods

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A Food Loss and Waste Strategy for Canada

NATIONAL ZERO WASTE COUNCIL

zeroWASTE
NATIONAL ZERO WASTE COUNCIL
An Initiative of Metro Vancouver

The National Zero Waste Council is a leadership initiative bringing together governments, businesses and non-government organizations to advance waste prevention and the circular economy in Canada.

VISION

Canada united in the achievement of zero waste, now and for future generations.

MISSION

To act collaboratively with business, government and the community, at the national and international level, as an agent of change for waste prevention and reduction in the design, production and use of goods.

nzwc.ca

May 2018

FORWARD

More than a third of food produced and distributed in Canada never gets eaten, with significant environmental, economic and social consequences.

This grossly inefficient use of resources forces local governments into excessive costs for waste disposal, generates avoidable greenhouse gases at all stages of the production and distribution chain, and costs the Canadian economy up to $100 billion annually[1]. In addition, organic waste in landfills, largely food, generates four per cent of Canada's greenhouse gases.

This problem is not unique to Canada. Global estimates are that nearly half the food produced never gets eaten. As a result, preventing and reducing food waste has become a matter of urgency around the world, featured prominently as an action item for governments, businesses, and consumers.

In September 2015, the United Nations set Sustainable Development Goals that included a commitment to reducing food waste by 50% by 2030. Shortly afterward, France became one of the world's leading change makers on food waste by passing a law that forbade grocery stores to throw away or destroy unsold food. UK's Waste and Resources Action Programme, established back in the early 2000's, has continued to ramp up its food waste reduction work, announcing increasingly robust voluntary agreements with grocers and manufacturers. Many other countries throughout Europe – Italy, Spain, Denmark, the Netherlands, to name but a few – have continued to support market innovations, and establish various policies and fiscal incentives to drive down food waste. Some have created national consumer campaigns. In the past three years, the US has seen a proposal for a national food recovery act, the launch of a national consumer campaign, and a published roadmap on how to comprehensively tackle food loss and waste. The Food and Agriculture Organization launched food loss and waste initiatives in Asia-Pacific with various partners, under its Save Food program, as early as 2013.

The list carries on. And the speed and level of sophistication in the adoption of successful activities is rapidly increasing.

In this context of international and North American action, Canada risks lagging behind. There have been a number of isolated initiatives, ranging from organics bans to regional consumer campaigns, and even national interest in a food policy that would include food loss and waste activities. However, overall Canadian action has been at best disparate and fragmented. There is a lack of coordination and collaboration, and there is no system-wide vision for change. The gap is startling.

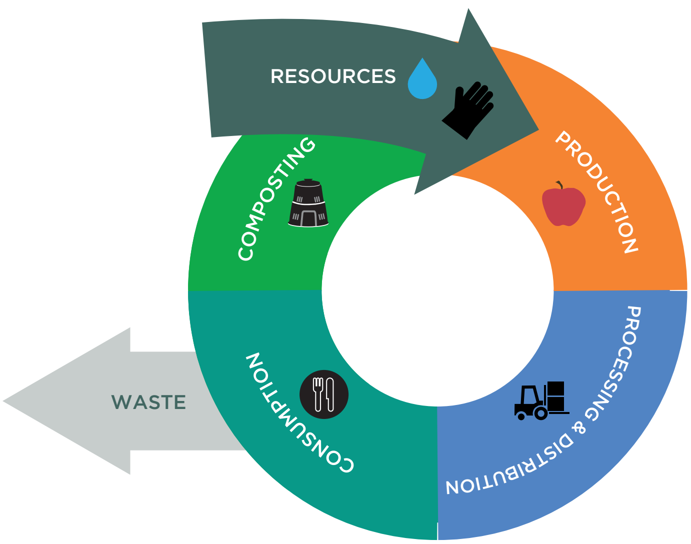
The National Zero Waste Council is responding to this gap by developing a collaborative food loss and waste strategy for Canada. It is hoped that this strategy offers a rallying point for numerous and diverse stakeholders; that it provides tangible solutions that leverage action emerging in Canada and other parts of the world; and that it offers a clear way forward.

The Council would like to acknowledge and thank the many individuals and organizations who contributed to the development of this strategy. In particular, we would like to thank Provision Coalition, who have been working tirelessly on advancing sustainability within Canada's food and beverage processing and manufacturing sector. We look forward to continued collaboration with Provision Coalition, and other Canadian champions, on addressing food loss and waste.

1 http://vcm-international.com/wp-content/uploads/2014/12/Food-Waste-in-Canada-27-Billion-Revisited-Dec-10-2014.pdf

INTRODUCTION

In 2016, the National Zero Waste Council prepared an outline for a strategy with a suite of tools to reduce food waste in Canada. The strategy was built around three pillars: national, provincial and local policy change; innovation in technology and community infrastructure; and behaviour change throughout the supply chain. The actions under each pillar combined to tackle food waste challenges, from post-farm through to the consumer.



The strategy was then deepened by analyzing its potential contribution to Canada's efforts to reduce greenhouse gas emissions. A broader proposal, *Reducing Food Waste & Cutting Canada's Carbon Emissions: Policies for Reaping the Environmental, Economic and Social Benefits*[2], was submitted in June 2016 to the federal government in response to their call for proposals to their Pan Canadian Framework on Clean Growth and Climate Change.

Subsequently, an abbreviated document, the *National Food Waste Reduction Strategy* was submitted to the federal government in early 2017 in support of efforts to develop a Food Policy for Canada.

The National Zero Waste Council

The Council is a leadership initiative bringing together governments, businesses and non-government organizations to advance waste prevention through the design, production and use of goods in Canada. It is tackling food waste as part of its overall commitment to waste prevention and the circular economy.

The Council then undertook a robust stakeholder engagement process to gain feedback on and refine the proposed strategy. While none of the actions that were presented in the strategy were wholly new, many had neither been tested in a Canadian context, nor previously recommended as part of a comprehensive, shared national effort. The specific goals of the stakeholder engagement were to identify potential collaborators, ensure the strategy aligned with new developments in Canadian policy and innovation, prioritize actions, and develop an implementation plan.

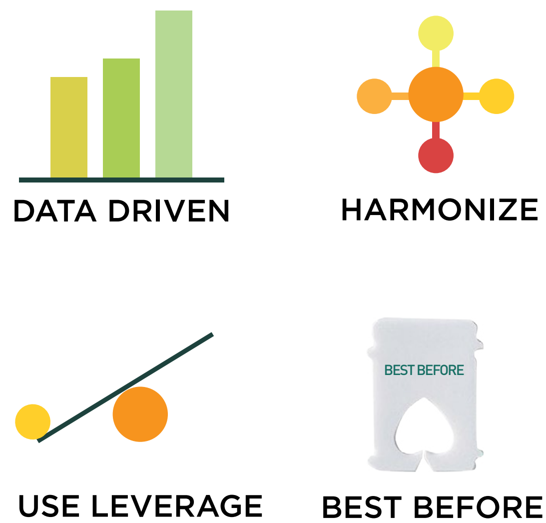
The stakeholder engagement program ran from February to September 2017, involving more than 900 representatives from the public, private and community sectors involved in food loss and waste activities in Canada. These representatives ranged

2 http://www.nzwc.ca/focus/food/national-food-waste-strategy/Documents/NZWCSubmissionOnPan-CanadianFrameworkForCombattingClimateChange.pdf

from global businesses, small enterprises and business associations, to all three levels of government, and non-governmental organizations working on environmental protection, food security, and sustainable consumption. Leading global champions, including the UK's Waste Resources and Action Programme (WRAP), the World Resources Institute (WRI), and ReFED also provided feedback that has been included in this document. The process utilized a range of engagement tools: an online survey, webinars, workshops, special event presentations, and targeted interviews.

The feedback received was generous and thorough. Highlights included confirmation that there is interest and support for a National Zero Waste Council-led national strategy, but that a full supply chain approach was needed, with the primary emphasis on upstream change, preventing food loss and reducing waste from farm to fork, rather than on waste diversion. It was recommended that collaborators include provincial and territorial-level governments, along with both established and emerging innovation hubs. Stakeholders suggested alignment and engagement with the emerging *Food Policy for Canada*. Recommendations for priority actions included addressing issues associated with best before dates, infrastructure investment that strengthens the capacity of the charitable sector, the development of a national consumer campaign, and educational and communication materials that support nutritious food donations.

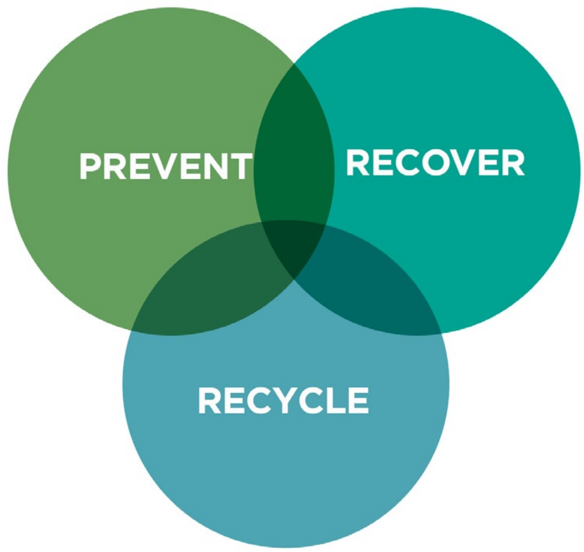
This document presents a revised strategy that gives thoughtful consideration to the feedback received. It presents a solid range of actions that will help Canada achieve a globally-aligned goal to cut food loss and waste in half by 2030.



A Food Loss and Waste Strategy for Canada

What is food loss and waste?

The loss of edible food and inedible food parts at the point of retail or consumer use is typically considered food waste. Food that is lost in the stages between production and distribution, where, for example, food may have spoiled as a result of production and processing technologies, is considered food loss. Food Loss and Waste (FLW) is used throughout this strategy. In some instances, food waste is used as a short-hand stand in for both loss and waste. This Strategy provides recommendations that address the full range of food loss and waste taking place throughout the supply chain.



The National Zero Waste Council has developed a nation-wide, multi-year framework for action that brings together the private sector, governments, and civil society in a collaborative and systematic effort to reduce the waste of edible food — throughout the value chain, from farm to fork. This strategy proposes an approach that closes the loop on food waste occurring during the production, processing, distribution and consumption of food, and supports the shift to a circular value chain. In this approach, waste is prevented first, then rescued and recovered, and finally recycled/composted, so that resources invested in food production are secured and optimized.

A Food Loss and Waste Strategy for Canada brings together insights, experiences, and thoughtful feedback from a wide array of leaders involved in food loss and waste, both within Canada and globally. These leaders range from global businesses to small enterprises, local governments to NGO's, recognized champions from WRAP and WRI to ReFED. It takes into consideration the vastness of Canada's geography, its economic structure, and the current context of Canadian action on the issue. The goal of the strategy is to reduce both food loss and waste by 50% by 2030 in alignment with Sustainable Development Goal 12.3 and the U.S. domestic target.

The strategy calls for the federal government to publicly announce a national target and takes a systems approach that aims to change practices and policies at key leverage points along the value chain and in the mandates of governments, as well as encourage new behaviours. It is anchored by three broad objectives:

- **Prevent** food waste from occurring in the first place;
- **Recover** safe and nutritious food for people and food scraps for animals; and
- **Recycle energy and nutrients** from the remaining, unavoidable food waste.

Included are an array of key elements that, working together, will contribute to optimizing the food value chain and will:

- Promote innovation and investment in emerging technologies and community infrastructure;
- Provide economically viable opportunities for businesses engaged in the food chain;
- Build community resiliency by encouraging the redistribution of nutritious, surplus food;
- Reduce the climate, water, energy and soil impacts of producing and distributing food that ends up uneaten;
- Reduce garbage disposal costs for municipalities; and
- Engage Canadians in becoming part of the solution.

THE CANADIAN CONTEXT

While leaders in other parts of the world hold lessons for us in Canada, we have a unique context that requires modified action, and in some cases, unique approaches. Our geography is vast, our urban centres relatively few and small in a global context and are complemented by large rural areas inhabited by small communities and isolated farmsteads. The distances over which we transport food are large. Rail and road infrastructure pass through sparsely settled areas. Food insecurity is found in both urban and rural contexts. We have a young food security support network. All this makes for greater challenges associated with, for example, cold storage and logistics.

The Canadian economy is largely made up of small and medium enterprises (SMEs). A recent study found 98% of the country's businesses have less than 500 employees, and that many share an ethos of sustainability[3]. Large businesses are fewer and hold larger shares of the market, making it both easier and more difficult to collaborate, as there are fewer interests to negotiate but potentially greater concerns over data-sharing and retaining competitive advantages. The large proportion of smaller enterprises in Canada's food economy, and their frequent alignment with sustainability interests, suggests a more nimble business environment, with less embedded inertia, than may be typical in the US or Europe.

COLLABORATION IS KEY

Successfully tackling food loss and waste throughout a supply chain necessitates coordinated action and true collaboration – within Canada, and globally. Across the country, many initiatives to reduce food waste are under way, though in varying degrees of isolation from each other. These initiatives are happening at a local government and provincial level (such as organics bans through to province-wide

3 Governing and Accelerating Transformative Entrepreneurship (GATE) Survey Report, 2018. Sarah Burch, Canada Research Chair in Sustainability Governance and Innovation, University of Waterloo.

organic waste frameworks), in business start-ups and with large retailers (from food sharing apps to consumer campaigns), and with various community organizations working on food security and environmental issues.

At a national level there is emerging, focused policy work on food system sustainability, climate protection, and the circular economy.

The National Zero Waste Council's Food Loss and Waste Strategy provides recommendations for addressing food waste that directly align with and help Canada deliver on these initiatives. T*he Pan Canadian Framework on Climate Change and Clean Growth* commits Canada to meeting ambitious targets for reductions in greenhouse gas [GHG]emissions that match the objectives under the Paris Agreement. A 44 million tonne gap exists between projections of GHG's in Canada and Canada's target for reductions by 2030. Reducing food waste could reduce Canada's carbon footprint and help to close this gap.[4]

A Food Policy for Canada is focused on making Canada's food system more efficient, sustainable and fair. It will set a long-term vision for health, environmental, social, and economic goals related to food. Reducing food loss and waste is being recognized as an important cross-cutting theme in this endeavour. A circular approach to food loss and waste resonates with emerging federal interest in the circular economy, as there is a shared interest in bolstering economic returns, supporting innovation, and building community resiliency while conserving resources.

Internationally, from the World Economic Forum through to Champions 12.3, businesses and governments are coming together to identify and implement strategic action. Collaboration across policy efforts amongst change agents will build a richer, more effective response to any issue. Therefore, this strategy pays attention to how action is coalescing in North America and Europe around the issue of food loss and waste, and building resilient food systems – and leverages this work in Canada. The Strategy builds on this momentum of action, and recommends linkages with other campaigns, targets, monitoring and measurement efforts, and innovative approaches to changes in physical infrastructure. The strategy uses a shared vocabulary, important for businesses operating in a global marketplace with supply chains operating in part, or in whole, in Canada. Joining an emerging powerful global network of businesses, governments and civil society representatives working on food waste and loss enables more effective, efficient action domestically, secures supportive partners, and helps keep Canada in step with change.

A Food Loss and Waste Strategy for Canada incorporates and builds upon this existing work, both inside and outside the country, pulling together the best practices used to date. The recommended actions that follow help bring together under one issue area the valuable, though disparate, actions across Canada.

4 http://www.nzwc.ca/focus/food/national-food-waste-strategy/Documents/NZWCSubmissionOnPan-CanadianFrameworkForCombattingClimateChange.pdf

They offer opportunities for knowledge sharing, efficiencies, greater potential for harmonized policies, and a touch-point for various Canadian actors to work together and leverage each other's work. The strategy also helps ensure that Canada can stay in-step with changes happening around the world.

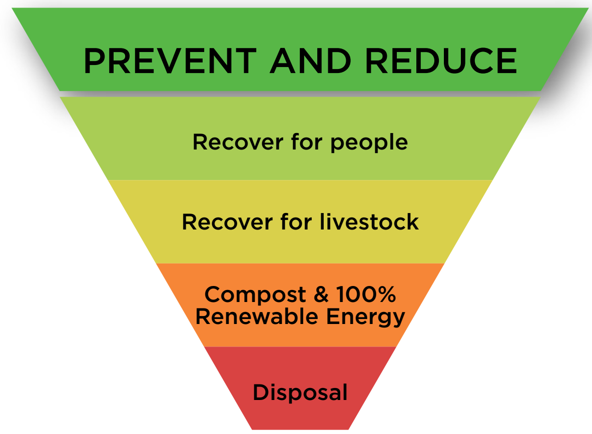
And to do so, the Council has begun to build the collaborative relationships needed to undertake the necessary work, on the home front and internationally.

THE FOOD RECOVERY HIERARCHY: A STRATEGIC FOUNDATION

The United States Environmental Protection Agency and other organizations and agencies working on FLW recommend an approach to reducing food waste that has wide acceptance, prioritizing the actions organizations can take based on their environmental benefit.

At the top of the list is preventing and reducing the volume of surplus food that is generated in the first place. As the EPA points out, the benefits include preventing the pollution related to the production of unused food, such as from fertilizers and pesticides, and the energy associated with growing, preparing and transporting it.

FOOD WASTE PYRAMID



Preventing waste at the top of the hierarchy also provides the greatest economic benefits by saving the waste of resources. The economic costs increase the further down the food chain that food is wasted. Investments in transportation and processing for food that ends up uneaten must be borne by companies and ultimately consumers. Some analysts have argued that food waste prevention could reduce the cost of food by 10-20 per cent.[5]

For these reasons, this hierarchy of actions is foundational to the strategy. Food loss and waste prevention and reduction is primary, followed by recovering food to feed people and then animals, and finally recycling and energy recovery through anaerobic digestion.

5 Food Waste: Aligning Government and Industry Within Value Chain Solutions, Gooch M., et al: Value Chain Management International Inc. 2016; and A Roadmap to Reduce U.S. Food Waste by 20 Percent, ReFED (Rethink Food Waste through Economics and Data), 2016

Sustainable Development and Food Waste

Seventeen Sustainable Development Goals (SDGs) were adopted as part of the 2030 Agenda for Sustainable Development[6]. Each goal has a set of targets.

SDG 12 seeks to "ensure sustainable consumption and production patterns." The third target under this goal, 12.3, states "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."

International organizations, from WRAP to the European Union's REFRESH and Champions 12.3, are bringing together a wide cross-sector of organizations to act on food waste, ensuring that action plans are aligning with efforts aimed at securing national and global sustainability.

CAUSES AND SOLUTIONS

The problem of food loss and waste has been most comprehensively articulated in Canada by the Value Chain Management Centre (VCM).[7] VCM found that waste occurs along all elements of the supply chain – from food production through to retail and post-consumer disposal as garbage. Essentially half of the food loss and waste in Canada is the result of decisions and actions of businesses within the food supply chain while consumers are responsible for the other half.

While a range of factors cause food loss and waste, Provision Coalition identifies five root causes:[8]

- Human behaviour and the incentives behind it (consumer, employee and management decisions);
- Time-limited biological reality of food – particularly fresh and unpackaged food;
- Limited or lack of advanced technology, equipment, packaging, etc.;
- Risk perception and risk avoidance among businesses and consumers; and
- Unintended consequences of regulation.

Reducing food loss and waste in Canada will be challenging, but many jurisdictions and businesses in Canada and across the globe demonstrate that food waste can be reduced through intentional actions. Key to long-term, lasting reductions is the application of a systems approach to ensure that unintended consequences do not emerge that simply relocate costs or impacts. For instance, actions to increase the amount of donated food going to community agencies and food banks who do not have the capacity to

6 http://www.un.org/millenniumgoals/pdf/mdg2007.pdf

7 http://vcm-international.com/wp-content/uploads/2016/10/Food-Waste-Aligning-Government-and-Industry-VCMI-Oct-4-2016.pdf

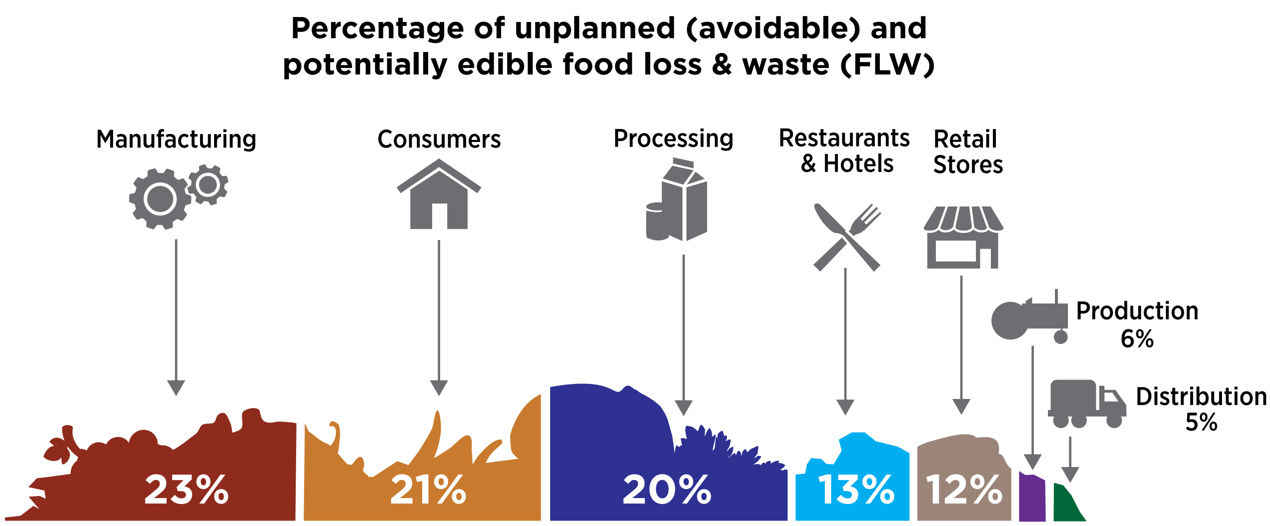
8 *Developing an Industry led Approach to Addressing Food Waste in Canada*, Uzea, Gooch and Sparling: Provision Coalition 2014

handle greater volumes could result in the same amount of food being disposed.

Farmers make decisions about what to grow long before their products will get to market. Businesses within the food value chain are making decisions based on market information, shareholder expectations and the regulatory environment. Consumers make decisions about the food they purchase and eat based on tastes and a range of social influences, including marketing efforts of businesses, as well as prices. Encompassing this value chain are governmental regulations and policies that seek to accomplish a variety of objectives, from the safety and quality of food to how and where food waste is directed. Canada's food system is complex, and reducing food waste will require a new level of collaboration amongst a wide array of stakeholders and value-chain influencers.

In summary, solving food waste requires a systems approach that addresses the causes of food waste and loss from farm to fork to landfill. This strategy takes that approach.

WHERE FOOD WASTE OCCURS THROUGH CANADA'S FOOD VALUE CHAIN[9]



Source: The Avoidable Crisis of Food Waste, Value Chain Management International, 2019

The staggering volume of food waste is caused by inappropriate decisions at all stages of the food chain. The opportunity is to engage all players in an integrated, national, food waste reduction strategy.

9 https://secondharvest.ca/wp-content/uploads/2019/01/Avoidable-Crisis-of-Food-Waste-Technical-Report-January-17-2019.pdf

1.0 Prevent

PREVENT

At the top of the food recovery hierarchy, with the highest economic and environmental benefits, is the prevention and reduction of food waste and loss. By reducing the amount of food waste, we avoid the loss of important resources like land, labour, water and energy invested in food that is not consumed. In addition, the externalities of food production and consumption can be avoided, such as water pollution associated with some agricultural and processing practices, and greenhouse gas emissions from production, transportation, and the storage of food. Less food waste will also generate cost savings throughout the food supply chain.

IMPORTANT ACTIONS INCLUDE:

1.1 ADOPT AND COMMUNICATE A NATIONAL TARGET

In Canada, the federal government should publicly set and widely promote a national food loss and waste target. This will provide a common, measurable objective to drive actions by all levels of governments, businesses, NGOs and even the public. A per-capita national target, with a sub-target index for retail businesses, manufacturers, and consumers, would elevate awareness, demonstrate the commitment to act, and serve as a rallying point for public and private sector strategies and initiatives.

We recommend that both governments and businesses work with the World Resources Institute and the UN Food and Agriculture Organization to implement the Food Loss and Waste Reporting and Accounting Standard, which sets out definitions and recommendations for targets and sub-indicators[10]. Research and investment will also be required to monitor and measure efforts to implement the target and index.

Monitoring and Measuring Tools

Provision Coalition's KPI Dashboard[11] is a readily available monitoring and tracking solution for FLW. While it has been specifically designed for food and beverage manufacturers, it can be extended to serve other businesses operating at other points in the supply chain.

In supporting cross-sector collaboration within Canada, it is key to:

- assist those who have expressed an interest in setting targets but are looking for tangible ways to align and implement them.
- ensure research agendas are shared to avoid duplication and to leverage findings

10 https://champions123.org/

11 https://provisioncoalition.com/tools/kpidashboard

1.2 HARMONIZE GOVERNMENT POLICIES

While municipalities, regions and provinces have different mandates and serve distinct jurisdictions, policies need to be coordinated and aligned as much as possible. Many of the businesses along the food value chain work across local, provincial, territorial, and national boundaries. As governments and their agencies, at all levels, develop new policies aimed at reducing food loss and waste, it is important that they are harmonized so that businesses can work within a common policy framework to avoid confusion, duplication and inefficiencies.

The Canadian Council of Ministers of the Environment (CCME) has typically played the role of coordinating inter-provincial and territorial initiatives. For initiatives such as Extended Producer Responsibility programs, this extends to sharing of best practices among ministry and provincial and territorial staff. If food waste was similarly prioritized by the CCME, the same could be done for food loss and waste prevention. Best practices could be more fully shared within an orchestrated approach to food waste prevention.

For instance, organics bans are recognized as effective means for diverting food waste from landfills and to comply with such bans, businesses must develop new systems and infrastructure to enable staff to sort organics from other waste. There also needs to be appropriate organics recycling infrastructure in place to receive sorted waste. However, currently there is little or no coordination amongst provinces to help ensure that businesses can work within standardized rules across provincial and territorial or even regional jurisdictions. Nor is there active leveraging of solutions in one jurisdiction to advance food waste prevention in another. One example would be a harmonized approach to establishing organics recycling infrastructure. Once a specific policy is demonstrated to be effective in reducing food waste, there must be greater efforts by governments and their agencies to adopt successful policies and work towards harmonization.

1.3 REDUCE CONFUSION OVER DATE LABELLING

Food items have an array of date labels that cause consumers to be wary of buying or consuming food close to “best before”, “use by”, “sell by” and “expiry” dates. Greater clarity about the information these date labels provide, and a change in wording that aligns with the Consumer Goods Forum (CGF) global voluntary guidance, and with the specific recommendations coming from the Food Marketing Institute (FMI) and the Grocery Manufacturers Association (GMA) in the U.S., would reduce the unnecessary disposal of safe and healthy food, either by consumers or businesses who remove them prematurely from their shelves.

For instance, in 2017, FMI and GMA announced voluntary guidance for industry to align around a two-code date labelling system - "Best if Used By" as a quality-based date, and "Use By" for a limited number of highly perishable products with potential food safety concerns. Later that year, CGF issued a global call to action to align to the two code system.

Reducing confusion includes not only the wording found on date labels, but also the physical placement of the text, legibility, and consistency of formats. Progress on reducing confusion on date labelling will involve actions involving the federal government, specifically the Canadian Food Inspection Agency (CFIA), and the food processing and retail industry.

The CFIA is involved in a food labelling modernization initiative that will ensure food safety, consumer protection and a fair and secure marketplace. Given the global market for food, new labelling policies as well as voluntary practices will need to align with those of similar agencies in the United States and Europe to avoid unnecessary generation of more food waste.

A wide array of stakeholders needs to be engaged in this discussion. Among those are organizations such as ReFED in the US and WRAP in the UK who have produced date labelling guidance[12]; the organizations mentioned previously including CGF, FMI, and GMA, and important industry organizations in Canada like the Retail Council of Canada and Provision Coalition. Incorporating educational messaging that helps consumers interpret current and future labelling should be an important element of public campaigns aimed at reducing food waste.

1.4 USE AND COMMUNICATE EVIDENCE-BASED APPROACHES TO PACKAGING

Exploring new packaging approaches to reduce food spoilage while responding to market demands is necessary.

Applying appropriate packaging where needed to reduce spoilage, exploring new packaging materials that support a circular economy, and re-sizing packaged food portions are all important.

Packaging food to protect and extend its shelf life, particularly for fresh fruit and vegetables, is a relatively simple solution. Any new food packaging introduced must be food grade and approved by food safety standards. Recent research identifies a strong correlation between foods with the highest percentage of wastage and the least amount of packaging.[13] So an important role for food packaging is to retain and optimize the value of food that has already been produced. An increase in the use of packaging may conflict with consumer views or preferences on amounts and types of packaging materials. However, in the solid waste stream handled by local governments in Canada, organic waste, including food waste, is a large component of the waste that has to be managed, not the packaging.

Clear research on the value of some packaging in reducing food waste, and a powerful communications campaign with the general public, are needed to ensure best practices can be implemented without raising public concern.

Food processors are engaged in packaging innovation, from changing the materials used to package food to technologies that help reduce contamination of packaged food on the assembly line. But more research is needed to understand what might be the most effective packaging approaches and technologies — passive technologies, or active and intelligent packaging through chemical or biological agents to prevent food spoilage. The goal is clear: reducing food waste while avoiding excessive increases in packaging materials, and maintaining packaging safety, quality and recyclability.

Packaging developments are also needed to respond to market demand that is evolving due to demographic changes. There is a growing number of single member households as well as older, "empty nester" homes, and families living in relatively small spaces. This market does not require, and cannot efficiently use, food in packages designed for larger families or groups, and as a result any foods that can't be eaten are discarded. Important actions in reducing food waste involve both portion-sizing and the type of

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12 *ReFED Date Labeling Standardization Tool*, ReFED 2017; *Labelling Guidance: Best practice on food date labelling and storage advice,* WRAP, Food Standards Agency, Department for Environment Food &Rural Affairs (DEFRA), 2017

13 *Quantifying the Value of Packaging – As a strategy to prevent food waste in America*, Ameripen 2018; and T*he Value of Flexible Packaging in Extending Shelf Life and Reducing Food Waste*, prepared by McEwen Associates for the Flexible Packaging Association

packaging used in fresh and prepared foods – actions that will involve the collaboration of businesses in processing and manufacturing as well as packaging design.

1.5 MANAGE INVENTORIES TO PREVENT LOSS AND WASTE

A critical step in food loss and waste reduction is ensuring inventories in the food supply chain are appropriately sized, both in businesses and in homes, and stored in ways that reduce spoilage. Optimizing procurement and technical innovations would all be useful in reducing inventory waste.

