Seizing the opportunity:

The Clean Energy Economy in Durham

PART 1: THE PLAN

DURHAM
COMMUNITY
ENERGY
PLAN

SSG SUSTAINABILITY SOLUTIONS GROUP
whatIf?

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Disclaimer

This analysis has been undertaken to identify a low carbon energy pathway for the community of Durham. Reasonable skill, care and diligence have been exercised to assess the information acquired during the preparation of this analysis, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and factors associated with implementation of the pathway are subject to changes that are beyond the control of the authors. The information provided by others is believed to be accurate, but has not been verified.

The population and employment projections that inform the analysis are based on information from the June 26, 2015 Region Official Plan Consolidation to 2031 at the time the document was published, and further projections from 2031 to 2050 are an estimate for the purpose of the Durham Community Energy Plan.

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Key Energy and Emissions Units

GHG emissions

1 ktCO2e = 1,000 tCO2e

Energy

1 MJ = 0.001 GJ

1 TJ = 1,000 GJ

1 PJ = 1,000,000 GJ

1 GJ = 278 kWh

1 MWh = 1,000 kWh

1 GWh = 1,000,000 kWh

Time Period

A number of charts cover the period of 2016 to 2050. Where actions are involved, the time period considered is 2018 to 2050 to ensure that actions do not begin prior to the current year. In other cases where five year increments are used, 2011 and 2051 are also presented.

Geography

The term “Durham Region” is used to describe the broader community in Durham including all organisations and citizens.

By the numbers, for Durham Region[1]

Population, 2016: 720,000[2]
Population, 2050: 1,368,000[3]

New dwellings, 2018–2050: 240,000 units
New non-residential floor space, 2018–2050: 6,720,000 m2 (72,315,000 ft2)

GHG emissions, 2016: 7.7 tCO2e/person
GHG emissions under the BAU scenario, 2050: 4.7 tCO2e/person
GHG emissions under the low carbon scenario, 2050: 1.4 tCO2e/person

Total energy consumption, 2016: 96,448,000 GJ
Total energy consumption under the BAU scenario, 2050: 122,894,000 GJ
Total energy consumption under the low carbon scenario, 2050: 60,798,000 GJ

1 Unless otherwise noted, numbers represent outputs of the analysis calculated for the Community Energy Plan.
2 Population total identified in Durham Regional Official Plan (2017).
3 Population assumptions were prepared specifically for this analysis.

Total expenditures on energy, 2016: $2.5 billion
Savings on fuel and electricity costs under the low carbon scenario, 2018–2050: $20 billion*
Average fuel and electricity costs per household, including transportation, in 2016: $5,800
Average fuel and electricity costs per household, including transportation, per year in 2050 as a result of the low carbon scenario: $2,650*

Total investment required for the low carbon pathway scenario, 2018–2050: $31 billion*
Total savings and revenue generation by the low carbon pathway, 2018-2050: $40.2 billion*
Direct person years of employment generated as a result of the low carbon investments, 2018–2050: 210,000

Total GHG emissions, 2016: 5,540,000 tCO2e
Total GHG emissions under the BAU scenario, 2050: 6,412,000 tCO2e
Total GHG emissions under the low carbon scenario, 2050: 1,907,000 tCO2e
Total GHG emissions under Region's 2050 GHG reduction target: 905,000 tCO2e

***** 2016 dollars, not discounted***

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Executive Summary

The Durham Community Energy Plan (DCEP) seeks to accelerate the transition to a clean energy economy, while simultaneously achieving multiple economic and social benefits. The energy system is in the midst of a profound transformation as decentralized electricity production and storage gain traction, transportation is electrified, and there is increasing momentum in both the public and private sectors to address climate change.

The transition to a cleaner energy economy requires using energy more efficiently, moving from fossil fuels to electricity wherever possible and generating electricity with low or zero carbon emissions. Specific activities include retrofitting nearly the entire existing building stock, dramatically increasing the energy performance of new buildings, rapidly deploying local renewable energy technologies, installing energy storage and electrifying personal and commercial vehicles.

Approach

The development of the DCEP involved three distinct stages: an engagement process with targeted stakeholders; the preparation of a baseline energy and emissions inventory; and technical analysis, modelling and plan development process.

The engagement process identified seven distinct elements of a vision for the DCEP:

1. Innovative, smart and diversified energy solutions
2. Transparent, accountable and committed to the vision
3. Reduced carbon footprint
4. Economic prosperity, and community and environmental health
5. Reliable, resilient, integrated, sustainable and financially viable energy sources
6. Affordable for all
7. Community collaboration for innovative solutions

The aim of the technical analysis is to provide an investment roadmap using a detailed energy and emissions model. The analysis begins by considering the drivers of the Region's energy consumption and greenhouse gas (GHG) emissions, answering the question "where are we now?" A business as usual (BAU) scenario explores the impact of continuation of current practices, a business as planned (BAP) scenario evaluates the impact of current and planned provincial and federal policies, and a low carbon pathway scenario explores the implications of achieving GHG reductions consistent with the Region's GHG targets and the visioning exercise of the DCEP.

Table 1. Durham Region Scenarios

SCENARIO	SHORT FORM	DEFINITION
Business as usual	BAU	The BAU scenario represents current patterns of energy consumption and extrapolates these out until 2050, while accounting for population growth, federal fuel efficiency standards and the impacts of climate change on heating requirements in buildings.
Business as planned	BAP	In addition to the assumptions in the BAU, the BAP scenario reflects the projected changes in provincial building codes, a slight increase in building retrofits in the residential and commercial sectors, an increase in the adoption of building-scale solar PV systems, an increase in electric vehicles and a modest increase in local large-scale solar and wind generation.
Low carbon pathway	LCP	The LCP scenario is a composite of 24 ambitious actions designed to achieve the Durham Region's GHG targets.

Transitioning the Energy System

The framework of Reduce-Improve-Switch is used to help frame the actions in the low carbon scenario. This approach is adapted from similar approaches such as the well-known Reduce-Reuse-Recycle (from the waste sector), and Avoid-Shift-Improve[4] (from the transportation sector). The focus is first on reducing or avoiding consumption of energy, secondly improving the efficiency of the energy system (supply and demand), and finally fuel switching to low carbon or zero carbon renewable sources. This approach minimizes the cost of the energy transition by avoiding installing capacity that is not subsequently required as a result of energy efficiency measures, for example.

In terms of reduction, overall energy consumption in the Region declines from 89.8 GJ/capita/year to 44.4 GJ/capita/year, indicating a more efficient use of energy. Electric vehicles are much more efficient than combustion-powered vehicles, and so the adoption of electric vehicles is a major contributor to the greater efficiency and lower conversion losses in the low carbon scenario.

4 GIZ. (2011). Sustainable urban transport: Avoid-shift-improve. Retrieved from http://www.sutp.org/files/contents/documents/resources/E_Fact-Sheets-and-Policy-Briefs/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf

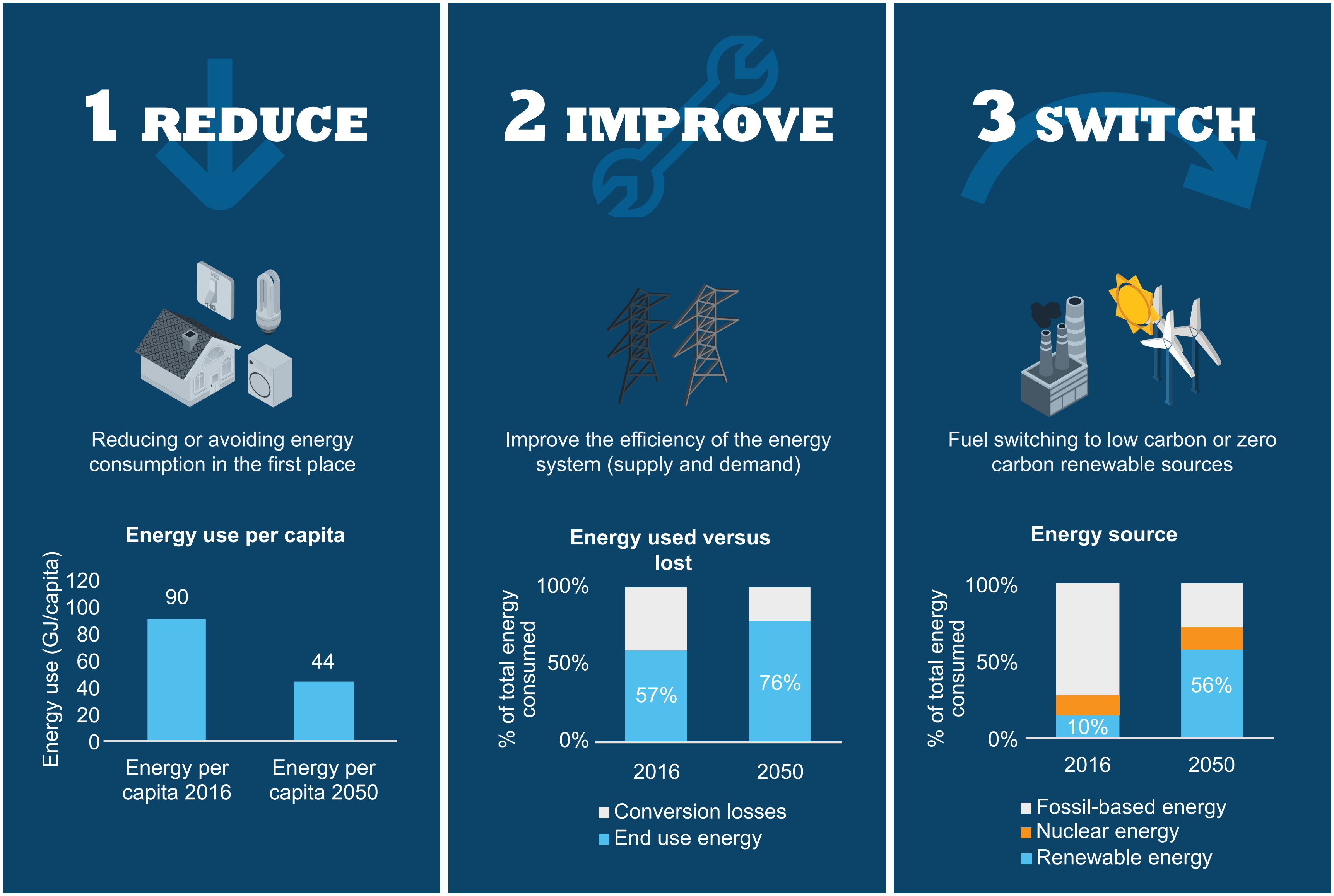

Figure 1. The low carbon scenario in the context of the reduce, improve and switch framework

A second aspect of community energy planning includes prioritizing interventions in terms of what lasts longest.[5] The first priority is land use planning and infrastructure, including density, mix of land uses, energy supply infrastructure and transportation infrastructure. The second is major production processes, transportation modes and buildings, including industrial process, choice of transportation modes, and building and site design. The final priority is energy-using equipment including transit vehicles, motors, appliances and HVAC systems.

This hierarchy explicitly concentrates the efforts on spheres of influence where there are fewer options to intervene, and it decreases the emphasis on the easier interventions which are likely to have greater short term returns. The World Bank defines this consideration as urgency,[6] posing the question: Is the option associated with high economic inertia such as a risk of costly lock-in, irreversibility, or higher costs, if action is delayed? If the answer is yes, then action is urgent; if not, it can be postponed.

Durham Region is projected to grow rapidly between 2018 and 2050, with the population almost doubling over the period.[7] In this context, a key variable is the pattern of land use, which locks in patterns of energy use into the future. Two different patterns of land use were developed to better understand how land use will influence Durham's LCP scenario. While this analysis provided some insights, it also gave rise to additional questions beyond the scope of this project. One key insight is that while the low carbon pathway can be achieved under current development patterns, increased intensification increases the societal benefit resulting from the pathway and decreases its capital cost. As an example, a trip to the store in the context of urban intensification can likely be achieved by walking or cycling, which has a very low capital cost, provides health benefits, and has zero emissions. In the urban expansion context, the same trip to the store is longer and likely necessitates a vehicle; in the low carbon scenario, this vehicle would be electric and would be powered by renewable energy, with associated capital and operating costs.

5 Jaccard, M., Failing, L., & Berry, T. (1997). From equipment to infrastructure: community energy management and greenhouse gas emission reduction. Energy Policy, 25(13), 1065–1074.

6 Fay, M., Hallegatte, S., Vogt-Schilb, A., Rozenberg, J., Narloch, U., & Kerr, T. M. (2015). Decarbonizing development: three steps to a zero-carbon future. Washington, DC: World Bank Group.

7 The GGH population projections on which this study is based were initially developed in 2011. Population projections were developed out until 2050 as part of the technical analysis for the DCEP.

Figure 2 illustrates the impact of the actions in the low carbon pathway (LCP) relative to the business as usual (BAU) scenario. The light grey area represents the remaining GHG emissions following the introduction of the actions and the reduction from each action is represented by a different colour. Greenhouse gas emissions in the LCP are 66% below 2016 levels, and 70% below the emissions projected for 2050 in the BAU scenario.

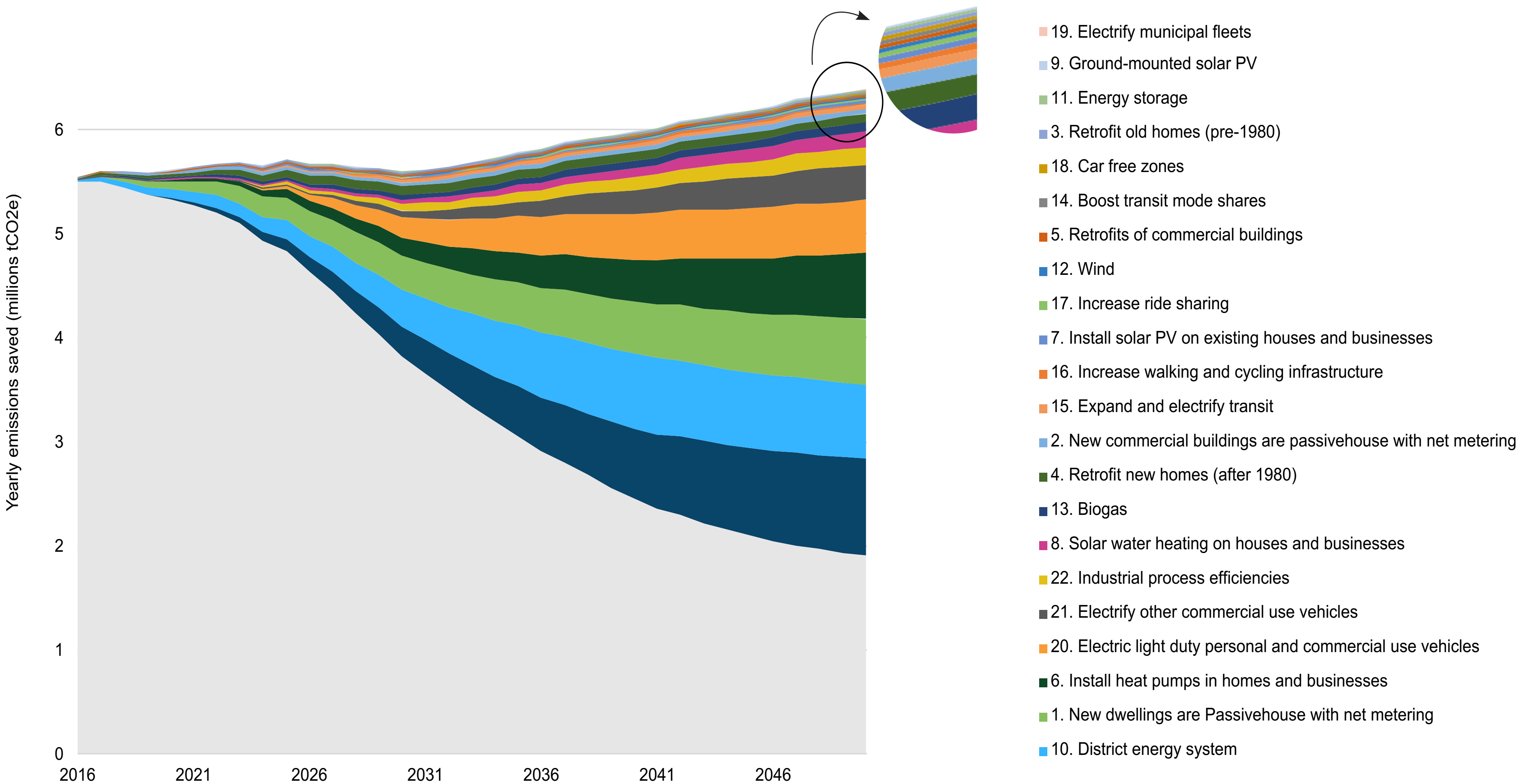

Figure 2. Projected emissions reductions from the actions in the LCP scenario, 2016–2050

Boosting Durham's Economy

In this analysis, all energy-related energy costs are taken into consideration. In addition to fuel and electricity costs, we include the capital costs of the buildings, vehicle and equipment that use the energy, the associated operating and maintenance costs, carbon premiums, and the capital costs and revenue of local generation. As shown in Figure 3, in the short term, net annual energy-related expenditures are higher than for the BAU scenario due to the up-front capital expenditures that lead to savings in the long term. By 2034, the savings from these investments result in the annual net costs of the LCP dropping below the other two scenarios for the rest of the period. After 2034, the gap between the LCP and the other scenarios continues to widen, and by 2050 the annual savings from the LCP reach $2.75 billion and are growing.

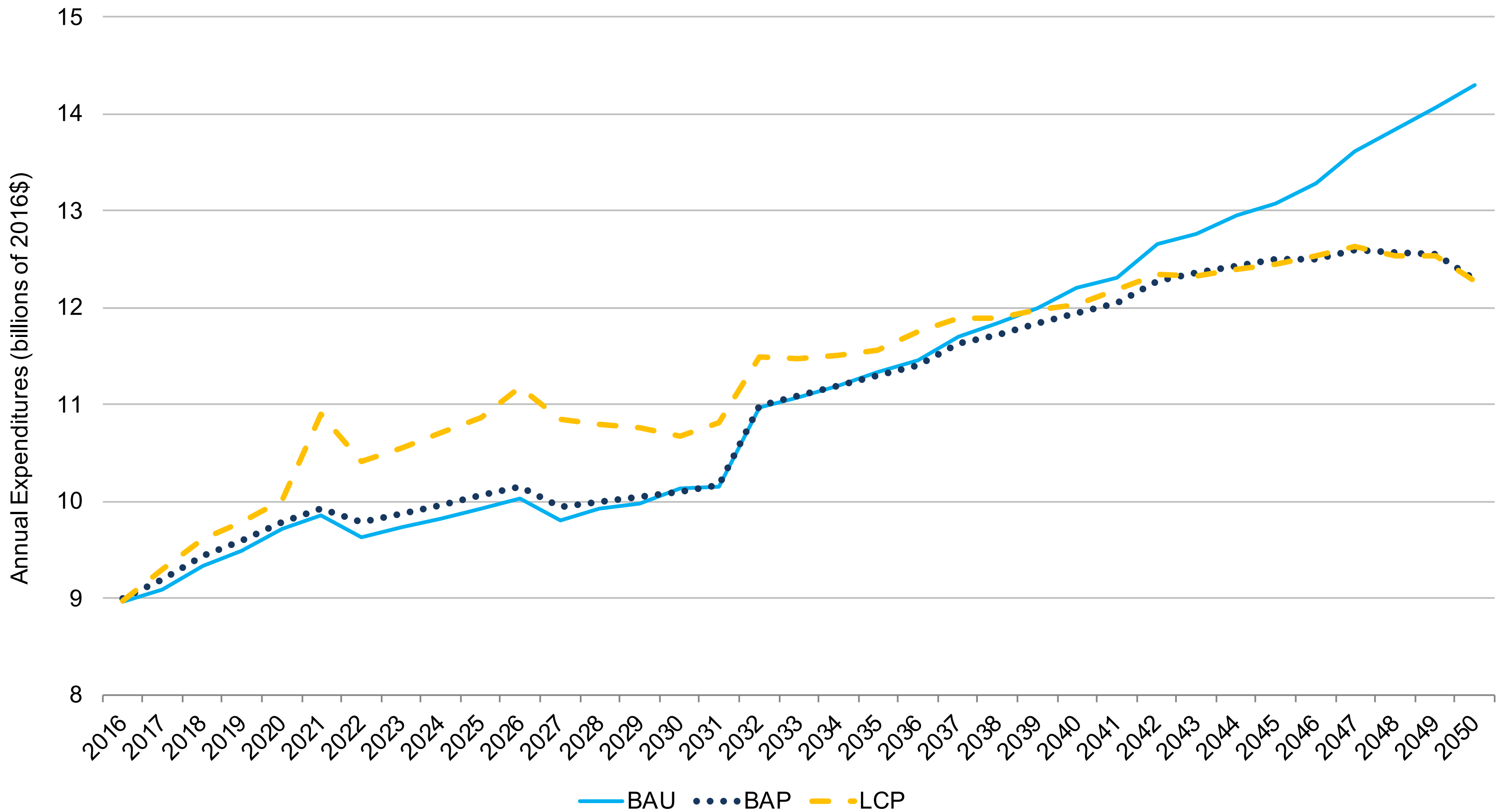

Figure 3. Net annual energy-related expenditures in Durham (including capital equipment, fuel and electricity, operation and maintenance, local generation revenue)

The majority of the LCP actions reduce GHG emissions and generate financial returns. The financial returns are a function of savings from energy efficiency and the declining capital cost of clean and renewable energy technologies. In addition, there are zero ongoing fuel costs associated with investments in renewables, so once the initial capital costs are paid off, the net financial returns increase. Figure 4 illustrates the ratio of the present value of the savings over the present value of the investment for each of the actions, assuming a 3% discount rate.[8] Actions with a positive ratio provide net financial benefit to society, while actions with a negative return on investment typically require subsidies or grants to finance, unless justified on the basis of collateral benefits.

