City of Charlottetown

Community Energy PLAN

For a naturally bright future.

CHARLOTTETOWN

PHOTO: TOURISM PEI @IVORYORPHAN INSTAGRAM

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GLOSSARY OF TERMS

BAU	Business-as-Usual
CAD	Canadian Dollars
tCO_2e	tonnes of Carbon Dioxide equivalent
CEP	Community Energy Plan
ICLEI	International Council for Local Canada Environmental Initiatives in Canada (also known as Local Governments for Sustainability)
ICSP	Integrated Community Sustainability Plan
FCM	Federation of Canadian Municipalities
GHGs	Greenhouse Gases
GJ	Gigajoule
GWP	Global Warming Potential
KwH	Kilowatt Hour
MCIP	Municipalities for Climate Innovation Program
MCH	Minimum Code Compliant Home
MSW	Municipal Solid Waste
PACE	Property Assessed Clean Energy
PCP	Partners for Climate Protection
PJ	Petajoule
PLE	Passive Low Energy Home
PV	Photovoltaic
QUEST	Quality Urban Energy Systems of Tomorrow (organization based in Canada)
RE	Renewable Energy
SCC	Social Cost of Carbon
TCBO	Total Cost of Building Ownership

HOW TO READ THE COMMUNITY ENERGY PLAN

This Community Energy Plan (CEP) provides a vision and direction to using only renewable sources to meet Charlottetown's energy needs. It is not intended to be prescriptive or provide a detailed roadmap. It provides an overview of what the City's 100% renewable energy commitment means and how it was developed, followed by some context in which the strategy must be considered. Detail is given on some potential technological options and actions that can be taken to transition Charlottetown's buildings and transportation to use only renewable energy. Throughout the CEP, "the City of Charlottetown" or "the City" refers to the municipal corporation, while "the city" (with a lower-case "c") refers to the whole community.

EXECUTIVE SUMMARY

Municipalities play an important role in the international, national, regional and local efforts to reduce greenhouse gas emissions through improving energy efficiency and increasing the use of renewable energy. This Community Energy Plan (CEP) helps define the City of Charlottetown's community energy priorities with a view to improving efficiency, cutting emissions, and driving economic development and addresses the City's sustainability goal to:

> **"Create a community greenhouse gas (GHG) emissions reduction strategy for the City of Charlottetown that includes setting and implementing long-term emission reduction targets at the corporate and community levels."**

First Steps

To set a baseline for this plan, 2015 corporate and community-level energy and emissions inventories were completed. The City's GHG inventory of municipal operations tracks its energy use, energy/waste disposal expenditures, and GHG emissions. GHG emissions in the City's municipal operations inventory in 2015 were almost 7,500 tonnes of carbon dioxide equivalent (tCO_2e), with annual expenditures of roughly $3.5-$4 million dollars, figures which will increase in the foreseeable future, with a business-as-usual (BAU) approach.

The Community Energy and Greenhouse Gas Inventory Report for 2015 indicated end-use energy of 5.35 petajoules (PJ), energy expenditures of $176 million, and emissions of 456,000 tCO_2e. Annual climate costs were estimated at $146 million. Chronic exposure to air pollution causes illness and death. An estimated seven mortalities each year in Charlottetown are associated with air pollution with the social costs of morbidity and mortality estimated at $85 million.

Clearly the climate and air pollution costs are too high to maintain. There is an ethical obligation to address these social costs. Furthermore, increasing energy efficiency and clean, renewable energies will generate new jobs, reduce energy demand, provide reliable and affordable energy, and lead to greater energy price stability.

The City of Charlottetown has held educational events on climate change and community energy planning. Public consultations and surveys engaged more than 300 residents. Emergent themes formed the basis of the City's community vision for sustainable energy.

Extensive research has been conducted, with assistance from a wide range of subject-matter experts, to evaluate various climate change and air pollution solutions which, taken together, can help to reduce energy use in buildings and transportation, make a shift to renewable energy sources, and foster sustainable community development. These measures and technologies (see Appendix B) underwent a comprehensive technical review by more than 50 experts and stakeholders. The CEP is remarkably flexible in terms of what measures and technologies may be used to reach energy goals. In other words, there are multiple pathways to a 100% renewable city.

The scenario on page 11 paints a picture of 2050 Charlottetown with 100% renewable energy, showing a 49% reduction in energy demand. The move to greater energy efficiency and renewable resources will lead to energy cost savings, energy price and economic stability, reduced climate and health costs and improved well-being. Energy efficiency upgrades could generate over 500 10-year full-time jobs, adding $60 million in GDP to the city annually over the next decade. Overall, this transition to a renewable city will create more than 600 30-year full-time jobs related to energy efficiency and renewable energy.

Community Vision for a Sustainable Energy Future

Charlottetown aims to quickly reduce community GHG and air pollutant emissions while securing reliable affordable energy locally, increasing energy efficiency, and creating jobs and economic growth. The City envisions exceeding current targets in 2030 and transitioning all energy for homes, businesses, cars, and trucks to clean, renewable sources before 2050. In short, the City's vision is:

> **"By 2050, Charlottetown is a carbon neutral, diverse and economically strong community, powered only by renewable energy."**

TARGETS

1. **Community:** Adopt the City of Charlottetown CEP and transition to a 100% renewable and carbon neutral city by 2050 at the latest, with GHG reductions of 50-65% relative to 2015 levels by 2030.
2. **Corporate:** Reduce GHGs in municipal operations by 40% by 2030. Across all corporate operations, strive to be 100% renewable and carbon neutral by 2050.

The following is an abbreviated list of actions that will lead to a 100% renewable city. Actions are categorized according to the four objectives which emerged from public feedback.

Objective: To significantly improve energy efficiency in buildings

1. Establish a financing mechanism for energy upgrades.
2. Complete comprehensive energy audits and retrofits of City-owned buildings and infrastructure.
3. Construct all new City buildings to Passive House and Zero Carbon Building Standards.
4. Support Passive House and Zero Carbon multi-story affordable housing developments.
5. Develop strategies to entice greater use of high efficiency heat pumps, thermal energy storage, solar PV, and other cleantech in both retrofits and new construction.
6. Increase collaboration with efficiencyPEI and the Province of PEI to encourage incentives for GHG reduction measures and technologies.

Objective: To greatly reduce energy use in transportation

7. Work with transit stakeholders to convert to four electric buses by 2022 and an entire electric fleet by 2030.
8. Work with partners to add at least 10 Level 2 electric vehicle (EV) chargers in Charlottetown by 2022.
9. Use incentives for installing at-home / public EV chargers. Help remove hurdles to EV adoption.
10. Update the City's entire corporate fleet of light vehicles to EVs between now and 2030-2035.
11. Continue to develop the City's mesh networking to improve connectivity and support smart city technologies.
12. Invest in traffic control technology to reduce idling and improve traffic flow in the city.
13. Reinvigorate the anti-idling campaign in the city and reassess the practicality of a bylaw.
14. Continue to monitor and expand the City's use of automated vehicle location fleet software.

15. Complete the Fitzroy Street bike lane per the City's 2018 Cycling Connectivity Report.
16. Investigate the potential of allowing low-speed biking on some sidewalks as done in other cities. Expand and connect dedicated cycling infrastructure and multi-use pathways.
17. Boost education campaigns for cycling and public transit to encourage multiple forms of mobility.
18. Demonstrate clean energy transport for City operations within the heavy-duty fleet.
19. Work with stakeholders to support switching transport to electric vehicles.

Objective: To transition to clean renewable energy

20. Work with the Province of PEI to explore developing more wind and solar capacity beyond current plans.
21. Increase the deployment and integration of renewable energies with smart technology and new market designs in the electricity sector.
22. Encourage a solar incentive program in the city.
23. Support private enterprise in the shift away from fossil fuels.
24. Examine the potential of large-scale cost-effective thermal storage of renewable energy.

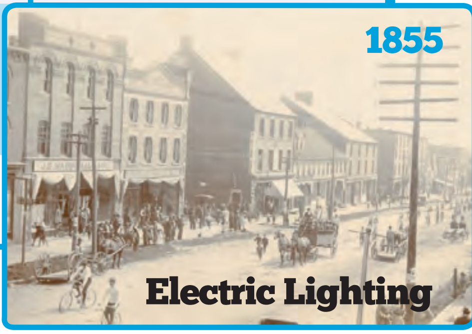
Objective: To foster sustainable community development

25. Support retraining of affected workers and training of the future workforce.
26. Invest in City staff capacity to implement this plan.
27. Incorporate a Green Procurement Policy with a life cycle assessment for the City of Charlottetown.
28. Incorporate measures and technologies into existing and new City zoning and development bylaws and relevant plans and strategies.
29. Develop and implement a corporate energy policy applicable to all City assets and services.
30. Improve data collection for tracking community energy, expenditures, and emissions.
31. Encourage greater residential and commercial density.
32. Support community bulk buys and neighbourhood approaches when practical to help reduce costs and fast-track the energy transition.
33. Collaborate with partners on the implementation of actions so they are as effective as possible.
34. Demonstrate low-carbon technology at all scales of City operations.
35. Continue implementing sustainability initiatives including those that help the private sector.
36. Promote common-sense approaches to waste reduction.
37. Foster entrepreneurship, innovation, and emerging technologies in the growing cleantech sector.
38. Ramp up community-driven climate resilience planning that strengthens City Planning and Climate Adaptation.

Charlottetown energy sources

At one time, people had to carry a whale oil lamp to see their way up a dark, muddy Queen Street because there were no streetlights to show the way. Coal for heat, a luxury not afforded to many, was delivered by horse drawn carts. These scenarios were the norm not so long ago, but since then, we've become accustomed to unwavering electricity at the flick of a switch and heat at the turn of a dial. Energy sources have evolved over time, but in recent years it has become increasingly clear that our reliance on fossil fuels is not sustainable. Fortunately, we're on our way to discovering the potential of clean, renewable sources like wind and solar to meet our energy needs.

Coal progressed from being exclusively a rich person's fuel to the most commonly used heat source on the Island over this time period. Wood burning was also a common way to generate heat.



Electric lighting came to the streets of Charlottetown, generated by coal-produced steam.

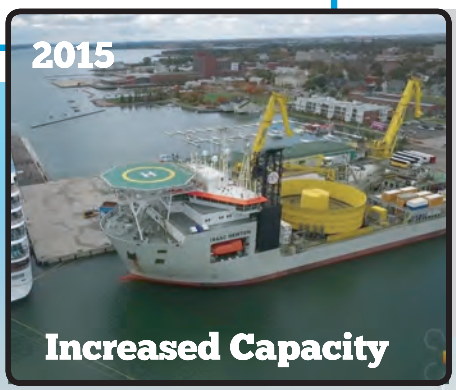
1960 Oil Heat

Many residents began making the switch from wood/ coal to oil heat.

1977 Undersea Power Cables

As per the Comprehensive Development Plan, two 100 MW undersea electricity transmission cables from New Brunswick were acquired and leased to Maritime Electric.

PEI Energy Systems became operational in 1983 and remains an important contributor to Charlottetown's energy mix today. It uses 40% municipal solid waste, 40% biomass, and 20% oil to provide heat to about 150 buildings including the QEH and the Charlottetown Mall.



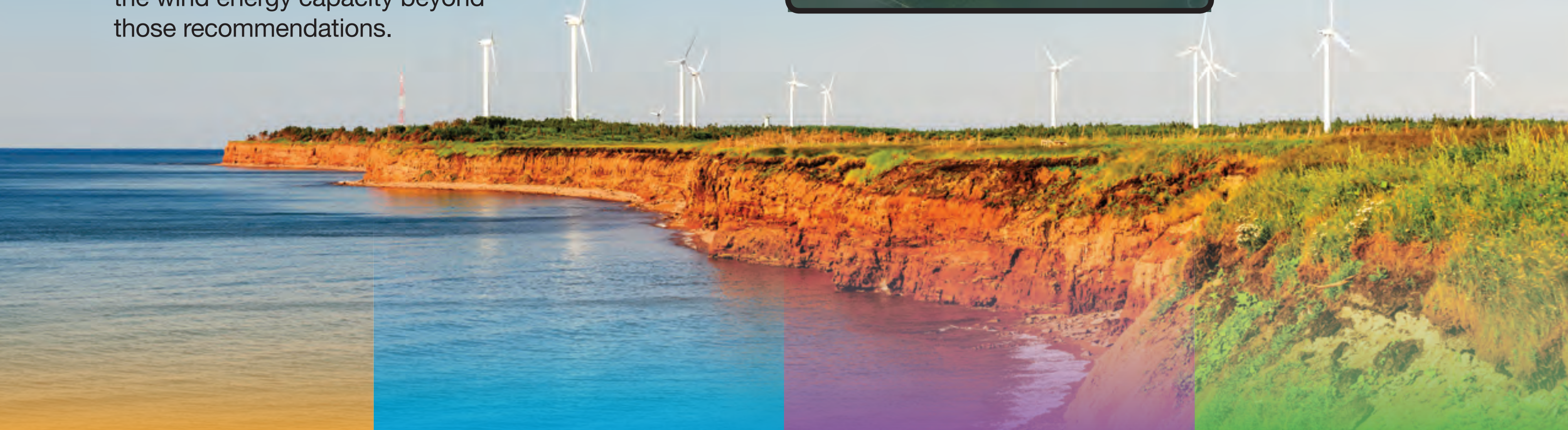
The Sir Isaac Newton, anchored in the Charlottetown Harbour (left), was used to lay two 180 MW undersea electric transmission cables to eventually replace the previous ones.

2015

The prevalence of oil heating systems declined in favour of more efficient options, such as high efficiency heat pumps. Heat pumps are becoming more mainstream and readily available.

2016 Wind Energy

More than 25% of the province's electrical needs were met by wind, the highest of any jurisdiction in North America. The Provincial Energy Strategy proposed a new 30MW wind project for 2019 and a further 40MW project in 2025. Charlottetown's CEP proposes expanding the wind energy capacity beyond those recommendations.



Key Highlights:

The infographic on the following page paints a picture of Charlottetown using 100% renewable energy in 2050.

- The City of Charlottetown's community end-use energy shifts from 25% electricity in 2015 to 89% in 2050.
- Increasing energy efficiency in buildings increases the city's GDP by $60 million per year for a decade.
- Ramping up energy efficiency retrofits could add an estimate of 526 10-year full-time jobs. Energy efficiency upgrades plus renewable energy installations could add the equivalent of 614 30-year full-time jobs.
- Quickly shifting to low energy buildings for new construction reduces energy demand and eliminates the need for expensive retrofits post construction.
- Most of the energy demand reduction results from electrification of heating and transport, mainly due to high efficiency heat pumps and electric vehicles.
- Air- and ground-source heat pumps provide heating and cooling; the former require only 25% of energy used by oil heating systems and the latter only 20%.
- Electric vehicles only need 25% of the energy conventional vehicles need to go the same distance.
- Solar and wind energy are clean sources that stabilize energy prices since the fuel costs are zero; energy price stability fosters stable economic conditions.
- Energy demand is reduced by 49%.
- Even with energy costs, delivery infrastructure, storage costs, and eventually excise tax, the community will see overall energy costs slightly lower than or similar to today's.
- The health and climate cost savings are substantial.