Large institutions which provide meals, such as schools, hospitals and prisons, are major purchasers of food. Their purchasing power gives them influence with their suppliers and the ability to affect change throughout the supply chain. Additionally, carefully considered procurement practices could significantly reduce food waste in their own operations. For example, procurement policies that consider food ordering within the context of meal types and size options for consumers, and how these tie to strict inventory management systems, are all essential. Timely food purchasing and for the types and amounts that can be eaten – not just bulk buys which offer best or most consistent pricing – can significantly reduce waste production. Procurement policies can and should include recommendations for food donations.

Support is needed for knowledge transfer on how to include food loss and waste prevention objectives and best practices. Procurement guidelines and training for businesses are also required to avoid large food surpluses. There is some overlap with institutional procurement guidelines, but considerable areas where there are unique requirements. Strategies ranging from loosening aesthetic requirements to whole crop purchasing should be considered.

Procurement Guidance to Reduce FLW

There are many existing resources to help guide waste-conscious procurement decisions. Examples from outside of Canada include recommendations for the health sector[14], more specific recommendations for hospital systems[15] or even guidelines for office purchasing.[16]

New digital technologies can create new opportunities to manage inventories, the shipment of food and the identification of food surplus issues in a timely manner. All could reduce food spoilage and food waste.

Investments and support for new technological approaches such as blockchain can assist with authenticating, monitoring, or modifying inventories in ways that would significantly reduce food loss and waste. Good data supporting inventory management could provide easier, real-time ordering, help capture

14 http://www.procuraplus.org/fileadmin/user_upload/Activities_files/Events/Rome_2016/reducing_food_waste_healthcare_sector_by_Grazia_Cioci_and_Paola_Hern%C3%A1ndez.pdf

15 https://www.researchgate.net/publication/241092161_Food_waste_catering_practices_and_public_procurement_A_case_study_of_hospital_food_systems_in_Wales

16 https://www.rockefellerfoundation.org/report/food-waste-toolkit-for-the-office/

value from unsold food, and can help track solutions that work at preventing, rescuing, and recovering food.

What is blockchain technology?

Blockchain is a decentralized, distributed and public digital ledger that is used to record transactions across many computers so that the record can't be altered without the agreement and active involvement of everyone in the network. Transactions can be viewed simultaneously and in real time, with both greater security and transparency. Blockchain's unique characteristics offer users an ability to be highly responsive to changes within a supply chain.

Inventory management can be applied in the home as well, and support for good design that better enables consumers to prevent and reduce waste is important. The design of fridges, freezers, even consumer apps that support food sharing and meal planning can help prevent food waste at home. Appropriate design for Canadian markets could come from partnerships among industrial design schools and businesses that engage with consumers and food storage. Solid government and health organization support for food sharing-technology is required for innovations to be successful, as public policy can facilitate – or create a barrier to - the uptake of new approaches to sharing food outside of standard commercial kitchens.

Food retailers can also take steps to help households better manage their inventories and reduce food waste. Marketing campaigns that push volume, like two-for-one sales, and packaging that doesn't allow consumers to easily separate portions required for a meal often lead to food waste.

1.6 DEVELOP NEW PRODUCTS AND MARKETS

Canada's food supply chain is largely made up of small to medium-sized enterprises (SMEs). These businesses tend to lack the capital and internal infrastructure to support the research and development required for new products (technological and otherwise) that could reduce food waste. In this context, government support for the creation and maintenance of a food innovation hub that supports linking food processors with investors, researchers and other businesses in the food supply chain would be valuable.

Relying on individual actors in a large, dispersed national food chain to connect to fully utilize food resources will delay efforts to create a circular food economy. And even if the connections are made, the access to capital to make ideas a reality are limited.

An innovation hub would help support businesses eager to initiate and pilot new ideas. It would also provide an opportunity for investors to act as brokers between ideas, projects, practices, and a place where capital could be pooled to build out larger projects.

New products created from food that is currently under-utilized but still edible could help reduce waste, and demonstrate how the food system could become more integrated into a circular economy. For instance, surplus bread has been used to create *Toast Ale beer*,[17] and new uses for whey, a cheese by-product,[18] are

17 https://www.toastale.com

18 https://dairygood.org/content/2017/knocking-out-food-waste-whey-cool?utm_source=Hub&utm_medium=NDC0302whey_campaign=Hub2017&utm_content=NDC

providing high-quality protein to consumers. Surplus spinach is being converted into dry 'pucks' for the smoothie market. The Greater Vancouver Food Bank is using surplus tomatoes from a local distributor and the skills of a local chef to make a tasty tomato sauce for their clients.

The above examples speak to not only finding new ways to use food that would otherwise go to waste, but also to redefining what people think of as an edible food product. The range of potential food products and markets is vast. The examples above are the results of individuals making connections, but a hub could expand idea and market development opportunities. At this point, examples of such hubs are few, and are too often limited to a web-presence, but opportunities to establish a better interface for those advancing ideas should be explored. [19]

In developing new products and markets, entrepreneurs and start-ups need access to financial resources as well as networks in the food industry. In the US, ReFED has developed a database of 400 start-ups with creative ideas and are actively trying to assemble capital for the most viable ones. In Canada, a network of investors and funders interested in food market opportunities could be linked to new enterprises with innovative and marketable ideas for new food products that would reduce the waste of food. There is also an important role for online platforms that would allow entrepreneurs to identify new opportunities for food products or new ingredients and to connect to potential funders or incubating opportunities.

Another innovation that could reduce food waste while providing farmers with more security is whole crop purchasing, which involves a food processor or food retailer committing to buying all of a certain farm product from a farmer at the beginning of the season. Whole crop purchasing reduces the amount of food left on the field and should stimulate the development of new products or marketing schemes. New digital applications may allow farmers to indicate what portion of their crop would be best destined for retail sale and which best destined for food processing due to cosmetic irregularities. Alternatively, interesting campaigns have been designed by food retailers on the value of irregular or 'ugly' produce.

Reducing FLW through Technological Innovation

Hyperspectural chemical imaging is a Canadian technology produced by P&P Optics that allows companies to sort product by quality.

1.7 ENCOURAGE A CULTURE SHIFT AND NEW BEHAVIOURS

Preventing and reducing food waste in Canada requires a culture shift in businesses within the food supply chain – from CEO and executive offices to the shop floor – that cutting food waste is an important financial as well as social and environmental objective. There is already leadership within some global corporations who see how prevention is linked to their competitiveness and profitability, corporate responsibility objectives, and brand. Champions 12.3 is a good example. In other food businesses, however, this kind of leadership is an opportunity yet to be seized.

19 https://furtherwithfood.org/ or Provision Coalition's online resources https://provisioncoalition.com/ideahub/ideahubdetail/welcome-to-provision-coalitions-online-sustainability-portal or EU Fusions https://www.eu-fusions.org/

In Canada, working directly with small and medium enterprises offers a potentially easier road forward. For example, training with procurement managers and assembly line workers can be more direct and with a smaller number of individuals who have significant inventory control, and where innovation can be piloted on-site with employees that can learn directly from new techniques and approaches.

Essential for making progress on preventing and reducing food waste is communicating this new commitment to staff and providing training at all levels of the business, from change management training at the leadership level to specific training on the shop floor. Staff need to know that reducing food waste is a new key performance indicator that will be important, and given information on, for example, how inventories of food products are to be managed, how to identify and maintain the quality of surplus food, and how to distinguish organic waste from material destined to the landfill. Changes to standard operating procedures, and staff training on how to prevent food loss along production lines will also be required.

This involves creating an ethos of waste prevention, where employees embrace the need for change and are provided enough information, skills and tools to implement new practices

Culture-shifting and SMEs

Provision Coalition, Canada's food and beverage sustainability association, provides training and technical support to food processors and manufacturers on how FLW can be addressed within their businesses – and how an ethos of waste prevention can be nurtured.

Since consumers are responsible for almost half of the food waste generated in Canada, engaging with them is essential. In the United Kingdom, WRAP's Love Food Hate Waste campaign has demonstrated the power of creating greater awareness of the amount of food waste generated in the home, and then providing simple tips for making positive changes. Through primarily the use of social media coupled with some targeted outreach and in-store promotions, consumers are given tangible and engaging messages about the environmental and economic impacts of food waste. They are provided with some relatively simple messages about how to use up the food they buy, store the food to preserve its freshness, and plan meals and shopping to better manage their home inventory.

Metro Vancouver, a regional government in British Columbia, has a licensing agreement that allowed them to introduce Love Food Hate Waste to the metropolitan area of Vancouver. In 2018, the National Zero Waste Council, in collaboration with local and provincial and territorial governments, national food retailers and NGO partners, will launch the country-wide Love Food Hate Waste Canada campaign in both official languages.

2.0 Recover

RECOVER

While the actions described under **1.0 Prevent** are intended to take place at the top end of the waste hierarchy, food recovery, or rescue, is needed to divert the remaining safe and nutritious food to people, and food scraps to animals.

Donations to community organizations and non-profits who organize meal and food programs, and developing mechanisms that assist neighbourhoods share food more effectively, help build community resilience and connection. Recovering food scraps for feeding animals maintains the value of food as an input into further food production rather than turning these scraps into garbage.

Ensuring that the resources invested in food production are not wasted but are instead used productively for feeding people or animals is an example of how circular economy concepts can be effectively integrated into the Canadian food system.

IMPORTANT ACTIONS INCLUDE:

2.1 ENHANCE INFRASTRUCTURE AND ENCOURAGE INNOVATION

Canada's geography – with significant distances between communities – presents transportation challenges for distribution and storage networks. Solving reverse logistics challenges and establishing opportunities for shared cold storage will assist in deepening food recovery. This will require advancements in IT-enabled transportation and better logistics software.

New on-line digital technologies will enable the creation of networks that can expedite the transfer of foods suitable for consumption to community organizations and non-profits. While food recovery activities have been operating for many years, there are still ways that new digital technologies could enhance the matching of food donors to community organizations.

On-line apps can also help community organizations provide potential donors with information on the type of food donations they generally require, including specific dietary needs or religious restrictions. Furthermore, creating networks that can operate rapidly is essential in moving fresh and perishable foods from donor to recipient organizations. This element is particularly important, as these are the foods that community organizations and food banks are looking for as they seek to develop more nutritious menus for their clients, and inventories of food products that include the full range of foods required for a healthy diet.

Reducing FLW through Social Innovation

FoodMesh was developed by two young Canadian entrepreneurs in 2015. They have created a network of investors, businesses, growers, processors and charities committed to a more circular food system. The on-line platform matches surplus food to demand from businesses and charities in real time. To date, FoodMesh has successfully provided hundreds of thousands of meals to people and has saved over a million dollars in food value by companies using the business to business platform.

The community infrastructure used by these organizations can also be enhanced, especially in terms of cold storage capacity in both warehouses and in vehicles, to expand the ability of these organizations to use fresh produce, milk products and fish and meat in their programs. Cold storage is essential for maintaining perishable foods at the quality required for food service. This is a challenge that governments could address through investment in public infrastructure, or businesses could include in their community responsibility or investment programs.

The redistribution of surplus foods is an important means for increasing community resiliency – it addresses a need and expands linkages between the private sector and the communities they operate within.

Facilitating the development of community kitchens and fridges, and promoting and supporting neighbourhood sharing apps, are examples of how community-based innovation and food waste rescue and recovery could contribute to greater trust between people, normalize reciprocity, and create a bridge between diverse populations. Philanthropic investment and local government policy change to encourage community-based innovation in sharing surplus food would help build this level of activity as would support and active engagement from health authorities.

Land use planning policies could also help stimulate efforts to strengthen this sector. Comprehensive development zoning that allows food hubs to be built, where a mix of commercial, industrial and residential activities all involving food from production to consumption would be helpful. Food hubs help reduce distribution distance, and can reduce food spoilage due to transportation.

Canada's rural areas face additional challenges in facilitating food rescue. The distances between donor and recipient organizations would usually be much greater than in urban areas, creating even more requirements for effective systems to quickly match potential donors with recipients, accompanied by rapid transportation and storage systems that include refrigeration.

2.2 IMPROVE FOOD SERVICE TRACKING AND DISTRIBUTION

Within food service operations, ranging from corporate and institutional cafeterias to local restaurants, there are actions that can be taken to improve their ability to recover food. These include establishing better waste-tracking equipment and procedures to record and monitor surplus food amounts; identifying best practices with respect to food service donations; increasing the understanding of the challenges associated with appropriate serving strategies, and how these impact food donation; as well as identifying how to best transport hot and cold food to appropriate destinations. Working with food service businesses to support a move toward trayless dining and plated menus over buffets is critical.

2.3 BUILD GLEANING NETWORKS

Farms can be important sites for recovering food. Gleaning is the recovery of vegetables and fruit that have not been shipped to market from a farm or orchard, and would otherwise be left to rot or be turned under in-field. The reasons why this produce did not get to market vary, including production in excess of contracts, or not meeting market requirements for size, shape, colour or condition. In a gleaning operation, farmworkers or volunteers collect the produce and then it is sent to be processed and distributed to communities locally, nationally or internationally. As a food recovery action, gleaning reduces food waste that would otherwise be generated on-field, and helps move food to communities in need. The gleaning organizations in Canada are looking to establish a national network that would allow cost efficiencies associated with bulk purchasing of supplies, storage, and administration services. Support for the development of a gleaning network in Canada would help increase their capacity and lead to greater food capture.

2.4 REMOVE FINANCIAL, LEGAL AND POLICY BARRIERS

Businesses which donate foods to charities typically face additional costs in sorting, storing and transporting food.

In general, to support the donation of surplus foods, provincial and territorial, and local health authorities need to provide guidance to donors on which surplus foods are most appropriate for donation and how to keep food safe during the donation process.

Aside from the logistics, potential food donors have expressed concerns about liabilities they may be exposed to as a result of donating food. However, in Canada there has not been a reported court decision imposing liability on a business or individual caused by donated foods.

The National Zero Waste Council has already initiated action on this front. The Council has produced food donation guidelines[20] for Alberta, Ontario, Quebec and Nova Scotia, based on similar guidelines for British Columbia produced by the BC Centre for Disease Control. These guidelines identify good food donation practices for food retail, service and processing businesses, including types of food and food storage requirements, and provide legal interpretations of Good Samaritan Acts that govern risk liability when donating food. These guidelines will be featured in knowledge transfer workshops conducted by the Council and Provision Coalition in 2018. Additional business training and education campaigns around the issue of liability with respect to food donation programs may be required.

There can be policies, coupled with public perceptions, that inadvertantly prevent market development leading to greater food waste recovery. These policies need to be updated, and consumer campaigns supporting a culture shift around food purchasing need to be undertaken. Market initiatives that are gaining traction in jurisdictions outside of Canada include businesses that feature recovered food sold at discount, or wholly feature foods past their best before dates, or consumer-tailored online ordering where portions better meet consumption needs. Similar business opportunities await for businesses in Canada. These types of creative, innovative market opportunities need to be captured and supported.

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20 http://www.nzwc.ca/focus/food/guidelines-for-food-donations/Pages/default.aspx

2.5 EXPAND THE RECOVERY OF FOOD SCRAPS TO FEED ANIMALS

There are two ways in which recovered food scraps can become animal feed. One is for a food business to donate their food scraps or surplus foods to an animal feed processing facility where the food is transformed into a dry, stable feed. This would include food for pets as well as farm animals. The alternative is for a business to donate its food scraps for operations that directly feed them to the animals. The only processing involved in the latter is that the food scraps may need to be de-packaged or ground into a slurry.

Not all food waste is appropriate for feeding animals. There are restrictions on what animals can be fed. Since provincial and territorial governments are responsible for managing agricultural operations, including livestock, there can be variations in these laws across Canada. To reduce food waste, it would be beneficial to harmonize the guidelines and regulations regarding the recovery of food waste for animal feed.

Distribution and de-packaging issues need to be resolved. Farmers need consistent flows of food waste to feed livestock, and farmers cannot be expected to de-package donated food on farm sites. Where de-packaging happens, and how donating businesses can support this process, is an important discussion. Some retailers are already making headway on this challenge. Facilitating, and then providing longer-term support for knowledge-transfer and relationship-building between processors, retailers, farmers and potentially community organizations, is required. Donated food waste to animals should be tracked and monitored, so it can inform future procurement decisions, and affect upstream loss and waste actions.

3.0 Recycle

RECYCLE

Systematic efforts to reduce the generation of surplus food and recover nutritious food that would otherwise be wasted will dramatically reduce the amount discarded. However, these strategies will take time to deliver results, and cannot be expected to completely eliminate the amount disposed in landfills. As a result, an additional set of activities is needed to prevent food waste being combined with other garbage in landfills. The purpose is to capture the embedded nutrients and energy from those food scraps and reduce the methane emissions from the decay of organic materials in landfills, which in itself accounts for approximately four per cent of Canada's greenhouse gas inventory.[21]

Composting plants and bioenergy facilities are opportunities that can create value from food waste. However, to operate effectively they all need a dedicated and predictable stream of food waste along with other organic materials, such as yard trimmings. As long as food waste is simply thrown away and discarded with other garbage into landfills, the business case for these recycling facilities, whether they are owned by local governments or by the private sector, will be weak. For this reason, there is a need for regulation, effective communications campaigns, and government support for infrastructure to capture the value of the food waste that remains after proactive steps to prevent and recover food waste.

IMPORTANT ACTIONS INCLUDE:

3.1 BAN ORGANICS FROM LANDFILLS

Composting and bioenergy facilities have been built by both the private sector and governments. But to be successful, both need a robust market for their product, compost, and a reliable and uncontaminated supply of their input material, food scraps. Gaining an uncontaminated supply of food scraps is challenging, since it requires new waste separation behaviours by restaurants, groceries and other businesses, institutions such as schools, and residents of single-and-multi-family homes.

To move forward and encourage the growth of these operations, a carefully coordinated set of policy changes and communications campaigns is needed. Local, regional or provincial and territorial governments can set the frame by banning the disposal of organic material in landfills. Ideally, organic bans are supported by provinces that are coordinating with each other, so that businesses operating across the country are responding to a harmonized policy environment. While there are challenges associated with localized residential pick-up and material processing facilities – particularly in rural areas – policy regimes can be modified to fit rural and urban contexts. Minimally, large urban areas across the country should consider developing complementary policy statements. Within metropolitan regions, it is recommended that implementation practices are synergistic as this would assist with measurement and monitoring efforts.

21 National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada. Available at: https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=662F9C56-1

The effectiveness of any ban will furthermore depend on additional efforts to encourage individuals in all situations to separate their food scraps from the garbage. Best practice has been to:

- Consult with businesses, institutions and the general public on the details of implementing the ban,
- Provide sufficient lead time for businesses and institutions to invest in new equipment and learn new systems, and
- Initiate and continue comprehensive communications and behaviour change campaigns to encourage everyone to separate food waste from garbage and place it into a separate collection stream.

Government bans on the disposal of food scraps in landfills, along with consumer and business engagement plans to build awareness and encourage new behaviours, have been implemented in several Canadian cities and regions. The result has been a dramatic reduction in food disposal in landfills, gradual improvement in reducing the contamination of other refuse in food waste streams, and the consequent growth of new businesses and technologies that turn food scraps into compost and bioenergy.

Whether local governments or the private sector own and operate the facilities taking in organics, revenue earned from material and energy sales can offset some of the costs of waste disposal. For instance, by creating both compost and biogas that can be substituted for natural gas, some anaerobic digesters may be able to accept food waste at a cost comparable to some landfills. In the process, they add value to the community by eliminating the methane emissions that food waste would have created in a landfill, generating energy that can offset the need for fossil fuel development, and providing a soil amendment that can return fertility to degraded soils and reduce the need for chemical fertilizers.

3.2 ENCOURAGE INVESTMENTS

Composting and biofuel facilities are capital intensive, and could be beyond the reach of many local governments. Continued federal support for their construction is needed. In addition, the Federation of Canadian Municipalities' Green Municipal Fund will need to continue providing financial support to local governments interested in building public composting facilities.

The financial viability of these operations also requires a strong market for compost. This could be facilitated through policies by local, regional or provincial and territorial governments that encourage the use of compost for landscaping or site remediation.

Other opportunities include working with organizations like the Solid Waste Association of North America and the Compost Council of Canada, academic institutions such as the University of British Columbia and the Environmental Research and Education Foundation in Ontario to undertake applied research to develop new technologies for recovering materials and energy from organics. Again, there is a role for the federal government to invest in research and development, but also in facilitating partnerships around clean technology innovation that targets food waste and greenhouse gas capture and transforms it into a green energy source.

3.3 INNOVATIONS IN DESIGN

Adding the separation of food scraps to the recycling efforts of homes, businesses and institutions adds complexity to regular tasks, and often requires additional space – from home and restaurant kitchens to apartment building garbage rooms, to the dining areas of fast-food restaurants.

Better Design Supports FLW Action

New U.S. design guidelines[22] for residential, commercial and institutional buildings are intended to support cities deliver on waste prevention and reduction goals. Produced by the US Centre for Architecture, with support from The Rockefeller Foundation, these guidelines offer advice on a wide range of strategies and best practices that span urban design to construction and demolition.

New designs of facilities and spaces are needed to simplify the responsibilities of employees and residents so that they can more easily separate their waste streams. Design guidelines informed by building codes can help designers, building operators and planners collaborate to build and systematize organic waste recycling. Design guidelines can work at the micro scale of individual buildings, through to multi-family building sites and neighbourhoods. They can include details ranging from organic waste chutes in new multi-family buildings to SMART monitoring within residences to help people track their food waste.

22 https://assets.rockefellerfoundation.org/app/uploads/20171113123723/Zero-Waste-Design-Guidelines-2017.pdf

Concluding Statement

Food loss and waste costs Canadians – economically, environmentally and socially. It is critical that Canada join other global leaders in addressing the problem – and by doing so, better position us to lead on innovation, support our SME's, strengthen our food system, and create stronger, more resilient communities. We collectively have a target to reach: by 2030, to halve per capita food waste and reduce food losses. To effectively reach this target will require new levels of collaboration across sectors, amongst all levels of government, and with diverse stakeholders. A greater willingness to work together, with greater transparency around how we are measuring and monitoring progress and action planning for success will be important. The actions and tools described in this national strategy provide a way forward, encouraging people and organizations to share knowledge and harmonize action along the way.

The National Zero Waste Council supports collaboration, fosters knowledge transfer, and animates action. We look forward to supporting champions in business/industry, government, and civil society who are diving deep into addressing food loss and waste – and building a more sustainable food system for all Canadians.

zeroWASTE
NATIONAL ZERO WASTE COUNCIL
An Initiative of Metro Vancouver

Committee of the Whole Report
For the Meeting of December 10, 2020

To:	Committee of the Whole	**Date:**	November 27, 2020
From:	Philip Bellefontaine, Director, Engineering & Public Works		
Subject:	Zero Waste Victoria		

RECOMMENDATION

That Council:

1. Approve Zero Waste Victoria;

2. Direct staff to begin implementing strategies in Zero Waste Victoria as outlined in the short-term action plan; and

3. Direct staff to report back with draft bylaw(s) for Council's consideration to regulate priority single-use items after new municipal authorities are conferred by the Province.

EXECUTIVE SUMMARY

Every day across the City of Victoria over 120 tonnes of materials are disposed and sent to the landfill. This waste includes demolished buildings, uneaten food, plastic and paper packaging, and old clothes and furniture. Reconsidering these materials as valuable resources instead of garbage and keeping them in use is a foundational principle of the circular economy and the area where cities have the biggest role to play in the transition to a more circular and sustainable future. Circulating materials instead of sending items to landfill is fundamental to preserving natural resources, reducing pollution, mitigating greenhouse gas emissions and supporting a resilient local economy. The City of Victoria is well positioned to lead material reuse and waste reduction initiatives across the community through its role as a solid waste service provider and using regulatory authorities granted to local governments.

This report builds on work completed by staff in the first development phase for the City's zero waste strategy to assess waste generation across Victoria and review best practices for municipal waste reduction. This report proposes a suite of strategies to achieve a 50% reduction in landfill disposal by 2040 through a renewed emphasis on material reduction and reuse. Material and product categories of focus for waste reduction initiatives are single-use items and packaging, materials from the built environment, food and organics, and durable goods. Together these categories represent more than 90% of the material sent to landfill from Victoria.

Stakeholders representing 57 organizations across the region were engaged to review the proposed strategies and identify considerations for prioritization of actions. Overall, participants supported the strategies proposed in Zero Waste Victoria and commonly noted considerations related to space requirements, accessibility and equity of services, consistency between jurisdictions and across levels of government, and opportunities to leverage existing leaders in the community.

This report also proposes a short-term action plan informed by Council direction and priorities, current staff resources and stakeholder feedback that includes new regulations banning single-use items and improved diversion of organics, recyclable and reusable materials across the community. The short-term actions address the most significant opportunities for waste reduction using existing municipal tools while also laying the foundation for longer term transformative change.

PURPOSE

The purpose of this report is to provide Council with the zero waste strategy and a proposed short-term action plan for approval.

BACKGROUND

The City of Victoria provides community solid waste management services including residential garbage and kitchen scraps collection, residential yard and garden waste drop-off and seasonal pickup programs, street cleaning, and public realm garbage, organics and recycling collection. The City's waste management role as a service provider is enabled by Provincial legislation and its responsibility to reduce landfill disposal is guided by the Capital Regional District's Solid Waste Management Plan. Over time, the City's solid waste mandate has evolved from a focus on managing the disposal of garbage to avoid litter towards a more sustainable model that incorporates landfill diversion, waste reduction and environmental stewardship.

In 2019, Council identified the development and implementation of a robust zero waste strategy to help support climate leadership and environmental stewardship strategic objectives. The initial development phase of the zero waste strategy was completed in 2019 and included a comprehensive analysis of waste generation across all sectors of the community and a review of best practice municipal zero waste programs. The outcomes of this work helped to reveal several insights for targeted engagement and strategy development:

- Victoria is generating a higher portion of regional waste than was previously understood due mainly to its position as the region's hub for employment, commerce and tourism.
- More policies and programs are needed to focus on waste avoidance, reduction and reuse.
- There is an opportunity to divert significantly more recyclable and organic material from the regional landfill.
- The City possesses a range of policy tools and services that complement the Capital Regional District's strategies to reduce landfill disposal.
- The City has an opportunity to demonstrate leadership through corporate waste management practices and share lessons with stakeholders.

In November 2019, Council directed staff to proceed with the second development phase of the zero waste strategy including engaging with key stakeholders to understand and develop the strategies and actions needed to shift towards zero waste for priority sectors and materials.

This report describes the analysis and stakeholder engagement that led to the development of the proposed waste reduction strategy and implementation plan.

ISSUES & ANALYSIS

The strategy for waste reduction across all sectors in Victoria – *Zero Waste Victoria* - is presented for Council's approval in Appendix A. The plan was informed by a comprehensive analysis of waste generation across the city, current evidence and scientific assessments of waste-related environmental impacts, municipal zero waste best practices from across the world, market and technology trends, municipal authorities under the *Community Charter* and *Local Government Act*, and direct feedback from a diversity of industry and community stakeholders. Key issues and considerations are presented below.

Focus Areas

Zero Waste Victoria identifies four categories of materials to focus municipal waste reduction strategies:

1. **Single-Use Items and Packaging**: This area consists of materials and products designed to be disposed after a single use or used to package goods, including cups, containers, checkout bags, paper and plastic packaging. Together these products comprise 17% of the material disposed in the regional landfill. In addition, plastic items and packaging that escape collection and enter the natural environment have been shown to harm animals, ecosystems and biodiversity[1]. Residential packaging recycling rates in British Columbia are amongst some of the highest in the world as a result of robust producer responsibility legislation at the Provincial level, but the recovery rate for plastics is less than 50% and flexible plastics less than 25%[2]. This suggests a need for additional initiatives focused on material avoidance and reusable alternatives. The City introduced the first municipal single-use item regulation in British Columbia with the adoption of its Checkout Bag Regulation Bylaw in January 2018. Additional single-use products that are prolific across Victoria but not currently regulated include cups, containers, straws, utensils and paper napkins.

2. **Built Environment**: Products in this category include materials from construction, renovation and demolition activities such as wood, concrete, metals, drywall and asphalt roofing. These materials are responsible for up to 37%[3] of Victoria's landfilled waste with wood products comprising approximately two-thirds of landfilled material from the built environment. Municipal authority to regulate land use and permit development and construction offers an opportunity for the City of Victoria to make a significant impact in this area. Local economic opportunities are also presented through the salvage and reuse of building materials[4]. Notwithstanding hazardous materials, few requirements have been developed to address the responsible management of construction,

[1] Science Assessment of Plastic Pollution. Environment and Climate Change Canada and Health Canada. October 2020. Retrieved from: https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/science-assessment-plastic-pollution.html

[2] Recycle BC – 2019 Annual Report. Recycle BC, 2019. Retrieved from: http://recyclebc.ca/wp-content/uploads/2020/06/RecycleBC2019-Final.pdf

[3] Between 50 – 75% of construction waste is estimated to leave the region and therefore not included in the reporting of material at the Hartland landfill.

[4] The Business Case for Deconstruction: Economic and environmental impacts of a demolition-deconstruction shift in Metro Vancouver. Vancouver Economic Commission. July 2020. Retrieved from: https://www.vancouvereconomic.com/research/the-business-case-for-deconstruction/

renovation and demolition waste.

3. **Food and Organics**: Materials in this category include uneaten food, food scraps (e.g. peels, shells and bones) and organic material generated from yard and gardening activities. Organic materials continue to represent the largest share of materials disposed at the Hartland landfill at 27% of all waste. Landfilled organic waste generated in Victoria produces the equivalent of 21,000 tonnes of CO_2 annually, approximately 6% of community greenhouse gas emissions. Together, apartment buildings and commercial properties are responsible for more than 85% of Victoria's landfilled organics. The City of Victoria's residential kitchen scraps collection service successfully diverts more than 2,000 tonnes of organics from the landfill each year. Nonetheless, organic materials still comprise one third of the City-collected residential garbage stream, indicating a need for enhancements and better compliance with the City's waste collection service. Despite the existence and development of regional organics processing infrastructure, significant improvements in the source separation of organics materials across all sectors of the community is required to mitigate community greenhouse gas emission and extend the life of the regional landfill.

4. **Durable Goods**: This category includes consumer products that can be used regularly for long periods of time such as furniture, appliances, electronics and clothing. Durable goods comprise 15% of the material disposed annually at Hartland landfill, half of which are textiles. Higher quality durable goods tend to retain their value and can be sold and reused through second-hand markets. Provincial producer responsibility programs have also enabled robust recycling systems for appliances and electronics. Nonetheless, excessive consumption, cost competition and the resulting degradation in quality of durable goods reflect broader societal trends that compromise initiatives to increase reuse and reduce waste. Although the outcomes may be less tangible than the categories above, the City of Victoria can help to foster the community values and behaviours for a circular economy by supporting sharing initiatives and local repair services. The City also has an opportunity to influence product design through corporate procurement strategies that encourage product durability and refurbishment.

