Achieving Net Zero Buildings by 2050

Brief Summary

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Authors' Note concerning Scope

Of necessity, we are going to talk about topics that impact all of Ontario, and all of Canada. That is because this opportunity needs to be approached at that level. However, it is important to realize that this version of the document is being prepared primarily by residents of Etobicoke, Ontario – and thus reflects a view coloured by that urban / suburban experience. We will focus where we can on that southern Ontario urban / suburban environment – and look to the proposed CERO-ZEB group to expand this to cover all of Canada – including the different climate zones and requirements of rural and other types of urban (i.e. small towns and cities) environments.

Land Acknowledgement

We acknowledge that Etobicoke lies on land that is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples and is now home to many diverse First Nations, Inuit and Métis. We also acknowledge that Etobicoke is covered by Treaty 13 with the Mississaugas of the Credit.

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Summary

The total life cycle GHG emissions associated with all Canadian buildings[1] must be greatly reduced, achieving net zero incremental emissions by 2050 or sooner. This paper makes recommendations on how to do that.

Climate Emergency Response Organization - Zero Emission Buildings (CERO-ZEB)

Our primary recommendation is that Canada must create a large, well funded, well staffed, **Climate Emergency Response Organization (CERO)**, which is endorsed by all levels of government, and includes wide participation from academia and industry. The mandate of this consortium will be to develop and implement a robust strategic plan to reach net zero. Where feasible, early action will be initiated. But, development of a full strategy will require some preparatory work, and will take some time.

Our focus here is on the CERO tasks associated with Zero Emission Buildings (ZEB – thus **CERO-ZEB**). Tasks this consortium would own:

Identify the Technology Options	–	Assure that all of the key technology options (including the storage and distribution of thermal energy, as well as the implications for the electrical network if mostly CC-ASHPs) are properly evaluated for end-to-end cost and time-to-market effectiveness. This evaluation must involve rigorous analysis and modelling conducted by experts with deep knowledge of the basic science as well as the realities of doing the kind of construction required. It must include evaluation of the impacts to existing and new utilities so that an apples-to-apples cost and effectiveness comparison is possible.
Identify the Financial Options	–	Work with governments at all levels, and with the financial industry, define the mechanisms which can be used to make the required capital available to property owners, utilities, and to governments which need to upgrade buildings, create district heating and cooling service utilities, or upgrade electrical generation, storage, and distribution utilities.
Rules, Regulations, Guidelines	–	Assuring that the rules, regulations, and guidelines for the different climate zones across the country are well understood and harmonized across the country, so that material can be manufactured to consistent code and used anywhere, and that training and capability certifications for the required skilled workers are acceptable across the entire country

[1] Note that building codes differentiate between different types of buildings. Bob Bach has stated that a key difference is "Part 9 Buildings - less than 400 sq. m. of gross floor area, and/or 3 or fewer stories above grade; and Part 3 Buildings - all buildings that are not Part 9. Single Family houses and townhouses are defined as Part 9 Housing, while most multi-unit residential buildings (MURBS) are defined as either Part 3 MURBs or Part 9 MURBs. The Energy Codes are very different for Part 9 Buildings and Part 3 Buildings." In this document - we refer to buildings - and assume that many important sub-classes will be further defined in the future.

Scalability – To retrofit all buildings in Canada by 2050, assuming we are in full motion by the beginning of 2023, we will need to do 2,000 buildings per day[2]. This means that a good deal of thought needs to be put into assuring the proposed solutions are massively scalable.

Background

- Per Table-ES3 in Greenhouse gas sources and sinks: executive summary 2021, we see that in 2019, the 3rd largest source of GHG emissions in Canada is buildings – 91 Mt[3] of CO2 equivalent (12% of the 730 Mt total) .

Economic sector	2005	2014	2015	2016	2017	2018	2019	
National GHG Total	**739**	**723**	**723**	**707**	**716**	**728**	**730**	100%
Oil and Gas	160	190	190	181	183	191	191	26%
Transport	160	171	172	174	179	184	186	25%
Buildings	84	85	83	81	86	90	91	12%
Heavy Industry	87	79	77	76	75	77	77	11%
Agriculture	72	71	71	72	71	73	73	10%
Electricity	118	76	79	74	72	62	61	8%
Waste and Others	57	50	50	50	50	51	51	7%

- We believe that as one of the top 3, buildings warrants particular attention.
- We believe that although doing the work to address this is “hard” – we already know (basically, and in broad strokes) what to do – so we should start without delay.
- Further – addressing this challenge is a fantastic opportunity for Canada to grow its economy in a way that benefits both its citizens and the rest of the world – by taking our place as a global innovator and a source of skilled people who can make it happen.
- To get this done in time and in an economically realistic fashion will require a number of key things explained in more detail in the following pages – and highlighted here.