Conclusion

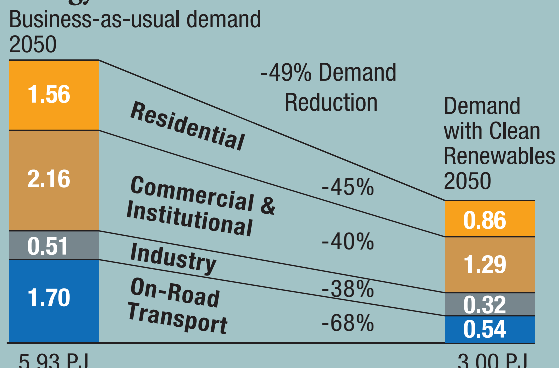
Charlottetown's transition to a renewable and carbon-neutral city will not happen overnight. Nevertheless, implementation of this Community Energy Plan will unlock many benefits including improved efficiency, fewer emissions, improved health and well-being, and significant climate benefits. On the economic front, benefits include growth and stability, increased jobs, and more affordable and stable energy pricing. In short, the city's shift will have significant benefits and relatively few downsides.

Charlottetown 2050

100% Renewable Energy for Homes, Businesses and Vehicles

CHARLOTTETOWN

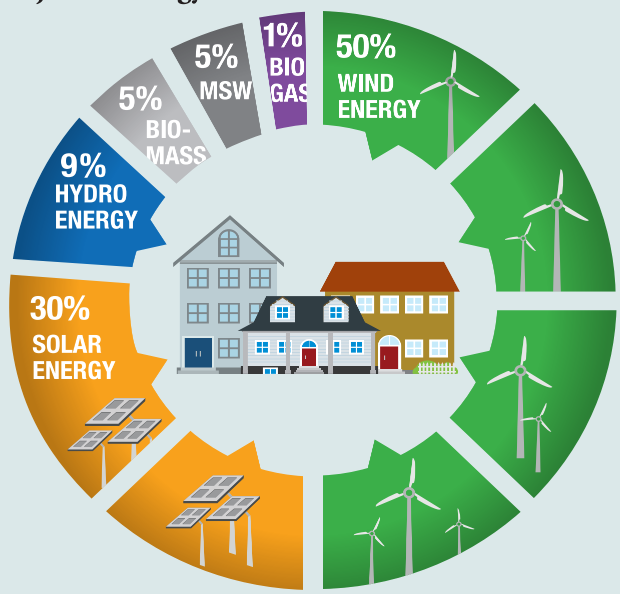
Energy Demand



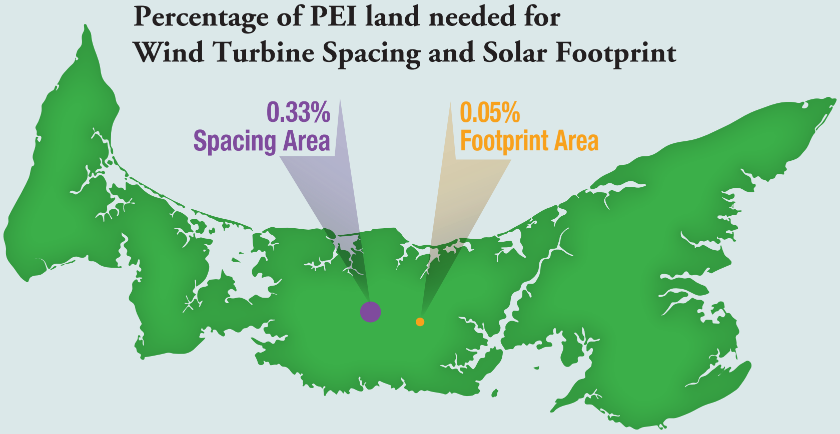
ENERGY COST SAVINGS: (Per Person Per Year) $130

ENERGY, HEALTH AND CLIMATE COST SAVINGS: (Per Person Per Year) $5,630

City of Charlottetown Projected Energy Mix - 2050



Percentage of PEI land needed for Wind Turbine Spacing and Solar Footprint



Job Creation

Energy Efficiency and Renewable Energy Jobs

614 30-Year Full-Time Jobs

INTRODUCTION

What is a Community Energy Plan?

A CEP is a tool to define community energy priorities with respect to improving efficiency, cutting emissions, and driving economic development. Though there is no standard approach to developing a CEP, it often contains community energy inventories and forecasts, energy and emissions reduction targets, target actions and timelines for implementation. Actions generally relate to:

- Energy efficiency in new and existing buildings
- Transportation and public transit
- Active transportation
- Low carbon vehicles and other transportation actions, including policies on anti-idling
- Waste, including landfill gas
- Renewable energy, district energy[1] and combined heat and power
- Water consumption
- Planning and policy measures
- Stakeholder outreach

This document contains a summary of the City of Charlottetown's community energy use and GHG emissions in 2015 as well as the energy, climate, and health costs associated with the City's energy use in this baseline year. It also provides the projected population and associated energy usage and GHG emissions from 2015 to 2050, if a business-as-usual approach is followed. A way forward to transition Charlottetown to a renewable city that is carbon neutral is outlined. And, finally, an overview of the implementation phase is provided.

Guiding the Way

This CEP is very beneficial to the city. It has helped the community to collaboratively establish targets and prioritize actions on energy and emissions. It also mobilizes stakeholders, policymakers and investors on an ongoing basis, giving them confidence in the community's commitment to act on energy and emissions.

CEP implementation can also help the community achieve several objectives at the same time, including goals related to economics, health, social well-being, resilience and the environment. Examples of these co-benefits include:

- Economic benefits from energy cost savings and local energy spending
- Reduced costs from local energy generation
- Increased savings from residential, commercial and industrial conservation programs
- Creation of jobs and keeping more dollars in the local economy
- Reduced costs from energy savings in transport
- Improved air quality, thanks to reduced energy demand, reduced energy consumption due to the use of electricity-powered heat pumps and electric vehicles, and reduced overall air pollution levels
- Health benefits including fewer doctor and emergency room visits, hospitalizations, reduced incidences of premature mortality because of improved air quality, and fewer lost work days and school days; leading to increased productivity and wages.
- Reduced obesity rates and increased longevity through active transportation improvements
- Social and resiliency benefits
- Energy maps to identify vulnerabilities
- Improved community access to reliable energy sources

1 District energy in the city is provided with a mix of approximately 40% waste-to-energy, 40% biomass, and 20% oil.

- Additional environmental benefits, including significantly reduced water use and water chemical pollution, avoidance of thermal pollution, reduced under-nutrition and fewer impacts on wildlife
- Reduced greenhouse gases (GHGs)
- Improved tree canopy through reforestation efforts

Quality Urban Energy Systems of Tomorrow (QUEST Canada), a solutions-oriented organization focusing on integrated community energy planning, maintains that if every Canadian community developed and implemented a CEP, GHG emissions would be reduced, urban air contaminants would be reduced, GDP would be increased, and jobs would increase. All very good reasons to implement this plan.

Energy and Sustainability

The City of Charlottetown initially developed an Integrated Community Sustainability Plan[2] (ICSP) in 2010 and most recently updated it in 2017. ICSP development was comprehensive in terms of public consultations, stakeholder meetings, surveys and staff meetings. This CEP is in direct response to one of the ICSP goals, namely:

> **"Create a community GHG emissions reduction strategy for the City of Charlottetown that includes setting and implementing long-term emission reduction targets at the corporate and community levels."**

The ICSP identified several themes: water; energy; transportation; food; healthy economy; infrastructure and the built environment; people and places; arts, culture and heritage; active healthy living; and nature.

2 City of Charlottetown Integrated Community Sustainability Plan (ICSP) 2017: https://www.charlottetown.ca/environment___sustainability/sustainability/sustainability_resources.

The ICSP energy theme stated:

> **"Improving energy efficiency, converting to renewable energy sources and reducing our dependency on fossil fuels are key components to community sustainability, as heard throughout the public consultation process."**

Mitigating Climate Change

Global warming increases heat stress, disease, severity of tropical storms and cyclones, ocean acidity, and sea levels as well as the melting of glaciers, snow pack, and sea ice. Further, it shifts viable agriculture locations, harms ecosystems and animal habitats, and changes the timing and magnitude of water supply.

PEI climate change predictions include increased summer heat stress, warmer winters with less snow, new pests and diseases coming from the south, more frequent and severe storms, rising ocean acidity and sea levels, higher storm surges, more rapid coastal erosion and less winter sea ice. Shifts in agricultural production (e.g., what crops are viable), changes to forest composition, the eventual loss of some commercial and recreational fisheries, and other ecosystem biodiversity changes are also expected. There will also be changes to the timing and intensity of precipitation, with related impacts on soil erosion and water supply. Arnold and Fenech (2017)[3] provide a comprehensive overview of the expected climate change impacts here on PEI, and many recommendations to help the province better adapt to the effects of climate change.

3 Arnold, S. and A. Fenech. (2017, October). Prince Edward Island Climate Change Adaptation Recommendations Report. University of Prince Edward Island Climate Lab. Charlottetown, Canada. Report submitted to the Department of Communities, Land and Environment, Government of Prince Edward Island, 172p. https://www.princeedwardisland.ca/en/information/communities-land-and-environment/climate-change-adaptation-recommendations-report

Locally and globally the effects of climate change are being witnessed and experienced first-hand, often with devastating consequences.

Limiting global warming through rapid and far-reaching transitions in energy across all sectors is critical to ensure a safe and sustainable world for everyone, now and in the future.

This CEP document is focused on climate change mitigation efforts, so that adaptation is more manageable.

The Paris Agreement[4] included the aim of strengthening the global response to the threat of climate change by "holding the increase in the global average temperature to well below 2°C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels."

The Intergovernmental Panel on Climate Change (IPCC) recently issued a Special Report on Global Warming of 1.5°C approved by governments.[5] The report finds that limiting global warming to 1.5°C would require "rapid and far-reaching" transitions in land, energy, industry, buildings, transport, and cities. Global net human-caused emissions of carbon dioxide (CO_2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. This means that any remaining emissions would need to be balanced by removing CO_2 from the air (see Appendix A, page 47).

Limiting global warming to 1.5°C compared with 2°C will reduce challenging impacts on ecosystems, human health and well-being, making it easier to achieve the United Nations Sustainable Development Goals. The decisions we make today are critical in ensuring a safe and sustainable world for everyone, both now and in the future.

A key message that comes out very strongly from this report is that we are already seeing the consequences of 1°C of global warming through more extreme weather, rising sea levels, diminishing Arctic sea ice, among other changes.

What difference does 0.5°C of global warming make? Every extra bit of warming matters, especially since warming of 1.5°C or higher increases the risk associated with long-lasting or irreversible changes, such as the loss of some ecosystems. Limiting global warming gives people and ecosystems more room to adapt and remain below relevant risk thresholds. The report highlights a number of climate change impacts that could be avoided by limiting global warming to 1.5°C compared to 2°C, or more. For instance, the likelihood of an Arctic Ocean free of sea ice in summer would be once per century with global warming of 1.5°C, compared with at least once per decade with 2°C.

Planning at All Levels

All levels of government have a role to play in reducing GHG emissions through improving energy efficiency and increasing the use of renewable energy. The Governments of Canada and Prince Edward Island (PEI) are working within the Pan-Canadian Framework on Clean Growth and Climate Change.[6] It includes a Canadian target for GHG emissions to reduce 2005 levels by at least 30% by 2030.

At the provincial level, the PEI Climate Change Action Plan 2018-2023 mirrors that target: "Government together with residents, businesses, and industries, will reduce provincial GHG emissions by 30% below 2005 levels by 2030."[7] In addition, the province has signed a voluntary agreement with the New England Governors and Eastern Canadian Premiers to reduce provincial GHG emissions by 35-45% below 1990 levels by 2030.[8]

The City of Charlottetown applauds commitments made at the provincial and federal level, but it wants to push these commitments even further and challenge the community to reach beyond those targets. There are two main reasons for this ambition. First, the City can do its part in helping to meet global climate targets which, according to the international community, requires ratcheting up current commitments. Secondly, feedback

4 The Paris Agreement was adopted by 195 nations at the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015.

5 http://www.ipcc.ch/report/sr15/

6 See Pan-Canadian Framework on Clean Growth and Climate Change, 2016: https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html.

7 See: PEI Climate Action Plan 2018-2023 (2018): https://www.princeedwardisland.ca/en/information/communities-land-and-environment/climate-change-action-plan-2018-2023.

8 See: NEG/ECP Resolution 39-1 (2015): http://www.coneg.org/Data/Sites/1/media/39-1-climate-change.pdf.

received through the consultations and surveys used to develop this plan showed a consensus that Charlottetown should take greater action, beyond the current federal and provincial commitments to reduce GHGs.

Creating a Plan

The plan was designed to evaluate and demonstrate whether there are viable pathways to stimulate cleantech innovation, create jobs, and set conditions for sustained economic development while reducing GHG and air pollutant emissions. The main goal of the City's CEP is to address emissions in the energy sector. Development of this CEP followed a five-phase process (see **Figure 1**):

Figure 1: Five-Phase Development Process

Accessing Funds

In 2016, the City of Charlottetown joined the Federation of Canadian Municipalities (FCM) - Partners for Climate Protection (PCP) program. Jointly managed and delivered by the FCM and the International Council for Local Environmental Initiatives in Canada (ICLEI Canada), the program empowers municipalities to act on climate change through a five-phase process similar to the one used to create this CEP.

The FCM Municipalities for Climate Innovation Program (MCIP) is a five-year, $75 million program that helps municipalities prepare for, and adapt to, climate change, and to reduce GHG emissions. Funded by the Government of Canada, MCIP is available to all municipalities and their partners. The City of Charlottetown secured $99,900 in MCIP funding. In addition, it received $5,000 from efficiencyPEI, and $1,500 from Maritime Electric. The City committed $18,500 for this initiative.

With the additional funding from MCIP, the City of Charlottetown is able to complete its community inventory and develop an official GHG Emissions Reduction Plan. The City has a lasting commitment to reducing its GHG emissions with the aim of contributing to the province's emissions reduction target.

Getting Advice

In-kind voluntary contributions, valued in the amount of $40,000, were provided by approximately 30 supporters, who committed to assist with the CEP prior to beginning this project. Once the project began, the number of in-kind contributions grew. An expansive list of in-kind contributors is provided in the Acknowledgements section.

In addition to these generous supporters, the City established an Internal Advisory Team to guide CEP development. Team members are:

- **Ramona Doyle**, Sustainability Officer, and CEP Project Manger
- **Jessica Brown**, Sustainability Outreach Officer
- **Richard MacEwen**, Manager of Water and Sewer Utility, and Lead Technical Advisor
- **Betty Pryor**, Sustainability Projects Officer
- **Beth Hoar**, Parkland Conservationist
- **Tyler Veinot**, GIS Technician, and Lead Community Mapping Specialist
- **Matt McCarville**, Community Energy Planner

Resident Input

Early in the process of developing the plan, the City organized a Climate Change 101 presentation, delivered by Stephanie Arnold, a researcher at the UPEI Climate Lab. More than 50 members of the public attended this presentation. It was subsequently offered to staff and Council. A similar number of people attended a Community Energy Speaker Session, hosted by Mayor Clifford Lee, featuring presentations by Eddie Oldfield, CEO of Spatial QUEST, and Dr. Matthew Hall, Professor at the UPEI Faculty of Sustainable Design Engineering.

In late 2017 and early 2018, 300 community energy surveys were completed. In addition, two public consultations were held, with a total of 65-70 participants. Dozens of residents also provided their input directly to staff, increasing the public feedback. These activities resulted in the identification of several themes which formed the basis for this plan. The vision to shift to a sustainable energy future was subjected to a rigorous evaluation process.

The draft CEP was collaboratively reviewed online by many in-kind contributors who had a chance to offer subject-matter expertise, guidance, and insights across a range of areas, as described below. This review was followed by a technical advisory meeting with local subject-matter experts. Feedback from these two processes fed the second draft of the CEP, which was subsequently shared for feedback with a diverse range of stakeholders. The third iteration of this document was released for another round of public consultation.