8 Discounting reflects the idea that people would rather have $100 now than $100 in ten years. From an ethical perspective, a higher discount rate indicates that future generations are worth less than current generations; for this reason the Stern Review recommended a discount rate of 1.4%, well below traditional discount rates. As Stern pointed out in a subsequent article, “A 2% pure-time discount rate means that the life of someone born 35 years from now (with given consumption patterns) is deemed half as valuable as that of someone born now (with the same patterns)”. The Government of Canada recommends 3% in circumstances where environmental and human health impacts are involved. A higher discount rate is conventionally used by businesses and would generally decrease the return on investment of the actions.

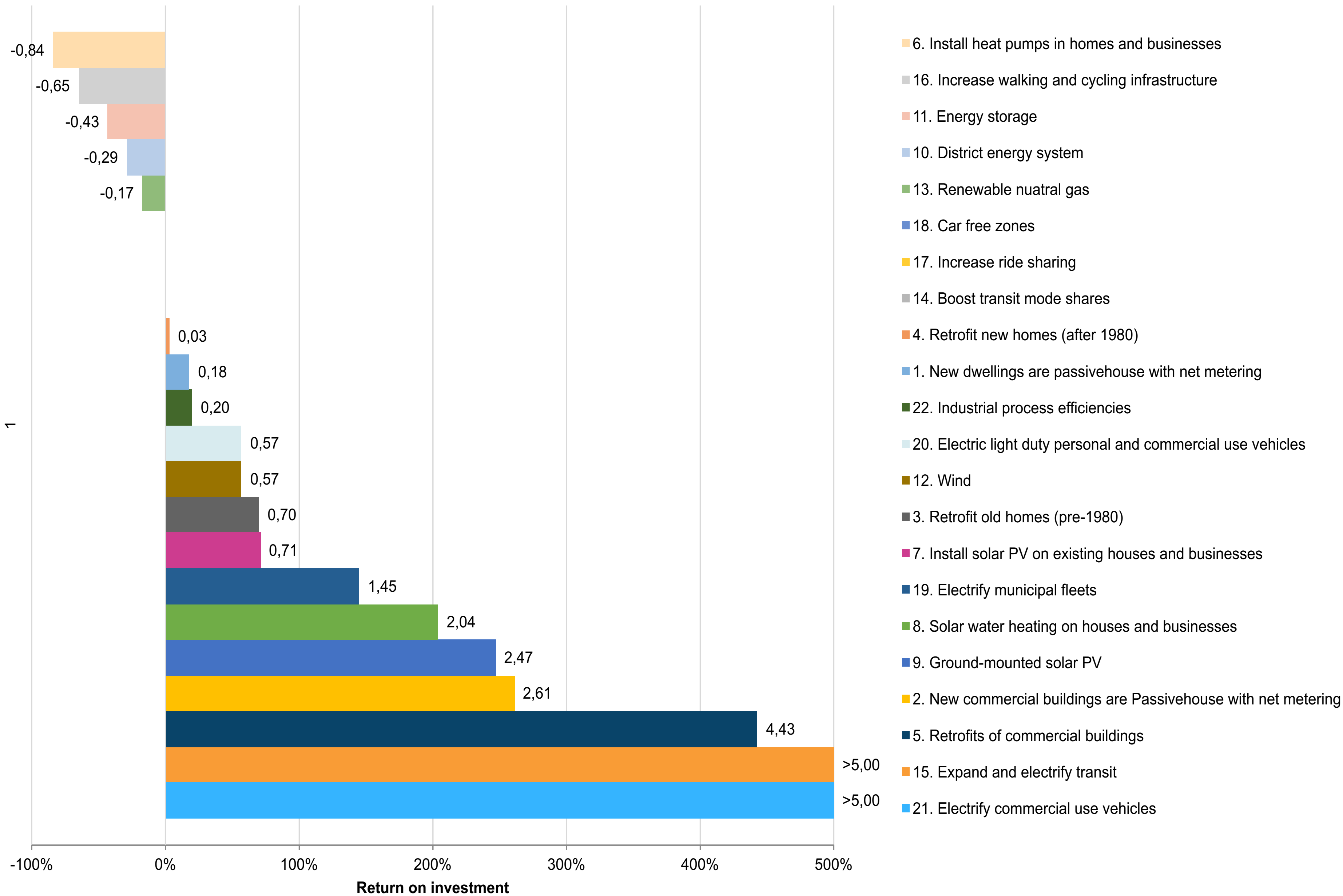

Figure 4. Ratio of the present value of savings over the present value of the expenditures for the actions evaluated in the LCP scenario

Reducing Household Energy Costs

Household expenditures on fuel and electricity are projected to decline in all three scenarios. In the BAU scenario, household energy costs decline because vehicles become more efficient due to national fuel efficiency standards and because of decreased heating requirements as the climate becomes milder due to climate change. There is a shift to electricity for both home heating and personal vehicles but the higher cost of electricity, as compared with fossil fuel, is more than offset by the increased efficiency of homes as required by building codes and in the case of electric vehicles by the high efficiency of the electric motors as compared to internal combustion engines. In the LCP, an average Durham household in 2050 spends $2,650 on fuel and electricity, 41% less than in the BAU scenario. Between 2018 and 2050, the LCP saves the average Durham household $34,600 in fuel and electricity expenditures.

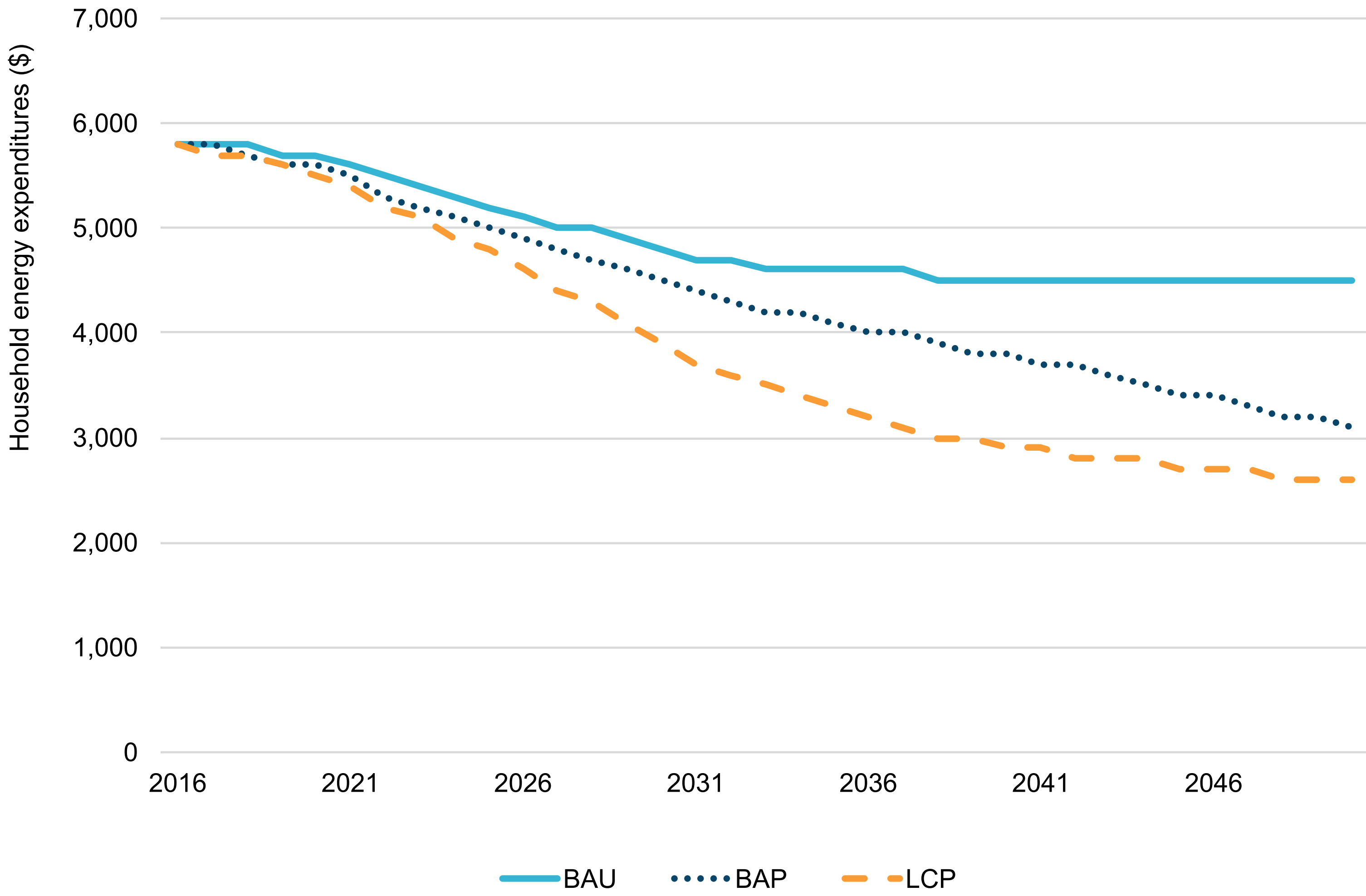

Figure 5. Average annual household expenditures on fuel and electricity for homes and transportation, 2016–2050

Achieving Deep GHG Reductions

The DCEP builds on the Region of Durham Community Climate Change Local Action Plan 2012, providing a more detailed analysis of the drivers underlying energy and emissions in Durham Region and the actions that will support the low carbon pathway.

In the LCP scenario, GHG emissions fall from 5.5 MtCO2e to 1.9 MtCO2e by 2050. The difference between the BAU and the BAP is just under half of this reduction, totalling 2 MtCO2e in 2050; this reduction represents the impact of policies that were current or planned by the Provincial and Federal governments while the plan was being prepared in early 2018. In the absence of these policies, the challenge of achieving the LCP scenario is accentuated and the benefits of the low carbon scenario are jeopardized.

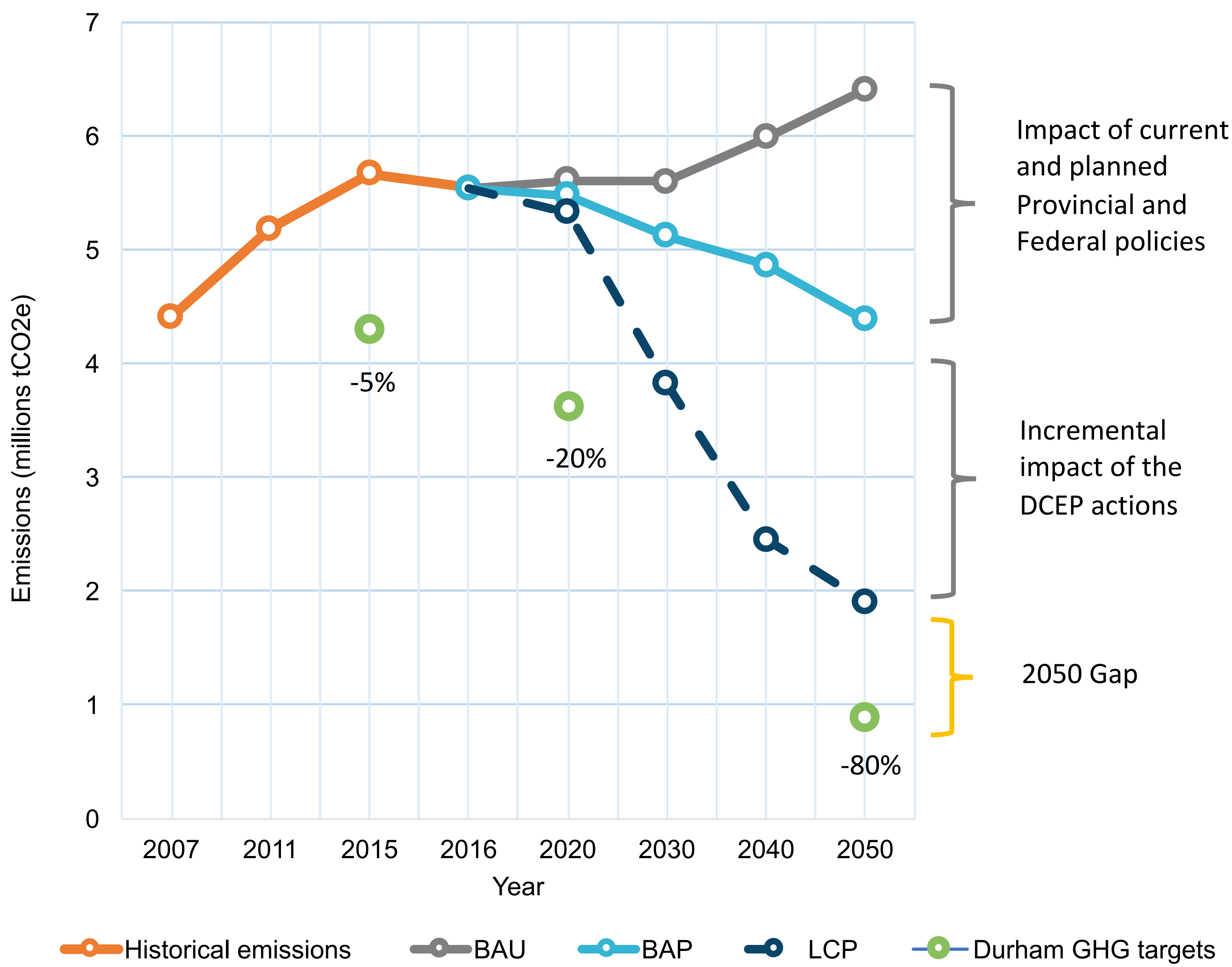

Figure 6. Annual GHG emissions for the DCEP scenarios relative to Durham's GHG targets, 2016–2050

Table 2 provides a detailed overview of the GHG emissions for each of the scenarios for each decade. The LCP scenario does not fully achieve the Region of Durham's GHG emissions targets and the remaining gap of 1 $MtCO_2e$ in 2050 will need to be addressed by either scaling up the actions in the low carbon scenario or identifying new technologies or approaches that further reduce GHG emissions. Closing this remaining gap will require a process of adaptive management, in which the community is continuously testing and learning from novel approaches.

Table 2. Summary of GHG emissions for the Durham Region

	2016	2020	2030	2040	2050
BAU	5,542,000	5,609,000	5,605,000	5,993,000	6,412,000
Per capita	7.7	7.2	6.0	5.3	4.7
BAP	5,542,000	5,477,000	5,120,000	4,869,000	4,383,000
Per capita	7.7	7.0	5.5	4.3	3.2
LCP	5,542,000	5,325,000	3,823,000	2,455,000	1,907,000
Per capita	7.7	6.8	4.1	2.2	1.4

Recommendation #1: The DCEP partners will continue to test novel approaches and identify new strategies to reduce GHG emissions as part of the monitoring and evaluation of the DCEP. New opportunities will be incorporated into the DCEP in order to address the gap between the Region's GHG targets and the LCP scenario.

A Community Effort

The DCEP is designed to be a community effort that involves both the public and private sectors and citizens. The DCEP is a collaboration of the municipalities of Ajax, Brock, Clarington, Oshawa, Pickering, Scugog, Uxbridge, Whitby, and the Region of Durham. Energy utilities are also involved in the steering committee. The DCEP is a pathway for the Durham Region, the municipalities and the broader community, and implementation therefore necessitates a “whole of society approach” that involves local and other levels of governments, citizens, businesses, educational institutions, non-profit organizations and other entities.

Recommendation #2: A central entity is required for leadership and coordination between the municipalities, the Region and other organizations within the community to ensure the implementation of the DCEP and to take advantage of economies of scale.

The Role of the Public Sector

Despite a compelling economic case for many of the actions incorporated within the low carbon scenario, these actions are not being advanced by the private sector, for a variety of reasons. The public sector has three key roles in overcoming these barriers to enable the implementation of the DCEP:

1. Identify the implementation strategies that maximize social benefits;
2. Create enabling conditions for private sector participation, for those cases in which participation maximizes social benefit; and
3. Provide support or directly deliver those actions which are not delivered by the private sector.

A mapping process was undertaken to identify programs that will support the actions identified in the LCP scenario, overcoming key barriers. In most cases, each program can support multiple actions.

Table 3. Short-term implementation program

PROGRAMS	KEY BARRIERS	DESCRIPTION
Program #1: Durham Green Standard: Enhanced energy performance for new buildings	Split incentive between builder and owner that limits investments in energy efficiency.	The Durham Green Standard is a tiered set of performance measures that is required through the planning approval process. The first tier is implemented through the planning approval process, whereas the upper tiers are voluntary. An incentive program is designed with the utilities and uses the PACE program to provide additional upfront capital, paid back over a 10–20-year period at a rate aligned with avoided energy costs.
Program #2: Durham Deep Retrofit Program: Transforming existing buildings	No systematic approach to large-scale retrofits to achieve economies of scale.	The deep retrofits program is envisioned as a partnership with the Provincial and Federal governments, utilities, industry and higher education. A financing package is developed using the Property Assessed Clean Energy (PACE) or Local Improvement Charge (LIC) mechanism, combined with incentives from other levels of government and the utilities, with investment raised through a combination of community bonds and green bonds. Retrofits are targeted to groups of buildings, such as neighbourhoods, sectors (restaurants, grocery stores, etc) as opposed to individual buildings to pool risk and develop larger, more sophisticated projects. Renewable energy including district energy, solar PV, energy storage and air- and ground-source heat pumps is included in the program.