The Highlights

1) We need to agree on the guiding principles: Act early, and urgently; beware of dead-ends; avoid agenda-hitching; don't let perfection be the enemy of good; work together to create a trusted voice; and understand that the solution will not be one size fits all.

[2] See the calculation in Industrial Scale Action - this is certainly in the right order of magnitude.

[3] The abbreviation “Mt” is the standard abbreviation for “Megatonne” - which is 1,000,000 tonnes. A tonne (sometimes called metric ton) is 1,000 kilograms - so a Mt is 1,000,000,000 kilograms.

2) We need to adopt an all hands on deck approach – we need to obtain cooperation between municipal, provincial, and federal governments to ensure we can work together with academia and industry. This includes immediately creating a climate emergency response organization (CERO) (centre of excellence, community of experts, institute, consortium, etc.) with the mandate, capability, capacity and resources to dive further into the issues outlined here, take them to the next level of detail, and provide leadership and expertise throughout the needed transition. We need to be non-partisan – we need support from all political parties. This document will work to define the CERO-ZEB - the part of the CERO tasked with getting Zero Emission Buildings in place.

3) A key job for the CERO-ZEB will be to examine the technologies available to get to net zero buildings, and make recommendations for when each is appropriate. We want to be clear – our definition of appropriate is that the solution is both cost effective and can be implemented in time to be useful. Even though we state above that "we already know what to do", we need the CERO-ZEB to build the required models, and to gather the hard evidence. We may be in for a surprise, but we believe this hard evidence will support the following.

    a) Shallow Retrofit will be important.
    b) Cold Climate Air Source Heat Pumps (CC-ASHP) will play a key role.
    c) District Heating and Cooling (DHC) will also play a key role.

    NOTE: Within our working group, there is a diversity of opinion regarding the relative importance of CC-ASHPs and DHC as far as the final solution. Some of us believe that CC-ASHPs will be the key. Others are very much convinced that DHC has a much bigger role to play than is currently widely acknowledged in Canada. The CERO-ZEB will need to generate the models and conduct the tests to decide which of these approaches to favour in each specific set of circumstances.

    d) Solar will play a big role – Solar PV for electrical, Solar Thermal for heating, and Solar PVT for both.
    e) Deep Retrofit will play some role – but we believe mostly minor.

4) As well as technology identification, we need to look at The Financial Angle and make sure that the property owners, utilities, and governments can afford to implement the solution. This will require some innovative financial thinking – as well as regulations and scalability.
    a) We need to make it possible for the property owner or new property builder to get the work done.
    b) We need to make it possible for the businesses required to do the work to gear up to the required scale by providing the required finance.
    c) We need to make it possible to finance the required utility upgrades.
    d) We need to make sure that the financial support is in place to allow people to retrain.

5) This is going to take a lot of work. Remember when we said this would be hard? Well, a key part of that hard work will be making sure that the Rules, Regulations, Guidelines, and Training being used are well understood, and consistent across the country.

6) With consistent rules, regulations, and guidelines in place across the country, the stage is set for to roll out the changes required – not by handcrafting a unique solution for each building – but by rolling out the changes as an Industrial Scale Action – where retrofit can proceed at the required pace with the cost savings of mass production instead of handcrafting. New buildings should also benefit from this improved capacity.

Appendix A: Further Discussion

Guiding Principles

The following guiding principles are key to success:

1) "Act early, and urgently"[4].
2) "Beware of dead-ends"[5].
3) We need to avoid agenda-hitching[6].
4) "The guiding principle should be to not let perfection be the enemy of good"[7].
5) We need to work together to create a voice that all Canadians feel they can trust to give advice on how to get all of our buildings to net zero.
6) The solution will not be one size fits all.

This means that:

- We need to act ASAP – if we had started back in 1980 – we would have time to react to this situation at a normal rate – but we have delayed – and we now have an emergency on our hands and doing what is necessary is our only sane option.
- Even though we need to act ASAP – we need to be very aware of solutions that do not get us to our goal. For instance, it is the wrong time to install a high efficiency natural gas (NG) furnace, or gas–fired heat pump – it lowers your carbon footprint – but does not get you to the desired end.
- Mark Jaccard's book, "The Citizen's Guide to Climate Success", does a great job discussing agenda-hitching. We all have things we think are important which are not directly related to getting to zero carbon. If we try to hitch all of these issues to the zero carbon objective, we just make things more complicated. We need to avoid this – we want almost all Canadians to be able to support our drive to get to zero carbon building – and that is much easier if we do not ask them to support a bunch of other issues that they may have other opinions about.
- As Mark Jaccard says, "the guiding principle should be to not let perfection be the enemy of good". That means that as we define technology, financial measures, and the other required parts of this solution – we will no doubt encounter solutions which will work – but which are not perfect. If it is good enough for now – and does not lead us to a dead end – then let's adopt it and move on!