Additional materials not categorized in the focus areas above include disposable diapers, pet waste and cigarette butt litter. Together these wastes comprise less than 7% of all material sent to the landfill but have considerable impacts on community sanitation and cleanliness.

Approach

Three established frameworks guide Zero Waste Victoria: the circular economy, zero waste and the waste reduction hierarchy.

Zero waste fits under the broader model of a circular economy; a paradigm that contrasts the conventional "linear economy" we currently rely on which extracts resources to create products that are used and then disposed – "take, make, waste" – and aims to build economic, natural and social capital based on three foundational principles:

- Design out waste and pollution.
- Keep products and materials in use.
- Regenerate natural systems.

Cities can incorporate all three principles into their planning and operations to help support the transition to a circular economy. The City of Victoria has already taken meaningful steps towards environmental stewardship through a range of initiatives including sustainable stormwater management and its urban forest master plan and climate leadership plan. However, given the concentration of manufactured products, material and resources that exists in cities, it is the second principle of keeping products and materials in use that presents municipalities with the biggest opportunity to advance the circular economy. Zero waste complements this principle by emphasizing the reduction, reuse and repurposing of products thereby maximizing the value of existing community resources.

Zero Waste Victoria also incorporates the waste reduction hierarchy to prioritize strategies and actions. The hierarchy follows a preferential order of action from reduce, reuse, repair, repurpose, to recycle while avoiding disposal. Zero Waste Victoria acknowledges that recycling alone will not achieve zero waste and therefore establishes a renewed framing of the long established 3R's (reduce, reuse, recycle) into three guiding initiatives that clarify and emphasize the City of Victoria's role and responsibility as follows:

1. **Eliminate the unnecessary**: This initiative includes strategies that address products and materials where the negative impacts to the environment and community outweigh the consumer benefits or where viable sustainable alternatives exist.

2. **Make reuse the norm**: This initiative includes strategies that help to establish reusable products and reuse practices (including repair and refurbishment) as the default option throughout the community.

3. **Recycle the rest**: This initiative includes strategies aimed at improving recycling for products that can no longer be used.

Underpinning each of these guiding initiatives is the recognition that the City of Victoria plays an important role in facilitating the transition to zero waste by leveraging knowledge and partners across the community and demonstrating leading waste reduction practices through its corporate operations.

Zero Waste Strategies

Zero Waste Victoria proposes 40 strategies to support the transition to zero waste across the community to 2040. The strategies, general implementation timeline and performance indicators are listed in Appendix B. The strategies are intended to be actionable over a 20-year period, guiding Council and staff in the development of new initiatives and continual improvement of existing services and programs.

Broadly, the tools available to the City of Victoria to action the strategies and reduce waste include:

- Municipal solid waste services and operations (e.g. garbage and kitchen scraps collection, public realm waste collection, litter pickup).
- Regulation, restrictions, prohibitions (e.g. material bans, fees, permits).
- Corporate procurement.
- Education and outreach programs.
- Advocacy to other levels of government.

The tools the City uses to implement Zero Waste Victoria will evolve over time as conditions change and as the community approaches waste reduction goals. Where appropriate, actions could reflect a phased regulatory approach following and supported by market approaches and voluntary measures. In other situations, the regulatory tools will be evaluated based on other considerations, including the viability of sustainable alternatives, community or business readiness, local capacity and understanding, and precedents in other jurisdictions.

Stakeholder Engagement

Between July and October 2020, staff engaged local and regional stakeholders to review draft strategies and inform and prioritize actions for Zero Waste Victoria. Staff conducted 10 online focus group sessions that included 98 participants representing 57 organizations. Participants included representation from government, businesses, private waste management service providers, mission-based organizations and neighbourhood associations.

Summaries of each of the focus group sessions are provided in Appendix C. Overall, participants supported the strategies proposed in Zero Waste Victoria and the need for the City of Victoria to take action to reduce waste across the community. Common considerations for implementing the strategies were noted as follows:

- The availability of space is an underlying issue that needs to be overcome to improve reuse and recycling activities throughout the community. S pace is required to store and sort materials at multifamily and commercial properties, warehouse wholesale and retail salvaged building products and used durable goods, and to locate waste management facilities.
- City solid waste management services ought to be reviewed to consider accessibility, equity and environmental stewardship.
- The City's actions should align with initiatives across levels of government and staff should collaborate with government counterparts.
- The City is well positioned to convene major waste generating institutions across the community and lead collective waste reduction initiatives.
- Clear and consistent education and guidance to support waste reduction initiatives is encouraged.

Implementation Planning

Zero Waste Victoria contemplates the preparation of detailed action plans every 3 – 5 years. Action plans will enable the City to respond to changing conditions and guide budget and resourcing considerations accordingly.

OPTIONS & IMPACTS

The following is the recommended option for the initial short-term action plan, targets and reporting for Council's consideration.

Short-Term Action Plan

Actions to implement the strategies in Zero Waste Victoria from 2021 through 2023 are proposed in Appendix D. Actions are categorized in terms of impactful initiatives and informed by Council direction and priorities, current staff capacity and stakeholder feedback. Priority initiatives include:

1. **Single-Use Item Bans**: Council's 2019 – 2022 Strategic Plan identifies the development of regulations to address problematic single-use items. Both the Federal and Provincial governments have recently announced proposals to address plastic pollution and the Province has indicated that it will provide new authority to local

governments to regulate specific products. This action considers the development of new single-use item bylaw(s) in alignment with other levels of government while incorporating accessibility needs and local issues.

2. **Demolition Material Reuse**: In November 2019, Council directed staff to report on policy considerations for sustainable building demolitions. Emerging services and technologies in the region offer potential opportunities for the City to phase in regulatory requirements to accelerate initiatives to reduce and salvage building demolition waste. A forthcoming report with options will be presented in early 2021 for Council's consideration.

3. **Multifamily and Commercial Source Separation**: Multifamily and commercial properties are served by private haulers providing a range of service levels/standards. The Capital Regional District's (CRD) draft Solid Waste Management Plan proposes the increase of residential and commercial diversion through source separation requirements as a medium-term (5 years) implementation goal. Stakeholder engagement also highlighted the desire for consistent standards for private organics, recycling and waste collection. This action considers development of source separation requirements in alignment with the CRD Solid Waste Management Plan.

4. **Enhancement of City Services**: In November 2019, Council directed staff to develop a plan to enhance the City's residential collection program and improve diversion of materials in the public realm. New public realm Zero Waste Stations were designed, fabricated and installed in 2020 and expansion is proposed in future years. Planning for residential waste collection began in 2020 and enhancements will be proposed for Council's consideration as opportunities arise; notably, operational efficiencies, equipment replacement, new technology or major grants.

5. **Education and Outreach**: Initiatives are proposed to build broad understanding of Zero Waste Victoria and to improve awareness of local and regional services and resources that support reduction, reuse and recycling.

Targets & Reporting

An evaluation of potential waste reduction impacts for each strategy was completed to determine targets for Zero Waste Victoria and to inform key performance indicators (KPIs) for individual strategies. Approximately half of the materials generated in Victoria currently goes to the landfill. Zero Waste Victoria proposes a reduction in this annual landfill disposal of 50% by 2040. This target reflects the opportunity for waste reduction using the current range of tools available to the City of Victoria. Further reductions are possible through supportive actions at higher levels of government and industry-led initiatives.

Focus area KPIs are included in Appendix B. These KPIs may be adjusted over time and new indicators and interim targets added during implementation of Zero Waste Victoria to ensure the City can capture legislative or market changes that arise.

Reporting on the progress of key initiatives and operational highlights will continue to be included as part of regular corporate accountability reporting. Budget and resource requirements will be incorporated into the financial planning process and informed by the short-term action plan. Detailed analysis of progress and issues will be undertaken as part of the proposed 3 – 5 year implementation planning cycles.

Accessibility Impact Statement

Waste management services and infrastructure have direct accessibility benefits and potential impacts. Accessibility stakeholders and people with lived experiences were engaged as part of the focus group sessions with 2 sessions dedicated to equity, inclusion, and accessibility. Equity and accessibility stakeholders will continue to be engaged in the implementation of the City's waste reduction policies, programs and services.

2019 – 2022 Strategic Plan

The draft Zero Waste Strategy and proposed implementation plan presented for Council's consideration in this report address three actions under the Climate Leadership and Environmental Stewardship Strategic Objective: (#1.) Develop a Zero Waste Strategy, (#11.) Introduce regulations to ban and/or restrict problematic single use items (coffee cups, take out containers, straws, etc.) while taking into consideration accessibility needs, and (#16.) Implement a robust Zero Waste Strategy.

Impacts to Financial Plan

In 2019, Council approved budget for two 2-year term staff positions to support development of the Zero Waste Strategy and in 2020 approved one additional continuous staff position. The proposed implementation plan can be accomplished using the staffing capacity of the solid waste engineering and planning section, noting the expiry of two positions in 2022 requiring term renewal or a change to continuous employment status.

Budget to implement Zero Waste Victoria in 2021 is proposed to be carried forward from Council's 2020 one-time commitment in addition to $95,000 proposed in the 2021 base capital budget for public realm collection infrastructure. Future operating and capital budget requirements to implement Zero Waste Victoria will be proposed through the financial planning process.

Official Community Plan Consistency Statement

Waste reduction is consistent with Plan Goals related to Infrastructure and Climate Change and Energy in the City of Victoria's Official Community Plan (OCP No. 12-013). Specifically, the OCP states that the City is to "support steps for Victoria to move towards a zero net solid waste community in partnership with the Capital Regional District (CRD) and the private sector" and provides the broad objective that "solid waste [is] managed as [a] closed loop system with optimal levels of recovery and re-use" across different stakeholder groups.

CONCLUSIONS

Staff have completed the second development phase of the City's Zero Waste Strategy (Zero Waste Victoria), which included drafting of strategies, stakeholder engagement and short-term implementation planning. A target of 50% reduction in annual landfill disposal by 2040 was established based on an assessment of the impacts of robust implementation of the strategies proposed in Zero Waste Victoria. A short-term action plan is proposed to guide the City's waste reduction actions from 2021 through 2023 including new regulations banning single-use items and improved diversion of organics and recyclable and reusable materials across the community.

Respectfully submitted,

Rory Tooke
Manager, Sustainability, Assets & Support Services

Philip Bellefontaine
Director, Engineering & Public Works

Report accepted and recommended by the City Manager

List of Attachments:

Appendix A: Zero Waste Victoria
Appendix B: Strategies Reference Table
Appendix C: Engagement Summary
Appendix D: Short-Term Action Plan

Resources From Waste:
A Guide to Integrated Resource Recovery



2009

BRITISH COLUMBIA
The Best Place on Earth
Ministry of Community Development

Resources from Waste : A Guide to Integrated Resource Recovery.

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1. Refuse and refuse disposal--Government policy--British Columbia. 2. Refuse disposal facilities--Government policy--British Columbia. 3. Recycling (Waste, etc.)--Government policy--British Columbia. 4. Waste minimization --Government policy--British Columbia. 5. Greenhouse gas mitigation--British Columbia. 6. Sustainable development--British Columbia. 7. Environmental policy--British Columbia. I. British Columbia. Ministry of Community Development II. Title.

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Foreword

This guide to Integrated Resource Recovery (IRR) emerged from an independent report released by the Government of British Columbia in May 2008. That report, entitled *Resources from Waste: Integrated Resource Management Study* examined approaches local governments across British Columbia might consider in using solid and liquid waste to create energy, reduce greenhouse gas emissions, conserve water, and recover nutrients. The document was composed of the report by a study team, the comments of a technical advisory committee and comments of four peer reviewers. The report illustrated that there is broad agreement that integrated resource recovery could aid local governments in reducing greenhouses gas emissions, diverting waste from landfills, and generating revenue from infrastructure.

This IRR Guide is intended for those who plan, design, and fund infrastructure - including water, wastewater, transportation, energy, and solid waste. Although it is technical in nature, it is also intended to be a resource for the broader community which uses this infrastructure. It offers suggestions for making municipal infrastructure, and the communities served by the infrastructure, more economically, environmentally, and socially sustainable by extracting value from the resources in waste.

The Ministry of Community Development would like to acknowledge the complementary work and contribution of the Community Energy Association (CEA). The Community Energy Association supports municipalities, regional districts and First Nations to tackle energy issues and climate change at the local level. CEA is a collaboration of the Province of British Columbia, Union of B.C. Municipalities, local government members, transit and energy service providers and professional organizations, and has been serving the needs of local governments for 15 years. CEA has a comprehensive Community Energy Planning toolkit, funding guide (updated quarterly on the CEA website), and renewable energy guide, comprised of four modules: *Heating Our Communities*, *Powering Our Communities*, *Utilities and Financing*, and *Policy and Governance Tools*. This guide is intended to complement CEA's publications which can be found on the web at: *www.communityenergy.bc.ca*

For more information, contact the Intergovernmental Relations and Planning Division at 250-387-4037. The website is: http://www.cd.gov.bc.ca/lgd

Or contact Enquiry B.C.:

In Victoria call: **250-387-6121**
In Vancouver call: **604-660-2421**
Elsewhere in B.C. call: **1-800 663-7867**
Outside B.C. call: **604-660-2421**
E-mail address: **EnquiryBC@gov.bc.ca**

Table of Contents

1.0 Introduction

Integrated Resource Recovery is a new way of thinking about waste. Rather than viewing waste as something to be disposed of, IRR views waste as a resource that can continually provide value and add to the inventory of opportunities available for use by communities. Outputs from human and industrial processes are considered as inputs into other processes to enhance the natural environment.

Such a system can provide economic, environmental and social benefits as outlined below:

Environmental:

- reduction of greenhouse gas emissions;
- provision of carbon-neutral forms of energy;
- reduced requirements for new energy sources;
- reduction of water pollution methane emissions from landfills; and
- reduction of use of high quality, potable water for non-potable purposes.

Social:

- flexible infrastructure that matches the growth of the community; and
- provision of local, sustainable employment in new industries based on recovering resources such as biofuels from waste.

Economic:

- production of new sources of revenue for communities to offset infrastructure cost;
- reduction of the life-cycle cost of infrastructure to taxpayers; and
- reduction of costs when compared managing each waste stream individually.

This guide introduces many techniques for recovering resources from waste including: aerobic composting of organic waste; anaerobic digestion to create fuel for heating or for vehicles; combustion or gasification of wood waste to create fuel; cogeneration of electricity and heat; district heating systems; reclamation of heat and cold from wastewater using heat pumps; water reuse through at sewage treatment plants; and extraction of nutrients from wastewater for use as fertilizer.

This guide focuses on tools for dealing with the benefits of integrating the management of energy, water and waste, and the tools for recovering and reusing the resources in waste.

Implementing these techniques requires planning beyond traditional “silos” such as engineering and planning departments, and liquid and solid waste divisions. It also involves partnerships beyond sectors that traditionally have operated separate waste management systems, such as local governments, agriculture, forestry, and transportation.

2.0 Setting the Context

2.1 Challenges With Current Waste Management Approaches

2.1.1 Inefficiencies, Cost and Lost Opportunities

The goal of conventional waste management is to protect people and the environment from pollution at reasonable cost and dispose of waste safely. While successful in making waste seemingly disappear, this approach overlooks the valuable resources embodied in waste. It also results in costs from greenhouse gas emissions, environmental degradation, and the over-consumption of energy, water, and minerals.

In addition, the costs of building and maintaining conventional waste disposal infrastructure are increasing at a time when this infrastructure in many communities is ageing and in need of replacement.

Finally, the availability of land for conventional disposal practices such as landfills is decreasing.

These pressures make it worthwhile to look for new ways to reduce costs and recover revenues from waste.

2.1.2 Administrative "Dis-integration"

"Silos", or individual departments in government can present a barrier to recognizing the value in waste. Departments which manage solid waste, liquid waste, potable water, transportation, land use planning, and greenhouse gas reduction strategies naturally focus on their own areas of responsibility. Other agencies, such as those responsible for the supply of electricity and fuels may not develop their strategic plans in coordination with local governments. This "dis-integration" of responsibilities makes it difficult for those heading these departments to see the cumulative impacts of their separate decisions.

"*When we try to pick out anything by itself, we find it attached to everything else in the universe.*"

- John Muir,
American Naturalist, 1892

However, if a broader, more integrated approach was taken to the planning, investment and implementation of infrastructure, individual departments could work in a more synchronized fashion. For example, organic waste could be diverted to produce biofuels for vehicles. An expanded wastewater treatment system could be designed to reduce demand for potable water and also provide heat for buildings. While the initial investment may be higher, long-term benefits may pay for those initial costs and more. This approach, referred to as "tunnelling through the cost barrier"[1] can result in lower overall costs and higher overall benefits.

Since organic material, water, energy, and climate change are connected in nature, it makes sense to integrate planning for these areas as well.

2.2 Relationships Between Climate, Energy, Water and Waste

Awareness of the impacts of energy, water and waste management systems on the climate is increasing, this was clearly outlined in B.C.'s Living Water Smart and Energy Plans, released in 2008. Knowledge of the connections among these systems is also increasing. In the current waste management system, energy, water and waste are connected in the following ways.

First, when organic waste is disposed in landfills it produces methane, a potent greenhouse gas that contributes to climate change. Further, disposal of organic matter in landfills makes it unavailable for reuse as fuel or as a source of nutrients.

Second, water is a key element of waste management. Large amounts of high quality potable water are consumed by moving and treating drinking water, storm water, and wastewater. This in turn consumes a considerable amount of energy. The production of this energy in turn requires large amounts of water - either directly through hydro-electric plants, or indirectly in cooling thermal generating plants.

In agriculture, too, pollution and water consumption are a result of this "once-through" approach. Producing artificial fertilizers for agriculture consumes fossil energy, and gives rise to greenhouse gas emissions. Runoff from agriculture carries artificial and mineral fertilizers away from fields into nearby waterways, resulting in water pollution. Much of farming depends on irrigation with surface water, or "fossil water" from ground sources which are not being adequately replenished.

Even solutions that have provided alternative energy sources to fossil fuels have unintended consequences on resources. For example, the production of biofuels is placing pressure on land availability and food prices, as land that was once used to grow food crops is converted to land to grow fuel crops.

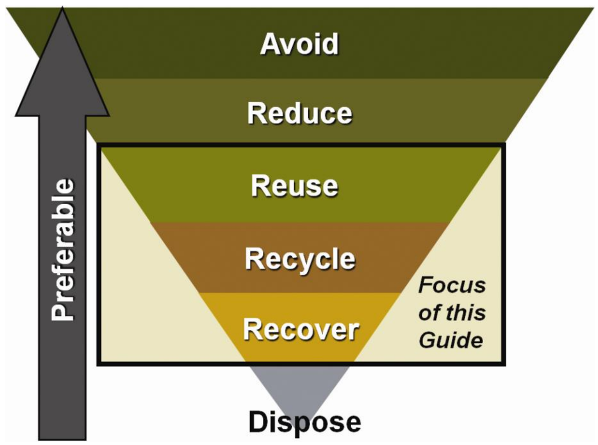
Underpinning this entire cycle is the decreasing availability of water from drought and changing rainfall patterns as a result of climate change.

If the connections among all of these elements – climate, energy, water and waste - were more fully understood and a new approach to waste management was adopted, there would be environmental, economic and social benefits for communities.

2.3 Viewing Waste as a Resource

2.3.1 Preventing and Reducing Waste

While the 3Rs of waste management have historically been known as “reduce, reuse, and recycle", new trends in the industry see this model evolving to 5Rs: "reduce, reuse, recycle, recover resources, and residual management (disposal)”.



Pollution Prevention Hierarchy

This guide focuses on the “reuse, recycle, recover” components of the Pollution Prevention Hierarchy. However, this does not mean that “avoid” and “reduce” through conservation are not still fundamental components of pollution prevention.

2.4 Asking Different Questions

One option for increasing integration is to bridge several functions in local government. While many regional governments maintain separate committees for solid waste, liquid waste, potable water, urban planning, and the environment, others are integrating them. For example, Metro Vancouver has integrated its planning for solid and liquid waste under a single "Waste Management Committee".

An integrated committee or an integrated department can ask better questions such as:

- What if planning for a solid and liquid waste was combined in order to minimize expenditures on infrastructure and maximize revenues from resources?
- What if plans were devised for potable water, liquid waste, and piping infrastructure to minimize life-cycle costs of all three?
- What if waste-to-energy facilities were planned in cooperation with other agencies such as the gas or electricity utility?
- What if *all* costs and benefits were taken into account, the economics of recovering resources from waste are evaluated, such as the:
    - value of electricity and heat consumed by buildings and vehicles, which could be displaced by energy recovered from waste;
    - value of surplus electricity which could be sold to BC Hydro;
    - value of surplus heat or biofuels which could be sold;
    - reduction in the cost of conventional waste disposal;
    - reduction in the cost of purchased greenhouse gas offsets required to meet regulations;
    - value of surplus greenhouse gas credits which can be sold; and
    - value of residues such as fertilizer or compost which can be sold.
- What if less quantifiable benefits were considered, such as the:
    - value of reduced pollution of air, land, and water;
    - value of local, sustainable employment;
    - value of using land for higher purposes than garbage disposal; and
    - opportunities for eco-municipal tourism and educational workshops based on resource recovery and opportunities to teach the next generation about the value of sustainability.

3.0 What is Integrated Resource Recovery (IRR)?

Integrated Resource Recovery begins when waste is viewed as a potential resource – not something to be disposed of. In an IRR approach, plans for municipal infrastructure are developed in an integrated and holistic manner to maximize the recovery of "value" from waste resource streams. This approach mimics the closed-loop cycles present in all ecosystems, provides local sources of energy, water and other resources, and reduces demand from external or new sources. As in nature, water, carbon, and nutrients are treated as renewable resources and continually recycled: nature has no waste.

Comparison of Conventional Waste Management and Integrated Resource Recovery

Resource	When is it Waste?	Conventional Approach	IRR Approach
Storm Water	When reaching drainage systems	Collect and discharge to receiving environment	• Collect, treat, and reuse on-site; • Divert to ecological uses; reduce amount of impermeable surfaces through water sensitive urban design; and • Follow natural drainage and hydrology.
Waste Water	When reaching collection systems	Collect, treat, and discharge to receiving environment	• Collect, treat, and reuse water for regulator-approved non-potable purposes.
Biosolids	When produced by wastewater treatment plants	Collect and landfill, or apply to Industrial Landscaping	• Collect and divert to composting or anaerobic digestion to produce biomethane; and • Recover nutrients through regulator-approved use of residuals.
Wet Organic Waste (e.g. food waste, agricultural waste)	When produced by farming as well as processing, retailing, preparation and consumption of food	Collect and landfill	• Collect and divert to composting or anaerobic digestion to produce biomethane; and • Recover nutrients through regulatory-approved use of residuals.
Dry Organic Waste (e.g. Yard waste, wood residuals, nonrecyclable paper)	After initial use	Collect and landfill	• Collect and divert to composting or to energy production; and • Recover nutrients through regulator-approved use of residuals.

4.0 Why Undertake Integrated Resource Recovery?

4.1 Benefits For Communities

An integrated approach to planning and managing energy, water and waste infrastructure can offer many synergies and benefits to a community. These include reduced greenhouse gas emissions, water consumption, infrastructure requirements, and infrastructure costs.

4.1.1 Reduced Greenhouse Gas Emissions

Greenhouse gas emissions contribute to climate change. Many local governments across British Columbia have committed to reducing greenhouse gas emissions and taking action to address climate change. Integrated Resource Recovery can significantly reduce greenhouse gas emissions and aid local governments in achieving these goals.

As of February 2009, over 170 local governments had signed on to the Climate Action Charter. The Charter is a voluntary initiative between the Provincial Government, Union of British Columbia Municipalities and signatory local governments.

By signing on to the Charter, local governments agree to the goals of:

- being carbon neutral in respect of their corporate operations by 2012, recognizing that solid waste facilities regulated under the *Environmental Management Act* are not included in operations for the purposes of the Charter;
- measuring and reporting on their community's greenhouse gas emissions profile; and
- developing compact communities.

Local governments who have signed the Climate Action Charter are eligible for the new Climate Action Revenue Incentive Program (CARIP) grant through the Ministry of Community Development. Under CARIP each eligible local government receives a grant equal to 100 percent of the carbon tax paid as a direct expenditure.

Another economic incentive is the *Greenhouse Gas Reduction* (*Cap and Trade*) *Act* (Bill 18). Under this legislation, greenhouse gas-neutral fuels, such as biofuels produced from IRR, are exempt from B.C.'s carbon tax. The result is that biofuels will likely become less expensive relative to fossil fuels over time.

Other relevant Provincial Government legislation includes the *Local Government* (*Green Communities) Statutes Amendment Act* (often referred to as Bill 27) which requires local governments to set greenhouse gas reduction targets, polices, and actions in their Official Community Plans by May 31, 2010 and Regional Growth Strategies by May 31, 2011.

4.1.2 Reduced Water Consumption

Demand for potable water can be reduced by reusing wastewater from sewage treatment processes, or by treating storm water. This water can then be used to serve the non-potable water needs of B.C.'s communities, such as for irrigation or water features. Reusing water saves money and resources by reducing the demand for new water sources. It also helps to protect the environment by reducing the need to tap pristine watersheds as additional water sources.

4.1.3 Reduced Infrastructure Requirements

Integrated Resource Recovery reduces the need for new waste management infrastructure such as landfills, pipes, and sewage treatment plants. Integrating the planning of wastewater collection and treatment systems reduces the combined physical infrastructure requirements, reduces the treatment plant's capacity requirements and therefore plant size and life cycle cost. Integrated planning may also lead to building smaller, distributed treatment plants which can be tailored to meet the needs of the region in which it resides.

4.1.4 Reduced Infrastructure Costs

Integrated Resource Recovery involves a broader geographical (e.g. the entire community rather than a single waste management facility) and time scale (e.g. considering the costs and benefits over several generations). This wider perspective provides the opportunity to look at infrastructure needs in an integrated way.

Integrating waste infrastructure with resource recovery, public transit, and energy utility planning can provide uses for the recovered resources, offer new partnership opportunities, and provide sources of revenue to offset infrastructure investment. For example, upgraded biogas may be used as fuel for vehicles, or it may be injected into a natural gas pipeline as a carbon-neutral source of methane.

Additionally, the needs of major energy and water consumers in a community (e.g. hospitals, and universities) can be taken into account when locating new wastewater treatment or waste-to-energy facilities. These institutions can then use the heat or fuel from these facilities at a lower cost. The fees that are paid for the heat or fuel can then be used to offset the cost of infrastructure and operations.

The benefits of integrated resource recovery will vary widely between each community. However, based on the independent study *Resources from Waste: Integrated Resource Management Study*, commissioned by the Provincial Government in 2008 a region with a population of approximately 350,000, could achieve the following savings[2]:

- greenhouse gas emissions reduction of 20-25%;
- energy recovered from waste to heat the equivalent of 30% of the community's homes;
- electricity recovered from waste to power 10% or more of the community's homes; and
- biofuels recovered from waste to run 10% or more of the vehicles in a community.

Integrating the planning of community waste infrastructure with local industrial and agricultural needs can also result in lower costs and greater benefits for all parties. The Revelstoke Community Energy Corporation, wholly owned by the City of Revelstoke, derives heat from a low-emitting wood residue burner located at a local sawmill to provide heating for several buildings in the community.

The anaerobic digester in Kristianstad, Sweden relies on waste from the community, food factories and farms, which converts the waste to biogas and to nutrient-rich fertilizer for farms.

4.2 Guiding Principles

Design with Nature: Designing infrastructure to work with, rather than against, nature is more efficient and sustainable. For example, directing storm water to permeable surfaces or bioswales rather than to waterways through pipes and pumps requires less infrastructure, less energy, and helps to recharge groundwater.

Integrate Land Use Planning and Infrastructure Decisions: Much of the infrastructure in B.C.'s communities is ageing and requires replacement or upgrading. This provides a unique opportunity to rethink traditional modes of land use and infrastructure planning. Local governments can ensure appropriate zoning is in place for an IRR approach, and also consider spatial requirements for IRR when Official Community Plans or Regional Growth Strategies are being revised.

Move Upstream to Prevent Waste: If waste resources can be recovered for the benefit of the community which produced them, then the cost of transportation to a central facility can be avoided. For example, wastewater in the City of Victoria's Dockside Green development is treated to the point where it can be used for non-potable purposes on the site. As a result, the development's *consumption* of fresh water and *production* of wastewater are both significantly reduced. This reduction is in addition to water conservation measures, which are first taken to reduce consumption.

Every Waste is a Potential Resource: Almost all waste is a potential resource. For example, organic waste in landfills decomposes to produce methane, a potent greenhouse gas. If this waste is diverted to an energy facility such as an anaerobic digester, the methane becomes a source of renewable energy instead of a pollutant.

Use Each Resource More Than Once: Resource streams can provide multiple benefits. At the Dockside Green development in Victoria, fresh water is used first for potable purposes, then again for non-potable uses. In a waste-to-energy facility, this solution not only provides a renewable energy source; it can produce a nutrient-rich residual that may be used as a replacement for artificial fertilizer.

Resource Recovery Generates Revenues: Just as it is economically beneficial to recycle metals than to pay for them to be buried in a landfill, it is also more profitable to recover usable resources from waste than to landfill them.