The second round of public consultations demonstrated that residents and stakeholders are highly engaged in Charlottetown's energy future. Feedback that was collected online and in-person at the consultation

"The Community Energy Plan is a great blueprint for our City moving forward. My family has chosen to live and work in Charlottetown. As we raise our two young children, we are excited to see the City taking steps to reduce energy use in areas such as transportation and to support and encourage sustainable community development. Focusing on these important areas will help to ensure our city remains a great place to live for us, our kids, and our future grandchildren."

- Feedback from a Charlottetown Resident on the Draft Community Energy Plan

event suggest that there is considerable support for the Community Energy Plan's vision for Charlottetown in 2050 as a carbon neutral, diverse and economically strong community powered only by renewable energy. Overall, participants felt the community- and corporate-level targets and actions were appropriate. They shared creative ideas for how to achieve the CEP targets and actions, and offered constructive suggestions for how to improve upon the draft CEP.

Weighing Solutions

To evaluate the best way to achieve the vision, proposed energy-related solutions were assessed for their potential to reduce global warming and air pollutant emissions while simultaneously examining other environmental impacts. Technical feasibility and economic viability were also evaluated, including an assessment of factors such as securing reliable supplies of affordable energy, potential to increase long term energy price and economic stability, and job creation. A range of energy conservation and energy efficiency measures were evaluated side-by-side with energy supply choices. The assessment covered existing low-cost measures and technologies plus emerging cleantech across all energy sectors of the economy. Negative emissions measures and technologies were also examined in some detail. See Appendix B for the full list of measures and technologies examined.

Reviewing the Plan

The July 2018 CEP draft, which at the time was principally a technical document, was circulated to internal reviewers across the City's departments as well as to in-kind technical reviewers locally and abroad. The document was circulated to more than 50 reviewers resulting in many edits. These edits as well as some from a subsequent technical advisory meeting held at City Hall were incorporated into this final document.

Input from City management and staff was also factored into the CEP. For example, they provided important feedback on the targets and actions.

This process resulted in a list of targets and actions that reflects the community's values and desire to quickly reduce GHGs and shift to sustainable energy.

STEPS TAKEN

Even in advance of the Community Energy Plan, the City has taken a number of actions within its municipal operations to address GHG emissions and promote sustainability. Actions relating to City-owned assets, by year, include:

2015

- An energy efficiency coordinator was hired to conduct energy audits of the City's corporate facilities, oversee the implementation of audit recommendations and complete a corporate GHG emissions inventory.

2016

- Following an audit conducted at the City Works Garage, several improvements were made to reduce oil and electricity consumption, including: interior/exterior LED lighting, automated controls for the heating system and the installation of heat pumps in office spaces.

"Don't plan for meeting minimum standards! Pour resources into improving energy efficiency in existing buildings. Lead the country on this.

Implement building codes that far supersede the national building code. By building Passive House buildings, we can significantly lower our residential and commercial energy usage."

- Feedback from Charlottetown resident

- Energy upgrades at the West Royalty Community Centre included heat-pump installation and attic insulation.

2017

- Automatic vehicle location was implemented in part of the City's vehicle fleet, reducing fuel costs, increasing productivity, and identifying new ways to cut GHG emissions.
- LED lighting retrofits were completed at City Hall, Simmons Arena and the Cody Banks Arena.
- Funding was secured through FCM, with financial support from efficiencyPEI, Maritime Electric, and the City to research and ultimately develop this CEP.
- An inventory of energy, expenditures, and GHGs for the City of Charlottetown's municipal operations was completed for the years 2013-2017.
- The Efficiency Coordinator transitioned into a Community Energy Planner role.
- Modifications were made to the anaerobic digestors at the Charlottetown Resource Recovery Facility to reduce methane leakage, a powerful GHG, and increase the usable methane for heating and process energy at the wastewater treatment plant.
- Several public transit improvements were made: bike racks installed on each of the several buses serving Charlottetown, Cornwall, and Stratford areas; buses are wheelchair accessible; 27 new bus shelters were added, including 15 in Charlottetown; free WiFi was made available on T3 buses; a free ReadyPass phone app was developed to help T3 riders have seamless, convenient commutes by allowing them to see where the buses are in real-time.
- Funding was awarded to the UPEI's School of Sustainable Design Engineering to research various opportunities relating to the transformation of the City's wastewater treatment plant to the Charlottetown Resource Recovery Facility.

2018

- Solar photovoltaic (PV) capacity (200 kilowatts) with seasonally adjustable racking was commissioned at the Miltonvale Wellfield and Booster Station; with an overall yield expected to double the energy output from the Jean Canfield Building's large solar PV system in Charlottetown.
- Requirements to electrify public transit were evaluated and an electric bus was demonstrated.
- MCIP funds were secured in the amount of $24,200 to complete a more comprehensive energy audit and structural assessment of the City Works garage, the largest source of emissions at any City-owned building, to identify measures to expand on the energy efficiency audit and retrofits to date at the facility in order to achieve deep GHG emission reductions. The City contributed $6,060.
- A sustainability research intern was hired to assist with a range of files – including community energy and GHG reductions – on a part-time basis.
- Measures are being taken to enhance the city's cycling culture and infrastructure.
- Lighting upgrades are complete at Queen and Fitzroy Parkades and partially complete at the Pownal Parkade.
- An LED retrofit is getting underway at the Police Station.
- To date, the City's free Showerhead Exchange Program has resulted in the installation of a few hundred low-flow showerheads with an estimated annual savings of 171 tonnes of CO_2, more than 12 million litres of water, and $77,000.

Miltonvale Wellfield and Booster Station

- 200 kW of new solar PV (photovoltaic) capacity added
- Installed two 100 kilowatt (kW) solar PV systems.
- Annual energy: 250,000 kWh
- Annual GHG savings: 150 tonnes CO_2

COMMUNITY ENERGY PROFILE

This section paints a picture of the community's 2015 energy profile constructed from a GHG emissions inventory; baseline energy usage; energy costs; and combined energy, climate and pollution costs. In 2015, Charlottetown's population was estimated at 37,200, slightly more than 25% of the province's official population estimate at that time.

Table 1: City of Charlottetown Greenhouse Gas Inventory, 2015

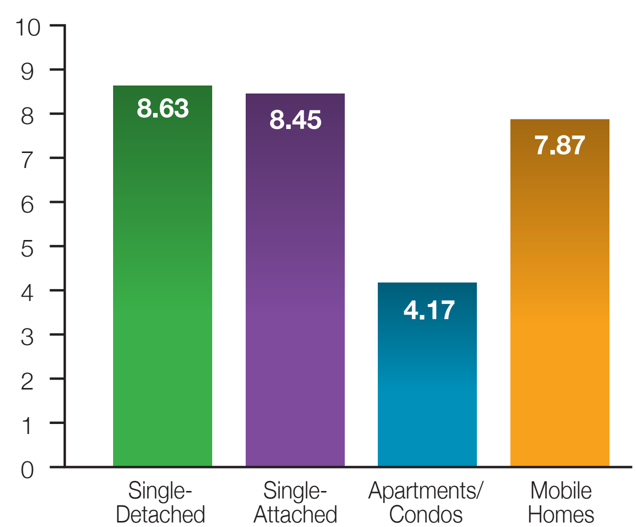
	Tonnes CO_2e
Residential	108,936
Commercial and Institutional	161,000
Industrial	35,286
Transportation	120,235
On-road	*100,051*
Off-road	*71*
Marine	*283*
Aviation	*19,830*
Waste	6,400
Landfill	*5,400*
Compost	*1,000*
Agriculture	170
Enteric Fermentation	*140*
Manure Management	*30*
Total GHGs	432,027
Per capita GHGs, Charlottetown	11.61
Per capita GHGs, PEI	15.53
Charlottetown % below PEI average	25%
Black Carbon (BC) Particles (tCO_2e)	24,000
Total tCO_2e (GHGs + BC)	**456,027**
Total Per Capita GHG + BC tCO_2e	**12.26**

Greenhouse Gas Emissions

The city's 2015 GHG inventory is discussed below in relation to residential, commercial and institutional, and industrial sectors as well as transportation, waste, and agriculture. A breakdown of the inventory is provided in **Table 1** on the left. It shows community-level GHG quantities by sector and subsector. The following provides some detail relating to the inventory table.

With respect to residential, there were an estimated 16,110 occupied dwellings. Urban areas generally benefit from greater density in the built environment which often reduces GHGs associated with space heating and transportation. Charlottetown's GHGs were lower than the province's due to the city having a higher percentage of households which are apartments and condominiums (41.1% vs 18.7%). While floor space in an apartment/condo averages more than half that of a typical single detached dwelling on PEI, the average overall energy use in them was less than half in comparison. In total, residential sector GHG emissions contributed an estimated 108,936 metric tonnes of carbon dioxide equivalent (tCO_2e), a per household average of slightly less than 6.76 tCO_2e. Average GHG emissions by household type are shown in **Figure 2**.

Figure 2: Average GHG Emissions by Household Type, 2015



The high proportion per capita commercial and institutional space in the City, compared to the rest of PEI, increased the City's per capita energy use and GHGs (161,000 tCO_2e) in the sector. The industrial sector GHG production was 35,286 tCO_2e.

The transportation results were broken down into four sectors, with on-road transport producing the highest level of GHGs (100,051 tCO_2e) followed by aviation (19,830 tCO_2e), marine[9] (283 tCO_2e) and off-road transport[10] (71 tCO_2e).

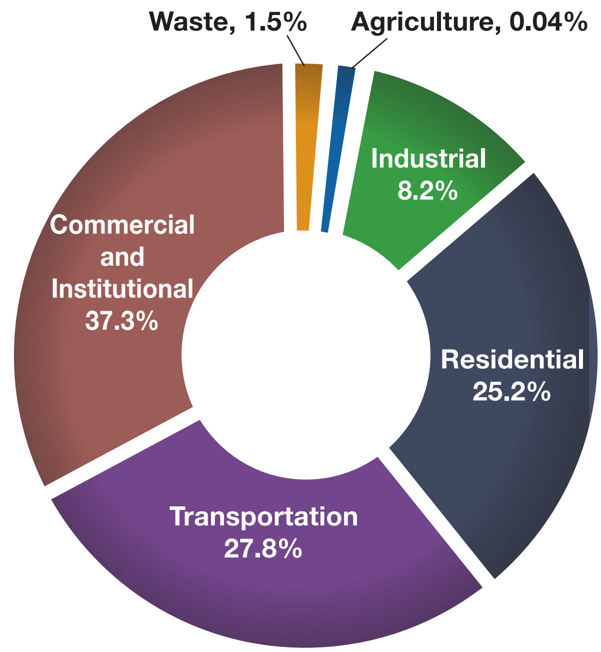
With respect to GHGs from municipal solid waste (MSW), city emissions per capita appeared less than the province's, largely because much of the Capital Region's MSW is burnable and therefore sent to the District Energy System (DES), thus reducing the amount that is landfilled and reducing landfill GHGs.

Agriculture-related GHGs were estimated at less than 0.1% of the city's emissions, whereas 20.3% of the province's GHGs were attributed to agriculture. Nevertheless, it is important to acknowledge the community's responsibility in reducing the carbon footprint associated with our diets by making informed choices. Low-carbon dietary choices can be healthy, affordable, and taste good.

Overall, in 2015, city GHGs were estimated at 432,000 metric tonnes of carbon dioxide equivalent ($tC0_2e$); that is 11.61 $tC0_2e$ per capita. This amount is approximately 25% below the estimate of PEI's GHGs, 15.53tCO_2e per capita, when including GHGs from "stack emissions" associated with PEI's electricity imports. These electricity import-related emissions are excluded in PEI's GHG inventory. Since all electricity-related emissions are typically included in municipal-level GHG inventories in Canada and around the world, estimating the GHGs from stack emissions associated with PEI's electricity imports allowed for a better apples-to-apples comparison.

In addition to all GHGs, the city's figure included a small amount of additional warming resulting from emissions in the upper atmosphere including heat-radiating fossil soot particles, due to commercial aviation attributable to Charlottetown. Though warming relating to black carbon (BC) particles is usually excluded in inventories,

Figure 3: Greenhouse Gas Emissions by Sector, 2015



Note – **Figure 3** includes the GHGs for black carbon emissions as calculated in the transport sector of Table 1. For more information, see the full report as mentioned in reference 14 on page 23.

it is factored in here as it is relevant to reducing warming. The 100-year global warming potential ($GWP_{100\text{-}yr}$) of BC attributable to all fuels across the city after aviation was estimated at about 24,000 tCO_2e. This addition brings the city's total $GWP_{100\text{-}yr}$ to 456,000 tCO_2e or 12.26 tCO_2e per capita.

The City of Charlottetown's community GHG emissions are shown as a percentage by sector in **Figure 3**.

More details on the city's GHG emissions estimates can be found in the City of Charlottetown's 2015 Community Energy and Greenhouse Gas Inventory Report.[11]

9 Primarily includes sea-doos, small yachts or sportfishing boats, and auxiliary engines of sailboats.

10 Includes estimates for all lawn mowing, golf carts, farm tractors, and snowmobiles, etc.

11 See full report, City of Charlottetown's Community Energy and Greenhouse Gas Inventory Report for 2015: https://www.charlottetown.ca/environment___sustainability/sustainability/programs_and_initiatives/community_energy_plan.

Setting a Baseline

The City established a 2015 baseline of energy use. **Table 2** shows estimates of Charlottetown's community-level energy quantities in natural units and gigajoules (GJ).[12]

Table 2: City of Charlottetown Community Energy Use by Source, 2015

	Natural Units		GJ	tCO_2e
Electricity	370,172,517	kWh[13]	1,332,622	141,881
District Energy	100,082	MWh	359,301	24,042
Fuel Oil	48,278,170	L	1,867,400	132,041
Gasoline	32,286,468	L	1,130,026	74,231
Diesel	9,667,312	L	370,258	26,338
Propane	3,695,275	L	93,527	5,706
Aviation Fuel	3,780,000	L	131,121	19,830
Wood	4,277,178	kg	54,723	812
Biogas	624,131	m^3	14,556	576
Total			**5,353,533**	**432,027**

More details on the City's energy use can be found in the City of Charlottetown's Community Energy and Greenhouse Gas Inventory Report for 2015.[14]

The Cost of Energy

Community energy expenditures in 2015 were estimated at $176 million (expressed in CAD 2017). Those expenditures are broken down by secondary energy sources[15] in **Table 3**.

Table 3: City of Charlottetown Energy Expenditures, 2015

	$Millions Nominal CAD 2015	$Millions CAD 2017
Electricity	$62.3	$64.3
Oil	$42.6	$44.0
Gasoline	$34.6	$35.7
Diesel	$11.1	$11.4
District Energy	$11.6	$12.0
Aviation Fuel	$4.3	$4.5
Propane	$2.9	$3.0
Wood	$1.0	$1.0
Total Expenditures ($M)	$170.4	$176.0

Tallying the Social Costs

Energy services offer society tremendous benefits. Yet these services have significant externalized social costs. There are ways to lessen the social costs by increasing energy efficiency and incorporating clean energy, providing the same quality energy services we enjoy today at similar costs, but with greater overall net benefits to our community and society.

12 A gigajoule is 278 kWh; 1,000,000 GJ = 1 PJ.

13 One kWh of energy = 1,000 watts of power used for an hour.

14 See full report, City of Charlottetown's Community Energy and Greenhouse Gas Inventory Report for 2015: https://www.charlottetown.ca/environment___sustainability/sustainability/programs_and_initiatives/community_energy_plan.