[4] See Net-Zero Pathways: Initial Observations at NZAB2050 Publications

[5] See Net-Zero Pathways: Initial Observations at NZAB2050 Publications

[6] See Mark Jaccard, "The Citizen's Guide to Climate Success", starting at the end of Chapter 6 for lots of discussion, including his statement that:
Mike Hulme noted in his book, Why We Disagree About Climate Change*, the climate-energy challenge has over time become like a "Christmas tree on which we each hang our own baubles"*

[7] Mark Jaccard, "The Citizen's Guide to Climate Success", Chapter 13, p254

- We need to create a trusted voice Canadians can look to for solid advice on the steps they should take to convert their existing building to zero carbon, and assure that any new buildings they are developing will be zero carbon. At this point – we seem to have a cacophony of opinions – and some of those opinions seem to not look at the whole problem. Thus, creating a community of experts (the CERO-ZEB) which can speak with a clear united voice to define the viable path(s) forward is key.
- Even in Etobicoke, let alone all of Canada, we have buildings of all sorts built over the last 200 years. When we consider all of Canada, the amount of climate variation is massive[8]. So – it is obvious that even in a single urban / suburban environment like Etobicoke – let alone all of Canada – more than one technology stack may be required.

  The same is true for financing – depending on the current ownership and many other factors – different types of financial arrangement may be preferred to make the conversion of an existing building to zero carbon, or creation of a new building as zero carbon.

All Hands on Deck

The quicker we can reduce our GHGs, the better off we will be. Also, our ability to use this opportunity as a way to grow our economy and become an exporter of expertise and products will be enhanced by moving sooner rather than later. That means that it is critical that we approach this as an all hands on deck effort.

This means we need to not treat this as a political issue. Per the letters we plan to send, we will be sending to members of the opposition as well as the government asking for them to all cooperate to make this happen as quickly as we can. Note that we are not taking a Pollyanna view here – we acknowledge the unpleasant fact that we can expect some push back at all three levels of government. But – we believe that the correct approach is to allow any politicians who wish to isolate themselves and their party from what we hope is a groundswell of public support to quickly get all buildings to zero emissions to make that choice. Then – come the next election – their choice can bear fruit – if the Canadian public is behind this effort – they will fail to be reelected.

Let's try to make the discussion more about how to do it directionally – rather than details – let that be the issue. Let's start with the assumption that all of us understand and believe that we must address GHG reduction[9], that is, let's assume positive intent from most participants in the discussion – and deal with it that way. In other words, let's work hard to get all Canadians on the same team and aligned with a national effort to get this done.[10]

[8] There are several interesting ways to define the climate zones of Canada. One of them is the Ecological Land Classification (ELC) 2017 standard which includes this interesting map: Terrestrial ecozones and ecoprovinces of Canada. Also of interest, searching the NRCAN website turns up several other definitions, but this Energy STAR definition which defines 3 climate zones, and this one which defines 4, may be the most useful. This NAIMA Definition (6 climate zones) is also of interest.

[9] However, "It Is Difficult to Get a Man to Understand Something When His Salary Depends Upon His Not Understanding It"what Upton Sinclair said in 1934 is worth remembering:

[10] Seth Kline talks about A Good war: Mobilizing Canada For The Climate Emergency. We agree with the idea, but want to avoid the war metaphor.

The Technology Options

To an important degree – this is the core matter. The CERO-ZEB is going to need to evaluate each of the possible technology approaches and make recommendations for when they should be used. Below is our list of which technologies we think are relevant, and our initial summary of when it is appropriate to use them.

Note that this section is written primarily with an eye on retrofit of existing buildings. A future version of this document may delve more deeply into the issues with new builds.

Summary

1) It makes sense to evaluate each building and perform shallow retrofit or deep retrofit on all buildings. We believe that in the majority of cases in Etobicoke, the appropriate option will be a shallow retrofit, mindful of the cost and disruption to building owners, including home-owners. We believe this process must be industrialized and the innovative financial model must be put in place, or it won't happen. This industrialization will apply to both the mass manufacture of components, as well as the installation. In some cases, it will make sense to address all the houses in a specific area at once to reduce effort and cost.

