The Town of Halton Hills

Vision Georgetown

Energy Masterplan

Issue | July 6, 2018

Job number 240009-00

Arup Canada Inc.
77 Water Street
New York
NY 10005
United States of America
www.arup.com

ARUP

Contents

1 Executive Summary

This report seeks to answer three main questions in the context of the new Vision Georgetown development:

1. Is a district energy system feasible based on a number of key criteria?
2. What combination of applicable technologies will help the development reduce its carbon footprint?
3. How will the final strategy be implemented?

1.1 Is a district energy system feasible based on a number of key criteria?

District Energy Systems (DES) are thermal grids that distribute heating and/or cooling by transporting hot and cold water to various buildings in a community. Individual buildings on DES have no boilers, chillers or cooling towers. All their heating and cooling is provided by the DES. This definition can be expanded to include electricity as well.

While there are numerous sources with which to provide heating, cooling or electricity to a community, one of the most common and easiest to evaluate is that of a cogeneration plant (also referred to as CHP – Combined Heat & Power). In evaluating the financial and economic applicability, it is important to have:

- A steady base load for both electricity and heat through a mix of different energy profiles (residential, commercial, industrial, retail and institutional) to allow for year-round operation
- High density and compact spatial arrangements to reduce the cost of pipework and reduce heat losses
- A low carbon energy source

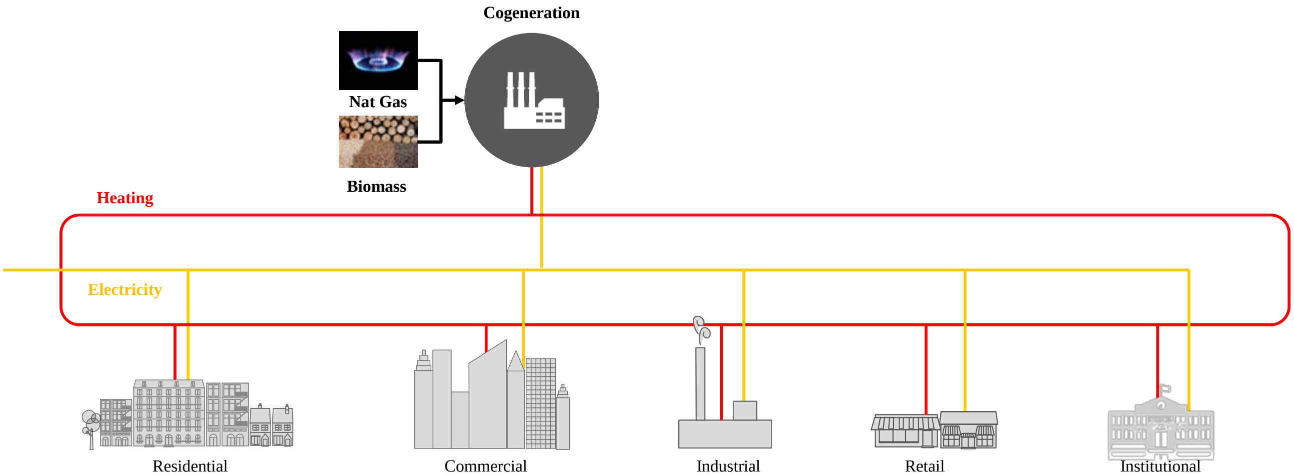


Figure 1 - Cogeneration plant providing heat and power to a range of consumer types

With this in mind three scenarios were developed:

1. A CHP system to meet the whole development load
2. A CHP system to meet the medium-high density areas only
3. A small/modular CHP system to meet pockets of high density demand only

These were then evaluated against the below four main criteria, in order of importance:

1. Financial return (simple payback)
2. CO2 reduction potential (for both a natural gas and biomass system)
3. % site demand met (# of units connected)
4. Resiliency

The table below is a high-level summary of the results of a Red/Amber/Green rating system applied across the three scenarios and the four main criteria.

Table 1 – CHP scenarios and decision criteria matrix

	1 Full Site CHP	2 Med-High Density CHP	3 Small CHP
			
Simple Payback[1]	39 yrs	20 yrs	12 yrs
CO_2 Reduction Potential (Natural Gas)	None	None	None
CO_2 Reduction Potential (Biomass)	High	Medium	Medium
% Site Demand	High	Medium	Medium
Resiliency	High	Medium	Medium

Simple Payback

The above table shows that the for the top criteria, financial return, a full site CHP system is not financially feasible because of the significant upfront capital costs associated with such a large network of pipes, but without a high density of energy demand. The payback becomes more favorable when the system is used to supply only medium to high density areas and becomes even more favorable when setup in small, modular nodes (thereby minimizing pipework) for high density areas e.g. the community core.

CO_2 Reduction

As the current Ontario electricity grid is cleaner than natural gas the use of natural gas as the CHP fuel source will mean that CO_2 emissions will increase in all cases. The use of biomass is a feasible, alternative fuel source as it has a very low carbon emissions factor which is currently significantly lower than Ontario's grid. Therefore, the larger the biomass CHP system, the more electricity (and heat) will be offset with a cleaner fuel and therefore the larger the CO_2 savings.

[1] Simple payback based on delta between baseline and a natural gas CHP for capex and savings. Financial analysis not based on a biomass CHP unit.

% Site Demand
The larger the CHP size, the larger the site demand that can be met. This also relates to the goal of Halton Hills connecting 2,713 dwellings to a District Energy System. However, if a financial payback or CO_2 reduction is not achieved, then this criterion should be reevaluated.

Resiliency
This is tied closely to site demand. In the event of an electricity outage, a larger CHP size means that more of the community can be provided with backup electricity and heating. However, again, if a financial payback or CO_2 reduction is not achieved, then the type of system should be re-evaluated. A simple backup generator might be preferable to a full District Energy System.

Recommended Option
As the main driving criteria is financial payback, the recommended option is to choose a small, modular CHP unit that is sized to the medium and high-density demand in the main town center (option 3 in the above table). In this case the system will also help contribute to achieving Halton Hills' high-level goal of connecting up to 2,713 dwellings to a district system by 2031.

However, as carbon is also a key criterion, consideration needs to be given to the type of fuel input. The use of natural gas requires minimal infrastructure, but because it is dirtier than the local grid, it means that carbon emissions will increase. Instead, the use of biomass as a fuel source will help to reduce carbon emissions, however, other factors need to be considered as well, and these are detailed in Section 6.3.2.

1.2 What combination of applicable technologies will help the development reduce its carbon footprint?

As a new community, Vision Georgetown has the opportunity to implement selected technologies and build modern structures that could drastically reduce the energy demand, compared to traditional construction. A community that sets the standard for the future would integrate smart building controls to optimize energy consumption while improving indoor environments. In addition, the new development can take crucial steps towards meeting climate, energy and emissions goals by generating and storing its own energy on site, and choosing site specific technologies that are both flexible and cost-effective.

1.2.1 Achieving Net Zero

Getting to Net-Zero Carbon requires a two-pronged strategy: aggressive demand side reduction measures, and innovative, yet applicable, supply side technologies.

From the demand side Halton Hills already has in place a progressive Green Development Standard (GDS) which is more stringent than the MNCEB, ASHRAE 90.1-2010 or the Ontario Building Code 2012. However, even more aggressive strategies than these will be required to reach Net Zero status.

From the supply side, there are a range of technologies that could be used. The diagram below illustrates each potential technology and whether it applies to heating, cooling or electricity. Given site specific considerations and feedback from the February 2016 workshop three key technologies were prioritized to feed into the scenario analysis: Cogeneration (natural gas or biomass), solar photovoltaics and solar thermal. These are highlighted in the dotted boxes in the below diagram.

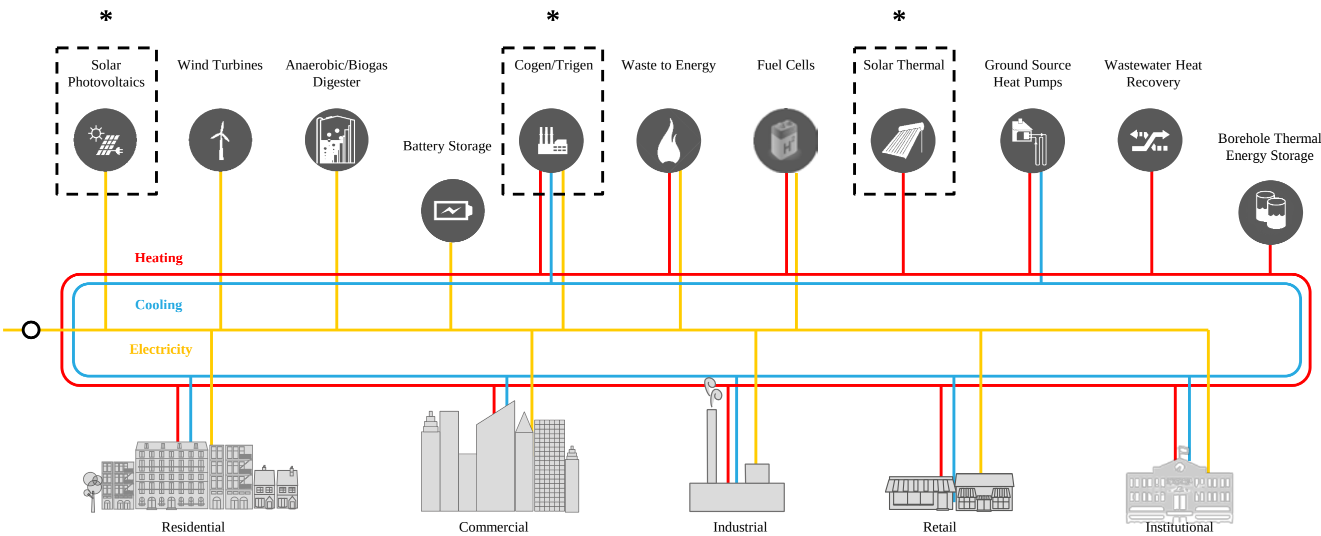


Figure 2 – Full range of supply side technologies with the prioritized technologies highlighted in a dotted outline

Three potential scenarios were then developed with the most applicable measures or technologies.

Scenario 1: Moderate

In this strategy, the Halton Hills GDS code is used to set the demand side reduction targets. Small natural gas CHP units (<1 MW) are then used to meet modular demand and provide resiliency to blocks of medium to high density areas. Solar photovoltaics and solar thermal are split evenly across 60% of all rooftop areas to help reduce carbon emissions.

Scenario 2: Aggressive

An even more aggressive target is set beyond the Halton Hills GDS to further reduce energy demand. An electric Air Source Heat Pump (ASHP) will provide heating and domestic hot water instead of a natural gas boiler. Solar photovoltaics will cover 60% of all rooftop areas. Going all electric lowers carbon emissions due to the clean grid.

Scenario 3: Reaching for Net Zero

As in scenario 2, an even more aggressive target is set beyond the Halton Hills GDS to further reduce energy demand. A biomass CHP (with backup biomass boilers) will be used to provide heat to the entire site. Solar photovoltaics will cover 60% of all rooftop areas.

The below waterfall diagram illustrates, from left to right, the initial reduction in CO_2 emissions as a result of more stringent buildings codes, and then proceeds to demonstrate the impact of each scenario, and that of the underlying technologies/strategies, on CO_2 emissions.

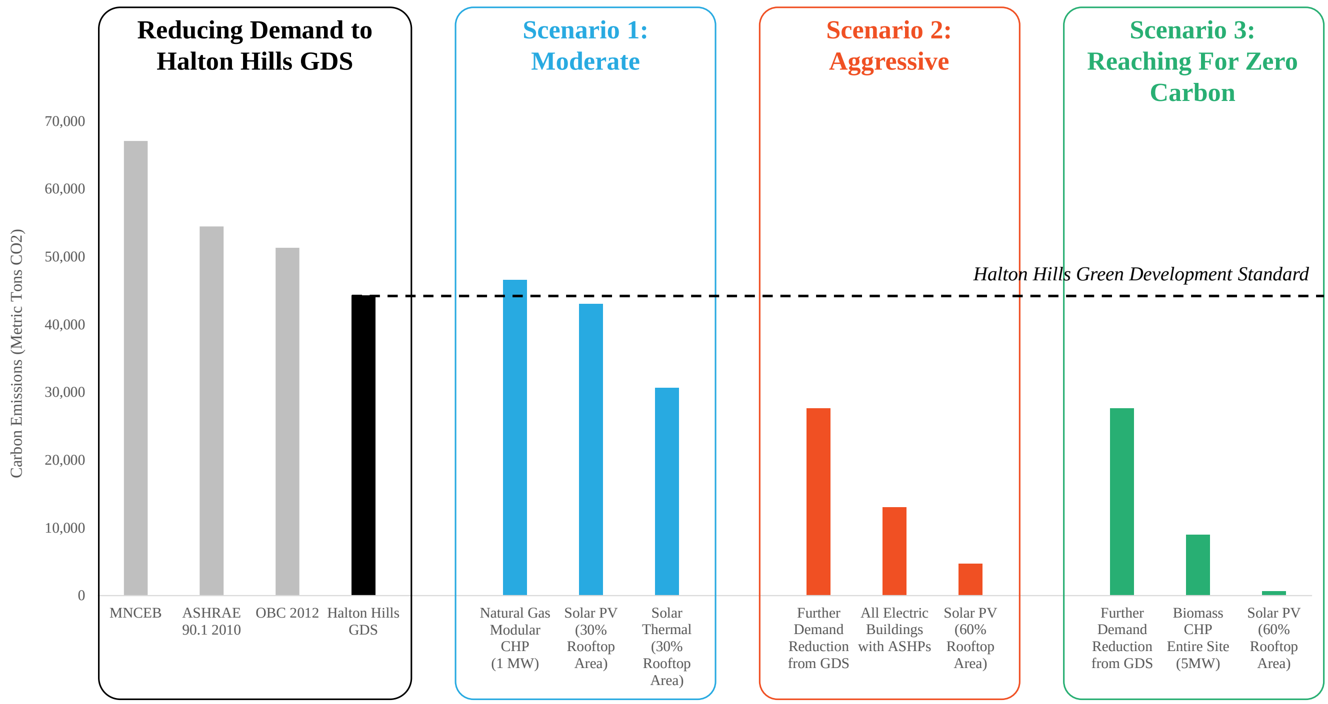


Figure 3 – Carbon emissions waterfall diagram for demand reduction and then the three defined scenarios

Recommended Option:

The scenarios were put together to test the potential of a combination of technologies to realize a reduction in carbon emissions. The recommendation, as before, depends on the key goals of Vision Georgetown, but will likely be a hybrid of the above scenarios. For example, a further reduction from the Halton Hills GDS energy demand, with a small 1 MW biomass CHP and small amounts of solar PV and solar thermal will help the development reduce its CO_2 emissions significantly. Other technologies can then be used to bridge the gap in the future years.

Or the all-electric option (aggressive in the table above) will allow the new development to effectively piggy back on the provincial electric grid becoming even cleaner in the years to come. It should be noted that Halton Hills Community Energy Corporation is interested in leading the evaluation of appropriate technologies for Vision Georgetown, as well as funding and managing innovative energy technologies that provide a good return on investment.

The other technologies not mentioned above can fit into two categories:

Potentially study further:

Ground Source Heat Pumps (GSHPs) with seasonal Borehole Thermal Energy Storage (BTES) and fuel cells (but these are very similar to small, modular CHP units). Batteries can be used to facilitate energy storage, but will not help with energy generation or carbon. Smartgrids can be implemented to help smartly align demand with supply.

Not Viable or Requires Significant Infrastructure:

Wind Turbines, Anaerobic/Biogas Digester, Waste to Energy Plant and Wastewater Heat Recovery

1.1 How will the final strategy be implemented?

Once the final strategy is selected there are a number of key considerations to bear in mind to ensure that it is properly and effectively implemented.

Continue to drive code improvements

The Halton Hills GDS is already quite progressive, but further code amendments will ensure that developers are building to the highest standard of energy efficiency design across the Americas and the world. This will ensure that there is a smaller CO2 gap to close when selecting supply technologies

Encourage developers to exceed the code

Encourage and incentivize the developers to meet, and exceed, the local code thereby ensuring that there is a smaller CO2 gap to close when selecting supply side technologies. Also ensure that buildings are at least solar PV or solar thermal ready.

Track and strategize applications for incentives and grants

The landscape is continually changing in terms of the available funding for energy efficiency, energy supply and other innovative technology projects. To ensure that the new development takes advantage of all possible “free” funding sources it is critical to develop a plan to continually track, and apply for, all relevant incentives. This includes recent $2 billion funding for Net Zero projects.

Determine the appropriate funding sources and financing strategy

The funding sources determine how costs are covered and/or how service providers are compensated for the services they provide. The financing strategy determines how debt, equity, grants (covered above) and other third party capital sources are used to help cover upfront capital expenditure. Halton Hills Community Energy Corporation and its affiliates are already engaged as a potential source of investment to both fund and manage key assets such as CHP, community solar, EV charging, or energy storage.

2 Georgetown Vision Statement

2.1 Halton Hills Mayor's Community Energy Plan and Net Zero

Halton Hills Mayor's Community Energy Plan provides a few initial goals for carbon reduction and district energy connections for the town of Halton Hills – both for existing buildings and new construction. The stretch goals are:

- 35% reduction in per capita greenhouse gas emissions by 2031
- 14% reduction in total greenhouse gas emissions by 2031
- Attach up to 2,713 dwellings to a district system by 2031
- Increase new dwelling energy efficiency by up to 60% over 2011 building stock

There are also strong aspirations to achieve "Net Zero" status, a goal championed by the Ontario Minister of Environment and Climate Change during his visit to the town in May 2016.

2.2 Georgetown High Level Land Use Targets

At a high level the following land use targets have been set for Vision Georgetown:

- Population Target: 19,000 people
- Employment Target: 1,700 jobs
- Minimum Density Target: 55 - 60 people and jobs/hectare
- Housing Unit Mix:
    - 62% low density residential units
    - 21% medium density residential units
    - 17% high density residential units

2.3 Georgetown Community Vision

The new Vision Georgetown community is to be an inspiring new urban community; distinctive in the way it looks and functions, fostering healthy lifestyles, neighbourliness, economic prosperity, and local pride. It will be a resilient, sustainable, complete, and compact community, with a thriving natural heritage system. It will feel like a small Town and will be physically connected to the broader community of Georgetown and the Town of Halton Hills. It will honor the rich heritage of the Town, emphasize people, and provide choices for day-to-day living. Overall, the new Vision Georgetown community will be an exceptional, forward thinking, and innovative model for new community development.

2.4 Georgetown Guiding Principles

Vision Georgetown has a set of fourteen guiding principles. These are listed below.

