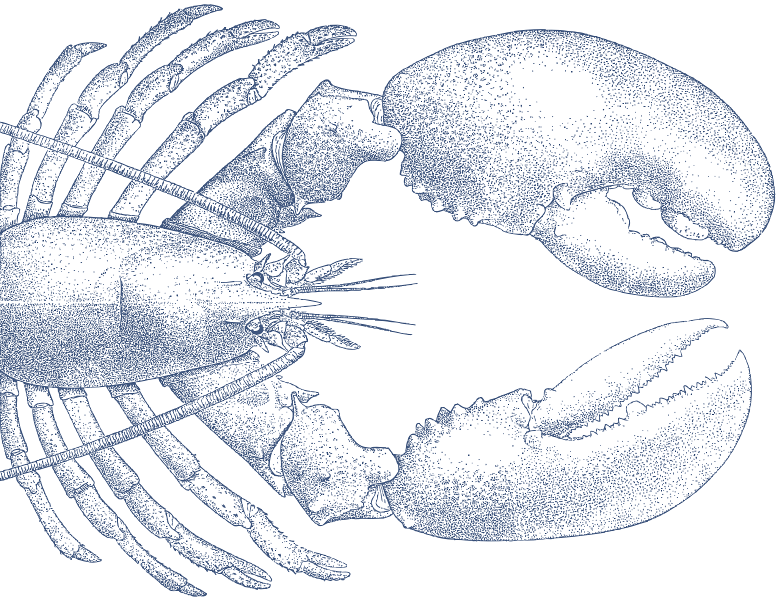
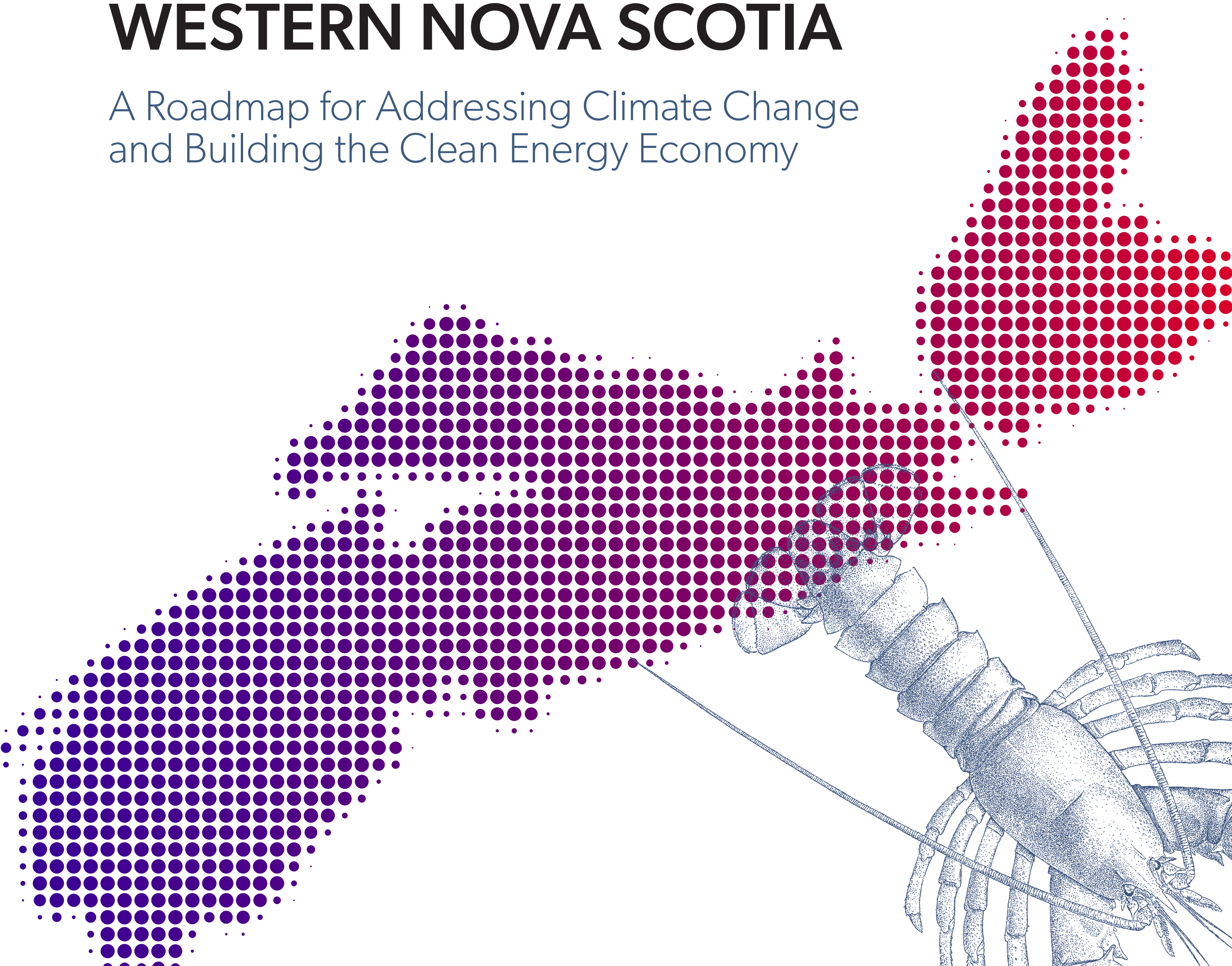


ENERGY INVESTMENT PLAN FOR WESTERN NOVA SCOTIA

A Roadmap for Addressing Climate Change and Building the Clean Energy Economy



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Disclaimer

This analysis has been undertaken to identify a community energy investment plan for the Western Region Enterprise Network (Western REN). 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.

This analysis includes high level estimates of costs and revenues that should not be relied upon for design or other purposes without verification. The authors do not accept responsibility for the use of this analysis for any purpose other than that stated above and does not accept responsibility to any third party for the use, in whole or in part, of the contents of this document.

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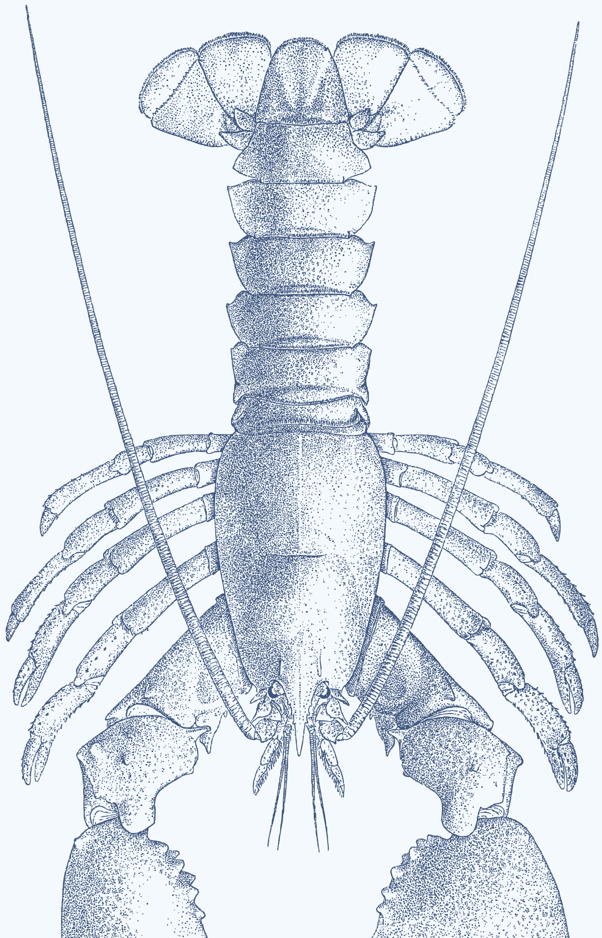

Glossary

BAU	Business as usual scenario
CES	Clean energy scenario
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalents
CDD	Cooling degree days
CH4	Methane
CHP	Combined Heat and Power
DE	District energy
GHG	Greenhouse gas emissions
GPC	Global Protocol for Community Scale Greenhouse Gas Emissions Inventories
GWP	Global warming potential
HDD	Heating degree days
HFC	Hydrofluorocarbons
HCFC	Hydrochlorofluorocarbons
ICI	Industrial, commercial, and institutional buildings
IRP	Integrated Resource Plan
NPV	Net present value
O&M	Operations and maintenance
REN	Region Economic Network
RNG	Renewable natural gas
PV	Photovoltaic
SCC	Social cost of carbon
VKT	Vehicle kilometers travelled
WREIP	Western Region Energy Investment Plan

Units

GHG emissions

1 $ktCO_2e$ = 1,000 tCO_2e

Energy

1 MJ= 0.0001 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

In the numbers, Western Region

Population, 2016	49,400
Population, 2050	48,300
Per capita GHG emissions, 2016	21.6 tCO_2e
Per capita GHG emissions in 2050 if the low energy scenario is implemented:	2.7 tCO_2e
Total energy consumption 2016	10.28 PJ
Total energy consumption under the business as usual scenario, 2050	8.71 PJ
Total energy consumption under the low energy scenario, 2050	4.91 PJ
Total expenditures on energy, 2016	$326.8 million
Savings on energy expenditures under the low energy scenario, 2018-2050	$1.8 billion
Average energy expenditures per household in 2016 (including transportation)	$5,842
Average energy savings per household per year in 2050	$2,100
Total investment required for the low energy scenario, 2021-2050	$1.6 billion
Person years of employment generated as a result of the low energy investments, 2018-2050	4,600
Total GHG emissions, 2016	1.1 million tCO_2e
Total GHG emissions in the absence of action: 2050	0.78 million tCO_2e
Total GHG emissions if the region implements the low energy scenario, 2050	0.13 million tCO_2e

A Note on the Impact of Coronavirus (COVID-19)

The analysis in this document was completed before COVID-19 began spreading rapidly in Canada. Even so, the analysis continues to be relevant not only because the climate crisis persists, but also because this document provides solutions that can stimulate the economy during the pandemic-induced recession. The solutions the report recommends, ranging from retrofits to investing in renewable energy, are designed to decrease emissions and increase energy efficiency while creating jobs.

In the context of COVID-19, here are some key points to consider:

- A global health crisis: The pandemic has radically transformed societies and economies, resulting in tragedy and disrupting work and home life everywhere.[1]
- The impacts of coronavirus are unclear: The negative impact of COVID-19 on people, workplaces, and the economy, as well as the duration of those impacts, presents many uncertainties. The recovery will be affected by a combination of factors such as public health guidance for opening up society, the evolution of the pandemic, the design of public policy responses and the continuing response by global institutions.
- The climate emergency remains an emergency: A decline in activity has resulted in a short term reduction in GHG emissions but concentrations of GHG emissions in the atmosphere continue to climb and global temperatures continue to increase.[2] The pandemic has also disrupted international efforts to address climate change.
- There are challenges and opportunities: In the short term, the impacts of COVID-19 both challenge and reinforce actions outlined in the WREIP.
- Substantively addressing climate change is more relevant than ever: Investments made now lock in emissions for decades. The WREIP identifies investments that stimulate the economy and decarbonise the western region out until 2050.
- Alignment with green stimulus: As Canada initiates efforts to recover from the impact of the coronavirus, there is an opportunity to stimulate the economy with investments that simultaneously address the climate crisis. This Plan describes an investment opportunity that will generate jobs, stimulate businesses, reduce GHG emissions, and provide benefits for local communities and the Region.

[1] World Health Organisation (2020). World health statistics 2020: monitoring health for the SDGs, sustainable development goals. Retrieved from: https://apps.who.int/iris/bitstream/handle/10665/332070/9789240005105-eng.pdf

[2] World Meteorological Organisation (2020). The Global Climate in 2015-2019. Retrieved from: https://library.wmo.int/doc_num.php?explnum_id=10251

Executive Summary

There are 10 years remaining to establish the systems and investments that will limit global warming to 1.5°C – or risk an exponential increase in climate-related disasters.[3] As a result, this decade will be the most critical in the fight against climate change: the final decade to avoid disaster.

The energy system is in the midst of a profound transformation with the increasing introduction of decentralised electricity production storage, the electrification of transportation and the advancement of policies at all levels of government to mitigate greenhouse gas emissions.

This report describes the role of, and opportunity for the Western Region of Nova Scotia ("Western Region"). Using detailed modelling, the analysis explores a transition to a clean energy economy, while simultaneously achieving multiple economic and social benefits.

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. This means extensive retrofits of the existing building stock, increasing the energy performance of new buildings, building new sources of zero- and low-carbon energy, including wind and solar, electrifying vehicles, heating systems, and many other products and processes.

These investments represent significant investment opportunities for the public and private sector, generating both financial returns and improving quality of life.

The Western Region has a track record, and decades of experience, on which to build, including renewable energy installations such as the 10 MW (total) Bear River Hydroelectric System, the 30 MW Digby Neck Wind Project, and the Annapolis Royal Generating Station.

The development of this investment plan involved three distinct components; an engagement process with targeted stakeholders, the preparation of a baseline inventory and extensive technical analysis exploring future scenarios.

The technical analysis provides an investment roadmap. The analysis began by considering the drivers that determine the Region's energy consumption and greenhouse gas (GHG) emissions, answering the question "where are we now?" Analysis of future trajectories included a business as usual (BAU) scenario, which evaluated what might happen if no additional policies or actions are put in place. A Clean Energy scenario explored the implications of achieving deep GHG reductions.

Six key opportunities are highlighted:

1. Building retrofits
2. Renewable energy
3. Renewable natural gas
4. Fuel switching in the marine fleet
5. Cellulose insulation
6. Electric vehicles

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[3] Intergovernmental Panel on Climate Change. (2018). Global warming of 1.5°C. http://www.ipcc.ch/report/sr15/

Specific targets have been identified for each of these opportunities, and the size of the required investment and likely job creation is described. Due to grid constraints, It is recommended that new renewable generation such as wind, solar PV, and tidal integrate storage to address the intermittency of supply. Continuous sources of electricity such as small-scale CHP based on biomass should be considered only in locations where all or most of the electricity can be consumed locally rather than exported to the transmission system.

Recommendations for implementation include four measures:

1. Regional Roundtable
2. Revolving Loan Fund
3. Renewable Energy Cooperative
4. Electric Vehicle Joint Venture

1. Introduction

The Western Regional Enterprise Network (Western REN) is an organisation composed of towns and municipalities focused on fostering healthy rural and regional economic development. The region has come together to develop the Western Region Energy Investment Plan (WREIP) in order to explore and evaluate a path to a clean energy economy.

The World Meteorological Organization reported that 2010 to 2019 was the warmest decade on record.[4] The impacts of these changes in climate, such as increases in temperature extremes, increases in severe weather events, ocean warming, rising sea levels, thinning glaciers, and thawing permafrost, have been observed both in Canada and abroad. Past and predicted warming for Canada, on average, is about double the magnitude of projected global warming.[5]

Climate risks are a direct function of cumulative emissions, so earlier action will significantly decrease the cost of future adjustments. As Mark Carney, the former Head of the Bank of Canada and Bank of England Governor points out, however, "Climate change is the Tragedy of the Horizon."[6] The catastrophic impacts of climate change will be felt beyond the business cycle, the political cycle, and the horizon of financial institutions like central banks, reducing the incentive for substantive action.

To highlight the need for urgent action, Canada's House of Commons declared a climate emergency in June 2019, joining countries and major cities around the world, as well as nearly five hundred Canadian municipalities.

COVID-19 has sent shock waves through society and the economy. As a result, governments are likely to make a once-in-a-generation investment in the economy.

The WREIP describes an investment program that addresses the underlying climate emergency, a strategy that diverges from investing public money in infrastructure and technologies that will be outdated within a decade.[7] Building on discussions framed around the notion of build back better,[8] this report provides a blueprint or roadmap for those investments.

The investments include widespread electrification of space heating and transportation, continuation of the transition to zero-carbon electricity generation and an unprecedented focus on energy efficiency. Combined, these three aspects will require an injection of capital in a variety of sectors. This report describes the challenge and opportunity and possible strategies to facilitate the opportunities.

[4] World Meteorological Organisation. (2020). WMO provisional statement on the state of the global climate in 2019. https://library.wmo.int/doc_num.php?explnum_id=10108

[5] For a review of the impacts of climate change in Canada, see: Canada, & Environment and Climate Change Canada. (2019). Canada's changing climate report. http://publications.gc.ca/collections/collection_2019/eccc/En4-368-2019-eng.pdf

[6] Carney, M. (2015). Breaking the Tragedy of the Horizon – climate change and financial stability. bankofengland.co.uk/-/media/boe/files/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.pdf?la=en&hash=7C67E785651862457D99511147C7424FF5EA0C1A

[7] Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J., & Zenghelis, D. (n.d.). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Oxford Review of Economic Policy. https://doi.org/10.1093/oxrep/graa015

[8] For example see the webinar series: https://www.corporateknights.com/

The WREIP includes:

1. An assessment of the current energy context in the region, including consideration of demographics, policies, geography, culture and economy;
2. Modelling of two different energy futures for the region; one aligned with current policies and one which advances the clean energy economy.
3. Identification of opportunities to stimulate and support the development of the local economy.
4. An evaluation of the economic impacts of the transition to a clean energy economy.

2. Method

The development of the WREIP involved a combination of energy and emissions modelling, financial modelling, literature review, and engagement with stakeholders and community members (Figure 1).

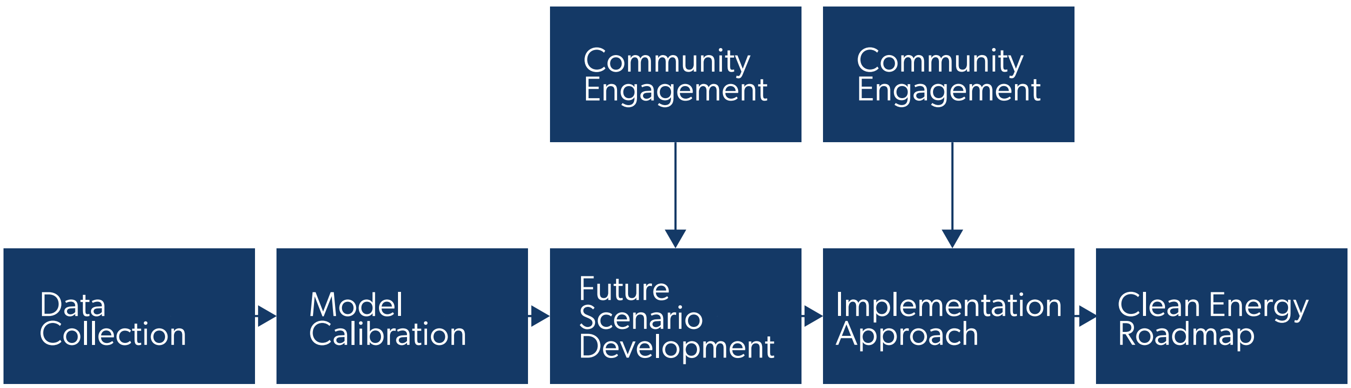


Figure 1. Project approach

2.1 Scenario Development

Future scenarios for the energy system in the Western Region were developed to support:[9]

- decision-making– "future proofing" a portfolio of activities and proposed actions;
- prioritization – determining where and how to allocate finite resources;
- 'testing' – using multiple "settings" to strengthen an existing strategy, innovation initiative, or priority;
- integrated analysis – applying judgment to complexity for making sense of the world;
- timing – reacting appropriately (i.e. neither overreacting nor underreacting);
- scanning – monitoring for deeper shifts in the external environment;
- anticipatory planning – combating reactive demands; taking affirmative steps to prepare for the future; and
- conversation– talking about difficulties in a safe (hypothetical) way. Two scenarios were developed, informed by a situational analysis and an engagement process.

Scenario planning is a powerful method to explore the direct consequences of decisions made today, which can be costly or in some cases impossible to undo. Figure 2 illustrates the 'lock-in

[9] Smith, E. (2007). Using a scenario approach: From business to regional futures. Engaging the future: Forecasts, scenarios, plans, and projects, 79–101.

effect' as a result of the durability of different categories of investments. Once the investment is made, it is difficult to undo financially, but also psychologically.

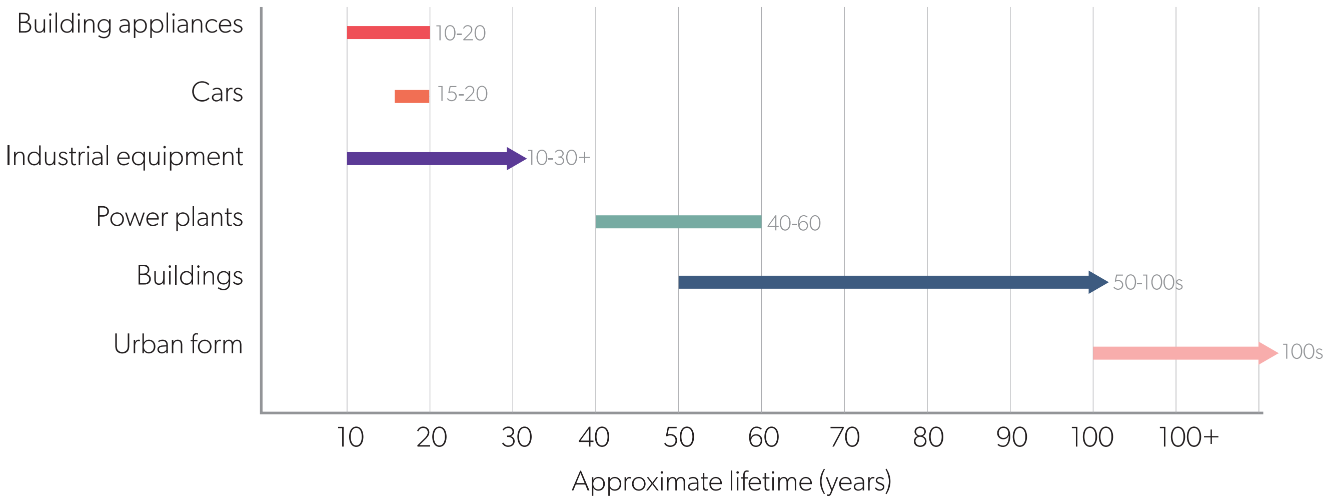


Figure 2. Lifetime of capital stocks

Consultation with community members, local businesses, and representatives of public utilities provided essential input to the development of the scenarios, identifying the priorities, concerns, and resources within the Western Region. The engagement process identified key industries that are in flux, or in jeopardy, due to economic and environmental changes within the region and within the province, and also highlighted the availability of a skilled workforce, and training and innovation resources at local colleges and the university.

2.2 Modelling

The scenarios were analysed in CityinSight, an energy and emissions model. CityInSight is an integrated, multi-fuel, multi-sector, spatially-disaggregated energy systems, emissions and finance model for cities. The model enables bottom-up accounting for energy supply and demand, including renewable resources, conventional fuels, energy consuming technology stocks (e.g. vehicles, appliances, dwellings, buildings) and all intermediate energy flows (e.g. electricity and heat).

CityInSight was populated with local data on energy generation, energy use, emissions associated with energy consumption, and the costs associated with both the energy and emissions.

Energy and GHG emissions are derived from a series of connected stock and flow models, evolving on the basis of current and future geographic and technology decisions/assumptions (e.g. the rate of adoption of electric vehicles. The model accounts for physical flows (i.e. energy use, new vehicles by technology, vehicle kilometres travelled) as determined by stocks (buildings, vehicles, heating equipment, etc).

For any given year out until 2050, CityInSight traces the flows and transformations of energy from sources through energy currencies (e.g. gasoline, electricity, hydrogen) to end uses (e.g. personal vehicle use, space heating) to energy costs and to GHG emissions. An energy balance is achieved by accounting for efficiencies, conservation rates, and trade and losses at each stage in the journey from source to end use.