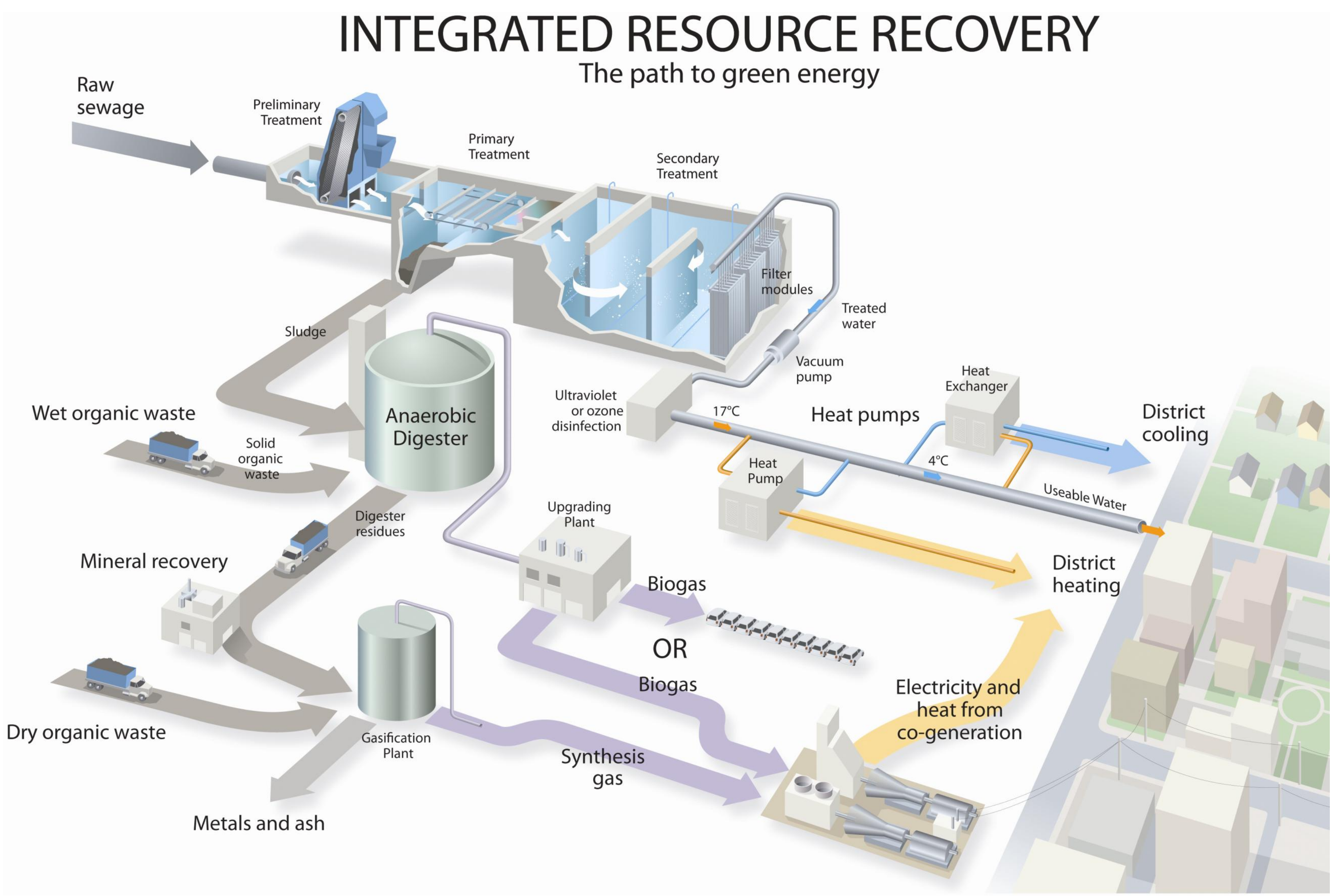
Integration of System Boundaries: Options for waste management increase significantly when system boundaries are viewed more broadly than they have been traditionally. For example, in the City of Revelstoke, the local sawmill is the site for a wood residue burner that provides heat for the sawmill, as well as for nearby buildings in the community.

Use Each Resource for its Highest Value: Waste can be recycled (e.g. metal cans back into cans), down-cycled (e.g. glass used as road base) or up-cycled (e.g. kitchen waste digested to biomethane). The value gained from each of these processes should be analyzed to determine which is most appropriate.

Evaluate Revenues First, Costs Second: Innovative models are emerging that consider not only the cost of infrastructure, but also the potential revenue that it could generate. For example, the Quesnel Community and Economic Development Corporation (owned by the City of Quesnel) is in the process of establishing a "Municipal Energy and Resource Corporation" (MERC) to take advantage of opportunities for resource recovery infrastructure such as community energy networks to be jointly owned with industrial or commercial entities.

New ways to recover revenues can be developed by looking at:

- potential markets for recovered resources (e.g. electricity and heat from co-generation);
- costs which can be avoided or reduced (e.g. lower waste disposal costs);
- cost sharing capitalization (i.e. Joint ownership of an anaerobic digester by a food processor and a community);
- existing infrastructure which could be used to produce resources (e.g. a wastewater plant);
- analyzing the total life cycle cost (economic, environmental, social) of new infrastructure;
- whether this infrastructure be located within existing assets (e.g. a wastewater plant); and
- infrastructure financing (e.g. via industrial partners or grants for sustainable infrastructure).


INTEGRATED RESOURCE RECOVERY
The path to green energy
Raw sewage
Preliminary Treatment
Primary Treatment
Secondary Treatment
Filter modules
Treated water
Vacuum pump
Sludge
Wet organic waste
Solid organic waste
Anaerobic Digester
Ultraviolet or ozone disinfection
17°C
Heat pumps
Heat Exchanger
4°C
Heat Pump
District cooling
Useable Water
Digester residues
Upgrading Plant
Mineral recovery
District heating
Biogas
OR
Biogas
Electricity and heat from co-generation
Dry organic waste
Gasification Plant
Synthesis gas
Metals and ash

5.0 Tools, Techniques and Methods of Integrated Resource Recovery

Integrated Resource Recovery includes many tools, techniques and methods of turning waste into resources which are illustrated in the diagram on the previous page. The particular solution which individual communities adopt will depend on the available waste resources and the community's needs.

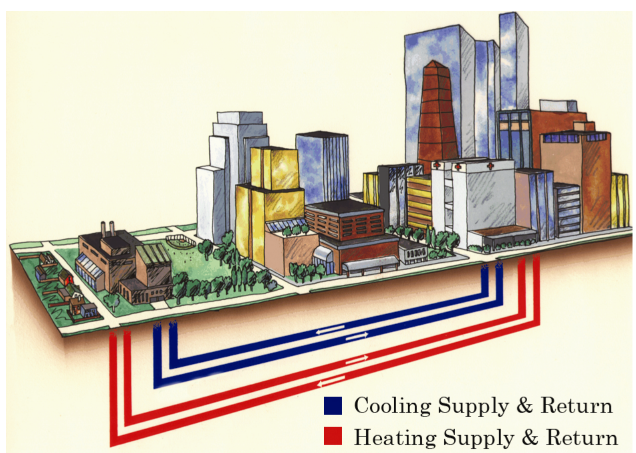
5.1 District Energy Systems for Heating and Cooling

In district energy systems, heat is transported from one or more sources to customers by means of insulated hot water pipes. These pipes provide energy for space heating and domestic hot water. A similar system can provide district cooling by supplying cold water to replace conventional air conditioning.

Other sources of heat can include:

- natural gas;
- industrial waste materials;
- industrial waste heat;
- cogeneration plants;
- heat pumps; and
- waste heat emitted from buildings.

One of the benefits of district energy systems is that they can simultaneously accept heat from several sources, which makes them flexible and robust.



District Heating and Cooling Scheme

District cooling systems pump chilled water (from heat pumps) through the piped network to provide cooling to customers. This reduces the need for electricity to run air conditioning and refrigeration equipment.

Cost Considerations

District heating and cooling pipes are insulated, buried, and include leak detection technology. Depending on the type and capacity of the pipes used, the installed costs range from $1-$2 million per kilometre. Maintenance of district heating and cooling pipes is technically uncomplicated, and the pipes are designed to last up to fifty years.

In order to connect to the district energy system, heat exchangers which transfer the heat (or cold) to the building's heating system are required. If the building relies on a hydronic system (e.g. hot water baseboards or hot water radiant heating), then conversion costs are relatively low. If the building uses a forced air heating system, then a "fan coil" (similar in function to a car's radiator) would have to be installed to transfer heat or cold from the community energy system to the building's ducts.

In the cases where electric baseboard heaters are required, these would need to be replaced with either a hydronic or a forced air system.

Local governments can support potential future district heating systems by encouraging the installation of hot water heating in new buildings.

Environmental Benefits

District energy systems can use larger sources of heat energy which are more energy efficient than the many small heating sources they replace. Since these systems can use non-conventional sources of heat (e.g. industrial waste heat, cogeneration heat) their energy costs can be lower than competing fossil or electrical sources, and their greenhouse gas emissions can be lower.

In the case of the Revelstoke Community Energy Corporation in the City of Revelstoke, the district energy system is heated by clean combustion of sawmill wood residues. Since these residues were diverted from a conventional wood waste burner, air pollution in the community was reduced.

Economic Benefits

District energy systems result in energy price stability because the heating system is not dependent on fluctuating fossil fuel prices. For example, customers of the Revelstoke Community Energy Corporation pay 5% less than propane heating, and are guaranteed that the rate will increase only at the rate of general inflation.

Social Benefits

As communities learn about district energy systems and their risks and benefits, a sense of autonomy can be gained. These systems create local sustainable jobs, and the revenues from these systems generally stay in the community. For example, the Revelstoke Community Energy Corporation is locally-owned, and provides a non-tax source of revenue to the City of Revelstoke. These funds can then be used to offset costs of other social programs.

Considerations

District energy systems are less expensive to implement when they are planned before new developments are built, or if the piping can be installed alongside other infrastructure. In Sweden, community energy companies cooperate with other utilities by sharing trench space set aside for infrastructure. If a telephone company plans to extend its fibre optic network into a community, or the sewage utility needs to repair a length of pipe, the community energy company is offered the chance to extend its network of district heating and cooling pipes at the same time.

Existing buildings that are heated conventionally will require investments in heat exchangers to make use of this heat source.

District Heating Pipes in Gothenburg, Sweden.

Organizations in B.C. which sell energy are regulated by the B.C. Utilities Commission. Local governments are exempt; if a local government establishes an energy utility the local government is the regulator, not the B.C. Utilities Commission[3]. This can be an

Where is it Done?

District energy systems are currently in operation in the cities of Revelstoke, Vancouver and North Vancouver, Whistler, and Victoria. They are being developed or considered in many other B.C. communities.

In Southeast False Creek in Vancouver, a Neighbourhood Energy Utility is being created to provide space heating and domestic hot water to 16,000 residents in the Southeast False Creek and Olympic Village sustainable community development. The first phase, expected to be completed by 2010, will recover heat directly from the municipal sewer system. It will also utilize heat from rooftop solar modules on three Olympic Village buildings. The project will receive $8.47 million from the federal Gas Tax fund.

District Heating Pipes in Revelstoke

The Capital Regional District will receive $2.98 million in funding from the federal Gas Tax fund to recover thermal energy from effluent at the Saanich Peninsula Wastewater Treatment Plant. This energy will be used to provide hot water and space heating in the plant and adjacent facilities, including the Panorama Recreation Centre, the Centre for Plant Health, and nearby elementary school.

Sweden

In Gothenburg, Sweden, waste heat from a refinery, wastewater-source heat pumps, and municipal waste-to-energy facilities are used as heat sources for nearby buildings. This municipally-owned energy utility (Göteborg Energi), employs approximately one thousand people in the business of recovering and distributing energy from waste sources. It sells heat to clients at a rate below the cost of fossil fuels. After a new client has subscribed to the service, the utility upgrades the insulation and glazing in the client's building to reduce the amount of energy drawn by that building. The investment to reduce the client's energy losses improves the energy utility's revenues, since more energy will then be left in the system to sell to future clients. In this case, the economic interests of the client and the utility are aligned with the community's interests in protecting the environment. The result is that energy is sold as as a service, rather than a commodity.

Getting Started

1. Local governments can investigate their opportunities to recover waste energy from industrial or municipal sources, and to connect those sources to clients through district energy systems.

2. Local governments can consider planning for providing district heating to major energy users such as factories, residential developments, government buildings, hospitals and educational and recreational facilities.

3. Communities can investigate the possibility of extending existing systems (e.g. those in place at universities) to serve other clients.

4. Communities can encourage the construction of district energy systems through their Regional Growth Strategies and Official Community Plans, and through the development permit approval process.

5. Communities can encourage the installation of hydronic heating systems in new developments which may be served by future district heating systems.

6. Communities can consider the benefits of mixed ownership of district energy infrastructure. For example, if a source of energy will be industrial wood residues, it may make sense for the wood-fired boiler to be owned by the industrial source, and for the district heating piping to be owned by a "Municipal Energy and Resource Company" with access to financing at favourable long-term rates.

7. Local government councils and staff can visit communities which operate district energy systems, in order to better understand the costs and benefits.

8. Communities can contact the Community Energy Association (www.communityenergy.bc.ca), the Canadian District Energy Association (www.cdea.ca), or Natural Resources Canada for more information about the feasibility of implementing a community energy system in their region.

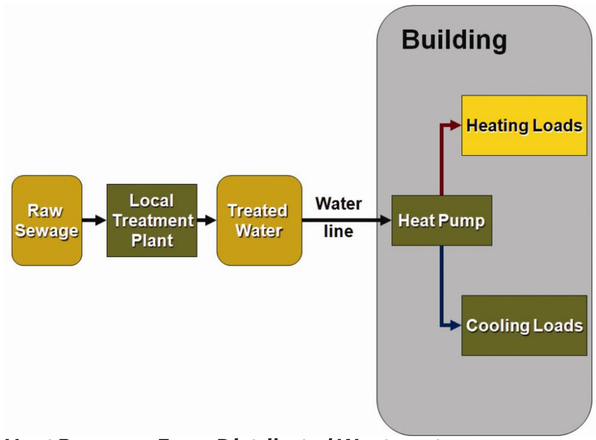
District Energy Summary

Resources Consumed	• Waste heat from cogeneration; • Heat recovered from wastewater through heat pumps; and • Electricity required to pump hot or cold water through the district energy pipes.
Resources Produced	• Heating for space heating and domestic hot water; and • Cooling for refrigeration and air conditioning.
Residuals Produced	• None. Residuals may be produced by the source of energy for the community energy system such as a gasifier or wood burner, but not by the community energy system itself.
GHG Reductions	• Avoided emissions from fossil fuels which are displaced by community energy; and • Avoided emissions from production of electricity displaced by district cooling which would otherwise be required to run refrigeration and air conditioning equipment.
Pollution Avoided	• Air pollution from combustion of fossil fuels for heating, and from production of electricity for refrigeration and air conditioning.
Other Benefits	• Local sustainable employment; and • Increased energy independence.

5.2 Reclaiming Heat and Cold from Wastewater Using Heat Pumps

How it Works

Heat pumps use electricity to recover low temperature heat, and to make this heat available at suitable temperatures for heating and for hot water systems. For every unit of electricity consumed by heat pumps, they typically produce three to four units of higher temperature heat.



Heat Recovery From Distributed Wastewater Treatment Plants

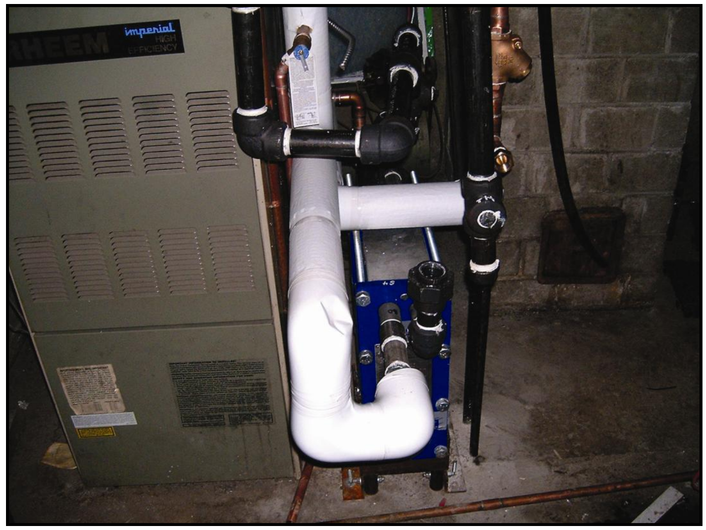
As treated wastewater is significantly warmer than other sources of energy for heat pumps (e.g. air during the winter, ground-sources, lakes or the ocean), energy can be recovered from wastewater more efficiently. This approach has the further advantage of avoiding the expense of the underground piping fields which are required by ground-source heat pumps. After the heat has been extracted from treated wastewater, the water is cold enough to be used for air conditioning or refrigeration through a district cooling network. This results in less demand for electricity for air conditioning or refrigeration.

Unlike their European counterparts, most Canadian cities do not have extensive networks of insulated district heating pipes. However, treated wastewater from local plants can be delivered through ordinary pipes to heat pumps located in buildings near treatment plants. If the needs of buildings for energy and reclaimed water are taken into account when communities plan for wastewater treatment infrastructure, then treatment plants can be sized and located to deliver the greatest amount of energy (and even reclaimed water) to the greatest number of buildings. This approach tends to favour a network of distributed small treatment plants over the more traditional option of large centralized plants.

Although it is possible to recover heat from untreated sewage, the cost is higher and the amount of heat recovered is lower when compared to recovering heat from treated wastewater. Additionally, if untreated sewage is cooled significantly by the extraction of heat from sewer collection pipes in advance of the wastewater treatment plant, then the efficiency of the biological treatment processes in the plant will be reduced.

Cost Considerations

Heating systems in buildings would need to be adapted to use this form of energy. Conversion costs would include the capital and operating costs of the heat pumps, heat exchangers, and any necessary modifications to the building's heating system. Heat pumps normally require replacement every twenty years.



Revelstoke District Heating Heat Exchanger

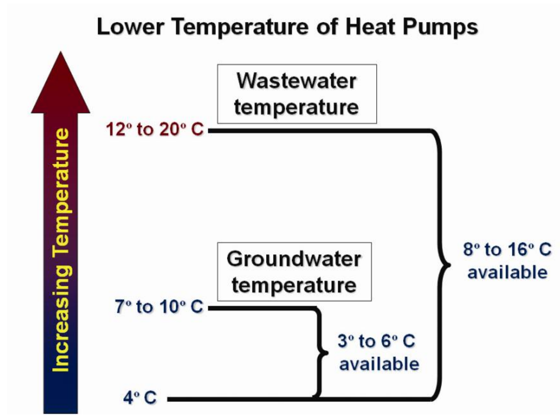
Either the community or a local energy company could pay for the cost of infrastructure such as the un-insulated water piping required to deliver the treated water to heat pumps. Building owners would pay less for this source of energy than subscribers of higher-temperature district energy systems which distribute hot water from cogeneration plants, since subscribers would carry the cost of operating the heat pumps required to recover the energy.

Environmental Benefits

Although the heat pumps consume electricity, the net greenhouse gas reductions achieved by replacing natural gas with heat recovered from treated wastewater or sewer lines are significant. Heat pumps cause no direct emissions, but are responsible for the upstream (or "indirect") pollution associated with the generation of the electricity they consume.

Economic Benefits

- The cost of wastewater treatment can be offset by revenues from energy subscribers paying for heat provided by the wastewater treatment plant.
- On a lifecycle basis, heat pumps cost less than other sources of heat, such as electric baseboard heating or fossil fuels, provided the buildings to be heated are located within a reasonable distance of the wastewater treatment plant (e.g. 1-2 kilometres).
- The price of energy from wastewater generally will not increase at the same rate as fossil fuels.
- Operating heat pumps during hours when electricity demand is lower can result in potential savings. The heated water can then be stored for use during peak heating demand hours.



Relative Temperatures of Sources for Heat Pumps

Social Benefits

Heat pumps produce no emissions and have no implications for climate change or public health.

Source Temperature and Heat Pump Performance

	Air-Source	Ground Source	Wastewater Source
Source Temperature	0ºC	7-10ºC	12-20ºC
Relative Efficiency[4]	3.3	3.7	4.3

Considerations

In older buildings where the heating system was designed for higher temperatures, other sources of heat will be needed to boost the heating system temperature on the coldest days.

Locating decentralized wastewater treatment plants near to clients for heat energy will require a different approach to planning on the part of local governments than the current system of fewer, centralized plants.

Existing buildings will require investments in heat exchangers in order to make use of this heat source.

The economics of heat pumps are strongly affected by the temperature of the heat source. The higher the temperature, the lower the capital and operating costs, as the heat pumps can be smaller in size. With rising temperatures, more heat is also available.

Where is it Done?

Okanagan College in Kelowna uses heat pumps to heat the campus from treated wastewater from the Kelowna Wastewater Treatment Plant. The system meets the entire college heating load when the outdoor temperature is above freezing, and meets 80% of the total heating requirements of the campus[5]. This arrangement saves the college $300,000 per year, while reducing its greenhouse gas emissions.

Okanagan College Heat Pumps

Wastewater-source heat pumps are common in Europe. For example in Stockholm, Sweden this source of energy provides heat to the equivalent of 80,000 homes (equal to one in five homes). In Stockholm, the Henricksdals wastewater plant is paid for this energy by the local energy company: these payments help offset the cost of wastewater treatment to taxpayers.

Getting Started

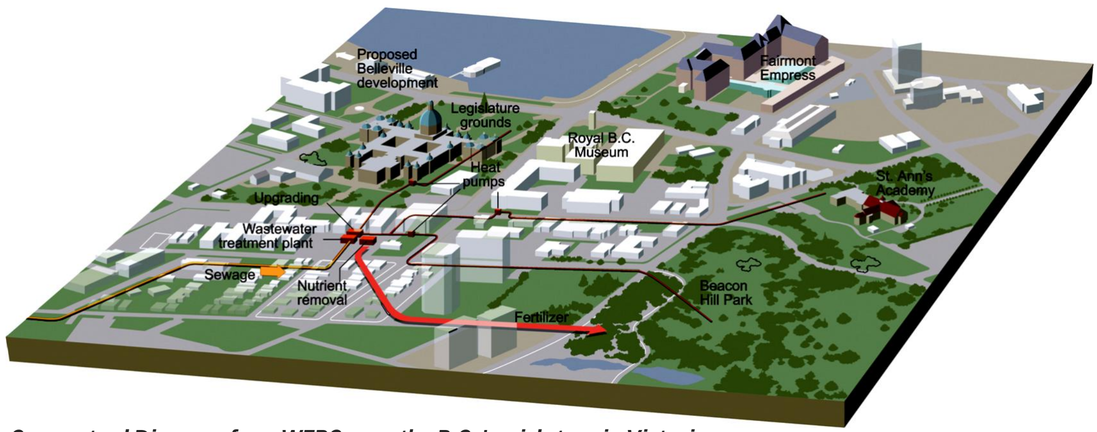
1. Heating systems which are designed to accept low-temperature heat can be designed into new buildings.

2. Communities could consider the costs and benefits of building wastewater treatment facilities which will minimize heat loss during treatment. Enclosed wastewater treatment facilities for example will lose less heat during the winter than facilities which use open tanks and lagoons. The temperature of wastewater can even increase as it is processed in small, enclosed wastewater treatment plants.

3. Communities can look for opportunities to locate small, decentralized wastewater treatment facilities near to users of heat energy, such as a residential development. Ideally, the development would also be able to use highly treated wastewater for non-potable purposes on the site. In this way, treated wastewater delivered through one pipe could help displace fossil fuels for heat, electricity for air conditioning, and potable water for irrigation.

Conceptual Case Study: Heating and Cooling From Wastewater Using Heat Pumps

The illustration below provides a conceptual example of a water and resource recovery "cell" (WERC) for the neighbourhood of James Bay in Victoria.



Conceptual Diagram for a WERC near the B.C. Legislature in Victoria

Conceptually, wastewater from the James Bay area of Victoria could be processed in a small treatment plant in the vicinity of the Provincial Legislature. Using modern technology, the plant could be small enough to be incorporated into an existing government-owned building near the Legislature. The plant would be designed to produce highly-treated water, which would meet regulatory standards allowing "unlimited human contact", and used for irrigation. Highly-treated wastewater would be carried in un-insulated water pipes (the red lines) to heat pumps in neighbouring buildings.

The Provincial Legislature, the Royal B.C. Museum, government buildings, the Fairmont Empress, other nearby hotels, the James Bay Community School, and the planned Belleville Development could all be potential customers for heating and cooling their building through heat pumps.

Once the highly-treated water has passed through the heat pumps, it could either be used for irrigation or discharged through a water feature. The Legislature grounds (including the water fountain), Beacon Hill Park, and St. Ann's Academy would be potential clients for reclaimed irrigation.

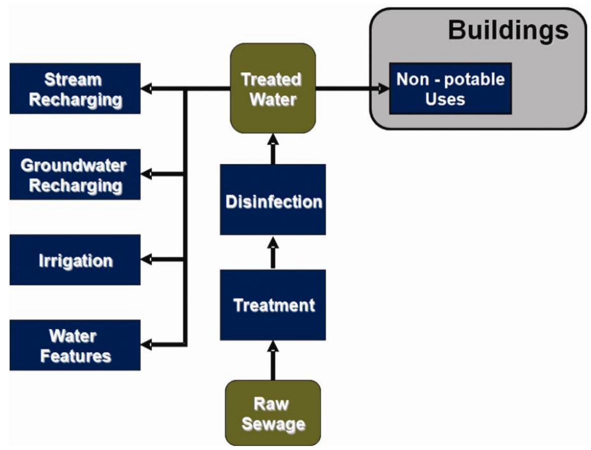
Wastewater Heat Pump Summary

Resources Consumed	• Electricity to operate the heat pumps.
Resources Produced	• Heat for space heating and domestic hot water; and • Cooling for refrigeration and air conditioning.
Residuals Produced	• None.
GHG Reduction	• Avoided greenhouse gas emissions which would otherwise have been produced from burning fossil fuels for heat; and • Avoided greenhouse gas emissions from the production of electricity which would otherwise be consumed for cooling and refrigeration.
Pollution Avoided	• Air pollution from combustion of fossil fuels for heating, and from production of electricity for refrigeration and air conditioning.
Other Benefits	• Local sustainable employment; and • Increased energy independence with respect to fossil fuels.

5.3 Reclaiming Wastewater

How it Works

Wastewater can be treated to the extent required for any re-use purpose. This is consistent with the principles of "highest and best use". Wastewater can even be brought to potable standards through appropriate processes of treatment and disinfection. Water recovered from wastewater is commonly referred to as "reclaimed" or "renovated" water.



Wastewater Reclamation Schematic

Cost Considerations

Costs for reclaimed water increase with the degree of treatment used. Taking an integrated approach, it is possible for the extra cost to be offset by reduced infrastructure costs and increased value in the community.

If potable water demand can be reduced by using reclaimed water for non-potable purposes (such as irrigation or street cleaning), local governments can delay an expansion of potable water supplies and distribution systems. Additional savings can result from the reduced pumping costs for potable water and wastewater.

Environmental Benefits

Reclaimed water can be put to many environmental uses. It can be used to recharge groundwater supplies, to augment stream flows during dry periods for fish protection and generally to reduce the consumption of potable water.

Economic Benefits

Reduced demand on potable water sources and systems delays investment in new infrastructure. Additional benefits include both capital and operating cost savings over the lifecycle of the infrastructure.

Social Benefits

Reclaimed water can be used to create water features which provide amenity and can serve as meeting places. Green spaces irrigated by reclaimed water can enhance healthy, active communities. The green spaces will not only have social and ecological value, but can serve as natural cooling cells in the summer months. These cooling cells can reduce the energy consumed for air conditioning in adjacent buildings.

Considerations

To fully explore the costs and benefits of water reclamation and reuse, an integrated, long-term approach must be taken. The capital and operating costs of potable water infrastructure and treatment, wastewater infrastructure and treatment, and the benefits of re-use must all be included in the analysis. For example, if highly-treated wastewater can be reused, the analysis would need to account for the cost savings of the reduced demand on potable water infrastructure and reduced demand on sewer infrastructure.

Public health concerns may be a perceived barrier and consultation must be fully explored. Treated water must comply with applicable regulations, including the *B.C. Building Code*, the *Drinking Water Protection Act* and the Code of Practice for the Use of Reclaimed Water (2001) under the *Municipal Sewage Regulation* and the *Environmental Management Act*.

Where is it Done?

The City of Sequim in Washington State (U.S.A.) treats all wastewater to the level where it can be used for non-potable purposes including irrigation. The City of Vernon uses highly-treated wastewater for irrigation. In Victoria, two commercial enterprises, the mixed use development Dockside Green, as well as Sooke Harbour House hotel treat wastewater on-site and use the reclaimed water for toilet flushing, irrigation, and water features.

Sequim, Washington

The City of San Diego (U.S.A.) treats wastewater to potable water standards, and returns the water to the city's potable water reservoir. At Metro Vancouver's Annacis Island Wastewater Treatment Plant, a portion of the treated wastewater undergoes additional treatment before being used to wash vehicles.

Getting Started

Local governments can integrate planning for water and wastewater to seize opportunities to reduce demand on potable (drinking) water sources by using reclaimed water for non-potable purposes.

Councillors and local government staff can visit communities which already use recycled water, in order to understand the implications of such a system in their own jurisdiction.

Local governments can take a holistic approach to assigning value to water, by including ecology and valuation in their planning processes. For example, what is the value to society of creating water features or improving fish habitat with reclaimed water?

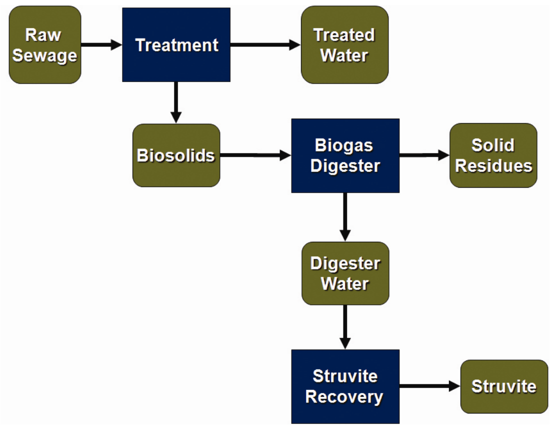
Reclaimed Wastewater Summary

Resources Consumed	• Energy to treat wastewater and electricity to operate the pumps to move the water to users.
Resources Produced	• Reclaimed water for non-potable purposes.
Residuals Produced	• None.
GHG Reductions	• Reduced GHG emissions associated with lower consumption of energy for pumping water; and • Lower energy consumption for cooling.
Pollution Avoided	• Exploitation of new watersheds; and • Depletion of groundwater.
Other Benefits	• Environmental benefits of recharging streams and groundwater; • Social benefits of amenity and beautification of water features which could not otherwise have been developed; and • Economic benefits of using lower-cost reclaimed water for non-potable purposes, and savings in potable water treatment infrastructure.

5.4 Reclaiming Nutrients from Wastewater

How it Works

Nutrients can be recovered from wastewater in several ways. In Europe, residues from biogas digesters, which process clean food waste, are safely applied to farmland[7]. In Canada, biosolids from wastewater treatment plants have been applied to land, but concerns over soil and groundwater contamination and odour tend to limit the scope of land applications.



Nutrient Recovery Schematic

Since sewage biosolids can be dewatered and used as a feed stock in a biogas plant or gasification plant, its highest and best use and value may be for energy.

A more innovative approach to recovering nutrients from wastewater is to extract nutrients in crystalline form. Fertilizer in crystal form can be recovered from wastewater treatment plants which have biogas digesters, using a technology developed at the University of British Columbia and commercialized by Ostara Nutrient Recovery Technologies in Vancouver.