2) If the CERO-ZEB group determines that the electrical demands can be met on the cold days where CC-ASHP drops in efficiency to 1.0 or 1.2 – then conversion of some buildings to use CC-ASHPs makes sense, since no new heating utility is required. But – the key caveat is that this only makes sense if the electrical demand can be met. CC-ASHP may be used, perhaps aided by some in-building thermal storage. These installations will have to be carefully planned with the local electrical distribution company to avoid overloading any of its equipment.

3) The next priority should be to consider if it is possible for each building to be connected to an existing or new district heating and cooling (DHC) system in order to minimize both capital and operating cost to consumers.

   We strongly believe that DHC has a very large role to play. This is because thermal energy is much easier to store in large quantities for extended periods of time, is easy to collect from a wide variety of sources, and it makes no sense to spend billions of dollars upgrading electricity systems while wasting abundant thermal energy. Thus, at a minimum, new developments (such as Etobicoke Centre, and the Christie Lands) should be planned to exploit this approach. We also believe that the CERO-ZEB group can create the business cases to retrofit DHC into many, or even most, existing neighbourhoods.

4) Solar will be important to both the CC-ASHP (Solar-PV) and DHC (Solar-Thermal) plans. The CERO will need to determine if this best approach is to include solar in each building – or to build very large solar thermal arrays only on certain large buildings or nearby spare land.

5) In some cases, deep retrofits of specific buildings may be warranted. It may take a lot of research to determine the exact ways to carry this out in the variegated circumstances that apply across Canada in order to minimize the cost and disruption to building owners and occupants. That's partly why the CERO-ZEB group is needed. Some of this expertise exists in various departments but needs to be focused on achieving NZ2050, without inciting a building owner or tenant revolt at its expense to them.

Shallow Retrofit

The objective with this approach is to take a “no regrets” approach to reducing the building's GHG emissions. In other words, these are measures that are fully compatible with fuel switching or other steps. This list needs to be reviewed by the CERO-ZEB group and further fleshed out.

Unless you are planning to do a Deep Retrofit, this should be your first step. These steps will get your building to a state where its ability to be effectively heated or cooled is improved, and its other GHG emissions are reduced.

1) Convert gas stove to electric induction.
   Many chefs give induction stoves rave reviews: they have the same “instant control” of heat – and they are much safer – fewer burns, and no worry about NG escaping into the kitchen. In Consumer Reports[11] induction ranges are also highly praised. Note that you may have to switch out any cookware that is not compatible with induction (flat bottom, magnetic material).
2) Convert gas water heater to electric. NRCan lists several types of water heaters with 0 GHGs: heat pump water heaters, Solar water heaters, Tank style electric water heaters, and tankless water heaters. NRCan also includes a Water Heater Guide which supplies additional information.
3) Convert gas clothing dryer to an electric dryer. If you already have an electric clothes dryer, or you are replacing a gas clothes dryer, consider a heat pump clothes dryer. Preliminary research indicates that there is a significant energy saving with the heat pump style, but that clothes do take longer to dry, and a water drain is required.
4) Improve air-tightness and manage ventilation. Have a look at Air Sealing Your Home for an excellent list. Also see the Weatherize page (both maintained by energy.gov).
5) Improve insulation where possible.[12]
6) Try to minimize embodied carbon (more about this later).
7) Double check that attic – make sure a good air-tightness barrier between the attic and the house, and that the insulation is still up to par.
8) Make sure those doors are sealing well.
9) In some cases, it will make sense to replace windows – in other cases – it is less obvious that this is a worthwhile step with a shallow retrofit.
10) Calking where obvious air leaks can be dealt with by this simple step.
11) In some cases, it may make sense to replace doors – in other cases it is less obvious that this is a worthwhile step.
12) In some cases, for homes with attics, it may make sense to add additional roof vents.
13) Review the NRCan Keeping the Heat In website for other applicable ideas.

[11] Accessible through Toronto Library system if you have a library card

[12] Note that NRCan’s Keeping the Heat In website includes a page on basement insulation that states “Some authorities have expressed concern about the possibility of frost action and structural damage when foundations are insulated from the inside. The concern is that frost will penetrate deeper down the outside of the foundation wall. Research has found that this is not a problem. Under some circumstances, such as in soils that are particularly frost-susceptible in extreme climates, there could be a problem caused by some construction techniques. Check with your local building authorities or find out if your neighbours have experienced any difficulties with frost action on their foundation.”

Deep Retrofit

In some cases, it will be worthwhile to consider a deep retrofit for a building. This will involve making significant changes to the building well in excess of those listed in the shallow retrofit section above. Typical steps might include:

1) Addition of ventilation management systems.
2) Addition of cladding on either the exterior and /or the interior of the house to improve airtightness and insulation values.
3) Reengineering of roof and attic spaces to improve insulation values and ventilation management.