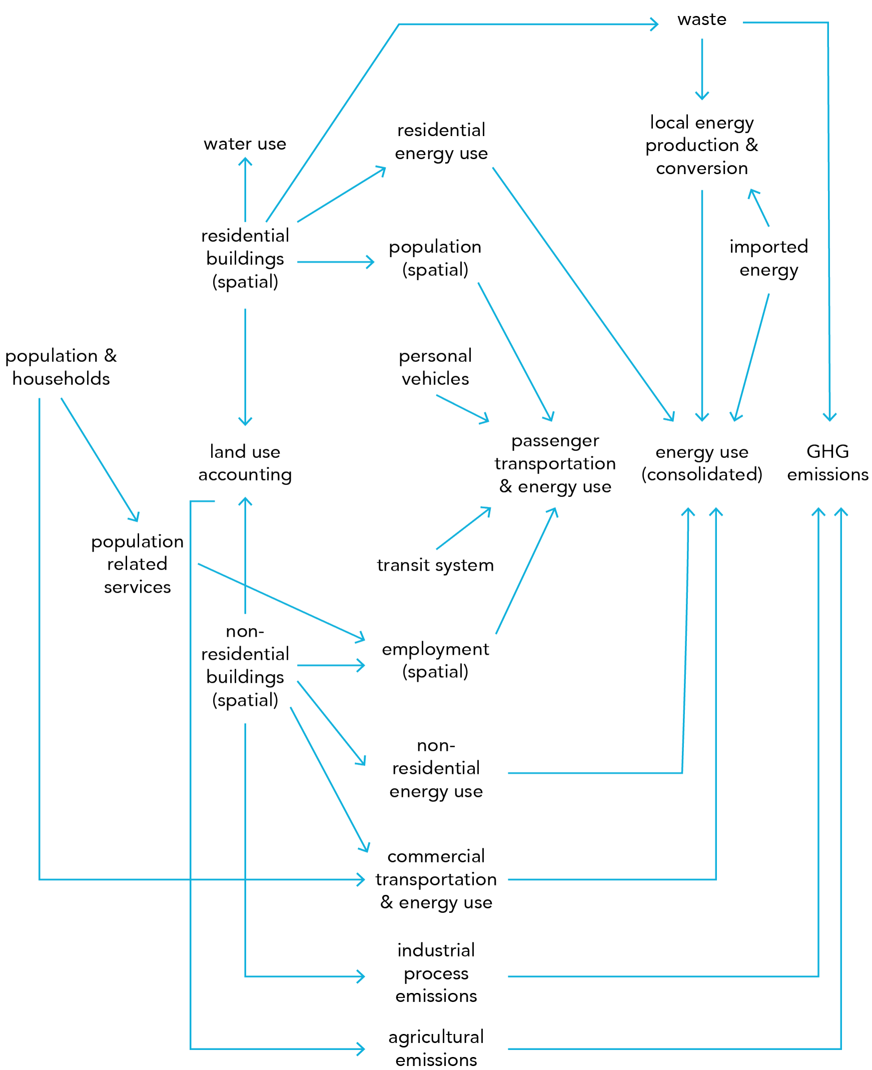


Figure 3. Representation of the integrated energy and emissions model

Population and demographics

Region-wide population is modelled using the standard population cohort-survival method, disaggregated by single year of age and gender. It accounts for various components of change: births, deaths, immigration and emigration.

Residential buildings

Residential buildings are spatially located and classified using a detailed set of 30+ building archetypes capturing footprint, height and type (single, double, row, apartment high, apartment low), in addition to year of construction. Coupled with thermal envelope performance and degree-days the model calculates space conditioning energy demand independent of any particular space heating or cooling technology and fuel. Energy service demand then drives stock levels of key service technologies (heating systems, air conditioners, water heaters). These stocks are modelled with a stock-turnover approach capturing equipment age, retirements, and additions - exposing opportunities for efficiency gains and fuel switching, but also showing the rate limits to new technology adoption and the effects of lock-in.

Non-residential buildings

Non-residential buildings are spatially located and classified by a detailed use/purpose-based set of 50+ archetypes, and the floorspace of these non-residential building archetypes can vary by location. Non-residential floorspace produces waste and demand for energy and water, and also provides an anchor point for locating employment of various types.

Passenger Transportation

The model includes a passenger transportation sub-model that responds to changes in land use, transit infrastructure, vehicle technology, travel behavior change and other factors. Trips are divided into four types (home-work, home-school, home-other, and non-home-based), each produced and attracted by a combination of spatial drivers (population, employment, classrooms, non-residential floorspace). Trip volumes are specified for each zone of origin and zone of destination pair. For each origin-destination pair trips are shared over walk/bike (for trips within the walkable distance threshold), public transit (for trips whose origin and destination are serviced by transit) and automobile. Following the mode share step, along with a network distance matrix, a projection of total personal vehicles kilometres travelled (VKT) is produced. The energy use and emissions associated with personal vehicles is calculated by assigning VKT to a stock-turnover personal vehicle model.

Waste

Households and non-residential buildings generate solid waste and wastewater, and the model traces various pathways to disposal, compost and sludge including those which capture energy from incineration and recovered gas. Emissions accounting is performed throughout the waste sub-model.

Energy flow and local energy production

Energy produced from primary sources (e.g. solar, wind) is modelled alongside energy converted from imported fuels (e.g. electricity generation, district energy, CHP). As with the transportation sub-model, the district energy supply model has an explicit spatial dimension and represents areas served by district energy networks.

Finance and employment

Energy related financial flows and employment impacts - while not shown explicitly in Figure 3 - are captured through an additional layer of model logic. Calculated financial flows include the capital, operating and maintenance cost of energy consuming stocks and energy producing stocks, including fuel costs. Employment related to the construction of new buildings, retrofit activities and energy infrastructure is modelled.

3. The Western Region

The Regional Enterprise Networks are a series of economic partnerships in Nova Scotia with the goal of fostering sustainable economic development outside of the Halifax Core. The Western REN is an inter-municipal corporation of seven (7) neighbouring municipal units – the Municipalities of Argyle, Barrington, Clare, Digby, and Yarmouth, and the Towns of Digby and Yarmouth. The Western REN receives its operational budget through a matching funding partnership with the Province of Nova Scotia.

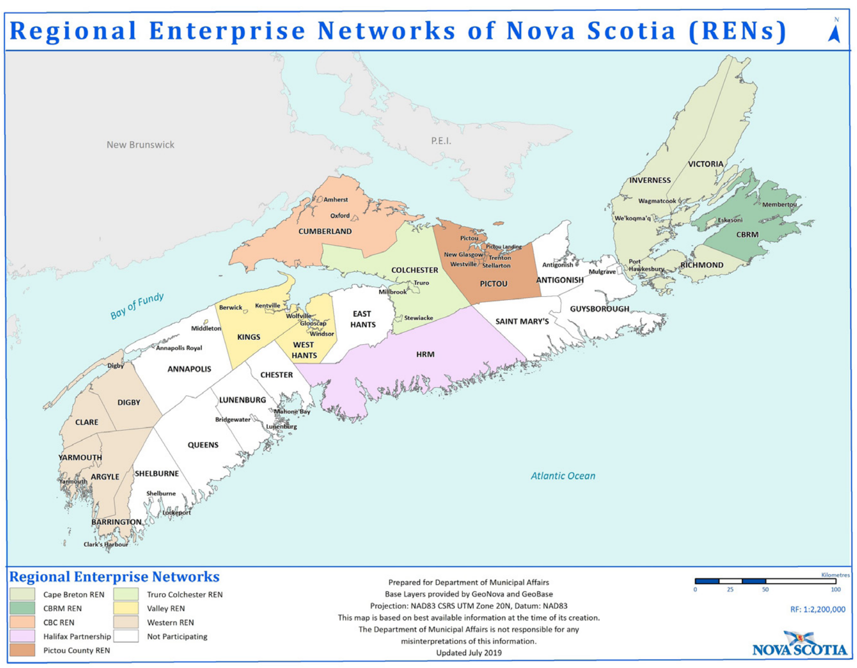


Figure 4. Current REN locations and boundaries.[10]

The municipalities and towns in the Western Region are predominantly along the coast of the province, with smaller towns and villages in the Municipal Regions of Yarmouth and Digby more inland. Due to the location, the Western Region faces climate impacts from sea level rise, storm surges, flooding and increased precipitation, and strong storms. Flooding events in the region are anticipated to increase due to sea level rise caused primarily by climate change.[11]

The communities within the Western Region are predominantly rural, characterised by low-rise developments and detached housing with concentrations of more urban and dense

[10] Department of Municipal Affairs, 2019. Regional Enterprise Networks of Nova Scotia (RENs) map.

[11] Municipality of the District of Yarmouth. (2013) "Thriving amidst uncertainty" Municipal Climate Change action plan.

development in the towns of Digby and Yarmouth. Because of the variety of settlement types included within the Western Region, delivery of services is not uniform across all regions of the municipality.

Urban settlements are primarily focused around the waterfronts of the Western Region communities. Urban settlement-designated areas have both municipal water and wastewater systems. Urban reserve areas have been set aside to ensure a supply of land for urban settlement with access to water and wastewater services.

Parks, open areas, lakes, agricultural lands, and rural settlements dominate the landscape of the Western Region. Three major water bodies are adjacent to the Western Region which shape the communities: The Bay of Fundy, the Gulf of Maine and the Atlantic Ocean. The Bay of Fundy is directly adjacent to Digby and is the basis of economic and tourist activity. Physically, the Bay of Fundy is noted as having the largest tides in the world, often draining to the sea bottom and rising several metres in a single day.

Modest levels of new development occurs equally in rural areas and in larger town centres of Yarmouth and Digby. Rural resource land use designations are prevalent in the region and are used to protect natural resources, the culture and heritage of the rural areas, and to support rural development. The waterfronts and harbours of Western Nova Scotia are a vital economic resource for the fishery industry and food exports. There are a reported 1,100 companies in Western Nova Scotia's waterfront with a growing bio-science fisheries industry, and an experienced boat building industry.[12]

The population of the Western Region has fallen from 66,876 people in 2011 to 64,305 in 2016, a decline of -3.8%. The population centres in the region are the Towns of Yarmouth and Digby. The Western Region is facing a shortage of young workers and families, and the fastest growing age cohort is the 65+ year-old group. Because of the demographic trends, communities in the Western Region are both looking for ways to bring new families to the region and are planning for services for seniors.

[12] Western REN. Why Western Nova Scotia? (2019). Retrieved from http://investinwesternns.com/

4. The Energy System

4.1 Baseline

ELECTRICITY IN THE WESTERN REGION

The Western Region is supplied with electricity by the provincial electricity utility, Nova Scotia Power Incorporated ('NS Power'). NS Power is a private corporation and is regulated by the Nova Scotia Utility and Review Board. NS Power generates electricity primarily through coal-fired power plants, with a lesser amount produced through renewable sources. The Tusket Combustion Turbine, located in the Western Region, has a capacity of 24 MW, and is fueled by fuel oil, is part of the NS Power generating grid. The Province of Nova Scotia has articulated its goals for reducing greenhouse gas emissions, in the Renewable Electricity Regulations and in Bill 213 – The Sustainable Development Goals Act, which commits Nova Scotia to reducing greenhouse gas emissions by 53% below 2005 levels by 2030, and to reaching a net-zero carbon footprint by 2050.

The average GHG intensity for electricity generation in Nova Scotia is 600 gCO_2 per kWh, the fourth-highest carbon intensity amongst the provinces in Canada.[13] The current fuel mix for electricity production is dominated by coal and petcoke resulting in a high grid intensity. Projections to 2021 show a decrease in fossil fuels and an increase in renewable or other sources with lower GHG intensities as shown under, is shown in Figure 5.

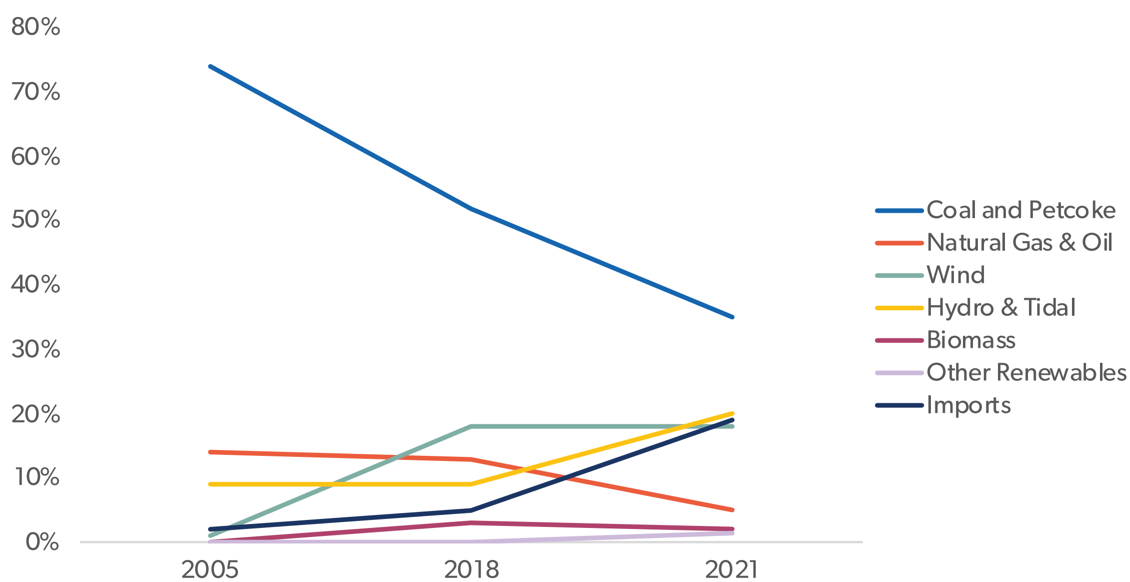


Figure 5. Actual 2007 and 2012 energy mix, and projected 2021 energy mix for electricity generation in Nova Scotia.[14]

[13] Canada Energy Regulator, 2019. Canada's Energy Future 2019: Energy Supply and Demand Projections to 2040. Government of Canada.

[14] Nova Scotia Utility and Review Board, 2018. Nova Scotia Power 10-Year System Outlook. 2018 Report- Revised.

NS Power is currently undertaking an Integrated Resource Plan (IRP), a long-term strategy for the electricity system required by the NS Utility and Review Board.[15] Two of the scenarios being evaluated by NS Power achieve net zero emissions by 2050.[16]

RENEWABLE ENERGY

As part of an assessment for renewables, the Canadian Wind Energy Association (CanWEA) found wind energy to be a major opportunity for the province of Nova Scotia because of strong winds across the province, and higher rates of production which correlate to peak demand. The Western Region also has some of the country's highest-value wind resources making wind energy the lowest-cost option for renewable electricity supply in Atlantic Canada.[17] The Western Region has several initiatives underway to make use of the wind resource 74.05 MW of energy (Table 1).

Table 1. Current Wind Energy in the Western Region (2019)[18]

LOCATIONS	# OF TURBINES	POWER GENERATED (MW)
DIGBY	1	0.05
MOUNT PLEASANT	1	0.8
GULLIVERS COVE	20	30
UNIVERSITE SAINTE-ANNE	2	0.1
GRAND PASSAGE	1	0.9
LITTLE BROOK	1	0.6
BRENTON	1	1.99
WELLINGTON	2	0.1
BLACK POND	1	1.99
LITTLE RIVER	1	1.99
WEDGEPORT	1	1.68
SHAG HARBOUR	2	3.2
BARRINGTON PASSAGE	1	0.05
PUBNICO POINT	17	30.6
TOTAL	52	74.05

The Annapolis Royal Generating Station Tidal energy is the only functioning tidal generation station in North America, with a capacity of 20 MW.[19]

[15] For more information on the IRP, see: https://irp.nspower.ca/document-library/

[16] NS Power (2020). April 28, 2020. Interim Modelling Update Workshop. Retrieved from: https://irp.nspower.ca/files/key-documents/presentations/Interim-Modeling-Update-Workshop-2020-04-28.pdf

[17] Western REN (2017) Investment Opportunities & Strategies.

[18] Data provided by Western REN.

[19] Nova Scotia Power Inc. 2019. Hydro and Tidal Power. Accessed May 2020. https://www.nspower.ca/clean-energy/renewable-energy-sources/tidal-power

A number of smaller hydroelectric generating stations are found in the Western Region, including in Tusket (2.7 MW), Sissiboo (24 MW), and Bear River (13 MW), which all feed into the NSPI electricity grid.

THE ELECTRICITY GRID

Several NS Power 69kV transmission lines (L5531, L5532 (which connects with L5541), L5533, and L5026) converge at Bear River near Digby (Figure 6). It is understood that if one line becomes overloaded, it is possible that protection and control equipment would cause the remaining two lines to trip, resulting in a wide blackout of Western Nova Scotia. NS Power has stated that the three lines are at or near the limit of their capacities.[20]

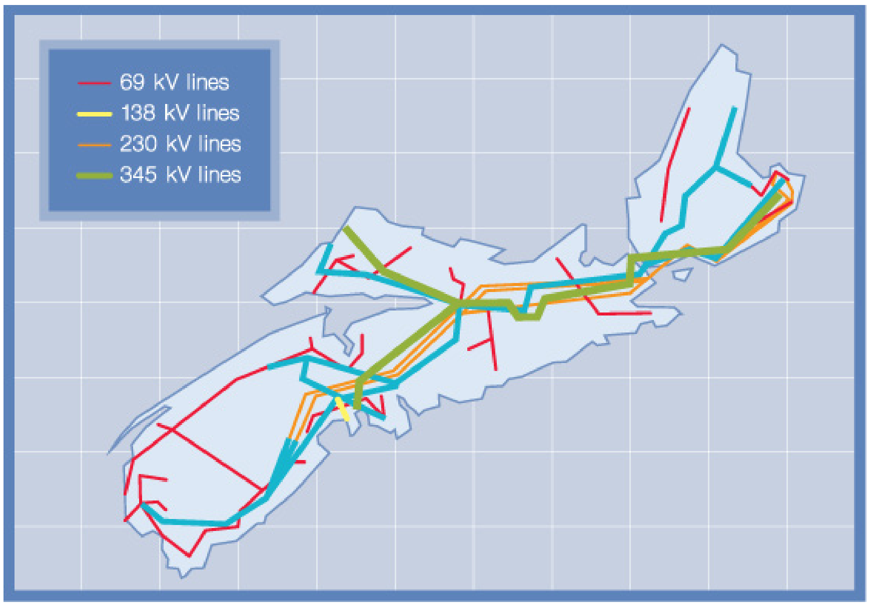


Figure 6. Electricity grid transmissions lines used by Nova Scotia Power, showing the capacity of the lines in Western REN.[21]

In 2012, NS Power estimated that the cost of upgrading approximately seventy km of one of the 69kV lines was $7 million.[22]

[20] Nova Scotia Power. March 2, 2012. Interconnection Feasibility Study Report GIP-IR378-FEAS-R1 Generator Information Request 378. 17pp

[21] Nova Scotia Power, 2020. How we deliver electricity. Accessed May 2020. https://www.nspower.ca/about-us/electricity/delivering

[22] Nova Scotia Power. March 2, 2012. Interconnection Feasibility Study Report GIP-IR378-FEAS-R1 Generator Information Request 378. 17pp.

5. The Energy Opportunity

5.1 Guiding principles

This report identified the opportunities and investments available to the Western Region, emphasising those projects which support the local communities, economy, and environment. Community-based investment opportunities enable the region to become more financially independent and resilient.

The guiding principles behind the development and investment plan include:

1. Local ownership and investment- by emphasizing opportunities within the local communities, employment opportunities will increase, and the communities will become more financially independent.
2. Economic diversity- by investing in a variety of industries and opportunities, the communities will be better able to withstand market fluctuations.
3. Innovation- The Western REN encompasses secondary education campuses, fertile options for renewable energy generation, and a workforce in transition from forest industries. By emphasizing innovation, the region can identify niches for economic growth within the region.
4. Social equity- Any economic strategy will best serve the communities if it emphasizes social equity as a key decision-making tool. Ensuring that vulnerable populations are included in community development will result in a more stable and resilient population.
5. Practical- By selecting opportunities that are practical, in terms of the technologies and economics, the project will be more likely to succeed, and thereby provide employment and stability to the region.
6. Locally appropriate- The local environment, culture, history, and people of western Nova Scotia must be at the heart of any development opportunities.
7. Consider climate- Climate change considerations, both in terms of mitigation of GHGs, and adaptation to projected climate impacts, must be central to all developments and opportunities for the region.

5.2 Scenarios

Two scenarios were developed to evaluate the future energy system for the Western Region. A BAU scenario reflects the implementation of current plans, as defined in Table 2. A second scenario, the Clean Energy scenario, evaluates a wide range of zero emissions or low carbon investments in the Region. The actions and assumptions for each scenario are described in Table 2.

A framework of reduce, improve and switch is used to help frame the actions in the Clean Energy scenario. This approach is adapted from similar approaches such as the well-known Reduce-Reuse-Recycle (from the waste sector), and Avoid-Shift-Improve (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.

Through technical analysis, research, and input from stakeholders and the consulting team, dozens of energy and emissions actions were vetted. The actions were modelled in CityInSight and a final suite of 25 actions were evaluated for the Clean Energy scenario. The actions are grouped into four general strategies:

- Energy efficient buildings. Accounting for 51% of emissions in 2016, (29% of emissions in 2050) and 32% of the total energy consumption in 2016 (38% by 2050), building retrofits are essential to reducing the energy demand of the Western Region. This strategy involves making deep energy retrofits to all buildings in the community and ensuring that new buildings are built to superior energy standards.
- Low-carbon transportation for residents and visitors. On-land transportation accounts for 38% of the total energy consumption in 2016, and marine transportation accounts for a further 30% of energy consumption. This strategy focuses on vehicle electrification, increasing and improving public transit services, and fuel switching in marine vessels to reduce reliance on fossil fuels.
- Local clean energy generation. Energy for buildings and vehicles can increasingly be produced locally. Waste represents 1% of the total GHG emissions shift in 2016. This strategy uses waste to generate energy, minimizes fugitive emissions, and provides locally generated electric and thermal power to reduce the use of natural gas and fossil fuel powered grid electricity.
- Marine energy demands account for 38% of the total energy demand in 2050, and 38% of emissions.

Table 2. Actions modelled to reduce energy and emissions in the Region

	BAU ACTIONS AND ASSUMPTIONS	CLEAN ENERGY SCENARIO ACTIONS AND ASSUMPTIONS
DEMOGRAPHICS		
Population and employment	No net growth, population and employment projections held constant.	No net growth, population and employment projections held constant.
EXISTING BUILDINGS		

		BAU ACTIONS AND ASSUMPTIONS	CLEAN ENERGY SCENARIO ACTIONS AND ASSUMPTIONS
1	**Retrofit single-family residential homes**	Existing building stock efficiency unchanged; efficiency held constant from 2016-2050	Energy for space heating decreases by 50% and electricity demand decreases by 50% in 75% of buildings by 2030. By 2050 an additional 15% of buildings meet this standard.
2	**Retrofit multi-unit residential buildings**		
3	**Retrofit commercial buildings**		
4	**Retrofit institutional buildings**		
5	**Retrofit municipal buildings**		
6	**Retrofit industrial buildings**		
7	**Industry process motors/ efficiency improvements**	Efficiency held constant	Efficiency
8	**Residential space heating**	99% of heat systems are replaced with the same technology at end of life; 1% of heat systems are replaced with resistance heating at end of life	50% of energy needed for space heating is electric (heat pumps) by 2030. Heat pumps also provide cooling.
9	**Residential water heating**	99% of water heaters are replaced with the same technology at end of life;1% of water heaters are replaced with electric tank water heaters at end of life	50% of water heating in residential buildings is electric (using CO_2 heat pump water heater) by 2030
10	**Non-residential space heating**	Fuel shares held constant	50% of space heating is electric (using heat pumps, split between 50% geothermal and 50% air source), and 25% is by biomass boiler, by 2030. 50% of space cooling is electric (heat pumps) by 2030, with heat pumps replacing older AC units.
11	**Non-residential water heating**	Fuel shares held constant	50% of water heating is electric and 25% by biomass boiler by 2030
LOW OR ZERO CARBON ENERGY GENERATION (SITE/BUILDING SCALE)			
12	**Solar PV - existing residential**	No solar PV on residential buildings	Scale up solar rooftop pv generating capacity to match 30% of electricity demand in residential 2030 (a total of 44 MW installed by 2030)
13	**Solar PV - existing non-res**	No solar PV on non-residential buildings	
14	**Energy storage - residential**	No battery storage in residential buildings	100% of installed solar PV on residential [above] includes storage, split between 50% thermal storage and 50% batteries

		BAU ACTIONS AND ASSUMPTIONS	CLEAN ENERGY SCENARIO ACTIONS AND ASSUMPTIONS
15	**Energy storage - non-residential**	No battery storage in non-residential buildings	100% of installed solar PV on non-residential buildings [above] includes storage, split between 25% thermal storage + 75% batteries
LOW OR ZERO CARBON ENERGY GENERATION (COMMUNITY SCALE)			
16	**Utility-scale solar PV - ground mount**	No utility-scale ground mount solar	Scale up ground mount solar pv from 2031 to 2050 to match 33% of remaining imported electricity in 2050 (a total of 110 MW installed by 2050)
17	**Onshore wind**	5.734 kW COMFIT wind capacity	Scale up ground mount solar pv from 2031 to 2050 to match 67% of remaining imported electricity in 2050 (a total of 221 MW installed by 2050)
20	**Energy storage - utility ground mount solar pv**	No utility scale storage	100% of installed ground mount solar PV includes battery storage
21	**Energy storage - wind**	No utility scale storage	100% of installed wind includes battery storage
TRANSIT			
22	**Electrify transit**	No electric transit buses	100% electric by 2030
VEHICLES			
23	**Electrify municipal fleets**	No EVs in municipal fleet	100% electric by 2030
24	**Electrify personal vehicles**	By 2050 10% of new vehicles are EV or hybrid	Scales up so that 30% of new vehicle sales are EVs by 2030, and 80% by 2040
25	**Electrify commercial vehicles**	No VKT allocated to EVs	
26	**Marine vehicles fuel switch**	All marine fuel use is diesel	Ferries: Starting in 2025, scales up so that by 2030: 60,000 GJ of CNG displaces diesel 7,800 GJ/year of biodiesel displaces diesel Fishing: Starting in 2035, scales up so that by 2045: 50% of diesel engines in fishing vessel fleet is replaced by hydrogen 50% of diesel engines in fishing vessel fleet is replaced by electric battery
WASTE			
27	**Waste diversion**	Waste diversion rate held constant	90% of residential and ICI waste diverted by 2030
WATER AND WASTEWATER			
28	**Water & WW energy**	Water and wastewater per capita rates held constant	Reduce water & WW treatment & pumping energy use 25% by 2030

6. The Clean Energy Economy

Marine transportation, on-road transportation, and the residential sector shape the energy profile of the Western Region, representing approximately 80% of consumption from 2016 to 2050.