Cost Considerations

Ostara Technologies has installed its equipment in the City of Edmonton, Alberta's Gold Bar wastewater treatment plant. The capital expenditure is expected to be recovered in approximately five years through lower maintenance costs and sales of a slow-release recovered fertilizer called "Crystal Green™" or "struvite".

Struvite fertilizer from Ostara Technologies

Environmental Benefits

Slow-release fertilizers result in less surface runoff to nearby water bodies, thereby causing less water pollution and eutrophication. Artificial and mineral fertilizer production accounts for 1.2% of global greenhouse gas emissions[8]; replacing artificial and mineral fertilizer with fertilizer recovered from the wastewater treatment process can help reduce greenhouse gas emissions.

Finally, phosphorous is essential to plant growth, and sources of this element are limited.

Economic Benefits

Sales of struvite also offset the capital and operating costs of the recovery equipment. Removing struvite from wastewater plants prevents it from accumulating in pipes, thereby reducing maintenance costs.

Social Benefits

Public acceptance of crystalline fertilizer applications to farmland is likely to be higher than it would be for applications of wastewater treatment plant biosolids.

Where is it Done?

Ostara Technologies equipment is installed in the City of Edmonton, Alberta, at the Gold Bar wastewater treatment plant.

Reclaimed Nutrient Summary

Resources Consumed	• Treated wastewater, and electricity to operate the recovery process, process chemicals.
Resources Produced	• Slow-release fertilizer.
Residuals Produced	• None.
GHG Reductions	• Reduction in emissions associated with the manufacture of artificial and mineral fertilizer.
Pollution Avoided	• Reduced eutrophication of water bodies caused by runoff of artificial and mineral fertilizer.
Other Benefits	• Reduced wastewater treatment plant maintenance costs.

5.5 Anaerobic Digestion of Wet Organic Waste

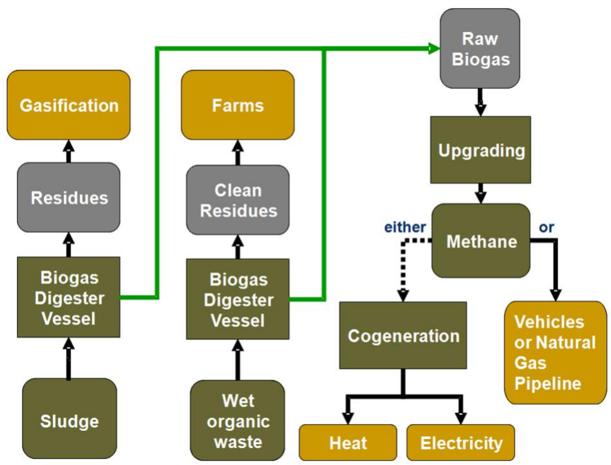
How it Works

Aerobic Versus Anaerobic Composting

Aerobic composting of wet organic waste (including residential kitchen waste, restaurant waste, food processing waste, wastewater treatment plant biosolids, and manure) is a common practice and considered a traditional method of resource recovery.

Aerobic composting can result in a significant reduction in greenhouse gas emissions (methane) from landfills[9]. Composting also recovers nutrients and soil-building materials for agriculture.

In aerobic composting, micro-organisms digest the organic materials, giving off metabolic heat and carbon dioxide (CO_2). Since the CO_2 is from atmospheric rather than fossil sources, it is considered greenhouse gas-neutral. The goal in composting is to expose organic materials to air as effectively as possible, in order to accelerate the decomposition process and to prevent anaerobic decomposition.



Biogas Production Process Schematic

However, a new type of composting with environmental advantages is emerging - *anaerobic* composting. In aerobic composting, chemical energy in the organic matter is lost as heat in the process. If instead waste is decomposed without oxygen in an *anaerobic* digester, the nutrients are still concentrated in the residues, but bacteria convert the waste into "biogas". Biogas is rich in methane which can be captured and used for fuel for vehicles, or to generate heat and electricity. Because the carbon in this methane (sometimes called biomethane) comes from food waste rather than fossil sources, this fuel is greenhouse-gas neutral.

Digester designs are tailored for the types of material they process (e.g. food waste, sewage biosolids, manure), and fall into two main categories. *Mesophilic* digesters operate at approximately 35ºC, and *thermophilic* digesters operate at the 55ºC range. Although mesophilic digesters are common, thermophilic digesters have the advantages of higher biogas yields, faster processing time, and pasteurization of pathogens.

Yields from the digester can be increased by making the organic material more available for decomposition by the digester's micro-organisms. Techniques include chopping the waste into smaller pieces and using high pressure, ultrasound, hydrolysis, or heat to make the organic material more digestible. The increased costs of preparation processes are offset by higher gas yields and smaller volumes of residues.

Yields of biogas from organic waste depend on a large number of factors including moisture content, composition of the waste, the method used to prepare the waste for digestion, and the type of digestion process used. Fortunately, biogas digesters operate more efficiently on a "mixed diet", in which the ratio of carbon to nitrogen are balanced.

Nutrients

Communities could consider that they have two options for recovering nutrients from organic waste: aerobic composting or anaerobic digestion. Aerobic and anaerobic digestion both recover nutrients and divert organic waste away from landfills; anaerobic digestion has the added benefit of providing greenhouse gas-neutral energy. The digestate from anaerobic digestion typically takes the form of wet slurry, while the residuals from composting contain less water and are therefore less costly to dewater and transport.

Cost Considerations

Capital costs depend on the technology, size of digester, and the extent of odour control measures required. If less than 10,000 tonnes/year of feed stock is available, then anaerobic digesters are not economically viable. Another cost consideration is that to achieve adequate inputs for a digester, curb-side collection of organic waste will likely be necessary.[10]

In Kristianstad, Sweden, farmers provide manure to the local biogas digester, and in turn receive the digester's residues (also known as "digestate"). The digestate is used to fertilize farmland, and farmers benefit from the fact that the digestate they receive contains a higher concentration of nutrients than the manure they supply to the digester. Farmers are not charged to drop off manure or to pick up the residues.

Environmental Benefits

Diverting wet organic waste from landfills reduces emissions of methane, landfill leachate, and the area of land needed for landfills. Common landfill gas capture systems recover only a fraction of methane produced (and only a fraction is captured), and the escaping portion is twenty-one times more potent for climate change than carbon dioxide. Further, biogas digesters produce a greenhouse gas-neutral fuel which can be used in vehicles or burned in a cogeneration plant to produce electricity and heat. Finally, if the feed stock is uncontaminated, digestate can be applied to farmland: the environmental benefits of doing so include reduced runoff from artificial and mineral fertilizers, as well as reduced greenhouse gas emissions produced during the manufacture of artificial and mineral fertilizers.

When compared to aerobic composting, the advantages of anaerobic composting include:

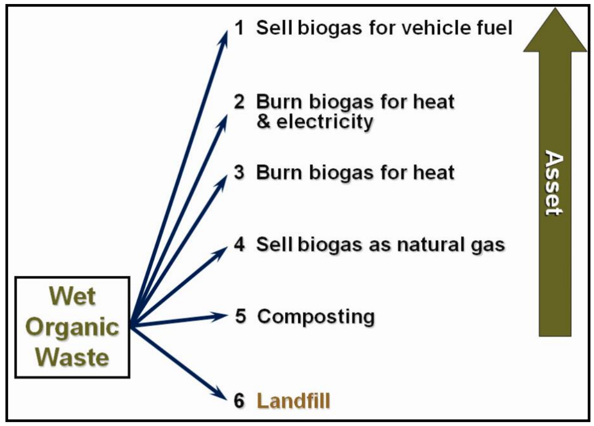
- production of a greenhouse gas – neutral energy;
- fewer odours;
- fewer greenhouse gas emissions;
- better inactivation of weed seeds (thermophilic digestion only); and
- better availability of nutrients in residues (especially nitrogen) for plants.

Economic Benefits

There are many uses for biogas and communities will need to assess the "highest and best use and value" for this resource based on their needs and means. As illustrated on the following page, the highest and best use for biogas is to sell it as biofuel.

A biogas plant generates revenue through tipping fees, sales of methane, and greenhouse gas credits. Biogas can be burned in cogeneration plants for electricity and heat, or upgraded to natural gas quality for use as a greenhouse gas-neutral vehicle fuel. Methane is also a building block molecule from which hydrogen, alcohols, and more complex hydrocarbons can be produced. It is even possible to convert the methane from biogas into synthetic jet fuels (kerosene) though gas-to-liquid (GTL) technologies[11].

Revenues generated from a biogas plant generally remain within the community and can be used to fund other sustainable initiatives.



Highest and Best Use and Value for Organic Waste and Biogas

Social Benefits

Biogas generation can be part of an overall energy program that moves a community towards energy independence. The United Nations Development Program recognizes anaerobic digestion as a source of decentralized energy supply[12].

Further, biogas engines are quieter, requires less maintenance, last longer and produce lower emissions of particulates and other pollutants than diesel or gasoline engines.

Considerations

Biogas plants must be designed to minimize odour through careful siting, and the use of building enclosures and biofilters. Locating biogas digesters within wastewater treatment plants is useful, since the digester can accept biosolids from the wastewater plant, and the wastewater plant can accept residual water from the digester.

Raw biogas contains hydrogen sulphide (H_2S) and sulphur dioxide (SO_2) which pose serious hazards to humans. Biogas plants must be designed to minimize the risk of raw biogas leaks, and to minimize the risk of exposure to leaks. These sulphur compounds can be removed by "scrubbing" the gas before it is used.

The methane in biogas is explosive, and the design and operating precautions which apply to installations which handle natural gas will also apply to biogas plants.

Anaerobic digestion is a biological process, which is sensitive to changes in the feed stock or "diet". Skill is required on the part of biogas plant operators to ensure the plants operate within optimal conditions such as temperature, carbon/nitrogen ratios, and moisture content.

If metals are present in the digester feed stocks, they will also be present in the residues. In Sweden, residues from digesters which only accept food waste and manure without heavy metals are provided to farmers at no cost, while residues from wastewater treatment plant digesters are only used for industrial landscaping.

Finally, operators of biogas plants need secure supplies of feed stock, and ensure that truck delivery traffic is no more disruptive to the community than garbage truck traffic.

Where is it Done?

In North America, it is common for larger wastewater treatment plants to use mesophilic digesters to produce biogas from sewage biosolids and to use the gas to produce heat and electricity for the plants. Metro Vancouver's Annacis Island Wastewater Treatment Plant incorporates thermophilic anaerobic digestion of the wastewater treatment biosolids.

Community Biogas Plant in Kristianstad, Sweden[13]

In Europe, over 4,000 biogas digesters are in operation, where the gas is used to produce electricity and heat, and as fuel for buses, cars, and trucks.

In Stockholm, Sweden a wastewater treatment plant co-digests kitchen waste with biosolids to produce enough biogas for 50 city buses, the number of buses using biogas will increase to 200 by 2010. In Kristianstad, Sweden, the biogas plant converts household compostable waste, food factory waste, and manure into biogas, a greenhouse gas-neutral source of methane.

Getting Started

Anaerobic digesters that create biogas are beginning to be constructed in B.C. For example, Metro Vancouver has been awarded 2.4 million dollars in federal grant funding under the Gas Tax program to proceed with the "B.C. Bioenergy from Biogas" project. This project will increase the biogas output of the Lulu Island wastewater treatment plant, clean the biogas and provide advanced co-generation to produce electricity and heat. Other communities can begin by undertaking the following actions.

Biogas Powered Car in Kristianstad

- Completing an inventory of waste streams, such as all organic solid waste from homes, food factories, and agriculture.
- An analysis of resource needs could then be undertaken, such as a need for greenhouse gas-neutral transit fuel. This information could then be used to develop business cases for the infrastructure required to recover waste from resources.
- A local government could increase the productivity or capacity of its wastewater treatment plant digestion process, and could also divert organic solid waste from landfills by undertaking anaerobic digestion in separate vessels at the wastewater treatment plant.
- If the community does not have a biogas digester, it could study the costs and benefits of building one. Existing municipal land and assets, as well as industrial sites, could be considered as locations for a new biogas digester.

The Fraser Valley is potentially a suitable location for one or more new biogas digesters, since it could intercept source-separated organic waste from Metro Vancouver, as well as agricultural waste, food factory waste, and manure from farms in the area[14]. Residues from the digester are similar to compost since they are rich in inorganic nutrients, and could be used by local farms to reduce their dependence on artificial and mineral fertilizers. The biogas produced could either be burned for cogeneration (if the heat from cogeneration can be used), or the gas could be upgraded and sold as vehicle fuel or injected into a gas distribution network.

Summary of Biogas

Resources Consumed	• Kitchen waste; • Restaurant waste; • Food processing waste; • Wastewater treatment plant biosolids; and • Manure.
Resources Produced	• Vehicle fuel or electricity and heat from a greenhouse gas-neutral source; and • Natural fertilizer as a replacement for artificial and mineral fertilizer.
Residuals Produced	• Residuals, or digestate, from clean organic waste can be returned to farmland; and • Residuals from wastewater treatment plant biosolids can be used for industrial landscaping. If the digestate is not suitable for application to land, it could be dewatered and included in the feedstock for a thermal process such as gasification.
GHG Reductions	• Reduced methane emissions from landfills, from the displacement of fossil fuels by biogas, and from the reduction in then need for artificial and mineral fertilizers.
Pollution Avoided	• Reduced leachate soil contamination, methane emissions, and land consumption from landfills; • Reduced upstream impacts of energy production (e.g. exploration, extraction, refining, and transportation); • Reduced particulate pollution from engines fuelled with biogas compared with fossil fuels; and • Reduced water pollution caused by runoff from artificial and mineral fertilizers.
Social and Economic Benefits	• Local sustainable employment; • Lower waste disposal costs for the community; • Revenues for community; and • Increased energy independence.

5.6 Combustion of Dry Organic Waste

The low moisture content of dry organic waste makes this resource less suitable for "biological" treatment such as aerobic composting or anaerobic digestion, and more suitable for "thermal" treatment through the application of heat. There are three methods of dealing with dry organic waste through heat: combustion of wood residues; incineration; and gasification.

5.6.1 Combustion of Wood Residues to Produce Heat

In 2004, the City of Revelstoke completed a heat-only community energy project which takes wood residues from a local sawmill and uses it as the source of fuel for producing heat. The system is operated by the Revelstoke Community Energy Corporation, which is owned by the City of Revelstoke. Since the wood residue burner produces lower air emissions than an old industrial beehive burner, this project helped improve air quality in Revelstoke.

***Wood Residue Burner for Community Energy in Revelstoke, B.C.*[15]**

Customers of the district heating system include an arena, community centre, school, aquatics centre, and hotels. They are served by two kilometres of district energy piping. The burner is located on land owned by the local sawmill, which processes heat from the system for a drying kiln; the sawmill and provides operations personnel to monitor the burner.

Funding for the $5.6 million project was provided by the Federation of Canadian Municipalities Green Municipal Investment Fund ($1.35 million in loans, and $1.35 million in grants), the City of Revelstoke, and the Revelstoke Credit Union.

This project has many positive outcomes, such as:

- reducing use of the old wood residue burner;
- improving air quality (the burner incorporates pollution control equipment in the form of an electrostatic precipitator);
- reducing greenhouse gas emissions;
- replacing propane as a source of fuel; and
- providing a non-tax source of revenue for the City of Revelstoke.

5.6.2 Incineration Of Municipal Waste

Incineration of municipal waste has traditionally been a commonly used method of solid waste disposal in B.C. Although incineration historically does not recover resources, there are new technologies which enable resource recovery. Incineration of sorted dry organic waste (e.g. wood residues, paper and cardboard which cannot be recycled) can now occur in a way which maximizes resource recovery and minimizes pollution.

One example is the City of Burnaby, which is home to a municipal waste incinerator that produces electricity as well as heat for a nearby paper recycling facility[16]. This waste-to-energy facility more than covers its costs.

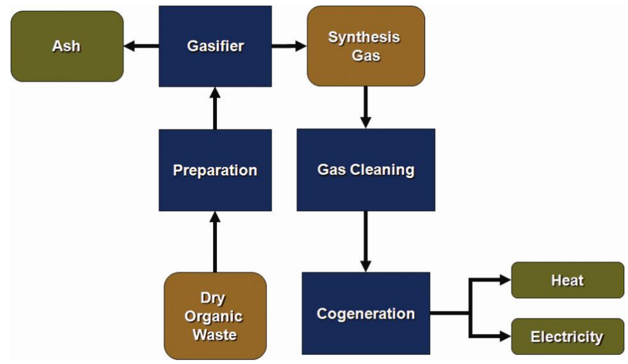
In Sweden, there are over thirty municipal waste incinerators which produce electricity and heat for district energy systems. Because of the source separation of burnable materials and advanced pollution control systems, the Swedish EPA reports that its incinerators emit a total of less than one gram of dioxins per year[17]. By contrast, a number of municipal waste incinerators in Canada emit as much as 1 to 4 grams of dioxins per year each[18]. In Sweden, a tax has recently been applied to incineration in an effort to steer more materials toward recycling. This is a good example of ensuring that waste resources are used for their highest value.

Although the environmental impact of incineration is being reduced through new technologies, the reduction of solid waste through diversion programs remains the preferred approach and the highest on the pollution prevention hierarchy.

5.7 Gasification of Dry Waste to Synthesis Gas

How it Works

Another IRR approach to dry organic waste (defined as wood residues with a moisture content below 50% such as yard and garden trimmings, and construction and demolition waste) is gasification.



Gasification Schematic

Gasification has been practiced for hundreds of years – since 1699 - originally to produce gas from coal. During gasification, the waste is heated in a vessel with limited amounts of oxygen. The waste decomposes to ash and "synthesis gas", a mixture of hydrogen, carbon monoxide, carbon dioxide, methane, and more complex hydrocarbons. Synthesis gas can be burned in a boiler for heat, or in a cogeneration plant to produce heat and electricity. It is not suitable for transmission through natural gas networks.

Gasification is a cleaner process than traditional incineration, since the process can be more tightly controlled and since it presents two opportunities for removing contaminants: first from the synthesis gas stream between the gasifier and the cogeneration engine or boiler, and again from the exhaust stream from the cogeneration engine or boiler to heat or electricity.

Nutrients

If the wood residues are free of contaminants then the ash could be used as fertilizer. If the ash contains metals it could be included with ore at a smelter in order to recover those metals. Because smelters have the necessary pollution control equipment to remove heavy metals, this option could be the safest use for contaminated ash. One pulp mill in Chetwynd, British Columbia sends the ash from its waste-to-energy plant to a mine, where the ash is blended with ore for recovery of the metals in a smelter.

Cost Considerations

Gasification and cogeneration plants can be economically viable down to sizes of 10,000 tonnes/year (equivalent to the dry organic waste from approximately 50,000 people). The economic viability depends on whether the plant receives tipping fees for waste; whether the energy can be sold via cogeneration of electricity and heat; and whether the greenhouse gas credits are sold. Land costs can also be reduced since gasification plants require relatively less space than biogas plants.

Environmental Benefits

Diverting dry organic waste from landfills reduces land consumption; lowers emissions of methane from decomposing waste; and reduces landfill leachate. Diverting construction and demolition waste away from uncontrolled incineration (e.g. a "waste burner") reduces air pollution. Gasification is also a cleaner process than conventional combustion of wood residues. Further, synthesis gas is a greenhouse gas-neutral fuel which can be burned in a cogeneration plant to produce electricity and heat. Finally, if the ash from thermal processes such as gasification is free of contaminants, it can be added to feed stocks for composting. In this way, the inorganic nutrients which were contained in the dry organic waste can be recovered and returned to the ecosystem.

Economic Benefits

A gasification and cogeneration plant can offset costs and produce revenue from tipping fees, sales of electricity and heat, and the sale of greenhouse gas credits.

Social Benefits

Revenues generated through gasification and cogeneration plants generally stay within the community. In addition, air quality and public health improves when wood residues are diverted to gasification.

Considerations

A waste-to-energy installation would need a secure and steady supply of feed stock. The availability of industrial wood residues is affected by industrial demand, since wood residues are also a source of energy for pulp mills and saw mills. On the other hand, the supply of dry organic waste from the community (e.g. yard and garden waste, construction and demolition waste) is relatively more reliable.

Wood residues would need to be source-separated to remove contaminants such as plastics.

When the moisture content of stockpiles of wood residues is high enough, spontaneous combustion caused by biological activity can occur. These risks can be reduced by minimizing the amount of wood residue stored on site.

Local governments need to ensure that truck delivery traffic is not disruptive to the community.

Where is it Done?

Gasifier installations are in place at the Tolko veneer mill in Hefly Creek and at the University of South Carolina, U.S.A., where electricity and heat are provided to the campus through gasification of wood residues. In Victoria, the Dockside Green gasification plant will be located in the heart of the development, and is expected to begin producing heat from wood residues in 2009.

Gasification installation at the University of South Carolina

Getting Started

Communities with wood residues which are not suitable for other uses could consider including this source with dry organic waste from the community (e.g. paper and cardboard products which cannot be recycled) as feed stock for a gasification and cogeneration plant. If the plant could be located on an existing industrial site, then capital and operating costs could be reduced by sharing operating and maintenance personnel.

Gasification Summary

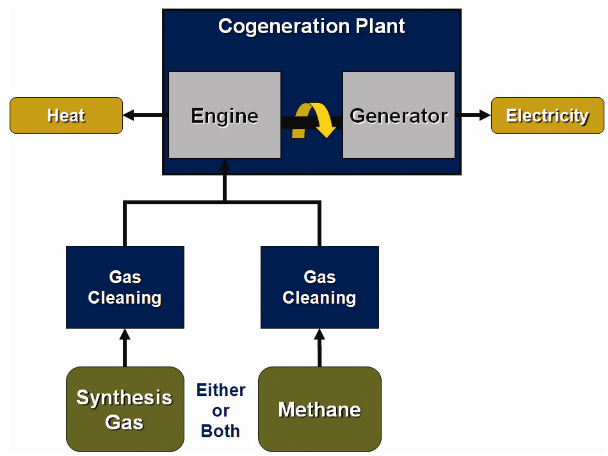
Resources Consumed	• Wood residues; • Cardboard and paper which cannot be recycled; • Yard and garden trimmings; • Construction and demolition waste.
Resources Produced	• Fuel which can be burned for heat, or for electricity and heat in a cogeneration plant.
Residuals Produced	• Ash, which could be used as fertilizer, as a component of cement production, or included with ore to allow recovery of metals.
GHG Reductions	• Avoided methane emissions from landfills; and • Avoided emissions from production of electricity and from combustion of fossil fuels which are displaced by heat from a cogeneration plant or gasification plant.
Pollution Avoided	• If wood waste is incinerated, air pollution, potentially including dioxins, from burning of unsorted construction and demolition waste; • If wood waste is buried, landfill leachate soil contamination, landfill methane emissions, land consumption; and • Upstream impacts of energy production (e.g. exploration, extraction, refining, and transportation).
Other Benefits	• Local sustainable employment; • Lower waste disposal costs for the community;. • Revenues for the community; and • Increased energy independence.

5.8 Cogeneration of Electricity and Heat

How it Works

Cogeneration refers to the process of fuel being burned in a steam plant, a reciprocating engine, a gas turbine, or fuel cell to produce electricity and heat. Heat can be recovered from the engine through heat exchangers and used as a source of heat for buildings or greenhouses.

Cogeneration plants can provide high-grade heat, at 100ºC or even higher (in the case of gas turbines), which is suitable for heating older buildings in cold climates. Cogeneration can also provide low-grade heat, at 70ºC to 80ºC, which can serve buildings which are designed to take advantage of lower-temperature sources of heat. Heat can be provided to clients through insulated underground district heating pipes.



Cogeneration Plant Schematic

Cogeneration plants are the link between sources of greenhouse gas-neutral fuels such as biogas digesters and gasification plants, and the district heating networks which can distribute the heat produced through cogeneration.

Cost Considerations

Locating cogeneration equipment in the same facility as biogas digesters or gasification plants reduces the capital and operating costs of cogeneration. Cogeneration plants using internal combustion engines can be economically viable in capacities below one megawatt, provided the heat can be sold.

Environmental Benefits

- When electricity is transmitted from central generating stations such as hydroelectric dams, to cities, approximately 10% of the electricity is lost during transmission. If on the other hand, electricity is produced locally from small, decentralized cogeneration plants, such transmission losses are minimized.
- If the source of fuel for the local cogeneration plant is greenhouse gas-neutral, then the electricity produced will have a low environmental impacts.
- Particulate emissions from cogeneration plants that burn biogas are 80% lower[20].

Economic Benefits

The rates offered by BC Hydro for energy from sustainable sources have trended upwards in recent years, and B.C.'s carbon tax has also improved the economic viability of cogeneration. Locally-produced electricity can generate revenues for local governments, while supporting Provincial and BC Hydro initiatives to generate all electricity from greenhouse gas-neutral sources. Organizations which produce electricity are able to realize the value either by reducing their own electricity costs (for example through BC Hydro's Net Metering program) or by selling electricity directly to BC Hydro.

Social Benefits

Revenues from cogeneration can remain within the community and be put toward social sustainability programs.

Electrical Requirements and Production Types

Source	Electrical Power (Megawatts)
Revelstoke Dam	1,700
Williams Lake Biomass Plant	60
Solid Waste from Greater Victoria, B.C.[19]	20
Commercial Windmill	2
Requirement for One Home	0.001

Considerations

Prices for sustainable electricity are rising, but the value of heat from a cogeneration plant can provide a significant proportion of a plant's revenues. For this reason, the full benefit of cogeneration can only be realized if the plants are located close to potential users of heat.

Cogeneration plants produce air emissions which must be minimized through the use of processes to clean the fuel (e.g. cleaning and upgrading processes for synthesis gas and biogas), and through pollution control equipment after combustion.

Cogeneration plants produce noise, the impacts of which can be minimized by the careful choice of location, and by enclosing the plant inside a secure building.

Where is it Done?

Larger wastewater treatment facilities such as Metro Vancouver's Annacis Island and Lulu Island plants generate electricity and heat for the operation through cogeneration. The engines in these treatment facilities burn biogas produced from biosolids in the plant's anaerobic digesters.

The Municipal / Private Landfill Gas Utilization Project in the Lower Mainland provides an example of developing a unique approach to local governance in order to achieve community goals such as clean air and healthy cities.

This twenty–year green energy project involves a partnership between two local governments, The Corporation of Delta, and the City of Vancouver; and two private organizations, CanAgro Produce Limited and Maxim Power Corp. The project consists of beneficially utilizing landfill gas from the City of Vancouver's Vancouver Landfill in a co-generation application, to generate electricity and heat. The electricity is sold to BC Hydro as "green" power and the heat is used to replace natural gas in the CanAgro Produce Limited South Delta greenhouse.

Cogeneration at the Iona Wastewater Treatment Plant

The project's substantial commitment in infrastructure is financed by the private sector, while both municipalities will receive environmental, social and economic benefits from the co-generation plant. Maxim Power Corp will provide the $8.5 million financing required for the 2.5 kilometre pipelines and cogeneration plant. In return for providing the LFG, the City of Vancouver will receive between $250,000 to $300,000 annually, while Delta will receive between $80,000 and $110,000 in new tax revenue. CanAgro Produce Limited will receive a secure, low-cost heating source from the cogeneration plant located on its property. BC Hydro will purchase all of the electricity under its Green Energy Program.

Replacing fossil fuels with methane from LFG to heat CanAgro's greenhouse will reduce carbon-dioxide emissions by an estimated 30,000 tonnes a year, equivalent to taking Translink's fleet of 1,100 diesel buses off the road for two months. Energy from the project is equivalent to providing the annual energy requirements to approximately 5,000 homes.

Another example of cogeneration is from the United States, where the University of South Carolina operates an integrated gasification and cogeneration plant which produces electricity and heat for the campus from wood residues. Additionally, the Wastewater Division of the King County (Seattle, U.S.A.) Department of Natural Resources has installed a 1 MW fuel cell alongside two 3.5 MW turbine generators to convert biogas into electricity and heat. [21]

Getting Started

1. Biogas digesters in existing wastewater treatment plants can be upgraded to improve their efficiency, and renovated to accept clean organic waste from the community for digestion in separate vessels beside existing facilities for digesting treatment plant biosolids.

2. Cogeneration can be incorporated into new waste-to-energy plants, which could be located close to potential users of the heat.

3. District heating networks can be used to deliver heat from the cogeneration plant to clients.

Cogeneration Summary

Resources Consumed	• Cleaned synthesis gas from gasification, or biogas from anaerobic digestion.
Resources Produced	• Electricity and heat from a greenhouse gas neutral source.
Residuals Produced	• Exhaust emissions.
GHG Reductions	• Reduced greenhouse gas emissions from the production of electricity and from the combustion of fossil fuels which are displaced by heat from the cogeneration plant.
Pollution Avoided	• Reduced upstream impacts of energy production (e.g. exploration, extraction, refining, and transportation); and • Emissions from biogas engines are cleaner than emissions from diesel and gasoline powered engines, since they contain lower levels of pollutants such as particulates.
Other Benefits	• Local sustainable employment; and • Increased energy independence.

5.9 Other Recovery Process

Biodiesel

Biodiesel is vegetable oil which has been converted into a form which can be used in diesel engines. The conversion is a chemical process called "esterification" which consumes methanol and sodium hydroxide, and produces glycerine.

Waste restaurant oil is the conventional feedstock for conversion into biodiesel, however, fat, oil and grease (FOG) from grease traps and wastewater treatment plants can also be converted[22]. Fat, oil, and grease can also be converted to biogas in a biogas digester. In New Zealand, strains of algae which contain up to 40% oil are grown in wastewater treatment ponds, and the oil is recovered for conversion to biodiesel. Ideally biodiesel production will be integrated with other resource recovery processes. For example, the glycerine by-product of biodiesel production is a resource for pharmaceutical manufacturing, and can also become a feed stock for anaerobic digestion.

Liquid Fuels

Biodiesel and aircraft fuel can be produced from biomethane (from anaerobic digestion) or synthesis gas (from gasification) through a catalytic conversion process (Fischer-Tropsch).

Cellulosic Ethanol

Cellulosic Ethanol is ethanol produced from woody material rather than from food crops. The cellulose in wood and paper residues can be converted into ethanol in at least two ways. First, residues can be gasified and the resulting synthesis gas can be reformed into liquid fuels, including ethanol. Second, cellulose can be converted to sugars through hydrolysis, allowing the sugars in turn to be fermented to ethanol. Research into both approaches is substantial in North America and Europe, and a number of pilot stage facilities have been built.

Microbial Fuel Cells

Microbial fuel cells are being developed by researchers at Washington University in St. Louis. These cells utilize bacteria to produce electricity while digesting organic materials in wastewater. Since 2005, the technology has been improved to produce ten times more electricity. Once another tenfold improvement in yield is achieved, the technology will be commercially viable for treating wastewater. This technology holds the potential to make wastewater treatment plants net energy producers.