Note that the NRCan Housing Innovation website contains much material which will be applicable to both deep retrofit and new buildings.

Solar

There seems little doubt that Solar will play a large role in reducing GHGs.

Solar PV

Solar PV (PV stands for photovoltaic) has become very commonplace and in a location like Etobicoke – the objective would be to integrate Solar PV into the grid. The CERO will need to determine the costs and mechanisms required to allow for large scale roll out of Solar PV to be effective. If most / many buildings are generating electricity, and the network capability to transmit and then store that electricity until it is needed does not exist, then why bother with that large build out of Solar PV generation capability?

Solar Thermal

If the DHC option is pursued, then we believe that Solar Thermal will have an extremely large role to play. In addition to DHC, NRCan lists several other attractive uses for Solar Thermal, including the water heater application already listed. It seems that Solar Thermal will have a larger role to play in large applications – that is – in things like DHC and large buildings where providing a heat sink for thermal energy storage is economically sensible.

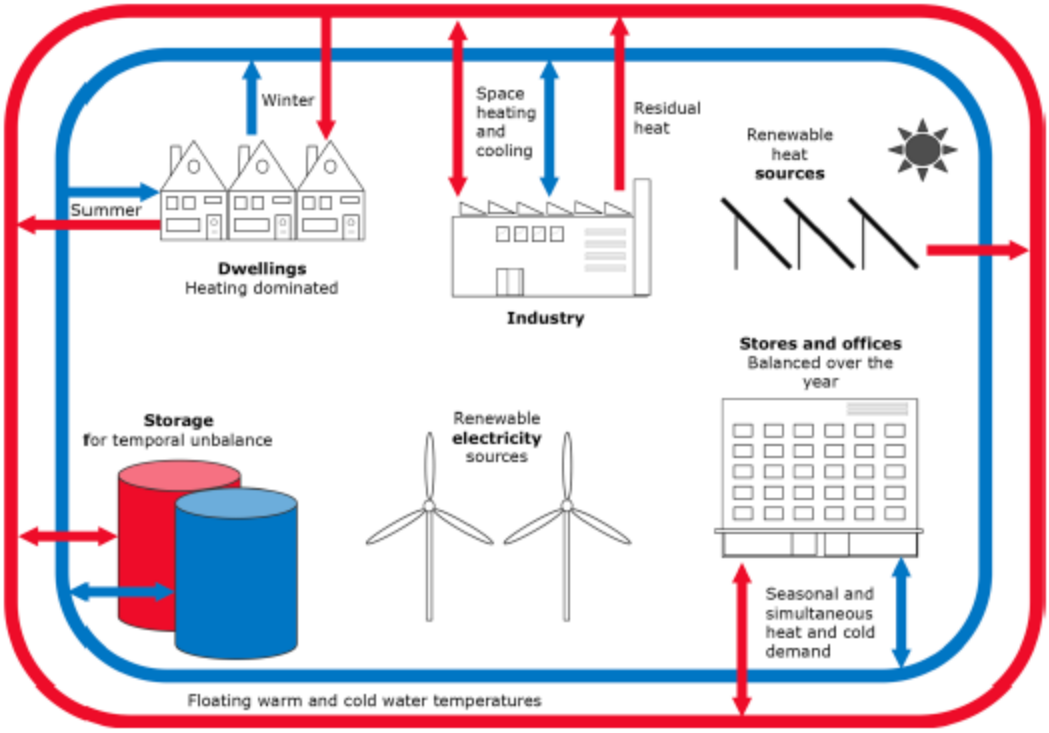
Solar PVT

Solar photovoltaic thermal (PVT) is the inclusion of both electrical generations and thermal energy collection into an integrated system.

With both Solar Thermal, and Solar PVT, the possibilities for exploitation of a Solar Assisted Heat Pump (SAHP) should also be investigated.

District Heating and Cooling (DHC)

Our working group believes that DHC must play a key role in getting to zero carbon building in urban and suburban areas.