PROGRAMS	KEY BARRIERS	DESCRIPTION
Program #3: Renewable Energy Co-operative: Stimulating local renewable energy projects	Long-term investments required by local entities that deliver community benefits.	The membership of the co-operative includes the Region, municipalities, utilities, industries and other partners. The co-operative advocates for, develops, commissions and finances projects, depending on which strategy is appropriate to a particular context. The co-operative is technology agnostic, with a mandate to work on district energy, wind, solar, storage and geothermal. Financing comes from community bonds, loans and grants from various levels of government.
Program #4: Electric Vehicle Joint Venture: Encouraging the adoption of electric vehicles	Lack of infrastructure and trust in a new technology.	The joint venture is established as a technical working group with representatives from each of the relevant organizations. The first deliverable is a five-year action plan/roadmap for electric vehicles in the Region.
Program #5: Education and Outreach Program: Engaging the community	Lack of awareness of the opportunities.	There are two key aspects: broad-based education and targeted stakeholder education. This program coordinates education and marketing efforts on behalf of the other programs, working with staff from the Region, municipalities and utilities.
Program #6: Coordinating land-use policies	Lack of consideration of energy and GHG emissions in land-use planning.	The Region and municipalities seek to embed policies that enable or directly conserve energy and reduce GHG emissions into official plans and secondary plans.

Recommendation #3: The partners of the DCEP develop a five-year implementation plan based

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on the six program areas identified in the DCEP.

Recommendation #4: The DCEP be both recognized and enabled by the forthcoming revisions of the Durham Region Official Plan and local municipal official plans.

Delivering the Investment Opportunities

The LCP scenario represents a signficiant incremental increase in capital investment, and perhaps more important, a change in the decisions and behaviours that govern current investments in buildings, transportation and energy infrastructure.

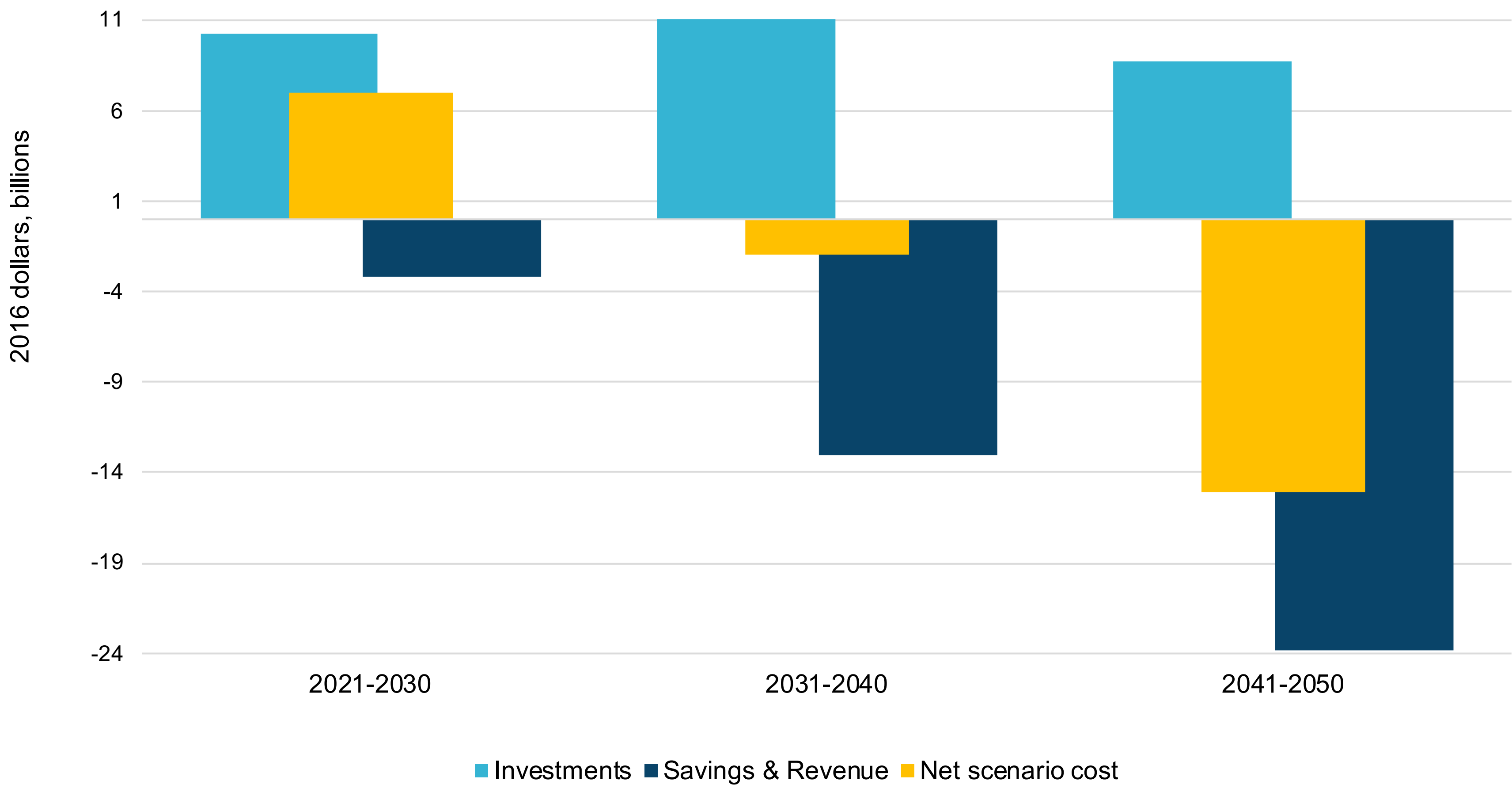


Figure 7. Capital investment and fuel expenditures by decade, undiscounted 2016$

The low carbon pathway requires total additional capital investments beyond those in the reference scenario of:

$1.0 billion per year from 2021–2030

$1.1 billion per year from 2031–2040

$0.87 million per year from 2041–2050

These captial investments result in savings in energy expenditures, revenue from local generation, operation and maintenance savings, and carbon fee savings, which grow every decade:

$0.3 billion per year from 2021–2030

$1.3 billion per year from 2031–2040

$2.38 billion per year from 2041–2050

The DCEP envisions that the required capital will be mobilized from a variety of sources including the public and private sectors. Examples of the mechanisms that can be used to raise the funds are as follows:

- Green Debentures: The proceeds from municipally issued Green Debentures serve as the funding source (i.e. debt financing). Green Debentures are gaining attention as a mechanism to raise funding for low carbon projects. Both the Government of Ontario and City of Ottawa have issued Green Debentures and the City of Toronto is planning to issue one in 2018.
- Securitization: A public entity pools together a series of "special charges" imposed on participating properties and sell notes backed by these assets to investors with the proceeds of sale being allocated to fund future projects.
- Third-Party Finance Partnership: A public entity enters into a partnership with a third party financing entity who provides the capital directly to projects. In turn, the public entity imposes special charges on the benefiting properties and facilitates repayment via the property tax bill.
- Infrastructure Ontario: Municipally led local improvement charge programs are deemed eligible for funding by Infrastructure Ontario. Staff will explore funding at more affordable rates and flexible terms offered by Infrastructure Ontario.

These investments represent major opportunities for new and existing businesses including companies providing heat pumps, building retrofits, renewable energy technologies, energy storage, electric vehicles, district energy, and energy controls, amongst others.

It is also important to view the roughly $1 billion per year investment in the DCEP in the context of the $5-$6 billion per year that Durham households, firms, and governments already invest in new homes, renovations, vehicles, transportation and other energy-using infrastructure and equipment, the $2.5 billion annual expenditures on fuel and electricity, and the additional $2 billion of annual operating and maintenance expenses.

Recommendation #5: Work with financial partners to develop a DCEP capitalization strategy.

Tracking Progress

Tracking the effectiveness of the actions in the DCEP helps to manage the risk and uncertainty associated with these efforts, as well as external forces such as evolving senior government policy, and new technologies which can disrupt the energy system. Key motivations for monitoring and evaluation include the following:

- Identify unanticipated outcomes.
- Adjust programs and policies based on their effectiveness.
- Manage and adapt to the uncertainty of climate change.
- Manage and adapt to emerging technologies.

Specific activities which have been identified to support the implementation of the DCEP include an annual work plan and review, an annual indicator report, an update of the GHG inventory every two years and an update of the DCEP every five years.

Recommendation #6: Implement the DCEP monitoring and evaluation strategy.

1. Introduction

The Energy Transition

The global energy system is in a process of transition, fuelled by technological change and policy. This transition is impacting every aspect of the energy system and the following charts illustrate two major disruptions in electricity generation and transportation respectively. Figure 8 illustrates the acceleration of the adoption of electric vehicles; the first million electric vehicles took 20 years to sell, the second million took 1.5 years and the third million took just over half a year. The second chart (Figure 9) is an indicator of transition in the generation of electricity. The all-in costs of ground-mounted solar PV has resulted in a corresponding increase in installations in the US; similar patterns are evident for other renewable energy technologies. The DCEP explores the implications of these and other trends on Durham's energy system.

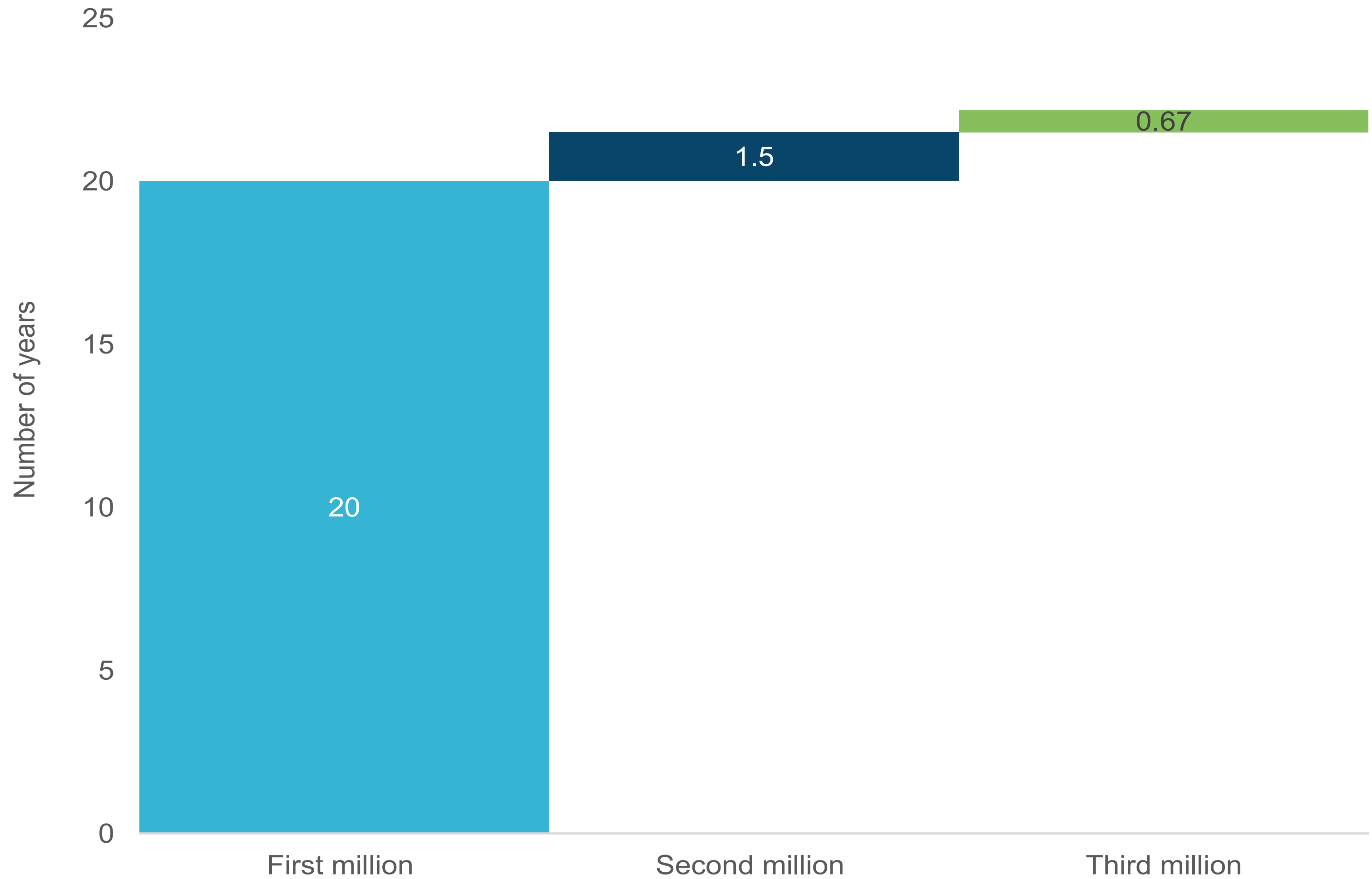


Figure 8. Number of years to sell one million electric vehicles globally[9]

9 Bloomberg New Energy Finance (2018). Presentation at the New Energy Finance Summit, New York.

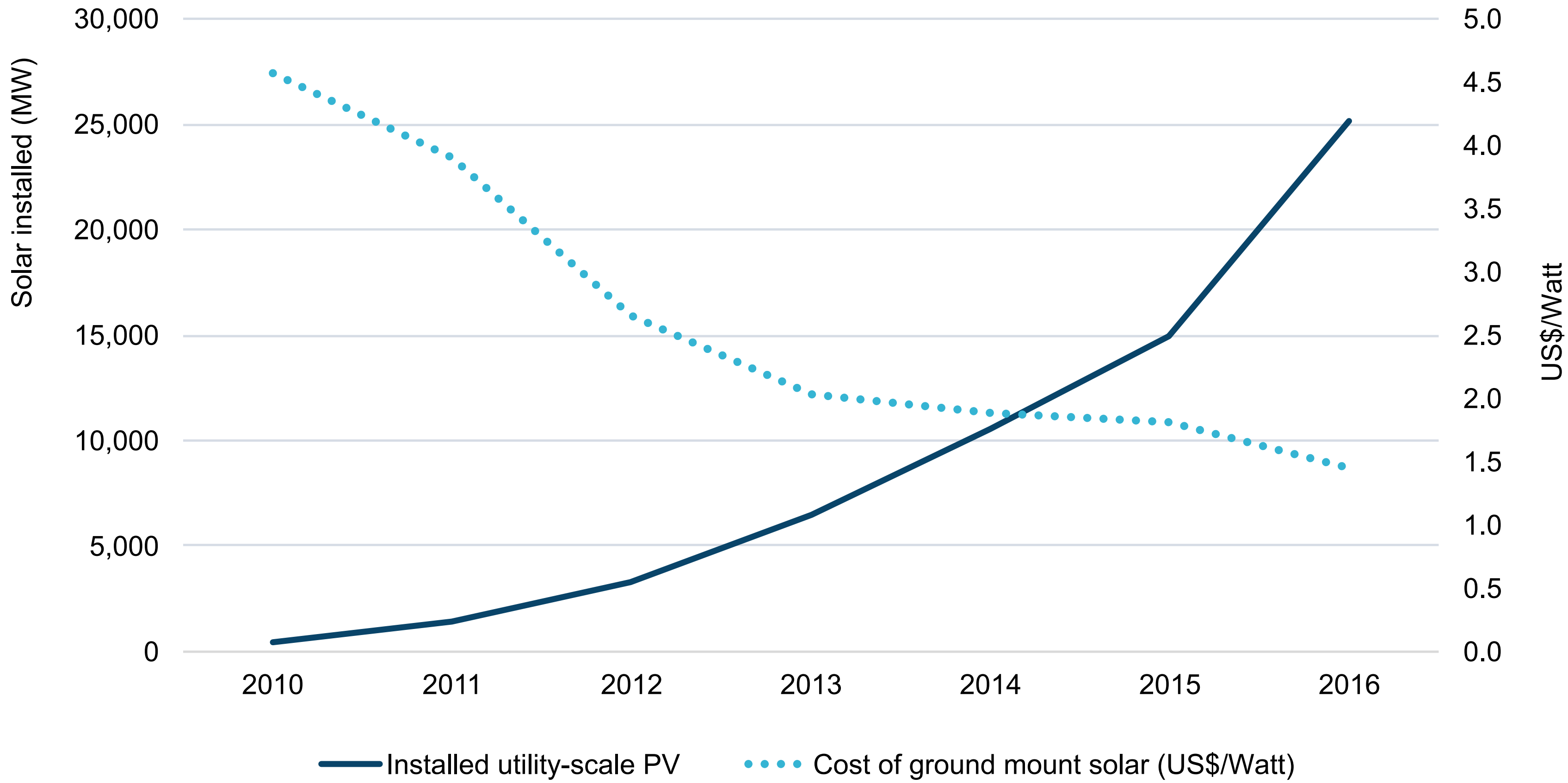


Figure 9. Declining costs of PV and increasing installations[10]

10 Fu, R., Feldman, D. J., Margolis, R. M., Woodhouse, M. A., & Ardani, K. B. (2017). US solar photovoltaic system cost benchmark: Q1 2017 (No. NREL/TP-6A20-68925). National Renewable Energy Laboratory (NREL), Golden, CO (United States).

The Policy Context

Climate change is driving energy policy globally, highlighted by the Paris Agreement, which entered into force on November 4, 2016 under the United Nations Framework Convention on Climate Change. The aims of the Paris Agreement are to limit global temperature rise compared to pre-industrial levels to less than 2 degrees Celsius by the end of the century and to pursue efforts to limit the increase to 1.5 degrees Celsius, in order to limit the impacts on oceans and extreme events.[11] Each country submits a strategy to achieve that objective, called a Nationally Determined Contribution (NDC).[12] Canada's NDC requires a 30% reduction in greenhouse gas emissions (GHG) below 2005 levels by 2030. Canada's most recent National Inventory Report in 2015 reported that GHG emissions were at 722 MtCO2e, approximately 40% above its 2030 target.[13]

The Pan-Canadian Framework on Climate Change is the federal strategy to achieve Canada's GHG targets. The Framework includes coordinated provincial and federal programs to reduce GHG emissions and a carbon pricing mechanism.[14] Major infrastructure investments are intended to support the transition to a low carbon economy.

11 The IPCC will be releasing a special report on 1.5 degrees in 2018. Details on this report are available here: http://ipcc.ch/report/sr15/

12 UNFCCC (n.d.) Summary of the Paris Agreement. Retrieved, 2018 from: http://bigpicture.unfccc.int/#content-the-paris-agreemen

13 Government of Canada (2018). Canada's national reports to the UNFCCC. https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/seventh-national-communication-third-biennial-report.html

14 Government of Canada. (14:10:00.0). Government of Canada announces Pan-Canadian pricing on carbon pollution [News Releases]. Retrieved November 22, 2016, from http://news.gc.ca/web/article-en.do?nid=1132149

The Province of Ontario's GHG targets are more aggressive than those of the Government of Canada up until 2030, targeting reductions of 15% in 2020, 37% in 2030 and 80% in 2050, all compared to 1990 levels. In comparison, the Durham Region's targets are reductions from 2007 levels of 5% by 2015, 20% by 2020 and 80% by 2050.

The Role of the Municipalities

The transition to a low-carbon energy system relies on municipalities.[15] Municipalities and regions in Canada have direct or indirect control over 50% of greenhouse gas emissions.[16] If municipalities are not built to stringent low carbon standards, land-use planning and infrastructure investments can lock in energy and GHG intensive patterns of development which inhibit or make cost prohibitive efficient and low carbon alternatives.[17]

Alternatively, compact urban form increases the feasibility of district energy and the introduction or improvement of public transit, in addition to reducing the financial cost and the GHG impact of providing municipal services such as roads, water and wastewater conveyance, ambulance, fire protection, school transportation, and even provision of home-based health care.

15 The Global Commission on the Economy and Climate. (2014). Better growth, better climate: The new climate economy report. Retrieved from http://newclimateeconomy.report/2014/wp-content/uploads/2014/08/NCE-cities-web.pdf; Seto, K. C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G. C., Dewar, D., … others. (2014). Human settlements, infrastructure and spatial planning. Retrieved from http://pure.iiasa.ac.at/11114/; International Energy Agency. (2016). Energy technology perspectives 2016: Towards sustainable urban energy systems.