Table 2 - Vision Georgetown's fourteen guiding principles

1	To design a community that is connected internally and integrated with the rest of Georgetown, and other surrounding communities, through a network of roads, paths and trails.
2	To provide a wide range of residential, commercial, and institutional uses, in a manner that reduces the need for an automobile to meet the daily needs of life.
3	To protect existing topographical and natural heritage features and areas, and their associated ecological functions, and identify a linked natural heritage and open space system.
4	To create distinct neighborhoods that feature community focal points and bring people and activities together.
5	To provide a range and mix of housing that is available to all ages, abilities, incomes and household sizes.
6	To provide adequate retail and service commercial development in a timely manner through various commercial areas, which are designed for people and pedestrians.
7	To encourage a high standard of design that reflects existing small town character, creates a sense of place, and contributes to civic pride.
8	To ensure convenient access to a range of types and sizes of parks and public spaces, which provide opportunities for recreation, neighborliness, community events, and cultural activities.
9	To provide a range of accessible community facilities in a timely manner and to co-locate these facilities where possible.
10	To establish a transportation system that safely and efficiently accommodates different forms of travel (including automobiles, walking, and cycling) and plans for future public transit.
11	To provide opportunities for local economic development in a manner that fosters competitiveness and a prosperous business environment.
12	To ensure new infrastructure is developed in a manner that minimizes social and environmental impacts, and considers long-term maintenance, operational, and financial requirements.
13	To apply sustainable development practices and encourage innovation, in order to maximize resource and energy conservation.
14	To conserve key cultural and built heritage resources as a vital link to our rich history.

3 Energy Context

It is important to understand the energy context on an international, national, provincial and local level. This helps to set a context for the current energy goals and aspirations for the Vision Georgetown development.

International

National

Provincial

Local

3.1 International

Canada's current national emissions reduction target (2015 INDC submission to the UNFCC) is 30% below 2005 levels (2% below 1900 levels) by 2030.

- On December 12, 2015, Canada and 194 other countries reached the Paris Agreement, an effort to limit global average temperature rise to below 2°C and to pursue limiting temperature rise to less than 1.5°C
- Canada withdrew from the Kyoto Protocol in 2011, but has maintained emissions reduction target of 17% below 2005 levels (limiting increases to 7% above 1900 levels) by 2020
- Canada and US have established the Clean Energy Dialogue to enhance collaboration on the development of clean energy research and development, and building a more efficient and renewable electricity grid

3.2 National

Canada’s energy policy is shared between the federal and provincial/territorial governments. Provinces/territories have significant authority over natural resources, energy, and the environment.

- Canadian Environmental Protection Act (1999) is federal government’s primary climate change statute
- Canadian Council of Ministers of the Environment is responsible for addressing climate change

- Government of Canada has committed to making significant new investments in green infrastructure and clean technologies (2015).
    - Endow $2 billion Low Carbon Economy Trust to fund emissions reduction projects
    - Fulfill G20 commitment to phase out fossil fuel subsidies
    - Develop a Canadian Energy Strategy to protect energy security, encourage energy conservation, and bring more renewable sources into the electricity grid

3.3 Provincial

3.3.1 Roles and Responsibilities of Key Provincial Entities

There are range of energy related government and independent entities that set and influence energy policy and initiatives. The key players, and their roles and responsibilities are listed below.

Ministry of Energy: Sets energy policy and targets, regulates energy standards and reporting, delivers targeted programs, has legislative responsibility over agencies including OEB, IESO, Hydro One, OPG.

Ontario Energy Board (OEB): Independent natural gas and electricity utility regulator for Ontario. Licensees and oversees energy companies, approves rates, creates and reviews regulatory energy policy.

Independent Electricity Systems Operator (IESO): Merged with Ontario Power Authority (OPA) in 2015. Manages reliability of power system, forecasts demand and supply, operates wholesale electricity market.

Local distribution companies (LDCs): Responsible for delivering electricity to customers and connecting distributed generation sources, both privately and publicly owned. Regulated by OEB.

Ontario Power Generation (OPG): Responsible for approximately 50% of electricity generation in province. Rates are regulated by OEB. Phased out all coal-based generation in 2014.

Hydro One: Provincially-owned company, operates 97% of Ontario’s transmission lines, serves as an electricity LDC for most of rural Ontario.

Halton Hills Hydro: Local distribution company for customers in Halton Hills. Promotes provincial initiatives and programs including time of use rates for businesses.

Union Gas: Natural gas storage, transmission and distribution company.

3.3.2 Driving Strategies and Plans

The key strategies and plans relevant to Ontario are listed in chronological order from newest to oldest.

Ontario's Cap and Trade (2016)

- Large gap to meet 2050 targets. Ontario will join the cap and trade system under the Western Climate Initiative, Inc.
- The government recently published its draft cap and trade legislation and regulation for public comment
- The carbon price is expected to start around $18 per tonne
- Likely to increase the price of fossil fuels such as natural gas
- Revenue from Cap and Trade will be reinvested back into Green infrastructure ($1-$2billion). Therefore, potential for more funding
- $325 million has already been invested in the Green Investment Fund as a down payment on the Cap and Trade Plan

Ontario's Climate Change Strategy (2015)

Outlines the province's plan to reduce emissions to 80% below 1990 levels by 2050.

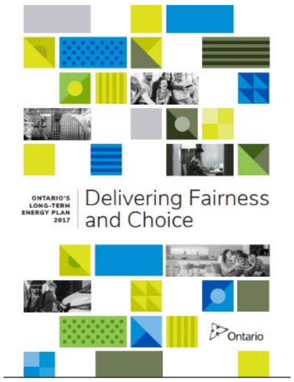
Strategy based on five areas of transformation:

1. Clean energy economy
2. Government collaboration and leadership
3. Resource conservation and efficiency
4. Emissions reductions across sectors
5. Climate change adaptation

Policy of conservation first to offset majority of growth in energy demand

Five-year action plan to be released in 2016

- Includes specific commitments to meet 2020 targets
- Establishes framework to meet 2030 and 2050 targets
- Reported on and renewed every five years



Ontario’s Long-Term Energy Plan (LTEP) 2017

The 2017 plan named ‘Delivering Fariness and Choice’ updates the 2013 plan to reflect changes in in the province’s electricity system and the actions taken to combat climate change.

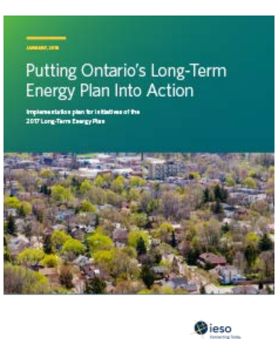
Introduces key elements of delivering fairness and choice

- Affordable and accessible energy
- Flexible energy systems
- Innovating to meet the future
- Improving value, transparency and performance for consumers
- Increasing energy conservation and efficiency
- Responding to the challenge of climate change
- Supporting native leadership and regional infrastructure

Primary areas of focus in the new plan:

- Market renewal (energy, capacity, operability)
- Distributed Energy Resources (DERs)
- Energy storage and electrification of transportation
- Net metering
- Grid modernization and innovation

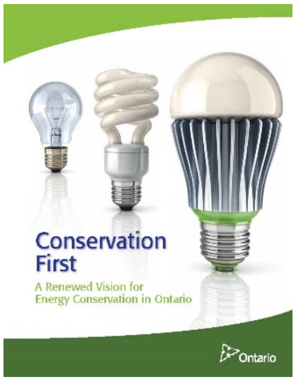
Implementation Plan for 2017 LTEP



An implementation plan for “Putting Ontario’s Long-Term Energy Plan Into Action” was created by the Independent Electricity System Operator (IESO), who’s whole is to inform and implement policy.

- For each initiative in the LTEP, the IESO outlines the scope, objectives, actions and major milestones that they will contribute to.

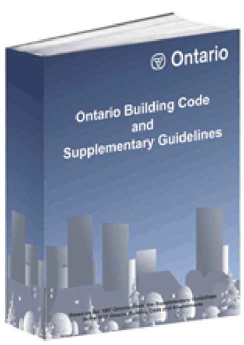
- The key points are to support indigenous capacity and leadership, encourage innovation and deliver a flexible and efficient system



Conservation First (2015-2020)

Establishes a new vision to prioritize conservation over new generation, build awareness, align tools and incentives with customer needs, encouraging innovation and leading by example.

- Previous Conservation and Demand Management framework began to wind down in 2014.
- Outlines objectives of new framework:
- More autonomy and programming choice for local distribution companies (LDCs)
- Clear accountability and mechanisms for meeting updated conservation goals
- Programs and provincial investments to encourage innovation (e.g. electricity storage and smart grid technology)

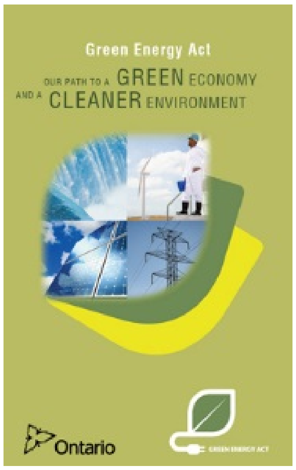


Ontario Building Code

- Building energy code was updated in 2012, and split into two sections for large buildings [SB-10] and housing (3 stories or less) [SB-12].
- New houses (SB-12) are allowed compliance by meeting a rating of 80 or more based on EneryGuide rating system
- Large buildings must meet one of the following energy criteria
- Meet ASHRAE 90.1-2010 as modified by SB-10 Chapter 2
- Exceed ASHRAE 90.1-2010 by at least 5%
- Exceed Model National Energy Code for Building (MNECB) 1997 by at least 25%
- Further enhancements in 2017 will require additional 15% reduction for homes and 13% for large buildings.
- On Jan 1, 2018 changes to the Ontario Building code regarding electrical vehicle charging systems came into effect.

  20% of parking spaces must be provided with Electrical Vehicles Supply Equipment (EVSE). The remaining 80% of parking spaces must be designed to allow for future installation of EV charging systems. Applicable to new commercial and industrial development.

New homes served by a garage, carport or driveway must also allow for future installation of EV supply equipment.



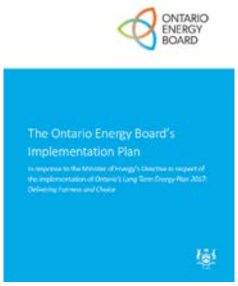
Green Energy Act (2009)

- Created to expand renewable energy generation, encourage energy conservation and promote creation of clean energy jobs.
- Establishes standards for renewable energy projects
- Streamlines approvals process, provides service guarantees for renewable energy projects
- Provides garunteed rates for energy generated from renewable sources
- Incorporates energy efficiency considerations into Ontario building code

Facilitates work with local utilities to reach energy conservation targets

The Power to Connect (2017)

- Created to advance customer-driven electricity solutions for Ontario as the generation, delivery and consumption of electricity shifts with the development of new technologies and a changing market.
- Prepares for anticipated changes in the next 10-15 years when the grid goes from a central, one-way power system to a distributed, two-way power flow
- Suggests that a diverse mix of generators, distributors and managers can prepare for future electricity demand
- Sates that Distributed Energy Resources (DER) will be a prominent factor in grid modernization and microgrid support



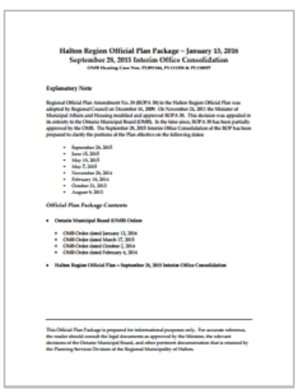
The Ontario Energy Board's Implementation Plan

Created by the Ontario Energy Board (OEB) as a response to the "Implementation of Ontario's Long-Term Energy Plan" in 2017, and defines the parts that OEB will concentrate on to meet the targets of the 2017 LTEP.

- Increase quality on service and focus on the end-user
- Involve customers and map out their preferences and how they inform investment plans
- Investigate incentives and their significance to service quality

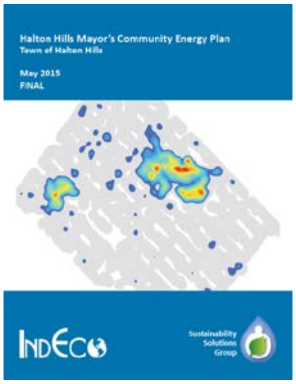
3.4 Local

The regional municipality of Halton is not directly involved with setting energy policy or administering programs. However, the municipality has been extremely active in developing future land use, energy efficiency and energy generation strategies and plans. The key ones are detailed below.


Halton Region Official Plan Package – January 13, 2016
September 28, 2015 Interim Office Consolidation

Halton Region Official Plan (2016 Update)

Halton Hills' guide for land use planning, which includes the Regional Official Plan (ROP) and amendments (ROPAs), supports energy efficiency, conservation and renewable generation.



The Mayor’s Community Energy Plan (2015)

Includes actions to increase energy efficiency, reduce operating costs, reduce GHG emissions, and create financial and environmental benefits.

- Plan was created to fulfill reporting/planning requirements of Green Energy and Economy Act, and to complete milestones of the Partners for Climate Protection Program
- Developed from Local Action Plan (LAP) and Corporate Energy Plan (CEP)
- Development incorporated a community engagement process and technical analysis component
- Three scenarios explore the impact of various actions for community energy use and emissions reduction
    1. Moderate Energy Efficiency: Land use intensification
    2. Towards a Low Carbon Community: GHG reduction through energy use reduction and renewables
    3. Low Carbon Community: Land use intensification and more ambitious GHG reductions
- Recommended actions for GHG reductions were determined through best practice research, community outreach and multi-criteria analysis

The Local Action Plan (LAP)

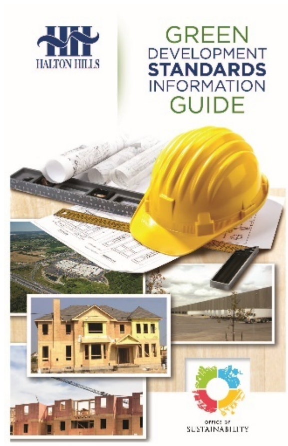
A component of the Mayor’s Community Action Plan that addresses energy use across the community.

Recommended Actions:

- Continued intensification and mixed-use development
- Property assessed payments (PAPER) for energy retrofits
- Revolving loan fund for financing energy efficiency projects
- Expand Green Development Standards to include renovations
- District energy for Vision Georgetown

Recommended GHG reduction targets:

- 35% per capita reduction from 2011 levels by 2031
- 14% total reduction compared to modeled baseline by 2031



Green Development Standard (GDS) 2014

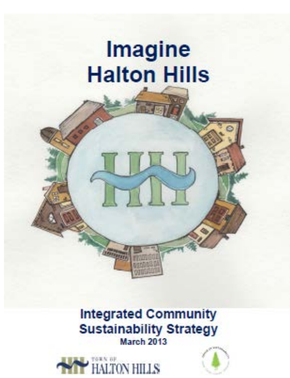
A highly flexible, yet stringent, set of criteria that apply town-wide for new applications submitted after June 2014. Anticipated to materialize into more sustainable, high-performance and efficient developments.

Three different checklists based on development type

1. Low-Rise Residential
2. Low-Rise Non-Residential
3. Mid to High Rise

Each checklist addresses the below main areas, with a project required to achieve a minimum of 40% of all points to meet the standard.

- Energy Conservation
- Water Conservation and Quality
- Community Design
- Air Quality
- Innovation and Green Features
- Waste management
- Communication



Imagine Halton Hills (2013)

A strategy for the entire community that captures what Halton Hills resident's value today and what they hope and dream for in the future.

4 Designing Net Zero Communities

The dynamics of Ontario's electricity system is changing to become more interconnected and decentralized, due to quickly evolving technology, development of microgrids, updated policies for climate change and consumers demanding a more active engagement. This new landscape creates unique opportunities for Vision Georgetown to become a Net Zero Community, which produces as much energy as it consumes.

Technically a Net Zero community can be defined two ways depending on the scope.

1. Narrow: Building Operations Carbon
2. Holistic: Total Carbon

4.1 Building Operations Carbon

One definition is to focus on the energy consumed by building operations. Net Zero is then a community of buildings for which, annually, all GHG produced through building operations are offset by carbon-free energy production.

As a new community, Vision Georgetown has the opportunity to build modern structures that will drastically reduce the energy demand compared to traditional construction. The buildings can be connected to a smart grid that uses controls to optimize the indoor environment, while reducing energy consumption. In addition, VG can take crucial steps towards meeting climate, energy and emissions policies by generating and storing its own electricity on site and implementing new technologies which are both flexible and cost-effective.

Building a Net Zero community will be a challenge. Vision Georgetown will have to be extremely aggressive on its building demand side design, pushing well past the recommended Green Development Standard (GDS). As can be seen in the below diagram the demand side will need to heavily target load reductions, passive systems, active systems and energy recovery.

Once the building consumption is as low as possible large-scale renewables will be required to close the gap and offset all energy consumption. Vision Georgetown is not a small community and therefore the size (in MW) and cost of such systems will be substantial. Solar PV and solar thermal will need to be installed on every rooftop and potentially in any open space as well; a site wide biomass CHP will be required and potentially other renewable energy generation technologies. A couple of scenarios defined and discussed in Section 7 show what technologies and strategies could potentially be used to get to Net Zero.

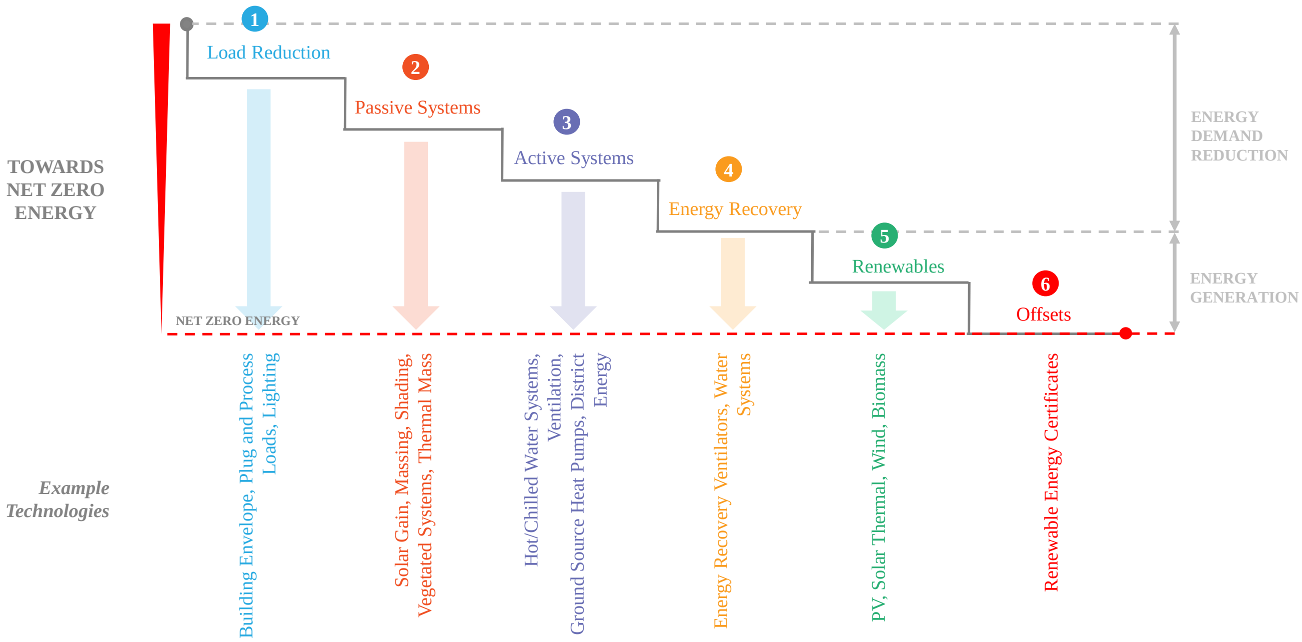


Figure 4 - Steps to getting to a Net Zero Carbon community of buildings

4.2 Total Carbon

An existing or new development has more carbon associated with it than just building operations. A holistic primary carbon approach looks at the full suite of carbon drivers (See list below) and implements strategies across all to drive to zero.