Actions in the building sector include deep energy retrofits, fuel switching heating and water systems to electricity, and improving industrial process energy use. These actions collectively achieve a reduction of approximately 5,580 kilotonnes of carbon dioxide equivalent (ktCO_2e) from 2020 to 2050. In terms of energy consumption, there is a cumulative reduction of nearly 32,000 TJ as a result of the actions, and nearly 1,400 TJ reduction per year by 2050.

The electrification of transit, municipal, commercial and personal vehicles provides an additional 956 ktCO_2e of cumulative emissions reductions by 2050 ("Electrify transportation" wedge in Figure 7).

Marine transportation is projected to shift away from diesel fuel, replaced with compressed natural gas in ferries, and hydrogen, electric batteries, and a small amount of biodiesel in fishing vessels.

Energy consumption by ferries stays relatively constant, with a 10% decrease in GHG emissions from 2016 to 2050. Fishing vessel fuel switching results in a 50% decrease in total energy consumption, and a 99% decrease in GHG emissions.

The total impact of new renewable electricity generation reaches nearly 3,200 ktCO_2e cumulative reductions by 2050 (110 KtCO_2e per year). This new carbon-free generation consists of rooftop solar photovoltaics (PV), larger-scale solar and wind installations.

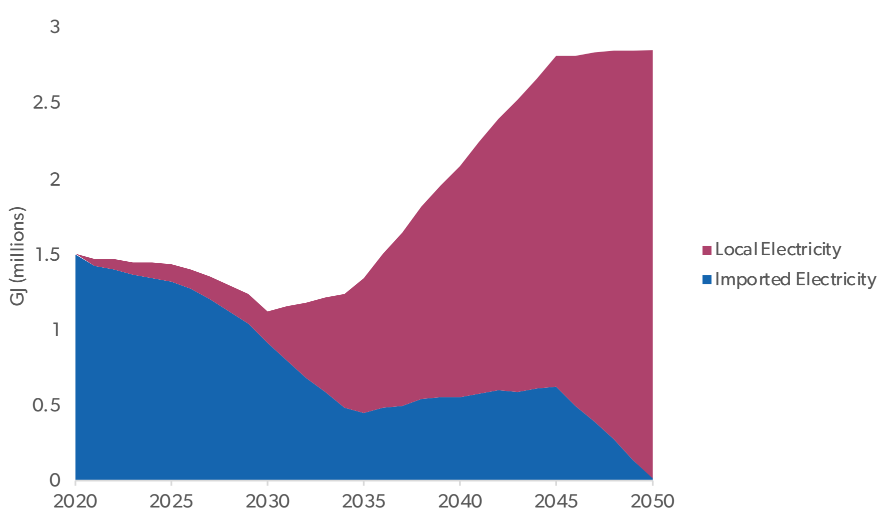


Figure 7. Local vs imported (grid) electricity in the Western Region, 2020-2050.

The following wedge diagrams illustrate the effect of the low carbon actions as they shape the energy and GHG emissions profile of the Western Region.

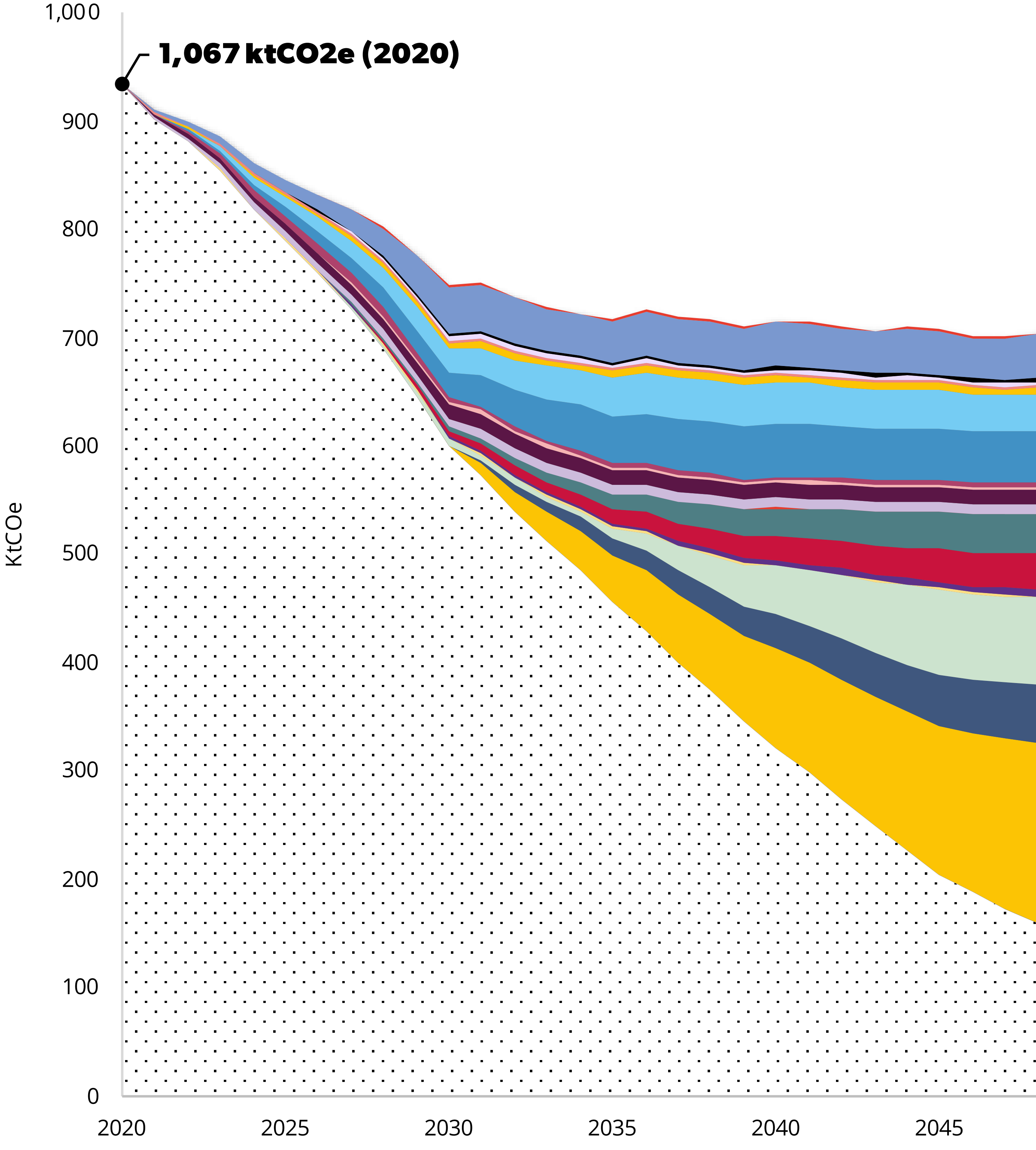


Figure 8. The impact on GHG emissions of the actions in the Clean Energy scenario relative to the BAU, 2020- 2050

131 KtCO2e
(2050)
2050
Retrofit single-family homes, 2031-2050
Retrofit multi-Unit Residential Buildings, 2031-2050
Retrofit commercial buildings, 2031-2050
Retrofit institutional buildings, 2031-2050
Retrofit municipal buildings, 2031-2050
Retrofit industrial buildings, 2031-2050
Industrial process motor & efficiency improvements
Residential heat pumps for space cooling
Residential water heating efficiency
Non-residential space heating & space cooling efficiency improvements
Non-residential water heating - efficiency improvements
Add Solar PV to existing res. buildings
Add Solar PV to existing non-res. buildings
Electrify transit
Electrify municipal fleets
Electrify personal vehicles
Electrify commercial vehicles
Increase waste diversion
Increase water and wastewater pumping energy efficiency
Marine vessel fuel switching
Utility-scale Solar PV
Onshore wind Energy
Carbon Gap

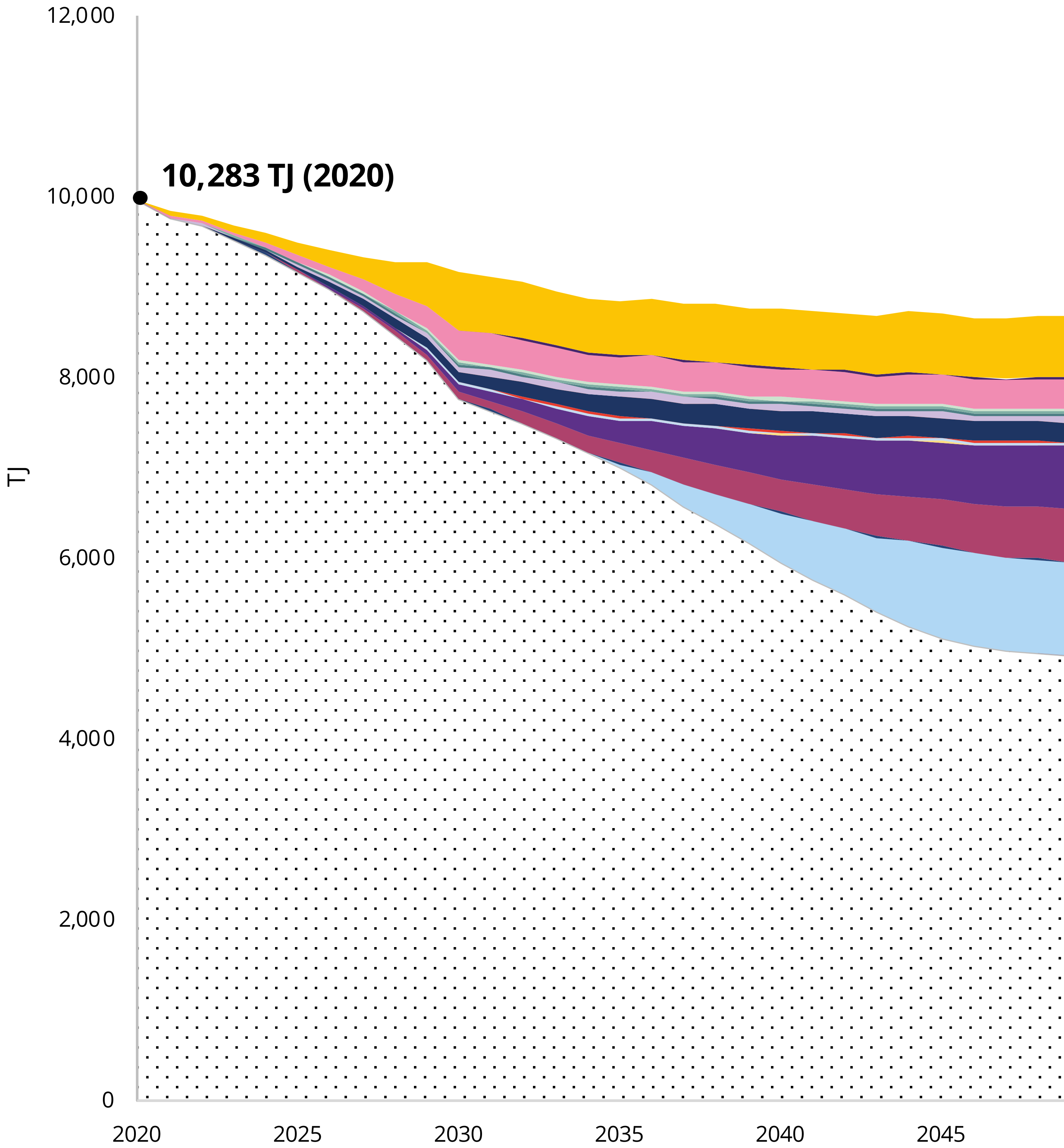


Figure 9. The impact on energy of the actions in the Clean Energy scenario relative to the BAU, 2020- 2050

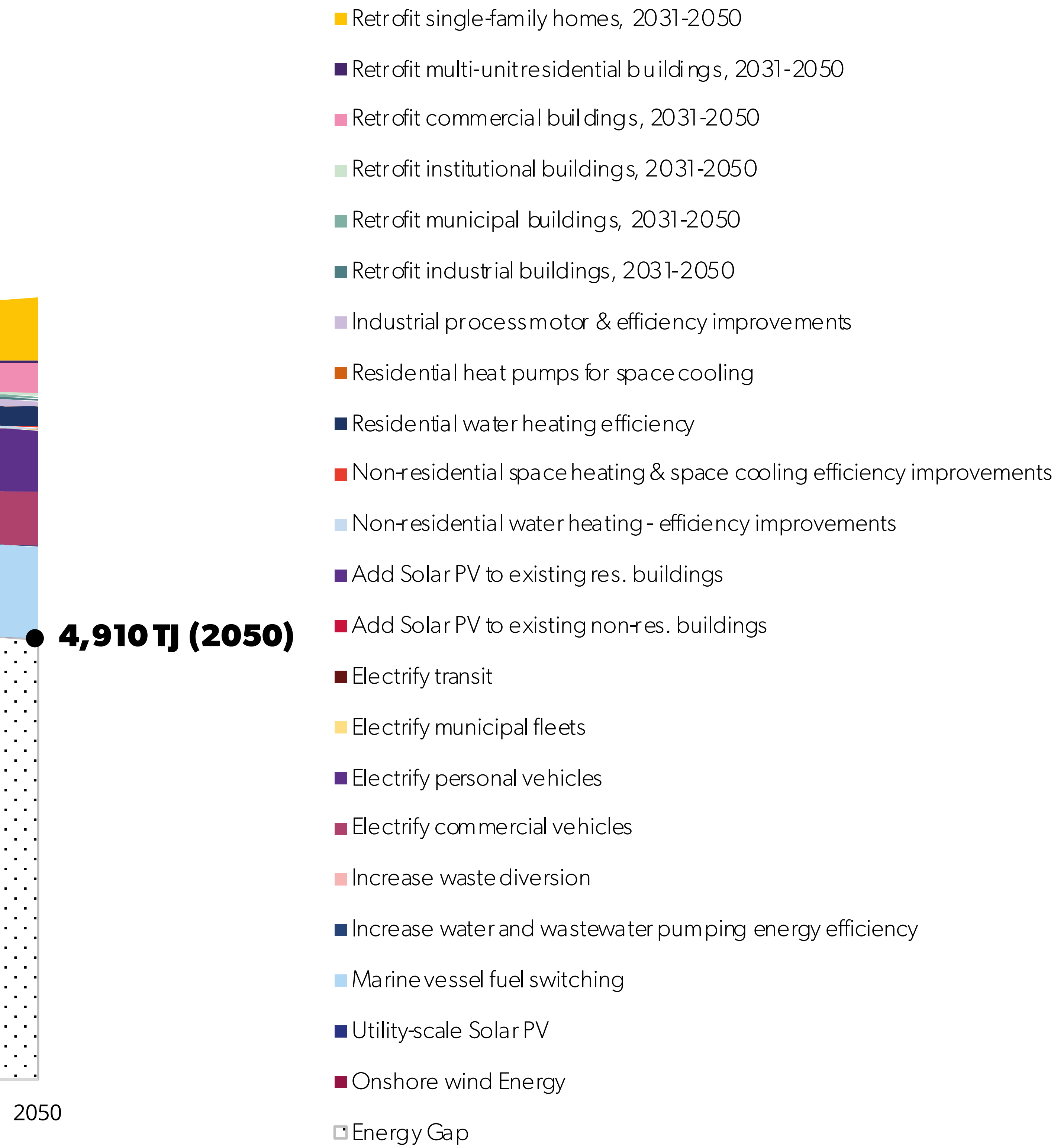

4,910 TJ (2050)
2050
Retrofit single-family homes, 2031-2050
Retrofit multi-unit residential buildings, 2031-2050
Retrofit commercial buildings, 2031-2050
Retrofit institutional buildings, 2031-2050
Retrofit municipal buildings, 2031-2050
Retrofit industrial buildings, 2031-2050
Industrial process motor & efficiency improvements
Residential heat pumps for space cooling
Residential water heating efficiency
Non-residential space heating & space cooling efficiency improvements
Non-residential water heating - efficiency improvements
Add Solar PV to existing res. buildings
Add Solar PV to existing non-res. buildings
Electrify transit
Electrify municipal fleets
Electrify personal vehicles
Electrify commercial vehicles
Increase waste diversion
Increase water and wastewater pumping energy efficiency
Marine vessel fuel switching
Utility-scale Solar PV
Onshore wind Energy
Energy Gap

Table 3. Cumulative reduction in energy consumption by action. Note that these reductions are a result of the interaction between actions, so implementation of single actions would result in less reduction in energy use.

ACTION	CUMULATIVE ENERGY USE REDUCTIONS IN 5 YEAR INTERVALS (TJ)						
	2020	2025	2030	2035	2040	2045	2050
Retrofit single-family residential homes	0	138	637	612	646	667	707
Retrofit multi-unit residential buildings	0	4	16	16	17	17	18
Retrofit commercial buildings	0	73	319	309	316	326	339
Retrofit institutional buildings	0	6	27	28	29	30	32
Retrofit municipal buildings	0	5	23	24	25	25	26
Retrofit industrial buildings	0	11	23	24	25	26	27
Industry process motors/ efficiency improvements	0	29	56	61	61	61	61
Residential space heating	0	1	-1	-9	-7	-8	-8
Residential water heating	0	38	120	217	235	231	229
Non-residential space heating	0	-4	5	17	13	18	16
Non-residential water heating	0	3	18	21	21	20	20
Solar PV - existing residential	0	0	0	0	0	0	0
Solar PV - existing non-res	0	0	0	0	0	0	0
Energy storage - residential	0	0	0	0	0	0	0
Energy storage - non-res	0	0	0	0	0	0	0
Electrify transit	0	1	2	2	2	2	2
Electrify municipal fleets	0	0	2	5	6	6	6
Electrify personal vehicles	0	4	66	255	483	635	686
Electrify commercial vehicles	0	10	79	211	375	519	599
Waste diversion	0	0	0	0	0	0	0
Water & WW energy	0	5	12	12	12	12	12
Marine vehicles fuel switch	0	0	0	50	536	1022	1022
Utility-scale solar PV - ground mount	0	0	0	0	0	0	0
Onshore wind	0	0	0	0	0	0	0
Energy storage - utility ground mount solar pv	0	0	0	0	0	0	0
Energy storage - wind	0	0	0	0	0	0	0

6.1 Energy Consumption

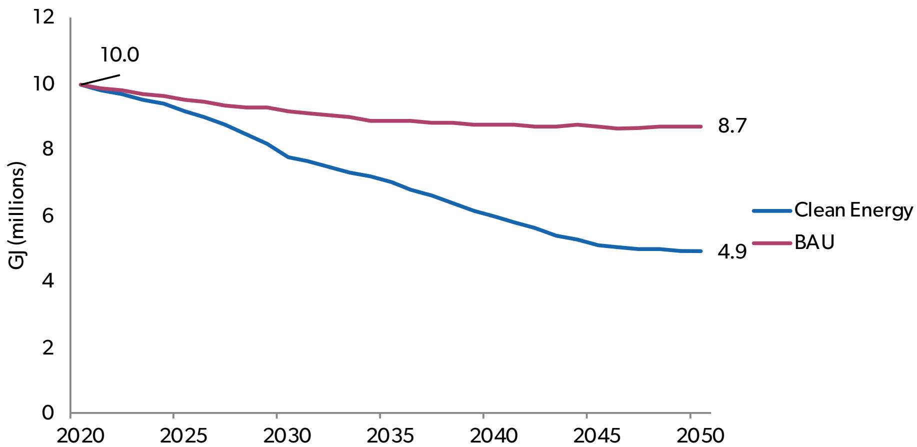


Figure 10. Total energy consumption, 2020-2050, for the BAU and Clean Energy scenarios

The results of the modelling indicate that by applying the actions described in section 5, overall energy consumption decreases by 52% between 2020 and 2050.

Marine transportation represents the largest consumer of energy by 2050, accounting for 38% of the energy use by 2050 in the clean energy scenario. On-road transportation accounts for a further 25% of all energy use in the clean energy scenario.

Transportation, both land and marine, accounts for nearly two thirds of the energy consumption in the Region in 2050.

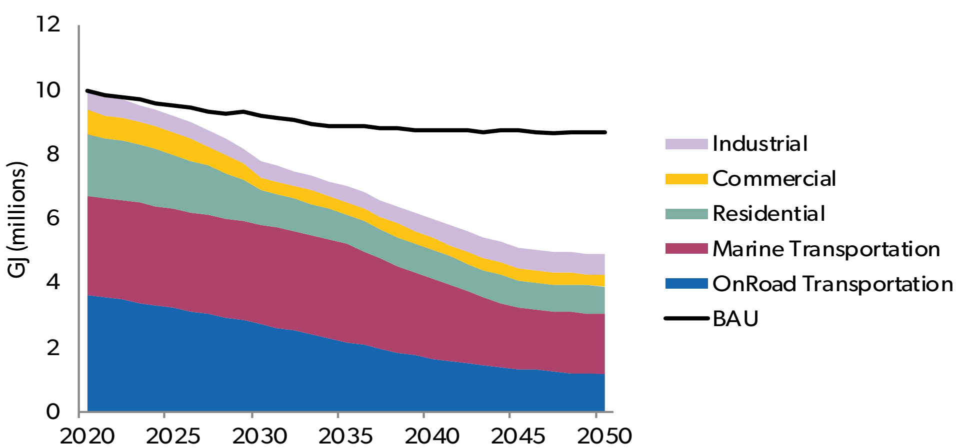


Figure 11. Projected energy consumption (million GJ) by sector in the Clean Energy scenario, 2050-2050.

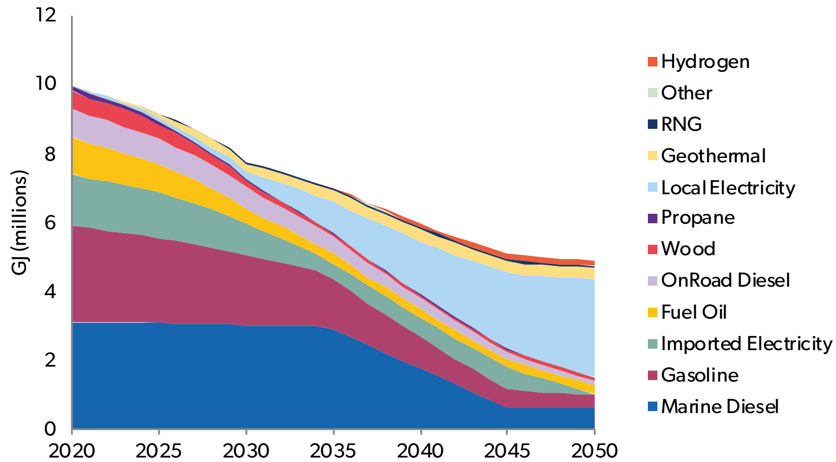


Figure 12. Projected energy consumption (million GJ) by fuel in the Clean Energy scenario, 2050-2050.

Energy consumption decreases by 57% in the residential sector, 70% in the on-road transportation sector, and 7% in the commercial sector. The building energy savings are primarily due to building improvements from retrofits, as well as switching to more energy-efficient heating systems. Conversion to EVs, and improvements in the efficiency of combustion vehicles account for the reduction in energy use in the on-road transportation sector.