[13]

The above diagram shows how a 5th generation DHC solution works. The idea is to use water not much above or below ambient as the storage of thermal energy – and then use a heat pump at each building to extract the energy. During the heating season, heat is extracted from the hot loop, and the cooler water is sent on its way in the cool loop. In the cooling season, the cool loop is used to extract heat from the house, and that heat is sent on its way in the hot loop where it can be seasonally stored for use during the heating season

So instead of an air source heat pump – it is a water to water heat pump. Much more efficient, since water is a better conductor of heat than air. Further, heat is much easier and cheaper to store than electricity[14]. Thus, our working group would make the following statements[15]:

- It makes sense to capture and use “low value” thermal energy for heating and cooling - and conserve “higher value” (and thus more expensive to generate) electrical energy for other high value purposes
- Even with costly retrofits, converting all houses to CC-ASHP is only viable if the large amounts of electric heating backup needed on very cold days when the COP will drop to around 1 can be made available.
- District energy, combined with solar panels and thermal storage, can meet all heating, cooling needs
- Optimal design will integrate components operating at different temperatures, as low as 5 C
- In many locations, what is currently considered waste heat can be captured and used by a DHC system

[13] By Stef Boesten, Wilfried Ivens, Stefan C. Dekker, Herman Eijdems - Stef Boesten, Wilfried Ivens, Stefan C. Dekker, Herman Eijdems: 5th generation district heating and cooling systems as a solution for renewable urban thermal energy supply. Adv. Geosci., 49, 129–136, 2019. https://doi.org/10.5194/adgeo-49-129-2019, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=92036189

[14] Many interesting papers about Borehole Thermal Energy Storage (BTES) exist. For instance, see ScienceDirect, the Drakes Landing article, or for thermal storage in general, see Thermal Energy Storage.

[15] See Martin Green’s 2021-10-15 Presentation to the GNN Retrofit group for a similar list

- Combination of modest retrofits and solar powered district energy is much less expensive than deep energy retrofits

So – we believe that DHC has a key role to play. The details of the exact economic model, including impacts due to regulations about where the heat lines can be run, and the storage facilities built may mean that DHC is only part of the solution. However, we strongly assert that it is a key part – and we are looking for the CERO-ZEB to further validate this.

Implementing DHC will is likely to require the creation of district energy utilities:

- The utility model will allow for the large capital outlay to create the infrastructure, and then be repaid over many years. Typical utility style lending periods to pay back large capital outlays can be in the 30 year range, and are often very attractive to investors like pension funds who are looking for safe long term investments.
- Challenge municipalities to be more flexible in dealing with DHC and its customers, e.g. forgive development charges on the extra rentable space opened up by DHC eliminating in-building boilers, chillers and cooling towers, allowing micro-grids to cross city streets.
- The standard practice for DHC is to install the energy transfer stations at little or no cost to the customers and charge rates that are no higher than the consumers current cost and slightly escalate over time in line with the consumers' income. DHC service contracts represent excellent collateral for large, very long-term debt at low interest rates (e.g. from the Canada Infrastructure Bank.)
- Hence, every cent of debt can be repaid with interest over 30 to 40 years.

For more information about DHC:

- Please see John Stephenson's work in this Folder
- Please see Martin Green's 2021-10-15 Presentation to the GNN Retrofit group
- Please see Martin Green 2021-12-01 submission to the Infrastructure and Environment Committee

Cold Climate Air Source Heat Pumps (CC-ASHP)

There is no doubt that CC-ASHPs are going to play an important role in getting us to buildings which emit zero GHGs. This is because they work very well when the temperature remains high enough for their Coefficient of Performance (COP) to remain high. However, at lower temperatures, as their COP falls near to 1 (or perhaps lower), the requirement for auxiliary heat grows large. Thus, the cost to the building owner can be high.

The reason Solar PV is likely an important part of a CC-ASHP solution is that when you compare the cost of NG to electricity you find out that electricity is much more expensive. If we look at the NRCan Data, and the NRCan Conversion rates, we find that 1 Gigajoule (GJ) of NG cost $8.781 and 1GJ of electricity costs $32.778[16,17] – which means electricity is nearly 4 times (3.732) the cost of NG. So – even though a high efficiency gas furnace will still have a COP < 1 (meaning you will need more energy than for an electric radiant heat solution which has a COP of 1), the cost of switching to electric will be very noticeable – unless the COP is very high (say, >3).

[16] NG - 1 GJ = 26.853 m^3 @ $0.327/$m^3$, Electricity - 1 GJ = 277.778 kWh @ $0.1118/kWh

[17] Alex Cameron notes that comparing these NRCAN rates to his rates - he sees that his NG charge for the last 12 months averaged $0.417/$m^3$ (higher) and that my electric charge for the last 3 bills averaged $0.1875/kWh (also higher). Of note - the difference in rate is still NG = $11.198/GJ and Electricity = $52.083/GJ - so electricity is more than 4 times as expensive

The question becomes “What is the cost to upgrade the electricity distribution network, electricity storage infrastructure, and electricity generation capabilities to deal with the inevitable cold snap which coincides with cloudy (i.e. low or no Solar PV availability)?” This is key. In fact, the heating peak generally occurs around 5 AM on a winter’s day before the sun comes up and the amount of energy required to keep a house warm at that low temperature for several hours makes even Tesla’s very expensive home battery systems inadequate.