1. Land Use Carbon
2. Energy Carbon (Electric and Thermal)
3. Transport Carbon
4. Water Carbon
5. Waste Carbon
6. Material Carbon
7. Carbon Sequestration

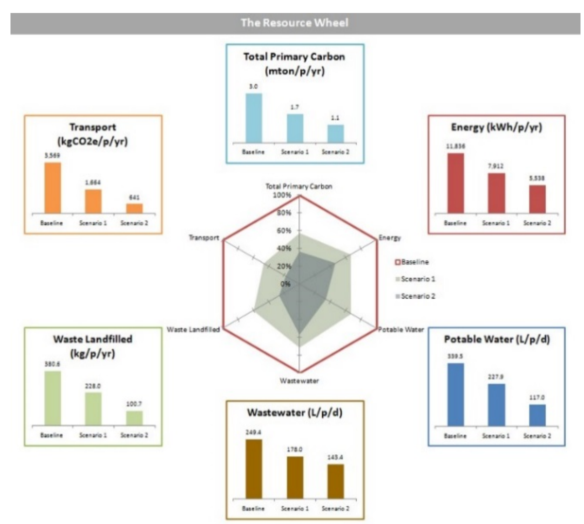


Figure 5 - Carbon resource wheel from Waterfront Toronto

An example of a project utilizing such an approach is Waterfront Toronto's West Don Lands. Arup worked in partnership with the Clinton Climate Initiative (CCI), with the funding from the

Ontario Power Authority, to develop an integrated resource sustainability model that allowed the client to determine the aggregate impacts of development decisions on total net project carbon emissions and total net energy and transportation requirements.

5 Energy Demand Opportunities

5.1 Building Energy Codes

Building and energy codes and standards are becoming more stringent with each significant revision. For example, ASHRAE Standard 90.1 2010 yields 30% more savings than ASHRAE 90.1 2004. However, technological advances and efficiency improvements could result in larger energy savings even when compared to a highly efficient code or standard.

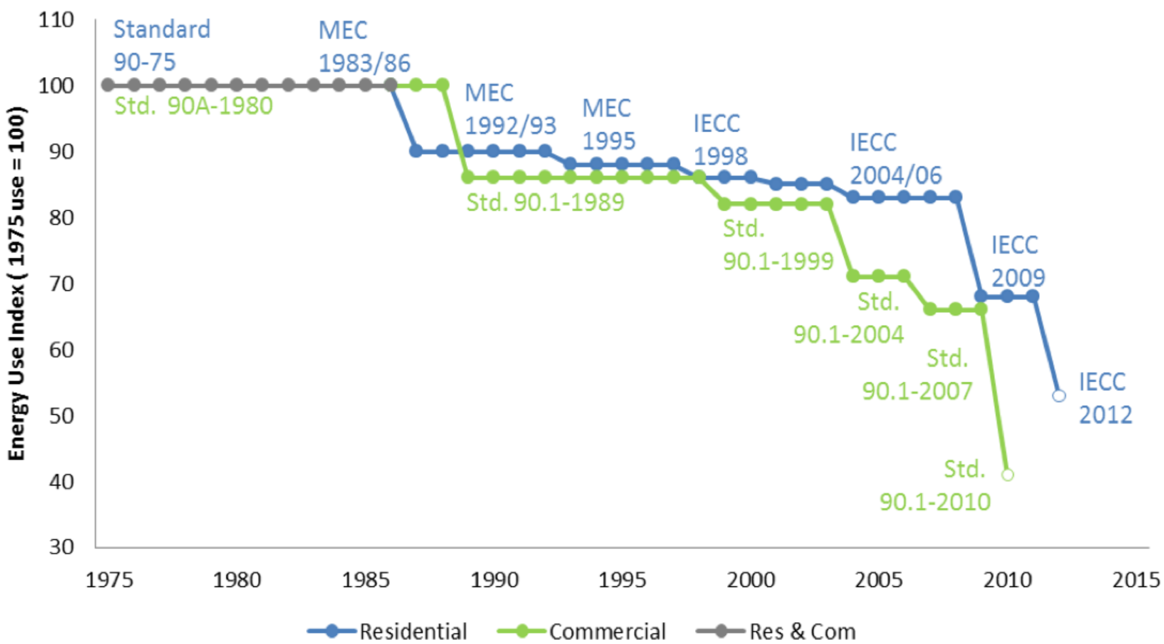


Figure 6: Efficiency improvements in ASHRAE Standard 90.1 and IECC (Source: ACEEE)

Analysis of the relevant building codes at a national, provincial and local level reveals more stringent requirements each step of the way. The chart below shows that the Canadian Model National Energy Code for Buildings (MNCEB) is the most relaxed standard. Applying ASHRAE 90.1-2010 yields approximately 20% more savings and the Ontario Building Code (OCB) yields another 5% savings on ASHRAE 90.1.

Halton Hills Green Development Standard (in light blue) is the most stringent, with slight reductions again (5%) in low rise non-residential and mid-high rise buildings (all types) and larger reductions (20%) in low rise residential. As discussed previously the GDS is a flexible set of criteria, similar to a LEED rating system, where developments must meet a minimum of 40% in order to comply. Developments might choose not to focus on energy credits if they prove too expensive to implement. However, for the purposes of modelling Vision Georgetown's energy demand it has been assumed that all buildings will pursue Energy Credit 1.

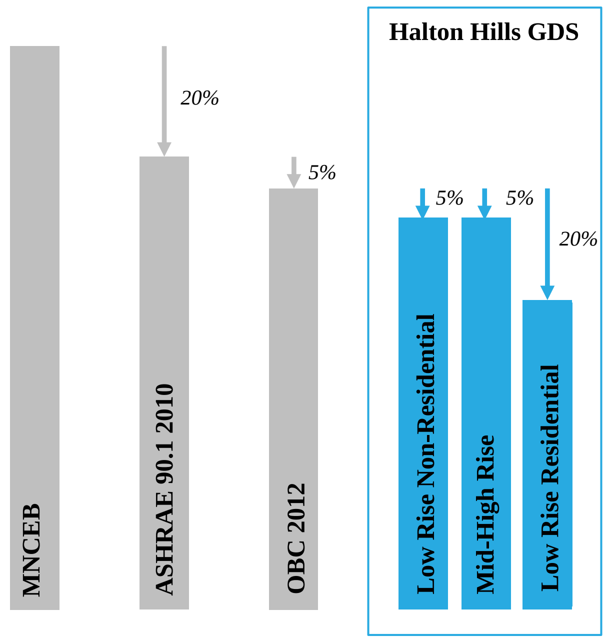


Figure 7 - Comparison of Halton Hills GDS to various national and provincial building codes

5.2 Energy Efficiency Measures

Low energy use in buildings can be achieved by reducing the energy demand through various energy efficiency measures. These measures vary with building type and activity. These measures can be used to not only meet Energy Credit 1 of the Halton Hills GDS, but also to meet the stretch goals of Vision Georgetown. The further the energy demand is reduced the less renewable energy generation is required to offset energy use.

A series of building level Energy Efficiency Measures (EEMs) are outlined below. These EEMs span several categories such as envelope, lighting, metering, plug and process load reduction, HVAC upgrades and operational strategies.

Not all efficiency measures are applicable to all types of buildings. This is a comprehensive list of EEMs but the design team should evaluate applicability for each individual building.

Table 3 - List of energy efficiency measures

Measure	Description
Roofs: Cool Roof	For a roof to be considered a cool roof, a Solar Reflectance Index (SRI) of 78 or higher is recommended. A high reflectance roof keeps much of the sun’s energy from being absorbed while a high thermal emissivity surface radiates away any solar energy that is absorbed, allowing the roof to cool more rapidly.
Roofs: Insulation	In cold climates like Ontario, increased roof and wall insulation help keep the heat in during the winter. This leads to lower heating energy

Measure	Description
	use. Installation of continuous roof insulation ensures that thermal bridges are minimized.
Wall Insulation	Similar to the roof insulation, wall insulation reduces unintended heat transfer from the interior to the exterior (or vice versa). Continuous insulation ensures that thermal bridging is minimized.
Air Leakage Control	Unintended air leakage through the building envelope can cause occupant discomfort and increase the energy usage. Therefore, a continuous air barrier system to control air infiltration (or exfiltration) should be designed and constructed.
Moisture control	Along with controlling air leakage, it is important that the building envelope should prevent condensation and wetting. Moisture control has direct impact on structural integrity of the building and occupant health.
Window orientation	Buildings should take advantage of the sun in the cold winter months through designs that maximizes south facing windows.
High performance glazing	Windows with higher SHGCs are typically installed in cold climates.
Daylighting	Daylighting is an essential component of an energy efficient design. Well- designed daylit spaces offset electrical lighting loads and reduce cooling loads. Several studies support the finding that daylighting promotes productivity and occupant comfort. However, daylight control is of equal importance to make sure glare is controlled. Daylighting strategies should be considered for spaces such as classrooms, offices, multipurpose rooms, gymnasiums, cafeterias and resource rooms.
Daylight sensors	Daylight sensors help regulate electrical lighting loads by turning off or dimming electrical lights when the space is sufficiently daylit.
Efficient lighting fixtures	It is recommended that efficient lighting fixtures such as LEDs or high efficiency CFLs be used to reduce electrical loads.
Occupancy sensors	Occupancy sensors should be installed in all classrooms, offices, mechanical/electrical rooms and multi-purpose rooms. These sensors make sure that the lights are turned off when the space is unoccupied thus saving electricity.
Exterior lighting and solar powered lighting	Efficient lighting fixtures such as LEDs and CFLs should be used instead of standard high-pressure sodium lamps which have poor color-rendering characteristics. Exterior illumination can successfully be powered by

Measure	Description
	integrated solar PV and used to light up pathways, parking lots and public parks.
Exterior lighting controls	Photocells or astronomical time switches should be installed on all exterior lighting to reduce lighting loads.
Energy recovery	Exhaust air recovery is an energy efficient way to reduce outdoor air heating load in cold climates.
High efficiency motors	NEMA premium efficiency motors should be specified, where applicable for motors or fans that are 1 hp or larger
Economizers	Economizers help save energy by providing free cooling when the outdoor conditions are suitable to meet all or part of the cooling load.
Demand controlled ventilation (DCV)	DCV can reduce the energy required to condition outdoor air for ventilation. Ventilation can be controlled through CO_2 sensing, occupancy sensors or time – of – day schedule in the building automation system. CO_2 sensing is typically used in densely occupied zones.
Commissioning	Commissioning is highly recommended on new and existing buildings to ensure that the systems perform as intended.
Air Source Heat Pumps (ASHPs)	Heat Pumps are technically a demand side reduction measure, but for the purposes of this report will be discussed in Section 6.4.
Water Source Heat Pumps (WSHPs)	
Ground Source Heat Pumps (GSHPs)	

5.3 Energy Demand Modelling

Energy modelling was first carried out using the Vision Georgetown Draft Concepts provided in July 2014. These were then revisited with the 2017 preferred option. Land use type, land area and density assumptions were used directly from the Concept A spreadsheet. Initial Energy Use Intensity (EUI) figures for both electricity and thermal demand were obtained for OBC complaint buildings from a report on the Development of Energy Efficiency Requirements for the Toronto Green Standard. All types of buildings were then assumed to pursue the relevant Energy Credit 1 in the Halton Hills GDS and therefore the applicable energy percentage reductions referenced in Section 5.1 were applied.

The below bar graph shows the gas and electricity energy use across the building categories of residential, commercial, retail and institutional and their sub categories. The line graph shows the corresponding built up area.

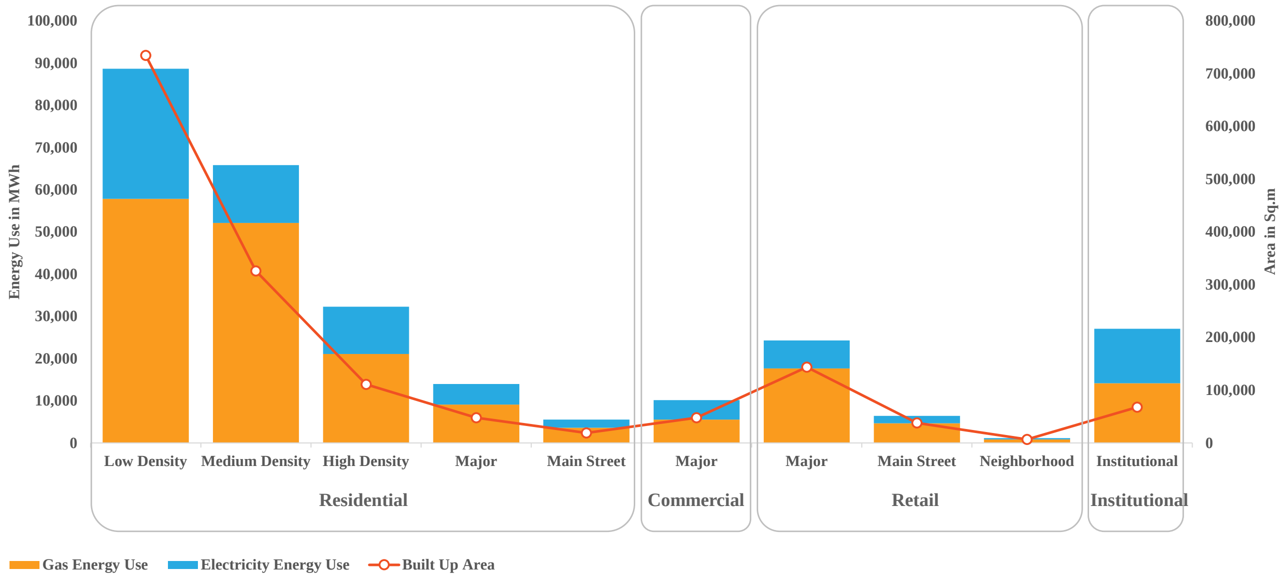


Figure 8 - Vision Georgetown's energy use broken down by land use type

The below graphic shows the hourly energy profile on a more granular level. A graph is provided for each high-level building type and energy use type (heating, cooling and electricity) on an hourly basis. This will help to illustrate some of the later concepts in Section 6.1 related to proper sizing and design of a district cogeneration system.

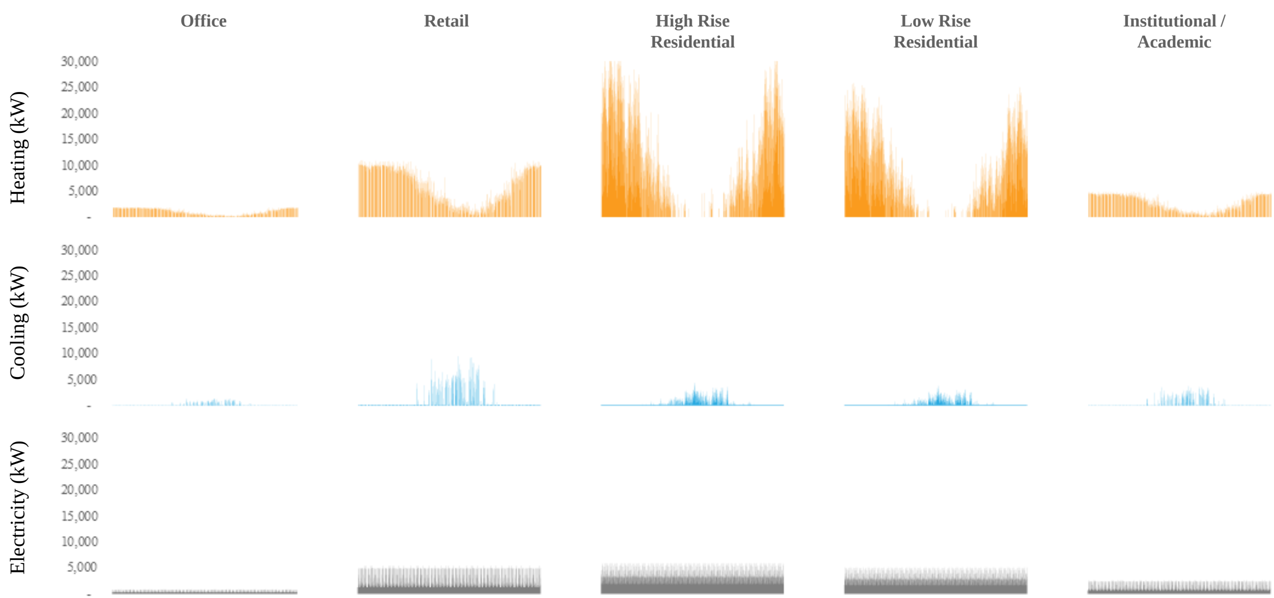


Figure 9 - Vision Georgetown's land use hourly energy profile

6 Energy Generation Opportunities

6.1 Defining District and Distributed Energy Systems

6.1.1 What is a District Energy System (DES)

District Energy Systems (DES) are thermal grids that distribute heating and/or cooling by transporting hot and cold water to various buildings in a community. Individual buildings connected to a DES have no boilers, chillers or cooling towers. All of their heating and cooling is provided by the DES.

Various technologies can feed into the DES with the most common being boilers or a cogeneration (CHP) system. Other technologies can feed into the system and these include waste to energy, fuel cells, solar thermal, ground source heat pumps, wastewater heat recovery and district storage in the form of borehole thermal energy storage. The below graphic illustrates the range of district technologies that can feed the system and the ideal mix of building use types that can draw from the system.

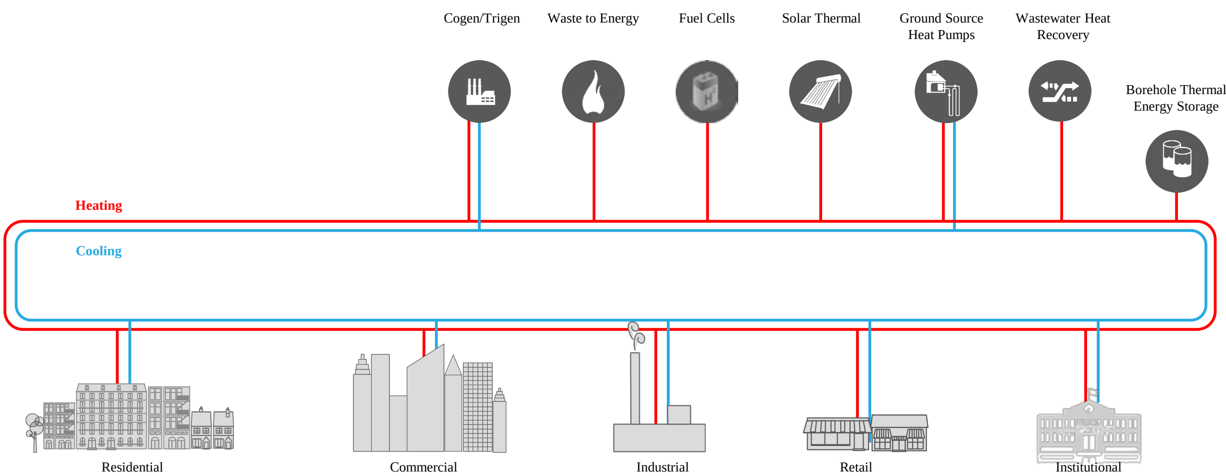


Figure 10 - Typical generation technologies and use types associated with a district heating system

There are a number of advantages associated with using a DES and these include:

- Dependable, high-quality thermal energy
- Higher reliability than conventional heating and cooling systems
- Reduced fuel costs and predictable long-term energy costs
- Reduced building operations and maintenance costs
- Reduced building level plant/equipment
- Avoidance of capital costs

- Reduced space requirements
- Reduced greenhouse gas emissions
- Ability to operate autonomously from grid (if cogeneration)
- Synergies with Transport Oriented Design (TOD)

6.1.2 What is a Distributed Energy System or Microgrid?

Distributed energy or microgrid consists of a range of smaller-scale and modular devices designed to provide electricity in locations close to consumers. They include fossil and renewable energy technologies, energy storage devices and combined heat and power systems. The below graphic illustrates that key technologies include solar photovoltaics, wind turbines, anaerobic digesters, cogeneration plants, waste to energy and fuel cells. Battery storage can be implemented as a further resiliency measure to provide backup power.