Local energy production replaces imported energy production, and this electricity is used in all sectors.

Energy consumption is reduced by more than 50% in most sectors by 2050.

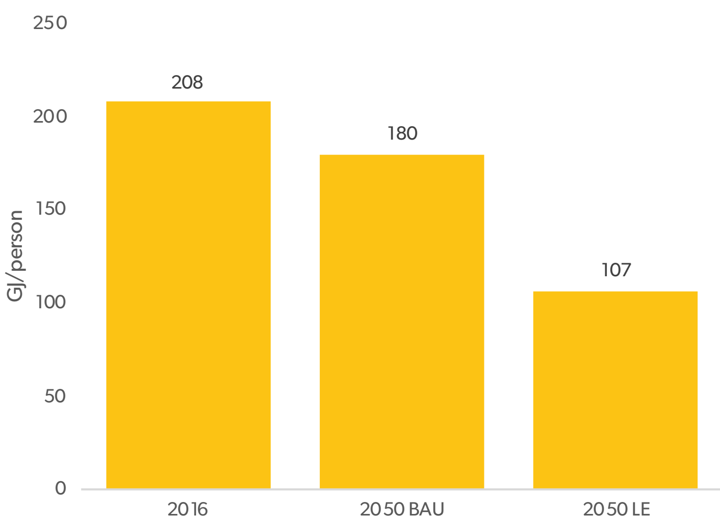


Figure 13. Energy consumption per capita in the BAU and Clean Energy scenarios (GJ/person), 2050 & 2050.

The per capita energy consumption decreases by 49% between 2016 and 2050 in the LE scenario.

The full breakdown of total energy consumption is shown in table A1.

6.2 GHG Emissions

Community emissions decrease by 88% between 2016 and 2050 in the low energy scenario, with significant decreases across all sectors. This decrease is primarily due to building retrofits, vehicle improvements, and fuel-switching to electricity and hydrogen. The electricity grid improves over time as lower-carbon fuel sources come on line. Additionally, the Region switches to locally-produced renewable electricity, reducing the dependence on the provincial grid, and further reducing GHG emissions.

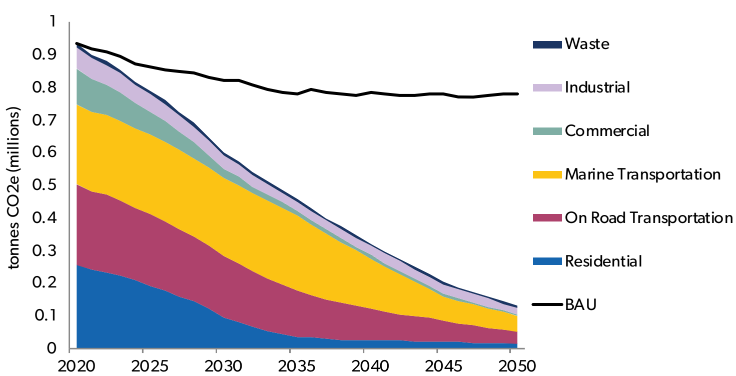


Figure 14. GHG emissions ($MtCO_2e$) by sector in the Clean Energy scenario, 2020-2050.

Per capita emissions decrease over this same period by 87%, decreasing from 21.6 tCO_2e/person in 2016 to 2.7 tCO_2e/person in 2050. The full details of the GHG emissions by sector and fuel type are shown in Table A2.

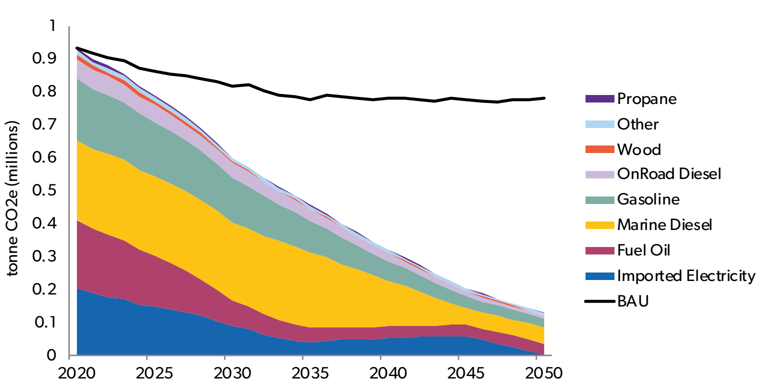


Figure 15. GHG emissions ($MtCO_2e$) in the Clean Energy scenario by source, 2020-2050.

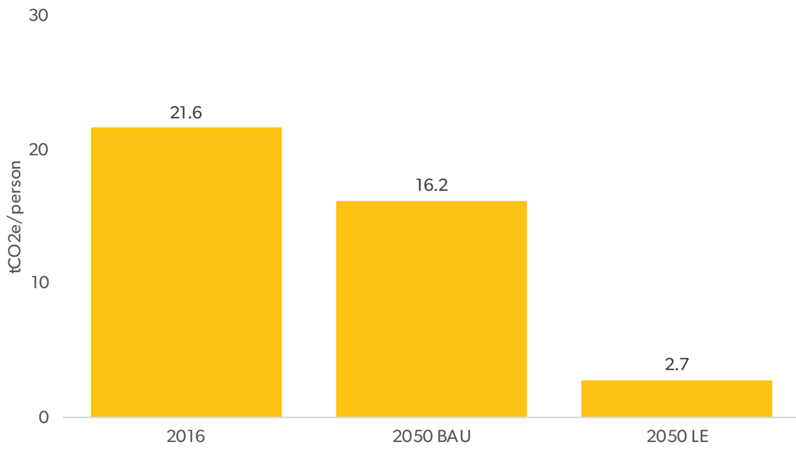


Figure 16. GHG emissions per capita (tCO_2e/person) in the Clean Energy and BAU scenarios.

Per capita GHG emissions decrease by 87% to 2.7 tCO_2e by 2050.

6.3 Buildings

GHG emissions from buildings are a function of the total quantity of floor space (m^2), the energy intensity of building operations (MJ/m^2), and the carbon intensity of the fuel and electricity supply (GHG emissions/MJ).

Energy use in buildings accounts for 339 million GJ of energy in 2016, decreasing by 43% to 1.8 million GJ by 2050 in the low energy scenario. The largest decrease is seen in the residential sector, as a result of building retrofits, and changing to more efficient space and water heating systems (heat pumps).

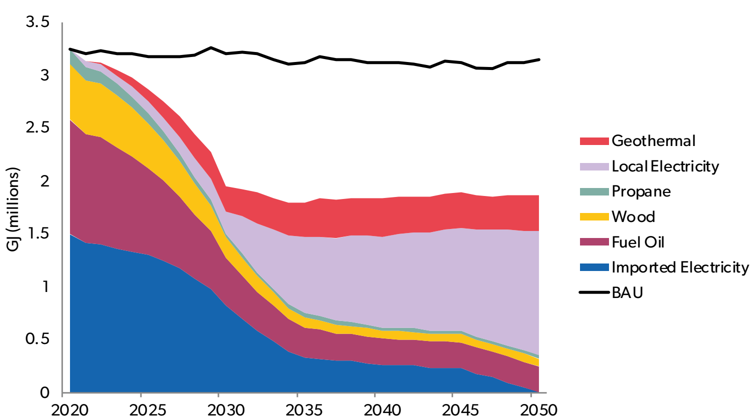


Figure 17. Energy use in buildings (million GJ) by fuel in the Clean Energy scenario, 2020-2050.

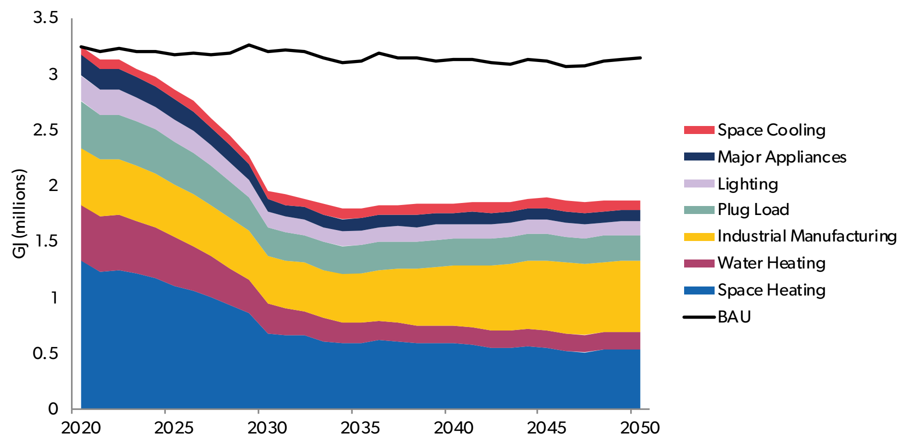


Figure 18. Energy use in buildings (million GJ) by end use in the Clean Energy scenario, 2020-2050.

Space heating and water heating show the biggest declines between 2016 and 2050, decreasing by 61% and 67%, respectively. This decrease is a result of building retrofits to reduce heating needs, a decrease in heating degree days from a warming climate, and switching to heat pumps and more efficient heating and water heating systems.

The proportion of primary energy consumed by households in the form of electricity has increased from 23.5% in 1990 to 36.8% in 2017. This represents an increase of 33%.[23] Locally-produced renewable electricity is used within the region where it is generated. By switching to electricity for space and water heating, the use of fuel oil and wood decreases.

Energy consumption declines across all building types in the Clean Energy scenario.

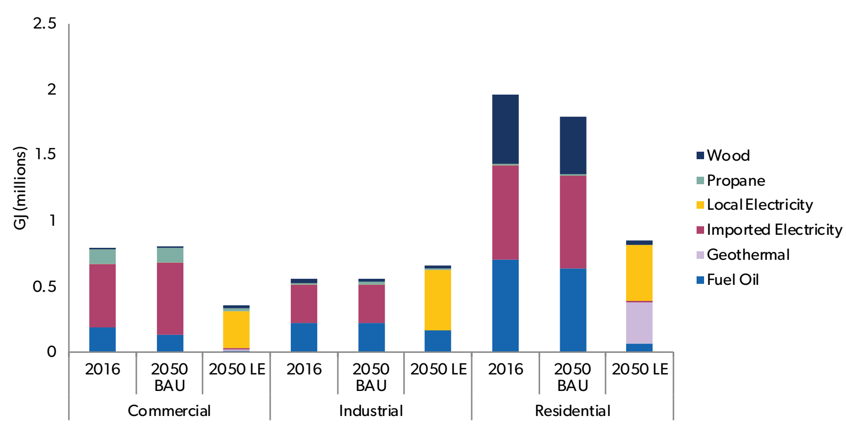


Figure 19. Energy use in buildings (million GJ) by building type and fuel in the BAU and Clean Energy scenarios.

[23] Natural Resources Canada. National Energy Use Database. Residential Sector, Nova Scotia, Table 1: Secondary Energy Use and GHG Emissions by Energy Source. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ns&rn=1&page=0 accessed March 1, 2020.

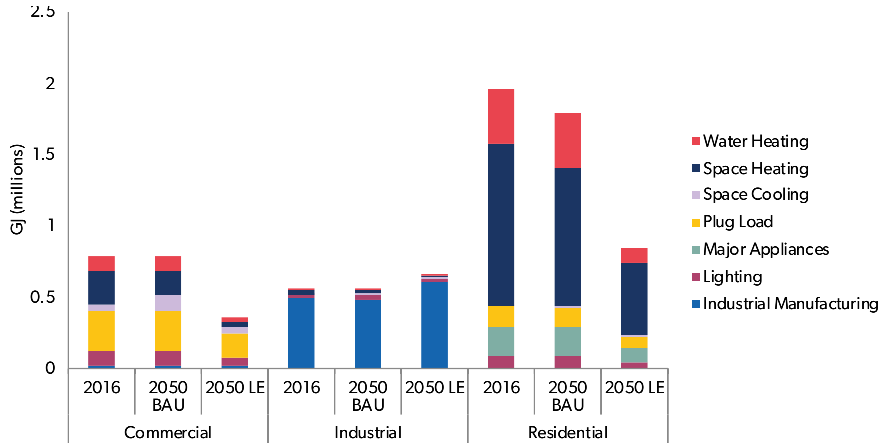


Figure 20. Energy use in buildings (million GJ) by building type and end use in the BAU and Clean Energy scenarios.

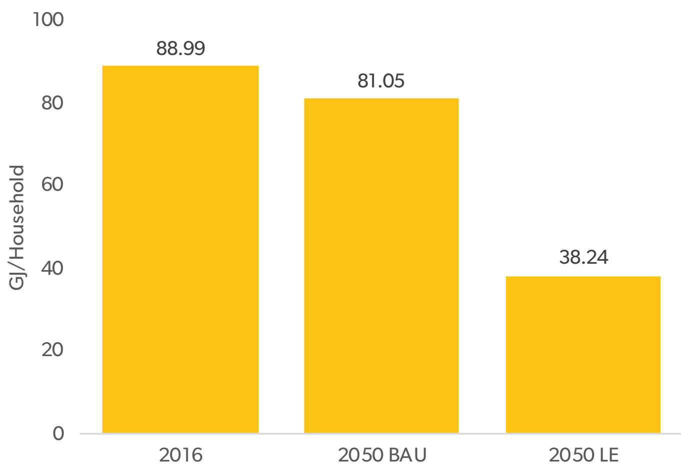


Figure 21. Residential energy per household (GJ/household) in the Clean Energy and BAU scenarios.

Residential energy consumption decreases 57% between 2016 and 2050 in the low energy scenario. This is due to the reduction in space and water heating costs from home retrofits, and conversion to efficient appliances and heating systems.

The full details of the building energy use can be seen in Table A3.

Household energy consumption declines by 57% by 2050.

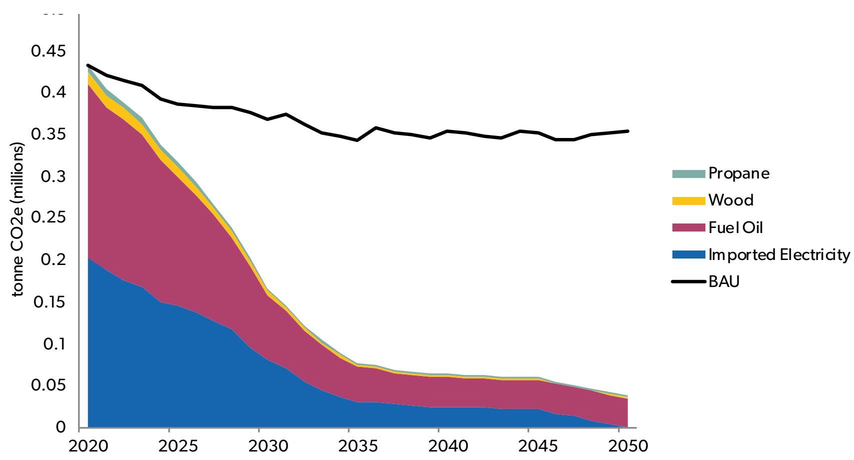


Figure 22. GHG emissions (Mt CO_2e) from buildings by source in the Clean Energy scenario, 2050-2050.

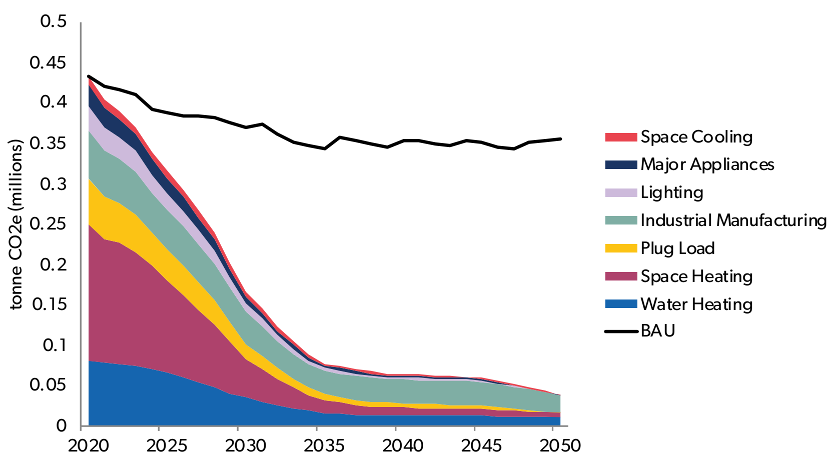


Figure 23. GHG emissions (Mt CO_2e) from buildings by end use in the Clean Energy scenario, 2050-2050.

GHG emissions from buildings decrease by 93% between 2016 and 2050 in the Clean Energy scenario. This is a result of switching away from emission-intensive fuels like fuel oil and woodstoves, as well as improvements to the provincial electricity grid. Coupled with this is the switch to locally-generated renewable electricity, reducing the need for grid electricity.

Because of the fuel-switching to electricity, and then switching to locally-produced electricity, GHG emissions from residential buildings are reduced dramatically in residential buildings, from 314 kt CO_2e of GHG emissions in 2016 to 14.5 kt CO_2e in 2050.

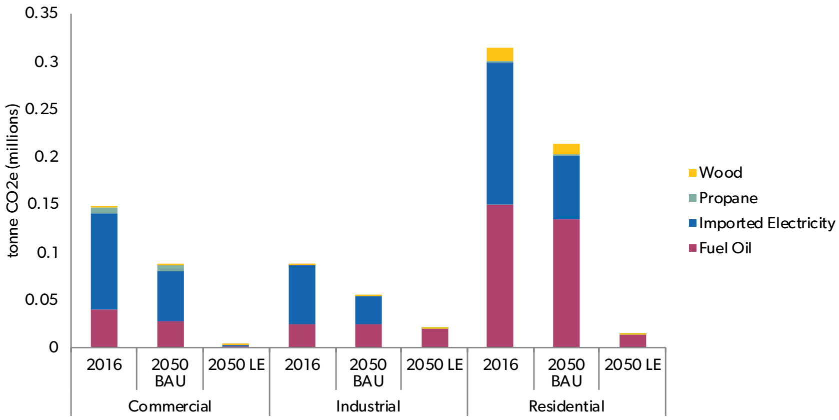


Figure 24. GHG emissions (Mt CO_2e) from buildings by building type and source in the BAU and Clean Energy scenarios.

GHG emissions from buildings fall by 93% by 2050.

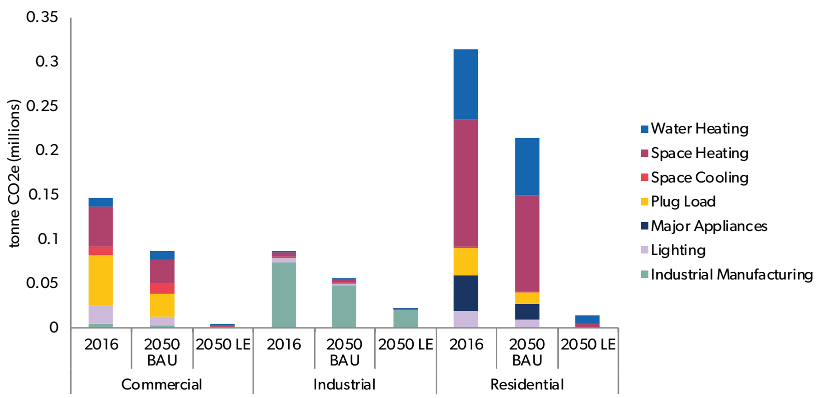


Figure 25. GHG emissions (Mt CO_2e) from buildings by building type and end use in the BAU and Clean Energy scenarios.

Residential GHG emissions reduce from 14.3 tCO_2e per household in 2016 to 0.7 tCO_2e per household in 2050, and 95% decrease.

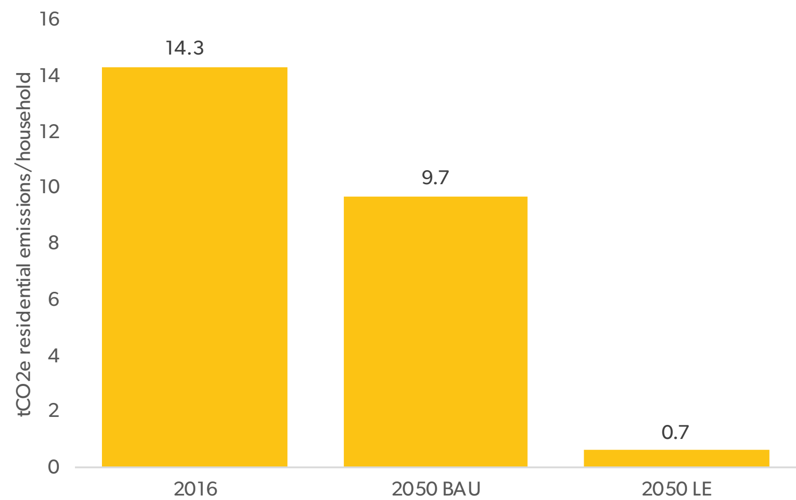


Figure 26. Residential GHG emissions per household (tCO_2e/household) in the BAU and Clean Energy scenarios

6.4 Transportation

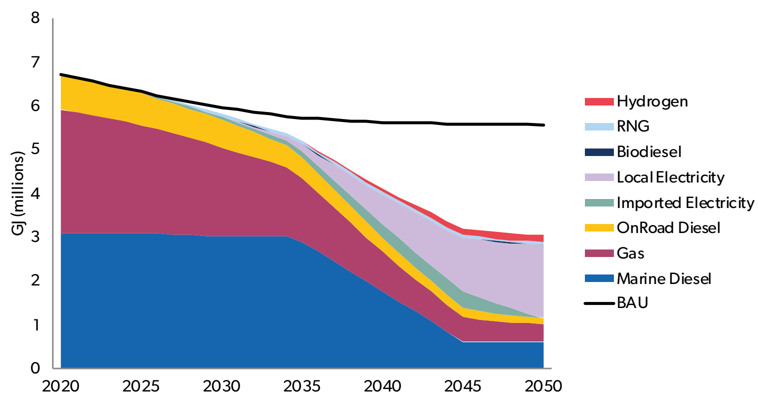


Figure 27. Energy use (million GJ) in transportation by fuel in the Clean Energy scenario, 2050-2050.

Marine diesel accounts for the majority of the energy consumed in the transportation sector in 2016, split between fishing vessels and ferries. When this is removed, transportation consumes 3.9 million GJ of energy in 2016, decreasing to 1.6 million GJ in 2050 in the low energy scenario.

Energy consumption decreases for on-road vehicles because of improvements to fuel efficiency standards in vehicles until 2030, but also from switching to electric vehicles, which consume less energy.

The full details of the energy consumption by transportation is shown in Table A5, below.

The fishing fleet consumed 2.4 million GJ of energy in 2016, 54% of the total energy used for transportation in the Region.

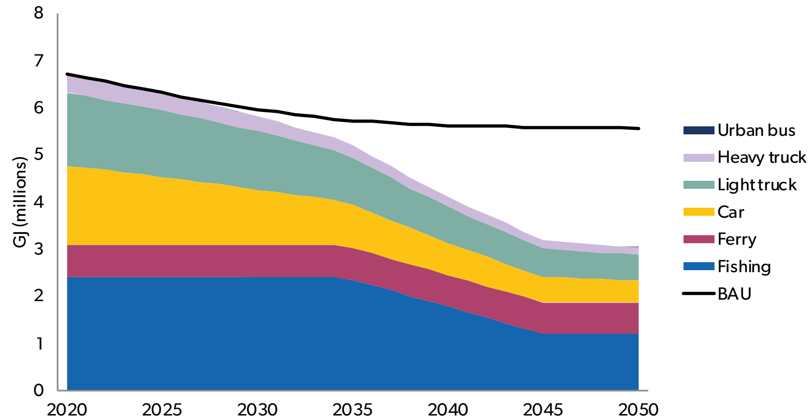


Figure 28. Energy use (million GJ) in transportation by vehicle type in the Clean Energy scenario, 2050-2050.

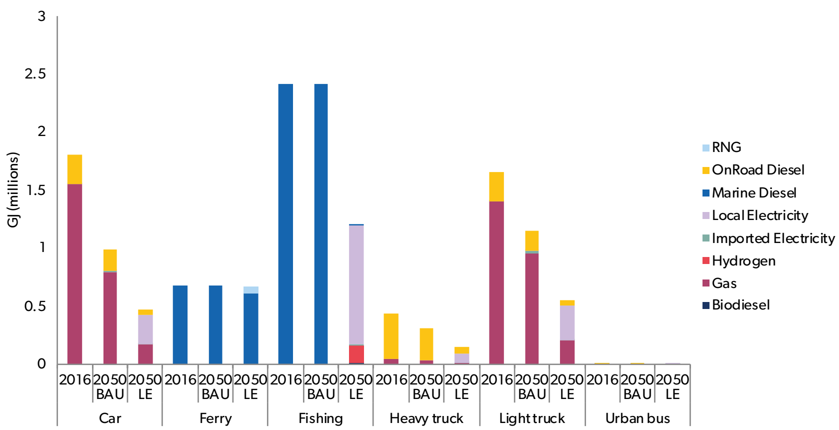


Figure 29. Energy use (million GJ) in transportation by vehicle type and fuel in the BAU and Clean Energy scenarios.