Thus, the job of the expert consortium becomes understanding what the costs are to upgrade the electrical network, storage, and generation capacity to deal with that scenario; and to model the cost to the consumer of using that amount of electricity, and to thus determine when CC-ASHPs make sense as part of the solution here in Etobicoke.

We note that most of Canada can expect this problem with CC-ASHPs to an even larger degree than here in Etobicoke (which is rated as Zone 5)[18]

Other Options

There are other options which may require consideration, and which the CERO-ZEB group should look into to determine if they are realistic. These include:

- Convert current NG usage for building heating to captured Natural Methane (e.g. swamp gas)
- Convert current NG usage for building heating to Hydrogen

We will not explore these further here since we do not believe them to be realistic. However, as previously noted, the CERO-ZEB group we propose will need to further evaluate these options, and they may have a bigger role to play than we currently believe.

Other options which may be important include:

- Biomass (provided care is taken to ensure it is truly low carbon such as biochar)
- Combined Heat and Power (a feed to DHC) from heat engines, other than those fired by fossil fuels, e.g. concentrated solar, biogas, biomass, deep geothermal, or nuclear.

The CERO-ZEB group will need to create and evaluate an authoritative list.

A Note About Embodied Emissions

First, for clarity we mean the GHGs emitted during the retrofit or initial construction of a building when we refer to its “embodied emissions”. Things get a bit tougher to clearly define when we start talking about the services (electric, water, DHC, transportation) which service that building – but at least in broad terms – we have a working definition.

So, when doing a retrofit, or planning a new building, it will be really useful to have a mechanism we can agree on to measure and compare embodied emissions of one approach to the embodied emissions of another approach.

[18] In addition to the climate zone information cited earlier, note that the NRCAN Air-Source Heat Pump Sizing And Selection Guide clarifies that the “climate zones” referenced in the NAIMA standard quoted earlier are defined by ANSI/ASHRAE Standard 169. This report also clarifies that when using “Climate Zones for ASHPs”, we find that “Canada is subdivided into five ASHP climate zones described as: Marine, Cold/dry, Cold/humid, Very cold, and Subarctic”.

For instance, when we compare the embodied emissions of building a DHC solution to a CC-ASHP solution – exactly where do we draw the line – and how do we do that comparison?

This leads us to consider some of the discussions around scope1, scope 2, scope 3 emissions. The IPCC and other organizations all appear to use the standards defined by the Greenhouse Gas Protocol Organization. The GHG Protocol for Cities defines the scopes for cities as follows:

Scope 1 – GHG emissions from sources located within the city boundary.
Scope 2 – GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3 – All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

The Corporate Value Chain (Scope 3) Standard defines scope 3 as all the emissions associated with a business that occur "outside of its own walls–from the goods it purchases to the disposal of the products it sells".

When defining embodied emissions, the CERO-ZEB will need to consider and align with these standards.

The Financial Angle

There are two key aspects to the financial angle of getting to green building that we want to discuss. First, we need to have a reply to the people who say "We can't afford to do this". Second, we need to define the mechanisms we can make available to building owners and communities to allow them to make the capital outlays required.

We Can't Afford This

We need to compile the authoritative numbers and have them available to quote. Because this statement is complete hogwash. If you compare the cost of climate change left unmitigated to the cost of addressing it – it is a slam dunk winner. It is much cheaper to address this sooner rather than later. That is just assuming we only deal with the concrete numbers caused by the cost of the multiple climate disasters. If you include a cost assigned to human suffering, the loss of diversity, and the other impacts of climate change, the case becomes even clearer.

The "we can't afford to fix it" attitude is hogwash. We must try to engage those who espouse it in a meaningful conversation and help them (or at least try to help them) understand the reality we must deal with.

Capital Outlays

So, yes, we can afford to fix this – because that is our only option – and it is cheaper than allowing runaway climate change to destroy the world. But – it is going to be a high capital investment project to make this happen. We have already highlighted the ability of utilities such as the electrical utility or the proposed DHC utility to take on long–term debt and keep costs to consumers low. What are some other methods that can be put in place to make this capital available? Another job for the CERO! But, some very good work has already been done on this, and we will highlight a few of these options:

First, let's consider Local Improvement Charges (LICs). The Clean Air Partnership has done some excellent work with its Collaboration on Home Energy Efficiency Retrofits in Ontario (CHEERIO) to define how a LIC could be used to make the capital costs associated with these upgrades manageable. As they state in their Local Improvement Charge Frequently Asked Questions document:

> *Local Improvement Charge (LIC) financing is enabled by the Ontario Ministry of Municipal Affairs and Housing and has been used in Ontario municipalities for decades. LICs are used by Ontario municipalities to finance local improvements such as sewers and sidewalks. For example, a municipality could finance the construction of a sewer system in a new residential development. It would recoup its investment, including capital, interest, and administration costs, by imposing a special charge on the property tax bill of the properties benefitting from the investment. The LIC charge is associated with the property, not the owner. So, if a home with an LIC is sold before the costs are fully recovered, the next owner continues paying the charge on the property tax bill until the full cost is recovered.*

The key is that the charge / loan is associated with the property – not with the person. The other key will no doubt be to assure that sufficient capital can be made available to the municipalities in the first place.

Second, we have heard people like Mark Carney talk at the UN and COP26 about sustainable finance. Well, let's hold them to that. We need to get some of these financial experts to offer input on ways to make this money available to do the capital investment required to jump start the utility model, as well as the gear up of training and business investment required to get this work done at industrial scale.

- The Canada Infrastructure Bank should be involved in financing as it did for Enwave, but much more broadly and its current budget of $30 billion is not likely to be anywhere near enough, Canada-wide.
- Maybe there is a role for "Green Bonds", or other financial instruments of that nature

Third, instead of tax credits associated with a person, we need to look at credits associated with the property and the community where the upgrades are happening. That is, we need to define more devices like a LIC which allow for the property and the community to be upgraded, without giving a gift to the owner.

Fourth, last but not least, let's consider training for the people who will be doing the work. Again, we will need innovative finance to assure that they can afford to get the training. Also, there will be a lot of opportunity for the creation of new business – and we need to assure that methods for these businesses to get the required seed funding are in place.
There are no doubt lots of good financial innovations which can be used to get this done – we need the CERO to define them.

Rules, Regulations, Guidelines, and Training

There will be a lot of work to be done all across Canada to get the required upgrades to community infrastructure (DHC, electrical networks) and individual building done. This creates a great opportunity to have people displaced in other industries upgrade their skills and continue to participate in a productive economy. To make this happen as quickly and efficiently as possible, we see the following steps as being key:

1) Take a national approach. Make sure that rules, regulations, guidelines, and training certifications are aligned at a federal level across the country.

2) Create CERO-ZEB sub-groups that work with each provincial authority in a cooperative way so that regional differences and requirements are respected and acknowledged.

3) As per the previous section about finance, it will be key to assure that people being trained to do the work have access to the required capital to get the training and continue to support their families while learning these new skills

4) A key to making this new approach to building and retrofitting work will be to assure that high quality production is possible. That is, the work will need to be of high quality, and the workers will need to be able to work fast and efficiently. Thus, certification to high standards, and good processes for monitoring and improving processes will be required.

Key examples will include:

- Building codes
- Moving away from new NG hookups
- Sunset clauses on existing NG
- Certifications of building components to various green standards
- Training & Certification of installers to various green standards
- etc

Industrial Scale Action

The task at hand is huge. The number of buildings that must be upgraded may be in the order of 13M across Canada[19]. That means that one-at-time handcrafted solutions are out.

- We want to get these building all to zero, at least scope 1 emissions, by 2050
- Let's assume (rather optimistically) that we are up and rolling with an industrial process by 2023-01-01
- That gives us 27 years
- That means 481K buildings need to be upgraded each year
- There are about 254 work days in a year (365/7*5 – 6 statutory holidays)
- That means across Canada – we need to average just under 2,000 buildings a day – for the next 27 years.

So – we need to make darned sure that we can

- Scale up the Availability of the Required Workers – Training and certification, and just a lot of people to do the work.

  This presents an opportunity – companies and employees in industries that are threatened by the transition to green technologies will often have the skills which lend themselves to retraining to work in the new green technology. This retraining and thus ability to keep working will act as an enabler of the transition.

- Rationalize the approval process to make the scale of the work possible

- Scaling Up the Availability of the Required Materials – Manufacturing and supply chain issues will be critical

[19] https://wiki.openstreetmap.org/wiki/Canada/Building_Canada_2020

Final Thoughts

This is a big job. Do not fool yourself, we will need a dedicated all hands on deck effort to make this happen. But – we can do it – because we must. Thanks for reading to the end – hopefully the next draft of this will be a bit shorter and easier to consume

“I apologize for such a long letter – I didn't have time to write a short one.”

— Mark Twain

Change History

The key contributors to this document are listed below.

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When	Description
2021-12-14	1st draft for limited review
2021-12-17	2nd draft for ECA core group review
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2021-12-22	4th Draft - for submission to NZAB2050 and further public review