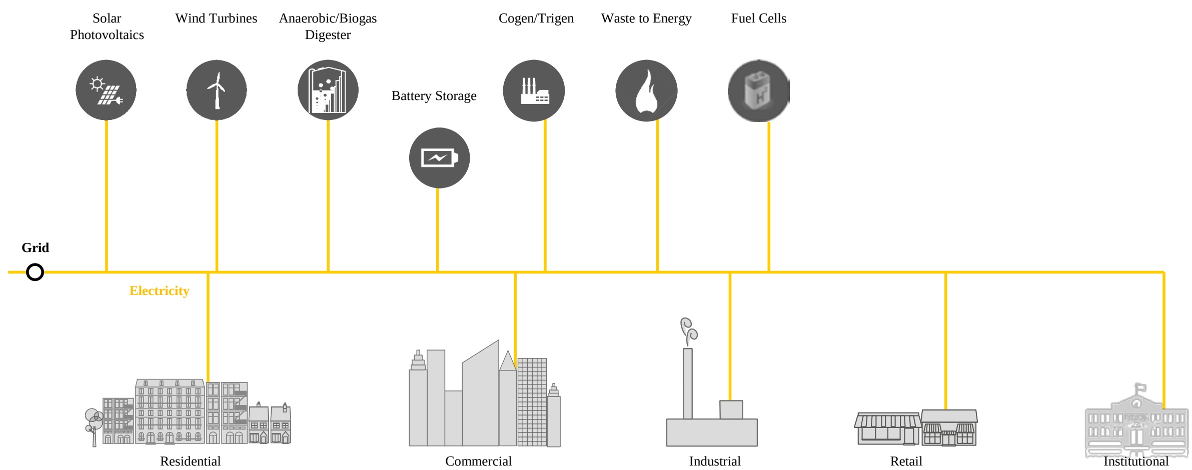


Figure 11 - Typical technologies used in a Distributed Energy System or Microgrid

Distributed energy offers solutions to many of the most pressing electric power problems, including:

- Blackouts and brownouts
- Energy security concerns
- Power quality issues
- Tighter emissions standards
- Transmission bottlenecks
- Desire for greater control over energy costs

6.1.3 Piecing it All Together

Piecing together the heating, cooling and electricity energy generation options reveals the below system with a range of technologies.

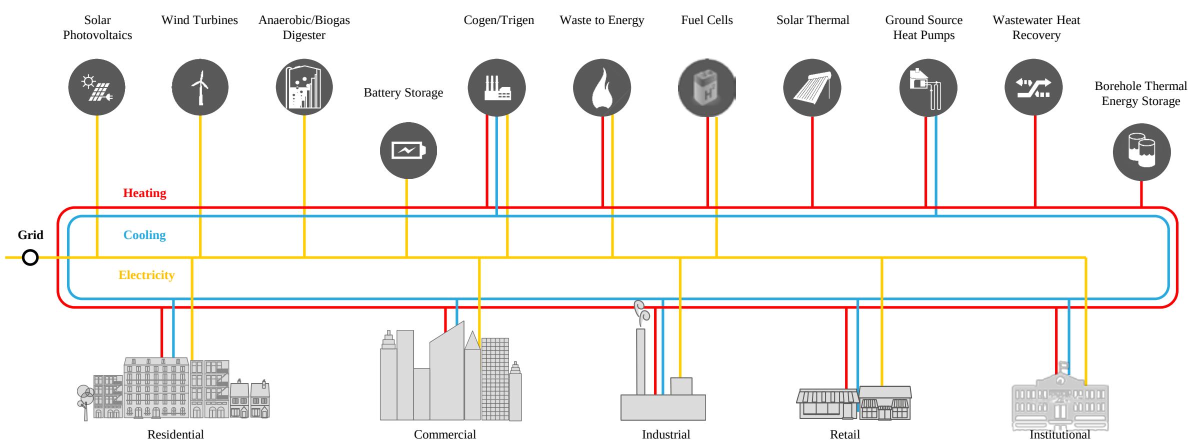


Figure 12 - Technologies working together to provide district heating, cooling and electricity

6.2 Key District Energy System Consideration Factors

When evaluating the feasibility of a district energy system there are three key factors that need to be considered.

1. Density and spatial arrangement of energy loads
2. Diverse consumer energy load profiles
3. Energy source type

6.2.1 Density and Spatial Arrangement of Energy Loads

The density of the proposed development and the spatial spread of the site are key variables that drive the feasibility of the system. In short:

1. Lower development densities mean less heat demand
2. An increasing spatial radius of the development means increasing cost of pipework
3. Increasing distance from the Energy Centre also means large distribution losses

All of this together (1 + 2 + 3) equals a higher $ / kWt delivered and therefore a lower financial payback.

Therefore, it is ideal to keep the energy centers serving higher density developments, as much as possible, and distributed to avoid large losses and high capital costs related to pipework. This will help keep the project cash flow positive.

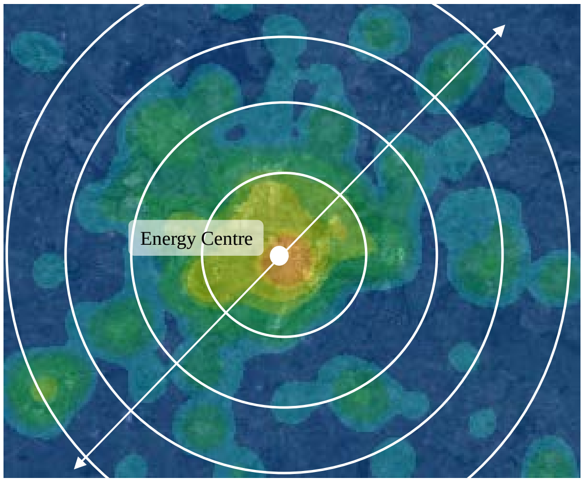


Figure 13 - Large energy center feeding lower development densities across an increasing spatial radius

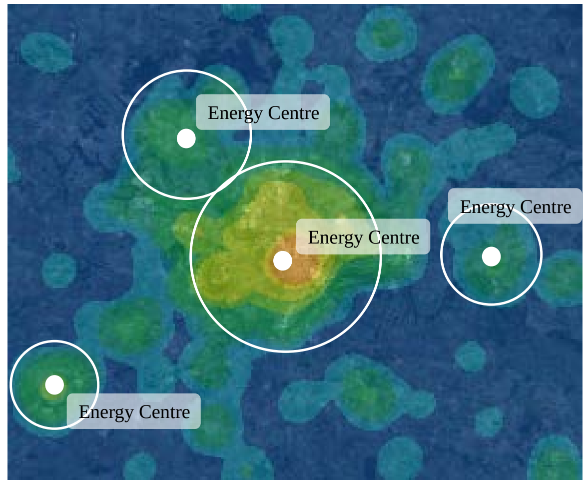


Figure 14 - Modular energy centers serving high development density demand in the immediate vicinity

6.2.2 Diverse Consumer Energy Load Profiles

It is important to have a steady base load to ensure continual operation of the CHP system and therefore ensure financial feasibility. Three main factors contribute to a more constant load profile.

1. The greater the mixture of building use types the better (residential, commercial, industrial, retail and institutional)
2. Complimentary night and day energy loads
3. Heat and electrical loads matching for efficient CHP operation

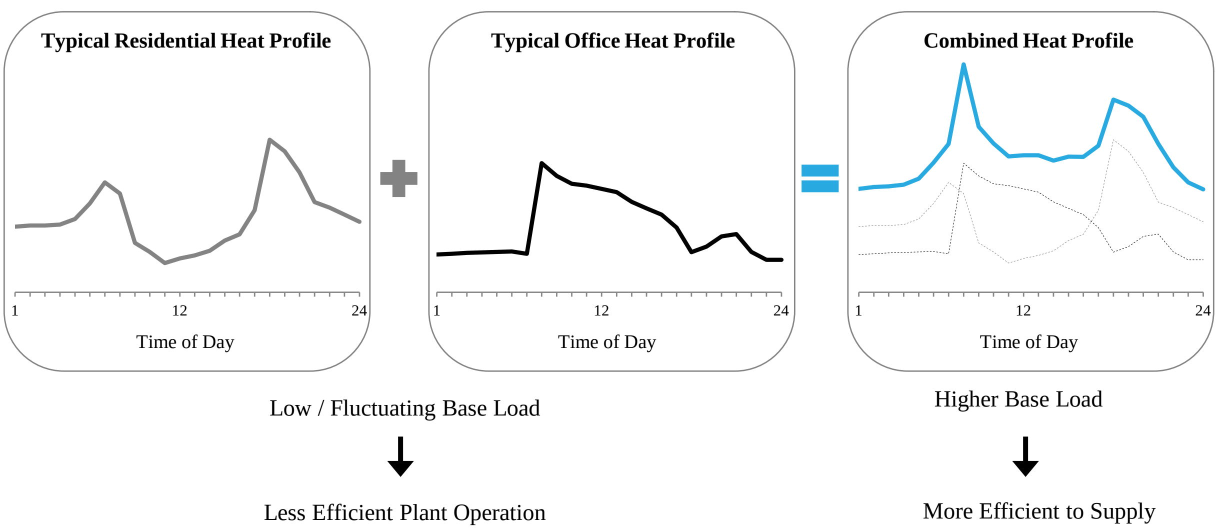


Figure 15 - Using multiple heat profiles to create a steady base load

6.2.3 Energy Source Type – Natural Gas vs Biomass

The energy source type is a key driver for both cost (capex and opex) and carbon emissions. The below bar graph shows the carbon emissions (kgCO_2/kWh) associated with various energy inputs. Obviously, coal and oil are being phased out as long-term energy sources so these are not under consideration. Natural gas and biomass are the only feasible energy inputs. Typically, natural gas CHP systems are easier to design and run compared to biomass, but biomass offers significant carbon emissions savings.

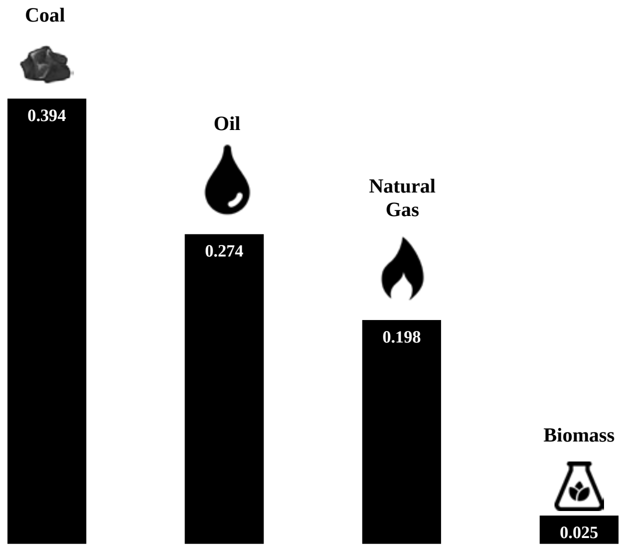


Figure 16 - Carbon emissions (kgCO2/kWh) associated with various fuel sources

In Ontario, there is an ongoing expansion of natural gas infrastructure, and better access is continuously developed to create greater customer choice to reduce overall energy costs, and allow consumers additional options in energy and economic development of their communities.

It is also worth to note that there are planned, innovative uses for Ontario's natural gas distribution system such as introducing renewable natural gas into the province's supply, as well as using it to expand the use of lower-carbon fuels for transportation.

6.3 Evaluating Basic District Energy Systems

6.3.1 District Cogeneration – Natural Gas Heat & Power (CHP)

The best way to evaluate the feasibility of a district system is to test it with as basic a system as possible, but one that is also known to pay back under certain scenarios - a natural gas combined heat and power unit.

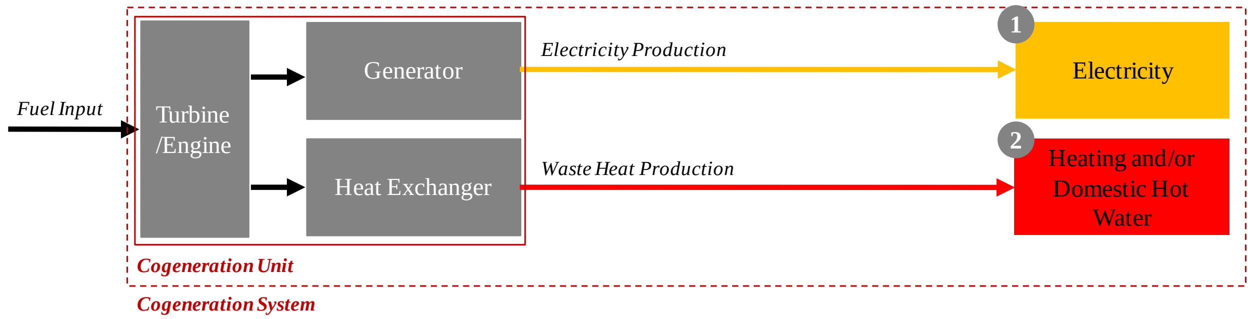


Figure 17 - Basic working of district cogeneration (heat and power)

As a starting point Arup used the Vision Georgetown Draft Concept A provided in July 2014 and developed three scenarios of differing sizes.

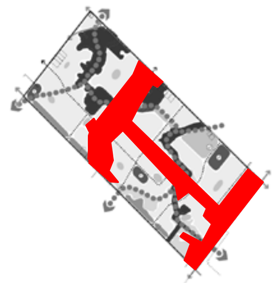
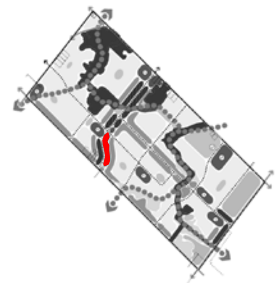
1. A CHP system to meet the whole development load
2. A CHP system to meet the medium-high density areas only
3. A small/modular CHP system to meet pockets of high density only

These were then evaluated against the below four main criteria, in order of importance. The criteria importance and weighting can of course be changed.

1. Financial return (simple payback)
2. CO_2 reduction potential
3. % site demand met (# of units connected)
4. Resiliency

The below table shows the high-level results for each of the above scenarios.

Table 4 – CHP scenarios and decision criteria matrix

	1 Full Site CHP	2 Med-High Density CHP	3 Small CHP
			
System Size (Elec)	7.2 MWe	4.5 MWe	0.4 MWe
System Size (Thermal)	9.0 MWt	5.6 MWt	0.5 MWt
Initial Capital Costs	$125.7m	$45.0m	$1.2m
Energy Savings (p.a)	$3.2m	$2.2m	$0.1m
Simple Payback	39 years	20 years	12 years
CO_2 Reduction Potential	None	None	None
% Site Demand	High	Medium	Medium
Resiliency	High	Medium	Medium

Simple Payback

It is immediately clear that, with a simple payback of nearly 40 years, an entire site CHP is not financially viable. This is because of the significant upfront capital costs associated with such a large network of pipes, but not a high density of energy demand. The payback becomes more favorable when the system is used to supply only medium to high density areas and becomes even more favorable when setup in small, modular nodes (thereby minimizing pipework) for high density areas. There is also middle point between Scenario 2 and 3 with a unit size of around 1 MWe. In this instance, the system will be reasonably priced (<$5m) and the payback will still be less than 15 years.

CO2 Reduction

As the current Ontario electricity grid is cleaner than natural gas the use of natural gas as the CHP fuel source will mean that CO_2 emissions will actually increase in all cases. As discussed previously in Section 6.2.3 the potentially cleaner fuel source of biomass could be used. Biomass has a proven track record, however there are also a number of key factors that need to be considered. These are detailed in section 6.3.1.2

% Site Demand

The larger the CHP size the larger the site demand that can be met. This also relates to a goal of Halton Hills to connect 2,713 dwellings to a district energy system. However, it could be argued that it does not entirely make sense to connect dwellings to a district energy system if the district energy system fails to meet either of the prior two criteria – i.e. not financially feasible and/or resulting an increase in CO_2 emissions.

Resiliency

This is tied closely to site demand. In the event of an electricity outage the larger the CHP size means that more of the community can be provided with backup electricity.

Recommended Option

As the main driving criteria is financial payback the recommended option is to choose a small, modular CHP unit that is sized to the medium and high-density demand in the main town center. This would be scenario 3, or potentially an option between scenario 2 and 3 in the above table. In these cases, the system will also help contribute to achieving Halton Hills' high-level goal of connecting up to 2,713 dwellings to a district system by 2031. However, CO_2 emissions will increase with any natural gas system. A potential alternative fuel source will be addressed in Section 6.3.2.

6.3.2 Final Concept (Elements) Plan (June/November 2017)

The Town of Halton Hills provided a revised Preferred Elements Plan in June 2017 which was endorsed November 2017. The revised plan was analyzed and the changes were favorable due the increase in medium and high residential densities in the community core. The main town center has been further solidified and has a good mix of commercial, residential and institutional that are all medium to high density. The high density mixed use is particularly beneficial as it provides a diversity which means a more consistent use of energy throughout the day. CHP systems require a consistent day long use. The proximity to the high school is also beneficial as it can be balanced with residential use if the school is used year-round i.e. in the holiday periods. The same three scenarios apply with the revised PEP and so do the take-aways. Scenario 2 and 3, or something in between, will still be the most feasible options in terms of financial payback.

Table 5 - Updated scenario maps based on revised May 2016 PEP

1

2

3

6.3.3 Sensitivity Analysis

It is important to note that there are a significant number of variables that feed into both the energy and financial modelling. A change in one variable has a flow on impact on downstream calculations, including the financial payback.

Two of the key variables from a cost perspective are the price of natural gas (the fuel input) and the price of electricity. Changes in either of these have a large impact on the feasibility of the system. The below figure shows the sensitivity analysis undertaken.