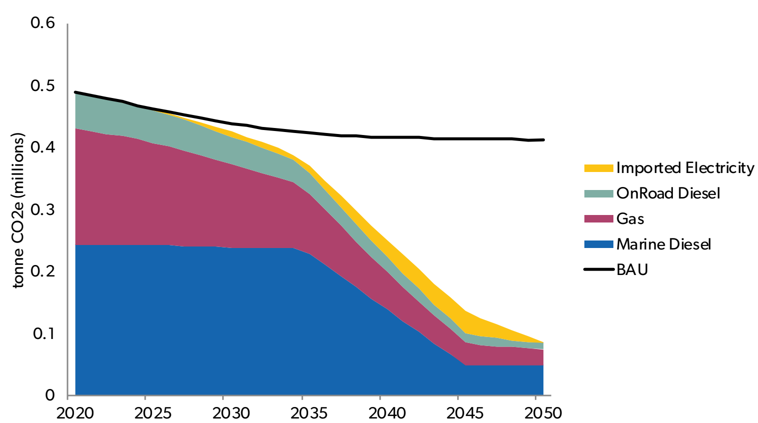


Figure 30. GHG emissions in transportation (Mt CO_2e) by source in the Clean Energy scenario, 2020-2050.

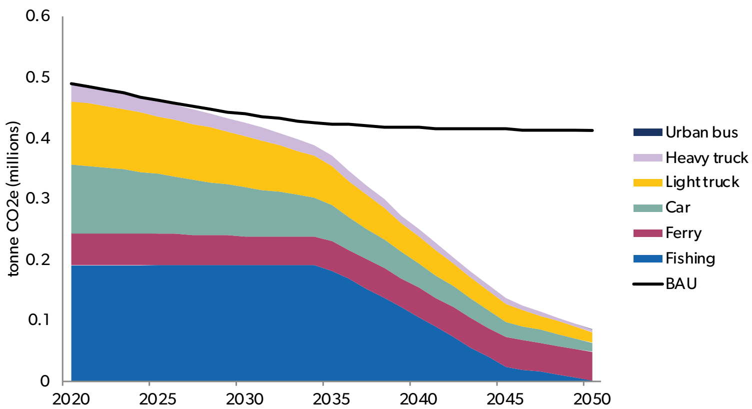


Figure 31. Figure 30. GHG emissions in transportation Mt CO_2e) by vehicle type in the Clean Energy scenario, 2020-2050.

Emissions from the transportation sector decrease by 83% from 2016 to 2050, representing a 79% decreased over the BAU scenario. Emissions are reduced for all fuel types except for grid electricity, because of the increased use of EVs.

Emissions reduce in on-land transportation because of switching to electricity instead of gasoline and diesel, and particularly the use of locally-generated renewable electricity, which produces no net GHG emissions.

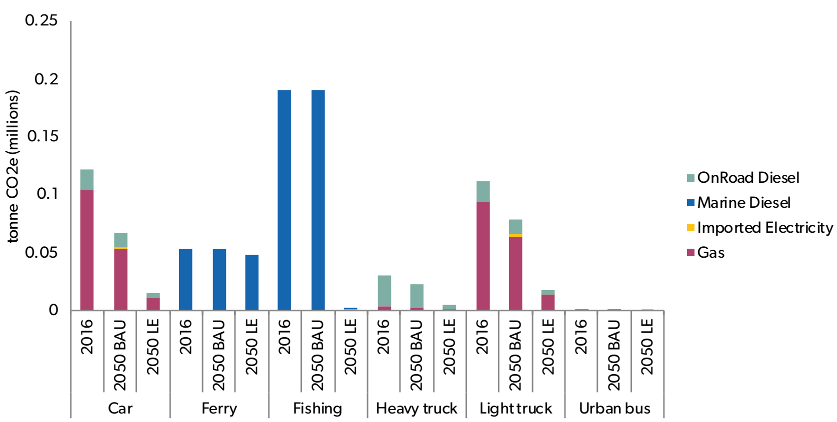


Figure 32. Figure 31. GHG emissions ($MtCO_2e$) from transportation by source and vehicle type in the BAU and Clean Energy scenarios.

Energy consumption from private vehicles falls by nearly 70% by 2050 in the Clean Energy scenario, primarily due to the efficiency of electric vehicles.

6.5 Waste

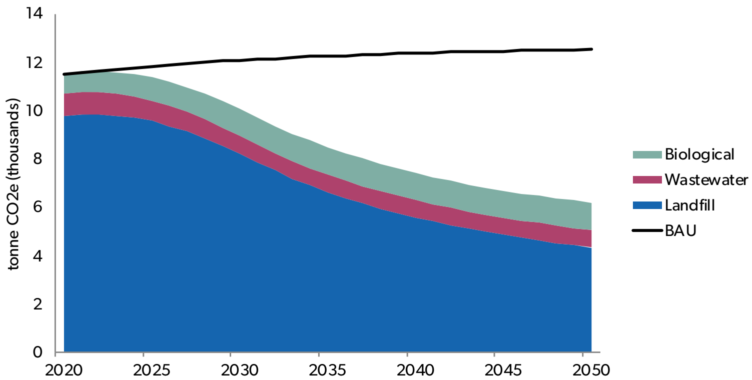


Figure 33. GHG emissions (ktCO_2e) from waste in the Clean Energy scenario, 2020-2050.

GHG emissions from landfill significantly outweigh emissions from wastewater and organics processing (biological). This is due to both the continued addition of waste to landfill, but also as a result of the ongoing decay of existing waste in landfill [that has been added over many years in the past] that continues to produce methane.

Waste emissions decrease by 44% from 2016 to 2050 under the low energy scenario, as a result of increased diversion of waste from landfills to recycling and composting facilities, as well as energetic efficiencies in water and wastewater pumping.

7. Economic Impact: The Big Picture

7.1 An Investment Opportunity

High-level financial analysis was undertaken to identify the required expenditures, savings, the net present value, marginal abatement costs, and employment impacts of all clean energy scenario actions. In both the BAU scenario and the Clean Energy scenario, buildings, transportation, and energy expenditures are made and savings occur. Financial information here is presented as the incremental additional expenditures required and costs and savings resulting from implementing the actions over expenditures, costs, and savings that would be incurred in the BAU scenario.

The Clean Energy Economy is a $1.6 billion dollar investment opportunity in the Western Region over the next 30 years.[24]

7.2 Unlocking Savings

Costs and savings modelling considers upfront capital expenditures, operating and maintenance costs (including fuel and electricity), and carbon pricing. Table 4 summarizes expenditure types that were evaluated. Figure 33 displays the Clean Energy scenario's modelled costs and savings.

Table 4. Categories of expenditures evaluated.

CATEGORY	DESCRIPTION
Residential buildings	Cost of dwelling construction and retrofitting; operating and maintenance costs (non-fuel).
Residential equipment	Cost of appliances and lighting, heating and cooling equipment.
Residential fuel	Energy costs for dwellings and residential transportation.
Residential emissions	Costs resulting from a carbon price on GHG emissions from dwellings and transportation.
Commercial buildings	Cost of building construction and retrofitting; operating and maintenance costs (non-fuel).
Commercial equipment	Cost of lighting, heating and cooling equipment.
Commercial vehicles	Cost of vehicle purchase; operating and maintenance costs (non-fuel).
Non-residential fuel	Energy costs for commercial buildings, industry and transport.

[24] The $1.6 billion capital investment is not discounted. With a 3% discount, the benefit is $1.1 billion.

CATEGORY	DESCRIPTION
Non-residential emissions	Costs resulting from a carbon price on GHG emissions from commercial buildings, production and transportation.
Energy production emissions	Costs resulting from a carbon price on GHG emissions for fuel used in the generation of electricity and heating.
Energy production fuel	Cost of purchasing fuel for generating local electricity, heating or cooling.
Energy production equipment	Cost of the equipment for generating local electricity, heating or cooling.
Municipal capital	Cost of the transit system additions (no other forms of municipal capital assessed).
Municipal fuel	Cost of fuel associated with the transit system.
Municipal emissions	Costs resulting from a carbon price on GHG emissions from the transit system.
Energy production revenue	Revenue derived from the sale of locally generated electricity or heat.
Personal use vehicles	Cost of vehicle purchase; operating and maintenance costs (non-fuel).
Transit fleet	Costs of transit vehicle purchase.
Active transportation infrastructure.	Costs of bike lane and sidewalk construction.

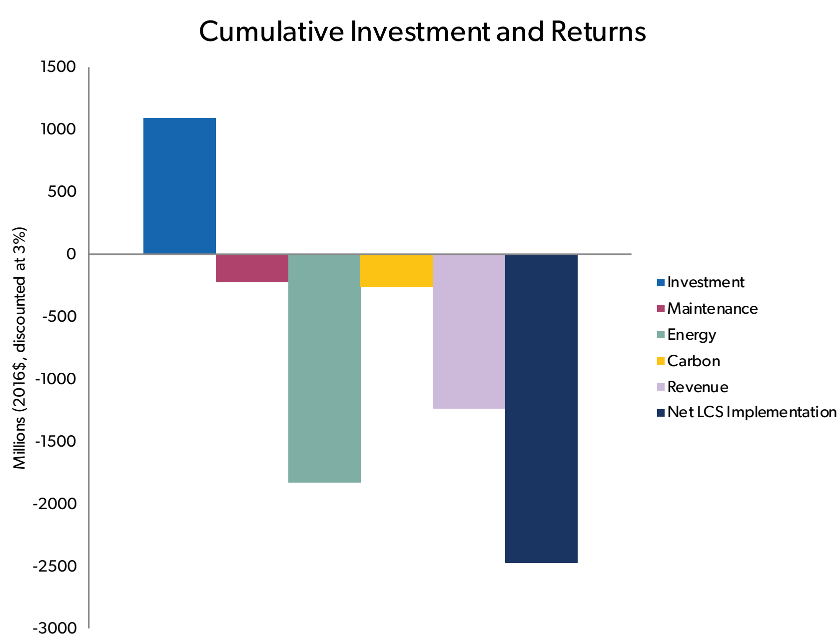


Figure 34. Total incremental costs (above X-axis) and savings (below x-axis) by category in the Clean Energy scenario over the BAU scenario, 2020-2050, discounted at 3%.

By 2050 cumulative Clean Energy scenario has a present value of $2,480 million (savings with a social discount rate of 3%). Without energy revenues, the net benefit is still $1,240 million. Savings in each category increase over time as energy efficiency and energy generation actions increasingly result in avoided operations and maintenance costs, carbon pricing, and energy costs.

After 2031 savings start to outweigh costs. This is the year when the Clean Energy scenario achieves its annual break-even point. Energy cost savings are experienced by households (dwelling and transportation energy expenditures), businesses and the public sector.

Table 5. Summary of financial metrics for the Clean Energy scenario (2016 $, millions).

CATEGORY	UNDISCOUNTED WITH REVENUE	DISCOUNTED WITH REVENUE	DISCOUNTED WITHOUT REVENUE
Investment	$1,666	$1,087	$1,087
Maintenance	-$244	-$223	-$223
Energy	-$2,670	-$1,829	-$1,829
Carbon	-$405	-$270	-$270
Revenue	-$2,556	-$1,245	0
Net savings	-$4,210	-$2,480	-$1,235

The investment in the Clean Energy Economy generates a net benefit of $4.2 billion. [25]

7.3 The Big Picture

Figure 35 provides a detailed year-by-year breakdown of costs, fuel and electricity savings, and carbon price credits in the Clean Energy scenario over the BAU scenario. The dotted line illustrates the cumulative cost/benefit of the investments and savings over the period. Over the long run, savings begin to accumulate as a result of the early investments, climbing to over $4.2 billion (2019$) by 2050.

The majority of costs (above the x-axis) are in renewable energy, building retrofits and equipment (e.g. heat pumps). The majority of savings (below the x-axis) are in residential and commercial avoided carbon pricing expenses, residential and commercial energy cost savings, and personal and commercial vehicle O&M and energy costs.

[25] The $4.2 billion is not discounted. With a 3% discount, the benefit is $2.5 billion.

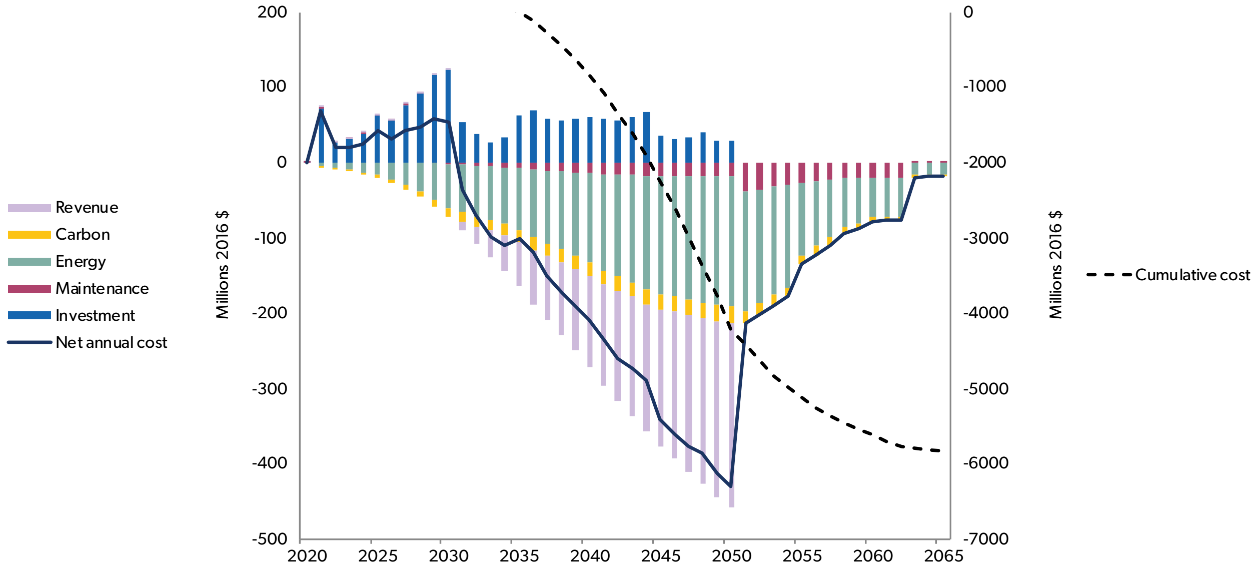


Figure 35. Annual incremental costs and savings in the Clean Energy scenario over the BAU scenario.

Residential fuel costs include those spent on fuel for vehicles. They switch from being a net cost to a net savings after 2031 as EV ownership reaches a tipping point – net vehicle fuel costs decrease as electricity is cheaper than gasoline and diesel. Businesses increasingly save on O&M and fuel costs as buildings energy efficiency increases.

Carbon pricing increases the value of fuel and electricity savings, modestly in the first half of the time period but more significantly in later years as it increases. In 2050, carbon pricing savings from the Clean Energy scenario implementation reaches over $22M. Cumulative carbon pricing savings over the 2020–2050 period totals $270M, with a present value of $269M.

7.4 Capital Investments

Capital costs for the Clean Energy scenario are summarized in Figure 36.

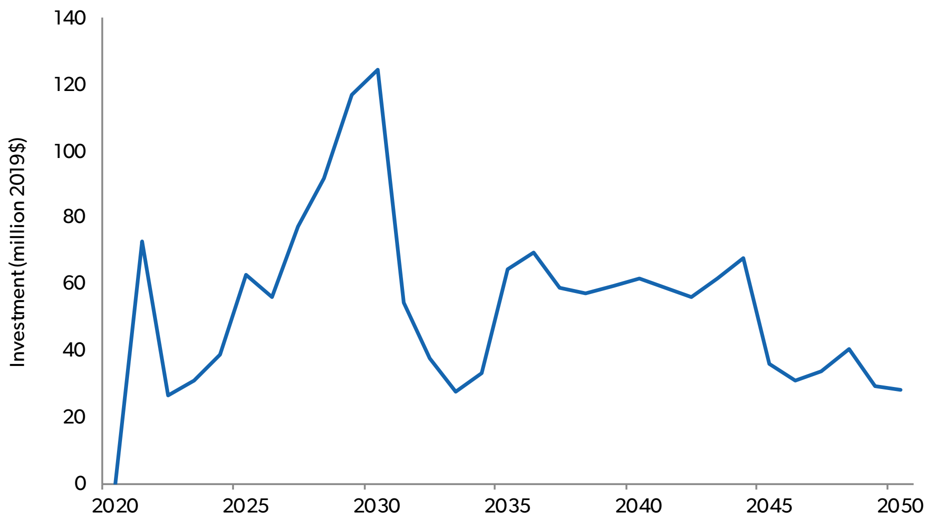


Figure 36. Annual incremental capital costs in the Clean Energy scenario over the BAU.[26]

Most major energy generation systems, and buildings occur in the first decade of the Clean Energy scenario. The average annual total expenditure over the 2020-2050 time period is ~$55M.

Residential and commercial retrofit costs increase over the time period, as more and more buildings are retrofit for energy efficiency. After peaking in the late 2020s, personal vehicle costs steadily decrease as EV ownership grows. The analysis assumes that the cost of electric vehicles will be lower than internal combustion engines by the middle of 2040, a conservative projection.[27]

[26] Details of this are shown in B3, in Appendix B.

[27] Some projections indicate that cost parity could be reached as early as 2025. See: https://about.bnef.com/blog/electric-cars-reach-price-parity-2025/

7.5 Energy Costs

Figure 36 depicts the expected total energy (fuel and electricity) costs for the Clean Energy scenario versus the BAU scenario.

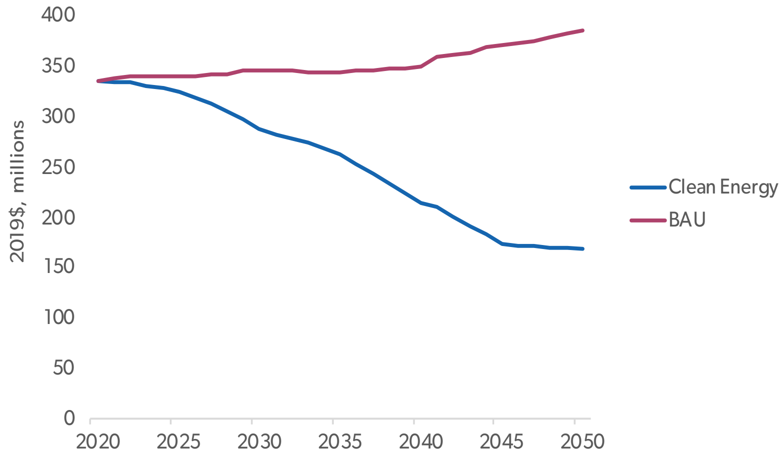


Figure 37. Estimated total annual energy costs for the BAU scenario (red and the Clean Energy scenario (blue).

In 2016, total energy costs paid by households, businesses and other organizations totalled $327M. Diesel accounted for 44% of costs, gasoline sales for 28%, electricity for 17%, and heating oil for 8%. Energy prices are projected to increase in the BAU scenario to $385 million by 2050, although ongoing improvements in vehicle and buildings efficiency offset some of the increase, resulting in a slight annual energy cost increase by 2050. Under the implementation of the Clean Energy scenario, energy costs are reduced by 56%.

In the BAU scenario, costs increase for nearly all sectors, as shown in Figure 38.

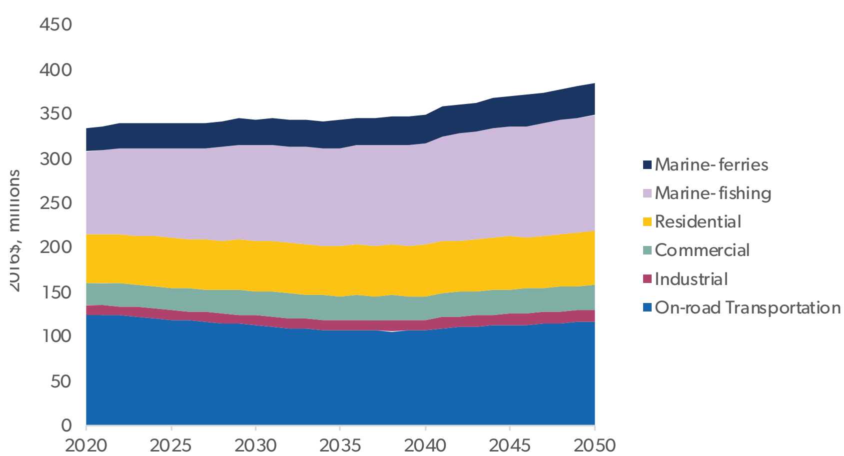


Figure 38. Total BAU annual energy costs by sector.

In the Clean Economy scenario, overall energy costs are lower than under the BAU scenario in all sectors. (Figure 38).

Energy costs are lower in the Clean Energy Economy. Energy expenditures in Western Region fall from $327 million per year to $168 million per year by 2050.

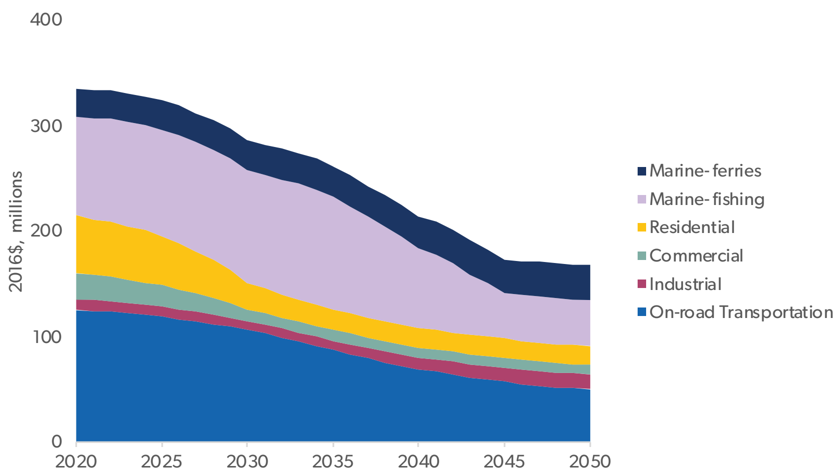


Figure 39. Projected energy expenditures by sector, 2016-2050, Clean Energy scenario.

Energy expenditures decrease by 48% between 2016 and 2050 in the Clean Economy scenario, with the biggest decreases in fuels to heat buildings (wood, fuel oil, and some propane) replaced by an increase in spending on electricity.

Expenditures on diesel decrease by 72%, with fuel switching to electricity, hydrogen and biodiesel both on land and on sea. The full details are shown in Table B1.

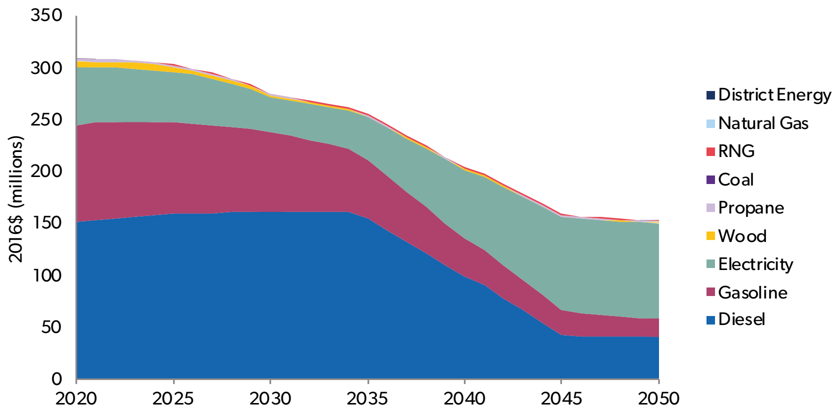


Figure 40. Projected energy expenditures, 2016-2050, Clean Energy scenario

Household energy expenditures fall from $5,800 to $2,100 by 2050.