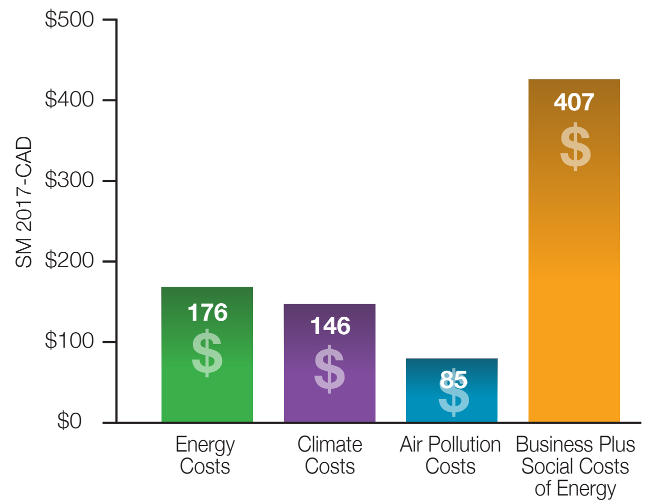
15 Secondary energy sources like refined gasoline, and diesel, are derived from a primary energy source like crude oil. Similarly, electricity is a secondary energy source, and primary its energy sources include wind, sun, and water.

Long-term global warming damages from the City's GHGs in 2015 were estimated at $146 million. Chronic exposure to air pollution causes illness and death. In Charlottetown, an estimated seven mortalities each year are associated with air pollution, with the social costs of morbidity and mortality estimated at $85 million.

The City's energy, climate, and air pollution costs associated with energy use today, as shown in **Figure 4**, were estimated in 2015 at $407 million/year (CAD 2017). The methods for calculating these costs can be found in the Supplemental Information section of the City of Charlottetown's 2015 Community Energy and Greenhouse Gas Inventory Report.[16]

The global warming damage costs to the world are known as the global social cost of carbon[17] (SCC). Global-SCC estimates are an attempt to quantify the externalized damage costs which are associated with GHG emissions. The global-SCC is estimated to be $417 USD ($177-$807) per tonne of CO_2, according to a September 2018 study published in Nature Climate Change.[18] Charlottetown's global-SCC estimate of $320/t$CO_2$e (CAD 2017) is within this range and could be used as a reasonable value.

Figure 4: City of Charlottetown Energy, Climate, and Air Pollution Costs, 2015

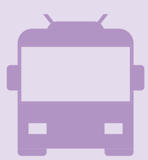


16 See full report, City of Charlottetown's Community Energy and Greenhouse Gas Inventory Report for 2015: https://www.charlottetown.ca/environment___sustainability/sustainability/programs_and_initiatives/community_energy_plan.

17 The global social cost of carbon (global-SCC) is a term used to describe an estimate of the monetary value in a given year of worldwide damage that will occur over the coming decades and centuries from emitting one additional tonne of carbon dioxide or equivalent greenhouse gas emissions.

18 Ricke et al., Country-level social cost of carbon, Nature Climate Change, vol. 8, p.895–900 (2018). https://www.nature.com/articles/s41558-018-0282-y.

Students on board with public transit



To increase the number of students using public transit to get to school, work and recreational activities, the City of Kingston gave out free bus passes. When that didn't do the trick, they launched a transit orientation program to familiarize students with the system, teach them about the environmental benefits, show them the cost savings from riding the bus rather than owning and operating a car, and highlight how public transit increases their freedom to get from place to place. Students are now on board! Students took nearly 600,000 public transit bus trips between September 2016 and August 2017 alone – a staggering increase from 30,000 trips in the project's first year.

Business-as-Usual Projections

The City of Charlottetown used recent provincial population projections to develop a business-as-usual (BAU) 2015-2050 projection of population, energy use, and GHG emissions for the community. BAU involves incremental changes such as modest energy efficiency and conservation measures, and slow uptake of cleantech like electric vehicles, rather than taking steps to ensure a more rapid energy transition.

The province's population projections for 2017-2056 were used to help develop population projections for the City of Charlottetown. Based on the data from the province's projection, and municipal and provincial population trends, Charlottetown's population is expected to increase by roughly 47% between 2015 and 2050, as shown in **Figure 5**.

Despite the 47% population increase, with BAU in 2050 the city's energy usage is projected to be only 12% higher than in 2015. This trend is depicted in **Figure 6**.

As **Figure 7** shows, community GHGs (including black carbon particle emissions) amounted to roughly 456,000 tCO_2e in 2015. With a BAU approach, GHGs in the City could increase to greater than 500,000 tCO_2e/year in 2025, before falling back to 2015 levels around 2040, and eventually reaching about 402,850 tCO_2e/year in 2050.

Potential reasons for shortfalls in meeting GHG reduction targets under BAU could stem from a lack of coordinated policies by municipal, provincial, and federal governments coupled with population growth and/or a lack of community-level buy-in to reduce GHG emissions. Ambitious climate change mitigation plans will help the city to do its share in limiting global warming as much as possible.

Figure 5: City of Charlottetown Population Projection, 2015-2050

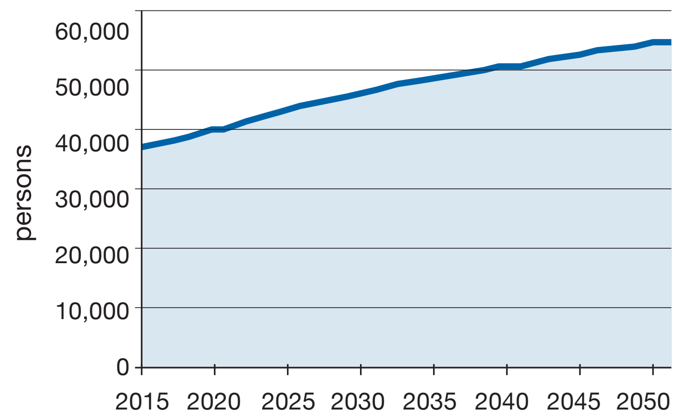


Figure 6: City of Charlottetown BAU End-Use Energy, 2015-2050

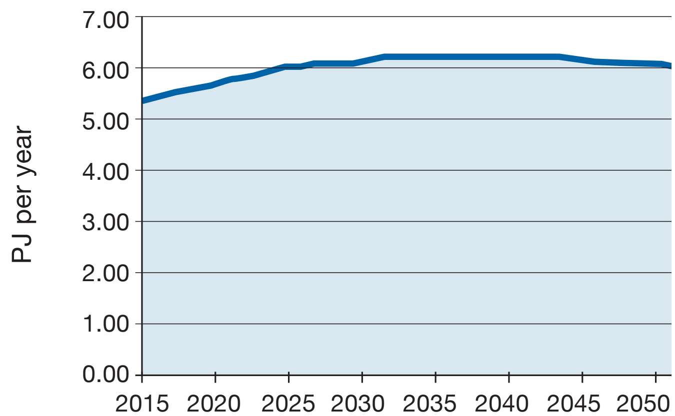
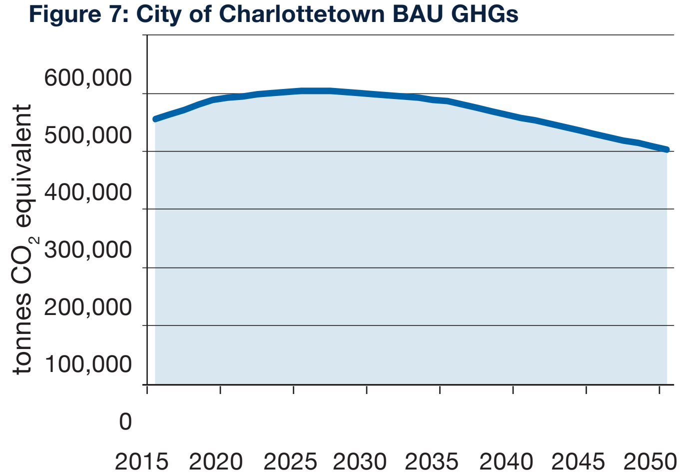


Figure 7: City of Charlottetown BAU GHGs



Warming from GHGs plus BC particles is expressed in tCO_2e.

Evaluating Measures and Technologies

As part of the development of this CEP, a comprehensive review was undertaken to evaluate proposed energy-related climate change solutions. First, measures and technologies were evaluated primarily in terms of their ability to minimize global warming and air pollution mortality, while considering other impacts of the proposed solutions, such as on land and water use, wildlife, resource availability, thermal pollution, water chemical pollution, and other environmental effects.

Secondly, combinations of the evaluated measures and technologies were examined in some detail with respect to whether they could provide energy security, ensure reliable affordable energy, increase economic and energy price stability, and create jobs.

There is consensus that society is moving towards an electricity-powered world.[19, 20] The economic, technical, ethical and social issues entangled with nuclear technologies and the unexpectedly fast expansion of renewable energies (largely wind and solar) point to an increasingly important role of the latter in electricity generation.[21]

19 Jacobson, M.Z., and Delucchi, M.A., "A path to sustainable energy by 2030," Scientific American, 2009.

20 Armaroli, N., and Balzani, V., "Towards an electricity-powered world," Energy and Environmental Science, pp. 4, 3193-3222, 2011.

21 Ibid.

An extensive evaluation process revealed many pathways (uses of measures and technologies and combinations of such) to 100% use of renewables in all energy sectors are technically obtainable and economically viable. In support of this revelation, a recent analysis of 60 scientific studies examining the replacement of fossil fuel energy sources with renewable energy (primarily wind and solar) concluded:

> **"the 100% renewable energy scenarios proposed in the literature are not just (technologically) feasible, but also (economically) viable.[22]"**

The evaluation resulted in more than 80 measures and technologies (see list at Appendix B) which the City of Charlottetown could use to help transition its energy infrastructure. These items are seen as either vital or possible elements of Charlottetown's transition to sustainable energy. Many options on this non-exhaustive list are cost-effective or becoming mainstream; almost all of them are available today, the rest of which are being designed. Ongoing research and evaluation will maximize the ability to capitalize on emerging opportunities.

22 Brown et al., Response to 'Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems', Renewable and Sustainable Energy Reviews, vol.92, September 2018, p.834-847. https://doi.org/10.1016/j.rser.2018.04.113.

THE WAY FORWARD

A glance back in time to Charlottetown 100 years ago, with horse drawn carriages on the streets and homes without electricity, illuminates the certainty and the constancy of change. The way we use energy, and the sources of energy we use are always evolving and improving based on new technology. We are now at a point in history where we have the knowledge and technology to harness clean renewable energy on a large scale, and doing so has become an immediate necessity. The good news is that the City of Charlottetown is well-positioned to progress on the path of innovation toward a much brighter future for all and this Community Energy Plan helps lights the way forward.

Fossil fuels can no longer be relied upon to provide the benefits they have in the past. The City can either postpone action and play catch-up at a later date, or act now to enhance quality of life, improve equity and make Charlottetown more economically strong. The choice is clear.

This section offers a community vision for a sustainable energy future for the City of Charlottetown, based on extensive public consultations, stakeholder input, subject-matter expert feedback and rigorous evaluation. It includes a scenario which paints a picture of a fully renewable and carbon neutral Charlottetown in 2050.

The targets and actions contained in this section can facilitate efforts within households, businesses, and all levels of government and foster collaboration to accelerate the shift to a clean energy economy.

Community Vision for Sustainable Energy

Charlottetown aims to quickly reduce community GHG and air pollutant emissions while securing reliable affordable energy locally, increasing efficiency energy, and creating jobs and economic growth. The City envisions exceeding current targets for 2030 and transitioning all energy for homes, businesses, cars, and trucks to clean, renewable sources before 2050. In short, the City's vision is:

> **"By 2050, Charlottetown is a carbon neutral, diverse and economically strong community, powered only by renewable energy."**

Though this vision sets a general direction for the community's energy transition, it is reasonably flexible with respect to timing and to the specific mix of renewable or clean measures and technologies used.

Which type of heating is more efficient, heat pumps or oil?

Ground- and air-source heat pumps require only 20-25% of the energy needed by average oil heating equipment, respectively. With wind energy nearly doubling in the winter, heat pumps are the eco-friendly way to go. efficiencyPEI offers great rebates.

There are many pathways to reach these overarching goals. To achieve this community vision, the following objectives were set:

Significantly Improve Energy Efficiency in Buildings

- Retrofit existing buildings
- Encourage efficient new buildings
- Encourage a shift to electricity-powered heat pumps, LED lighting, etc.

Greatly Reduce Energy Use in Transportation

- Encourage walking, cycling, transit culture/infrastructure
- Switch on-road and off-road ground transport to electricity
- Encourage electric vehicle charging infrastructure

Transition to Clean Renewable Energy

- Create a smart city with the integration of electricity, heat, transport and industrial sectors
- Fuel-switch to electricity, increase renewable electricity supply and its integration
- Encourage energy storage for heat and cold, in the transport sector, with grid batteries and other clean energy storage technologies

Foster Sustainable Community Development

- Encourage energy innovation and emerging technologies; the City should lead by example
- Significantly increase social marketing opportunities for education and awareness
- Plan for greater density and mixed land use; preserve heritage in energy retrofits
- Secure economic benefits from reduced energy use
- Seek affordable energy for residents and businesses at similar or reduced costs
- Increase energy price stability for sustained conditions for economic growth
- Communicate benefits in terms of job creation
- Communicate the social costs of GHG and air pollutant emissions, and the value or benefits of reducing these costs.

Appendix E has links and resources which illustrate the viability of various pathways to a renewable city.

TARGETS

The overall community and City energy-related and GHG emission reduction targets are:

1. **Community:** Adopt the City of Charlottetown CEP and transition to a 100% renewable and carbon neutral city by 2050 at the latest, with GHG reductions of 50-65% relative to 2015 levels by 2030.

2. **Corporate:** Reduce GHGs in municipal operations by 40% by 2030. Across all corporate operations, strive to be 100% renewable and carbon neutral by 2050.

The following actions which will lead to a 100% renewable city are categorized according to the objectives which emerged from public feedback.

Objective: To significantly improve energy efficiency in buildings

1. **Establish** a financing mechanism, such as the Property Assessed Clean Energy (PACE) program, for energy upgrades. PACE programs provide financing for energy efficiency retrofits – including building envelopes, lighting improvements, installations of high efficiency heat pumps – and solar photovoltaics (PV). A financing mechanism such as this could help low-income households, for example, to access the upfront capital outlay necessary to access rebate programs and complete cost-effective energy improvements that reduce GHGs. Begin planning for PACE programming in 2019-2020 either in collaboration with the Province of PEI or through the Water and Sewer Utility. If warranted, the program will be expanded in subsequent years.
2. **Complete** comprehensive energy audits and necessary retrofits of all City-owned buildings and facilities, including the Water and Sewer Utility and street lighting. Seek financial assistance to complete retrofits. Work will commence as soon as possible with the aim of being completed by 2022.

Affordable and energy efficient social housing

Karen's Place, a 42-unit affordable housing complex in Ottawa for those with mental health conditions, meets the Passive House standard - and does so on a shoestring budget. These buildings are so energy efficient the units only cost $30 annually to heat. Over the lifetime of the complex, the total costs of building to the Passive House standard are far less than for those built cheaply. Marrying affordable housing with environmental sustainability to address the needs of vulnerable groups is a win-win-win.