- The current analysis with the cost of electricity at \$0.128/kWh and cost of natural gas at \$0.131/m^3 shows a simple payback of 20-21 years
- If the cost of natural gas increases, and cost of electricity stays the same, then the financial payback of the system will be poorer and simple payback will increase
- If the cost of natural gas stays the same, but the price of electricity increases then the financial payback will be better and the simple payback will decrease
- There are range of other combinations and these can be evaluated to the extent they are shown on the below diagram

Cost of Heat (per m3)	Cost of Electricity (kWh)								
	$0.118	$0.128	$0.138	$0.148	$0.158	$0.168	$0.178	$0.188	$0.198
$0.271	37	30	26	22	20	18	16	14	13
$0.251	34	28	24	21	19	17	15	14	13
$0.231	32	27	23	20	18	16	15	14	13
$0.211	30	25	22	19	17	16	14	13	12
$0.191	28	24	21	19	17	15	14	13	12
$0.171	26	23	20	18	16	15	14	13	12
$0.151	25	22	19	17	16	14	13	12	11
$0.131	24	21	18	17	15	14	13	12	11
$0.111	23	20	18	16	15	13	12	12	11

Figure 18 - Natural gas and electricity pricing simple payback sensitivity analysis

6.3.4 District Cogeneration – Biomass Gas Heat & Power (CHP)

The results in the prior section associated with a natural gas CHP system clearly show that a natural gas system will not decrease, but instead increase, the carbon emissions of the new community. This is because natural gas is a dirtier fuel source than the current Ontario electric grid (as can be seen in the below diagram). This gap is likely to increase in future years as Ontario strives to hit its renewable energy generation targets.

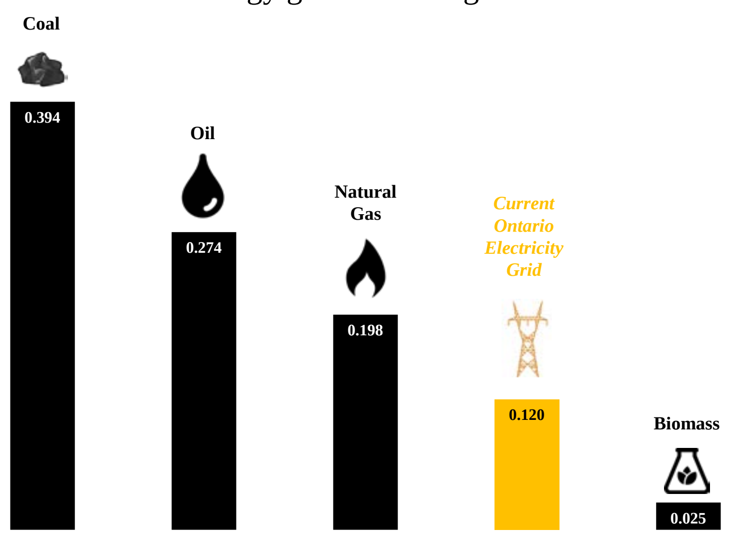


Figure 19 - Carbon emissions (kgCO2/kWh) associated with various fuel sources including the Ontario grid electricity

Therefore, biomass is the only other potential fuel source that has a carbon emission rate that is significantly below the current Ontario grid. Use of this fuel source will result in a decrease in carbon emissions.

However, there are some key questions/considerations to take into account when assessing the applicability of biomass and these include:

Is biomass considered renewable by local or national bodies?

Biomass is any organic matter, typically plant-based matter that is available on a renewable basis. Energy from biomass (bioenergy) is energy produced from renewable, biological material that comes from living or recently living plants, including trees. In Canada biomass is considered a renewable energy, but only if its rate of consumption does not exceed its rate of generation.

Are the biomass sources in a close proximity to the energy center?

The availability of biomass feedstock in close proximity to a biomass power project is a critical factor in their efficient utilization. An in-depth evaluation of the available quantity of a given resource should be conducted to determine initial feasibility of a project, as well as subsequent fuel availability issues. The primary reasons for failure of biomass power projects are changes in fuel supply or demand (wrongly assumed during the planning stage) and changes in fuel quality. Fuel considerations that should be analyzed in a preliminary evaluation include:

- Typical moisture content (including the effects of storage options)
- Typical yield
- Seasonality of the resource
- Proximity to the power generation site
- Alternative uses of the resource that could affect future availability or price
- Range of fuel quality (i.e., contaminants that could affect power generation equipment)
- Weather-related issues
- For agricultural residues: percentage of farmers contracted to sell residues

What is the biomass supply in your area and what are the associated costs?

Biomass fuel has varying energy intensities which can affect the quantity required. Below is a summary of the United States Environmental Protection Agency estimates for energy use intensity and anticipated costs.

Table 6 - Summary of biomass fuel energy intensities (Source: U.S. EPA)

	Energy Content		Estimated Prices (U.S. EPA)
Fuel Source	**Dry (MWh/MT)**	**Wet (MWh/MT)**	**Average Price ($USD/ton)**
Wheat Straw	4.42	3.53	$50.00
Corn Stover	4.88	3.42	$30.00
Forest Residues and Forest Thinnings	5.54	3.32	$30.00
Mill Residue	5.54	-	$29.00
Hybrid Poplar	2.65	5.30	$49.50
Hybrid Willow	2.65	5.30	$49.50
Switchgrass	3.92	5.60	$42.50

	Energy Content		Estimated Prices (U.S. EPA)
Fuel Source	**Dry (MWh/MT)**	**Wet (MWh/MT)**	**Average Price ($USD/ton)**
Urban Biowastes (yard trimmings)	3.97	2.97	$13.50

A detailed lifecycle assessment needs to be conducted, once a biomass fuel profile has been selected, in order to determine the accurate carbon emissions impacts from biomass. Although considered 100% renewable, the transportation and processing of biomass has an emissions impact.

6.3.5 District Heat Only (Boilers)

Building level boilers have become very efficient in recent years, especially with widespread implementation of condensing boiler technology (95% efficiency). It is difficult for district heating systems to achieve efficiencies greater than this, especially when taking into account distribution losses.

This also applies from a cost perspective as the cost of distribution infrastructure is significant. A cogeneration unit will typically make more sense with the additional production of electricity under favorable economic pricing. The cogeneration unit section 6.3.1 is a more applicable option.

6.3.6 District Trigeneration – Heat, Coolth & Power

District trigeneration involves adding another output from a CHP engine. It uses some of the waste heat and converts it to cooling through an absorption chiller, thereby providing heating, cooling and electricity. The below diagram details this process.

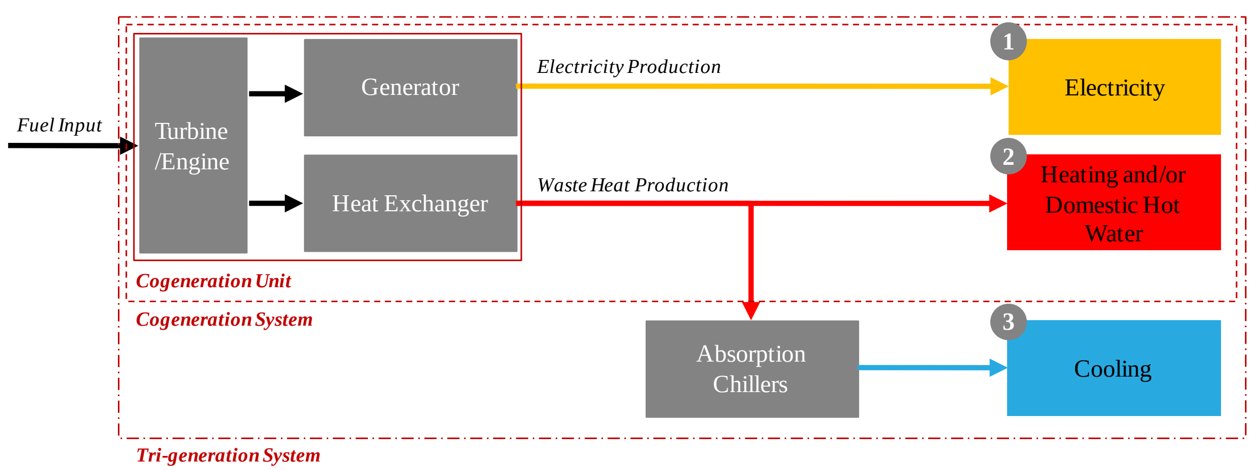


Figure 20 - Basic working of district trigeneration (heat, power and coolth)

However, two factors mean that this kind of system is not financially feasible for Vision Georgetown. Firstly, there will be additional costs associated with absorption chillers and district cooling pipes and secondly, the demand for cooling is low in Canada. The cogeneration unit section 6.3.1 is a more applicable option.

6.4 Other Energy Generation, Storage & Electrification Technologies

6.4.1 Summary Table

Outside of a basic district energy system there are a range of other energy generation or storage technologies that can benefit a new community when viewed through the lenses of cost, carbon and resiliency.

The table below contains a list of these main technologies broken into three categories as they relate to Vision Georgetown and the analysis undertaken to date:

1. **Implement:** Technologies analyzed for Vision Georgetown that show clear financial and/or carbon savings.
2. **Study Further:** Technologies that have the potential to address the goals of carbon reduction or resiliency and should be studied further, but might provide a financial payback.
3. **Not Currently Applicable:** Technologies that do not have a strong track record in similar climate zones and developments; require significant infrastructure investment that is unlikely to be available for Vision Georgetown; or were deemed not applicable during the February 2016 workshop.

Table 7 - Summary of energy generation, electrification & storage technologies

Technology	Energy Relation	Implement	Study Further	Currently N/A
Solar Photovoltaics	Electricity	X		
Solar Thermal	Heat	X		
Heat Pumps (GSHPs, WSHPs, ASHPs)	Heating/ Cooling & Electrification		X	
Fuel Cells	Electricity & Heat		X	
Energy Storage	Storage		X	
EV Charging*	Electrification	X		
SmartGrid	Electricity Intelligence	X		
Wind Turbines	Electricity			X

Anaerobic/Biogas Digester	Electricity			X
Waste to Energy	Electricity & Heat			X
Wastewater Heat Recovery	Heat			X
Borehole Thermal Energy Storage	Heat Storage			X

*Required by building code

The following sub sections describe and analyze (where applicable) the above technologies in the same order they are presented in the table.

6.4.2 Solar Energy

6.4.2.1 Solar Photovoltaics

Technology Definition:

Solar photovoltaic systems consist of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling and other electrical accessories to set up a working system.

Analysis/Discussion:

The following graph shows the potential electricity generation (MWh/yr) that can be obtained with various rooftop coverage percentages across Vision Georgetown.

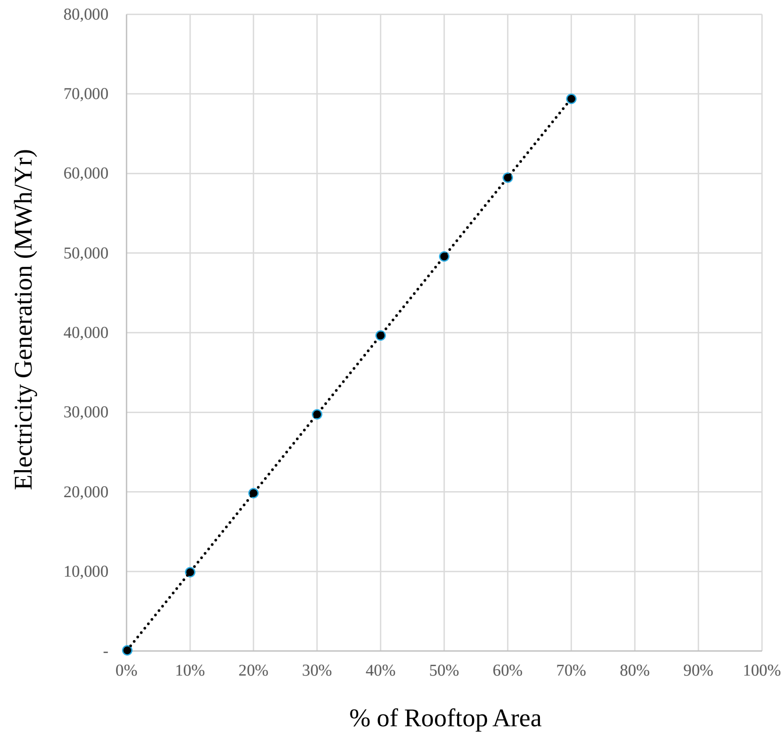


Figure 21 - Vision Georgetown solar PV generation potential by roof area %

Applying the above rooftop areas to initial capital costs per unit and various other outputs from the Vision Georgetown energy plan yields the following data table.

Table 8 - Solar PV generation, capital costs and % demand met

% of Total Roof Area	Array Size (sqm)	System Size (MW)	Total Capital Cost ($m)	Power Generation (MWh/yr)	% Elec Demand (from GDS)	% Total Energy Demand (from GDS)
70%	533,864	61	$245m	69,388	78%	25%
60%	457,598	52	$210m	59,475	67%	22%
50%	381,332	44	$175m	49,563	56%	18%
40%	305,065	35	$140m	39,650	45%	14%
30%	228,799	26	$105m	29,738	34%	11%
20%	152,533	17	$70m	19,825	22%	7%
10%	76,266	9	$35m	9,913	11%	4%

The investment at the high end is substantial, but the array can meet a significant amount of the electricity demand and reduce carbon emissions as a result. Smaller arrays have a smaller impact.

The average cost of photovoltaics has declined significantly in recent years. The simple payback of this system is typically 12-20 years depending on the cost of electricity and Feed-in-Tariff rates (assumed to be between $0.128/kWh and $0.225/kWh for this analysis). There are incentives that can potentially help to further reduce capital costs.

6.4.2.2 Solar Thermal

Technology Definition:

Solar thermal technology uses heat from the sun to provide energy for domestic hot water and heating. There is a strong precedent of use in cold northern climates to meet heating requirements. However, there are some limitations:

1. Because the sun shines stronger and for a longer time in the summer than in the winter, there is a need for a means of riding through long harsh winters with little solar resource to provide heat

2. Mismatch between times of heat supply and demand - building demand for heat occurs during early mornings (showers) and also at night, when the outdoor air is coldest, but solar supply occurs during the day

The above indicates that for solar thermal to be most effective it should be combined with some form of thermal storage system. Borehole Thermal Energy Storage (BTES) discussed in Section 6.4.11 is such a system. However, there is a significant increase in the required upfront capital costs.

Analysis/Discussion:

The following graph shows the potential electricity generation (MWh/yr) that can be obtained with various rooftop coverage percentages across Vision Georgetown.

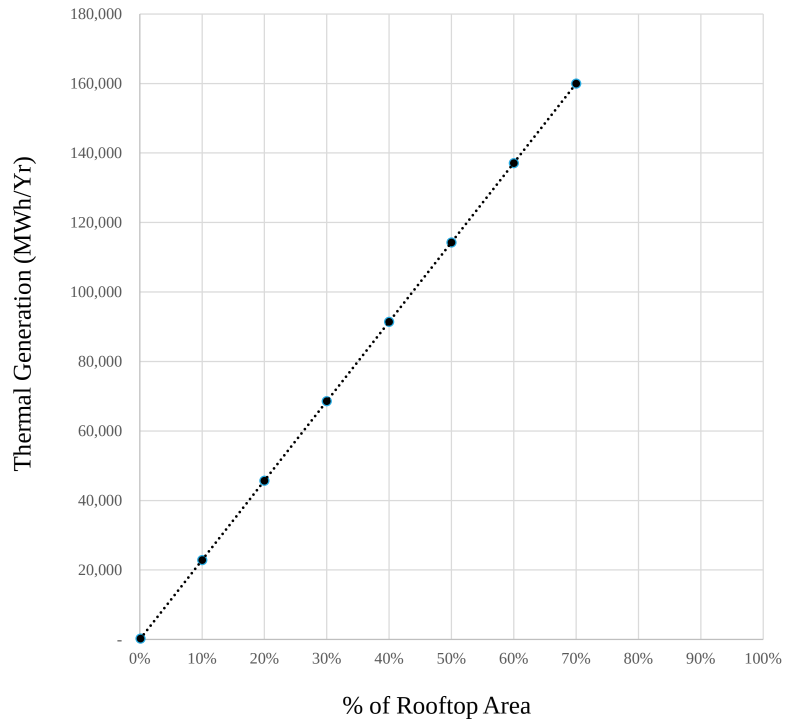


Figure 22 - Vision Georgetown solar thermal generation potential by roof area %

Applying the above rooftop areas to initial capital costs per unit and various other outputs from the Vision Georgetown energy plan yields the following data table.

Table 9 - Solar thermal generation, capital costs and % demand met

% of Total Roof Area	Array Size (sqm)	System Size (MW)	Total Capital Cost ($m)	Power Generation (MWh/yr)	% Heat Demand (from GDS)	% Total Energy Demand (from GDS)
70%	533,864	144	$314m	159,951	86%	58%
60%	457,598	123	$271m	137,100	73%	50%
50%	381,332	102	$226m	114,250	61%	41%
40%	305,065	82	$181m	91,400	49%	33%
30%	228,799	62	$136m	68,550	37%	25%
20%	152,533	41	$91m	45,700	24%	17%
10%	76,266	21	$45m	22,850	12%	8%

Similar to solar photovoltaics the investment at the high end is substantial, but the array can meet a significant amount of the heat demand. Smaller arrays obviously have a smaller impact. However, because of the low price of natural gas prices in Ontario, the simple payback of this system is typically over 50 years. This figure will increase if thermal storage is included in the initial capital cost.

Solar thermal has a larger impact than solar photovoltaics in reducing carbon emissions as the fuel it displaces in the baseline building is less clean (natural gas).

6.4.3 Solar Photovoltaics vs Solar Thermal (Cost and CO_2)

The table below compares the typical cost per kWh installed for solar photovoltaics and solar thermal against the current cost of electricity or natural gas. For the system to provide a decent financial payback the cost per kWh installed should be less than the relevant cost of natural gas or electricity.

The table also shows the carbon offset value per kWh. The carbon story is switched with solar thermal having a larger reduction potential per unit.

Table 10 - Cost and carbon comparison of solar PV vs solar thermal

	Solar PV	Solar Thermal
Cost per kWh installed	$0.14	$0.08
Current Cost of Electricity / Natural Gas per kWh	$0.128 (mid price for HHH) $0.225 (FIT 2016 rate)	$0.015
Carbon Value Offset per kWh	0.12 $kgCO_2$/kWh Ontario Grid Emissions	0.198 $kgCO_2$/kWh Natural Gas Boiler

6.4.4 Heat Pumps (Moving to Electrified Buildings)

Heat pumps are technically demand reduction or efficiency measures and not related to energy generation, as discussed in Section 5.2. However, as heat pump technology will feed into one of the modelled scenarios the description and analysis was included in this section to highlight its importance.

Technology Description:

Heat pumps offer an energy-efficient alternative to boilers and air conditioners. Like a refrigerator, heat pumps use electricity to move heat from a cool space to a warm space, making the cool space cooler and the warm space warmer. During the heating season, heat pumps move heat from the cool outdoors into the warm building and during the cooling season, heat pumps move heat from the cool building into the warm outdoors. Because they move heat rather than generate heat, heat pumps can provide equivalent space conditioning at as little as one quarter of the cost of operating conventional heating or cooling appliances.

There are three types of heat pumps: air source heat pumps (ASHPs), ground source heat pumps (GSHPs) and water source heat pumps (WSHPs).