Table 6. Household energy expenditures in the BAU and Clean Energy scenarios

	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU- 2050 LE
Diesel	$ 99	2%	$ 100	2%	$22	1%	-78%	-78%
Electricity	$ 1,365	23%	$1,464	27%	$1,386	66%	2%	-5%
Fuel oil	$ 851	15%	$ 1,046	19%	$105	5%	-88%	-90%
Gasoline	$ 3,261	56%	$ 2,564	47%	$ 569	27%	-83%	-78%
Propane	$18	0%	$ 21	0%	$ 1	0%	-93%	-94%
Wood	$ 248	4%	$ 290	5%	$ 16	1%	-93%	-94%
Total	$5,842		$ 5,486		$ 2,100		-64%	-62%

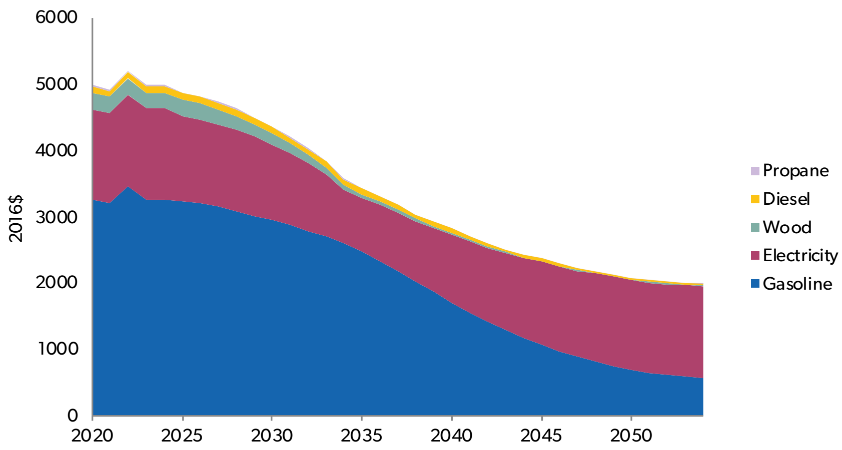


Figure 41. Projected energy expenditures per household by fuel, 2016-2050, Clean Energy scenario.

7.6 Marginal Abatement Costs

The marginal abatement cost (MAC) is a measure of the cost or savings of reducing GHG emissions for a particular action. The MAC divides the total costs or savings of the action, as represented by the net present value (NPV), by the total GHG emissions reductions associated with that action over its lifetime. The result is a cost or savings per tonne of GHG emissions reduced. An action with a high positive cost/tonne is an expensive GHG emissions reduction, whereas an action with a negative marginal abatement cost indicates that money is saved for every tonne of GHG emissions reduced.

Figure 42 summarizes the MAC analysis for the Clean Energy scenario. All but four of the actions result in savings in present dollars, discounted at 3%, over the period from 2020 to 2050.

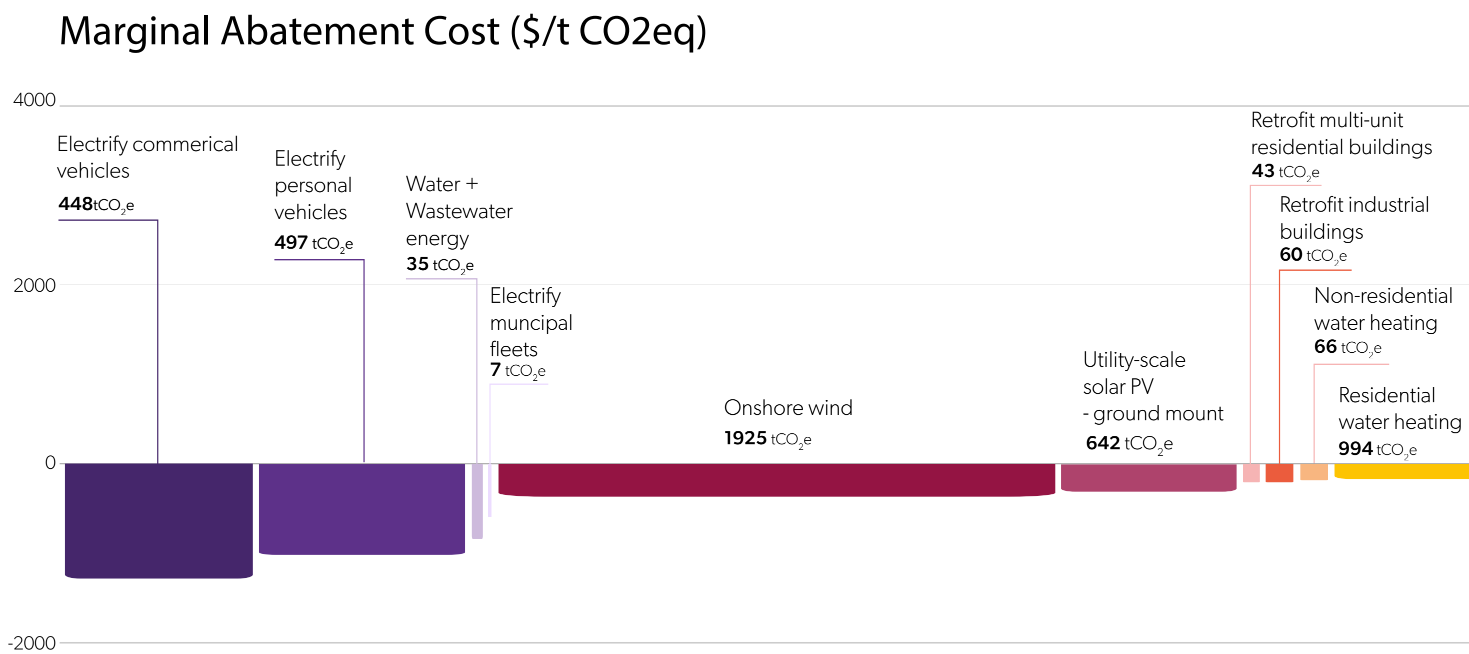
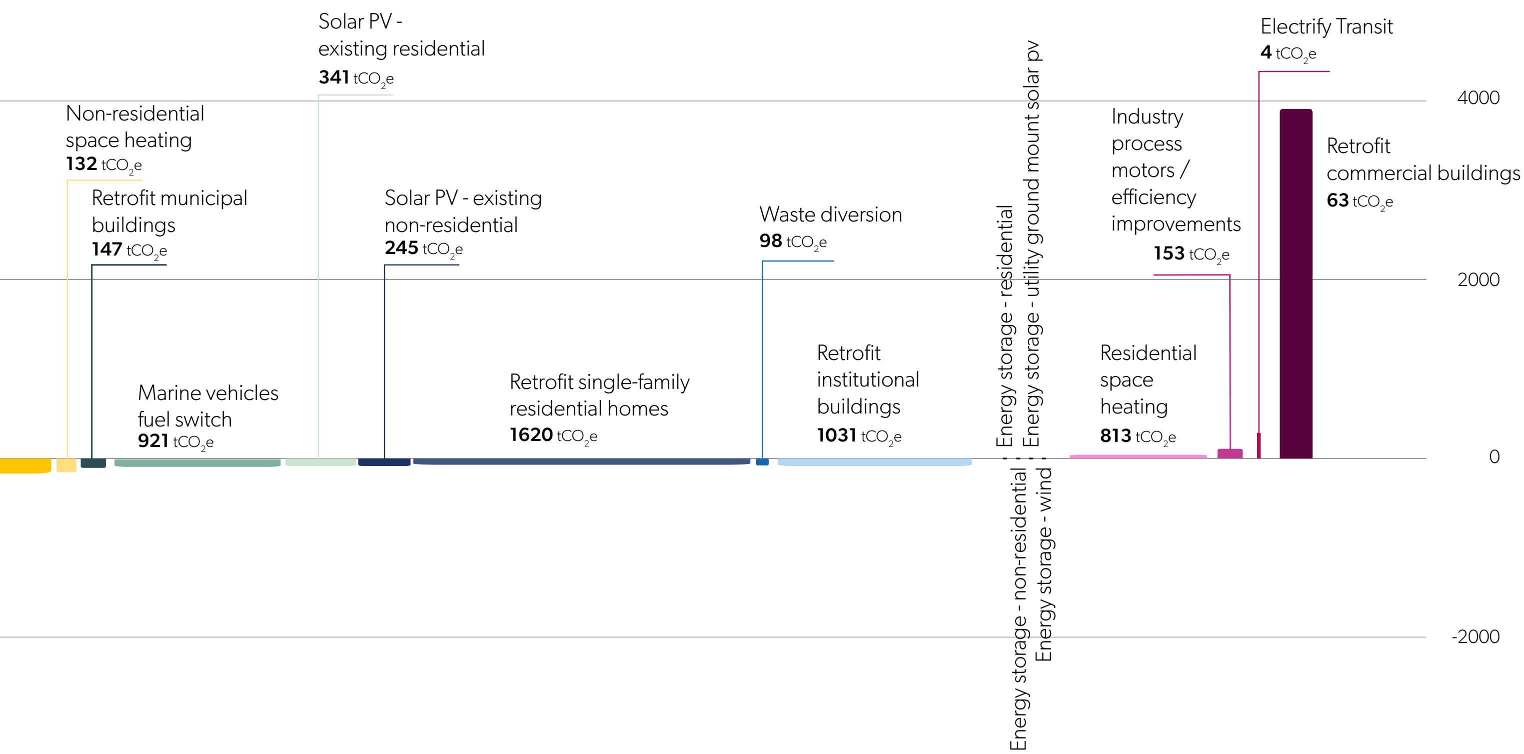


Figure 42. Marginal abatement cost curve for the Clean Energy scenario, showing the cost/savings per tonne of emissions reduced. Horizontal axis: tonnes CO_2e reduced by the action (wider bars = greater reductions). Vertical axis: net financial return or cost of the action (taller bars = greater return/cost).

Commercial retrofits, residential heat pumps, and the electification of transit result in emissions reductions but have a positive abatement cost. These measures therefore impose a net financial cost on the community, even over the long term, although this could change in the future as technologies develop and markets expand. It is important to note that marginal abatement cost is only one metric for evaluating the merits of actions. It does not consider other co-benefits that may also be important to the community (e.g. employment, air quality, local environmental impacts).

A carbon price aligned with the federal projection that starts at \$10/tCO_2 in 2018, increasing to \$50/tCO_2 by 2022, and to \$114 \$/tCO_2 by 2050[28] was applied to BAU carbon emissions (CO_2 only) to 2050 to approximate the cost of carbon.

Total carbon cost expenditures climbs from \$27 million in 2020 to \$38 million in 2050 in the BAU. In the Clean Economy scenario, this cost falls to \$6 million by 2050. Figure 42. Projected carbon expenditures by sector, 2016-2050.



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28 Government of Canada (2018). Technical paper: federal carbon pricing backstop. Retrieved from: https://www.canada.ca/en/services/environment/weather/climatechange/technical-paper-federal-carbon-pricing-backstop.html

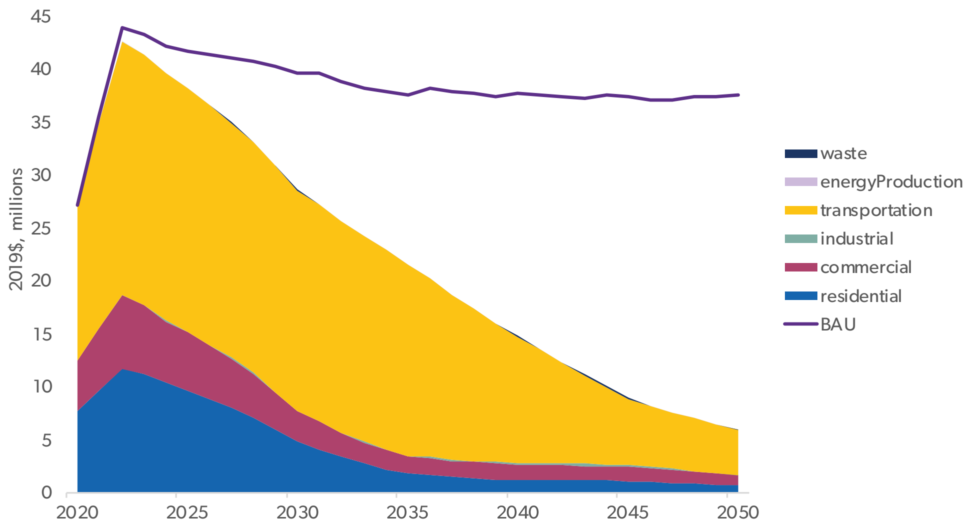

Figure 43. Projected carbon expenditures by sector, 2020-2050.

7.7 Employment

Capital expenditures in the Clean Energy scenario result in increased employment in the Western Region. Employment factors for each sector were used to translate each million dollars of activity into full-time equivalent jobs. The Clean Energy scenario is estimated to generate almost 4,800 person years of employment between 2020 and 2050, or an average of over 160 per year over the BAU scenario. More than 1,600 of these positions occur in the next ten years, to provide retrofits in residential and commercial buildings. Some automotive jobs are expected to decline as a result of automation, but the net result is still an increase in employment.

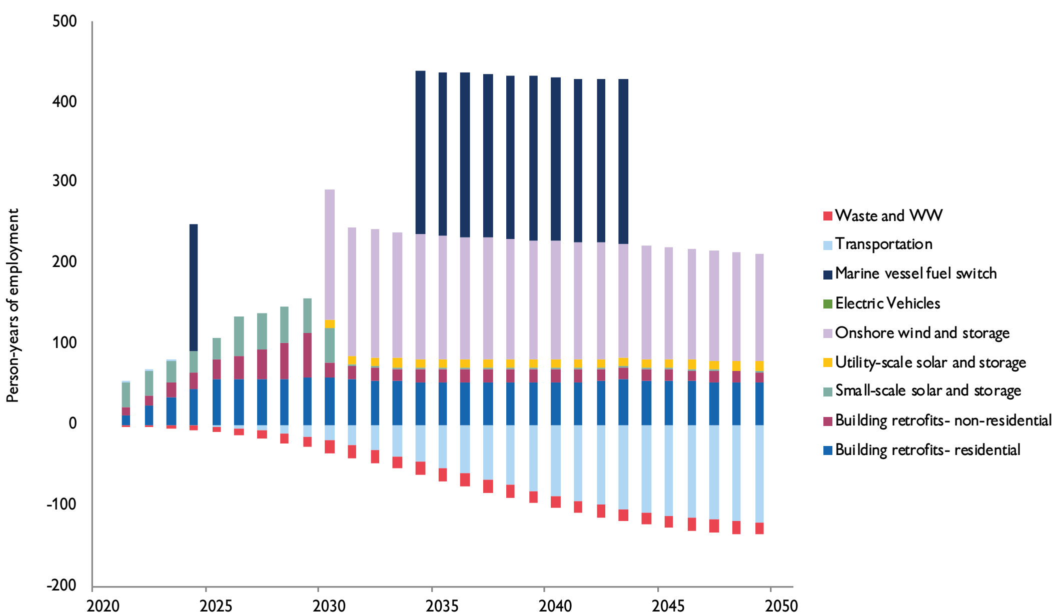

Figure 44. Impacts of investments in the Clean Energy scenario on employment by sector, 2020-2050

Investments in the Clean Energy Economy will generate more than 1,600 job-years of employment over the next ten years.

7.8 Summary

This analysis reveals that implementation of the Clean Energy scenario will require upfront investments by the municipalities, public and non-profit institutions, residents, and the private sector, especially in the coming decade. However, long-term savings far outweigh these investment costs, and will therefore create significant economic value for the community over the long-term.

This discussion has focused on the benefits of implementing the Clean Energy scenario. Conversely, the risk of doing nothing is also significant. Risk is defined as the probability of an event combined with the severity of its impacts. In the context of this analysis, risks include the following:

- A slower response to mitigation and therefore more severe impacts of climate change;
- A missed opportunity to transition to low carbon systems and therefore an increased burden on the Western Region, households and the private sector to support the transition;
- A missed opportunity for leadership in the public and private sector; and
- A missed opportunity to acquire co-benefits in improved health outcomes, economic development, a more resilient energy system, and improved quality of living that are synergistic with the Clean Energy scenario energy and emissions outcomes.

8. Opportunities

Meeting climate goals requires...

"Rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems. These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed..." [29]

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2018)

[29] Hoegh-Guldberg, O., Jacob, D., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., ... & Hijioka, Y. (2018). Impacts of 1.5 C global warming on natural and human systems. Global warming of 1.5° C. An IPCC Special Report

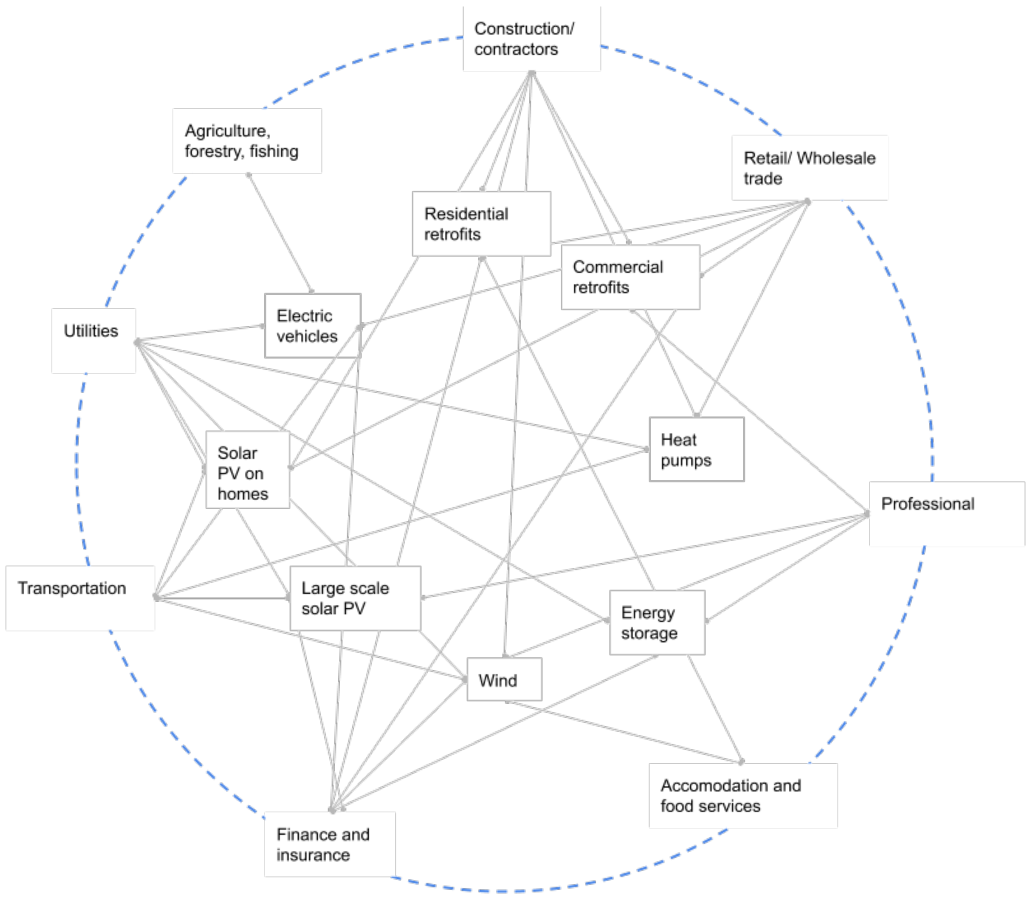

Figure 45. Mapping the opportunities from key actions in the Clean Energy scenario to employment sectors in the Western Region.

The actions evaluated in the Clean Energy scenario constitute a package of investments that can be undertaken in the Western Region. In many cases the actions are synergistic, for example, retrofits reduce electricity consumption and create space on the grid for electrification of transportation. Depending on the business case, these investments can be undertaken by the private or public sector. In each case, the financial package and delivery mechanism will be different, and some of the actions can be bundled together- for example, a retrofit package can combine thermal envelope retrofits, heat pumps and solar PV. Possible delivery mechanisms will be explored in detail in the implementation chapter.

Table 7. GHG emissions and financial impacts of the actions modelling in the Clean Energy scenario.

OPPORTUNITY	CUMULATIVE EMISSIONS REDUCTION (KT CO2EQ)	MARGINAL ABATEMENT COST ($ / T CO2 EQ)	COST OF INVESTMENT	GAIN OF INVESTMENT
Retrofit single-family residential homes	1,620	-$35	$383,508,000	-$440,036,000
Retrofit multi-unit residential buildings	43	-$205	$1,671,000	-$10,500,000
Retrofit commercial buildings	-63	$3,925	$7,797,000	-$256,358,000
Retrofit institutional buildings	1,031	-$16	$5,593,000	-$22,453,000
Retrofit municipal buildings	147	-$85	$6,954,000	-$19,371,000
Retrofit industrial buildings	60	-$204	$1,662,000	-$13,952,000
Industry process motors/ efficiency improvements	153	$99	$35,366,000	-$20,127,000
Residential space heating	813	$21	$122,864,000	-$105,935,000
Residential water heating	994	-$175	$14,450,000	-$188,643,000
Non-residential space heating	132	-$171	$1,692,000	-$24,177,000
Non-residential water heating	66	-$183	$151,000	-$12,255,000
Solar PV - existing residential	341	-$48	$75,315,000	-$91,646,000
Solar PV - existing non-res	245	-$46	$54,486,000	-$65,717,000
Energy storage - residential	0	$0	$28,196,000	$0
Energy storage - non-res	0	$0	$21,156,000	$0
Electrify transit	4	$292	$3,520,000	-$2,422,000
Electrify municipal fleets	7	-$566	$185,000	-$4,095,000
Electrify personal vehicles	497	-$1,019	$15,529,000	-$522,033,000
Electrify commercial vehicles	448	-$1,275	$869,000	-$572,634,000
Waste diversion	98	-$19	$0	-$1,902,000
Water & WW energy	35	-$841	$1,118,000	-$30,465,000
Marine vehicles fuel switch	921	-$48	$182,746,000	-$227,237,000
Utility-scale solar PV - ground mount	642	-$296	$127,962,000	-$317,949,000
Onshore wind	1,925	-$377	$228,913,000	-$954,020,000
Energy storage - utility ground mount solar PV	0	$0	$27,379,000	$0
Energy storage - wind	0	$0	$54,767,000	$0

8.1 Building Retrofits

1.BUILDING RETROFITS (2020-2050)	
Dwellings retrofit	19,800
Commercial floor space retrofit	1 million m^2
Investment	$581 million
Person years of employment	2,044
Sectors	Primary: Construction, Secondary: Retail/Wholesale, Professional Services, Finance/Insurance, Utilities
Possible Innovation	Commodification of retrofits

Retrofits reduce the energy use intensity of building operations and the GHG emissions intensity of fuels used in a building. Envelope retrofits minimize thermal energy loss through the walls, windows and roof of a building, requiring less energy to maintain the same levels of comfort. Achieving zero carbon or nearly zero carbon in existing buildings also requires on-site generation to meet residual energy needs, and fuel switching.

Retrofits are essential to a broader decarbonization effort for the following reasons:

- The financial savings from the efficiency gains retrofits provide a cash flow for fuel switching to higher cost but lower carbon fuels (i.e. from natural gas to electricity).
- The avoided electricity consumption creates space on the electricity grid for electric vehicles and electric heating without requiring major investments in new generating and transmission capacity.

Retrofits also support a wide range of co-benefits such as reducing energy poverty. Building retrofits can improve ventilation in existing buildings, which can support improved health for its employees, and can actually contribute to improve work performance.[30] Retrofits are critical to increasing resilience to climate changes. Energy efficiency retrofits for buildings, both residential and non-residential, will result in energy use savings. These retrofits include improvements to the building envelope, switching to heat pumps for space heating and cooling and water heating, and switching to efficient appliances to reduce energy demands. To meet these ambitious building retrofit targets, a new industry of local workers, materials, and expertise will need to be built. Within this industry, several promising opportunities stand out.

[30] MacNaughton, P., Satish, U., Laurent, J. G. C., Flanigan, S., Vallarino, J., Coull, B., … Allen, J. G. (2017). The impact of working in a green certified building on cognitive function and health. Building and Environment, 114, 178–186. https://doi.org/10.1016/j.buildenv.2016.11.041

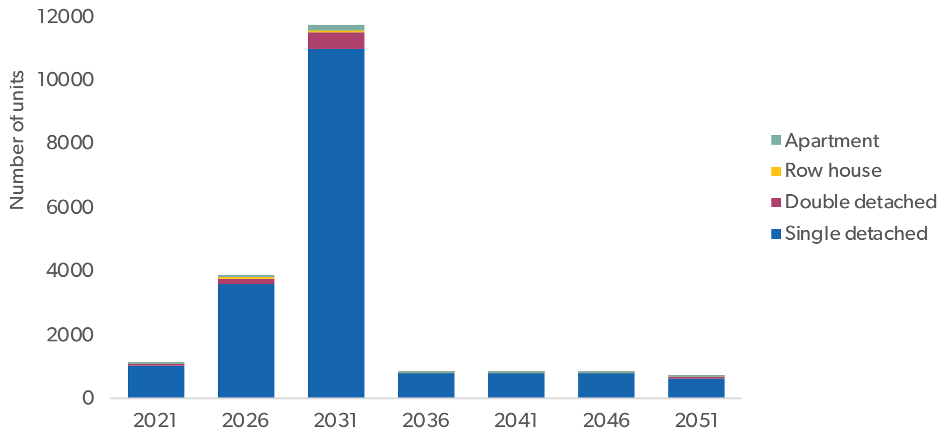

Figure 46. Number of dwellings targeted for deep retrofits in the Clean Energy scenario.