3. **Construct** all new municipally-owned buildings to Passive House and Zero Carbon Building Standards.
4. **Support** a Passive House and Zero Carbon affordable housing multi-story development in Charlottetown that will serve as a demonstration. Collaborate with stakeholders from Charlottetown's Affordable Housing Incentive Program, the Canada Mortgage and Housing Corporation's National Housing Strategy, PEI's Provincial Housing Action Plan, and the Province of PEI's Climate Change Action Plan.
5. **Develop** a strategy for using high efficiency heat pumps, thermal energy storages, and solar PV in retrofits as well as new commercial and residential buildings. Create incentives for meeting new Passive House and Zero Carbon standards. Work with stakeholders to build capacity such that all new buildings are constructed to Passive House and Zero Carbon Standards by 2030 or sooner.
6. **Increase** collaboration with efficiencyPEI and the Province of PEI to encourage incentives for technologies; collaborate with efficiencyPEI to educate and raise public awareness around energy efficiency and its benefits.

Objective: To greatly reduce energy use in transportation

7. **Collaborate** with T3 Transit as well as municipal, provincial, and federal partners, to transition to electric buses by 2030, with the interim goal of four e-buses by 2022.
8. **Work** with partners to add at least 10 Level 2 electric vehicle (EV) chargers in Charlottetown by 2022. Encourage the use of Open Protocols for all EV charging infrastructure.
9. **Use** incentives for installing at-home and public EV chargers to encourage individuals, families and businesses to be early adopters of EVs. Work with stakeholders to encourage dealer access, service locations and financial incentives for EVs.
10. **Update** the City's corporate fleet of light vehicles to EVs. Strive to have at least five light-duty EVs by 2020. By the 2022-2023 fiscal year, aim to have most new light vehicles purchases, including pickup trucks and vans, be electric. Strive for the City's full fleet of light vehicles to be electric by 2030-2035.
11. **Continue to develop** the City's mesh networking technology to improve connectivity and support smart cities technologies.
12. **Invest** in traffic control technologies to reduce idling and improve the flow of traffic in the city to reduce GHG emissions.
13. **Reinvigorate** the City's anti-idling campaign and reassess the practicality of a bylaw.
14. **Continue to monitor** the City's fleet using automated vehicle location software and invest in new emerging opportunities to further improve efficiency. Communicate the benefits to other fleet managers across the community.

Charlottetown transportation

CHARLOTTETOWN

Not so long ago, folks had to hitch up their favourite horse to travel to a neighbouring community. Gas-powered vehicles were seen as an unwelcome advancement on a well-established way of life. Innovation in the transportation sector was a major driver of change in our society back then - and it still is today. We are now faced with the tough realization that the convenience with which we've been able to travel has a much greater cost than what we pay at the pumps. Luckily, the transportation sector keeps us moving forward in more ways than one.

Horse & Carriage
1800s

1871-1875
Railway

The PEI Railway was constructed, dramatically changing the transportation sector.

1886
Cycling

Cycling was a very popular form of transportation, with road races being the first sporting rivalries between communities.

1908-1913
Automobile Ban

Automobiles, deemed “instruments of death,” were banned, making international headlines. Even after it was repealed in 1913, 90% of Islanders voted to keep the ban in place.

1989
Rails to Trails

The PEI Railway officially closed and the rail lines were converted to “Rails to Trails” multi-use trails.

1997
Fixed Link

In a contentious vote in 1988, 54.5% of Islanders favoured construction of a fixed link to the mainland.

2012 Cycling

A Regional Active Transportation Plan for the Greater Charlottetown Area recommended a number of improvements to cycling conditions in Charlottetown.

2016 Transit

T3 Transit had record-breaking ridership year, recording 553,000 passengers, a 13% increase from the year before.

2018
Bike Path

The City of Charlottetown received approval for 50% of the costs of developing an east-west cycling lane in the downtown area to be funded through the federal Municipal Gas Tax Fund.

2018 Electric Vehicles

Electric cars are becoming mainstream. The provincial government aims to establish electric vehicle fast-charging stations across the Island.

2018
Zero Emissions

T3 Transit, with the help of the municipalities of Charlottetown, Cornwall, and Stratford, test-drove an electric “zero emissions” bus for a week-long pilot demonstration.

15. **Seek** financial assistance to complete a dedicated bike lane on Fitzroy Street per recommendations in the City's 2018 Cycling Connectivity Report. The lane would interconnect the City's major cycling arteries, linking communities in and around Charlottetown with the downtown core – from households to workplaces/businesses and to Victoria Park.
16. **Investigate** the potential of allowing low-speed biking on some City sidewalks. This approach, used in many urban areas, fosters cycling, promotes safety, and reduces the costs of multiple forms of transport infrastructure. The City will work to continue expanding and connecting networks of dedicated cycling infrastructure and multi-use pathways.
17. **Enhance** education campaigns for cycling and public transit to encourage multiple forms of mobility. The campaigns should reach a spectrum of audiences including youth at school.
18. **Demonstrate** clean energy transport for City operations within the heavy-duty fleet. Seek heavy-duty EVs or hydrogen fuel cell-electric hybrids.
19. **Work** with key stakeholders to support the switch from fossil fuel-based transportation to electric vehicles.

Objective: To transition to clean renewable energy

20. **Work** with the Province of PEI to explore opportunities to install more wind and solar capacity than is currently planned.
21. **Increase** the deployment and integration of renewable energies with smart technology and new market designs in the electricity sector. Such efforts enable innovation and reduce GHG emissions quickly at low cost.
22. **Encourage** a solar incentive program in the city. Work with stakeholders, including other municipalities, to encourage the province to introduce financial incentives and more favourable policies for solar photovoltaics.
23. **Support** private enterprise in its transition away from fossil fuels.
24. **Work** with stakeholders to examine the potential of cost-effective large-scale thermal storage of wind and solar energy.

How much more efficient are electric cars than gasoline or diesel cars?

Electric cars are 80% efficient; they need only one-quarter of the energy to travel the same distance as gas or diesel cars.

CHARLOTTETOWN RESIDENT, MIKE KENNY'S NISSAN LEAF EV PARKED ON VICTORIA ROW

Objective: To foster sustainable community development

25. **Support** educational institutions in training workers affected by the transition to renewable energy. Work with stakeholders, including educational institutions and provincial and federal governments, to ensure supports are in place to facilitate a just, equitable transition (e.g., rights of workers and communities are respected, and vulnerable groups are looked after).
26. **Invest** in City staff capacity to implement this plan.
27. **Develop** a green procurement policy for the City of Charlottetown and implement it across all City departments, incorporating life cycle costing into all purchases.
28. **Incorporate** identified measures and technologies into existing and new City zoning and development bylaws, the City's Official Plan and all relevant strategic plans.
29. **Develop** and implement a corporate energy policy applicable to all City facilities and services.
30. **Improve** data collection to provide more accurate estimates of community energy, expenditures, and emissions. Develop and implement methodologies to help monitor progress on the city's community energy transition and GHG reductions and to report to the public on progress. Encourage a voluntary energy benchmarking program.
31. **Encourage** greater residential and commercial density, including through mixed-use development to entice more walking and cycling. Explore ways to encourage more density and affordable housing developments along public transit routes.
32. **Support** community bulk buys and neighbourhood approaches when practical to enhance efficiency improvements, heat pump and solar installations, EV adoption, EV charger installations and more. This approach can reduce costs and accelerate the energy transition.
33. **Collaborate** with Holland College's Energy Systems Engineering Technology Program, other Holland College programs, the UPEI School of Sustainable Design Engineering, and all stakeholders to help the City fine tune the implementation of its actions so they are as effective as possible.
34. **Demonstrate** low-carbon technology at all scales of City operations, including clean energy for grilling at events, electric lawn care and property maintenance in selected locations.
35. **Continue** implementing the ICSP, the Regional Active Transportation Plan for the Greater Charlottetown Area, and environmental sustainability initiatives in support of the private sector. Modify and expand on these as necessary.
36. **Promote** common-sense approaches to waste reduction that minimize related GHGs: reduce, reuse, recycle. Businesses can be proactive in terms of waste reduction and consumers can choose to support the ones that are.
37. **Foster** entrepreneurship, innovation, and emerging technologies within the growing cleantech sector, including: smart technology, thermal energy storage technologies for heat and cold, grid batteries, smart EV charging, vehicle-to-grid technology, fuel cells and their related infrastructure.
38. **Ramp up** community-driven climate resilience planning by engaging the community and partnering with key stakeholders like the electric utility.

100% Renewable Energy

This Plan summarizes energy conservation, energy efficiency, and electricity plus direct heat technologies (listed in Appendix B of this document) to transition all Charlottetown's energy to clean, renewable sources. The residential, commercial and institutional, industrial, and on-road transportation sectors account for 97.5% of the energy use shown in the 2015 Community Energy and Greenhouse Gas Inventory. Therefore, the following analysis focuses on these sectors. An infographic showing one of many possible scenarios for Charlottetown's 100% renewable energy picture in 2050 can be found on the facing page.

Reduced Energy Demand

By increasing energy conservation, energy efficiency measures, and transitioning to 100% renewable energy for all purposes across these sectors as shown in this scenario, an end-use energy demand reduction of 49% is attainable.

Table 4 shows the end-use energy demand across the four main sectors, showing the amounts for the 2015 baseline, the projected 2050 BAU results, the projected 2050 100% renewable energy results and the overall demand reduction.

Which emits more fine particulate matter: oil boilers, wood pellet heating systems or EPA certified wood stoves?

Wood pellet and EPA certified woodstoves emit about 100-400 times the fine particles (PM2.5) as oil heating systems. Electric heat, such as that provided by high-efficiency heat pumps would help to improve urban air quality significantly and reduce climate change.

Table 4: End-Use Energy by Sector, 2015 and 2050 Business-as-Usual Versus 100% Renewable Energy Scenario

	2015 Baseline PJ	2050 BAU PJ	2050 100% RE PJ	2050 Demand Reduction
Residential	1.37	1.56	0.86	45%
Commercial and Institutional	1.90	2.16	1.29	40%
Industrial	0.45	0.51	0.32	38%
On-road Transportation	1.49	1.70	0.54	68%
Totals	**5.22**	**5.93**	**3.00**	**49%**

By 2050, the residential sector can reduce end-use energy demand by 45% relative to BAU by transitioning to clean, renewable energy. The commercial and institutional (C&I) sector can see a reduction in end-use energy of 40% compared to BAU by transitioning to renewables.

Existing and new building transitions are modeled separately. Many of the buildings in 2030 and 2050 projections already exist today. Each end-use is examined in detail to determine the potential for efficiency and conservation measures such as air sealing, insulation, new windows and doors, efficient lighting and appliances, etc. Then existing heating sources, aside from buildings using district heating, are electrified (discussed below).

It is assumed both residential and C&I floorspace will increase by 25% by 2030 and 47% by 2050. From 2015-2030, new buildings are assumed to be at least 50% more energy efficient than the existing building stock, which includes some very inefficient old buildings. Between 2030 and 2050, new buildings could be at least 80% more energy efficient than existing ones.

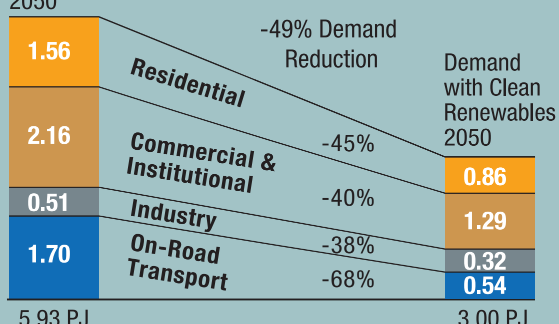
For space conditioning, a combination of high-efficiency heat pumps can provide most of the heating and cooling needs. In some cases, low-cost thermal storages will be used with heat pumps. Some standard electric heating can use some form of low-cost thermal storage to integrate wind and solar. In the C&I sector, efficiency measures include LED lighting; energy

Charlottetown 2050

100% Renewable Energy for Homes, Businesses and Vehicles

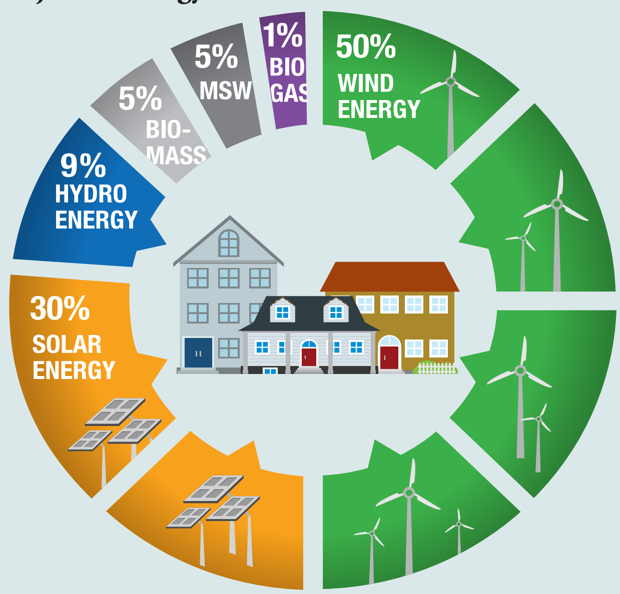
CHARLOTTETOWN

Energy Demand

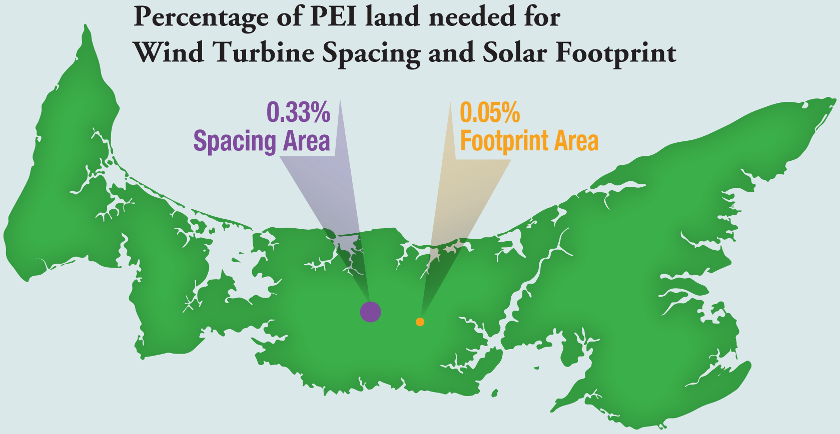


ENERGY COST SAVINGS: (Per Person Per Year)	$130
ENERGY, HEALTH AND CLIMATE COST SAVINGS: (Per Person Per Year)	$5,630

City of Charlottetown Projected Energy Mix - 2050



Percentage of PEI land needed for Wind Turbine Spacing and Solar Footprint



Job Creation

Energy Efficiency and Renewable Energy Jobs

614 30-Year Full-Time Jobs

efficiency retrofits of existing buildings to improve insulation, air tightness, efficiency of windows and doors, and other measures. For water heating, heat pump water heaters can be used.

Minimum Code Compliant Home vs. Passive Low Energy Home

A PEI Home Case Study compares a Minimum Code[23] Compliant Home (MCH) that uses heating oil, to a Passive Low Energy Home (PLE), designed using the Passive House Planning Package. The findings show that the average increase in initial cost for a PLE over MCH in PEI is 10% to 20%. But when the total cost of building ownership (TCBO) is considered, the TCBO savings are:

- $19,652 over 12-years (average Canadian home ownership term per house);
- $111,035 over 25-years (the mortgage term); and,
- $553,000 over 60-years (the useful life of a home prior to major renewal).

Results show that PLE homes yield significant financial savings over the building's life cycle, increased home value, and GHG reduction.

See Appendix D to review the complete PEI Home Case Study with additional detail and compelling information.