Analysis/Discussion:

The key consideration is that heat pumps use ***electricity*** to provide heating and cooling and can sometimes do it much more efficiently than traditional heating systems involving natural gas. Having systems that make a community "all electric" allows communities to "piggy back" on electric grids that will become cleaner with time. These type of heat pumps systems should be studied further as part of a long-term carbon emission reduction strategy.

6.4.5 Air Source Heat Pumps (ASHPs)

Technology Description:

Air source heat pumps (ASHPs), as the name implies, "pump" heat from colder reservoirs to warmer ones, opposing the natural flow of heat from hot to cold. Using this technology, heat can be extracted from outdoor colder air in the winter, and from indoor air in the summer.

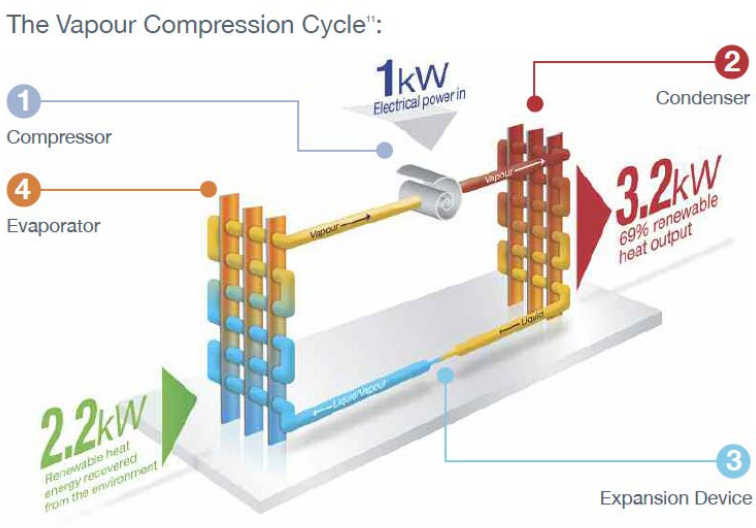


Figure 23 - ASHP demonstration diagram (Source: Mitsubishi Electric)

ASHPs are not as efficient as GSHPs and WSHPs, especially during periods of low outdoor air temperature. However, ASHPs are significantly cheaper than GSHPs and WSHPs. Although conservatively little reductions in energy may be attributed to ASHPs, carbon savings stem from the switch from fossil-fuel based heating to electric heating (supplied by Ontario's clean electricity network).

6.4.6 Ground Source Heat Pumps (GSHPs)

Technology Description:

Ground Source Heat Pumps (GSHPs) are often referred to as geothermal heat pumps, and use the ground as an efficient storage mechanism for thermal energy instead of AC units and boilers to reject or add heat. During the summer, the heat pumps extract heat from the building and transfer it to the ground. When the building requires heating, heat is transferred from the ground into the building. Electrically-powered heat pumps are at the heart of the technology. This efficient heating and cooling technology can be made low-carbon if paired with low-carbon electricity, such as that of the Ontario grid.

GSHPs, however, have higher capital costs, are dependent on space constraints and soil conditions and rely on balanced heating and cooling loads.

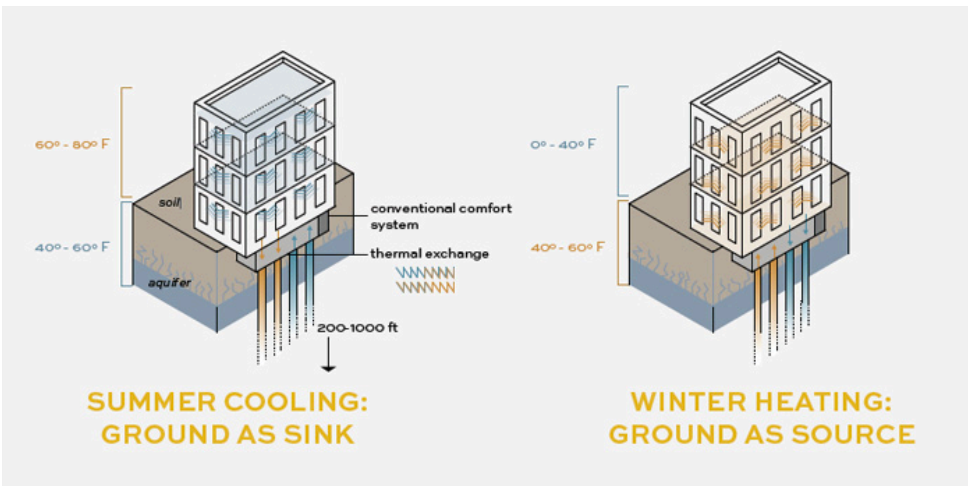


Figure 24 - Operation of GSHPs in summer and winter

Analysis/Discussion:

An analysis was undertaken for one low rise residential house within the development of Vision Georgetown. The key outcomes of this analysis were:

- Potential to meet entire cooling demand and heating demand with a 5kW system (1.5 Ton) horizontal system
- Total 5 kW system cost around $3,500-$5,000
- Consideration needs to be giving to balancing cooling and heating load
- Detailed site analysis required for feasibility
- With current electric to natural gas price payback would be poor, but with Ontario's potential Cap & Trade and Canada's decreasing grid carbon intensity, these type of system are better equipped for future scenarios

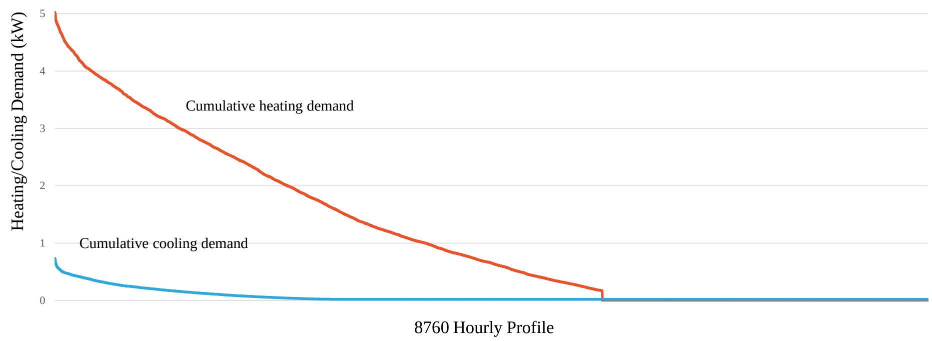


Figure 25 - Typical residential heating and cooling demand profile for Vision Georgetown

6.4.7 Water Source Heat Pumps (WSHPs)

Technology Description:

Like GSHPs, water source heat pumps (WSHPs) can use water bodies as sources or sinks for heat. Large water bodies are needed, especially for district sized systems.

Water heat sources include:

- Potable water system
- Wastewater system
- Lake Ontario

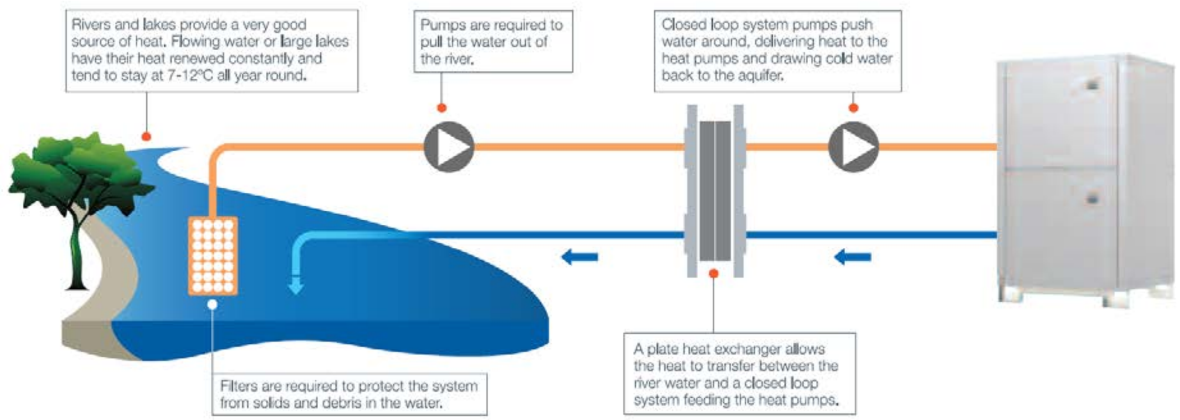


Figure 26 - WSHP demonstration diagram (Source: Mitsubishi Electric)

Similar energy and carbon reductions can be realized for WSHPs and for GSHPs.

6.4.8 Fuel Cells

Technology Description:

Fuel cells are another technology that takes a fuel input, primarily natural gas, and provides an output of both heat and electricity. Fuel cells are useful for building-level generation/microgrids and resiliency measures.

Figure 27: Fuel Cell

Analysis/Discussion:

These systems have a higher efficiency and lower pollution level that traditional CHP system that was analyzed in section 6.3.1. However, they are still relatively expensive, but might become more financially viable in the years to come. In additional they have the same inherit downside in that they burn natural gas, which is dirtier than the Ontario grid and will therefore increase carbon emissions.

This system should be studied further as part of a microgrid and/or resiliency strategy.

6.4.9 Energy Storage

Technology Description: Energy storage is a collection of methods used to store various types of energy within a utility grid. Energy is stored during times when production (especially from intermittent sources such as wind power, tidal power, solar power) exceeds consumption, and is then returned to the grid when production falls below consumption. Energy storage can be designed to provide back-up to large-scale utility networks as well as to individual buildings, to produce power when it is the cleanest and least expensive, as well as provide a continuous source of power.

Energy storage technologies:

- Batteries
- Flywheels

- Thermal
- Pumped Hydro-Power

Analysis/Discussion:

- Storage, such as batteries, pair well with solar photovoltaics, since the energy generated from solar can be stored during the day for overnight use, helping to smooth out supply and consumption peaks.
- Energy storage allows beneficial load shifting, which can lower demand peaks and reduce both energy cost as well as GHG emissions.
- Storage can play a key role in challenges that arise with an increasing EV charging demand during peak-hours.
- Can replace conventional fossil fuel fired generators for reliability
- Can generate revenue by providing “ancillary services” for the grid
- Can allow the building to operate during a power outage for small periods of time. Smart controls of emergency loads, combined with solar charging, can extend this period of outage ride-through.

Energy storage should be studied further as part of a microgrid and/or resiliency strategy.

6.4.10 Electric Vehicle Charging

Analysis/Discussion:

As previously discussed in the Driving Strategies and Plans section, the Ontario building code recently implemented new regulations for EV charging systems, which will affect the new mixed-use development at Vision Georgetown.

The replacement of internal combustion engine vehicles with EV is essential to the province’s commitment to reducing harmful air pollutants and GHG emissions, and supporting the goals of Ontario’s Climate Change Strategy.

EV growth and providing EV infrastructure are inherently tied. Besides complying with the updated building code, Vision Georgetown has an opportunity to extensively incorporate charging stations to encourage zero emissions vehicle use and contribute to reaching municipal targets, while showing a commitment to green building, improving local air quality, and attracting tenants and businesses.

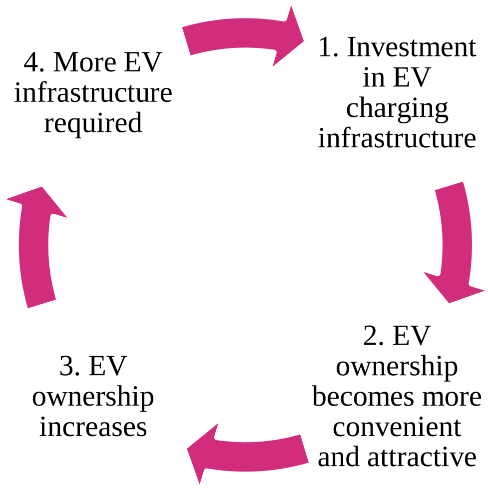


Figure 28: EV feedback loop

Several synergies exist between solar PV and EVs. With a growth in electrified transportation, a larger fraction of potential renewable production might be utilized for charging. However, EVs also have the capacity to serve as a fleet of mobile lithium-ion batteries for solar power, which can provide supplementary services to a community. It is recommended that further analysis is done to determine additional utility demand from EV, and to understand how charging stations may shift electric loads.

Figure 29 - EV Charging Station

The Canadian utility provides Solar Net Metering Programs, which allow the power generated and supplied from solar during the day to be subtracted from the total daily consumption of electricity. The net metering is calculated as a kilowatt per hour credit, or a dollar credit against the bill. This is a way of allowing solar PV systems to offset the need for more electricity, while saving money, even when EV charging takes place overnight.

6.4.11 SmartGrid

Technology Description:

A SmartGrid refers to a modernization of the electricity delivery system so that it monitors, protects, and automatically optimizes the operation of its integrated and interconnected elements. The elements can be anything from Distributed Energy Resources (DER) through the distribution system, to industrial users and building automation systems, to energy storage installations, to end-use consumers and their thermostats, EVs, appliances, and other household devices.

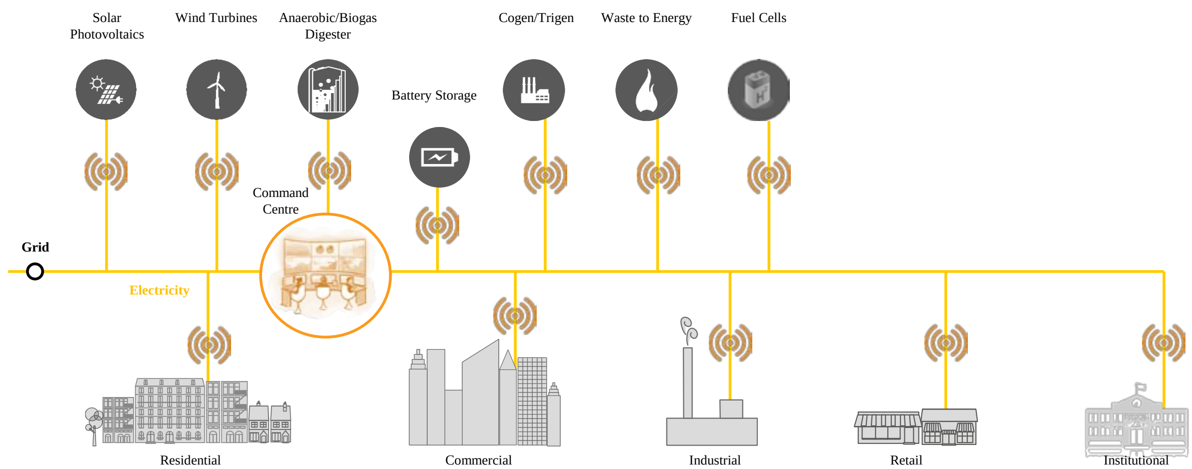


Figure 30 - SmartGrid linking energy demand with energy supply

Analysis/Discussion:

Ontario has made a significant effort to modernize the grid and enable DER, such as small-scale solar, and has added new generating capacity at the distribution level. The goal is to increase consumer options and control, as well as implementing innovative solutions to make the grid more efficient and reliable. The DER initiative will continue to enable a focus on renewables that provide electricity services, as well as technologies that serve different functions, such as EV smart chargers.

The new structures at Vision Georgetown can be connected to a SmartGrid that uses controls to optimize the indoor environment, while reducing energy consumption. Although SmartGrid capital costs can be significant, there are currently numerous funding mechanisms available across Canada for various levels of implementation.

6.4.12 Wind Turbines

Technology Description:

A wind turbine is a device that converts kinetic energy from the wind into electrical power. Utility-scale turbines range in size from 100 kilowatts to as large as several megawatts. Larger wind turbines are more cost effective and are typically grouped together into wind farms, which provide bulk power to the electrical grid.

Figure 31 - Small scale - building mounted

Figure 32 - Large scale

Analysis/Discussion:

The average wind speed in Halton Hills is 4.3 m/s (measured at 10 m). The site can be categorized as a Class 2 (out of 7) wind power site. Class 2 and above wind speeds can provide sufficient energy to drive a small wind turbine as part of a demonstration project. Utility sized turbines usually need at least Class 3 wind conditions to operate. The below graphic demonstrates this by showing the wind speed ranges for each size of turbine and relating this to the daily average wind speed across the year.

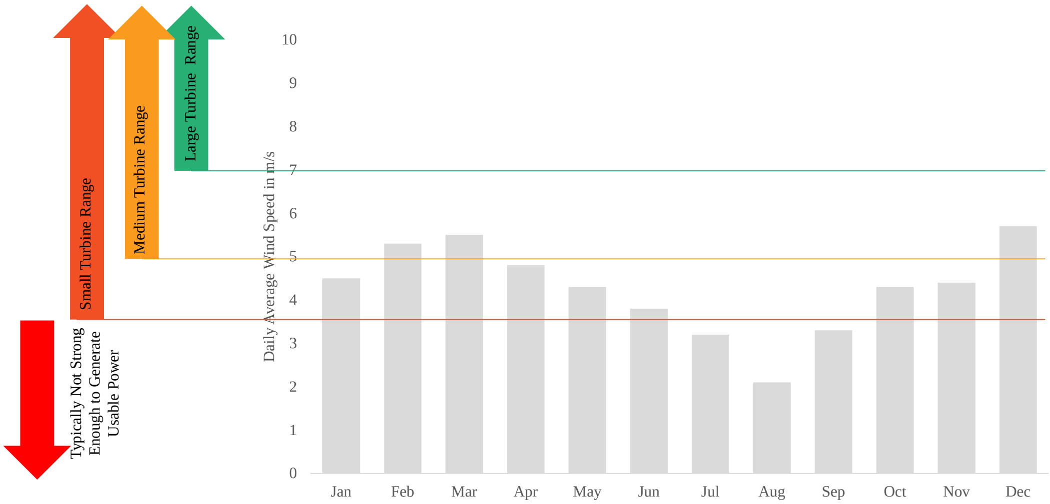


Figure 33 - Wind speed ranges of various turbines mapped to Georgetown's average wind speed

Given the economics, wind generation likely only makes sense as an iconic and educational expression of commitment to sustainability.

6.4.13 Anaerobic/Biogas Digester

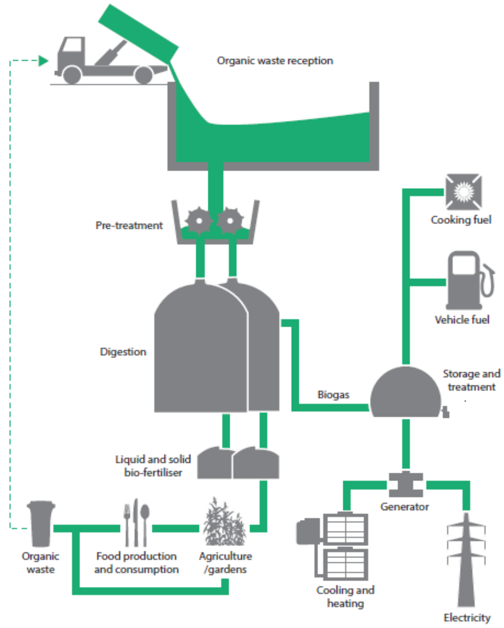


Figure 34 - Anaerobic digester infographic

Technology Description:

Anaerobic Digestion is the natural decomposition (digestion) of organic waste in an oxygen-free (anaerobic) environment. The process generates a biogas, comprised of approximately 60% methane and 40% carbon dioxide. This biogas can be burned to generate combined heat and power (CHP) or the biogas can be upgraded (scrubbed) to biomethane for use as a vehicle fuel. A solid and liquid digestate is also generated from the process that can be used as an organic fertilizer for soil improvement.