Hydrogen

Hydrogen is produced during one of the natural stages of anaerobic digestion. Research is underway to alter the behaviour of the bacterial processes at work, in order to recover hydrogen rather than methane from anaerobic digestion[23]. This source of hydrogen would have a lower ecological footprint than hydrogen produced with electricity through hydrolysis, since most North American electricity comes from non-renewable sources.

6.0 How Communities Can Implement Integrated Resource Recovery

6.1 Overcoming the Barriers

All of the processes which have been described in this Guide are well-established and commercially available, yet many of them are more common in industrial rather than municipal processes. Below are some of the barriers local governments may experience when implementing IRR.

Staff Capacity Few local governments have direct experience with waste-to-energy infrastructure or greenhouse gas modelling, since these areas have not typically been part of their core operations. Local governments could consider holding joint training workshops with staff from experienced jurisdictions.

Conservatism and Risk Management A certain level of risk aversion in the design and planning of infrastructure is both necessary and responsible. Although resource recovery facilities may entail a greater degree of economic and social risk than conventional infrastructure water pipes, local governments can learn from other communities which have already encountered these issues. Many communities in Europe, for example, can be looked to for advice on risk mitigation.

Regulatory Environment Many communities have implemented elements of resource recovery and have worked through the regulations which applied to their initiatives. No regulatory barriers to Integrated Resource Recovery exist per se: communities which are determined to take a truly integrated approach will deal with the many regulations which apply to the environment, water, and energy as a matter of course. It will be helpful if these regulations are not weakened, but are coordinated by regulators to facilitate an integrated approach to resource recovery.

Community Acceptance Closing the ecological loops by recovering resources from waste means that new facilities will be built within city limits and near residential areas. However, when a facility to recover resources from waste is proposed for a community, there may be resistance from residents. Local governments will need to engage citizens about the environmental, social, and economic costs of current waste management approaches, and the benefits of resource recovery.

Dis-integration There are many organizations which need to be involved to implement IRR projects. These include those managing solid waste, liquid waste, potable water, transportation, land use planning, greenhouse gas reduction strategies, public transit and the supply of electricity and fuels. They are seldom integrated, however. These divisions occur not only in local and senior governments, but also in the consulting firms which serve them. One consultant may be asked to prepare plans for greenhouse gas reductions, while another prepares plans for upgrading wastewater treatment facilities, and yet another prepares a report on managing organic waste. Thus, education concerning IRR needs to cross both public and private sectors.

6.2 Policies that Support Integrated Resource Recovery

Integrated Resource Recovery requires a major shift in approaches to waste management. Despite the relatively few projects "on the ground" in British Columbia, communities can begin this shift with the following actions:

- introduce resource recovery into their Regional Growth Strategies, Official Community Plans, Community Energy Plans, and Sustainability Plans;
- ensure the processes for revising Liquid Waste Management Plans, Solid Waste Management Plans, development permit processes, building codes, zoning processes, bylaws, tax incentives, and financial grant programs encourage rather than hinder resource recovery;
- complete an audit and inventory of waste resources available and markets for energy, reclaimed water, and nutrients to identify resource recovery opportunities. The audit could include waste resources from the community as well as industry, and could identify:
    - opportunities to reduce energy and water consumption in the community;
    - liquid waste flows and their potential for energy recovery and water reuse;
    - solid waste flows and their potential for diversion to composting or energy production;
    - trends in water supply, including drought management plans;
    - streams whose environmental function could be improved with additional water;
    - industries which can provide waste or receive recovered resources; and

    - new developments which could provide waste or receive recovered resources.

- identify and remove policy barriers. For example, do regulations and local policies make it easier or harder for communities and developments to be sustainable, treat sewage on-site, or to recover resources from waste? Do building codes and related bylaws make it easier or harder to implement community energy systems?

- identify and pursue funding from the Provincial and Federal agencies for sustainable infrastructure, green electricity, and greenhouse gas reduction initiatives.

7.0 Related Provincial Government Plans, Programs and Legislation

Related plans, legislation, and programs are outlined in the table below. A table outlining funding programs is on the following page.

Provincial Plans & Goals Potentially Assisted by IRR

***Greenhouse Gas Reduction Targets Act* (Bill 44)**	• Requirement to reduce GHG emissions by 33% below 2007 levels by 2020.
Landfill Gas Management Regulation	• Under the *Greenhouse Gas Reduction (Emissions Standards) Statutes Amendment Act; and* • Establishes province-wide criteria for landfill gas capture from municipal solid waste landfills.
BC Energy Plan	• Reduce greenhouse gas emissions from energy production; and • Meet new energy needs through conservation and from sustainable sources.
BC Air Action Plan	• Reduce air pollution, including pollution from energy production and use.
BC Bioenergy Strategy	• Biofuel production to meet 50% or more of the province's renewable fuel requirements by 2020.
Living Water Smart Plan	• Reduce municipal water use by 50%; and • Improve the health of streams.
***Local Government (Green Communities) Statutes Amendment Act* (Bill 27)**	• To require local governments to set greenhouse gas emission targets, policies and actions in Official Community Plans by May 31, 2010 and Regional Growth Strategies by May 31, 2011; and • There are also new Development Cost Charges and Development Permit Area authorities.
BC Agriculture Plan	• Minimize the agriculture industry's impact on climate change.

Funding Programs for Integrated Resource Recovery Projects

Provincial	**Website**
Infrastructure Planning Grant Program	http://www.cd.gov.bc.ca/lgd/infra/infrastructure_grants/index.htm
Towns for Tomorrow	http://www.townsfortomorrow.gov.bc.ca
Innovative Clean Energy Fund	http://www.tted.gov.bc.ca/ICEFund
Smart Development Partnerships (for innovative land use planning)	http://www.cd.gov.bc.ca/lgd/intergov_relations/index.htm
Provincial / Federal	
Building Canada Fund: Communities Component	http://www.cd.gov.bc.ca/infra/infrastructure_grants/index.htm
Federal	
Federation of Canadian Municipalities Green Municipal Fund	http://www.sustainablecommunities.fcm.ca/home
Western Economic Diversification Canada	http://www.wd.gc.ca/eng/16.asp
Sustainable Development Technology Canada	http://www.sdtc.ca

8.0 Links to Additional Information

Provincial	**Website**
BC Hydro	http://www.bchydro.com
BC Ministry of Agriculture and Lands	http://www.cd.gov.bc.ca/al
BC Ministry of Community Development	http://www.gov.bc.ca/cd
BC Ministry of Energy, Mines and Petroleum Resources	http://www.gov.bc.ca/empr
BC Sustainable Energy Association	http://www.bcsea.org
Federal	
Natural Resources Canada—Sustainable Buildings and Communities	http://www.sbc.nrcan.gc.ca
Other	
Canada Green Building Council	http://www.cagbc.org
Canadian Biogas Association	http://www.biogas.ca
Canadian District Energy Association	http://www.communityenergy.bc.ca
Danish Biogas Association	http://www.biogasbranchen.dk
The Natural Step	http://www.naturalstep.ca
Swedish Environmental Protection Agency	http://wwww.naturvardsverket.se/en/In-English

9.0 Glossary

Biogas	Biogas is a product of anaerobic digestion of organic waste. Raw biogas is composed of approximately 2/3 methane, 1/3 carbon dioxide, and trace amounts of hydrogen sulphide and sulphur dioxide. The sulphur compounds are removed before biogas is used for cogeneration, and the carbon dioxide is removed before the gas is used for vehicle fuel.
Biofuels	Fuels produced from biomass such as ethanol from corn or sugar cane, as well as fuels produced from waste materials such as kitchen waste and biosolids from wastewater treatment plants.
Dry Organic Waste	Wood residues, yard and garden trimmings, and construction and demolition waste. Plastics which can be safely gasified (e.g. those which do not contain chlorine) could be included, provided a better use such as recycling is not possible. In this guide, Dry Organic Waste does not include unsorted municipal solid waste.
Extended Producer Responsibility	Under EPR, manufacturers of products and packaging are required to take responsibility for the environmental costs associated with the use and disposal of their products over the product's life cycle. The Organization for Economic Co-operation and Development (OECD) defines EPR as "an environmental policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle."
GHG	Greenhouse gas
Global Warming Potential	An indicator of the extent to which a given amount of a greenhouse gas contributes to global warming. Carbon dioxide has a Global Warming Potential of 1 by definition, while methane has a Global Warming Potential of 21. In other words 1 tonne of methane is equivalent to 21 tonnes of carbon dioxide in terms of the potential of methane to cause global warming.
GJ	A gigajoule is a unit of energy, equal to one billion joules. A typical Canadian home consumes approximately 130 GJ of energy for heating and hot water per year.
GW	A gigawatt is a unit of power, equal to one billion watts.

Glossary Continued...

GWh	A gigawatt hour is a unit of energy, equal to one gigawatt of power supplied over one hour.
MW	A megawatt is a unit of power, equal to one million watts.
MWh	A megawatt hour is a unit of energy, equal to one million watts of power supplied over one hour. A typical Canadian home consumes approximately 10 MWh of electricity per year.
Struvite	A slow-release fertilizer recovered from wastewater treatment plants which have biogas digesters - magnesium ammonium phosphate (MgNH3PO4·6H2O).
Synthesis Gas	The product of heating dry organic waste with little or no air. Synthesis gas is composed of hydrogen, carbon dioxide, carbon monoxide, methane, and higher hydrocarbons.
WERC	Water and Resource Recovery Cell - an alternative name for a small, decentralized wastewater treatment plant which has been sited primarily to take advantage of the heat available in wastewater, and to take advantage of reclaimed water.
Wet Organic Waste	Kitchen waste, restaurant waste, food factory waste, wastewater treatment plant biosolids, manure and others.

10.0 Endnotes

1. Hawken, P., Lovins, A., Lovins, L. 1999. Little, Brown and Company, Natural Capitalism. 396 pages.

2. Corps GC, Salter SJ, Lucey WP, and O'Riordan J. Resources From Waste: Integrated Resource Management Study Phase 1 Report. February 29, 2008. 181 pages.

3. Utilities Commission Act RSB.C. 1996, Part 1

4. Efficiency of heat pumps is measured in terms of Coefficient of Performance, which is the ratio of high-temperature heat available per unit of electricity consumed.

5. Community Energy Association. 2007. Heating Our Communities: A module of the Renewable Energy Guide for Local Governments in British Columbia. 44 pages.

6. Source: City of San Diego

7. Swedish Environmental Protection Agency

8. Kongshaug, G. 1998. Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. IFA Technical Conference, Marrakech, Morocco, 28 September-1 October, 1998. 18 pages.

9. Björklund, A. et al. Evaluating a municipal waste management plan using ORWARE. 1999. Journal of Cleaner Production, vol. 7 pp 271-280.

10. Cost information is based on eight Canadian and American biogas installations.

11. Aviation. Kjelgaard, C. 2007. Qatar Leads New Research into Cleaner Jet Fuel.

12. The Bioenergy Primer: Modernised Biomass Energy for Sustainable Development. 2000. United Nations Development Program. 133 pages.

13. Source: Municipality of Kristianstad

14. Electrigaz Technologies. 2007. Feasibility Study – Anaerobic Digester and Gas Processing Facility in the Fraser Valley, British Columbia. Prepared for the B.C. BioProducts Association. 105 pages.

15. Source: Revelstoke Community Energy Corporation

16. Metro Vancouver. 2006. Waste-to-Energy Facility.

17. Swedish Environmental Protection Agency

Endnotes Continued…

18. Environment Canada's National Pollutant Release Inventory

19. Assuming all solid waste is used to produce electricity through cogeneration.

20. Westport Innovations Inc.

21. US Department of Energy. 2005. Wastewater Treatment Gas to Energy for Federal Facilities: Biomass and Alternative Methane Fuels. 4 pages.

22. East Bay Municipal Utility District, Oakland California

23. Jeong Ok Kim et al. 2006. Enhancing continuous hydrogen gas production by the addition of nitrate into an anaerobic reactor. Process Biochemistry. Volume 41, Issue 5, May 2006, Pages 1208-1212.

ZERO WASTE VICTORIA

TARGET

50% reduction in landfill disposal by 2040

CITY OF VICTORIA

ZERO WASTE VICTORIA

Contents

Introduction

Zero Waste Victoria guides Victoria's transition to a future where products and materials are avoided, reduced and reused instead of disposed in the landfill. Zero waste as a goal has become a common priority among cities and governments in order to address unsustainable trends in material production, use and disposal. Zero waste programs and circular systems are required to keep materials at their highest and best use for as long as possible, and to better manage materials across their entire life cycle.

The purpose of zero waste goes beyond reducing waste going to landfill. One of the key drivers in a future with zero waste is environmental stewardship. Environmental benefits include reduced greenhouse gas (GHG) emissions and reduced upstream ecological damage from resource extraction, in addition to cleaner shorelines and green spaces. Zero waste initiatives also present new economic opportunities for local innovation and for sharing, reuse and salvage businesses.

Victoria has unique characteristics that have shaped its plan for zero waste. Victoria is the main urban centre in South Vancouver Island and the source of one third of the waste disposed at Hartland Landfill. Victoria is a centre for employment, with a high daytime population. Victoria has many multifamily buildings and is experiencing densification and development. Being a vibrant coastal city, Victoria is a popular tourist destination, with numerous hotels, restaurants and attractions. The City is also home to light and medium industry, has distinct shopping districts, and has many parks and beaches.

Government, businesses, residents and tourists play important roles in the responsible management of waste. This plan builds on the strong foundation of the community's sustainability values. Many local businesses and community members already embrace zero waste practices. This local knowledge and experience will be crucial for developing the pathways to zero waste across the community.

Organizational Alignment

Zero Waste Victoria aligns with overarching goals of the City and existing corporate plans.

Victoria's responsibility and direction for solid waste reduction is established through legislation in the City's **Official Community Plan** (Bylaw No. 12-013), which states that the City is to "support steps for Victoria to move towards a zero net solid waste community in partnership with the Capital Regional District (CRD) and the private sector" and provides the broad objective that "solid waste [is] managed as [a] closed loop system with optimal levels of recovery and re-use" across different stakeholder groups.[1]

Reducing overall waste generation and disposal, while realizing economic and community benefits in the process, is also a key component of the City's **Climate Leadership Plan**[2]. Reducing waste and consumption, changing consumer and business behaviours and creating better design and planning for infrastructure are all goals of the Climate Leadership Plan that directly align with zero waste and circular economy principles.

Victoria's Economic Action Plan, Victoria 3.0[3], emphasises the need to build our economy within the limits of the Earth's capacity to sustain us. Moving towards zero waste is crucial for achieving this goal. Zero Waste Victoria identifies key actions the City can take to reduce our footprint in a way that generates new economic opportunities. Victoria 3.0 also places a high value on innovation, with its vision of the City as an "influencer and innovator". Zero Waste Victoria aligns with this by putting forth a leading plan for waste that highlights the importance of business opportunities and the innovation businesses will achieve as part of the shift towards a circular economy. Additionally, a key action within Victoria 3.0 is to create an Ocean Futures Cluster. Many synergies are possible between this future Cluster, focused on marine science innovation, and zero waste initiatives given that a shared goal is improving environmental sustainability.

1 City of Victoria; 27 February, 2020; *Official Community Plan*; https://www.victoria.ca/EN/main/residents/community-planning/official-community-plan.html

2 City of Victoria; 2018; Climate Leadership Plan; https://www.victoria.ca/EN/main/residents/climate-change/climate-leadership.html

3 City of Victoria; 14 May 2020; Victoria 3.0 – Recovery Reinvention Resilience – 2020-2041; https://www.victoria.ca/EN/main/city/mayor-council-committees/mayor-lisa-helps/victoria-3-0-recovery-reinvention-resilience.html

The History of Waste Management in Victoria

The ocean has historically been used for waste disposal in many places around the world, with the assumption of limitless capacity. From the late 1800s to the mid 1950s the City of Victoria disposed of waste in ocean waters surrounding the city.[4]

Local historian, Janis Ringuette, writes, *"...municipal workers loaded garbage on scows at the city's garbage wharf near the Blue Bridge on Johnson Street. A tug towed the scows past Ogden Point and dumped the garbage into the sea. ... Victoria adopted the scow system ... after years of garbage problems on land. Smelly open dumps burned constantly in five areas of the city, attracting rats, flies, gulls and unending complaints from neighbours."* [5]

Much of the garbage dumped in the ocean ended up floating to local beaches and the community began to take notice.[6] In 1956, the City's Public Works Committee initiated a series of recommendations to City Council that ocean dumping be replaced with a sanitary landfill.[7] The City stopped disposing of waste in the ocean in 1958.[8]

City of Victoria Archives. CoV-CR-0296-M07077 (1957)

City of Victoria Archives. AC1-M07620 (1927)

4 CRD; Background – Our Garbage; https://www.crd.bc.ca/docs/default-source/recycling-waste-pdf/backgrounder-garbage.pdf?sfvrsn=7a4f8fc9_4

5 Ringuette, Janis; City of Gardens was once a City of Garbage; https://beaconhillparkhistory.org/articles/122_garbage.htm

6 City of Victoria Archives; 5 October 1896; *Sanitary Inspector Notebook*; CR-009

7 City of Victoria Archives; 22 November 1956; *City Council Minutes*; CR-13338

8 Daily Colonist; 25 June 1958; Garbage Won't Come Back: http://archive.org/stream/dailycolonist0658uvic_19

Late 1800s – 1950s	**Ocean garbage disposal**
1958	**Stopped disposing of garbage in ocean**
1970	**BC deposit program for cans and bottles**
1985	**CRD acquires dump at Hartland and invests to turn it into an Engineered Sanitary Landfill**
1989	**Bluebox recycling program introduced**
1990s	**Expansion of EPR programs**
2013	**Victoria introduces residential kitchen scraps collection**
2014	**EPR introduced for packaging**
2018	**Victoria introduces Checkout Bag Regulation**

Unregulated dumping at the Hartland Landfill in Saanich began in the 1950s, however the modern engineered sanitary landfill did not take shape until 1985 when the CRD assumed responsibility for the site and invested in infrastructure and environmental controls.[9] The City continued to use the down-town garbage wharf until 1986 to transfer garbage bound for Hartland.[5]

The region's curbside blue box recycling program began in 1989, with the collection of glass bottles, tin and aluminum cans and newspapers. The program operated in Oak Bay, Saanich, Victoria and Esquimalt[10]. The CRD banned card-board from disposal at the Hartland Landfill in 1993 and continued to ban other recyclable materials in subsequent years. The curbside program added mixed paper in 1995, and corrugated cardboard and rigid plastic containers in 2000.[11]

9 CRD; 2019; Hartland Landfill FAQ; https://www.crd.bc.ca/docs/default-source/recycling-waste-pdf/hartlandfaq.pdf?sfvrsn=66dc01ca_6

10 Times Colonist; 1 October 2015; *CRD directors mull scrapping blue boxes for wheeled totes*; https://www.timescolonist.com/news/local/crd-directors-mull-scrapping-blue-boxes-for-wheeled-totes-1.2074062

11 CRD; 2014; The 3R Hierarchy: A learning resource for K-7 educator's about the 3R's and waste in the capital region; https://www.crd.bc.ca/docs/default-source/Partnerships-PDF/3r-hierarchy-resources/3r-hierarchy-whole-document.pdf?sfvrsn=1cdb53ca_0

Producer Pay

British Columbia first introduced a product stewardship model for recycling in 1970 with the implementation of a deposit program for soft drink cans and bottles – the first in North America.[12] The provincial government made a leap in recycling legislation in the 1990s with the introduction of Extended Producer Responsibility (EPR) requirements for waste paint, beverage containers, medications, and household hazardous waste.[13] The provincial government introduced the Recycling Regulation in 2004 to simplify the regulatory structure for EPR programs and create a results-based approach[14]. Electronic and electrical products were subsequently added to the regulation.

The EPR program for residential packaging and printed paper began in 2014. Under agreement with the product steward for this material, the CRD continues to provide curbside recycling collection to single family homes in the region. Most multifamily residences are served by private waste collectors.

Kitchen scraps collection

In 2013, the City of Victoria added the collection of kitchen scraps to its residential waste service in response to the 2015 ban on food waste disposal at the Hartland Landfill. The CRD's priorities were to save landfill space and meet waste diversion and GHG reduction targets. Prior to the ban, organic waste made up about one third of waste sent to the landfill.[15]

Services today

Today, the City of Victoria provides community solid waste management services including residential garbage and kitchen scraps collection, residential yard and garden waste drop-off and seasonal pickup programs, public realm waste, recycling and food scraps collection, street cleaning and cigarette butt collection and recycling.

Over the years, the City's waste management mandate has evolved from a focus on garbage disposal to avoid litter and open burning, to a more modern and sustainable model involving stewardship and waste reduction. The City's waste management function is enabled by provincial legislation and its responsibility to reduce landfill disposal is guided by the region's Solid Waste Management Plan (SWMP).

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12 Encorp Pacific (Canada); 30 May 2014; Stewardship Plan 2014-2018; https://www2.gov.bc.ca/assets/gov/environment/waste-management/recycling/recycle/beverage-containers/sp/encorp-stew-plan-2014.pdf

13 Return-It; 10 March 2011; BC Product Stewardship Model; https://www.youtube.com/watch?v=RGWNfMfoSjU&feature=player_embedded#!

14 Recycle BC; Extended Producer Responsibility in BC; https://recyclebc.ca/about-recyclebc/epr/

15 CRD; September 2010; CRD Solid Waste Stream Composition Study 2009-2010; https://www.crd.bc.ca/docs/default-source/recycling-waste-pdf/WasteCompositionStudy2010.pdf?sfvrsn=9cd38fc9_2

Zero Waste Victoria Vision

A community where nothing is wasted.

The vision for Zero Waste Victoria is a community where nothing is wasted. Where reducing, reusing, and repurposing materials is the norm and helps our community thrive. Where a circular economy allows innovators to succeed and local businesses to flourish. Our community's culture of sharing and repairing helps us to connect with our neighbours. Our homes and places of work are constructed using salvaged and recycled materials, putting less pressure on our valuable natural resources. Our vision is a community where no food goes to waste and any scraps are converted into energy and nutrient rich soil. Where the convenience of take-out doesn't require disposable single-use products. Where celebrations and gifts don't always require stuff, but meaningful experiences that support local businesses. Where "think global, act local" is put into practice every day and future generations are not an afterthought. Where throwing things "away" is not an option or an impulse. Where Victoria leads, innovates, and takes action.

Values

The following set of community values motivate the direction and strategies for advancing zero waste across Victoria. In many cases, these values will converge to inform the design and implementation of policies, programs and services. There will also be times when values are in conflict with each other and decision-making will be challenged to identify a balanced compromise.

1. CLEANLINESS AND SANITATION

The City's waste management operations have a commitment to cleanliness and sanitation. The health and safety of residents and City staff is essential and changes to waste management operations must maintain current sanitation standards. Our City should also be tidy, with roadways and open spaces that are free of litter and debris.

2. CONVENIENCE AND CHOICE

Our current economy designs and supplies products that are convenient to use and dispose while the full costs and impacts of these product choices are often hidden from the consumer. Reusable products and fully recyclable materials should offer a competitive alternative to disposable products.

3. ENVIRONMENTAL SUSTAINABILITY

Eliminating waste is a critical step towards regenerating the natural environment and reducing GHG emissions. The landfill should be used as a last resort. The release of plastic waste to the environment should be eliminated.

4. AFFORDABILITY

Collecting and disposing of waste is currently a significant cost for the City, which is passed on to residents and businesses. Reducing the amount of waste generated has the potential to bring this cost down. Waste reduction efforts must also ensure that vulnerable, underserved populations are not disproportionately impacted.

5. PROSPERITY

Waste reduction and diversion should present new business opportunities, including for innovative entrepreneurs and small businesses. Waste reduction and diversion should contribute to an inclusive high-value economy in our region, as well as to low-carbon prosperity.

6. TIMELY LEADERSHIP

The City should regularly review and amend its policies and programs to incorporate best practices and rapidly respond when faced with evidence of unsustainable practices. The City should lead by example, ensuring that corporate operations and facilities avoid waste and stimulate reuse and recovery systems. The City should also connect people, leverage local expertise and foster innovation.

Waste Reduction Frameworks

Three established frameworks guide Zero Waste Victoria and the sequence of actions taken to reduce waste:

1. **Zero Waste** provides an ambitious goal to guide continual improvements to the waste management system.

2. The **Circular Economy** establishes a paradigm that couples economic wellbeing with environmental sustainability.

3. The **Waste Reduction Hierarchy** provides a decision-making framework for prioritizing actions.

Zero Waste Defined

Zero Waste can be interpreted as both a goal and a concept for setting policy. The Zero Waste International Alliance specifically defines Zero Waste as:

"The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health."[16]

The *Zero Waste International Alliance* encourages communities to reduce disposal, either to landfill or by incineration, by 90%.[17]

16 Zero Waste International Alliance; 2018; Zero Waste Definition; http://zwia.org/zero-waste-definition/
17 Zero Waste International Alliance; May 2014; Zero Waste Community Certification; http://zwia.org/zero-waste-community-certification/

Circular Economy

The Circular Economy is an alternative to a traditional linear economy in which society extracts natural resources to make short-lived products that are then disposed. A Circular Economy also goes beyond the current Recycling Economy, in which products are typically downcycled and eventually disposed. In a Circular Economy products and materials are reused, repurposed and recycled in such a way that nothing is sent to landfill.

The Circular Economy framework is based on three principles:

- **Design out waste and pollution**
- **Keep products and materials in use**
- **Regenerate natural systems**[18]

A Circular Economy defines and prioritizes the processes that fully capture the value of our products and materials. The Ellen MacArthur Foundation describes policy levers that municipal governments can use to align with and support a Circular Economy. These levers span the breadth of municipal government functions, including urban planning, public engagement, asset management and procurement.[19] Many of these levers also support the objective of zero waste by preventing waste and encouraging the recovery of materials. While the Circular Economy is considered more broadly as a model for the entire economy, it is complementary to the goal of zero waste and the two frameworks can be applied in parallel.

18 Ellen MacArthur Foundation; 2017; Concept: What is a circular economy? A framework for an economy that is restorative and regenerative by design; https://www.ellenmacarthurfoundation.org/circular-economy/concept

19 Ellen MacArthur Foundation; March 2019; City Governments and their Role in Enabling a Circular Economy Transition; https://www.ellenmacarthurfoundation.org/assets downloads/CE-in-Cities_Policy-Levers_Mar19.pdf

LINEAR ECONOMY	RECYCLING ECONOMY	CIRCULAR ECONOMY
Resource Extraction	Resource Extraction	Resource Extraction
Use	Use - Recycle	Use - Reuse - Repair
Disposal	Disposal	

Waste Reduction Hierarchy

The waste reduction hierarchy emphasizes reduction and reuse over recycling and disposal. This framework provides guidance for prioritizing waste management actions. Reduction is at the top of the hierarchy, indicating that effort and resources should first be allocated towards avoiding waste or reducing the amount generated. Reuse, repair and repurpose follow in descending order of priority. Recycling and disposal are at the bottom of the hierarchy, indicating that they should be used only after the higher levels of the hierarchy have been applied. This framework also often includes energy recovery in between recycle and dispose.

1. **Avoid**
2. **Reduce**
3. **Reuse**
4. **Repair**
5. **Refurbish**
6. **Recycle**
7. **Recover (energy, nutrients)**
8. **Disposal**

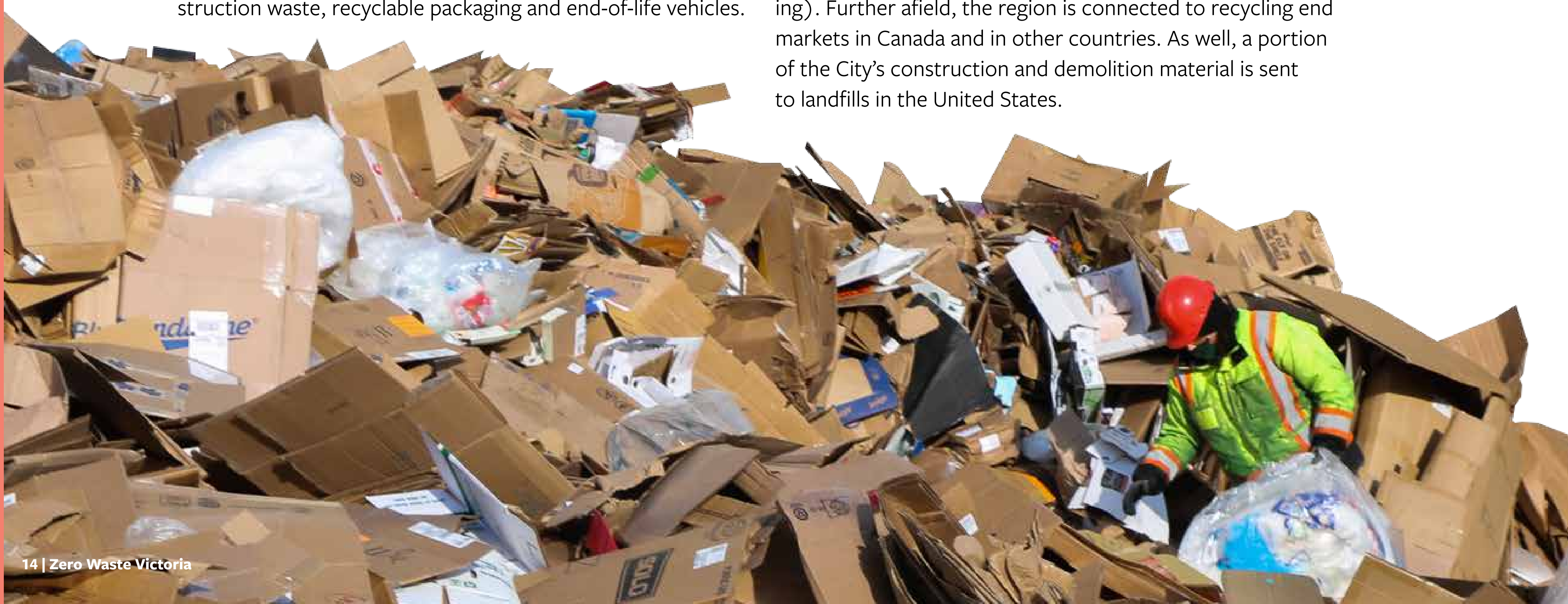
Our Waste Management System

The regional waste management system involves multiple, interconnected participants, activities and processes. The City provides a range of waste services including residential garbage and organics collection. Private haulers collect waste, recyclable and compostable material from multifamily residential buildings and from the industrial, commercial and institutional (ICI) sector. The CRD manages the curbside blue box program on behalf of Recycle BC, the provincial stewardship agency responsible for residential packaging and paper products.