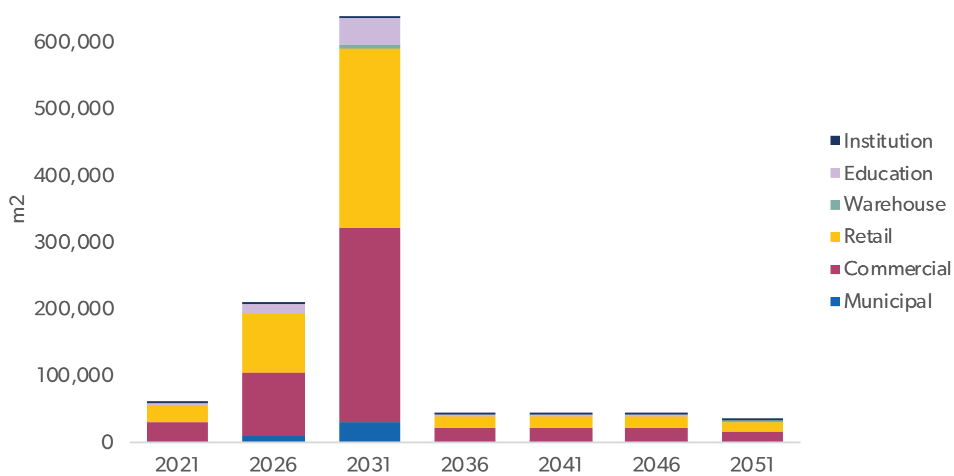

Figure 47. Floor space of non-residential buildings targeted for deep retrofits in the Clean Energy scenario.

HEAT PUMP INSTALLATION

Building retrofits will require a skilled labourforce that is trained to install a variety of heat pumps. Traditional air-source heat pumps use HFCs or HCFCs as a refrigerant gas, which is being phased out in Canada. The alternative is to install R744 heat pumps, which use CO_2 as the refrigerant gas, rather than HFCs or HCFCs. These heat pumps can extract heat from the outdoor air down to -15°C, provide heat and cooling up to 90°C, and have a higher coefficient of performance than traditional heat pumps.

The table below gives a high-level comparison of the estimated costs and benefits of converting oil furnaces to electric heat pumps, for individual homes and for Western Nova Scotia. It was assumed that the average size of homes is 150 m^2.

CO_2 heat pumps do not require a refrigeration mechanic to be installed, and can instead be installed by a plumber. This style of heat pump is used in locations across Canada, and around the world.

BUILDING RETROFIT BUSINESSES

To coordinate and facilitate wide-spread building retrofits, particularly residential retrofits, will require the development of new businesses that can carry out all phases of a retrofit, from electrical upgrades, water efficiency modifications, building envelope improvements, and heat pump installations.

The building retrofit industry would generate over 2,000 person-years of employment between 2021 and 2050, with the majority of those by 2030.

COMMODIFICATION OF RETROFITS

Achieving the levels of energy efficiency that would be consistent with the deep decarbonization required to respond to the climate emergency will require the commodification of building retrofits. Further, this commodification must not be achieved at the expense of the depth of the savings achieved in individual buildings. On the contrary, the retrofits must transform the thermal efficiency of building envelopes to low energy building status, while at the same time achieving widespread adoption of electric heat pumps, thermal networks, increasing cooling demands related to warming temperatures and building-based electricity generation and storage. Commodification of retrofits implies bulk purchasing of equipment, economy of scale and a shift in focus from individual buildings to a portfolio.

ENERGIESPRONG: TRANSFORMING THE RETROFIT MARKET

The EnergieSprong program provides a turn-key retrofit service to existing buildings to convert them to Net-Zero or Net-Zero ready when renewable energy is available.[31] Energiesprong retrofits can be completed in 10 days and have been successful in updating social housing without requiring upfront capital from tenants.[32] As the process has evolved for Energiesprong, costs have decreased by 60% in three years.[33] While EnergieSprong has currently focused on houses, New York State Energy Research and Development Authority (NYSERDA)'s program RetrofitNY is based on EnergieSprong with the objective of creating a volume market for net-zero retrofits with larger buildings. Natural Resources Canada is currently working on a similar project titled Prefabricated Exterior Energy Retrofits (PEER) in the National Capital Region. To date, the EnergieSprong model has been primarily applied to single family homes and small apartment buildings.

CELLULOSE INSULATION MANUFACTURING

Traditional foam insulations used in buildings are made of polystyrene or polyurethane foam, derived from petroleum products and expanded using HFCs, a potent greenhouse gas. As a signatory to the Kigali amendment to the Montreal Protocol, which was agreed to by 198 countries in October, 2016, Canada has committed to phasing out the use of these gases.

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31 Sustainable Buildings Canada. (2016). Energiesprong Summary Report. Retrieved from: https://sbcanada.org/wp-content/uploads/2017/09/Energiesprong-Summary-Report.pdf

32 "How-to-Guide: Net-Zero Retrofit Technical and Cost Benchmark Studies." Rocky Mountain Institute, n.d. https://www.rmi.org/rmi_techno_economic_study_how_to_guide/.

33 Ibid.

Cellulosic insulation is one alternative to foam or fibreglass insulation. This material is made from recycled newspaper or waste wood, which is treated with a fire retardant. The thermal performance of cellulosic insulation is comparable to that of fibreglass, at between 0.038 and 0.040 W/m^2K. Cellulosic insulation can either be blown into the wall cavities and attic spaces of existing buildings, or installed in the form of batts under floors and in walls in new construction.

From an economic development point of view, wood waste has a value of $100 to $120 per tonne as fuel, while high density cellulose is worth more than $1,200 per tonne.

Potentially, this insulation could be blended with shredded used fabric and clothing. Doing so would create a high-value use for a component of solid waste which is otherwise difficult to recycle. Used clothing comprises a significant fraction of solid waste.

The Western REN could support the development of a cellulose insulation manufacturing plant, in conjunction with the local forestry industry to ensure a reliable supply of waste wood, and could support the development of training for small, local companies to develop the expertise to install cellulose insulation, along with completing other building retrofits.

TRAINING A NEW WORKFORCE

Western Nova Scotia is home to two campuses of the Nova Scotia Community College, in Digby and Yarmouth, as well as L'Université Sainte-Anne, in Pointe-de-l'Église. These education centres could develop training programs to equip the retrofit workforce with the skills they will need. In addition, by working closely with the university and college campuses, the potential for collaboration, exploration, and innovation greatly increases.

The Western REN can support this by working with the secondary education centres to develop training programs to help develop this workforce, as well as encouraging small pilot projects and experimentation to test new technologies in the community.

8.2 Energy

2. RENEWABLE ENERGY (2020-2030)	
Wind	221 MW
Solar	161 MW
Energy storage	285 MW
Investment	$618 million
Jobs	3,560
Sectors	Primary: Utilities, Construction, Secondary: Retail/Wholesale, Professional Services, Finance/ Insurance
Possible Innovation	Microgrids

The Clean Energy scenario envisions the installation of 221 MW of wind energy and 161 MW of solar PV primarily for local consumption. Each installation would be accompanied by storage to balance the intermittent generation characteristics of the renewable technologies. There are various strategies for the deployment of these renewable technologies, including negotiating with NS power, developing one or more microgrids and lobbying the provincial government for enabling legislation.

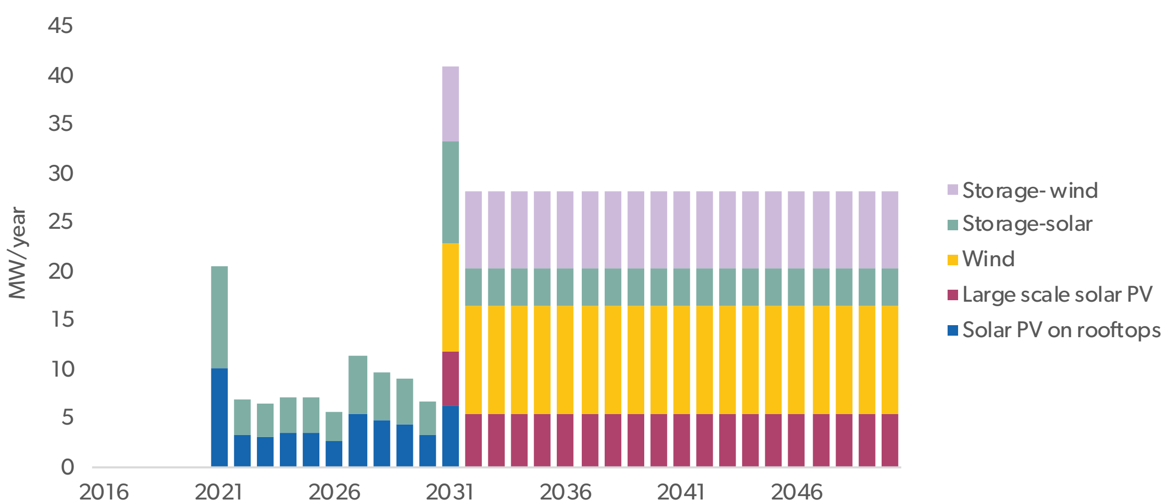

Figure 48. Annual capacity (MW) of renewable energy and storage installed in the Clean Energy scenario.

A share of the solar PV capacity will be installed on homes and businesses through a program such as net metered. Every installation, irrespective of scale, incorporates storage (both battery and Electric Thermal Storage) to manage peak demands and avoid curtailment during periods of low demand.

A simple comparison shows that electricity generated through solar PV and stored with a modest amount of battery capacity is competitive with purchased electricity today. If low-interest loans (say at 2%) are made available for this purpose, then the cost of electricity from a solar PV and battery installation would be about 10% lower than the value shown in the table.

Table 8. Solar PV costs, 2020

	VALUE	UNITS	NOTES
SOLAR PV POTENTIAL, NOVA SCOTIA	**1,200**	**KWH/ KW/YR**	
Installation Area, Typical	50	m^2	
PV Module Performance	160	W/m^2	Canadian Solar 330W units
Capacity of Each Installation	8.0	kW	
Electricity Yield	9,600	kWh/yr	
Annual Electricity Consumption	18,800	kWh/yr	
Average Hourly Electricity Consumption	2.2	kW	
Peak Hourly Electricity Consumption	8.4	kW	
Hours of Peak Battery Capacity Required	4	hours	
Battery Capacity Required	33.8	kWh	
Installed Price of Solar PV Panels	$2.10	$/Watt	
Installed Price of Batteries	$250	$/kWh	Price Trend
FOR DESCRIBED INSTALLATION:			
Cost of Solar PV Equipment	$16,800		Panels, inverters, controller
Cost of Batteries	$8,400		
Cost of Installation Labour	$8,000		
Total Cost	$33,200		
Electricity Cost Savings, Peak Basis	$1,940		
Financing costs	$1,900		25 years at 3% interest

A NOTE ON TIDAL ELECTRICITY GENERATION

The Western Region has several existing tidal generation locations within the Digby area, and surroundings. One of these stations, located in Granville Ferry,feeds into the NSPI electricity grid, and so is accounted for in the provincial averages used to assess GHG emissions from power generation, and the capacity of the grid. The other two stations on Digby Neck are experimental, and not yet grid-connected.

The Bay of Fundy, however, has immense potential to provide significant tidally-generated electricity. The bay has multiple experimental generation platforms, testing designs able to withstand the forces and environment of the Bay. While none are currently producing grid-connected electricity, continued investment and experimentation makes tidal generation likely in the future.

This modelled scenario doesn't explicitly include estimates for tidal generation, but any or all of the renewable electricity currently earmarked as solar or wind could be accommodated by tidal generation without significant changes to the GHG reductions, or energy future for the region. Changing to turbines in the ocean from turbines on land would have impacts on the financial projections in this report, but deviation from the modelled results is expected with technological improvements and changes. Because of the differences in the efficiency of tidal generation compared with wind generation, less tidal infrastructure may be required to meet the energy demand.

FEDERAL GOVERNMENT RENEWABLE ENERGY PROCUREMENT

As a result of a commitment to purchase 100% renewable electricity by 2022, the Government of Canada will be procuring new wind and solar generation in Nova Scotia in the near future.[34] There are opportunities to both supply this renewable energy and to join the procurement as a municipality or other entity.

EMERGING TRENDS IN THE ELECTRICITY SECTOR

- Solar + storage: Solar PV is now frequently installed with battery storage, to reduce the variability of solar-supplied electricity. It also allows solar PV to function in a power outage, which improves climate resilience.
- Building integrated solar: This refers to solar PV that is integrated into building components, such as roof tiles, facades and windows. Building integrated solar can in theory reduce costs of installation because it directly replaces a building component that is already required.
- Microgrids: Decentralized energy systems or microgrids can also be installed on a neighbourhood or city-block scale. They can also be installed alongside thermal district energy systems in a cogeneration system, providing a single source of energy and heating for a large group of buildings, integrated with various forms of storage.
- Power to hydrogen: Hydrogen is useful fuel that can be used for transportation, industry, energy storage and heat and power generation. Power to hydrogen uses periods of excess generation from intermittent renewable energy to generate hydrogen using electrolysis. While this process is currently expensive, the economics are projected to become more favourable in the future.[35]
- Blockchain: Blockchains provides a record keeping mechanism to enable distributed energy providers and consumers to trade energy surplus or flexible demand efficiently without centralised control, including tracking contributions to shared energy storage platforms.[36]

[34] For more information on the renewable energy procurement, see: https://novascotia.ca/news/release/?id=20200226008

[35] Glenk, G., & Reichelstein, S. (2019). Economics of converting renewable power to hydrogen. Nature Energy, 4(3), 216–222. https://doi.org/10.1038/s41560-019-0326-1

[36] Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., … Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. Renewable and Sustainable Energy Reviews, 100, 143–174. https://doi.org/10.1016/j.rser.2018.10.014

WEYMOUTH ANAEROBIC DIGESTER

3. RENEWABLE NATURAL GAS	
Energy generation	10,000 GJ
Investment	Not identified
Person years of employment	Not identified
Sectors	Primary: Public sector Secondary: Agriculture/Forestry
Possible Innovation	RNG in ships

The currently-unused anaerobic digester in Weymouth has a capacity of 1,500 m3. While this facility is not currently operational, it could be used to produce biogas from organic waste.[37] This biogas would be used in the following ways:

- Removing hydrogen sulphide but not carbon dioxide from the biogas, and piping it to the community of Weymouth. There, the scrubbed biogas could be burned in an engine to produce electricity and heat. The community is about 400 metres from the Weymouth AD facility.
- If energy from biogas cannot be effectively used in Weymouth, then a better use of this resource could be to remove both hydrogen sulphide and carbon dioxide from the biogas, and compress the resulting biomethane (RNG) for transportation to ferry terminals where it could be used to replace fossil fuel in ferries which are converted to burn compressed natural gas.

If organic waste is digested at the Weymouth facility, then an estimated 10,000 GJ per year of biogas could be produced. If this biogas is burned as RNG/CNG in marine vessels, it would be equivalent to approximately 300,000 litres of diesel per year. If this biogas is burned in an internal combustion engine to produce heat and electricity (CHP), then an estimated 950,000 kWh of electricity and 1,300,000 kWh of heat could be produced per year.

Two options to expand anaerobic digestion in Western Nova Scotia are to “go bigger” and to “go smaller”.

In the smaller-scale approach, containerized anaerobic digesters with small electric generators could be installed at local farms. These digesters could process organic waste and manure, and would produce heat and electricity for use at the farms.

In the larger-scale option, either the Weymouth facility could be expanded or a second facility could be developed at a farm or industrial site. A larger anaerobic digestion facility could potentially receive:

- Well-sorted municipal organic waste from all communities in Western Nova Scotia;
- Organic waste from fish processing and mink farming;
- Primary and secondary biosolids from wastewater treatment plants in Western Nova Scotia;

[37] This facility has recently been sold to a local company who is exploring options for feedstock and value-added products from the digester.

- Organic waste and manure from local farms;
- Waste cooking oils, yellow grease, and brown grease (please see the Other Biodiesel Options - Biomethane (RNG) Waste Oil section); and
- Waste food from grocery stores.

If anaerobic digestion capacity is increased, then an estimated 60,000 GJ per year of biogas could be produced. If this biogas is burned as RNG/CNG in marine vessels, it would be equivalent to approximately 1.7 million litres of diesel per year. If this biogas is burned in an internal combustion engine to produce heat and electricity (CHP), then an estimated 5,400,000 kWh of electricity and 7,700,000 kWh of heat could be produced per year. Since it may be challenging to use this quantity of heat, a better use for energy from a larger facility would be to replace fuel in marine vessels.

BIOMASS

Although greenhouse gas reporting protocols treat carbon dioxide from burning biomass as biogenic and carbon-neutral, in an important physical sense this is inaccurate. If a tree is harvested and burned for energy, the resulting carbon dioxide goes to the atmosphere immediately. This carbon dioxide is only removed from the atmosphere over sixty or seventy years, however. Climate scientists are clearly stating that the timing of emission reductions is important; reductions in the next decade are much more valuable than reductions sixty years from now if the worst effects of global warming are to be avoided. For this reason, only biomass which would otherwise be wasted should be used for energy. Sources of biomass which could be considered carbon neutral include urban wood waste diverted from landfilling, and forestry residuals diverted from open burning.

LNG

Nova Scotia Power has contemplated the idea of importing LNG as a fuel for future generating capacity in Western Nova Scotia.[38] LNG and natural gas have been promoted by the fossil fuel industry as being cleaner than coal, and therefore a useful "bridge fuel" until the time in the future when renewable energy "becomes practical". While the carbon dioxide emissions per unit of energy from burning natural gas are lower than those from burning coal, on a lifecycle basis the emissions are significantly higher. Lifecycle emissions include fugitive emissions of methane from well drilling, well completion, abandoned wells, gas transmission, gas refining, and finally gas distribution.

[38] Nova Scotia Power. October 18, 2019. Nova Scotia Power Final Pre-IRP Report. 479pp. (https://irp.nspower.ca/files/key-documents/pre-irp-deliverables/October-18-2019-NS-Power-Pre-IRP-Deliverables.pdf)

8.3 Marine Transportation

4. MARINE FLEET	
Investment	$182 million
Jobs	2,180
Sectors	Primary: Agriculture/Fishery
Innovation	Introduction of Renewable Natural Gas, conversion to electricity, conversion to hydrogen fuel.

FUEL SWITCHING

Electric hybridization of ferries and fishing boats does not result in economic benefits, as the majority of energy savings from hybrid diesel-electric motors comes during acceleration. Marine vessels expend the majority of their energy during periods of constant speed and travel, when diesel fuel is being consumed.

Instead of converting to hybridization, there is some potential to develop a biodiesel production facility, using waste cooking oil, yellow grease from grease traps, and brown grease from wastewater treatment. Currently, marine vessels engines can accommodate 5-10% biodiesel replacement, depending on the specific engine.

While fully electric ferries are being used in locations in British Columbia, electrification of the large ferries that travel between the Western Region and Maine would be expensive, and unlikely. These ferries could be converted more easily to burn RNG, generated through anaerobic digestion.

Small passenger ferries used on the Digby Neck could be converted to electricity, reducing reliance on petroleum products, and lowering GHG emissions.

GREEN HYDROGEN FOR FISHING FLEET

Renewable electricity sources are episodic, generating electricity when the sun shines, or the wind blows, and in order to most efficiently maximize the efficiency of a system powered by renewable sources, the excess electricity generated must be stored. One strategy for storing excess generation of wind or solar is to use electrolysis to generate what is known as 'green' hydrogen. 'Grey' hydrogen in contrast is generated using fossil fuels. Hydrogen is a versatile fuel which can be used for industrial applications and for heavy transport more readily than electricity, with potential for marine applications such as powering the fishing fleet. Green hydrogen is still expensive, but as the technology improves, prices will decrease, and the fuel will become more accessible.

The fishing industry is responsible for a large portion of energy consumption in the region, and currently uses marine diesel. By switching to electric motors, as well as hydrogen-powered motors, the energy consumption would decrease, as would the GHG production by the marine sector.

One concept that could be advanced by the Western REN is a microgrid with wind generation and hydrogen storage. The hydrogen could then be used for powering some of the fishing fleet.[39]

8.4 Forestry

5. CELLULOSE INSULATION	
Investment	Not identified
Jobs	Not identified
Sectors	Primary: Agriculture/Fishery
Innovation	Primary manufacturing to support local retrofits- circular economy.

CELLULOSE INSULATION

The closure of pulp mills across Nova Scotia has left the forestry industry without a reliable market for waste wood products. As discussed above, this waste wood could be converted into cellulose insulation, feeding the local building retrofit industry. The market price for insulation is significantly higher than waste wood used as fuel, making this a lucrative market opportunity.

Currently, Thermocell Industries[40] operates a plant that makes cellulose insulation, as well as other products from wood pulp, in Debert, Nova Scotia. The Western REN could support the development of a cellulose insulation facility by coordinating between industry leaders, including Thermocell Industries, and the local forestry and business community to identify opportunities for sharing information, and industry best practices, as well as business development.

On a smaller scale, wood pulp is being used for innovative purposes, including for the manufacturing of N95 masks[41], used in medical facilities, and those at risk of airborne diseases. These masks have been an essential commodity during the treatment and prevention of COVID 19. By partnering with the colleges and the university in the region, as well as those outside of the Western Region, more pilot projects could identify opportunities to use waste wood and wood pulp outside of the pulp mills.

DISTRICT ENERGY

It is challenging to make district energy viable in smaller communities, because economies of scale favour larger projects. One niche for district energy was explored for Western Nova Scotia, however, would use Combined Heating and Power (CHP), in the following way:

- The Western REN estimates that in regional forestry operations, 2/3 of the harvested wood is usable while 1/3 becomes firewood, goes to lower-value uses, or is wasted. Only waste wood which is diverted from a fate which would result in higher greenhouse gas emissions (e.g. open burning or landfilling) would be used for CHP and district energy.

[39] Fuel cells are being used or are planned for a range of marine applications, including a cruise ship: https://plugboats.com/revolutionary-fuel-cell-powered-cruise-ship-norway/; and merchant ships: https://www.rivieramm.com/news-content-hub/news-content-hub/hydrogen-fuel-cells-will-be-built-for-merchant-ships-58887

[40] Thermocell Industries. http://www.thermocell.com/

[41] CBC News, May 13, 2020. Halifax researchers working to turn wood pulp into N95 masks. Accessed May 20, 2020. https://www.cbc.ca/news/canada/nova-scotia/nova-scotia-covid-19-n95-masks-pulp-research-1.5566691

- Biomass would be chipped and burned in a burner which heats thermal oil rather than water.
- The thermal oil would be circulated to an Organic Rankine Cycle (ORC) turbine to generate electricity, and heat rejected by the ORC would be used for district heating. This technology is suggested since steam turbines are not economically viable at small scales, and since ORCs are simpler to operate and maintain than steam turbines.
- The biomass boilers and ORCs would be factory-built as small package plants or shipping containers.
- To reduce capital and operating costs, the package plants would be installed at locations of higher heating and electricity demand, i.e. local hospitals. Hospitals typically also have skilled personnel who could operate and maintain the units, and may also have space either within (or adjacent to) their utility/boiler rooms. The main customer for electricity and heat produced by the package plants would therefore be hospitals.
- Additional heat could be piped to nearby buildings. Candidate buildings in Yarmouth could include the Big Box stores on Highway 3, and in Digby could include the Recreation Centre, Library, and stores which are located within 1 km of the Digby General Hospital.

An alternative approach could be to locate a larger biomass CHP near Digby, near the point where the three 69 kV transmissions lines connect. Electricity from this plant could potentially feed all three lines. Additional biomass for a larger plant could come from diverting wood away from residential woodstoves.

The table below shows an estimate of the potential for district energy installations based on CHP in Yarmouth and Digby. The table shows that this approach would only offset a small proportion of the total electricity consumption of Western Nova Scotia, and for this reason was not modelled in the Clean Energy scenario. A pre-feasibility study would be needed to estimate the capital and operating costs of this approach, to determine if it is worth pursuing.