Analysis/Discussion:

An anaerobic digester requires significant upfront investment and a continual source of organic waste. Small scale installations are viable with multiple sources of waste, but dependent on waste stream generation from Georgetown and wider community. The feedback from the February 2016 workshop was that this technology was not currently applicable to the development.

However, if the community decides to pursue a Net Zero goal this technology is carbon neutral and therefore perfect for the zero carbon generation of electricity or fuel for cars.

6.4.14 Waste to Energy

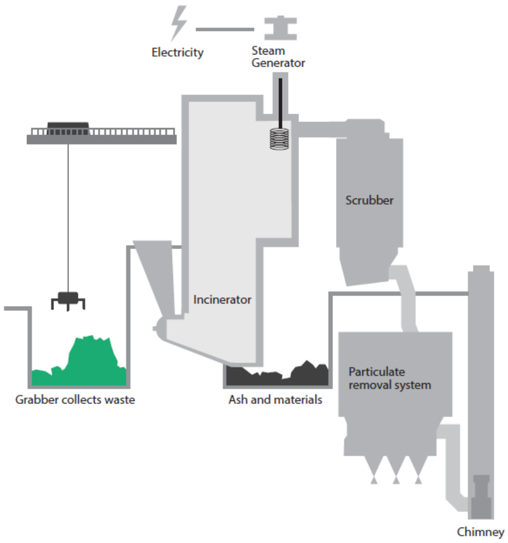


Figure 35 - Waste to energy infographic

Technology Description:

Incineration (i.e. mass burn) is one of the most common forms of thermal waste treatment technology. It involves the combustion of waste materials in a chamber that contains excess air. There are two main types of incinerators: moving grate incinerators and fluidized bed incinerators. In a moving grate incinerator, waste is combusted at temperatures between 1,000°C - 1,300°C as it moves through the furnace by a mechanically driven grate. Waste is successively feed to the combustion chamber on one end and the solid residues are discharged at the other end. In a fluidized bed incinerator, the bottom of the combustion system is lined with sand (granulars). Heated air is then bubbled through the sand bed and mixes with the waste to achieve a good burnout.

Analysis/Discussion:

A waste to energy plant is only feasible when built at scale and therefore requires significant upfront investment and a large, continual source of municipal waste. The feedback from the February 2016 workshop was that this technology was not currently applicable to Vision Georgetown.

6.4.15 Wastewater Heat Recovery

Technology Description:

The process of wastewater heat recovery can be undertaken on a community or building level. The general concept is that the sewage is run through a filter to get any waste products out, then it's pumped through a heat exchange system where heat pumps take the heat out. That heat is then transferred to pipes which carry the hot water into the homes and buildings of the nearby customers for the community scale system or back into the building for a building scale system. Vancouver has in place a successful community scale system and there are numerous building scale systems such as the SHARC. Examples of these projects can be found in the case studies section of this report.

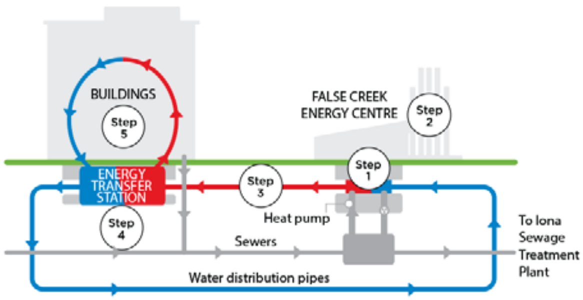


Figure 36: Vancouver Southeast False Creek Neighbourhood Energy Utility

Figure 37 - SHARC building level wastewater recovery unit (Source: SHARC)

Analysis/Discussion:

A community wastewater heat recovery requires access to large community sewage output and significant infrastructure which might not be feasible for Vision Georgetown. The feedback from the February 2016 workshop was that this technology was not currently applicable to the development.

However, building level wastewater heat recovery systems, such as SHARC, should be considered for medium-high density developments.

6.4.16 Borehole Thermal Energy Storage

Technology Description:

A borehole thermal energy storage (BTES) system is an underground structure for storing large quantities of solar heat collected in summer (usually through rooftop solar thermal) for use later in winter. It is basically a large, underground heat exchanger.

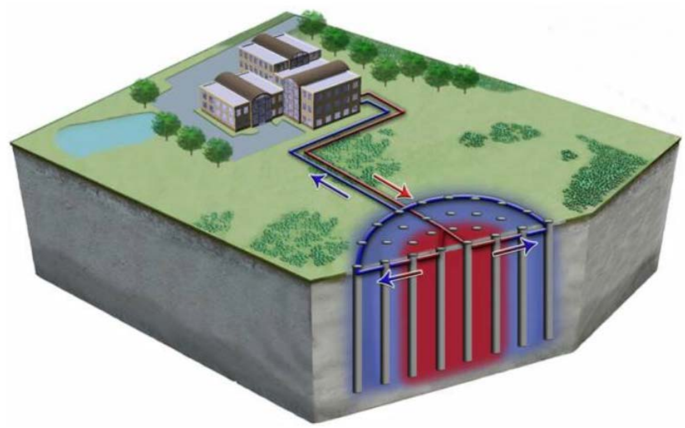


Figure 38 - Borehole Thermal Energy Storage System showing hot and cold piles

Analysis/Discussion:

Such a system, paired with solar thermal, has the potential to meet a significant portion of the heating demand of Vision Georgetown as detailed in Section 6.4.2.2. This kind of system has been implemented, on a much small scale, at Drake Landing Solar Community in Alberta, Canada.

However, BTES first capital costs are significant and given the low price of natural gas in Ontario such a system is unlikely to pay back unless significant grants or funding can be obtained.

6.5 High Level Technology Costs

The below table provides some high level initial costs for each technology discussed in this section.

Table 11- High level technology cost per unit

ELECTRICITY	HEAT	ELECTRICITY & HEAT
Solar Photovoltaics *Utility Scale: $2,000 - $3,000 / kWe* *Residential: $4,000 - $5,000 / kWe* *O&M: $20-$30 / kWe*	**Solar Thermal** *$600 / sqm (roughly 2,200 / kWt)*	**Combined Heat and Power** *Plant: $2,000 - 3,000 / kWe* *Piping: $1,500 - $2,500 / lm* *O&M: $55 / kWe per year*
Wind Turbines *< 100 kW: $3,000-$8,000 / kWe* *O&M: $30 - $40 / kWe*	**Ground Source Heat Pumps** *$2,500-3,500 / ton ($700 - $1,000 / kW)*	**Waste to Energy** *<15 MW: $10,000-$14,000 / kWe* *Direct Combustion*
Anaerobic/Biogas Digester *Plant: $500 - $900 / tonne* *Opex: $23 - $95 / tonne*	**Borehole Thermal Energy Storage** *Cannot be simplified to a basic per unit price. Dependent on a variety of factors*	**Fuel Cells** *$3,500 - $6,500 / kWe*
Smartgrid *Resi: $150 - $230 / year* *Comm: $1,000 - $$1,500 / year* *Ind: $15,000 - $23,000 / year*	**Wastewater Heat Recovery** *Cannot be simplified to a basic per unit price. Dependent on a variety of factors*	
Battery Storage *$2,000 - 3,000 / kW* *$500 - 700 / kWh*		

7 Scenarios and Carbon

7.1 Scenario Overview

Getting to Net-Zero Carbon requires a two-pronged strategy: aggressive demand side reduction measures and innovative, yet applicable, supply side technologies.

From the demand side Halton Hills already has in place a progressive Green Development Standard (GDS) which is more stringent than the MNCEB, ASHRAE 90.1-2010 or the Ontario Building Code 2012. However, even more aggressive strategies will be required to reach Net Zero.

From the supply side there are a range of technologies that could be used. The diagram below illustrates each potential technology and whether it applies to heating, cooling or electricity. Given site specific considerations and feedback from the February 2016 workshop three key technologies were prioritized to feed into the scenario analysis: Cogeneration (natural gas or biomass), solar photovoltaics and solar thermal. These are highlighted in the dotted boxes in the below diagram.

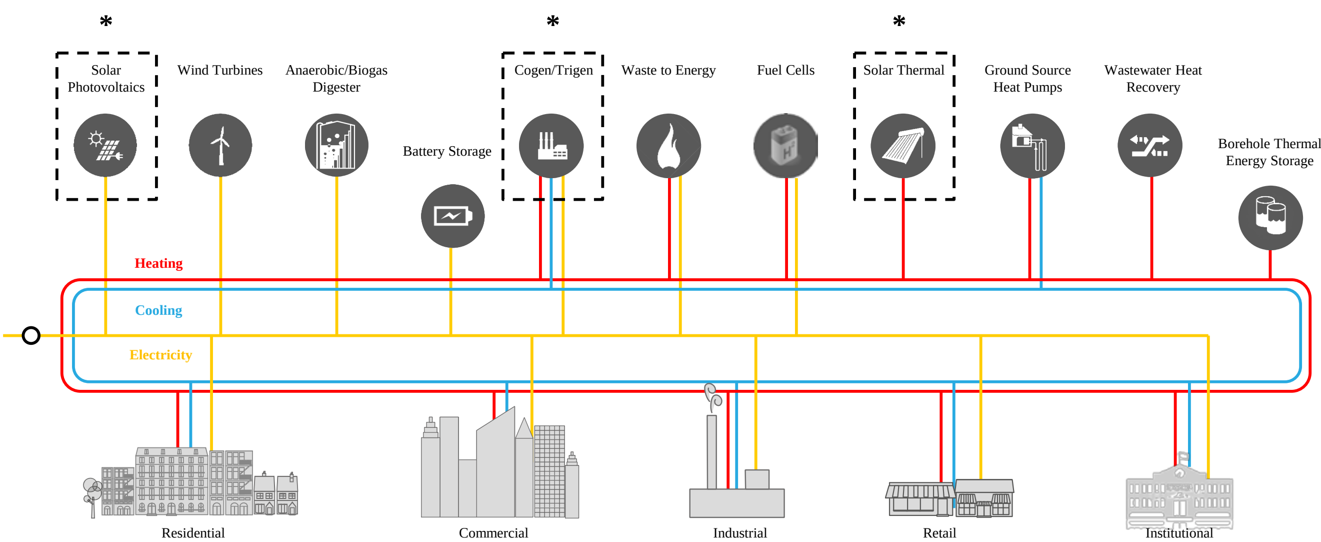


Figure 39 – Full range of supply side technologies with the prioritized technologies highlighted in a dotted outline

Three potential scenarios were then developed with the most applicable measures or technologies.

Scenario 1: Moderate – In this strategy the Halton Hills GDS code is used to set the demand side reduction targets. Small natural gas CHP units (<1 MW) are then used to meet modular demand and provide resiliency to blocks of medium to high density areas. Solar photovoltaics and solar thermal are split evenly across 60% of all rooftop areas to help reduce carbon emissions.

Scenario 2: Aggressive – An even more aggressive target is set beyond the Halton Hills GDS to further reduce energy demand. An electric Air Source Heat Pump (ASHP) will provide heating and domestic hot water instead of a natural gas boiler. Solar photovoltaics will cover 60% of all rooftop areas. Going all electric lowers carbon emissions due to the clean grid.

Scenario 3: Reaching for Net Zero – As in scenario 2, an even more aggressive target is set beyond the Halton Hills GDS to further reduce energy demand. A biomass CHP (with backup biomass boilers) will be used to provide heat to the entire site. Solar photovoltaics will cover 60% of all rooftop areas.

The below waterfall diagram illustrates, from left to right, the initial reduction in CO_2 emissions as a result of more stringent buildings codes, and then proceeds to demonstrate the impact of each scenario, and that of the underlying technologies/strategies, on CO_2 emissions.

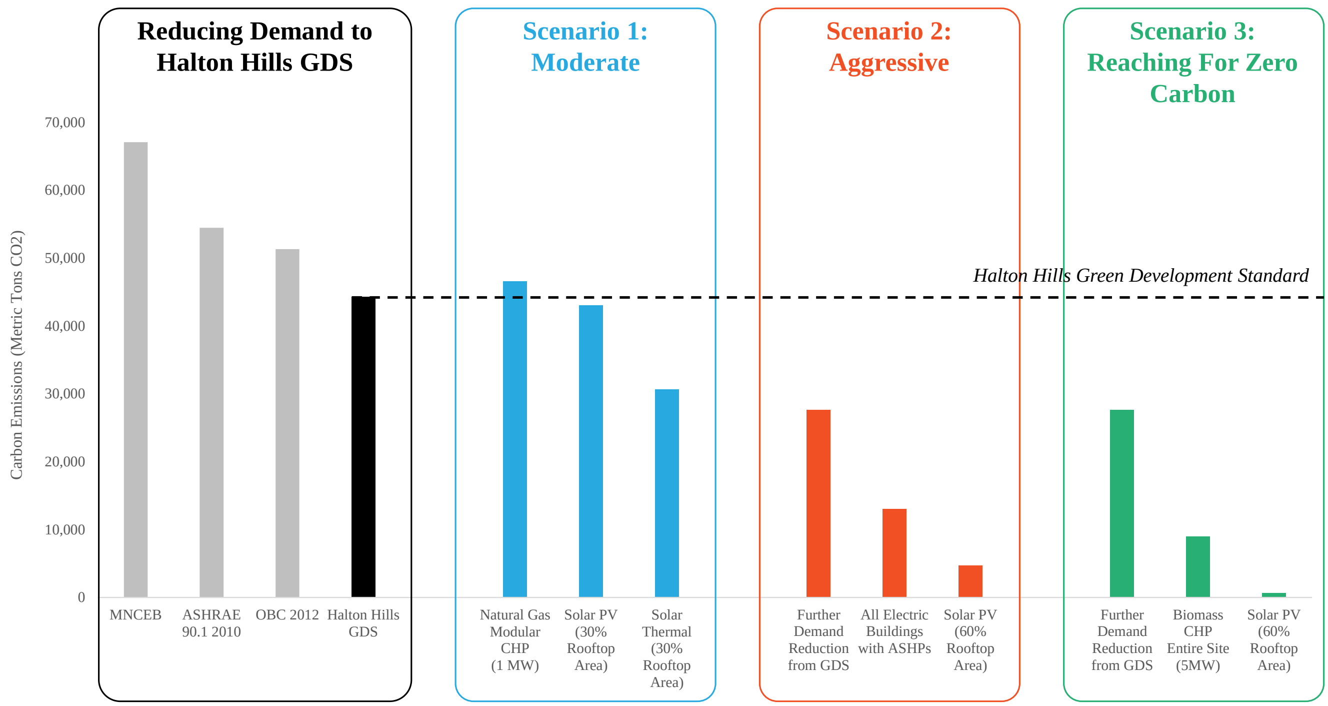


Figure 40 – Carbon emissions waterfall diagram for demand reduction and then the three defined scenarios

7.2 Scenario 1: Moderate

This scenario was developed to meet both the goals of connecting to a district system and contributing to a ***moderate*** reduction in greenhouse gas emissions. The following measures were used:

Small Natural Gas CHP Unit (<1MW)

The small/modular CHP unit, determined to be the most economically feasible in section 6.3.1, will be used to provide heat and electricity, and a resilient energy source, to the medium-high density development in the main town center (up to a maximum of 2,589 units connecting to the district heating system). However, the use of natural gas as a fuel source will act to increase carbon emissions. This will need to be offset by the following two technologies.

Solar Photovoltaics (30% Rooftop)

Solar photovoltaics will be placed on 30% of all available rooftops (or this % rooftop will be made solar PV ready). This will amount to roughly 229,000 sqm of array and produce a peak output of 26 MWe. This array will meet roughly 34% of all of Vision Georgetown's yearly electric demand or 11% of its total demand.

This will help to reduce the carbon emissions of the development and provide resiliency.

Solar Thermal (30% Rooftop)

Solar thermal will also be placed on 30% of all available rooftop (or this % rooftop will be made solar thermal ready). Again this will amount to roughly 229,000 sqm of array and produce a peak output of 62 MWt. This array will meet roughly 37% of all of Vision Georgetown's yearly electric demand or 25% of its total demand.

This will help to reduce the carbon emissions of the development even further as it will be offsetting traditional natural gas heating systems.

7.3 Scenario 2: Aggressive

This scenario was developed to meet the goal of contributing to an ***aggressive*** reduction in greenhouse gas emissions. In addition this scenario will push the development to all electric systems which means that its carbon emissions will be directly linked to the Ontario electric grid carbon emissions rate which should become cleaner with time. The following measures were used:

Further Demand Reduction

An extremely aggressive target above and beyond the Halton Hills GDS will be used to drive energy demand down as much as possible. This will involve a 30% further reduction in electricity and a 40% further reduction in heating demand.

Air Source Heat Pump (ASHPs)

The baseline systems of natural gas boilers and electric air conditioning units will be replaced with electric Air Source Heat Pumps. This will mean that the development is entirely electric driven. This will reduce carbon emissions significantly as the Ontario grid is currently 40% cleaner than natural gas.

Solar Photovoltaics (70% Rooftop)

Solar photovoltaics will be placed on nearly 70% of all available rooftops (or this % rooftop will be made solar PV ready). This will amount to roughly 534,000 sqm of array and produce a peak output of 61 MWe. This array will meet roughly 64% of all of Vision Georgetown's remaining yearly electric demand (or total demand as the community will be all-electric).

This will help to significantly reduce the carbon emissions of the development and provide resiliency.

7.4 Scenario 3: Reaching for Net Zero Carbon

This scenario was developed to meet the goal of Net Zero Carbon. The following measures were used:

Further Demand Reduction

An extremely aggressive target above and beyond the Halton Hills GDS will be used to drive energy demand down as much as possible. This will involve a 30% further reduction in electricity and a 40% further reduction in heating demand.

Entire Site Biomass CHP

An entire site biomass CHP in the size range of 5MW – 7MW will be used to provide heat, electricity and a resilient energy source. The unit size is chosen to ensure that the next step of solar photovoltaics will bring the community to Net Zero Carbon.

Solar Photovoltaics (70% Rooftop)

Solar photovoltaics will be placed on nearly 70% of all available rooftops (or this % rooftop will be made solar PV ready). This will amount to roughly 534,000 sqm of array and produce a peak output of 61 MWe. This array will meet roughly 183% of all of Vision Georgetown's remaining yearly electric demand or 100% of the remaining total energy demand – thereby making the community Net Zero Carbon.

7.5 Discussion and Recommended Option

The scenarios were put together to test the potential of a combination of technologies to realize an incremental reduction in carbon emissions. The recommendation depends on the key goals of Vision Georgetown.

The first scenario (moderate) utilizes a technology which does not help meet the carbon aspirations of the development and then will require a significant amount of capital resourcing on solar photovoltaics and solar thermal to reduce carbon emissions a moderate amount..

The second (aggressive) and third (reaching for net zero carbon) are more applicable scenarios given the aspirations to significantly reduce carbon. The second, all-electric, option allows the new development to effectively piggy back on the Ontario grid becoming even cleaner in years to come.