16 Torrie, R. (2015). Low carbon futures in Canada – the role of urban climate change mitigation: Briefing on urban energy use and greenhouse gas emissions. Stockholm Environment Institute. Retrieved from https://data.bloomberglp.com/dotorg/sites/2/2015/10/Low-Carbon-Futures-in-Canada.pdf

17 Erickson, P., & Tempest, K. (2015). Keeping cities green: Avoiding carbon lock-in due to urban development. Stockholm Environment Institute. Retrieved from https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2015-11-C40-Cities-carbon-lock-in.pdf

Recognizing this role of municipalities, the Province has embedded climate change into land-use planning policy. The Provincial Policy Statement (2014) requires consideration of climate change directly with respect to the impact of land-use patterns on GHG emissions and the Growth Plan (2017) requires municipalities to develop policies in their official plans that will reduce greenhouse gas emissions, and encourages municipalities to develop greenhouse gas inventories and to establish municipal interim and long-term greenhouse gas emission reduction targets. Funding programs from both the federal and provincial governments support municipal investments and activities to reduce GHG emissions. The multiple roles of municipalities are as follows:

- **A mobilizer:** Municipalities can engage people, municipalities and other organizations around a vision, goals, objectives and targets. Examples include a community engagement program and a bulk purchase of renewable energy on behalf of citizens.
- **An innovator:** Municipalities can directly or indirectly support innovation by reducing risk through investments, partnerships or policies that support low carbon projects or enterprises. An example is the provision of electric vehicle charging infrastructure.
- **A collaborator:** There are multiple opportunities for collaboration in the energy transition; with other levels of government, transit authorities, utilities, municipalities, regions, businesses, non-profit organizations, neighbourhoods and governments in other parts of the world. Collaboration can take the form of shared targets or policies or joint projects or investments. An example is a coordinated retrofit program between municipalities and utilities.
- **An investor:** Municipalities can use their access to low interest capital to make investments directly in areas such as building retrofits and renewable energy technologies. Alternatively, and in tandem, the Region can enable investments by third parties. An example is local improvement charges as a way to finance building retrofits.
- **An implementer**: Through policies and incentives, municipalities can support businesses and households in the energy transition. An example is a district energy connection bylaw which enables low carbon district energy systems.
- **An incubator:** Municipalities can cultivate the

development of new technologies or applications that enable the low carbon economy by supporting and attracting new and existing businesses and creating a hub or ecosystem in which the businesses and organizations support each other. An example is a low carbon business park or incentives for different levels of building performance that stimulate innovation by builders.

Key Trends

- **Governments are increasingly supporting low or zero carbon options:** Federal and provincial policies are increasingly oriented toward supporting low or zero carbon options for the energy system. This means decreased funding or incentives for fossil fuel industries and increased programs and support for renewable energy and conservation activities.
- **Renewable energy is increasingly accessible:** It is relatively easy and becoming easier for households and businesses to generate their own energy. As the cost of solar PV systems decline, they will become increasingly accessible. New financing mechanisms are also reducing barriers.
- **Energy storage technologies are changing the grid:** Energy storage technologies such as batteries are already available for houses and businesses and as the costs continue to decline, the number of installations will increase rapidly.
- **New models of electric vehicles are available every day:** As the purchase price decreases and the range increases, the number of electric vehicles on the road is set to increase exponentially.
- **Heating systems remain a challenge, but new options are coming online:** Heat pumps continue to improve in efficiency and district energy systems are gaining traction as a more efficient system for

providing heating and cooling to communities with the flexibility to add or subtract energy generation technologies as required.

- **Microgrids are breaking down the barriers between heating and electricity: M**icrogrids combine electricity generation from solar or combined heat and power with electric batteries and other technologies.
- **New financing strategies are increasing participation:** Municipalities and financial institutions are offering mechanisms that reduce financial barriers to energy retrofits and renewable technologies.

Municipalities around the world are creating innovative policies and strategies to take advantage of these trends. These policies and strategies also enable municipalities to simultaneously advance local priorities such as reducing air pollution, stimulating economic development and new employment opportunities, increasing the liveability of the community, and improving affordability.

2. Purpose and Objectives

The DCEP is a comprehensive long-term energy plan to improve energy efficiency and reduce energy consumption and greenhouse gas emissions in established and new community areas. The DCEP is a roadmap to achieve deep emissions reductions and energy savings for every fuel type while driving local economic development and job creation. The DCEP builds on the Region of Durham Community Climate Change Local Action Plan 2012, providing an enhanced analysis of the drivers underlying energy and emissions in the Durham Region and the actions that will support the low carbon pathway. To develop the roadmap, the DCEP explored a range of questions, including the following:

- How is energy currently used in the Region?
- What are the factors that influence patterns of energy use?
- What are the greenhouse gas emissions associated with the use of energy?
- What is the cost of energy in the Region and who pays what?
- What are the opportunities for saving energy and money?
- What are the future trends of energy use?
- What is the role of the clean energy transition in the economic development of the Region?
- What are the impacts of policies or actions undertaken by the Region, local governments and utilities?
- What are the investment requirements to support the transition to a clean energy economy?

Municipalities are energy systems, and how they are planned, built and lived in largely determines the level and pattern of greenhouse gas emissions in that system. The DCEP explored the potential of different land-use policies to impact energy and emissions.

Scope

The DCEP has been developed according to the process outlined in the Ontario Municipal Energy Plan (MEP) program. The MEP represents a comprehensive long-term approach to improve energy efficiency, reduce energy consumption and greenhouse gas emissions, foster green energy solutions and support economic development. The sectors evaluated include buildings, transportation, waste management, local energy generation and land-use. The DCEP applies the Global Protocol for City-Scale (GPC) GHG Emissions Inventories as an accounting framework to guide the reporting on energy and emissions. GPC reports are included as an appendix in part 2 of this report.

Overall Process

The DCEP follows a four-step process that includes stakeholder engagement in stage 1, a baseline data study in stage 2, programs and scenarios development in stage 3 and finally the preparation of the plan in stage 4.

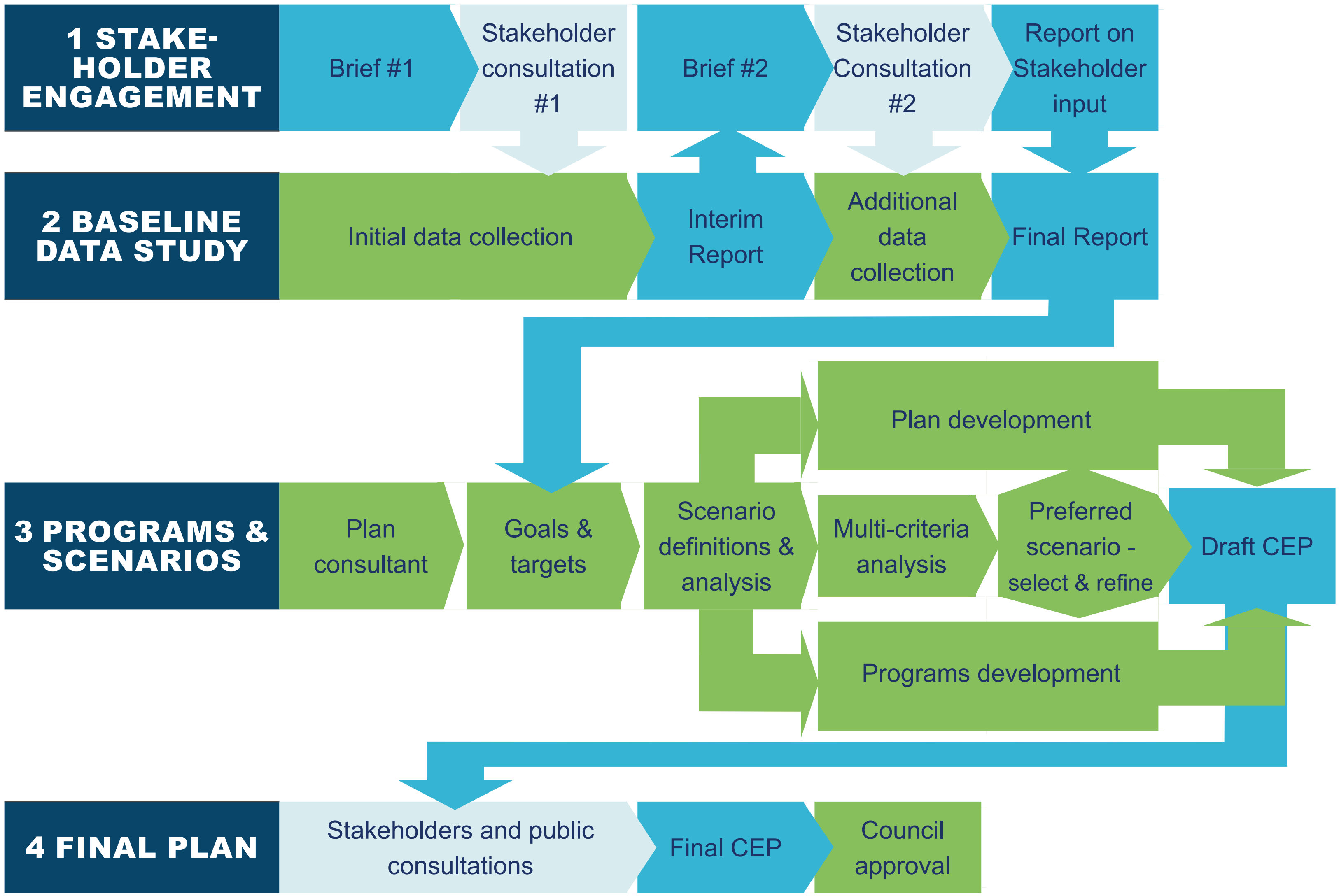


Figure 10. Schematic of the development of the DCEP

The scenario development stage involves the application of CityInSight, a detailed energy, emissions and finance model; for more details on CityInSight, see section 2, Technical analysis. CityInSight is calibrated using data resulting from stage 2 and scenarios are then developed to explore possible futures for the Durham Region. Table 4 describes the scenarios developed following an iterative process.

Principles of Community Energy Planning

Reduce, improve, switch: An approach of reduce, improve and switch, is used to help frame the actions. This approach is adapted from similar approaches such as the well-known Reduce-Reuse-Recycle (from the waste sector), and Avoid-Shift-Improve[18] (from the transportation sector). The focus is therefore first on reducing or avoiding consumption of energy, secondly improving the efficiency of the energy system (supply and demand), and finally fuel switching to low carbon or zero carbon renewable sources. This approach minimizes the cost of the energy transition by avoiding installing capacity that is not subsequently required, as a result of energy efficiency measures, for example.

What lasts longest first: A second aspect of community energy planning includes prioritizing interventions in terms of a hierarchy based on what lasts longest.[19] The first priority is land-use planning and

18 GIZ. (2011). Sustainable urban transport: Avoid-shift-improve. Retrieved from http://www.sutp.org/files/contents/documents/resources/E_Fact-Sheets-and-Policy-Briefs/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf

19 Jaccard, M., Failing, L., & Berry, T. (1997). From equipment to infrastructure: community energy management and greenhouse gas emission reduction. Energy Policy, 25(13), 1065–1074.

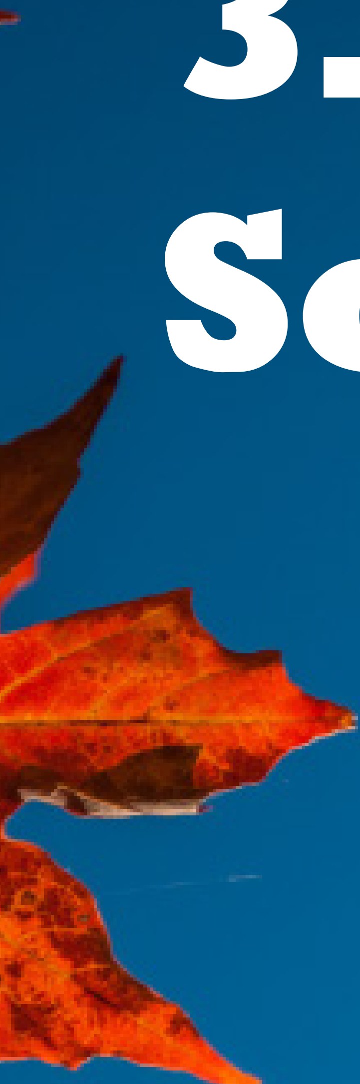
infrastructure, including density, mix of land uses, energy supply infrastructure and transportation infrastructure. The second is major production processes, transportation modes and buildings, including industrial process, choice of transportation modes, and building and site design. The final priority is energy-using equipment including transit vehicles, motors, appliances and HVAC systems.

Urgency: This hierarchy explicitly concentrates the efforts on spheres of influence where there are fewer options to intervene, and it decreases the emphasis on the easier interventions which are likely to have greater short-term returns. The World Bank defines this consideration as urgency,[20] posing the question: Is the option associated with high economic inertia such as a risk of costly lock-in, irreversibility, or higher costs, if action is delayed? If the answer is yes, then action is urgent; if not, it can be postponed. From this perspective, land-use planning is an urgent mitigation action.

The concepts and approaches of reduce-improve-switch, turnover inertia, and community energy planning described above guide the analysis and identification of a final list of actions for modelling, as well as the sequencing of actions in modelling. The stocks and flows logic underpinning the CityInSight model embeds consideration of inertia into the analysis.

20 Fay, M., Hallegatte, S., Vogt-Schilb, A., Rozenberg, J., Narloch, U., & Kerr, T. M. (2015). Decarbonizing development: three steps to a zero-carbon future. Washington, DC: World Bank Group.

3. The Scenarios



Three scenarios were developed in order to explore firstly what might happen if no new policies or programs are implemented, secondly a scenario that represents current federal and provincial policies and finally a low carbon pathway that is aligned with Durham Region's GHG targets. Table 4 describes the three scenarios.

Table 4. DCEP Scenarios[21]

SCENARIO	SHORT FORM	DEFINITION
Business as usual	BAU	The BAU scenario represents current patterns of energy consumption and extrapolates these out until 2050, while accounting for population increases, federal fuel efficiency standards and the impacts of climate change on heating requirements in buildings.
Business as planned	BAP	In addition to the assumptions in the BAU, the BAP scenario reflects the projected increases in provincial building codes, a slight increase in building retrofits in the residential and commercial sectors, current land-use policy in Official Plans, an increase in the adoption of building-scale solar PV systems, an increase in electric vehicles, and a modest increase in local large-scale solar and wind generation.
Low carbon pathway	LCP	The LCP scenario is a composite of ambitious actions designed to achieve the Region of Durham's GHG targets.

In the BAU scenario, energy consumption for the Region is projected to increase by 30% by 2050, from 97 million GJ in 2016 to 123 million GJ. This increase is modest, given the projected doubling in population. Drivers of the increased efficiency on a per capita basis include the reduced heating degree days, improved fuel efficiency in vehicles, the increased adoption of electric vehicles and increased requirements for energy performance in the building code. The LCP scenario results in a decline of nearly 37% in energy to 61 million GJ.

21 For detailed descriptions of the scenarios, see: Part 2, page 13, Table 2 for the details of the assumptions under the three scenarios.

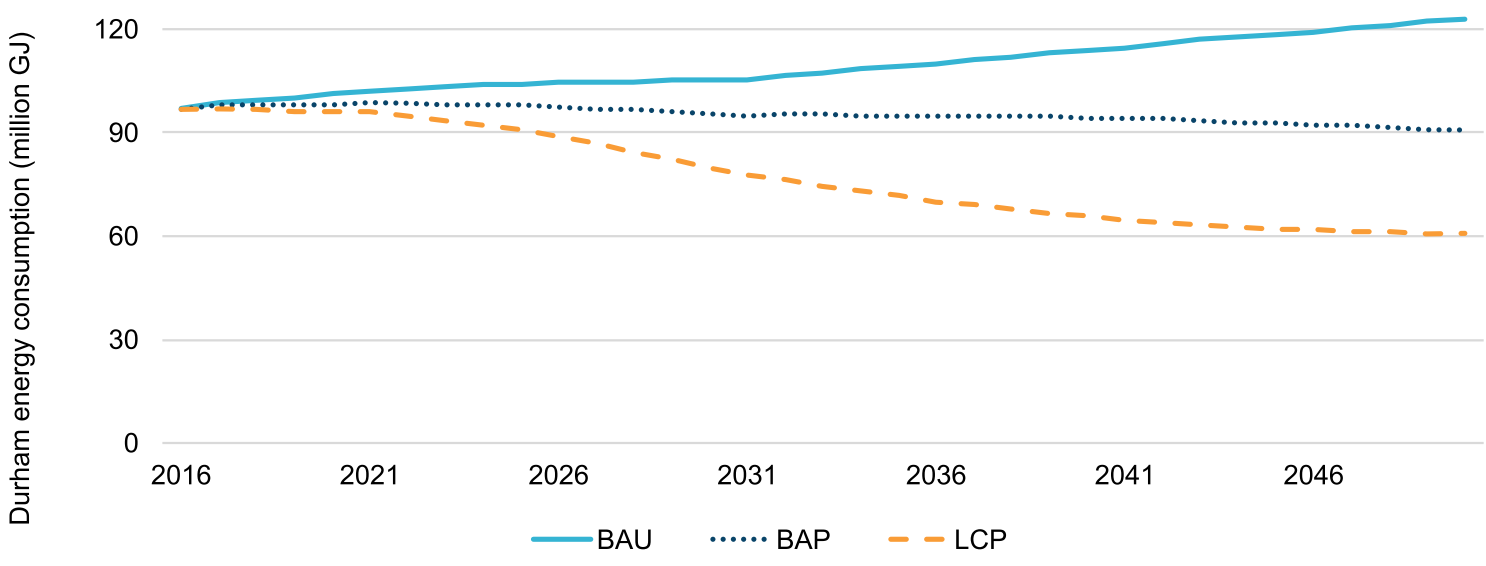


Figure 11. Annual energy consumption (GJ) by scenario, 2016–2050

The GHG emissions trajectory for each of the scenarios is illustrated in Figure 12. Even in the business as usual (BAU) scenario, despite the doubling of the population in 2050, GHG emissions climb by less than 20%, primarily as a result of a decreased heating load due to climate change and the increased fuel efficiency of vehicles as a result of federal fuel efficiency standards. In the LCP scenario, by 2050 annual emissions are 4.6 MtCO2e below the BAU scenario, a 70% reduction. Almost half of this reduction, 2 MtCO2e, results from other Provincial and Federal government policies and incentives, as defined by the BAP scenario.