For the industrial sector, it is possible to reduce end-use energy demand in 2050 by 38% compared to BAU while transitioning to clean, renewable energy. A lot of the contemporary electricity use is from motor systems. The efficiency of motor systems can be improved using variable frequency drives. Like with the residential and C&I sectors, LED lighting can reduce electricity demand in the industrial sector. This sector's demand for energy is assumed to increase as the city's population grows. High-temperature electricity-powered heat pumps and electric resistance heating are largely proposed to provide heating requirements within the industrial sector. This improves energy efficiency greatly compared with fossil fuels or bioenergy.

By 2050, all light-duty vehicles in the on-road transportation sector can be battery operated electric vehicles. This reduces end-use energy significantly due to the efficiency of electric motors compared to internal combustion engine vehicles. Much of medium- and heavy-duty transport fleets can be fully electric. Some hydrogen fuel cell-electric hybrids are expected to be available for long-distance heavy-duty transport. In these instances, end-use energy accounts for production of hydrogen using electrolysers, compression into tanks, and fuel cell efficiency. These fuel cell vehicles are less efficient than electric drive vehicles but slightly more efficient than conventional internal combustion engines.

Cost Savings for Residents

Energy costs include energy, delivery infrastructure, storage, and includes equivalent revenues to the gas taxes, that help to fund infrastructure. Energy prices will stabilize because once installations are in place, the energy to power them (i.e., wind and sun) are free.

Energy costs in Charlottetown with a 100% renewable city are expected to be slightly less than today's, due to a reduction in energy demand.

Annual community energy savings are expected to be $7.1M in 2050. With a projected population of 54,850, the per capita savings are estimated at $130.

There are also savings related to a reduction in health and climate costs. The transition to a clean economy will reduce air pollution thus greatly cutting down on related illnesses and avoiding an estimated seven deaths per year – generating annual health cost savings of $85 million. Global social costs of carbon (global-SCC) estimates are an attempt to quantify the externalized damage costs which are associated with GHG emissions. The global-SCC is expected to be $540/tCO$_2$e in 2050. With BAU, all-sector emissions are about 402,850 tCO$_2$e in 2050. Transitioning to a

23 National Building Code.

100% renewable and carbon neutral city can avoid annual global warming damage costs of $217 million in 2050. Climate and health cost savings per person per year are estimated to be slightly more than $5,500. The net benefit of transition to a clean economy is approximately $5,630/person/year in 2050 (2017 CAD).

A list of measures and actions being taken by Islanders that result in annual energy savings, financial savings, GHG savings, and water savings are shown in Appendix C.

Energy Sources

A number of renewable energy sources will be used in 2050 to meet the community's energy demand across the four main sectors. **Table 5** shows a possible supply mix, including wind (50%), solar (30%), hydro (9%), biomass (5%), municipal solid waste (5%), and biogas (1%).

Table 5: City of Charlottetown Community End-Use Energy, 2050 Possible Supply Mix

	GJ	Shares %
Wind	1,500,345	50%
Solar	910,924	30%
Hydro	267,919	9%
Biomass	156,265	5%
MSW	143,762	5%
Biogas	24,015	1%
	3,003,230	

Wind and Solar Energy

Increased harnessing of wind and solar will be an important component of the City's move toward 100% renewable energy. **Table 6** displays the wind and solar plants or devices to supply 80% of all energy across the main sectors in Charlottetown in 2050.

The physical footprint of the wind and solar devices required to supply that energy demand is 0.05% of PEI's land base. For comparison, 42.5% of PEI's land base is dedicated to agriculture. Solar and wind combined would have a physical footprint 800 times smaller than agriculture on PEI. The spacing between wind and solar devices remains useful for other purposes as well.

Jobs

Transitioning to a low-carbon future is expected to result in job creation in the community. PEI results from the recent modeling on energy efficiency-related jobs, scaled to the population of Charlottetown, suggest that increased energy efficiency retrofits could add 526 10-year full-time jobs. GDP in the city could grow by $60 million annually over the next decade from increased energy efficiency retrofits in buildings.

Solar installations create employment within the City. More jobs will be created within the Island's economy by transitioning to clean, renewable energy sources

Table 6: Wind and Solar Installations, Power, Land and Rooftop Areas

Type of Device or Plant	Rated Capacity of Device or Plant (MW)	Capacity Factor[a]	Number of Devices or Plants	Rated Capacity (MW)	Average Power Output (MW)	Average End-Use Demand Met by Wind & Solar (MW)	Spacing (km^2)	Footprint (km^2)	Other Areas (km^2)[g]
Onshore Wind Turbines	3	42.0%	50	150	63.0	47.6[c]	18.8[f]	0.38	0.0007
Solar PV Plants	15	14.8%	12	180	26.6			2.51[f]	
Res Rooftop PV	0.008	13.6%	1800	14.4	2.0	28.9[d]			0.0652
C&I Rooftop PV	0.075	13.9%	400	30	4.2				0.1630
Total Average Power (MW)					95.8	76.4[b]			
Percentage Footprint/Spacing							0.33%	0.05%	

Notes:

a. Capacity factors are conservative estimates of the annual average power output as a percentage of installed or rated capacity.

b. The difference between total power generation and end-use power delivered accounts for the assumed transmission and distribution (T&D), storage losses, and curtailment. The wind plus solar output's transmission and distribution (T&D), storage losses, and curtailment is assumed to average 20.2%.

c. Wind's T&D, storage losses, and curtailment from output to end-use is assumed to average 24.5% on an annual basis.

d. Solar's assumed annually-averaged T&D, storage losses, and curtailment from output to end-use is 11.9%.

e. Wind turbine spacing assumes oversized blade diameters (D) of 116 meters per 3 MW wind turbine, with array spacing of 4Dx7D. Array spacing can be determined based on numerous factors. Spacing of 3Dx6D has been used in cases, 12.1 km^2 or 0.21% of PEI's land base. If 6Dx9D is used, 36.3 km^2 of spacing is required, 0.64% of PEI's land. If 6Dx6D is used, depending on nature of prevailing winds, then 24.2 km^2 is needed or 0.43% of PEI's land. If wind turbines are placed offshore there are tradeoffs, including no inland spacing.

f. For solar PV, Sunpower X22 panels are used. This determines rooftop areas, which have no land use. For solar PV plants, spacing between rows of panels is still accounted for as footprint although this space between panels could be dual-use (e.g. – grazing/beekeeping).

g. Other areas, for wind is turbine towers touching ground (included in its footprint). For rooftop PV, no land is needed. There is slightly more spacing for C&I rooftop PV vs residential per unit of installed capacity, as space between rows of panels can be used on flat roofs.

like wind and solar as most of the annual average energy comes from local supplies and efficiency retrofits create employment.

The projected energy efficiency and renewable energy jobs[23] numbers are shown in **Table 7**. These jobs[24] are estimated to add 614 30-year full-time jobs that contribute to economic growth between now and 2050.

Table 7: Projected Energy Efficiency and Renewable Energy Jobs

Technology	Full-Time Jobs	
	1 Year Jobs	30 Year Jobs
Energy Efficiency	5,264	175
Res Rooftop PV	643	21
Com/Gov Rooftop PV	950	32
Utility Solar PV Plant	8,719	291
Onshore Wind	2,850	95
Totals	**18,425**	**614**

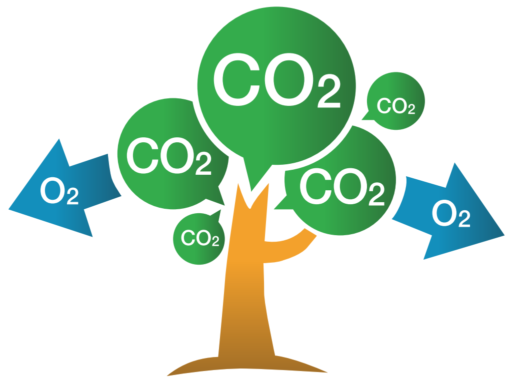
Greenhouse Gas Emissions in 2050

It is assumed here that the remaining energy sectors will be addressed with clean technology. In terms of agriculture, it is not expected there will be ruminant livestock within the city in 2050. With respect to waste, while the population is expected to grow, there are opportunities to improve waste management further to avoid waste-related GHGs. The city's total GHG emissions could decrease from roughly 456,000 tCO_2e in 2015 to about 22,500 (20,000-25,000) tCO_2e in 2050, a decrease of approximately 95%.

Carbon Neutrality by 2050

The City of Charlottetown aims to transition to 100% renewable energy for all purposes. The plan is to transition the urban area to entirely renewable sources by 2050 at the latest, with a goal of eliminating the majority of GHGs by 2030. It is possible to reduce gross positive GHGs by 95% by 2050 and become a carbon neutral city by introducing measures and technologies that result in negative emissions.

To that end, the City is exploring ways to offset remaining climate-relevant emissions with activities such as: a) tree planting, afforestation or reforestation, b) soil carbon sequestration, c) using biochar[25] as a soil amendment, d) direct air capture of CO_2, and e) protecting and restoring carbon sinks such as Island seagrasses.



Timeline for Transitioning Main Sectors

The overall timeline for transitioning to clean, renewable energy is at least 50-85% by 2030 and 100% by 2050. The GHG reduction targets are 65% below 2015 levels by 2030 and to be carbon neutral by 2050. For context, Toronto has established a goal of GHG emissions being reduced to 65% below 1990 levels by 2030. To meet this timeline, rapid transitions are needed.

23 Renewable energy jobs are calculated using the US National Renewable Energy Laboratory's Jobs and Economic Development Indicator (NREL JEDI) Models.

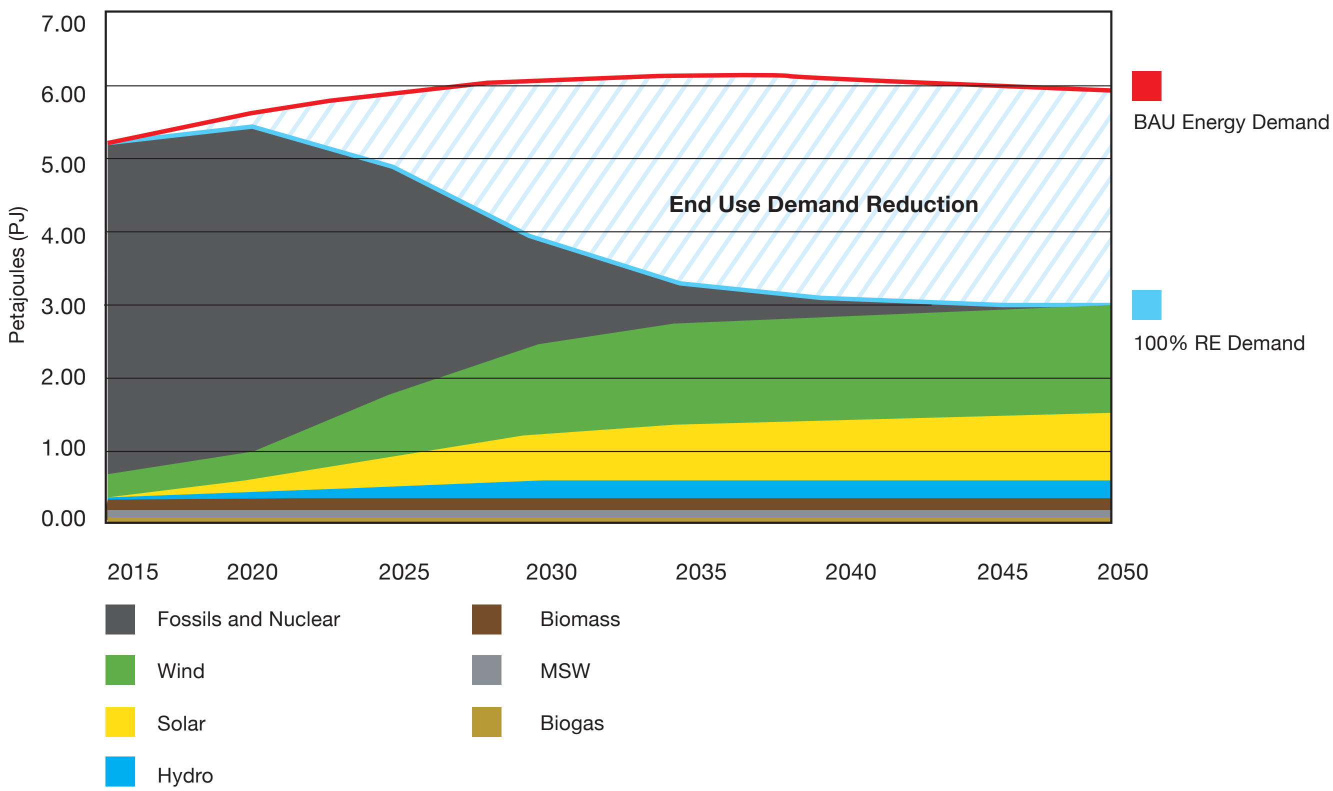
24 Clean Energy Canada, "Less is More," Technical Report, 2018. GDP growth from energy efficiency retrofits and added efficiency jobs based on above study results for PEI. Provincial results scaled to Charlottetown by population. http://cleanenergycanada.org/report/less-is-more/.

25 Biochar is a soil amendment that rich in carbon, and can endure in soil for thousands of years.

Figure 8 shows Charlottetown's transition to a 100% renewable City by 2050. The residential, commercial and institutional, industrial, and on-road transportation sectors cover 97.5% of energy in the community. The remaining energy services can be satisfied using clean technologies outlined in Appendix B or in other ways. The top red line represents projected end-use energy demand with BAU. The red line compared to the blue line is the difference in energy demand between BAU and a shift to a 100% renewable city. The energy demand reduction occurs from a combination of energy conservation measures, energy efficiency measures, and electrification technologies beyond BAU.

Remaining fossil and nuclear can be seen phased out in favor of clean renewable energy, namely wind, and solar, although in this scenario there are niche roles for hydro, biomass, municipal solid waste, and biogas.

Figure 8: Charlottetown's Transition to a 100% Renewable City by 2050.



IMPLEMENTATION PLAN

Communities that undertake to implement a CEP with a business-as-usual approach will have limited success. Communities that stretch beyond business-as-usual and keep community energy planning and implementation top of mind for elected officials, City staff and community stakeholders tend to see much better results. This section guides movement from the community energy planning phase through the implementation phase.

Putting the CEP into Practice

Council support is critical for implementation, as it provides direction, inspiration and impetus for City staff and the community to prioritize community energy planning. Early engagement can help to surface key questions, considerations and possible challenges and can guide the CEP implementation team to focus on the aspects of the plan that matter most to the community. Their continued interest in the community energy planning process will help garner support from other community stakeholders and can ensure that the CEP remains a priority in City planning.

Simply put, implementation means putting the actions identified in this CEP into practice. City staff will reassess and track the ongoing evolution of emerging clean technologies, ensuring that Charlottetown is at the forefront of innovation. Working more closely to strengthen existing partnerships, and by forging new ones, staff will move toward greater innovation and economic development at the community level and within City operations.

Throughout the implementation phase, community energy planning must be an ongoing process. The City is expected to spend in the range of $3.5-$4 million annually in energy costs over the next number of years within its corporate operations and there is a business case to substantially reduce energy demand across these operations and save money while reducing GHG emissions.

Sustainable community development requires recognition of the relationship between environment, economics and social instruments within the community.

An adaptive management approach geared to creating sustainable community energy and climate change mitigation policies and practices also emphasizes the connection and confluence of those elements. Looking into the cultural mechanisms which contribute to Charlottetown's evolving community value system will be useful to adaptive management practices.