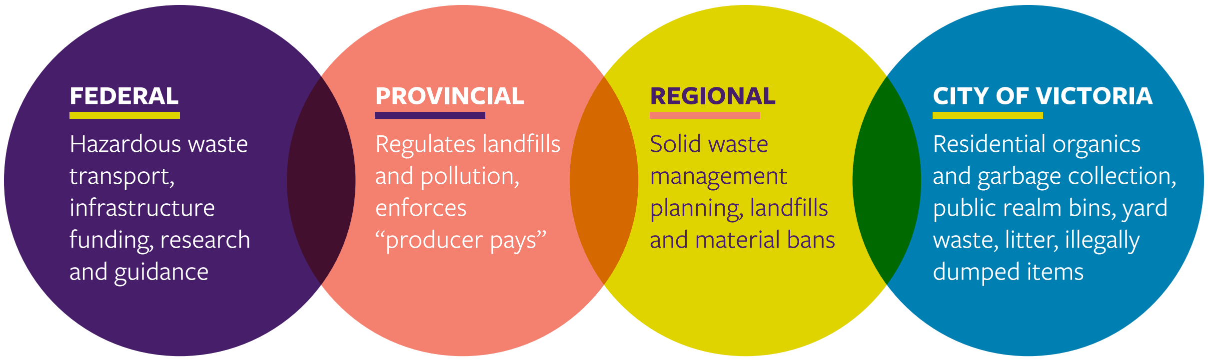
Depots serve as drop-off locations and transfer points for numerous types of ICI and residential material, including construction waste, recyclable packaging and end-of-life vehicles.

Material recovery facilities separate recyclables and group them for shipment outside the region. Hartland Landfill is the primary landfill in the region and has collection facilities for organics, recyclable material and household hazardous waste. Several facilities in the region, including municipally-owned facilities, compost yard and garden waste.

The regional waste management system is connected to broader networks outside the region. Industrial compost facilities in Southern Vancouver Island process kitchen scraps and yard waste. Given limited recycling processing on Vancouver Island, recyclable material is often sent to processors in the Lower Mainland (e.g., for drywall and plastic packaging). Further afield, the region is connected to recycling end markets in Canada and in other countries. As well, a portion of the City's construction and demolition material is sent to landfills in the United States.



Government Roles and Responsibilities



FEDERAL GOVERNMENT

The federal government contributes to waste reduction by conducting national studies on waste and pollution, providing guidance on best practices and broad scale strategic direction, and by funding research and major infrastructure projects. The federal government also contributes as a member of the Canadian Council of Ministers of the Environment (CCME), which enables intergovernmental targets and policy coordination on waste.

The federal government can mitigate the upstream generation of toxic substances that have the potential to harm the environment under the *Canadian Environmental Protection Act*. The federal government also regulates the international and interprovincial transportation of hazardous waste and recyclable material.

The federal government establishes national mandates that align with international efforts on waste reduction and pollution prevention. For example, the federal government is a signatory to the Ocean Plastics Charter, which supports the design of plastics for reuse and recycling and aims to reduce plastic pollution.[20]

PROVINCIAL GOVERNMENT

The Province of British Columbia sets requirements for municipal solid waste management in the *Environmental Management Act* (EMA). The EMA and associated regulations include requirements for regional district solid waste management planning, landfill operation, composting and hazardous waste management. The Recycling Regulation under the EMA establishes British Columbia's EPR program.

20 Government of Canada; 31 July 2020;Ocean Plastics Charter; https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/international-commitments/ocean-plastics-charter.html

British Columbia's EPR framework, a regulated model and the most comprehensive in Canada, has been very successful at increasing access to recycling for a wide range of products, and at establishing an industry-funded model for recycling in the province. However, the framework does have some shortcomings. Most significantly, EPR emphasises recycling rather than the higher levels of the pollution prevention hierarchy; reduction and reuse. Also, certain product categories have low recovery rates, and access to depots is inadequate in some communities.

Local government can develop policy that complements the EPR framework. Given that EPR is intended to shift the financial burden of managing end-of-life products from the taxpayer to producers, municipalities should look to producers to offset the financial burden of managing these materials in the community. Local government can also advocate to the province for continual improvement of the EPR framework, including expanded product categories, stronger enforcement and improved outcomes.

REGIONAL GOVERNMENT

As noted above, the EMA requires that Regional Districts develop plans for the management of municipal solid waste and recyclable materials and grants them authority to regulate these materials using a number of mechanisms including, but not limited to, landfill material bans, material-specific disposal fees and site/facility licensing.

The CRD's SWMP includes a target to significantly reduce landfill disposal, with the intention of extending the life of the Hartland Landfill beyond 2100. The SWMP follows the pollution prevention hierarchy and includes strategies for reduction and reuse that align with Zero Waste Victoria. The SWMP relies on municipalities to use regulatory powers and authorities not available to the Regional District, to enhance or provide new services, and to amplify regional advocacy, education and outreach activities.

The CRD owns and operates the Hartland Landfill, a multi-purpose site which, in addition to landfill services for general refuse and controlled waste, provides drop-off for recycling, compostable organics and household hazardous waste. Landfill capacity is limited and impacted greatly by increasing volumes of municipal solid waste.

The CRD manages the curbside single-family blue box collection service on behalf of Recycle BC (stewardship agency for packaging and printed paper).

MUNICIPAL GOVERNMENT

Municipalities in British Columbia provide services related to solid waste, such as collection of residential garbage and kitchen scraps, public realm collection through waste bins, street cleaning and pickup of illegally dumped items. Some municipalities also operate recycling collection programs with support from Recycle BC. Municipalities have bylaws and run communication programs to support service delivery. The Community Charter provides statutory authority for these services and programs.

The City of Victoria provides the following services:

- Collection of garbage and organics from single family homes, duplexes, triplexes and some ground oriented multifamily buildings
- Public realm waste, recycling and organics collection, yard waste program, including drop-off and seasonal collection
- Street cleaning/litter collection including cigarette butt recycling
- Collection of illegally dumped items

Municipalities have authorities under the *Community Charter and Local Government Act* that influence the generation of waste including zoning, permitting, business regulation and nuisance regulation. Local governments also have authority, subject to provincial approval, to make regulations for the protection of the natural environment. Since solid waste can have direct impact on the natural environment, local governments can further influence the generation of solid waste in the community by exercising this power.

Waste Generation in Victoria

Baseline

Analysis using best available data was completed to provide an estimate of the source and destination of materials generated across the community. Analysis included assessment of Victoria's portion of regional landfilled waste, by accounting for the share of regional economic activity and multifamily homes, as well as the portion of waste disposed outside the region. The baseline establishes an understanding of waste in Victoria to identify priority materials and sectors. The baseline also provides a reference point for setting targets and monitoring the performance of waste reduction measures.

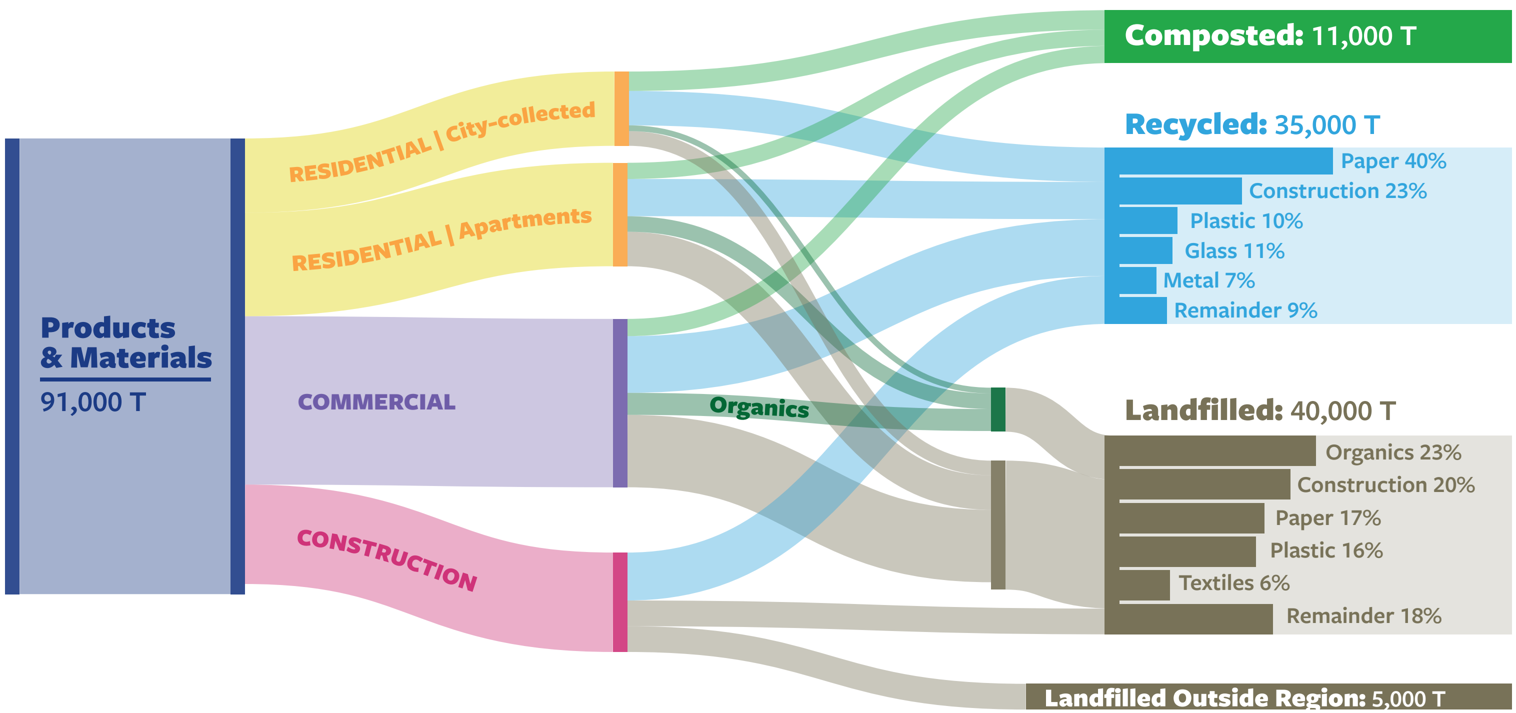


Figure 1. Average annual flow of materials in Victoria

Projections

Materials sent to landfill from Victoria are projected to increase by up to 40% by 2040 without meaningful intervention.

Analysis of the strategies proposed in Zero Waste Victoria was completed to assess their impacts on waste disposal. Based on this analysis Zero Waste Victoria established a target of a 50% reduction in landfill disposal by 2040. This target reflects the opportunity for waste reduction using existing tools available to the City of Victoria assuming ambitious implementation of the strategies. Further reductions are possible through supportive actions at higher levels of government and industry-led initiatives.

It is important to note that variables outside the scope of Zero Waste Victoria, such as economic activity, consumption behaviours and population and jobs growth will influence waste generation.

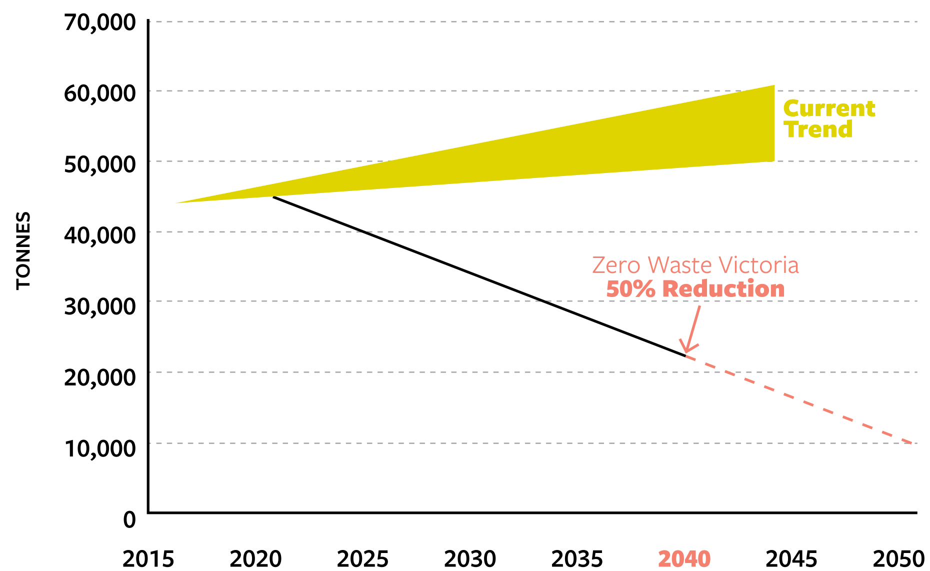


Figure 2. Landfill disposal targets

The Approach

Zero Waste Victoria draws on the frameworks of Zero Waste, the Circular Economy and the Waste Reduction Hierarchy. Specifically, Zero Waste Victoria incorporates the waste reduction hierarchy to prioritize strategies and actions. The hierarchy follows a preferential order of action from reduce, reuse, repair, repurpose, to recycle while avoiding disposal. Moreover, Zero Waste Victoria establishes three guiding initiatives to categorize waste reduction strategies based on the City's authority and influence to support the long-term vision for Zero Waste in the community as follows:

1. **Eliminate the unnecessary**
   This initiative includes strategies that address products and materials where the negative impacts to the environment and community outweigh the consumer benefits or where viable sustainable alternatives exist.

2. **Make reuse the norm**
   This initiative includes strategies that help to establish reusable products and reuse practices (including repair and refurbishment) as the default option throughout the community.

3. **Recycle the rest**
   This initiative includes strategies aimed at improving recycling for products that can no longer be used.

Underpinning each of these guiding initiatives is the recognition that the City of Victoria plays an important role in facilitating the transition to zero waste by leveraging knowledge and partners across the community and demonstrating leading waste reduction practices through its corporate operations. This includes empowering community leaders and facilitating local zero waste networking, strengthening local reuse markets, and identifying opportunities to remove barriers within the City's jurisdiction. Also crucial to Zero Waste Victoria will be collaboration and alignment with other levels of government and other municipalities.

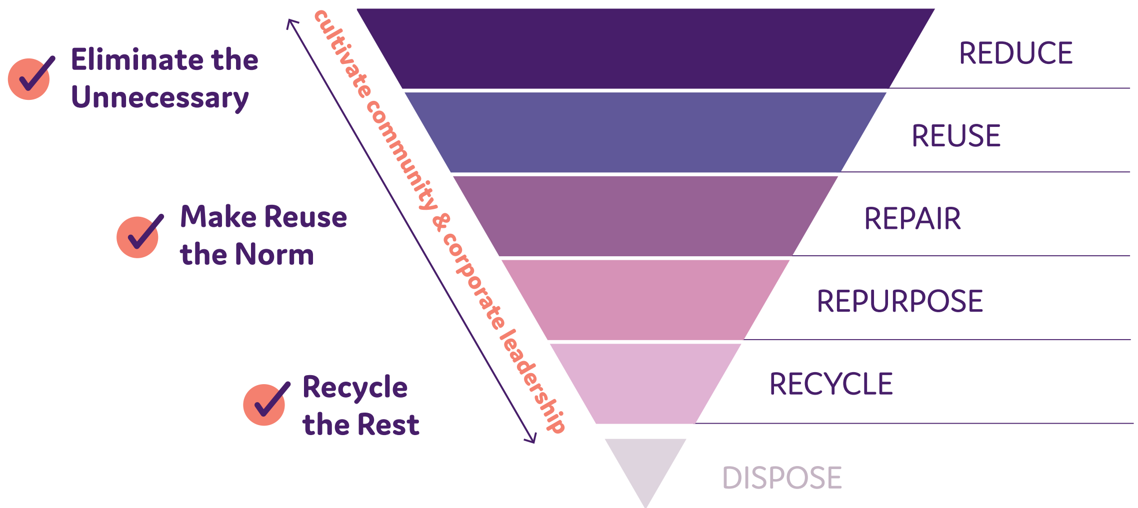


Figure 3. Waste reduction hierarchy

Tools

The strategies in Zero Waste Victoria may be implemented using a range of tools. Broadly, the tools available to the City of Victoria to reduce waste include:

- Municipal solid waste services and operations (e.g. garbage and kitchen scraps collection, public realm waste collection, litter pickup)
- Regulation, restrictions, prohibitions (e.g. material bans, fees, permits)
- Corporate procurement
- Education and outreach programs
- Advocacy to other levels of government

The actions the City takes to fulfill the strategies in Zero Waste Victoria will evolve over time, as conditions change and as we move closer to zero waste. The strategies are designed to be flexible over the duration of Zero Waste Victoria, so that the City can revisit them on a regular basis and revise the time-specific actions as needed. Where appropriate, time-specific actions could reflect a phased approach, with regulation following and supported by market approaches and voluntary measures. In other situations, the appropriateness of regulatory tools will be evaluated based on other considerations, including the existence of sustainable alternatives, community or business readiness, local capacity and understanding, and precedents in other jurisdictions.

Focus Areas

Zero Waste Victoria focuses on four categories of waste:

- Single-Use Items & Packaging
- Built Environment (construction, renovation, and demolition products and materials)
- Food & Organics
- Durable Goods

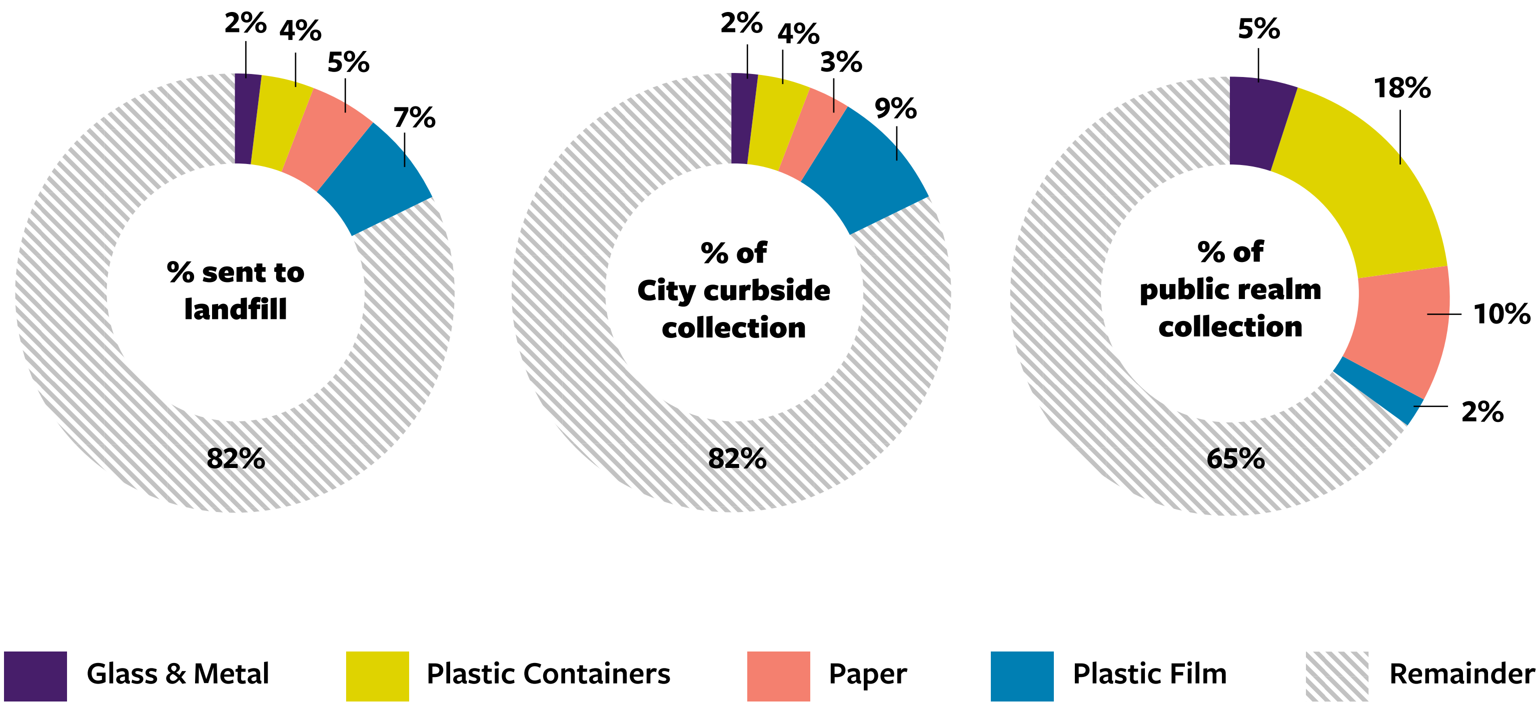
These material categories were chosen because they comprise the largest quantity of material being sent to landfill across the community, there are significant environmental and economic benefits from reducing the disposal of these materials, and there are proven tools the City can use to make an impact.

Details, goals and strategies to reduce waste in each of the focus areas are provided in the following sections.

Single-Use Items & Packaging

DESCRIPTION

Single-Use Items (SUIs) include a range of product types that are designed for a single use and typically disposed of after one or a few uses. SUIs are heavily used in the food service sector for the purpose of convenience and in some cases to address health and safety or accessibility requirements. Commonly distributed SUIs include checkout bags, cups, containers and food service accessory items such as straws, stir sticks and cutlery. This focus area also includes other types of consumer product packaging such as boxes, plastic film and paper wrapping.


2%
4%
5%
7%
% sent to landfill
82%
2%
4%
3%
9%
% of City curbside collection
82%
5%
18%
% of public realm collection
10%
2%
65%
Glass & Metal
Plastic Containers
Paper
Plastic Film
Remainder

ISSUES

The CCME reports that global plastic pollution causes over $13 billion in environmental damages annually, while $100 to $150 billion worth of material value in plastic packaging is lost to the global economy[21]. Globally, only 14% of plastics are collected for recycling and only a portion of these are turned into products with equivalent properties.

There are numerous challenges to plastics recycling including a volatile market for recycled materials, contamination, processing technology limitations, designs that prohibit disassembly, unfavorable economics and inexpensive disposal alternatives such as landfilling and incineration[22].

While paper, glass and metal SUIs and packaging do not pose the same threats to natural areas as plastic materials when littered, their production and consumption presents other environmental impacts. The manufacture and transportation of paper bags and other packaging, even with recycled content, consumes raw materials, emits greenhouse gases, and has the potential to pollute water and air. Also, paper packaging sent to the landfill in wet climates generates methane as it breaks down.

There are also emerging issues with the increased production and use of compostable plastic SUIs and packaging. Compostable plastics and other bioplastics are made from renewable natural resources such as corn or sugarcane. Bio-based plastics are intended to reduce reliance on fossil fuels for plastic production and mitigate plastic pollution in the environment, however these products still carry a significant environmental impact during production and disposal. Compostable plastics are often screened out during the pre-processing stage at composting facilities because they are indistinguishable from conventional plastics. In addition, existing industrial composting facilities do not provide the conditions required to completely decompose these materials leading to contamination and persistence in the environment.[23] Compostable plastics also compromise the recycling of conventional plastics.

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21 CCME; 2018; *Strategy on Zero Plastic Waste*; PN 1583

22 Organization for Economic Co-operation and Development; 2018; *Improving Plastics Management: Trends, Policy Responses, and the Role of International Co-operation and Trade*

23 Oregon DEQ.; Fact Sheet: Packaging Material Attributes Report; https://www.oregon.gov/deq/FilterDocs/packagingFS.pdf

The Ellen MacArthur Foundation's New Plastics Economy Initiative acknowledges "while improving recycling is crucial, we cannot recycle our way out of the plastics issues we currently face. Elimination of problematic or unnecessary plastic packaging through redesign, innovation, and new delivery models is a priority. Reuse models need to be applied where relevant, reducing the need for single-use packaging"[24].

24 Ellen MacArthur Foundation; 11 October 2019; The New Plastics Economy Global Commitment – 2019 Progress Report; https://www.newplasticseconomy.org/assets/doc/Global-Commitment-2019-Progress-Report.pdf

SINGLE-USE ITEMS AND PACKAGING IN OUR COMMUNITY

In 2019, the provincial recovery rate for overall residential packaging was 78%, while the specific recovery rate for plastic packaging was 46% and film packaging 22%.[25] Despite strong program performance relative to recycling programs in other jurisdictions, SUIs and packaging continue to be found in material sent to the Hartland Landfill. In 2016, film packaging made up 7% of the waste by weight sent to Hartland. This is a significant quantity of products considering the light weight nature of this material. Other types of packaging, such as paper packaging, corrugated cardboard, and glass, plastic and metal food and beverage containers comprised 11% of the waste sent to Hartland.[26]

An audit of waste from the City of Victoria's residential collection service in 2020 found that both plastic containers and paper packaging each comprised about 4% of the sampled weight. By item count, takeout containers and plastic bags were the most disposed SUI, followed by utensils and cups. It is estimated that the City of Victoria collects a total of 5.4 million disposed SUIs a year through its curbside collection service.

SUI and packaging waste and litter in Victoria's public spaces is a further challenge. A 2019 audit of the City's waste bins located on sidewalks and in parks indicated that cups were the most disposed SUI, followed by takeout containers and utensils (by item count). It is estimated that 25,000 SUIs are collected across the public realm by City crews every day. Plastic items are also littered on Victoria's streets, parks and beaches and the City's stormwater and sanitary infrastructure is susceptible to fouling and contamination from these plastics. Community members and businesses also contribute substantial time and funds towards initiatives such as beach cleanups and business-sponsored litter collection programs.

25 Recycle BC; 2019; Recycle BC – 2019 Annual Report; http://recyclebc.ca/wp-content/uploads/2020/06/RecycleBC2019-Final.pdf

26 CRD; December 2016; 2016 Solid Waste Stream Composition Study; https://www.crd.bc.ca/docs/default-source/recycling-waste-pdf/WasteCompositionStudy2016.pdf?sfvrsn=baab36ca_4

SHARED RESPONSIBILITY

Complementary action needs to be taken at all levels of government to reduce the waste associated with SUIs and packaging and to mitigate the impacts of plastic pollution. While the provincial EPR program for residential packaging and paper products diverts a significant quantity of recyclable material from the landfill, improvements to EPR to include commercial packaging and stronger requirements to adhere to the top of the pollution prevention hierarchy is important at the provincial level.

At a local level, the National Zero Waste Council recommends that municipalities employ the following regulatory tools to mitigate the impact of SUIs[27]:

- Controlled usage such as bans or restrictions
- Economic incentives or disincentives such as mandatory fees at point-of-sale
- Increased littering fines
- Supports for reusable packaging

CITY OF VICTORIA ACTION

The City of Victoria is well positioned to reduce unnecessary SUI and packaging waste, in concert with action by the federal and provincial governments. In keeping with the values of the community, the City can work with businesses to regulate SUIs and support viable reusable alternatives. For example, the City of Victoria took early action to mitigate plastic waste through the introduction of the Checkout Bag Regulation Bylaw. This City initiative has been embraced by the community and businesses, and helped to normalize the shift to reusable bags. The City can also work to ensure that unavoidable SUI and packaging waste is recycled, building on the existing provincial EPR program.

The City can have an additional impact by further reducing and diverting SUIs and packaging from its internal operations.

When addressing SUIs and packaging, the City must consider equity impacts. These considerations include accessibility (e.g., straws) and the affordability of reusable alternatives. It is also important to consider those members of the community who collect refundable beverage containers throughout the city and rely on redeemed deposits as a source of income.

27 National Zero Waste Council; 6 December 2019; National Zero Waste Council, Plastics Advisory Panel: Regulatory Approaches for Priority Plastic Wastes; http://www.nzwc.ca/Documents/RegulatoryApproachesforPriorityPlasticWastes.pdf

GOALS

1. **Unnecessary and problematic single-use items and packaging are eliminated**
2. **Reusable products are the default**

GUIDING INITIATIVES	STRATEGIES
Eliminate the Unnecessary	Introduce bans and/or fees for single-use items with proven sustainable alternatives
	Expand access to public drinking water fountains
Make Reuse the Norm	Facilitate the establishment of reusable container services
Recycle the Rest	Require the source separation of recyclable materials across the community
	Improve access to recycling depots
	Support consumer awareness and improved standards for compostable food and beverage packaging
	Support programs that reduce waste disposal and litter in public spaces
	Work with the tourism industry to promote local zero waste initiatives[28]
Cultivate Corporate and Community Leadership	Ensure the corporation leads the community in packaging and paper reduction and diversion
	Reduce and divert waste at special events[28]

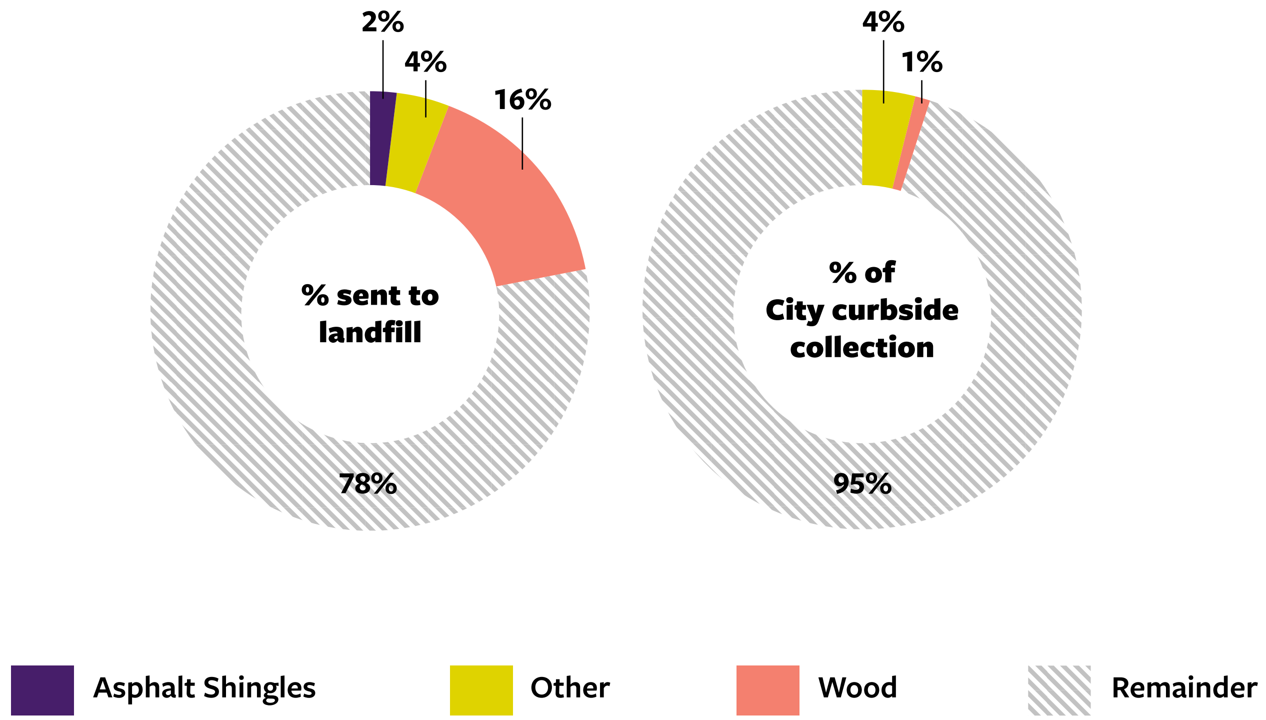
28 This strategy appears in both the Single Use Items & Packaging and Food & Organics focus areas

Built Environment

DESCRIPTION

Construction, renovation and demolition material (construction waste) includes treated wood, drywall, asphalt shingles, pallets/skids, painted wood, plywood/particle board, roofing felt, insulation, clean wood, film packaging and durable plastic products.