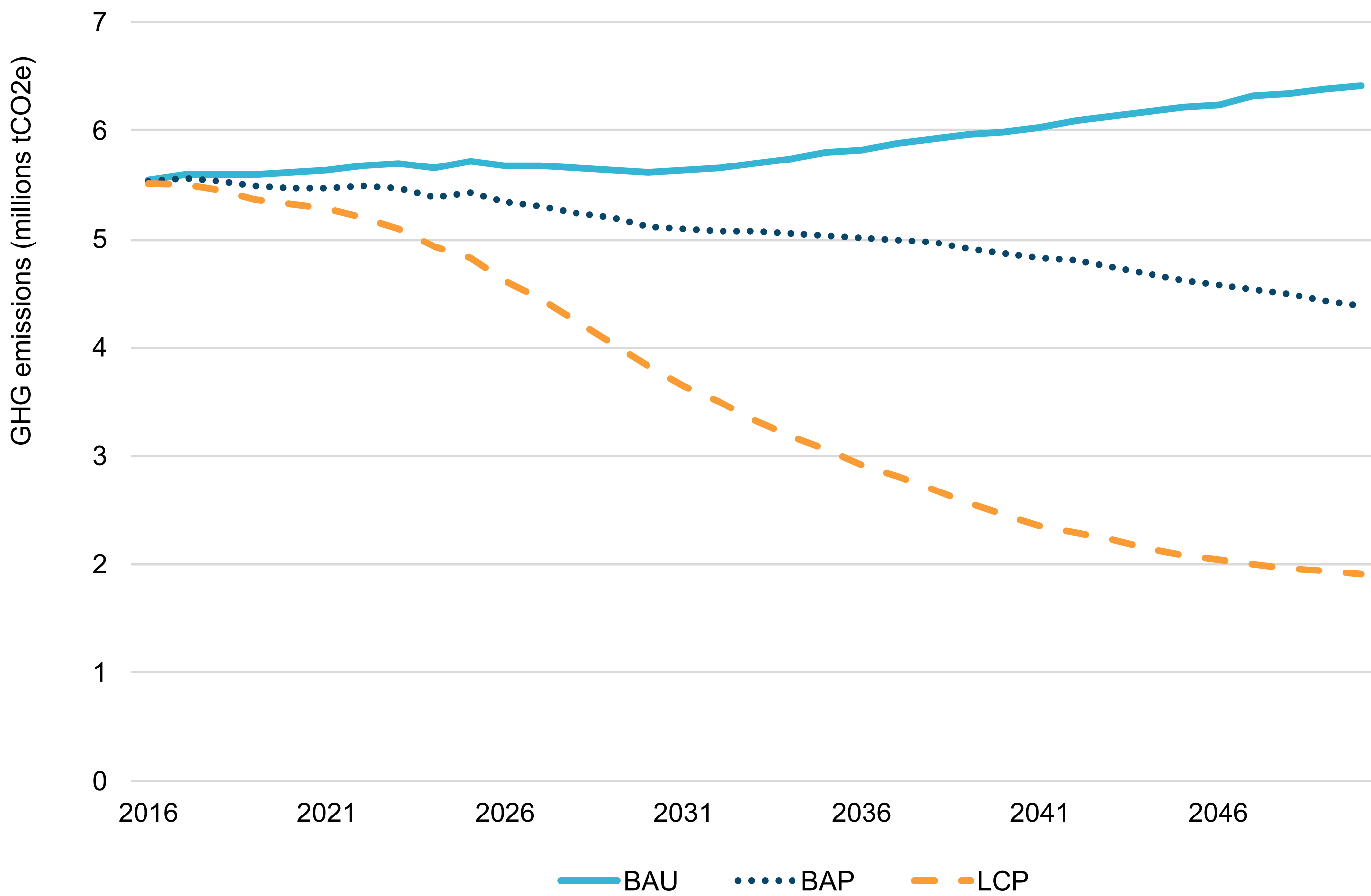


Figure 12. Annual GHG emissions for the three scenarios, 2016–2050

4. The Pathway

Following an analysis of the scenarios, a process of structured decision making was used to select the LCP scenario as the preferred scenario, and the one that most closely aligns with the Durham Region GHG targets.

The proportionate reductions from each action are distributed on a year over year basis to generate a wedge diagram, illustrated below. The wedge diagram shows the contribution of each action to the overall emissions reduction trajectory. As there are dependencies and feedback cycles between the actions, which are captured by the model, the wedge diagram shows a simplified representation of the results.

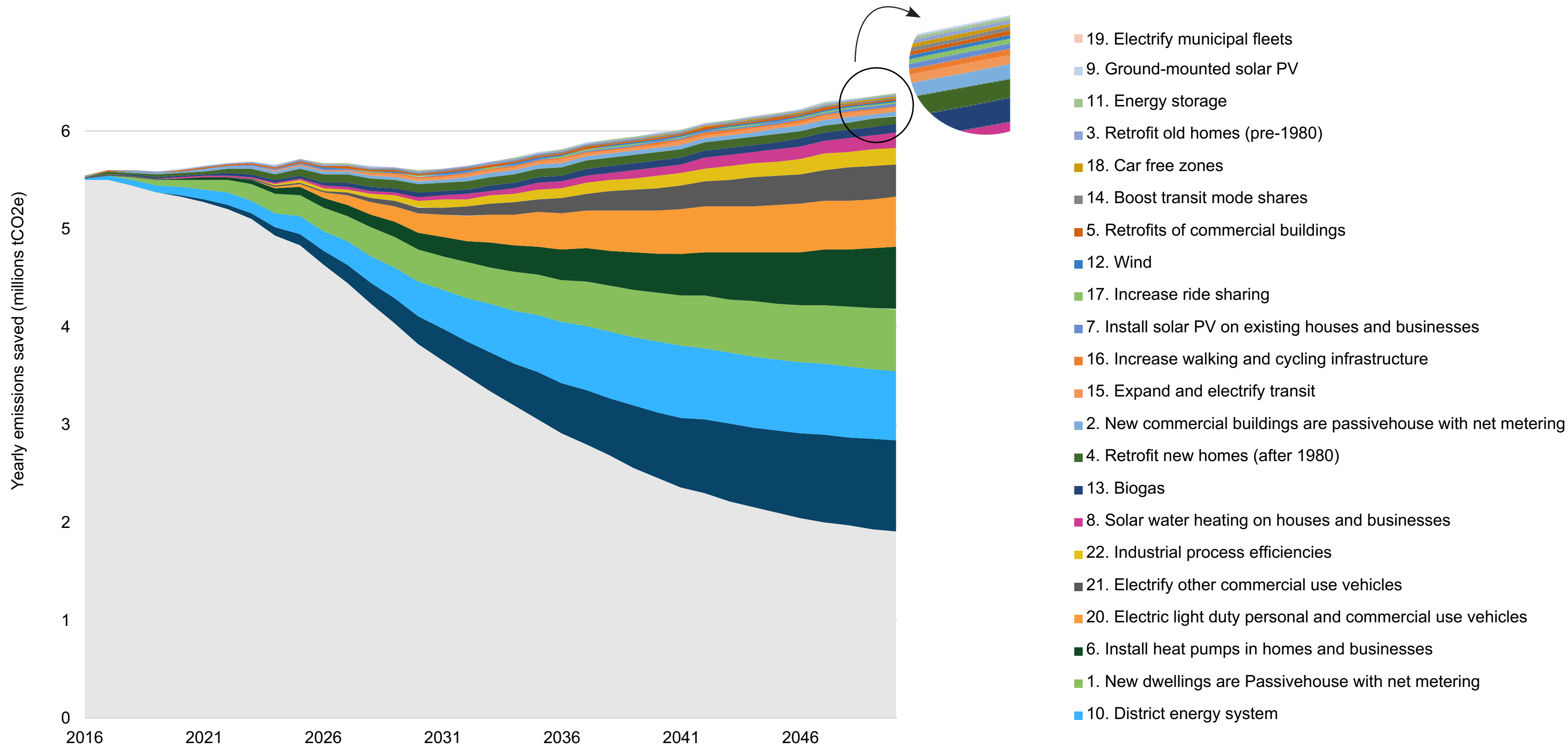


Figure 13. Annual emissions reductions from the actions in the LCP scenario, 2016–2050

The GHG reductions illustrated in Table 5 are a snapshot in 2050, categorized according to the action number. Major sources of GHG reductions include efficiency requirements in new commercial, institutional and industrial buildings, the installation of heat pumps which displace natural gas with electricity, district energy, industrial efficiencies and the electrification of vehicles. The electrification of commercial vehicles results in greater GHG reductions than personal vehicles in 2050, because personal vehicles are largely electrified in the BAU scenario, so the incremental electrification in the LCP is relatively small.

Table 5. GHG reductions from BAU levels resulting from the LCP actions, 2050[22]

ACTION #	DESCRIPTION	GHG REDUCTION (KTCO2E)	CHANGE %
New buildings – buildings codes & standards			
1	New residential buildings	640	14.2%
2	New commercial, institutional and industrial buildings	54	1.2%
Existing buildings – retrofitting			
3	Retrofit homes built prior to 1980	12	0.3%
4	Retrofit homes built after 1980 but before 2017	73	1.6%
5	Retrofits of commercial and industrial	15	0.3%
Renewable energy generation (on-site, building scale)			
6	Installation of heat pumps	1,566	35.0%

22 Percentages may not sum to 100% due to rounding.

ACTION #	DESCRIPTION	GHG REDUCTION (KTCO2E)	CHANGE %
7	Solar PV – net metering	45	1.0%
8	Solar hot water	153	3.4%
Low or zero carbon energy generation (commercial scale)			
9	Solar PV – ground mount commercial scale	6	0.1%
10	District energy	706	15.7%
11	Energy storage	12	0.3%
12	Wind	16	0.4%
13	Renewable natural gas	91	2.0%
Transit			
14, 15	Expand and electrify transit	48	1.1%
Active			
16	Increase/improve cycling & walking infrastructure	22	0.5%
17	Increased rideshare	17	0.4%
18	Car free zones	13	0.3%
Private/personal use			

ACTION #	DESCRIPTION	GHG REDUCTION (KTCO2E)	CHANGE %
19	Electrify municipal fleets	0.5	Not significant
20	Electrify personal vehicles	506	11.2%
21	Electrify commercial vehicles	340	7.5%
Industrial			
22	Industrial efficiencies	168	3.7%
Total		4,504	100%

Note: only 4 of these measures (installation of heat pumps at 35.0%, district energy at 15.7%, new residential buildings at 14.2% and electrify personal vehicles at 11.2%) account for three quarters (76.1%) of the total GHG reductions.

Economic Impact

The economic impact of the LCP scenario results from the stimulus created by the investments required to implement the LCP actions, and the long-term savings in fuel and electricity costs. In 2018, households, firms and governments in Durham spent a total of $2.5 billion on fuel and electricity, and in a business-as-usual future this total is projected to increase to $3.9 billion by 2050. The actions in the LCP scenario would reduce this $1.4 billion per year, a 35% gain. Beyond these savings, some of the actions in the LCP scenario generate savings in other areas, such as reduced operating and maintenance costs. Investments are required up front to achieve the savings, which increase from 2030 to 2050.

The actions in the LCP scenario require investments that result in savings and, in the case of local electricity generation, revenues. It is a classic case of pay now to save later. Incremental expenditures, (as compared with the business-as-usual case) in buildings, vehicles and other energy-related equipment and infrastructure increase costs in the short term in return for long term savings. There are some captial expenditures that are actually lower in the LCP than in the business-as-usual case, in particular electric vehicles, but in general achieving the low carbon pathway requires incremental additions to the background level of investment. The net incremental capital investments in the low carbon pathway, as compared to the business-as-usual scenario, quickly ramp up to about $1 billion per year by the early 2020's. By 2050, the cumulative investment in the low carbon pathway reaches $31 billion with a present value in 2018 of $19.2 billion. As noted earlier, this incremental investment in the LCP occurs against a background level of investment in buildings, vehicles, and energy using equipment and infrastructure that currently totals over $5 billion per year in Durham, and by 2050 accumulates to $165 billion, with a present value of more than $100 billion.

On the other side of the ledger are the fuel and electricity cost savings, the monetary value of the carbon reductions from carbon pricing, some specified savings in operation and maintenance costs, and revenue from locallly generated energy generation.

The largest contribution to the value of the LCP comes from lower energy bills; by 2050, fuel and electricity expenditures in Durham are $1.4 billion per year lower than in the business-as-usual scenario. Cumulative savings reach $20 billion by 2050, with a present value of $10.1 billion.

Carbon pricing effectively increases the value of fuel and electricity savings, and especially fuel savings, modestly in the first half of the program but more significantly in the later years as the effective carbon price increases. In 2050, the annual carbon “premium” from the LCP reaches $520 million and the cumulative premium over the 2018–2050 period totals $7 billion, with a present value in 2018 of $3.5 billion.

The low carbon pathway includes investments in local energy generation facilities in Durham that generate a steadily growing stream of revenue that reaches $365 million per year by 2050 and a cumulative total $6.4 billion with a present value in 2018 of $3.4 million.

Finally, the low carbon investments also result in lower operation and maintenance costs for all sorts of energy using equipment, partly as the result of the lower demands placed on equipment as the result of more efficienct buildings and infrastructure, but more importantly as the result of the lower maintenance costs associated with electric motors as compared to internal combustion engines. These maintenance savings grow strongly in the latter years of the program when electric vehicles are also growing quickly, and by 2050 reach $520 million per year with a cumulative value over the 2018-2050 period of $6.9 billion (net present value of $3.2 billion).

The above five categories of investments, energy savings, carbon credits, O&M savings, and energy generation revenue are summarized in Figure 14 below. On an annual basis, the increased capital expenditures exceed the savings and revenues until the break-even point in the mid 2030’s and then the net benefits begin to exceed the annual investment by an ever widening margin. By 2050, the annual net payback from the plan reaches $2.75 billion per year. By that point the cumulative investment reaches $31 billion as compared to the cumulative benefits of $40.2 billion. As illustrated in Figure 15, the Low Carbon Pathway has a positive net present value in 2018, with energy savings, O&M savings, carbon premiums and local generation revenue more than offsetting the incremental capital investments in the program. Because a greater portion of the savings and revenues occur later in the program as compared to the investments, they are more heavily discounted than the investments. This is a high level summary that includes all the costs and all the benefits of all the measures in the Low Carbon Pathway, over a range of cost effectiveness.

The incremental investments to put Durham on the low carbon pathway -- about $1 billion per year -- compare with the $2.5 billion per year that is already being spent on fuel and electricity, a figure that is projected to grow to $3.9 billion per year in the business-as-usual outlook. They represent an even smaller percentage of the baseline levels of investment in Durham for buildings, vehicles and other energy using equipment and infrastructure.

In 2018, Durham households, businesses and other organizations will spend $1.8 billion on new cars and $351 million on commercial vehicles, $1.3 billion on new homes and $1 billion on renovations of existing houses, $709 million on new commercial buildings, and at least another $140 million on other energy using equipment and infrastructure. In addition, the operation and maintenance of all these buildings, vehicles, equipment and infrastructure totals another $2 billion per year. Combined with the fuel and electricity expenditures, this brings current annual energy-related capital and operating expenditures in Durham to over $9 billion, a figure that is on track to top $14 billion per year by mid century, and a cumulative total between now and 2050 of $374 billion. In the LCP scenario, this total would be $4 billion higher, just one percent more than business-as-usual. Add in the carbon price premium and the new revenue from local generation and the total net cost of the Low Carbon Pathway drops below the business-as-usual case by $5 billion before discounting and to about the same overall net cost as business-as-usual after discounting.

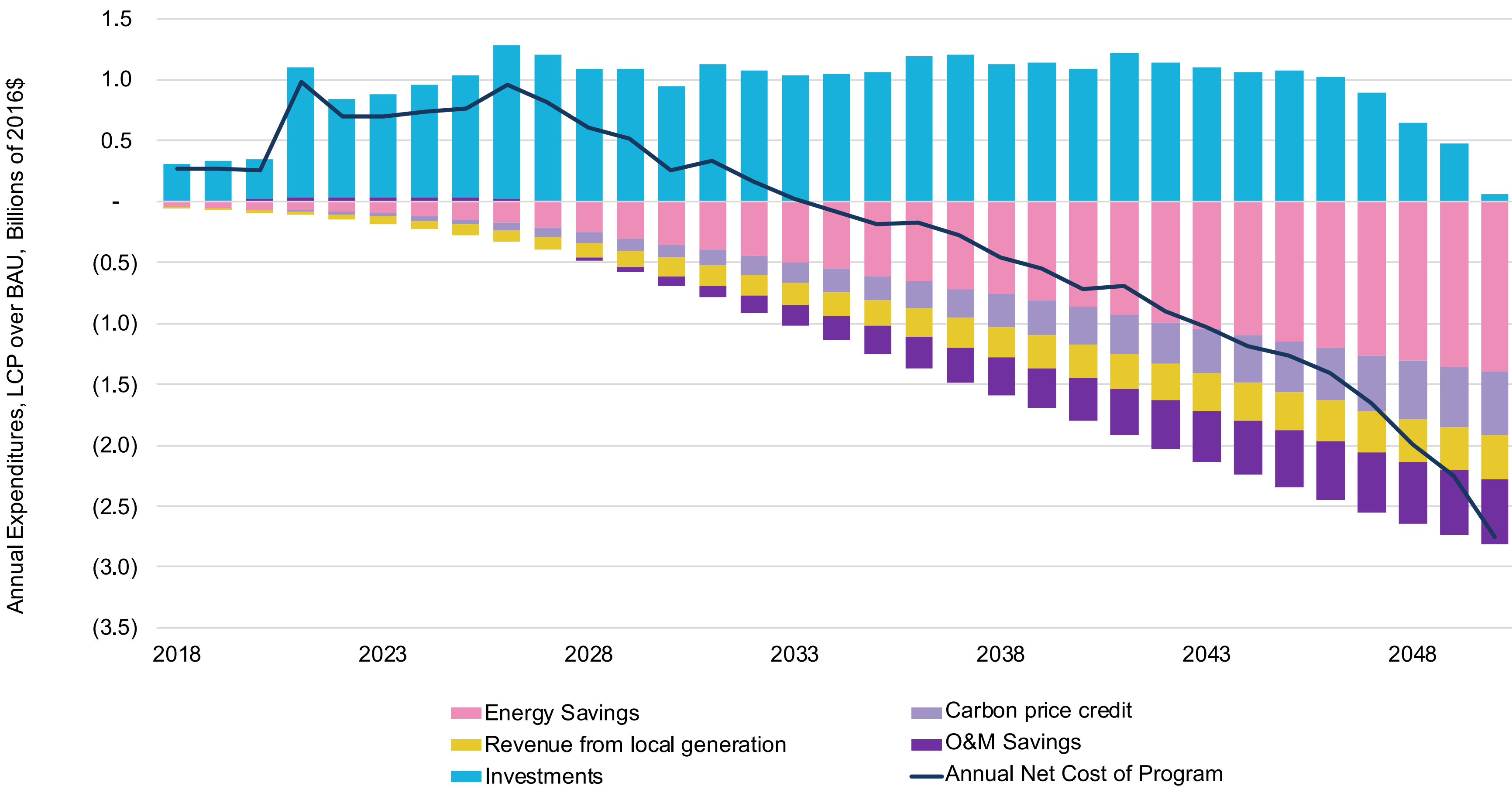


Figure 14. Expenditures, savings and revenues from the LCP, relative to business-as-usual. (Values are presented as costs in this figure, so expenditures are above the line and savings and revenue are below the line).