As part of implementation, the City may explore the possibility of a real-life test and experimentation environment where users and producers co-create innovations. This collaboration can involve public, private, and people-driven partnerships for user-driven and open innovation by bringing existing stakeholders, and new ones, together to facilitate and enhance the:

- co-design process by users and producers;
- discovery of emerging usages, behaviours and market opportunities in cleantech;
- implementation of live, test scenarios within our community of energy users; and
- assessment of concepts, products and services according to various criteria.

Finally, CEP implementation involves improving energy and GHG inventories in the future as access to data allows, comparing progress from previous inventories.

"We can put ourselves on the world stage if we take an aggressive approach to climate change.

We could become the first city/ province/state in North America to be 100% carbon neutral.

Our small population has an advantage in creating a model for how to live sustainably through wind power, solar power, etc."

- Feedback from Charlottetown resident

Building Citizen Sensor Network

Work is underway to build a citizen-led community sensor network using low-power, long-range LoRaWAN technology. The network seeks to collect data from a geographically dispersed collection of low-cost sensors measuring temperature, humidity, solar radiation, air pollution, sound, and other conditions. This process will provide the community with a richer pool of data from which to derive trend information and to guide climate policy.

Advisory Group:

- **Peter Rukavina**, Open Data Advocate, Project Manager
- **Michelle Cottreau**, Medical Physicist, Queen Elizabeth Hospital
- **David Cairns**, Former Director of Computer Services, University of PEI
- **Rosemary Le Faive**, Digital Infrastructure and Discovery Librarian, University of PEI
- **Ramona Doyle**, Sustainability Officer, City of Charlottetown
- **Matt McCarville**, Community Energy Planner, City of Charlottetown

Partnerships

Charlottetown's success as a renewable city depends on strong partnerships between all levels of government, businesses, utilities, community groups, households and individuals. These partnerships will enable coordinated efforts and engagement, greener households and operations, and better tracking of data to inform future actions.

Working together, the City and its residents will make forward-looking energy decisions for the benefit of all.

Reporting

City staff responsible for the CEP's implementation will maintain an annual energy, expenditures, and GHG inventory for corporate operations and provide regular (e.g. quarterly) reports to Council or committees of Council. Reports can be mostly qualitative however measurable updates can be included if the data is available. They will describe measurable benefits of implementation (e.g., progress on GHG reductions). Additional presentations to Council may be made as needed to report on the community energy planning process and implementation milestones. Council approval will be sought to proceed with specific projects.

With respect to City operations, staff will look at baseline energy, expenditures, and GHGs before and after facility retrofits. Monitoring and reporting the benefits will provide motivation to proceed with the next steps in reducing GHGs. More sophisticated energy management software, clean energy project analysis software, and real-time manual and automated energy management capabilities would aid in the achievement of positive outcomes and the reporting of such.

To communicate with city businesses and residents, the Annual Sustainability Report will include a dedicated section to update on CEP implementation progress.

Summerside Drives Innovation and Economic Development

Summerside is becoming recognized worldwide for innovative green approaches. Its Living Lab is an environment (the geographic community) in which people and technology gather and in which the everyday context stimulates and encourages research, development, innovation and ultimately commercialization. Among the many Living Lab initiatives are: development of the province's largest solar array (with a solar carport and battery storage system); introduction of cutting-edge artificial intelligence to integrate even more clean, renewable energy while reducing energy costs; and an exploration into moving to electric transit.

Renewal

At a minimum, the community-level energy and GHG inventory, and subsequent CEP, will be renewed every five years. With the passage of enough time, a comparison between the original and updated inventories will be valuable to determine if community-level progress has been made. Ideally, the inventory and energy plan will be conceptualized as living documents, or works-in-progress, subject to ongoing renewal as better data and new information emerges.

The implementation phase will feature a dynamic ongoing learning process that feeds back into the improvement of the community inventory and community energy planning. New governance models will ensure practical implementation of the CEP is as successful as possible and greater cooperation between community stakeholders will entice energy innovation and marketable solutions. An emphasis will be placed on increased public engagement on energy and climate issues, greater engagement of elected officials regarding these inter-related files, and the continuous renewal of inventories and plans to track and reduce energy use, energy expenditures, and its externalities like global warming damages costs and air pollution health costs.

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- **Charlottetown Area Development Corporation**

- **City Council**
- **City Council Environment and Sustainability Committee**
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- **Howard, Steve** – Renewable Lifestyles
- **Howarth, Robert** – Ecologist and Earth System Scientist, Cornell University
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- **International Energy Agency**
- **Invesco Enterprise Services**
- **Island Waste Management Corporation**
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APPENDIX A: GLOBAL PATHWAYS TO AVOID 1.5°C OF GLOBAL WARMING

Figures 1, 2, and 3 show global GHG reduction pathways to avoid 1.5°C of global warming

- Without any negative emissions, limiting global warming to 1.5°C requires zero emissions in 10-20 years;
- Negative emissions generally refers to techniques that remove CO_2 from the air;
- Greater deployment of negative emissions measures and technologies allows for slightly slower short-term mitigation or reduction of GHGs;
- **Figure 1** shows the negative emissions requirements in a scenario of reducing GHGs by 35% relative to today's levels in 2030, and being carbon neutral in 2050 – the negative emission requirements for future generations may be unmanageable;
- **Figure 2** shows 50% GHG reductions in 2030, and net zero emissions in 2050 – there still are challenging negative emissions required to limit global warming by 2100;
- **Figure 3** shows that by reducing GHGs 65% relative to today's levels in 2030, and being net zero emissions in 2050, the negative emissions requirements for future generations are much more manageable;
- Negative emissions should start today to get to the necessary scale;
- To avoid more than 1.5°C of global warming, carbon neutrality must be achieved by 2050 at the latest; and
- The recent IPCC on Global Warming of 1.5°C notes that it is possible within the laws of chemistry and physics to limit warming to 1.5°C, but doing so requires unprecedented changes. Allowing the global temperature to temporarily exceed or 'overshoot' 1.5°C means a greater reliance on techniques that remove CO_2 from the air (negative emissions) to return global temperature to below 1.5°C by 2100. The effectiveness of such techniques are, unproven at large scale, and some may carry significant risks for sustainable development.

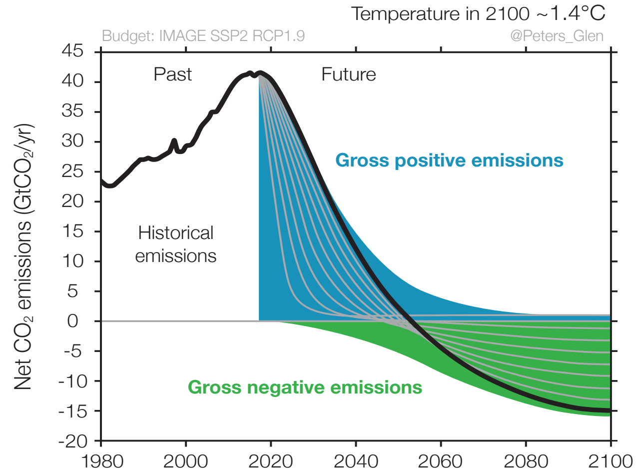

Figure 1: Global pathway with 35% GHG reductions by 2030.

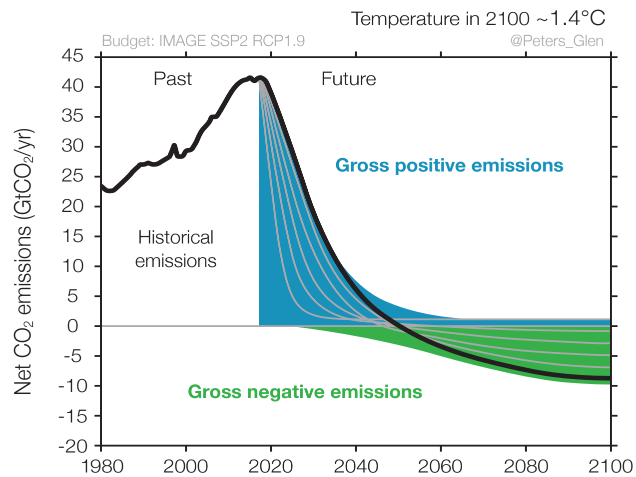

Figure 2: Global pathway with 50% GHG reductions by 2030.

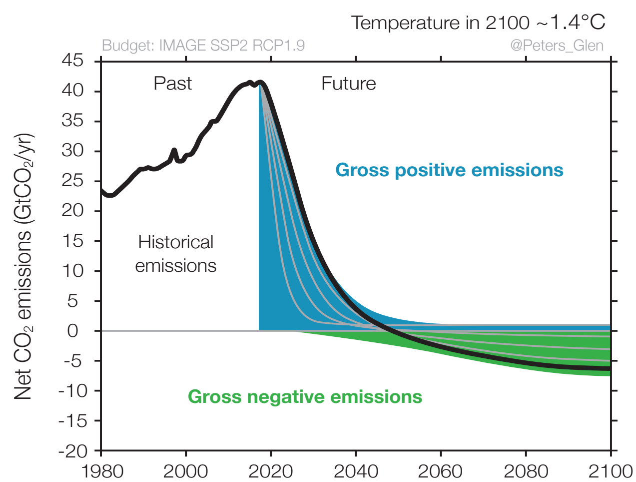

Figure 3: Global pathway with 65% GHG reductions by 2030.

APPENDIX B: MEASURES AND TECHNOLOGIES FOR TRANSITIONING TO CLEAN, RENEWABLE ENERGY

A non-exhaustive list of measures and technologies the city evaluated is provided below. Most of these measures and technologies could comprise elements of the City's energy transition. This community energy plan is non-prescriptive. The list does not necessarily preclude the inclusion of other measures or technologies.

A. Energy Efficiency Measures / Energy Demand Reduction

a. Increased Efficiency in Buildings Through:
   i. Lighting
      1. LED lighting
      2. Advanced lighting controls
   ii. Appliances
      1. High efficiency industrial pumps and motors
      2. High efficiency commercial appliances
      3. Induction cooktops
      4. Energy efficient residential appliances
      5. Variable refrigerant flow (VRF or VRV)
   iii. Heating and Cooling Efficiency in Buildings
      1. Programmable thermostats
      2. Improved wall, floor, ceiling, and pipe insulation
      3. High-efficiency triple-pane windows
      4. Energy efficient framing practices (including heritage window retrofits)
      5. Passive solar / passive house / zero carbon building design
      6. Sealing doors, windows, walls, outlets, and fireplaces to reduce heat/cold loss
      7. Ductless heat pumps for heating and air conditioning
      8. Central (ducted or air-to-water) air-source heat pumps
      9. Central air-source heat pumps with thermal energy storage (TES)
      10. Night ventilation cooling, and passive ventilation design
      11. Combined space heating/cooling and water heating
      12. Air flow management of IT infrastructure
      13. Heat recovery ventilation
      14. Building energy monitoring and management
   iv. Water Efficiency
      1. High efficiency residential and commercial water fixtures
      2. Greywater re-use systems
      3. Drainwater heat recovery

b. Reduced Transportation Demand Through:
   i. Telecommuting rather than commuting by car or air
   ii. Improved biking and pedestrian infrastructure
   iii. Electric pedal-assist bikes and scooters
   iv. Improved public transportation
   v. Transportation demand management programs

vi. Automatic vehicle location fleet monitoring
vii. Improved carpooling and ride-sharing programs and technologies
viii. Urban land use practices to reduce demand

c. Improved Vehicle Efficiency Through:
  i. Low rolling resistance tires
  ii. Lightweight materials
  iii. Regenerative braking systems
  iv. High efficiency settings or dashboard efficiency displays
  v. Properly inflated tires
  vi. Reduced idling
  vii. Slow acceleration and easy stops

B. Clean, Renewable Electric Power Generators

a. Onshore/offshore wind turbines (PEI/region, *included in scenario)
b. Solar photovoltaics for rooftops and power plants (PEI/region, *included in scenario)
c. Geothermal power plants for electricity (NB)
d. Tidal turbines (Maritime region)
e. Wave devices (Atlantic region)
f. Existing large hydroelectric reservoirs (QUE, NL, NB, *included in scenario)
g. New small hydroelectric reservoirs (NB)
h. In-stream hydroelectric turbines (Eastern Canada region)

C. Low-Temperature Heat Generators

a. Geothermal (ground-source) heat pumps
b. Solar thermal collection devices
c. District Heating/Cooling
  i. Low-temperature district heat using solar thermal collectors and/or surplus renewable electricity with TES, including seasonal energy storage

D. High-Temperature Heat Generators

a. District Energy (electricity and heat generators)
  i. Biomass
  ii. Waste-to-energy
  iii. High-temperature TES of surplus wind energy in hot rocks for electricity and heat
b. High temperature industrial heat pumps
c. Biogas from wastewater treatment
d. Renewable natural gas produced through methanation with surplus renewable electricity
e. Biomass

E. Electricity Storage

a. Batteries
b. Adiabatic compressed air energy storage
c. Pumped hydroelectric storage
d. Flow batteries
e. Flywheels
f. High temperature thermal energy storage for electricity generation

F. Heat Storage Devices

a. Hot water tanks
b. Thermal energy storage in dense, ceramic bricks, or phase change materials
c. Heat pumps coupled to phase-change materials
d. Thermal walls and floors
e. High temperature thermal energy storage for cogeneration
f. Borehole thermal energy storage for seasonable energy storage
g. Pit thermal energy storage for seasonal energy storage
h. Aquifer thermal energy storage for seasonal energy storage

G. Cold Storage Devices

a. Chilled water tanks
b. Ice storage
c. Chilled slabs
d. Borehole thermal energy storage for seasonal energy storage
e. Pit thermal energy storage for seasonal energy storage
f. Aquifer thermal energy storage for seasonal energy storage

H. Hydrogen Storage Devices

a. Electrolysers to produce hydrogen (H_2)
b. Electric compressors to compress H_2
c. Tanks to store H_2

I. Demand Response

a. Technology to enable remote start up and shut down of appliances and equipment that have flexible demand
b. Utilities provide incentives for industry, companies, and individuals to shift their electricity use for certain uses and processes to non-peak times of day or night.