Construction, renovation and demolition waste streams include similar materials, however the composition of each will vary based on the activity generating the waste.


2%
4%
16%
% sent to landfill
78%
4%
1%
% of City curbside collection
95%
Asphalt Shingles
Other
Wood
Remainder

ISSUES

Construction waste makes up a significant quantity of waste sent to landfill in Canada. The construction of new buildings consumes large quantities of raw materials, such as wood, metals and minerals, which become waste when a building is demolished. Wood (clean, engineered, painted, treated), asphalt roofing and drywall are the construction materials most commonly disposed in Canada.[29]

Wood sent to landfill in a wet climate generates methane, a strong GHG, as it decomposes. Also, there is significant economic value in construction materials that could be recovered through more effective waste reduction and diversion policies.

Globally, cities are applying a range of measures to reduce construction waste streams. Efforts are also being made to apply circular economy principles to the built environment. Key initiatives include a combination of land use zoning requirements, deconstruction and recycling bylaws, encouraging design-for-disassembly practices, and providing business incentives and support to improve the market for recycled products (e.g., through procurement).

WASTE FROM THE BUILT ENVIRONMENT IN OUR COMMUNITY

Material from the construction sector makes up between 23 to 37% of Victoria's landfilled waste. Regionally, wood and wood products comprise 64% of waste from the construction and demolition sector disposed at Hartland Landfill.

Additional construction materials landfilled in the region include asphalt shingles, roofing felt, insulation, and plastics[26]. Some materials, such as metals, heritage or architectural features and structural wood have value and are already being diverted. However, there are several challenges to reducing and diverting other types of construction waste including:[28]

- Limited markets for used building materials such as wood, especially if painted or treated
- Commingled waste (lack of separation at source)
- Presence of hazardous materials, such as paint, wood coatings and asbestos
- Unknown composition of demolition waste; unknown presence of hazardous materials
- Time and labour required to separate materials or sort different types of waste
- Limited space at construction sites for bins to store separated waste

There are additional challenges for reducing construction waste in Victoria. First, the quantity and characteristics of construction waste generated in Victoria are not known with certainty. Loads of construction waste arriving at Hartland can include material from multiple municipalities, with waste haulers self-reporting a single point of origin. There is also limited public information about the amount of salvageable construction materials, the current local market demand, and the value placed on these materials. Second, a significant quantity of construction waste destined for disposal is transported off Vancouver Island to landfills in the United States or elsewhere in BC. Landfill bans and higher tipping fees can

Construction waste is generated from the process of building new structures.

Renovation waste is generated when improvements and repairs are made to existing structures. Renovation waste is a mixture of construction and demolition waste.

Demolition waste is generated when existing structures are demolished. Demolition waste is often difficult to separate for the purpose of reusing or recycling its constituent materials[29].

Deconstruction is the systematic dismantling of a structure so that building materials can be salvaged and reused. Deconstruction minimizes waste and is an alternative to demolition.

House moving is the relocation of a whole house by lifting it onto a truck or barge and transporting it to a new location. Other structures can also be moved. Moving a building enables the entire structure to be reused and avoids generating waste.

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29 CCME; 2019; Guide for Identifying, Evaluating and Selecting Policies for influencing Construction, Renovation and Demolition Waste Management; https://www.ccme.ca/files/Resources/waste/wst_mgmt/CRD%20Guidance%20-%20secured.pdf

contribute to out-of-region migration but can be mitigated through supporting policy that encourages diversion. Such supporting policy could include mandatory salvage or recycling requirements, source separation bylaws or incentives.

SHARED RESPONSIBILITY

The provincial government has committed to creating EPR programs for construction materials, as part of its target to implement the CCME Canada-Wide Action Plan for EPR. However, EPR might not be the best policy approach for all building materials, given the lifespan of a building and the longevity of materials. Instead, EPR might be suitable for specific materials. For example, an assessment of EPR as a policy tool in Metro Vancouver recommends that asphalt shingles, carpet, sheet plastic, and wood are strong candidates for EPR.[30]

The CRD has taken steps to reduce construction waste disposal. Hartland Landfill has bans in place for aggregate, asbestos-containing materials, concrete, and drywall, as well as tipping fee disincentives. However, as noted above, this leads to out-of-region migration of construction waste and can lead to illegal dumping of these items. The CRD is also considering a ban on clean wood waste at Hartland Landfill.[31]

The CRD's SWMP includes a strategy focused on increasing construction materials diversion, with plans to develop a comprehensive regional strategy, as well as educational tools and resources to help drive demand for diverted materials.[30]

CITY OF VICTORIA ACTION

The Built Environment represents a significant opportunity for waste reduction in Victoria. A large quantity of construction waste is generated in Victoria. Much of this waste could be diverted, with recovery of its economic value. The City has the authority to regulate land use, with existing permitting processes in place for development and construction. The City can also influence the local market for reused and recycled construction materials, as a significant land holder/purchaser, and through major expenditures for capital projects.

The strategies below contemplate new requirements for contractors, property owners and developers to recover waste materials during construction, renovation and demolition. The strategies also include measures to strengthen the market for salvaged and recycled materials, including City procurement practices intended to increase demand for these materials.

The City is home to an innovative design and build community, with architects, developers and contractors who have demonstrated a commitment to green construction practices. There is also demand for residential and commercial development that meets a higher standard of environmental performance. The City can leverage these community assets to support implementation of the strategies below.

30 Balba, Andrea; Montauban, Cecilia; Kim, Jenny (Yeon Mi); Yeh, Debbie; 07 May 2013; Assessing the potential for extended producer responsibility in construction, renovation and demolition waste in Metro Vancouver; https://open.library.ubc.ca/cIRcle/collections/undergraduateresearch/52966/items/1.0074565

31 CRD; SWMP: Proposed Strategies and Actions; https://www.crd.bc.ca/docs/default-source/solid-waste-management-plan-2019/strategies.pdf?sfvrsn=8af064cb_2

GOALS

1. **All reusable and recyclable demolition materials are diverted from landfill**
2. **Reuse and deconstruction practices are common**
3. **Buildings are constructed to facilitate longevity and reuse, as well as deconstruction and recovery of materials at end of life**
4. **New construction minimizes waste and maximizes use of reused and recycled materials**

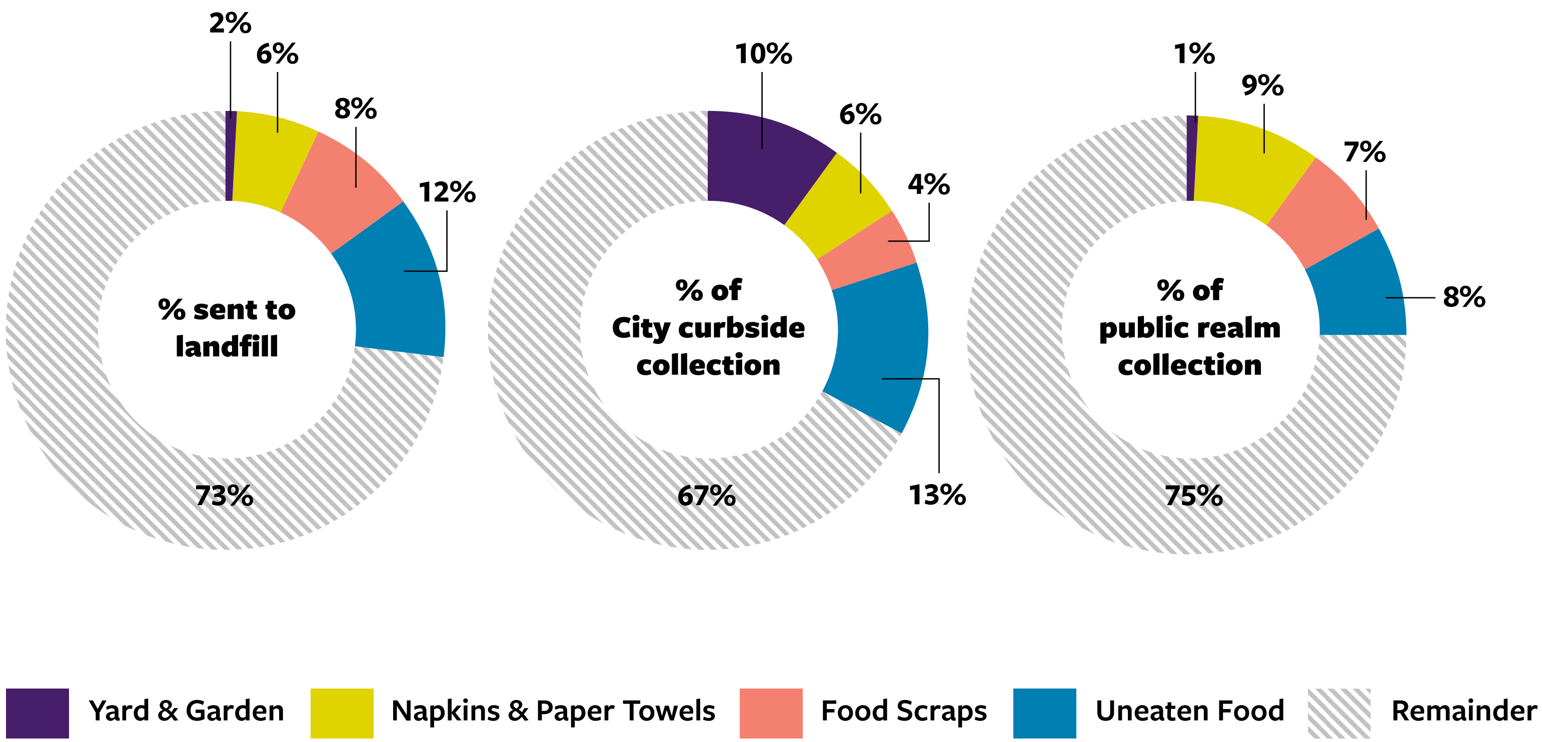
GUIDING INITIATIVES	STRATEGIES
Eliminate the Unnecessary	Regulate problematic construction products or practices that compromise material reuse and recycling
	Encourage design standards and practices that minimize waste
	Fully use and optimize existing buildings through shared and mixed use
Make Reuse the Norm	Encourage circular and adaptable design, and design for disassembly
	Support and enable house moving
	Require the salvage of reusable materials from building demolitions
Recycle the Rest	Require the recycling of materials from demolition, renovation and construction
	Work with regional partners to plan for the mitigation of waste from disasters
Cultivate Corporate and Community Leadership	Strengthen reuse markets for building materials
	Ensure City operations, roadwork and construction do not produce litter
	Improve regional waste flow data disclosure

Food & Organics

DESCRIPTION

Food waste includes unavoidable kitchen scraps such as bones, eggshells, banana peels and other trimmings created through meal preparation, and avoidable or donatable food wasted as a result of over-purchasing, not finishing meals and/or misinterpretation of best before and expiry labelling. Other organic waste includes yard and garden materials such as lawn clippings, woody debris, leaves, plant trimmings and cut flowers.

FOCUS AREA | Food & Organics



ISSUES

Approximately one third of the food produced around the world is wasted, a significant loss considering the number of people who are hungry or malnourished. This wasted food represents US$940 billion in annual economic losses, uses one quarter of the water used for agriculture globally, occupies more land than the size of China, and produces about 8% of annual global GHG emissions.[32]

Love Food Hate Waste Canada reports that 63% of household food waste in Canada is avoidable. An average household throws away $1,100 of edible food per year. That adds up to almost 2.2 million tonnes of edible food wasted each year in Canada, at a cost of more than $17 billion while contributing to Canada's GHG emissions.[33]

Sending organic waste to the landfill also has environmental impacts. The material contributes to leachate and generates methane, a strong GHG, as it decomposes in the landfill. Separating organic waste from other waste streams and treating it through composting or anaerobic digestion keeps this material out of the landfill and enables nutrient and energy recovery. Similar to the waste reduction hierarchy, the food waste hierarchy provides guidance for prioritizing actions.

32 Food Loss and Waste Protocol; About the Food Loss and Waste Accounting and Reporting Standard; https://flwprotocol.org/wp-content/uploads/2019/04/About-The-FLW-Standard.pdf

33 Love Food Hate Waste Canada; Food Waste in the Home; https://lovefoodhatewaste.ca/about/food-waste/

FOOD AND ORGANIC WASTE IN OUR COMMUNITY

Victoria collects kitchen scraps as part of its curbside residential service and runs a yard waste program. However, this does not capture all food and organic waste generated in Victoria.

Compostable organics comprised the largest share of waste disposed at Hartland by weight in 2016, amounting to 27%. Just under half of this organic waste was avoidable food waste. Waste from multifamily residences consisted of 31% compostable organics, significantly higher than the overall waste stream, while waste from the ICI sector consisted of 23% compostable organics. Landfilled organic waste from the City of Victoria produces the equivalent of about 21,000 tonnes of CO_2 annually, contributing approximately 6% of our community's GHG emissions, based on 2019 estimates.

By weight, organics are the largest share of material collected through the City's residential curbside garbage service. Almost one third of the waste sampled was made up of compostable organics, with avoidable food waste accounting for 13% of the waste sampled, yard and garden waste 10%, and unavoidable food waste 4%. The City's kitchen scraps collection service provides a system to divert this material. The quantity of organics in the City's residential collection points to ongoing opportunities to enhance the service, change behaviour and improve compliance.

Larger multifamily buildings and the ICI sector together are responsible for approximately 85% of landfilled organics from Victoria. There are several challenges with diverting this material, including limited space on residential and commercial properties for material diversion and storage, contamination of streams, and an absence of source separation requirements or standards. Low accountability is also a challenge inherent with numerous users of common waste storage bins and facilities.

There is limited capacity in the region for industrial composting of kitchen scraps. While current demand is being met, increased organics diversion and population growth will require additional capacity. Increasing the demand for compost products is an important consideration to help support the economics for additional capacity. Challenges to overcome for finding new markets for finished compost include variable compost quality, potential contamination from plastic, and limited awareness about municipal compost characteristics and production. Landscape operations form the largest market for municipal compost given fewer requirements for consistent quality.[34]

34 McIllfaterick, M; 2017; Identifying Sustainable Markets for Compost Products: An Evaluation of the Market for Compost Produced from Municipal Organic Waste and Factors Affecting Compost Utilization in Metro Vancouver; https://sustain.ubc.ca/sites/default/files/2017-17_Identifying%20Sustainable%20Markets%20for%20Compost%20Products_McIllfaterick.pdf

SHARED RESPONSIBILITY

The provincial government has set a target of 95% organic waste diverion from landfills by 2030 and continue to develop programs to support achieving this objective.

The *Food Donor Encouragement Act* also enables food rescue by limiting the liability of the donor.[35]

The CRD has a landfill ban in place for yard and garden materials, food scraps, and soiled paper products. Increased enforcement of landfill bans can substantially improve organice material diversion. Moreover, the CRD's SWMP includes a strategy focused on reducing avoidable food waste through efforts that include:

- Outreach to support residential food waste reduction,
- Working with food retailers to encourage more edible food donations and supporting food recovery organizations, and
- Advocating for regulatory clarity for 'best before' dates.[31]

The SWMP includes strategies to increase organics diversion and processing capacity.

CITY OF VICTORIA ACTION

The organics stream presents a significant opportunity to reduce waste while providing benefits in terms of food security and GHG emissions reductions. The City plays a direct role in diverting organic material from the landfill through its residential kitchen scraps collection program. The City was also a founding partner of Love Food Hate Waste Canada, an outreach campaign aimed at reducing avoidable household food waste.

Victoria and the region have several advantages that will support the City's efforts to reduce food and organic waste, such as:

- Curbside residential organics collection services
- Food rescue and distribution systems
- Industrial composting facilities
- Backyard composting
- Local food production

The City of Victoria can encourage the reduction of avoidable food waste from residents and businesses and support food rescue systems. The City can also require improvements to the source separation of organic waste and strengthen local organics processing capacity to ensure that unavoidable food waste can be composted.

35 Food Donor Encouragement Act, SBC 1997; http://www.bclaws.ca/civix/document/id/complete/statreg/00_97008_01


CITY OF
VICTORIA
ZERO
WASTE
VICTORIA
FOOD AND PAPER
EMPTY CONTAINERS
FOOD AND PAPER
EMPTY CONTAINERS
GARBAGE

GOALS

1 **All edible food is eaten**

2 **All unavoidable food and organic waste is recovered**

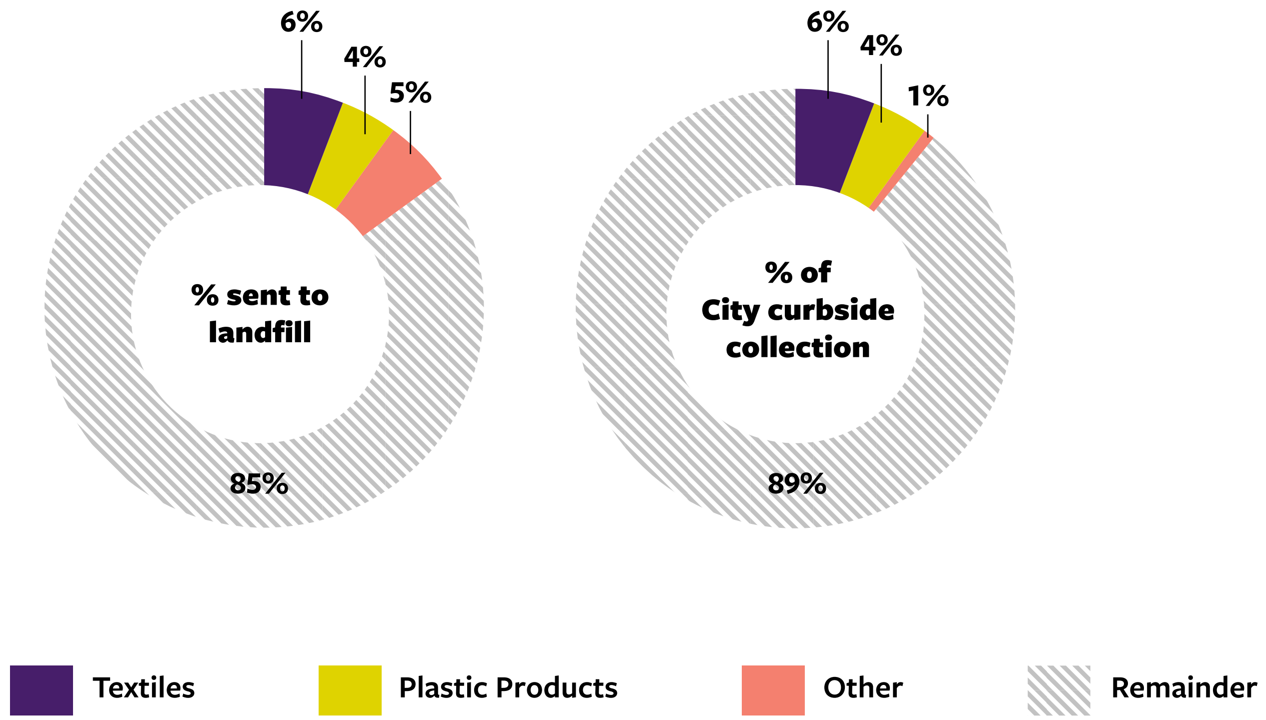
GUIDING INITIATIVES	STRATEGIES
Eliminate the Unnecessary	Encourage reduction of avoidable food waste
Make Reuse the Norm	Strengthen food redistribution throughout the community
Recycle the Rest	Require the source separation of organic materials across the community
	Enhance or introduce municipal services to improve organics diversion
	Support regional organics processing capacity
	Work with the tourism industry to promote local zero waste initiatives[28]
Cultivate Corporate and Community Leadership	Ensure the corporation leads the community in organics reduction, redistribution and diversion
	Reduce and divert waste at special events[28]

Durable Goods

DESCRIPTION

A durable good is a consumer product that can be used regularly for long periods of time. Many consumer products fall under this category including clothing, toys, sporting goods, electronics, lawn and garden equipment and household tools, as well as bulky items such as appliances, furniture and mattresses.

FOCUS AREA | Durable Goods



ISSUES

Durable goods include a broad range of products and materials, which are associated with numerous end-of-life management approaches, environmental considerations, and potential waste reduction solutions. Some durable goods, such as furniture, tools and textiles (e.g., clothing), have value and can be reused (perhaps with some repair) for many years, avoiding the need for disposal and conserving the natural resources needed to manufacture new products. Other durable goods, such as large appliances, are made from high value materials and can be recycled at their end of life. For many goods, quality is poor, reuse or recycling options are not available, and the inexpensive cost of new products encourages disposal and replacement. Waste reduction resulting from repair and reuse is also difficult to measure.

The reduction of durable goods waste through reuse and recycling has the potential for high economic value in terms of local job creation. Repairing and refurbishing durable goods can be labour-intensive, often requiring specialized skills. Examples of this are shoe repair, furniture refinishing and reupholstering and household appliance repair. Recycling durable goods can also require dismantling and segregating materials by hand.

DURABLE GOODS WASTE IN OUR COMMUNITY

The 2016 CRD waste composition study found that durable goods made up 15% of the waste sent to Hartland Landfill. This material was made up of small quantities of a range of different items, except for textiles, which represented 6% of the waste disposed at Hartland Landfill. The 2020 audit of waste collected through the City's residential curbside service found clothing and accessories comprised 6% of the waste sampled, and composite plastic products comprised 4%.

Durable goods, such as furniture, electronics and appliances, make up most of the illegally dumped items collected by City crews. The City of Victoria receives over 1000 service calls annually for illegally dumped items, and requests are steadily increasing year-over-year.

A 2016 report published by the Community Social Planning Council of Greater Victoria analyzed and identified priority waste streams that have the greatest potential for low-barrier job creation. Among the priority materials are textiles, carpets, and bulky items such as mattresses and furniture. The report recommends creating a recycling social enterprise for mattresses and furniture to help resolve a common waste diversion challenge while creating training and jobs for those facing barriers to employment in the community.[36]

36 Community Social Planning Council; 2020; Local Waste into Local Jobs: Labour Market Strategies for the Capital Region Resource Recovery Sector; https://communitycouncil.ca/wp-content/uploads/2020/01/Local-Waste-into-Local-Jobs-press-release-2016.pdf

SHARED RESPONSIBILITY

There are provincial EPR programs for several types of durable goods, including electronics, lighting and large and small appliances. There are currently no EPR programs for other bulky objects such as mattresses, carpets, flooring, furniture, or textiles. There are multiple barriers to recycling these materials, primarily the high cost and energy intensity of separating the composite materials. Additionally, there often aren't viable markets for the material components. Nylon and polyester carpet, which if successfully separated from the foam matting can be pelletized and sold in the plastics commodity market, is an exception.

The CRD's SWMP includes strategies to encourage waste prevention and support reuse activities in the region.

CITY OF VICTORIA ACTION

City strategies to reduce the waste from durable goods can include alternatives to purchasing durable goods and facilitating repair and reuse to extend the life of products in use. The City can leverage existing communication channels and its position as a community resource to provide guidance and promote sharing and repair initiatives. The City's recreational programming could be used to deliver educational workshops or other events that encourage durable goods waste reduction. The City can also play a leadership role by ensuring that procurement policies reduce durable goods waste generated by the City for products such as furnishings, equipment and clothing.

Measures to reduce and mitigate illegal dumping are also important for improving the management of durable goods. The City already provides street cleaning and collection for illegally dumped items, many of which are durable goods. The City can build on these services and take advantage of the associated corporate knowledge and experience. For example, the City could improve access to reuse and recycling alternatives for durable goods as a way of preventing illegal dumping and reducing waste sent to landfill. The City could also discourage illegal dumping through outreach, bylaw enforcement or by providing other disposal options.

GOALS

1 **All textiles are repaired or donated for reuse, repurposing or recycling**

2 **Appliance, furniture and electronic goods repair is common and accessible**

3 **All reusable and recyclable appliances and furniture are repurposed or recycled at end of life**

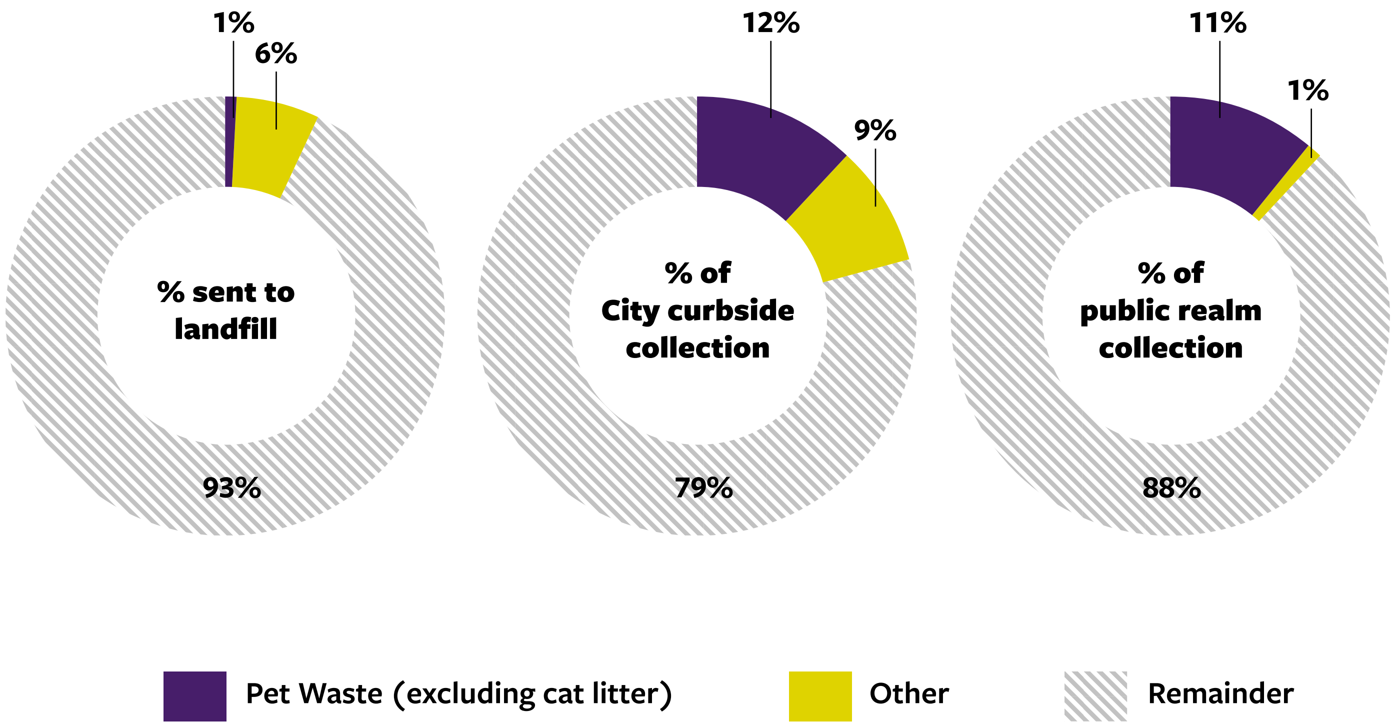
4 **The local sharing economy is robust and valued**

GUIDING INITIATIVES	STRATEGIES
Eliminate the Unnecessary	Encourage the purchase of experiences instead of things
	Encourage and facilitate the sharing economy
Make Reuse the Norm	Support reuse and repair to increase the longevity of durable goods
	Improve access to textile donation and collection services
Recycle the Rest	Improve access to bulky item recycling
Cultivate Corporate and Community Leadership	Establish corporate circular procurement policies
	Foster reuse and sharing culture in the workplace

Additional Wastes

DESCRIPTION

There are several other types of waste that do not fit into the categories above. While present in smaller quantities, or associated with fewer waste reduction options, these materials present challenges for the community and impacts to the environment.


1%
6%
% sent to landfill
93%
12%
9%
% of City curbside collection
79%
11%
1%
% of public realm collection
88%
Pet Waste (excluding cat litter)
Other
Remainder

ISSUES

In 2016, animal waste, cat litter, disposable diapers, and other hygiene products made up 7% of the total material sent to the Hartland Landfill.

Pet waste

Pet waste releases methane when landfilled and presents health and safety concerns for municipal workers handling this waste. Pet waste (excluding cat litter) comprised 12% of municipally collected residential waste during the 2020 audit. Pet waste comprised 11% of waste collected from the public realm and contributed one third of the waste collected from City parks.

Pet waste is challenging to reduce and divert. It may be possible to separate dog waste collected from public bins in City parks, however recovery or recycling of this material requires specialized facilities.

Disposable diapers and other sanitary products

Diaper contents release methane when landfilled. Disposable diapers and household hygiene products comprise 9% of municipally collected residential waste. Reusable diapers and services can support waste reduction, but disposable diapers will continue to be required for some people with disabilities.

Cigarette butts

Cigarette butts make up a large share of litter on City streets and are repeatedly the most common waste collected during beach clean ups[37]. Littered cigarette butts can be flushed into the stormwater system and end up on the shoreline. In addition, the toxins in cigarettes leach out when wet and pose a threat to marine life.

CITY OF VICTORIA ACTION

The City runs a program to collect and recycle cigarette butts discarded in public areas. There are more than 100 canisters across the community, which enable the collection and recycling of over 150,000 cigarette butts per year, helping to reduce a significant source of litter.

The actions below represent initial steps the City can take to address pet waste, disposable diapers and hygiene products. New infrastructure, technology and treatment approaches may present additional opportunities in the future.

37 Surfrider Foundation Vancouver Island; 2020; Hold On To Your Butt; https://vancouverisland.surfrider.org/hold-on-to-your-butt/

GOALS

1 **Pet waste is diverted from landfill and processed safely**

2 **Disposable diaper waste sent to landfill is minimized**

3 **Cigarette litter is eliminated**

GUIDING INITIATIVES	STRATEGIES
Eliminate the Unnecessary	
Make Reuse the Norm	Promote reusable diapers as an alternative to disposables
Recycle the Rest	Promote source separation and recycling options for pet waste
	Continue and enhance cigarette butt recycling
Cultivate Corporate and Community Leadership	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CITY OF VICTORIA

ZERO WASTE VICTORIA

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