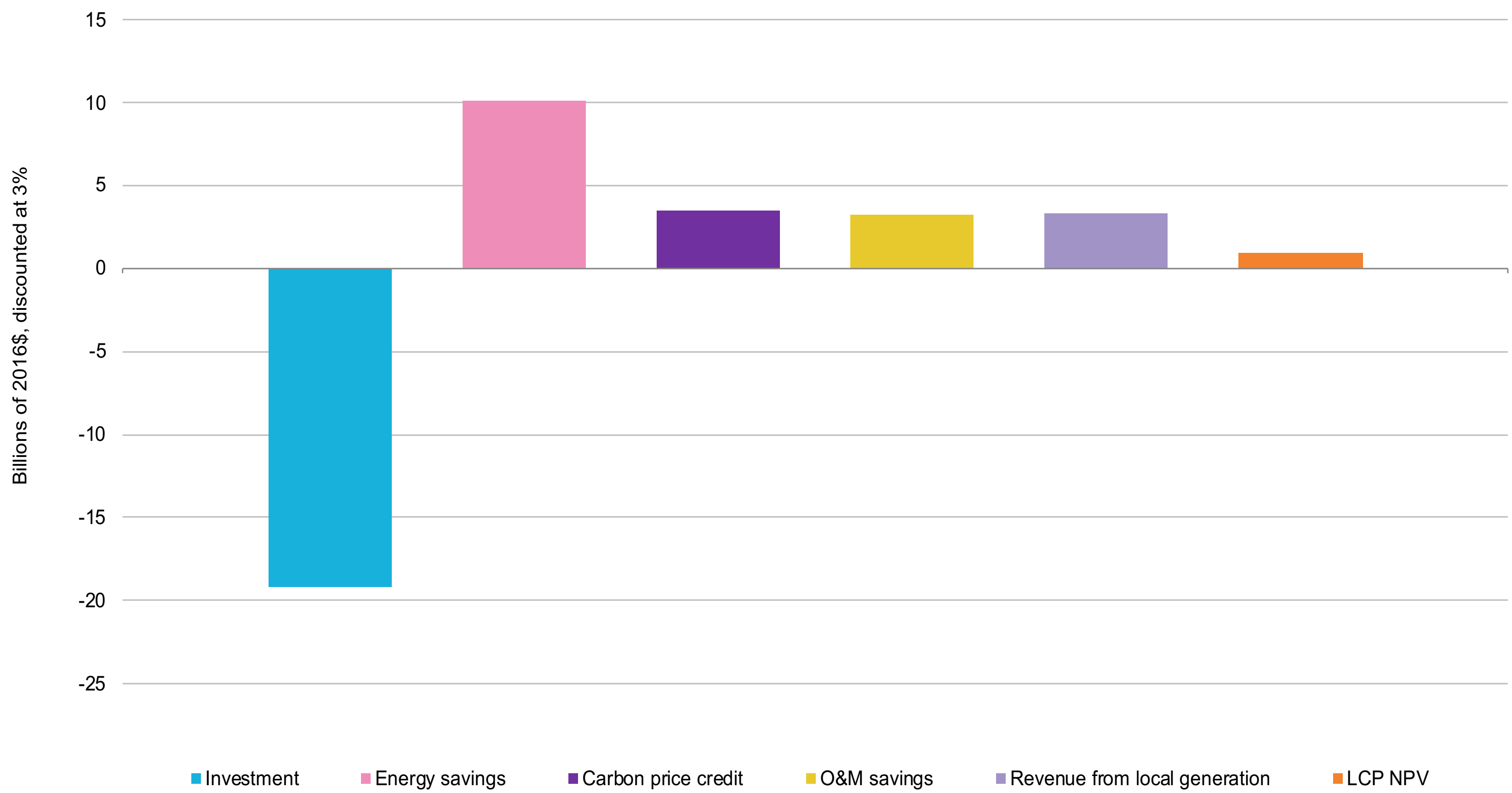


Figure 15. Net present value of expenditures, savings and revenues from the LCP scenario. (This figure shows present value, with costs shown below the line, and revenues and savings above the line.)

At the level of the household, expenditures on energy – natural gas, electricity, gasoline and diesel – are projected to decline in all three scenarios. In the BAU, household energy expenditures are projected to decline because vehicles become more efficient due to national fuel efficiency standards and because of decreased heating requirements as the climate becomes milder due to climate change. The low carbon scenario involves shifting away from natural gas and gasoline to electricity, a more costly energy source. The increased cost of electricity, however, is more than offset by the increased efficiency of homes as required by building codes, and of vehicles as a result of the efficiency of electric motors. By 2050, an average household spends $2,650 on fuel and electricity, 30% less than in the BAU scenario. Over the period between 2018 and 2050, the average household energy savings in the LCP scenario accumulate to $34,600.

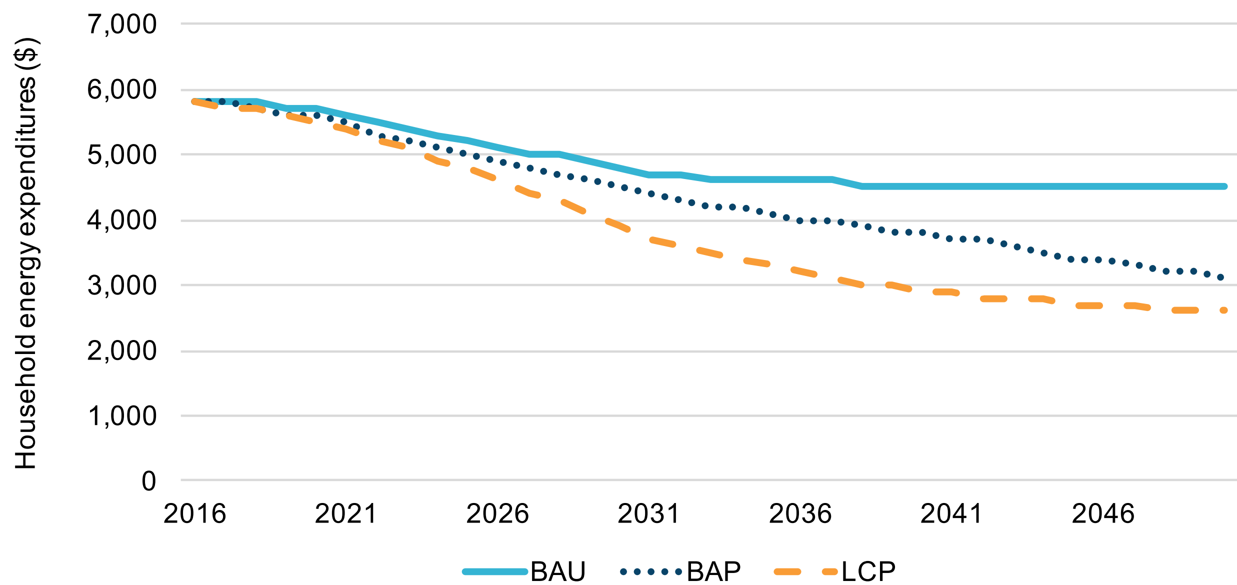


Figure 16. Annual household expenditures on energy for homes and transportation, 2016–2050

Investment Opportunities

Most of the actions evaluated are GHG reduction investment opportunities, in that the actions result in both GHG reductions and financial returns – a win-win situation. The exceptions are: district energy, heat pumps, walking and cycling infrastructure, and energy storage. Marginal abatement cost (MAC) curves are a visual illustration of whether a GHG reduction costs money or saves money. The marginal abatement cost is calculated by dividing the net present value (NPV) of an action or policy by the GHG emissions reductions that are generated over the lifetime of that project. NPV involves assessing the dollar value of the initial costs, as well as the costs and benefits over the duration of the project life, using the social discount rate of 3% to arrive at the present value. These costs or savings are calculated by implementing the action against the BAU scenario. The capital investments associated with the LCP action are tracked each year and the operations and maintenance cost savings associated with that action are tracked for the lifetime of each component. Many actions incorporate multiple components (boilers, air conditioners, insulation) that have different lifetimes.

All of the actions to the left of the centre line generate financial savings, while those to the right of the centre line result in additional costs relative to the BAU scenario. Note that this analysis is undertaken from the perspective of society as a whole; when it comes to implementing a specific pathway, policies and strategies may be required that align investments with benefits. As an example of the disconnect, when a building owner makes an investment in energy efficiency, the lessee may receive the benefit in terms of reduced energy costs. The solution in this case is to design a lease that aligns investments and benefits in order to facilitate the investment.

The marginal abatement costs in Figure 17 are shown with and without carbon pricing. Carbon pricing has the effect in general of increasing the financial benefit of low carbon actions by between 3% and 20% depending on the characteristics of the action.

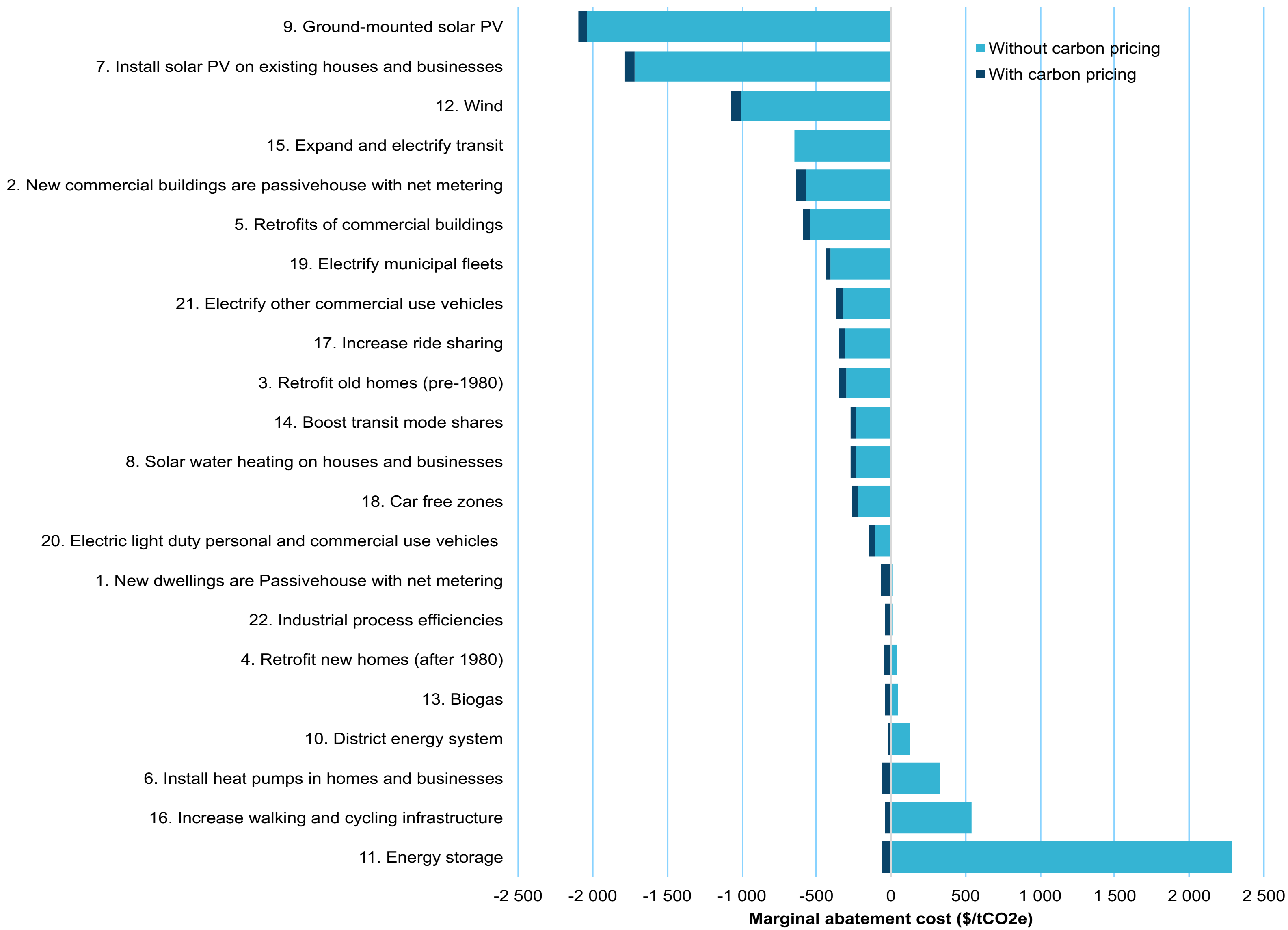


Figure 17. Marginal abatement costs of the LCP actions, 2016–2050

The amount of GHG reductions for each action varies considerably, and this is described in the implementation tables below. An analysis of the internal rate of return (IRR) also indicated opportunities for investment, with actions ranging from 2.5% to greater than 20%.

Targets

In order to compare historical inventories and future GHG emissions projections, the 2007 and 2015 inventories are adjusted to align with the CityInSight results. To make the GHG inventories comparable, the following assumptions are made:

- GHG emissions from coal and coke and fugitive sources in 2011 are applied to the 2007 inventory (red text) as they were not calculated in 2007.
- GHG emissions from waste and fugitive sources for 2015 in the CityInSight model are added to the 2015 inventory (blue text), which is calculated separately.
- GHG emissions calculations for waste and transportation are generally comparable for each of the years, as different calculation methods were used.

Table 6. Updated GHG inventories (tCO2e)

GHG EMISSIONS SOURCE	2007	2011	2015
Diesel	378,681	447,714	519,846
Electricity	898,445	447,433	227,294
Fuel oil	115,450	129,055	85,678
Gasoline	628,705	1,407,914	1,901,614
Natural gas	1,613,800	1,869,904	1,646,815
Other (coke and coal)	543,994	543,994	494,545
Propane	72,946	66,642	54,802
Waste	135,447	247,901	708,714
Fugitive	23,939	23,939	28,133
Total	4,411,407	5,184,494	5,667,441

The analysis of the DCEP scenarios relative to the Durham Region's GHG targets illustrates firstly that GHG emissions have been increasing in the Region and the Region has missed its 2015 target (emissions 5% below 2007 levels) and will likely miss its 2020 target (emissions 20% below 2007 levels).

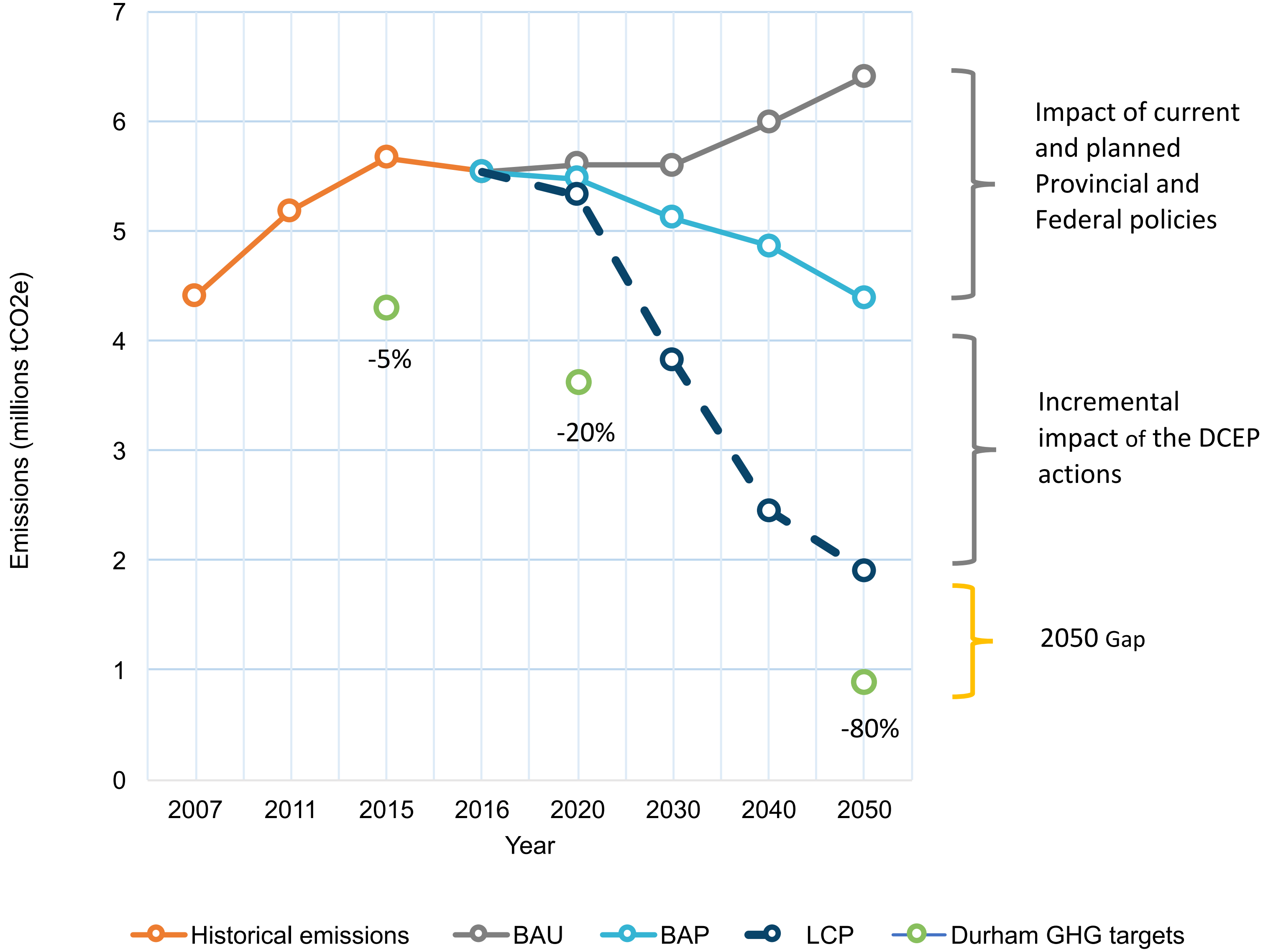


Figure 18. DCEP scenarios relative to the Durham Region GHG targets

The LCP scenario does not achieve the 2050 target (emissions 80% below 2007 levels), with a gap of 1 MtCO2e between the LCP scenario and the 2050 target. This gap means that the Durham Region will need to continue to seek new opportunities – both technologies and approaches – to more rapidly reduce GHG emissions. Table 7 describes the GHG emissions for each period.

Table 7. Historical and projected GHG emissions (tCO2e)

	YEAR							
	2007	2011	2015	2016	2020	2030	2040	2050
Historical emissions	4,523,860	4,822,338	5,655,419	5,542,000				
BAU				5,542,000	5,609,000	5,605,000	5,993,000	6,412,000
BAP				5,542,000	5,477,000	5,120,000	4,869,000	4,383,000
LCP				5,542,000	5,325,000	3,823,000	2,455,000	1,907,000
Durham GHG targets			4,299,000		3,620,000			905,000

The Impact of Land-use Change

As part of the technical analysis, the LCP scenario is evaluated with an enhanced intensification action beyond current Official Plans of the Region and the Area Municipalities; this action is further described in the technical report. The increase in intensification is modest and results in a shift by 2051 of 3.9% of the single-family dwellings to apartments or rows, away from single-family dwellings. The reduction in energy consumption from more compact forms of dwellings is commensurately small. This gain is offset by increased commercial and institutional floor space associated with more local employment that results from the intensification action. Other gains occur as a result of a small decrease in vehicular mode share as dwelling units that were previously located in areas without walking, cycling or transit access shift to zones with access to these modes as a result of intensification. These gains influence internal trips in the Region as well as shorter trips; external trips are not influenced and because these trips tend to be longer, the impact of shifting shorter, internal trips on overall VKT and energy use is also small. Another insight is that as the energy system decarbonizes, the GHG impacts of the intensification action decline. For example, intensification means people can walk for a greater portion of their trips, but if electric vehicles are used with a clean source of electricity, there is no GHG reduction associated with shifting that trip from an electric vehicle to walking. The larger implication is that a low carbon scenario with enhanced land-use intensification will cost less to implement and therefore generate greater economic benefits, as well as other corollary benefits including for public health, accessibility and community vitality. These factors are not evaluated as part of this analysis.

Autonomous Vehicles

The impact of shared autonomous vehicles is evaluated as part of the scenario analysis, but is not included in the final scenarios. The introduction of autonomous vehicles (AVs) is assumed to follow an adoption rate which results in 100% AVs by 2035 (this assumption includes all AVs will be EVs). Total number of vehicles on the road is assumed to decline by 80% because of the increased utilization of the vehicles in a shared fleet, but average lifetime of the car decreases due to increased use. Overall VKT increases by 200% as people shift from other modes to AVs due to the increased convenience and increased use by non-drivers such as youth and the elderly. The increased VKT results in an increase in electricity consumption; while relatively clean, there are still some GHG emissions associated with electricity in 2050 and therefore emissions increase as a result of the introduction of AVs. There are also major financial implications. More money is spent annually in Durham on vehicles than on buildings, and as fewer cars are purchased this expenditure declines by 80%, saving billions of dollars over the period. The decline in the number of vehicles purchased reduces employment in manufacturing. AVs also replace drivers of cabs and delivery vehicles, further contributing to job losses in this sector. Many aspects of the impact of AVs are speculative and the development of policy on AVs therefore requires careful consideration in order to limit GHG emissions, increased energy consumption and unanticipated social impacts.

5. Implementation

Programs

The LCP scenario represents a major new effort by the Durham Region to invest in the energy system, an investment that will result in dramatically reduced greenhouse gas emissions, lower energy costs for households and businesses, the creation of new businesses and jobs, reduced air pollution and other co-benefits.