J. Electric Vehicles

a. Light-, medium-, and heavy-duty on-road automobiles can mostly be all-electric
b. Short-distance trucks, and buses, such as transit buses can be all-electric
c. All-electric aircraft for short-haul flights
d. Most off-road vehicle equipment can be electrified
e. Agricultural equipment can be primarily electric
f. Forestry equipment can typically be electric
g. Forklifts and scissor lifts, and other machines are already electric

K. Hydrogen Fuel Cell-Electric Hybrid Vehicles

a. Long-distance trucks for heavy-duty ground transportation can be hydrogen fuel cell-electric hybrids
b. Long-distance buses can be hydrogen fuel cell-electric hybrids
c. Long-distance ships can be moved with hydrogen fuel cell-electric hybrids
d. Aircraft for long-distances can be hydrogen fuel cell-electric hybrids
e. Heavy-duty municipal, and construction equipment can be hydrogen fuel cell-electric hybrids as necessary
f. Agricultural equipment can also be fuel cell-electric hybrids

L. Electric Car Charging Infrastructure

a. Home car chargers with smart charging and vehicle-to-grid (V2G)
b. Public chargers with smart charging and V2G
c. Fast chargers

M. High-Temperature Industrial Equipment

a. Electric arc furnaces
b. Dielectric heaters
c. Electric induction furnaces
d. Converting excess low-price wind and solar electricity into high-temperature stored heat

N. Electric Appliances to Replace Oil, Propane, or Gasoline

a. Battery electric lawnmowers and whipper snippers
b. Electricity-powered or electrolytic hydrogen-fueled outdoor cooking

O. Negative Emissions Measures and Technologies

a. Tree planting, afforestation or reforestation
b. Soil carbon sequestration
c. Biochar
d. Direct air capture of CO_2
e. Protecting and restoring carbon sinks such as Island seagrasses

APPENDIX C: WAYS TO SAVE CO_2, ENERGY, WATER AND MONEY

Below is a list of measures and actions being taken by Islanders that result in annual GHG, energy, water, and financial savings:

Reducing Electricity

- **Using a clothes line in the warm season** – estimated annual savings: 85 kilograms (kg) of carbon dioxide (CO_2), 304 kilowatt-hours (kWh) of electricity, and $46;
- **Reducing standby power throughout a household** – estimated annual savings: 103 kg of CO_2, 368 kWh of electricity, and $56;
- **Using a toaster oven when possible** – estimated annual savings: 108 kg of CO_2, 385 kWh of electricity, and $58;
- **Keeping refrigerator seals and clothes dryer lint filters clean** – estimated annual savings: 60 kg of CO_2, 216 kWh of electricity, and $33;
- **Installing LED light bulbs** – estimated annual savings: 298 kg of CO_2, 1,063 kWh of electricity, and $160;
- **Keeping lights off when not in use** – savings were 118 kg of CO_2, 420 kWh of electricity, and $63;
- **Use ceiling fan instead of an air conditioner for hot days** – estimated annual savings: 113 kg of CO_2, 405 kWh of electricity, and $61;
- **Unplugging a garage door opener and parking outside in non-winter months, plus using a power bar for the microwave to eliminate standby electricity** – estimated annual savings: 15 kg of CO_2, 55 kilowatt-hours of electricity, and $8;
- **Unplugging a heat recovery ventilator in the warm season (if no unfavorable effects – stale air, condensation)** – estimated annual savings: 171 kg of CO_2, 612 kWh of electricity, and $92;
- **Installing a 7-kW solar photovoltaic (PV) system** – estimated annual savings: 2,404 kg of CO_2, 8,585 kWh of electricity, and $1,246;

Conserving Water

- **Brushing teeth using cold tap water sparingly** – estimated annual savings (one person): 2 kg of CO_2, 11,497 litres (L) of water, and $10;
- **Taking shorter showers** – estimated annual savings (one person): 77 kg of CO_2, 5,460 L of hot water, 28 L of oil; and $35;
- **Switching to ultra-low-flow** showerhead **with Charlottetown Free Exchange** – estimated annual savings (household of four): 667 kg of CO_2, 47,309 L of hot water, 244 L of oil, and $303;
- **Switching to a low-flow toilet** – estimated annual savings (household of four): 13 kg of CO_2, 67,095 L of water, and $57;
- **Using a rain barrel** – estimated annual savings were 0.4 kg of CO_2, 2,160 L of municipal water, and $2;

Reducing Heating Requirements

- **Using passive solar heating design** – up to 30% of a conventional home's heating needs can be obtained;
- **Upgrading attic insulation** – estimated annual savings (R-12 to R-60, 1288 square foot attic): 1,767 kg of CO_2, 646 L of oil, and $696;
- **Using solar hot water preheating** – estimated annual savings: 1,974 kg of CO_2, 734 L of oil, and $773;
- **Getting a heat pump water heater vs oil** – estimated annual savings: 1,490 kg CO_2, 698 L of oil, and $526;
- **Using a high-efficiency ductless mini-split air-source heat pump to offset standard electric space heating** – estimated annual savings: 3,280 kg of CO_2, 11,717 kWh of electricity, and $1,539;

- **Using a high-efficiency ductless mini-split air-source heat pump to offset space heating using oil** – estimated annual savings: 3,728 kg of CO_2, 1,963 L of oil, and $1,231;
- **Using a ground-source heat pump to replace space and water heating using oil** – estimated annual savings: 5,898 kg of CO_2, 2,765 L of oil, and $2,082;
- **Using a programmable thermostat** – estimated annual savings: 358 kg of CO_2, 131 L of oil, and $141;

Transportation Choices

- **Commuting by bicycle** – estimated annual savings: 805 kg of CO_2, 350 L of gasoline, and $445
- **Youth biking in summer to activities like sports and sleepovers** – estimate annual savings: 106 kg of CO_2, 46 L of gasoline, and $59;
- **Commuting using public transit** – estimated annual savings: 949 kg of CO_2, 413 L of gasoline, and $525-$1,125 (high financial savings include avoided monthly parking passes)
- **Making lists and planning trips** – estimated annual savings: 126 kg of CO_2, 55 L of gasoline, and $70;
- **Keeping tires properly inflated** – estimated annual savings: 193 kg of CO_2, 84 L of gasoline, and $107;
- **Reduce idling** – estimated annual savings: 209 kg of CO_2, 91 L of gasoline, and $116;
- **Accelerating slowly and using easy stops** – estimated annual savings: 492 kg of CO_2, 214 L of gasoline, and $272;
- **Choosing an electric car** – estimated annual savings (with 20,000 kilometers traveled per year versus a six-cylinder vehicle): 4,078 kg of CO_2, 2,180 L of gasoline, and $2,270;

Food Choices

- **Shifting from high meat-eater to medium meat-eater** – estimated annual savings: 569 kg of CO_2
- **Shifting from high meat-eater to low meat-eater** - estimated annual savings: 920 kg of CO_2
- **Shifting from high meat-eater to fish-eater** - estimated annual savings: 1,197 kg of CO_2
- **Shifting from high meat-eater to vegetarian** - estimated annual savings: 1,234 kg of CO_2
- **Shifting from high meat-eater to vegan** - estimated annual savings: 1,570 kg of CO_2
- **Shifting from medium meat-eater to low meat-eater** – estimated annual savings: 350 kg of CO_2
- **Shifting from medium meat-eater to fish-eater** – estimated annual savings: 628 kg of CO_2
- **Shifting from medium meat-eater to vegetarian** – estimated annual savings: 664 kg of CO_2
- **Shifting from medium meat-eater to vegan** – estimated annual savings: 1,000 kg of CO_2
- **Shifting from low meat-eater to fish-eater** – estimated annual savings: 227 kg of CO_2
- **Shifting from low meat-eater to vegetarian** – estimated annual savings: 314 kg of CO_2
- **Shifting from low meat-eater to vegan** – estimated annual savings: 650 kg of CO_2
- **Shifting from fish-eater to vegetarian** – estimated annual savings: 37 kg of CO_2
- **Shifting from fish-eater to vegan** – estimated annual savings: 372 kg of CO_2
- **Shifting from vegetarian to vegan** – estimated annual savings: 336 kg of CO_2

Outdoor Practices

- Using a reel mower for emissions-free lawn-care – estimated annual savings: 85 kg of CO_2, 36 L of gasoline, and $46;

Notes:

a. In a few examples, such as using an air-source heat pump to offset oil, GHGs and financial costs for the electricity are accounted for, but the electricity needed to operate the heat pump is not shown. Likewise, electricity use has GHGs and costs associated for electric cars, which is accounted for, but this electricity consumption is not shown.

b. Results vary on a case-by-case basis. Savings reflect real-world examples of residents who are acting to reduce their carbon footprints within our capital region.

c. Financial savings are calculated using energy prices effective early October 2018.

d. For food choices, results based on UK study, and a standard diet of 2,000 food calories (kcal or Cal) daily. High meat-eater means >100 g/d, medium meat-eater is 50 to 99 g/d, low meat-eater is <50 g/d. See Scarborough, P., Appleby, P.N., Mizdrak, A. et al. Climatic Change (2014) 125: 179. https://doi.org/10.1007/s10584-014-1169-1.

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Minimum Code Compliant Home vs Passive Low Energy Home

Summary

This case study compares a Minimum Code* Compliant Home (MCH) that uses heating oil, to a Passive Low Energy Home (PLE), designed using the Passive House Planning Package. Our findings show that the average increase in initial cost for a PLE over MCH in PEI is 10% to 20%. But when the total cost of building ownership (TCBO) is considered, the TCBO savings are:

- $19,652 over 12-years (average Canadian home ownership term per house);
- $111,035 over 25-years (the mortgage term); and,
- $553,000 over 60-years (the useful life of a home prior to major renewal).

Background

Building owners, designers, accountants, economists, lenders and governments, often lack sufficient or consistent methods of determining the investment value and cost savings when it comes to investing in energy efficient and/or sustainable building features. The most common techniques used are simple payback, return on investment (ROI), or net present value (NPV). However, these parameters do not show the real value of PLE; in part because they are often calculated over a short time period, such as 10 or 20 years, or over the useful life of a single building component. A better approach would be to:

- Evaluate the whole building as a sustainable design system, as opposed to a single component.
- Evaluate the useful life of the building, which could easily be 60-years before major renewal is required. This period could be extended considerably by making the building more sustainable and durable.
- Determine the value by calculating the TCBO. The TCBO is determined using the SEEFAR-Valuation© which includes all the costs of building ownership such as mortgage interest, utility costs, maintenance, GHG emission tax, property tax, and insurance, using aggregate component life cycle analysis.

* National Building Code

It is important to understand that a Passive Low Energy Building could easily be defined as a building that can integrate and optimize all major building performance attributes, including energy efficiency, durability, life-cycle performance, and occupant productivity, and is sometimes referred to as a high-performance home.

The durability and sustainability of building materials is important because it has an impact on how often building components need to be replaced, and at what cost. A recyclable metal roof with a 50-year plus life is more durable than asphalt shingles with an 18-year life that end up in landfill. In addition, occupant comfort, productivity and a building free from harmful materials is important. To simplify the analysis for this study, however, we do not include a comprehensive analysis of options for more durable materials.

This case study is focused on a comparative analysis of the TCBO of a MCH (using heating oil) to a PLE (all electric) with International Passive House design features. The table below describes the construction features of each home:

Home Comparison Construction Design Features

TABLE 1	PEI Minimum Code Compliant Home (MCH)	PEI Passive Low Energy (PLE)
Utility description summary	#2 Heating Oil - Electric	All Electric
R-value of above grade walls	R17	R60.2
R-value of attic space	R50	R78.8
R-value of below grade walls	R17	R43
R-value of foundation floor	R11	R40.8
Area of conditioned space	2,117 ft^2	2,117 ft^2
Window type	Dual pane	Passive - U 0.14
Window area	227	227
Exterior door type	Insulated steel	R7.1
Heating system description	87% AFUE oil warm air furnace	1,500 watts of Electric baseboards
Ventilation system description	HRV	Zehnder 350 Comfoair 92% efficiency
Cooling system description	none	none
Water heating description	75% eff oil water heater	Electric tank
Lighting description	LED	LED
Appliance description	Electric	Electric

Table 2 shows the initial capital cost of the homes. The first row shows costs of the components that affect energy consumption; this includes many of the items described in the construction comparison. The first row also shows that the PLE home used in this analysis has a 40% higher cost for the energy configuration construction design.

The second row shows that the cost of non-energy-related components were intentionally kept identical to eliminate the impact of differences and therefore assumes that the interior and exterior finishes, cabinets, and trims on both homes are identical.

The last row shows the total construction cost, which is 19% higher for the PLE home used in this analysis.

TABLE 2	PEI Minimum Code Compliant Home (MCH)	PEI Passive Home (HPH)	Total Cost Differences
Energy-related construction costs	$199,2666	$279,157	40%
Non energy-related construction costs	$211,700	$211,700	0%
Total Construction Costs	$410,966	$490,857	19%

There are additional inputs to the SEEFAR-Valuation© such as equipment cost, equipment life in years, energy costs and consumption, GHG burden, cost escalations, and others. These all have a bearing on the TCBO and are based on published industry information.

Results

TABLE 3	PEI Minimum Code Compliant Home (MCH)	PEI Passive Home (HPH)	Total Savings	Savings %
60-year Greenhouse gas emissions (kg)	490,251	52,942	437,309	89.2%
Energy use index (EUI) (kWh/m2/year)	203	49	154	76%
TCBO* at 12-years	$274,197	$254,545	$19,652	7%
TCBO* at 25-years	$618,768	$507,733	$111,035	18%
TCBO* at 60-years	$1,741,812	$1,189,253	$553,000	32%

*These costs are independent of site purchase and site services (driveway, well, septic).

The first row shows that the greenhouse gas (GHG) emissions are 89.2% lower for the PLE. This reflects the low emission rate of PEI electricity as compared to the emission rate of heating oil in PEI.

The second row shows the Energy Use Index (EUI). The energy consumption is 76% lower for the PLE home. This is an important consideration because energy costs and utility infrastructure are rising faster than inflation, due to the renewal investment demand of aging infrastructure.

Rows three, four and five compare the TCBO over 12-years; 25-years; and, 60-years.

In terms of the real costs of monthly utilities, the MCH will have an average monthly utility bill of $400 per month (at year one) while the PLE home will have an average annual monthly utility bill of $148 per month (at year one). At the current level of rate increases, it will take 40-years for the PLE to reach the same $400 monthly cost level, by which time the monthly costs for the MCH will have tripled.

After allowing for 1/10th of one percent difference in the annual market value retention rate of the PLE home, once the 25-year mortgage is paid off, the PLE home is projected to have $62,985 in higher net market value. This represents a 3.1% annual return premium on the $79,891 higher initial investment cost of the home.

This higher initial investment of $79,891 also produces a cost savings value stream with Net Present Value of $94,208 by the end of the 25-year mortgage term (2.71% discount rate). This means that the PLE home produces homeowner value in both lower TCBO and higher market value retention.

Every building has its own unique design and construction characteristics that need be accounted for in optimizing the investment value. The SEEFAR-Valuation© allows the user to conduct a scenario analysis process to evaluate the impact of the potential building components and design features. The energy use and durability are reflected the TCBO outcomes.

Scenario modeling can also demonstrate how the TCBO is affected by using more durable materials such as ceramic tile floors, metal roofing, more durable hot water tanks or more efficient components that can reduce emissions and save money, such as solar photovoltaic panels. This process will help to optimize the TCBO projections at the early design stage.

A SEEFAR-Valuation© methodology is the most definitive way to monetize the relevant benefits of each design option, and of comparative home designs.

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A Note on Case Study Conclusions

The SEEFAR-Valuation© demonstrates that the life-cycle variance in the total cost of building ownership (TCBO) between different designs for two similar homes can easily be in the six-figure range. Therefore, drawing '*general*' conclusions about the TCBO differences between any two home types can prove to be misleading. The same risk applies when drawing TCBO conclusions based on units of '*building area*'.

As a matter of financial logic, homes that are more sustainable are more likely to have lower TCBO levels; larger homes are more likely to have higher TCBO levels; and, homes that reduce heat loss through high performance building envelopes can be expected to have lower TCBO levels than homes that offset heat loss through mechanical systems. For that reason, it is recommended that the type of aggregated, multi-component life cycle analysis used in the SEEFAR-Valuation© assessment be conducted on each home design option being considered.

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APPENDIX E: LINKS & RESOURCES

Energy efficiency information, rebates, programs, and incentives: (link)

Renewable Cities: (link)

Electric Vehicle Advantage/Information: Plug ‘n Drive (link)

100% Renewable Energy Vancouver: (video)

100% Renewable Energy Overview by Professor Mark Jacobson: (video)

A Techno-Economic Study of an Entirely Renewable Energy-Based Power Supply for North America for 2030 Conditions: (study)

100% Renewable Energy hourly visualizations (world, NA, Canada, Canada-East region): (link)

Christian Breyer on 100% Renewable Energy: (video) (study)

100% Renewable Energy Scenario for Denmark: (video)

Evolv1 - Canada’s first zero carbon building in Waterloo, ON: (case study)

Canada’s first net zero supermarket - Ontario: (link)

For questions, or comments please contact:

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