The third scenario does reach for Net Zero, which was the intent. However, a more realistic and financially viable option would be to not reach as aggressively for Net Zero, but install a smaller/modular biomass CHP (<1 MW) that will serve the medium/high density areas and solar photovoltaics on 70% of the roof area.

8 Technology Implementation

It is important to determine the appropriate delivery method through both qualitative and quantitative methods. The delivery method includes the following sub-components, which are inter-related:

- Identification of appropriate governance/legal/ownership structures
- Definition of the project business model, which helps define the roles and responsibilities of the project participants, the contractual obligations between the parties to provide and receive services, and how service providers are compensated by the customers.
- Identification of funding sources and financing strategy. The funding sources determine how costs are covered and/or how service providers are compensated for the services they provide. The financing strategy determines how debt, equity, grants and other third party capital sources are used to help cover upfront capital expenditure.
- Determination the procurement strategy. This strategy determines how the owner engages with one or more third parties to design, construct, finance and operate the system. The more these functions are packaged and contracted to fewer third party entities, the more delivery risk is passed from the owner to the contractor(s)

The qualitative method used to determine the appropriate delivery method includes a review of the merits of potential methods against the goals of the key stakeholders and other established criteria. The qualitative review also includes a project risk assessment to determine the key project risks, which is then followed by an exercise to determine how these risks are best managed by the project participants.

The quantitative review involves the development of a financial model that determines the delivery method that yields the most benefit to key stakeholders over time on a net present value (NPV) basis. The delivery options that most appropriately manages the identified risks and yields the greatest benefits over time is selected as the "Preferred Option."

9 Incentives/Funding Strategies

9.1 Local Funding / Incentives

9.1.1 Halton Hills Community Energy Corporation

- Halton Hills Community Energy Corporation is interested in investing in innovative technologies with satisfactory return on investment
- Corporation owned by the Town of Halton Hills
- Owns 100% of the regulated Utility Halton Hills Hydro

9.1.2 Halton Hills Hydro – saveONenergy

This program is currently available until 2020, and is offered and controlled by IESO and delivered through local utilities (e.g. HHH) to provide rebates and resources to commercial and residential customers.

Capacity-Based Demand Response: Program to bring contracted demand response providers from Demand Response 3 (DR3) Program into the wholesale energy market. New initiatives are under development to capture even greater value from the province's demand response capability.

High Performance New Construction (HPNC): Provides design assistance and incentives for building owners and planners who design and implement energy efficient equipment within new spaces intended for commercial, institutional, industrial or multi-residential occupancy. Project must be pre-approved by your local electric utility and must be designed and built to an energy performance that exceeds the minimum required by the relevant building code. Requires planning from the very early stages of a project.

New Home Construction: Incentives available to home builders and renovators for the installation of energy-efficient measures. Eligible houses must be three or fewer stories, less than 600m² and classified residential.

9.1.3 Union Gas

Space Heating Programs: Multiple incentives for the installation of energy saving technologies including condensing boilers and energy and heat recovery ventilators.

New and Retrofitted Equipment: Incentives for commercial and industrial customers to help implement an energy saving measure or install high efficiency equipment to save natural gas or improve energy efficiency. Both new and retrofit applications are eligible.

Demonstrating New Technologies: Offers 25% of incremental high efficiency upgrade costs up to $75,000 for adoption of a new technology, or a technology not previously used with a market segment to save natural gas or improve energy efficiency.

9.2 Provincial Incentives and Programs

Green Ontario Fund: Offers multiple incentives to encourage people and business to implement clean energy and energy saving strategies reduce their GHG emissions. A range of programs are available for home geothermal energy, air source heat pumps, high performance windows, smart thermostats and other technologies.

Smart Grid Fund: Current application window closed. Provides 50% of eligible project costs up to $2,000,000 to support advanced energy technologies (e.g. microgrids, AMI, V2G)

Community Energy Partnerships Program (CEPP): The Community Energy Partnerships Program (CEPP) is designed to provide funding for communities to develop renewable energy generation facilities.

Alternative Renewable Fuels 'Plus' R&D Fund: Enable continuous improvement in the alternative renewable fuels industry products and processes; Promote agricultural value-added opportunities in the bio products and alternative renewable fuels industries in Ontario; and assist alternative renewable fuels and bio based production facilities in Ontario to be major participants in these new worldwide markets. Government of Ontario, Ministry of Agriculture, Food and Rural Affairs.

9.3 National Incentives and Programs

Natural Resources Canada Clean Energy Fund Program: Currently fully allocated. Introduced in 2009 to support the development of new, cutting-edge energy technologies. A total of $795 million was allocated.

Natural Resources Canada ecoEnergy for Renewable Power: Launched in 2007 to encourage renewable energy generation. No new contribution agreements have been made since 2011, but the program will end in 2021.

Infrastructure Canada Small Communities Fund: Provides 1/3rd federal cost-sharing for infrastructure projects in municipalities with less than 100,000 residents. Eligible project categories include green energy and innovation, and meet the program objectives of economic growth, a clean environment, and stronger communities.

Federation of Canadian Municipalities Green Municipal Fund: Offers below-market loans, usually in combination with grants, to implement capital projects. Funding is provided for up to 80% of eligible project costs. The loan maximum is $10 million, and the grant amount is set at up to 20% of the loan to a maximum of $1 million. Funding is available in five categories: brownfields, energy, transportation, waste, and water. Energy recovery and district energy projects must demonstrate the potential to capture and use residual energy or create new capacity to transmit and use thermal energy, and reduce energy consumption by at least 20% for one or more existing municipal facilities within one year of implementation compared to baseline data.

10 Community Case Studies / Precedents

		ELECTRICITY					HEAT				ELECTRICITY & HEAT		
Markham DE	Canada										✓		
Drake Landing	Canada						✓		✓				
Crailsheim	Germany						✓		✓				
Marstal	Denmark						✓	✓	✓		✓		
Samso Island	Denmark	✓	✓		✓		✓				✓		
Bornholm Island	Denmark	✓	✓		✓		✓				✓		
Microgrid Research	Canada	✓			✓	✓					✓		✓
Woodstock Microgrid	Canada	✓			✓	✓							
Nelson Community	Canada	✓											
False Creek	Canada									✓			
Seven35	Canada									✓			
River District	Canada										✓		
Georgian Bluffs	Canada			✓									
Seabreeze Biodigester	Canada			✓									
Regent Park Phase 1	Canada												
BedZED	UK	✓									✓		

City of Markham District Energy System, Ontario, Canada

Markham District Energy is a thermal energy utility owned by the City of Markham that has been operating for 15 years. The first facility was built for Markham Centre, which, when fully developed, was planned for 30 million square feet of residential, commercial and institutional buildings (41,000 residents and 39,000 employees) with ***anchor*** customers including IBM, the Pan-Am pool, and the Markham Civic Centre. The second facility was built for the Cornell community, which was planned for 10 million square feet of residential, commercial and institutional buildings (10,000 residents and 10,000 employees) with the Markham Stouffville Hospital as the anchor customer. CHP is currently being added to the second facility to generate power as well.

		Georgetown
Number of Dwellings	-	6,500
Population	51,000 residents* 49,000 employees*	19,000 residents 1,700 employees
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	District Heating and Cooling, then CHP added
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD30 million, not including 4MW CHP
Funding: City of Markham's Utility Provider

* When fully built out. More equipment might need to be installed to meet the final demand.

Drake Landing Solar Community, Okotoks, Alberta, Canada

This 52-house subdivision seeks to approach renewable energy production by providing for the energy source closer to the consumer. A combination of seasonal and short-term thermal storage (STTS) facilitates collection and storage of solar energy in the summer for use in space heating in the winter. Borehole thermal energy storage (BTES) utilizes an in-ground heat- sink for seasonal energy storage much like a geothermal heating system. A district loop moves heat from the thermal storage to the houses. 90% heating requirements met.

		Georgetown
Number of Dwellings	52	6,500
Population	-	19,000
Area (hectares)	3	240
Units/Hectare	16	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD7 million
Funding: CAD5.5 million federal/federation/province

Solar Thermal Heating District, Crailsheim, Germany

Crailsheim is Germany´s largest solar thermal plant. 7,300 m2 of solar thermal flat plate collectors provide 50 % of the heat for a housing area with 260 units. Parts of the collectors are mounted on a noise barrier. Heat is stored in two water tanks (100 m3 and 480 m3) and in a seasonal borehole storage with 37,500 m3. The current size was originally planned as 1st phase of the solar installation. For the second phase, a collector area of 9,700 m2 (6.8 MWth) and a borehole storage of 75,800 m3 is foreseen.

		Georgetown
Number of Dwellings	260	6,500
Population	2,000	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD11 million
Funding: 50% by Ministry for the Environment

Marstal District Heating, Denmark

In 2012 an existing solar heating plant with 18,300 m3 of solar collectors and 10,000 m3 of seasonal storage was expanded with an extra 15,000 m3 of solar collectors, 75,000 m3 of seasonal pit storage and a 1.5MW heat pump under the EU supported SUNSTORE4 project. This has led to a 55% solar supply and 45% biomass supply for town of 2,100 inhabitants.

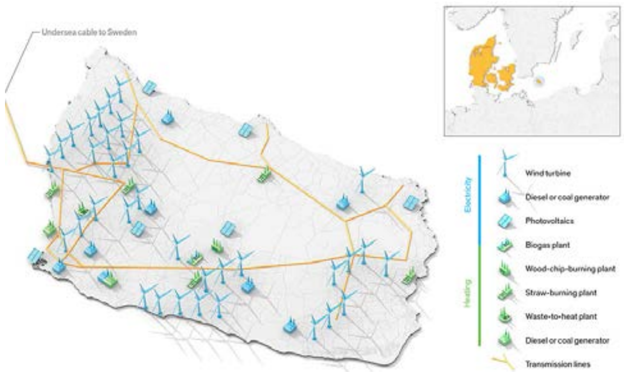
		Georgetown
Number of Dwellings	-	6,500
Population	2,100	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD11.4 million
Funding: 37% in subsidies from the EU

Samso Island, Denmark

Bornholm Island, Denmark



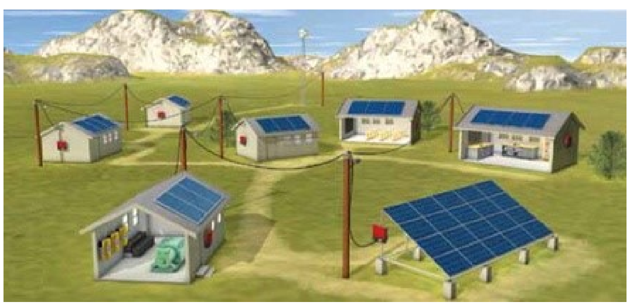
The system comprise ~28.000 electricity customers and has very high penetration of a variety of low-carbon energy resources, including wind power (30 MW), CHP (16 MW), active demand smartgrid, Photo Voltaic (6.5MW) and electric vehicles. Attempts are currently underway to increase the amount of renewable energy resources, especially wind power as well as storage. The distribution grid includes a meshed 60 kV network with 16 60/10 kV substations, 91 10 kV feeders and approximately 1000 10/0.4 substations.

		Georgetown
Number of Dwellings	-	6,500
Population	28,000	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD33 million for smartgrid alone
Funding: Partly EU funded

Microgrid Research and Innovation Park, UOIT, Canada



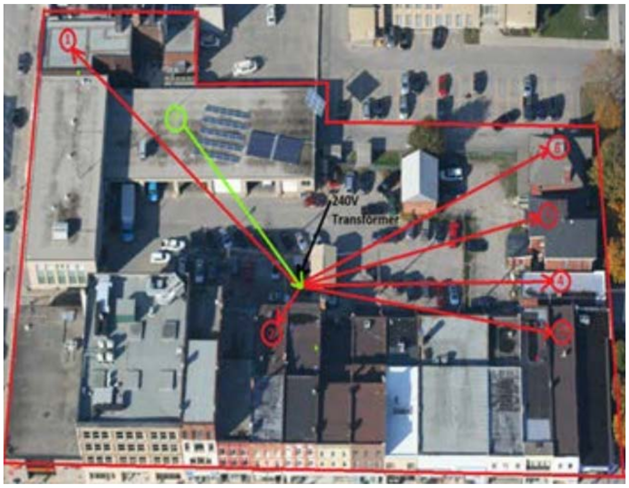
The Microgrid Research and Innovation Park will develop and demonstrate a functioning 'grid-tied' microgrid at the University of Ontario Institute of Technology (UOIT) campus in Oshawa. A 500kW Lithium ion (Li-ion) battery energy storage system, inverter system, 50kW solar PV generation and microgrid controller/optimizer will be integrated with the existing 1.6MW diesel and 2.4MW Combined Heat and Power (CHP) generation plants for this microgrid. The islanded microgrid will power first-priority critical loads during grid interruptions that are isolated from the grid until overall power is restored.

		Georgetown
Number of Dwellings	-	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD3.8 million
Funding: 100% publicly funded

Woodstock Microgrid/Smartgrid Project, Ontario, Canada



Sixteen residential and commercial loads will be supported by a microgrid to test smart metering technology, energy storage, renewable distributed generation and electric vehicles.

		Georgetown
Number of Dwellings	-	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD310,000
Funding: 100% publically funded

Nelson Community Solar, British Columbia, Canada

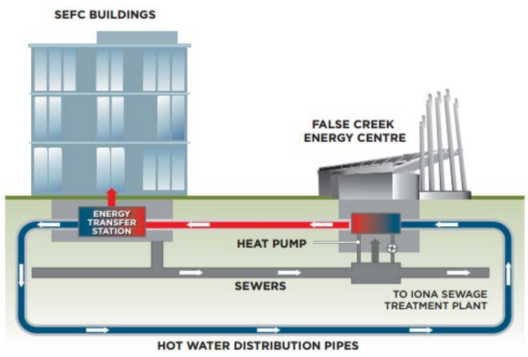
The City of Nelson's electric utility, Nelson Hydro, is set to offer solar energy to its customers. This type of community solar project makes solar more accessible. This will be the first of its kind in Canada, where the solar credit is returned on the customer's electric bill. There will be a 4 week pre-sale phase in which 75% of a 50kW array must be pre-sold, this is approximately 150 panels. Depending on the interest, the project may expand to 100kW's, which is about 400 panels.

		Georgetown
Number of Dwellings	-	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD200,000
Funding: Community

False Creek Energy Centre, Vancouver, Canada



The False Creek Energy Centre in Vancouver, B.C., is the first application of localized sewer heat recovery in North America — and the only one to use untreated sewage. For about two years, the plant has provided hot water and heating for the Neighborhood Energy Utility (NEU) in Vancouver. The plant supplies 100 percent of the heating and hot water demand — 70 percent from sewage heat recovery and 30 percent from natural gas boilers.

		Georgetown
Number of Dwellings	7,000	6,500
Population	16,000	19,000
Area (hectares)	68	240
Units/Hectare	100	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD30 million
Funding: 30% Federal Grant

Seven35, Vancouver, Canada

Seven35 is a collection of 60 stacked urban townhouses situated in North Vancouver, B.C. It achieved LEED ® Platinum and Built Green Gold certification using the SHARC sewage-heat recovery system as the key sustainability feature. The system has a capacity for 120,000 BTU's per hour. It provides 600% efficiency and an annual GHG emission reduction of 150 tonnes. The installation provides a net energy saving of 75.2% on the production of hot water. It is the first private waste-water heat recovery project in North America. 3-5 year break even point.

		Georgetown
Number of Dwellings	60	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Investment Cost: CAD150,000
Funding: Private Development

River District, Vancouver, Canada

		Georgetown
Number of Dwellings	30,000	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

The River District development in South Vancouver, Canada, will have a district energy utility that provides heat and hot water (940,000 tonnes of steam) by capturing waste heat from the 500,000 tonne Metro Vancouver mass-burn incinerator. This is in addition to the 170,000 kWh MWh of electricity already produced per year. District heat, which applies to whole neighbourhoods, is attractive because it offsets the use of natural gas and reduces greenhouse gases, making it five times more energy efficient. The electrical sales revenue offsets the operational costs of Metro Vancouver's solid waste management system.

Investment Cost: CAD400 million for new facility
Funding: Private Funding

Wainright Small Scale Waste to Energy, Alberta, Canada

		Georgetown
Number of Dwellings	-	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

A municipal Waste-to-Energy (WTE) combustor began operation in the town of Wainwright, Alberta, Canada in 1995. This 30 Ton Per Day (TPD) system is the first small scale facility built to meet the Canadian Council of Ministers of the Environment (CCME) 1989 operation and air emission standards for Municipal Solid Waste combustor.

Investment Cost: CAD4 million
Funding:

Georgian Bluffs Biogas Cogeneration Project, Ontario, Canada

		Georgetown
Number of Dwellings	-	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

Anaerobic Digestion. This facility digests sewage and other organic waste (FOG, SSO Leachate, Pet Food, Ice Cream, DAF), and produces biogas for a 100 kW generator. The project was a cooperative venture between the communities of Georgian Bluffs and Chatsworth, Ontario.

Investment Cost: CAD3.72 million
Funding: Federal Government and Ontario

Seebreeze Farm

		Georgetown
Number of Dwellings	-	6,500
Population	-	19,000
Area (hectares)	-	240
Units/Hectare	-	27.5

Electricity	Heat	Electricity & Heat
Solar Photovoltaics	Solar Thermal	Combined Heat and Power
Wind Turbines	Ground Source Heat Pumps	Waste to Energy
Anaerobic/ Biogas Digester	Borehole Thermal Energy Storage	Fuel Cells
Microgrid/ Smartgrid	Wastewater Heat Recovery	

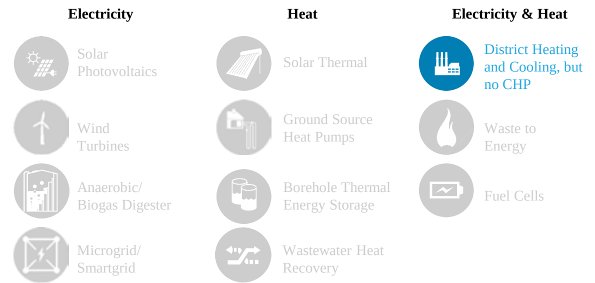
This project is a farm-based anaerobic digester project that will process the farm's dairy manure as well as approximately 12,000 tons/yr of off-farm organics. The facility will produce biogas that will be cleaned and then sold to FortisBC and injected into the existing natural gas pipeline. A unique aspect of this project is the digestate that is produced will be further processed on-site to produce a number of co-products.

Investment Cost: CAD329,000
Funding: Public Grant

Regent Park Revitalization Phase 1, Toronto, Canada

No microCHP

		Georgetown
Number of Dwellings	1,030	6,500
Population	-	19,000
Area (hectares)	4.3	240
Units/Hectare	240	27.5



Regent Park is undergoing a revitalization of a former social housing development that is seeing it transformed into a mixed income and mixed use neighbourhood accommodating 12,500 residents across 69 acres. Phase 1 of the development includes 1,030 units and other mixed use space. There is a central energy plant made up of chillers and natural gas boilers. The energy plant has the ability to expand to feed the rest of the development and also take on board other technologies such as cogeneration, trigeneration, geoexchange, waste heat and solar.

Investment Cost:
Funding: 15% Federal and Ontario Gov. Grants