Implementing the DCEP is a complex, multi-faceted endeavour with multiple partners and new programs that require:

- Financing and innovative financial instruments
- Training and mobilization of required human resources (e.g. building retrofits)
- Changes to municipal policies
- Infrastructure to support energy technologies such as EVs
- Innovative partnerships and business models

In order to identify the programs and policies that will support implementation, the DCEP is governed by the following principles:

- **Vision and Leadership**. Provide the "big picture" of a future vision of a sustainable energy future for Durham, and lead by example.
- **Engagement.** The objectives of the DCEP can only be achieved by the active engagement of the stakeholders that affect the level and pattern of energy use in the community.
- **Alignment.** Identify and exploit the alignment between DCEP objectives and stakeholder objectives.
- **Leverage**. Strategic use of local government financial, regulatory and planning resources to leverage accelerated progress toward DCEP objectives.

Based on these principles and the objectives identified in the stakeholder engagement process, six programs of activity are identified which enable the GHG reductions identified as a result of the actions modelled in the LCP scenario. The ability of the program to scale up over time and for the program to address multiple actions are also criteria which guided program development. Table 8 illustrates the relationship between the LCP themes (bundled actions), the programs and cumulative GHG reductions associated with the relevant LCP actions. No specific program area is identified for the industrial energy and emissions; a coordinated effort for this sector needs to be developed between relevant industries, the utilities and municipal governments.

Table 8. Programs of activity

THEME	PROGRAM	CUMULATIVE GHG REDUCTIONS IN LCP, COMPARED TO BAU, 2018-2050 (KTCO2E)
New buildings - buildings codes & standards	1.Durham Green Standard	13,700
Existing buildings - retrofitting	2. Durham Deep Retrofit Program	27,500
Renewable energy generation (on-site, building scale)	2. Durham Deep Retrofit Program	2,800
Low or zero carbon energy generation (commercial scale)	3. Renewable Energy Co-operative	17,700
Private/personal use	4. Electric Vehicle Joint Venture	14,500
Ride sharing	5. Education and Outreach	200
Active transportation infrastructure	6. Coordinating land-use policies	800
Industrial	To be developed	2,800
Total		80,260

Program #1: Durham Green Standard

Objective: Increasing the performance of new buildings is much more cost effective than trying to retrofit them after they have been constructed. Providing a clear pathway and incentives to the building industry gives certainty and offsets any additional capital costs. Toronto's Green Standard is an established program that has been accepted by the development market.

Design: The Durham Green Standard is a tiered set of performance measures implemented through the planning approval process. The first tier is required through planning approval, whereas the upper tiers are voluntary. An incentive program is designed with the utilities and also uses the LIC program to provide additional upfront capital, which is paid back over a 10–20-year period at a rate aligned with avoided energy costs. This approach can be implemented by Area Municipalities in coordination with the Region and can build on Area Municipality green development standards where they exist.

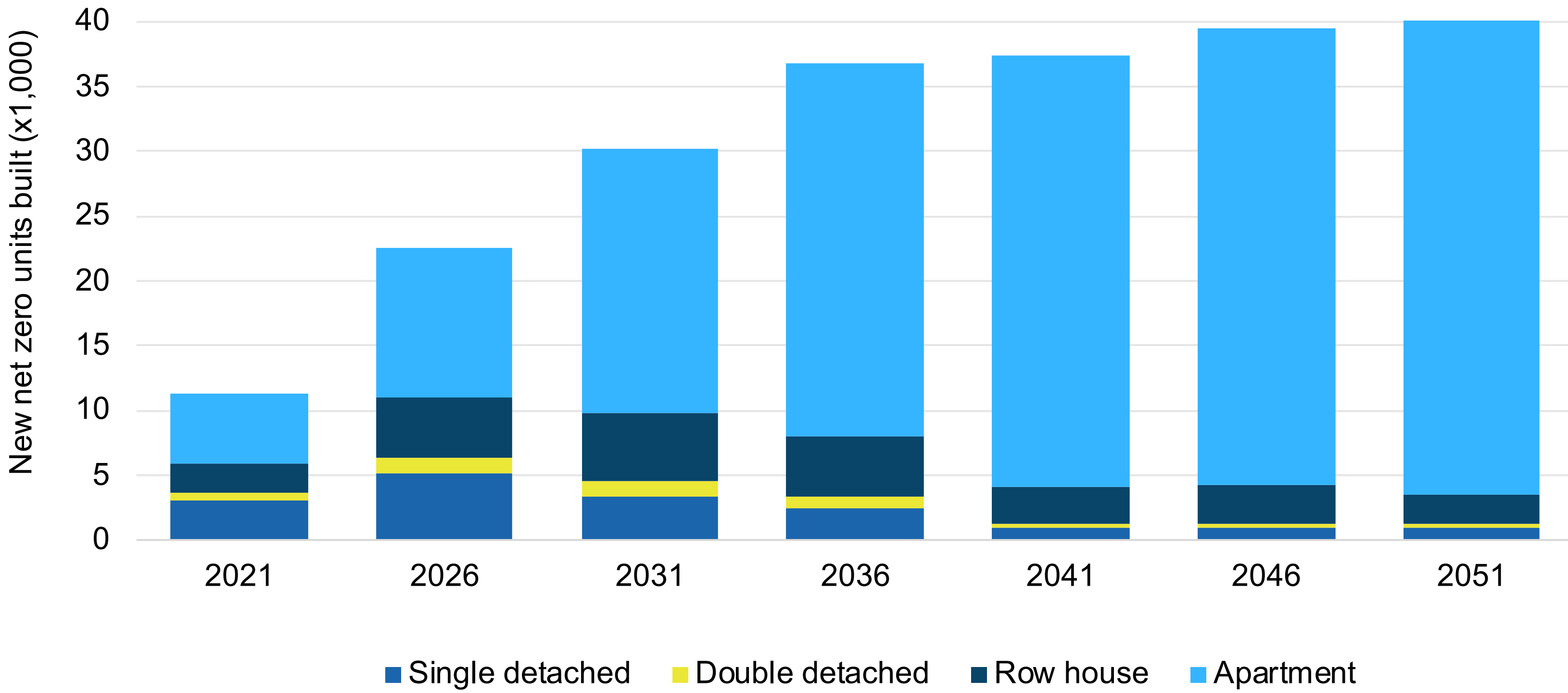


Figure 19. Residential dwelling units built to net zero energy

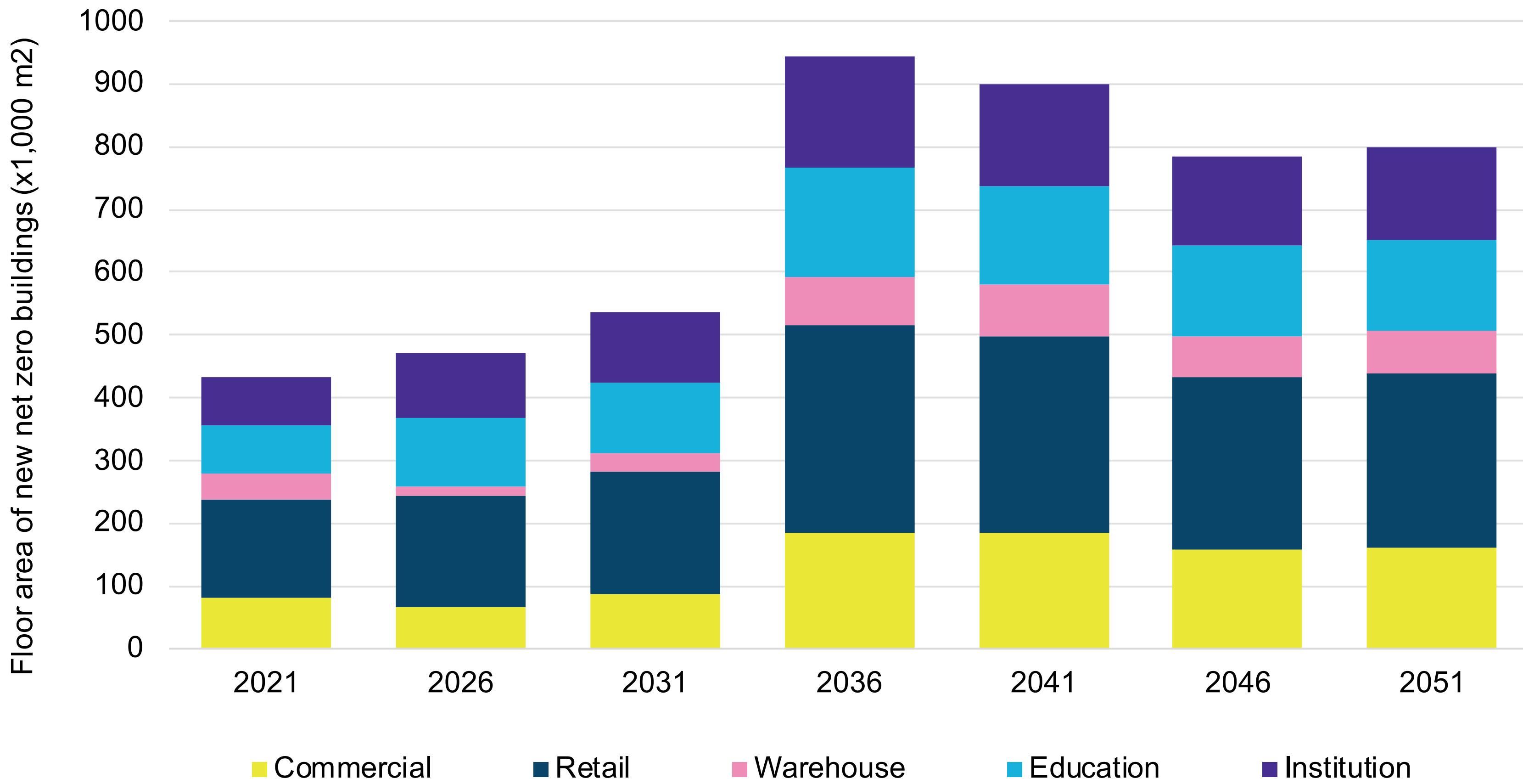


Figure 20. Commercial floor space that achieves net zero energy

Program #2: Deep retrofits

Objective: The preferred scenario involves retrofitting nearly all the residential, commercial and institutional buildings in the Region over a period of 30 years. This objective requires a new and enhanced focus on deep, whole-building retrofits, as well as a new industry and aligns with the Comprehensive Residential Retrofit program recommended in the Durham Community Climate Change Local Action Plan.

Design: The deep retrofits program is envisioned as a partnership with the Provincial and Federal governments, utilities, industry and higher education. A financing package is developed using the PACE or LIC mechanism, combined with incentives from other levels of government and the utilities, with investment raised through a combination of community bonds and green bonds. Retrofits are targeted to groups of buildings, such as neighbourhoods, sectors (restaurants, grocery stores, etc) as opposed to individual buildings, to pool risk and develop larger, more sophisticated projects. Renewable energy including district energy, solar PV, energy storage, and air- and ground-source heat pumps are included in the program.

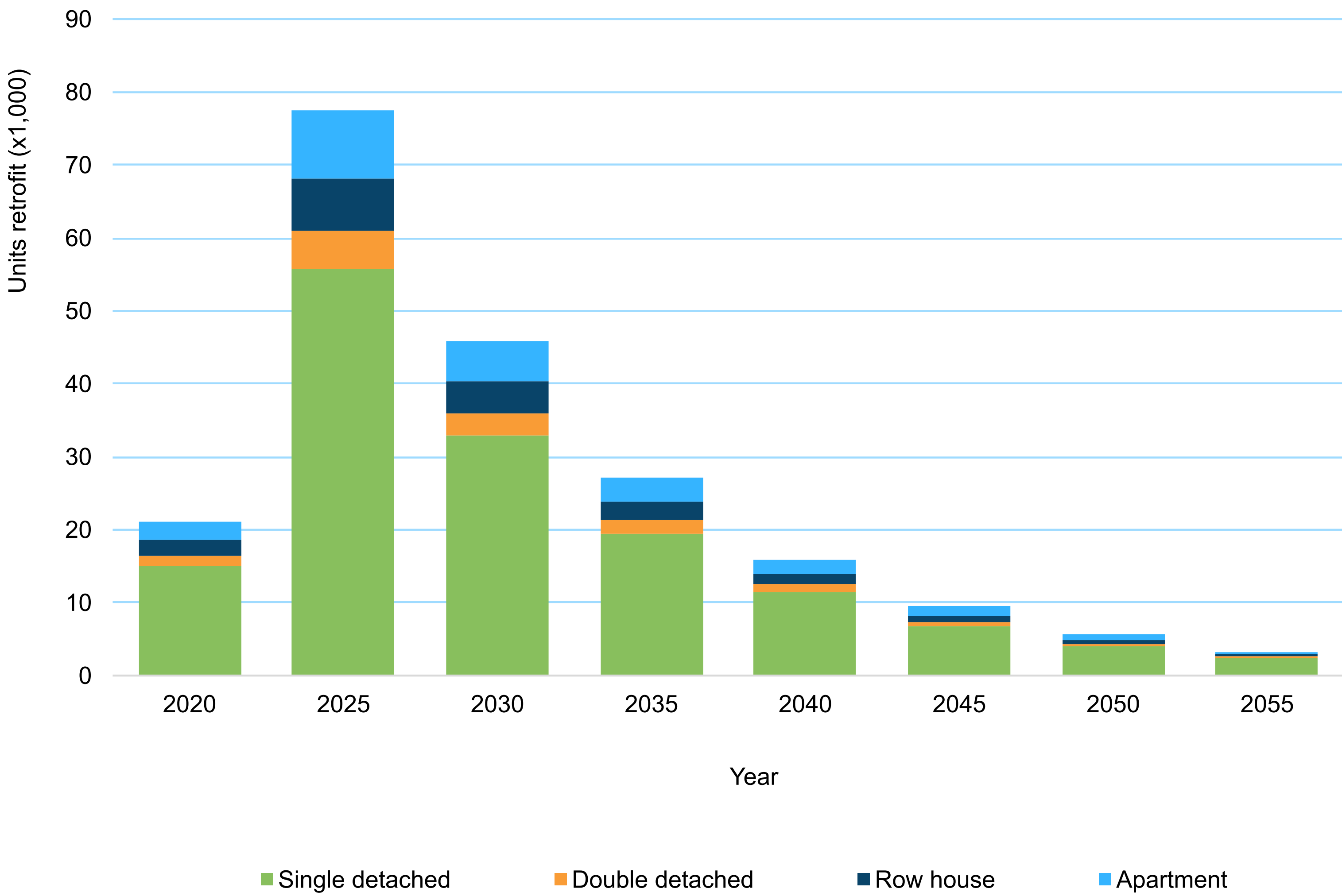


Figure 21. Number of dwellings retrofit in five-year increments

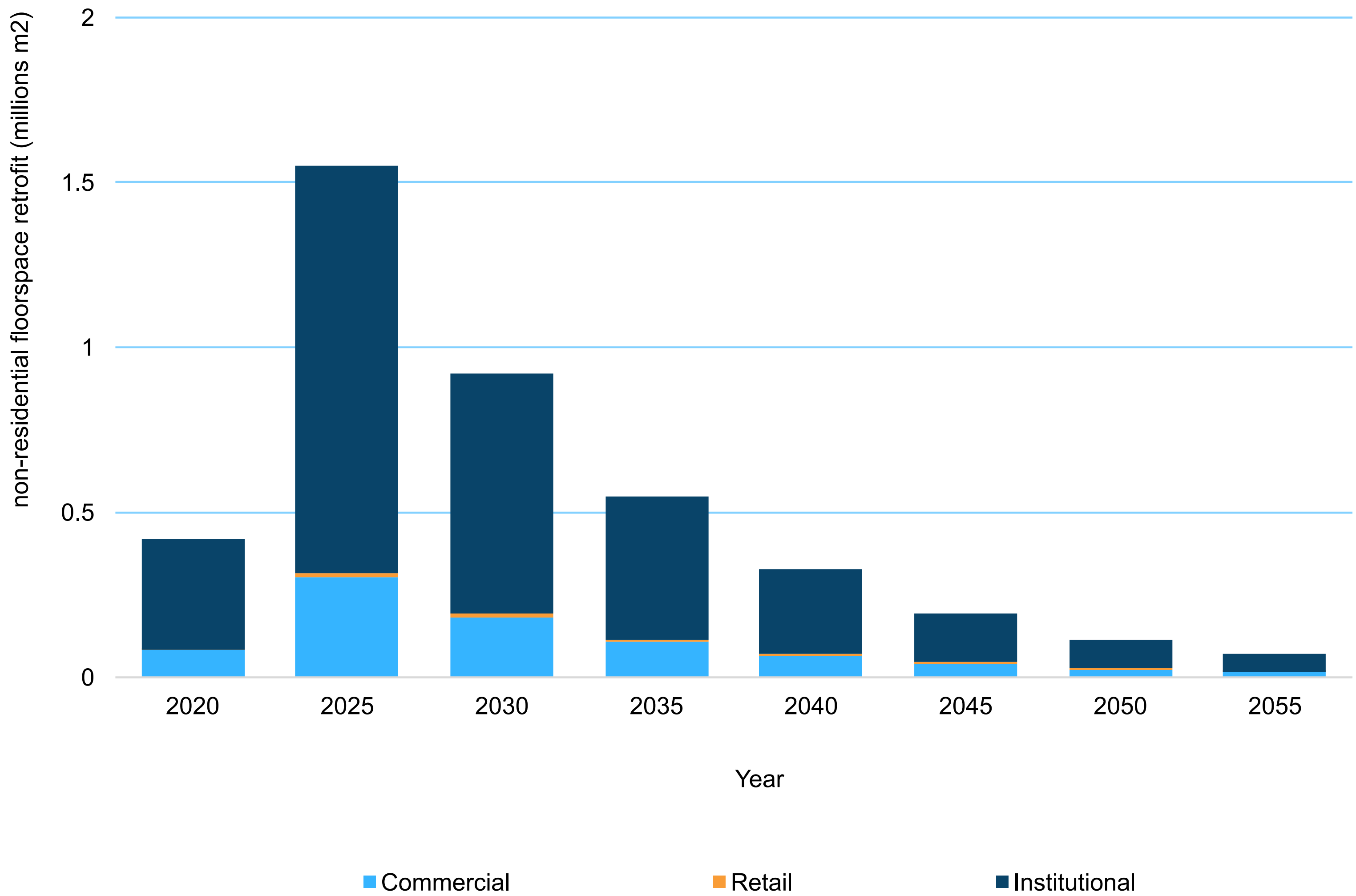


Figure 22. Non-residential floor space retrofit in five-year increments

Program #3: Renewable energy co-operative

Objective: The renewable energy co-operative is an entity which coordinates and advances the renewable energy objectives of the DCEP, using an entrepreneurial approach. In addition to the renewable energy mandate, it has a mandate to develop local expertise, stimulate the local economy and provide energy security and resilience.

Design: The membership of the co-operative includes the Region, municipalities, utilities and other partners. The co-operative advocates for, develops, commissions and finances projects, depending on which strategy is appropriate to a particular context, with greater flexibility than the existing utilities. The co-operative is technology agnostic, with a mandate to work on district energy, wind, solar, storage and geothermal. Financing comes from community bonds, loans and grants from various levels of government. GridSmartCity Cooperative is an example of a similar approach amongst utilities in Ontario.

Note: The spike in 2020 is the addition of solar PV from 2018 to 2020, as a result of the way in which solar was added in the first five year period.

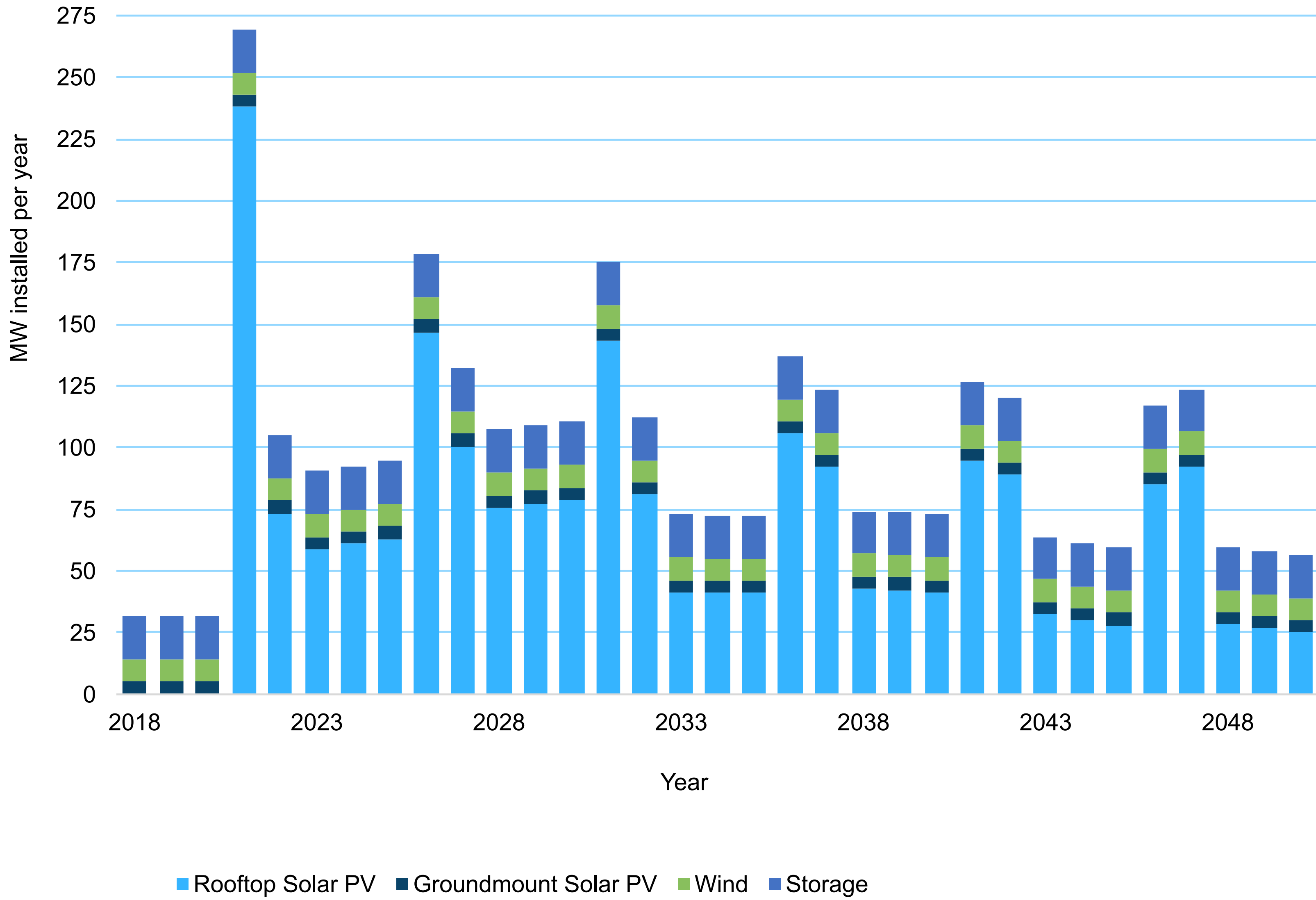


Figure 23. Annual renewable energy installations, 2018–2050.

Program #4: Electric vehicle joint venture

Objective: The Region, municipalities and utilities undertake a joint strategy to support electric vehicles. The mandate is to coordinate infrastructure investments, educational activities and municipal policies relating to charging stations and incentives.

Design: The joint venture is established as a technical working group with representatives from each of the relevant organizations. The first deliverable is a five-year action plan/roadmap for electric vehicles in the Region. Leadership by the Region and Area Municipalities on electrification of their fleets is also included within this program area.

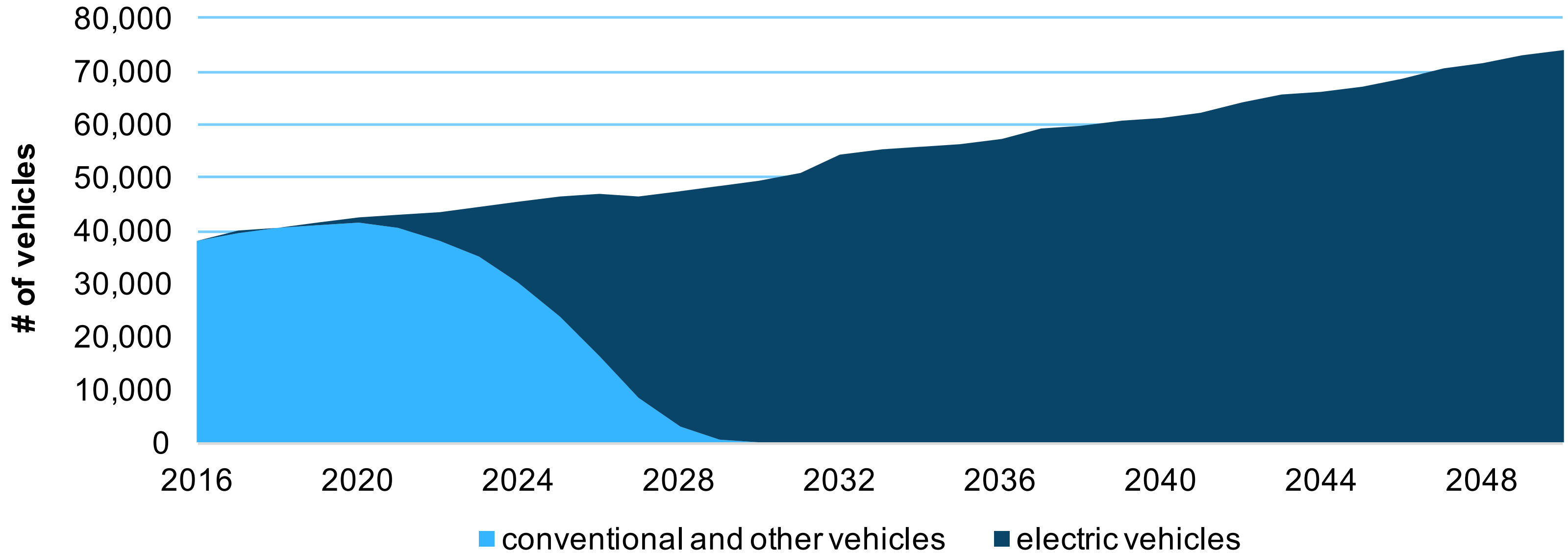


Figure 24. Conventional vs electric vehicles projection for Durham Region, 2016–2050

Program #5: Education and outreach

Objective: Education and outreach are a cross-cutting effort to support the implementation of the DCEP.

Design: There are two key aspects: broad-based education and targeted stakeholder education. This program coordinates education and marketing efforts on behalf of the other programs, working with staff from the Region, municipalities and utilities. The education and outreach program is intended to support all of the actions in general, but the ride-sharing action in particular.

- Brand and website: A compelling brand that highlights key aspects of the DCEP is developed and supported by an interactive website. The website houses all important project information, especially the community engagement activities and involved parties.
- Energy Partnership: A learning and action program for local businesses and organizations that encourages innovative energy solutions and increases the collective knowledge of energy sustainability. Energy Partners hold bi-monthly workshops to learn about energy issues and how to address them in practical ways.
- Energy Laboratory: A project incubator for innovative energy projects that demonstrate practical approaches to achieving a local energy economy. A panel of judges evaluates projects and awards small grants to support and encourage innovation.

Program #6: Coordinating land-use policies

Objective: The DCEP partners ensure policies in Official Plans and Secondary Plans support the actions in the DCEP.

Design: The Region and municipalities seek to embed policies that enable or directly conserve energy and reduce GHG emissions into Official Plans and Secondary Plans.

Coordination

Objective: The implementation of the DCEP is complex with multiple partners and dimensions, combined with a high level of ambition and will therefore require coordination and leadership.

Design: A central entity is governed by the DCEP partners but designed to be nimble and entrepreneurial with a broad mandate to implement the DCEP including:

- Carry/advance the vision of the DCEP
- Maintain a region-wide perspective
- Deliver shared services
- Coordinate activities
- Address all forms of energy
- Advance economic development

In addition to coordinating the implementation of the DCEP overall, a coordinated approach specifically works with industry to support GHG emissions reductions in that sector.

6. Monitoring and evaluation

Tracking the effectiveness of the actions in the DCEP helps to manage the risk and uncertainty associated with these efforts, as well as external forces such as evolving senior government policy, and new technologies which can disrupt the energy system. Key motivations for monitoring and evaluation include the following:

- Identify unanticipated outcomes.
- Adjust programs and policies based on their effectiveness.
- Manage and adapt to the uncertainty of climate change.
- Manage and adapt to emerging technologies.

Specific activities which have been identified to support the implementation of the DCEP include an annual work plan and review, an annual indicator report, an update of the GHG inventory every two years and an update of the DCEP every five years.

Table 9. Monitoring and evaluation activities

ACTIVITY	PURPOSE	DESCRIPTION	FREQUENCY
1. Annual work plan and review	Review work to-date and set annual priority actions	Annual report with prioritized actions	Annual
2. Annual indicator report	Track effectiveness of actions	Annual report on set of indicators with an analysis of the results	Annual
3. Inventory	Update energy and GHG emissions profile	Re-calculate the GHG emissions and energy inventory	Every 2 years
4. Update the DCEP	Update the DCEP to reflect changing conditions	Review each action and the progress being achieved. Identify new actions.	Every 5 years

Annual Work Plan and Review

An annual work plan identifies all relevant activities to achieve the actions and policies in the plan, the responsible parties, the budget and the schedule. The results of the previous year's work plan should be reviewed to inform the development of subsequent work plans. The work plan is prepared by the DCEP coordinating body, as identified by the DCEP partners.

Annual Indicator Report

There are two aspects involved in the application of indicators: collecting data on indicators (monitoring), and interpreting the results of those indicators (evaluation). Over time, the Region can also evaluate its effectiveness in embedding the knowledge and wisdom gained through this process into the organization.

From the perspective of the DCEP, there are multiple purposes for which data is collected: to evaluate the effectiveness of the actions, to evaluate the impact of the actions on the community, and to evaluate the uptake of the lessons from the evaluation.

The Region could release its implementation report on Earth Day each year.

Table 10. Types of indicators

INDICATOR CATEGORY	QUESTION
1. Effectiveness indicators	Are the actions achieving their objectives?
2. Impact indicators	What is the impact of the actions on the community?

Effectiveness Indicators

These indicators are designed to evaluate whether or not policies or actions are having an effect; they vary from municipality to municipality according to the specifics of the community energy and emissions plan. The results of the indicators are then compared against the assumption in the modelling to monitor whether or not the community is on track with projections. Indicators should be developed for each policy or mechanism.

Impact Indicators

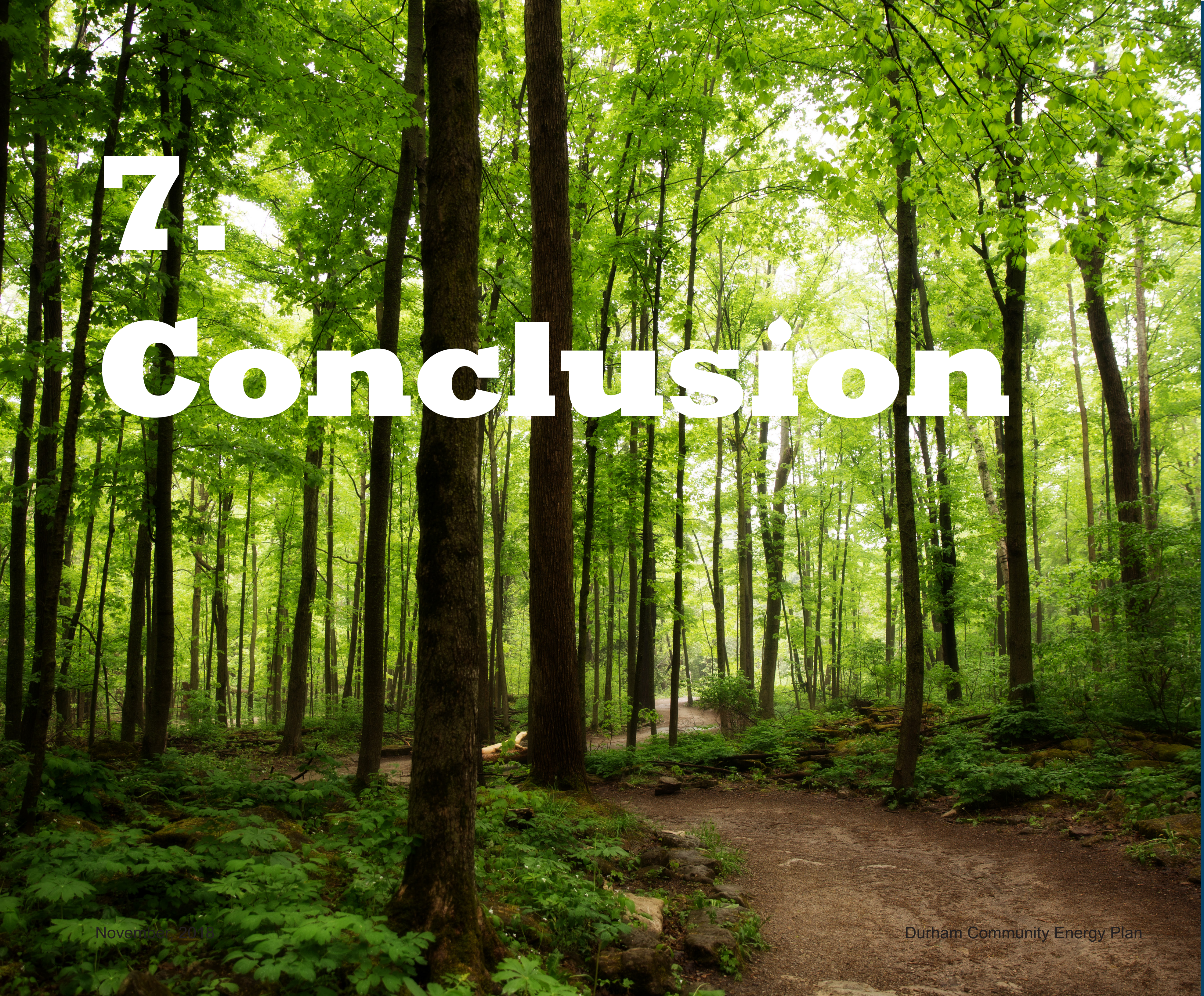
The Region should develop a set of indicators in consultation with local municipalities that track macro trends and drivers of GHG emissions in the Region. These are designed to be reported on each year.

Table 11: Indicators

INDICATOR	TREND	DATA SOURCES
Total new dwellings by type	An indication of the growth of the building stock.	Building permits
Average total floor area of new dwellings	An indication as to whether there is more or less floor space to heat or cool.	Building permits
Diversity of dwelling types	An indication of the types of dwellings and whether or not they have shared walls.	Building permits
Total new non-residential floorspace by type	An indication of the growth of the building stock.	Building permits
Total demolitions	An indication of the change in the building stock.	Demolition permits
Percentage of new dwelling units that are in downtown	An indication as to whether residential development is occurring in areas more appropriate for walking, cycling and transit.	Building permits and GIS analysis
Percentage of non-residential floorspace that is occurring in downtown	An indication as to whether commercial development is occurring in areas more appropriate for walking, cycling and transit.	Building permits and GIS analysis
Number of new dwellings that are within 400m of a transit stop	Indication of transit accessibility.	GIS layers of transit and building footprint
Annual or monthly energy price by fuel (electricity, gasoline, diesel) ($/GJ)	Energy costs are an important indicator of opportunities for energy savings and renewable energy, household, municipal and business energy costs.	Available from the utilities

INDICATOR	TREND	DATA SOURCES
Total energy consumption by sector for electricity (GJ)	An indication of trends in energy use in buildings.	Available from the utilities
Total solar PV installs (# of installations)	An indication of extent of decentralized renewable energy.	Building permits or utilities.
Total gasoline sales ($)	An indication of GHG emissions from vehicles.	Available for purchase from Kent Group Ltd.
Total transit trips	An indication of whether non-vehicular trips are increasing.	Available from DRT and Metrolinx
Length of physically separated cycling lanes	An indicator of opportunity for people of all ages to cycle.	Region

7. Conclusion



The DCEP is a pathway to a low carbon future. This pathway requires new investments by the public sector, the private sector and households, and will stimulate a new economy.

Municipal and regional interventions will be foundational. These efforts will unlock key strategies to advance the low carbon scenario, including creating policies to support district energy, land-use planning, supporting advanced building performance standards, financing retrofits and renewable energy, and education and support.

The low carbon pathway nearly achieves Durham's GHG targets. New opportunities will need to be incorporated into the DCEP in order to address the gap between the Region's GHG targets and the LCP scenario.

Recommendation #1: The DCEP partners continue to test novel approaches and identify new strategies to reduce GHG emissions as part of the monitoring and evaluation of the DCEP.

A coordinating entity is required. The implementation of the actions requires a novel, integrated approach that brings together the municipalities, the Region and utilities in an entity that is both nimble and entrepreneurial. A regional implementation organization is recommended as a strategy that balances control by the municipalities with entrepreneurial-ism.

Recommendation #2: A central entity is required for leadership and coordination between the municipalities, the Region and other organizations within the community to ensure the implementation of the DCEP and to take advantage of economies of scale.

Implementation focuses on six program areas. The transition requires efforts firstly to reduce energy consumption through high performance building codes and land-use planning, secondly to improve the energy system by retrofitting existing buildings, and thirdly to switch to renewable energy, primarily electricity and to a lesser degree renewable natural gas. The DCEP outlines specific actions and programs that will implement those actions.

Recommendation #3: The partners of the DCEP will develop a five-year implementation plan based on the six program areas identified in the DCEP.

Durham Region is not alone. Many other cities and regions around the world are exploring similar pathways, and there are opportunities to compare notes and learn from successes and challenges going forward.

Land-use policy will enable implementation. Energy and GHG gains that occur as a result of land-use planning are essentially free in that they require no investment and deliver a range of other co-benefits. Therefore municipalities should continue to advance intensification strategies as an enabling strategy to reduce GHG emissions. Other policies in the Official Plan will also support the delivery of the programs and the implementation of the actions.

Recommendation #4: The DCEP be both recognized and enabled by the forthcoming revisions of the Durham Region Official Plan and local municipal official plans.

The DCEP is an economic development strategy. There are opportunities for new and existing businesses in the fields of heat pumps, building retrofits, renewable energy, district energy, energy storage and others yet to be determined.

Major investments are required. The transition to the Low Carbon Pathway will require capital investments in buildings, vehicles and infrastructure of $30 billion over 30 years. In the business-as-usual scenario, capital expenditures in buildings, vehicles and energy-related infrastructure and equipment is projected to total $165 billion, so put in this context the Low Carbon Pathway requires an 18% increase in capital expenditures in these areas. That incremental $30 billion capital investment will return fuel and electricity savings, carbon premiums, operating and maintenance savings and revenue from local generation that together total $35 billion over the 2018-2050 period.

Recommendation #5: Work with financial partners to develop a DCEP capitalization strategy.

The LCP actions modelled have varying returns on investment and risk profiles. Some investments will be more suited to the public sector, whereas others will be more appropriate for private businesses. Determining which action is best associated with which entity has yet to be done but there are many promising investment opportunities.

New jobs will be created. The investments in the energy system will generate employment in building design, retrofits, district energy, renewable energy, electric vehicle manufacturing and other sectors. A total of 210,000 direct person years of employment will be created over the period as a result of the implementation of the LCP scenario.

The low carbon pathway will evolve. As new technologies emerge and new approaches to deployment are developed, the approach to implementing the actions will change. The earlier the Durham Region can undertake the investments contemplated in the pathway, the greater financial and environmental benefits will be for the communities and the Region as a whole. Delay will result in, for example, increasing household energy costs for a longer period.

Recommendation #6: Implement the DCEP monitoring and evaluation strategy.

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