Table 9. District energy concept for Yarmouth.

POTENTIAL LOADS:		
Yarmouth Regional Hospital	17,000	GJ/yr
Other Buildings	6,000	GJ/yr
Total	23,000	GJ/yr
Boiler Efficiency	75%	
Electrical Efficiency	19%	
Thermal Efficiency	49%	
Energy from Fuel Required	47,300	GJ/yr
Biomass Required	2,800	ODT/yr
Biomass Required	3,800	Green tonnes/yr
Nominal Boiler Capacity	1.13	MW(th)
Nominal ORC Capacity	214	kW(e)
Electrical Output	1,850	MWh(e)/yr
Heat Output	6,370	MWh(th)/yr
Fuel Cost	$380,000	

POTENTIAL LOADS:	
Value of Electricity	$300,000
Value of Heat	$851,000
Value of Carbon Tax	$122,667

Table 10. District energy concept for Digby.

POTENTIAL LOADS:		
Digby General Hospital	7,000	GJ/yr
Other Buildings	5,000	GJ/yr
Total	12,000	GJ/yr
Boiler Efficiency	75%	
Electrical Efficiency	19%	
Thermal Efficiency	49%	
Energy from Fuel Required	24,691	GJ/yr
Biomass Required	1,496	ODT/yr
Biomass Required	1,995	Green tonnes/yr
Nominal Boiler Capacity	0.59	MW(th)
Nominal ORC Capacity	112	kW(e)
Electrical Output	950	MWh(e)/yr
Heat Output	3,330	MWh(th)/yr
Fuel Cost	$200,000	
Value of Electricity	$156,000	
Value of Heat	$444,000	
Value of Carbon Tax	$64,000	

8.5 Road Transportation

6. ELECTRIC VEHICLES	
# of personal EVs sold by 2050	43,970
Incremental investment	$15.5 million
Jobs	Possible decline in jobs due to reduced maintenance
Sectors	Primary: Retail/Wholesale Secondary: Finance/Insurance, Transportation
Innovation	Bulk purchases, charging infrastructure

Switching to electric vehicles will increase the reliance on electricity as a fuel source, but won't result in an overall net increase in electricity demand, because of the efficiencies gained through building retrofits, and other actions. Electric vehicles are typically charged overnight, reducing the demand on peak hours.

Table 11. Cost Comparison of Electric Vehicles and Internal Combustion Engine in 2020[42]

	ELECTRIC	UNITS	ICEL	UNITS
PURCHASE PRICE	**$50,000**		**$30,000**	
Distance Travelled per Year	17,000	km/yr	17,000	km/yr
Fuel or Electricity Economy	6.2	km/kWh	10.5	km/litre
Fuel or Electricity Consumed	2,742	kWh/yr	1,619	litre/yr
Fuel or Electricity Price	$0.08878	$/kWh	$1.20	$/litre
Fuel or Electricity Cost	$243	$/yr	$1,943	$/yr
Carbon Tax	$0	$/yr	$202	$/yr
Battery Replacement Allowance	$333	$/yr	$0	$/yr
Maintenance	$80	$/yr	$400	$/yr
Financing (Principal and Interest)	$4,689	$/yr	$2,814	$/yr
Total Annual Cost	$5,346		$5,359	$/yr

Table 11, above, illustrates how electric vehicles, while often more expensive than gasoline vehicles can be competitive. In particular, operation and maintenance costs for electric vehicles are markedly lower than for combustion vehicles. Within Nova Scotia, the company AllEV Canada, Inc[43] is refurbishing and selling used electric vehicles for more affordable prices.

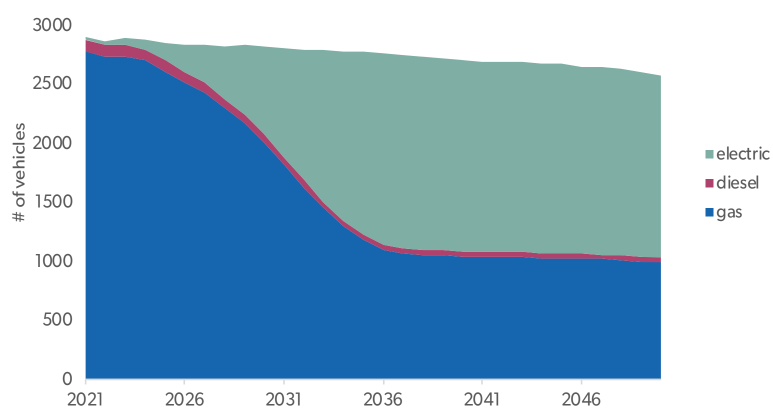

Figure 49. Annual sales of personal vehicles by vehicle type in the Clean Energy scenario.

With the uptake of electric vehicles, the need for charging stations, charging infrastructure, and skilled mechanics specializing in electric vehicles will grow.

[42] Assuming a financing period of 10 years at 3% interest, and the battery life is 15 years.

[43] All EV, Inc. https://www.allev.ca/

Teleworking

Teleworking structures allow employees in certain sectors of the economy to work from home, which minimizes commuting trips to and from work, which has been widely deployed during COVID-19. Teleworking also reduces the floor area of buildings required for office space. The most significant barrier to teleworking in the Western Region is the quality of the internet service.

8.6 Eco-industrial park

7. ECO-INDUSTRIAL PARK	
Investment	Not determined.
Jobs	Not determined.
Sectors	Primary: All
Innovation	Circular economy

To support economic development, reduce waste, and maximize efficiency, a number of businesses could be built in a new eco-business park. These businesses would operate together, with waste products from one feeding into the source materials for another, while sharing operating costs and infrastructure to maximize efficiency and reduce costs. The following businesses could be sited in the new park, although if the anaerobic digester is included as a key business, the location of the business park is restricted to the Weymouth area. Table 12 gives examples of the kinds of exchanges which could take place within an eco-industrial park.

Table 12. Circular economy for the eco-industrial park

PROCESS	INPUTS	BY-PRODUCTS	PRODUCTS
Anaerobic Digestion (AD)	Municipal organic waste Waste from farms Organic waste from a greenhouse Solid+liquid waste from aquaculture Glycerol from biodiesel	CO_2 from upgrading biogas to biomethane	Biomethane (RNG/CNG) Organic fertilizer for a greenhouse
Biodiesel	Waste oil, grease Methanol Sodium hydroxide	Glycerol to AD	Biodiesel
Greenhouse	Organic fertilizer from AD CO_2 for fertilization Heat from CHP of RNG Electricity for lights from CHP of RNG	Organic waste to AD Waste heat to AD	Marijuana, herbs, high-value crops for humans Food crops for fish
Land-based Aquaculture	Food crops as fish food Waste heat	Solid waste Liquid waste	Fish, oils, collagen

8.7 Université Sainte-Anne

The university, located in Pointe-de-l'Église, has undertaken a number of projects to improve the life of students, staff and the community, while reducing the impact of the campus on the environment. These projects have been undertaken by the university as an example of rural development that is lasting, and ecologically sustainable.[44]

The university has installed 118 solar hot water panels used for heating and hot water in the student residences, as well as a biomass gasification system for space heating. Additionally, the university has installed two 50 kW wind turbines, reducing the energy required from the provincial grid by 40% annually. The university was also successful in the 2019 Solar for Community Buildings Program, with finding through the Nova Scotia Department of Energy, and plan on installing a 70 kW solar system through this program.

A charging station for EVs was installed in 2016, and the university encourages students to bike, carpool, and use a common bus for trips to grocery stores and other external locations.

As a leader in the area of GHG reductions and implementation of energy efficient projects, the university is a useful resource in the region, both as an example of possible projects, and as a location for further expansion of energy saving measures.

[44] Université Sainte-Anne, 2020. La Vie en Verte. Accessed May 2020: https://www.usainteanne.ca/la-vie-en-vert#espaces-vert

9. Disruptors

Future energy use by the communities in the Western Region will depend on the size of the population, economic activity and transportation patterns. These factors are subject to disruption by a number of “megatrends'' that introduce uncertainty for future energy use over the long term. Seven megatrends of particular relevance.

9.1 Connectivity

The increasing speed, capacity, and reliability of data transmission is expanding the realm of human communications. Telepresence and Internet of Things will impact most aspects of energy demand, including GHG emissions from building energy use, embodied carbon in procured goods and services, business travel, and employee commutes.

9.2 Mobility Transition

The way the world moves is changing—from mobility-as-a-service business models to electric and autonomous vehicles. The greatest impact of the mobility transition on the Western Region will be on the GHG emissions from commuting. Low carbon intensity electricity grids, and the electrification of personal mobility vehicles have the potential to virtually eliminate transportation-related GHG emissions. The development of autonomous vehicles may have further impacts on the acceleration of electrification of the vehicle fleet, but they could also have unintended consequences, such as an increasing reliance on vehicles.

9.3 Electricity Transition

Future electricity grids are projected to incorporate distributed energy from “prosumers” who will use advanced control technologies to manage their energy generation, storage, and demand to maximize their financial advantage. In addition, vehicle charging infrastructure will become an increasingly important tool to support the use of electric vehicles, which can both draw on and feed the grid.

9.4 Circular Economy

The term circular economy refers to a zero-waste economy that emulates the sustainable pattern of material and energy flows in natural ecosystems. In a circular economy, products and services are designed to maximize the efficiency of energy and materials consumption, and ultimately eliminate waste and non-renewable energy. Under a circular economy system, products would be designed for durability, and to facilitate reuse and recycling at end-of-life.

9.5 Climate Change Policy

Canada’s commitment to taking action on climate change by reducing GHG emissions has a direct influence on the direction of the Western Region.

For example, the implementation of high performance standards in building and infrastructure industries can have an impact on resource and energy use, as well as life-cycle embodied carbon and, therefore, reductions in GHGs emissions. Government policies and regulations can also determine how rapidly market transformations take place. Buildings and infrastructure have long life-cycles, which makes it imperative that buildings constructed today are built for the needs of the future low-carbon and climate resilient economy. As a result, the faster the penetration of net-zero building standards and technologies, the greater the impact on mitigating climate change through near-term and long-term GHG emissions reductions.

9.6 Artificial Intelligence

There are many components of work that are well-suited to machine or computer automation, and that may be augmented by human-artificial intelligence (AI) collaboration. While AI will not necessarily lead to reductions in the regional economy, it will certainly change the nature of work, the attributes of the workforce, and the amount and type of workspace that will best support that work.

9.7 Impacts of Climate Change

The impacts of climate change will influence energy use in the Western Region. Average winter temperatures will be warmer, resulting in fewer heating degree days and, therefore, reductions in the demand for heating needs. At the same time, warmer average summer temperatures will increase cooling degree days and, therefore, increase cooling loads. Depending on the degree of change in both heating and cooling days, energy use and GHG emissions may increase or decline as the climate changes.

In addition, the projected increase in the frequency and severity of extreme weather events as the climate changes increases the risk of damage for infrastructure. In 2016, the Office of the Parliamentary Budget Officer estimated that the average annual losses due to extreme weather events, including hurricanes, winter storms, and floods in Canada could reach $4.92 billion between 2016 to 2021.[45] These average costs are expected to grow as the climate continues to change. These impacts will result in potentially greater risks and increased costs to the government, households, employees, and the economy due to increases in energy disruptions and physical damages.

[45] Parliamentary Budget Officer. (2016). Estimate of the average annual cost for disaster financial assistance arrangements due to weather events. Retrieved from: https://www.pbo-dpb.gc.ca/web/default/files/Documents/Reports/2016/DFAA/DFAA_EN.pdf

10. Implementation

10.1 Implementation considerations

Deep GHG emission reductions require an innovative and rapid diffusion of new technologies, in order to reshape the markets and socio-economic systems. The low-carbon transition is as much a social transition as a technological and economic shift. The key to success is the alignment of interests so that governments, business, and society support each other in a reinforcing feedback or "ambition loop".

Transitions are, by definition, disruptive. A just transition is an approach that aims to minimize the negative impact on workers and communities, and to engage with the individuals and organizations who are negatively impacted.[46] In addition to a just transition, the government can preferentially deploy strategies or actions that simultaneously deliver other objectives related to health, inequality, poverty alleviation, and reconciliation.

The Clean Energy scenario represents a major new effort by the Western 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 scenario 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 WRIEP is governed by the following principles:

- Leadership and Vision. Provide the "big picture" of a future vision of a sustainable energy future.
- Engagement. The Clean Energy scenario 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 the Clean Energy scenario objectives and stakeholder objectives.
- Leverage. Strategic use of local government financial, regulatory and planning resources to leverage accelerated progress toward the Clean Energy scenario.

[46] Task Force on Just Transition for Canadian Coal Power Workers and Communities, Canada, & Environment and Climate Change Canada. (2019). A just and fair transition for Canadian coal power workers and communities.Retrieved from: http://epe.lac-bac.gc.ca/100/201/301/weekly_acquisitions_list-ef/2019/19-11/publications.gc.ca/collections/collection_2019/eccc/En4-361-2019-eng.pdf

10.2 Programs

Based on these principles and the objectives identified in the stakeholder engagement process, four programs of activity are identified which enable the GHG reductions identified as a result of the actions modelled in the Clean Energy 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.

PROGRAM 1: REGIONAL ROUNDTABLE

Roundtables have been a popular mechanism for deliberating on environmental issues in Canada and beyond. Roundtables seek to develop consensus amongst interested parties, which represent various spheres of activity, as opposed to experts in particular disciplines, establishing a structure through which all parties have an equal voice. The participants in the roundtable draw their legitimacy from their responsiveness to the needs, concerns and input of constituencies.[47]

Roundtables are most successful when they involve recognised leaders in their respective constituencies. A sponsoring organisation, such as the Western REN, will invite prominent individuals or community leaders to be the founding members, and the roundtable itself will define its scope of work in response to its mandate. In this example, its advice or recommendations would go directly to Council or Mayors and Wardens.

The roundtable approach as applied by the Commission on Resources and the Environment (CORE) (see examples below) drew on Canadian experience in mediation and facilitation of consensual agreements to apply principles of interest-based negotiations.[48] These principles are as follows:

- Separate the people and the personalities from the issues to be negotiated;
- identify the interests that must be accommodated to achieve agreement;
- translate interests into clear objectives and evaluation criteria;
- negotiate on the basis of accommodating or reconciling interests rather than trading positions;
- develop and assess options on the basis of interest-based objectives and criteria; and
- give careful consideration to the alternatives to a negotiated agreement and recognize that these influence the potential for agreement.

PROGRAM 2: REVOLVING LOAN FUND

Salix is an independent, not-for-profit company set up as an integral part of the UK's Climate Change Programme. It is designed specifically to address the issue of public sector investment capital and annual financing rules. The role of Salix is to help public sector bodies reduce energy costs and carbon emissions and show leadership in tackling climate change by providing funding and expertise. Typically, progress in reducing greenhouse gas emissions from the public sector has been hampered by lack of investment capital and revenue/capital barriers (the "annuality"

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[47] Pasquero, J. (1991). Supraorganizational Collaboration: The Canadian Environmental Experiment. The Journal of Applied Behavioral Science, 27(1), 38–64. https://doi.org/10.1177/0021886391271003

[48] Jackson, T., & Curry, J. (2004). Peace in the woods: Sustainability and the democratization of land use planning and resource management on Crown lands in British Columbia. International Planning Studies, 9(1), 27–42. https://doi.org/10.1080/1356347042000234961

problem). Salix stimulates investment by establishing ring-fenced, interest-free funds matched by the public sector. The funds are unique in that they recycle savings back to the organization. Salix currently has more than one hundred partner organizations, including local authorities, higher education institutions, emergency services, and the National Health Services. The fund has financed nearly twenty thousand projects, worth $1.5 billion.

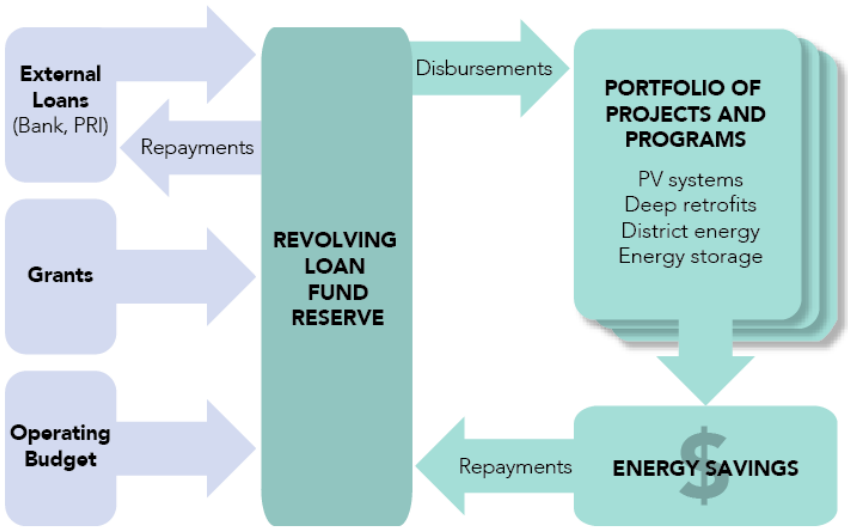

Figure 50. Conceptual model of the revolving loan fund

A number of cities in Ontario have a similar mechanism, including Guelph, Waterloo, Pickering, and Burlington.[49] Another example is Edmonton's Energy Management Revolving Fund, created in 1995, which has grown to over $30 million.[50]

PROGRAM 3: RENEWABLE ENERGY CO-OPERATIVE

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

The membership of the co-operative could include the Western REN, First Nations, municipalities, and other partners. The co-operative would advocate for, develop, contract and finance projects, depending on which strategy is appropriate to a particular context, with greater flexibility than the existing utilities. The co-operative would be technology agnostic, with a mandate to work on district energy, wind, solar, storage and others. Financing would 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.

[49] See: City of Oshawa (2018). Report on Revolving Energy Fund. http://app.oshawa.ca/agendas/finance/2018/05-10/report_fin-18-28.pdf

[50] City of Edmonton (n.d.) Energy Management Revolving Fund. https://www.edmonton.ca/city_government/documents/EnergyManRevolvingFund.pdf

PROGRAM 4: ELECTRIC VEHICLE JOINT VENTURE

The Western REN, municipalities and NS Power would undertake a joint strategy to support electric vehicles. The mandate would be to coordinate infrastructure investments, educational activities and municipal policies relating to charging stations and incentives.

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

10.3 Risks

Implementation risks are inherent in strategies, policies, and actions. A risk is defined as "the effect of uncertainty on objectives" and is the expression of the likelihood and impact of an event with the potential to affect the achievement of an organization's objectives.[51] This section identifies some potential risks to Roadmap implementation and related mitigation and contingency strategies. Risks are classified according to the matrix in Table 13.

Table 13. Risk classification.

IMPACT↓	RISK CLASSIFICATION			
Catastrophic	High	Very high	Very high	Very high
Major	Moderate	High	High	Very high
Moderate	Low	Moderate	Moderate	High
Minor	Low	Low	Low	Moderate
Probability→	Unlikely	Possible	Likely	Very likely

[51] Government of Canada Guide to Corporate Risk Profiles. Retrieved from: https://www.canada.ca/en/treasury-board-secretariat/corporate/risk-management/corporate-risk-profiles.html

10.3.1 THE RISK OF DOING NOTHING

If the Clean Energy scenario is not implemented, the BAU scenario, or other scenario would proceed. The BAU scenario assumes no major changes are made to the energy system in the Western Region.

Table 14. The risks of doing nothing.

RISK	DESCRIPTION	PROBABILITY	IMPACT	OVERALL RISK
Stranded assets	Communities and businesses invest in fossil fuel-based infrastructure that must be replaced prior to the end of its useful life, either to meet its GHG reduction commitments or due to changing market conditions as a result of global climate action.	Very likely	Major	Very high
Regional reputation damaged	The reputation of the Region is damaged because its operations do not align with its broader policies to reduce GHG emissions.	Likely	Major	High
Infrastructure failure	Buildings and other infrastructure are in poor or critical condition due to deferred maintenance, which risks failure.	Very likely	Major	Very high
Vulnerability to energy price shocks	Communities are vulnerable to global fossil fuel prices, which will fluctuate in the future.	Likely	Minor	Low
Infrastructure damage from extreme weather	Infrastructure conditions result in increased damage from extreme weather events.	Likely	Major	High
Cumulative energy expenditures are greater than they would be under strategy implementation	The BAU scenario is more costly than the Clean Energy scenario.	Very likely	Minor	Moderate
GHG emissions increase or stabilize	GHG emissions will continue to increase, imposing a burden on future generations. The cost of future mitigation will also increase, requiring more extensive retrofits. Rising emissions also pose additional reputational risks.	Very likely	Major	Very high
Operational costs increase	Opportunities to reduce operational and maintenance costs are missed.	Very likely	Major	Very high

10.4 Labour-Related Risks

The implementation of the Clean Energy scenario is dependent on the availability and skill of contractor workforces (Table 15).

Table 15. Labour-related risks.

RISK	PROBABILITY	IMPACT	OVERALL RISKS	MITIGATION	CONTINGENCY
Lack of skilled workers to perform the work identified in the Clean Energy scenario. Emissions reduction activities are delayed and project labour costs increase.	Very likely	Major	Very high	Western REN convenes a working group with colleges and trade schools to identify requirements and programs	Workers are imported from other jurisdictions

10.5 Electricity Risks

Changes to electricity generation sources and in electricity demand will have associated risks for achieving GHG emissions reduction objectives (Table 16).

Table 16. Electricity-related risks.

RISK	PROBABILITY	IMPACT	OVERALL RISKS	MITIGATION	CONTINGENCY
The emissions factor for the NS electricity grid increases	Likely	Major	High	Behind-the-meter solar PV recommended on all buildings.	Purchase more renewable electricity.
Electrification reduces energy system redundancy, making operations more vulnerable to disruption in the event of power outages.	Likely	Major	High	Buildings and energy design for redundancy. For example, battery storage included in the building retrofit program.	Microgrids installed in targeted nodes to create additional resiliency.
Electrification increases peak electricity demand, increasing expenditures on electricity.	Likely	Moderate	Moderate	EVs are charged overnight.	

10.6 Energy Market Risks

Energy supply and costs are dependent on market forces. Changes in the energy market have inherent risks that can impact the successful implementation of several Clean Energy scenario actions (Table 17).

Table 17. Energy market-related risks.

RISK	PROBABILITY	IMPACT	OVERALL RISKS	MITIGATION	CONTINGENCY
Fossil fuel price decline challenges the business case for individual projects.	Likely	Moderate	Moderate	Federal building codes are likely to require high levels of energy performance	
Renewable energy price increase threatens the business case of renewable energy installations.	Possible	Major	High	Renewable energy projects are delayed.	District energy provides a flexible platform for different technologies.
Lack of technology/ component availability threatens the viability of installing new renewable energy infrastructure.	Possible	Major	High	Purchasing agreements with suppliers identifying longer term requirements.	

10.7 Governance Risks

Competing government priorities and timelines will affect the implementation of the Clean Energy scenario. Strong leadership and timely and consistent implementation by departmental staff are critical for success (Table 18).

Table 18. Governance-related risks.

RISK	PROBABILITY	IMPACT	OVERALL RISK	MITIGATION	CONTINGENCY
Lack of leadership and follow through stalls implementation.	Likely	Major	High	Create a round table with the mandate for implementation. Publish annual report for transparency	
Other initiatives take funding priority and implementation is delayed or descoped. Buildings projects continue in status quo.	Very likely	Major	Very high	No response.	
Unforeseen events impact the nature of the society and economy	Very likely	Major	Very high	No response.	

Appendix A. Detailed Energy and Emissions Modelling Results

Table A1. Community energy consumption by sector and fuel, for 2016 BAU, and 2050 BAU and LE

ENERGY BY SECTOR (GJ)	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Commercial	784,496	8%	792,005	9%	358,392	7%	-54%	-55%
Industrial	555,112	5%	561,805	6%	658,750	13%	19%	17%
Residential	1,957,206	19%	1,793,242	21%	846,032	17%	-57%	-53%
Marine Transportation	3,090,107	30%	3,090,107	35%	1,872,007	38%	-39%	-39%
On-road Transportation	3,895,670	38%	2,468,898	28%	1,174,753	24%	-70%	-52%
Total	10,282,591		8,706,057		4,909,935		-52%	-44%
ENERGY BY FUEL (GJ)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Fuel Oil	1,112,083	10.82%	990,264	11.37%	246,180	5%	-78%	-75%
Gasoline	3,018,548	29.36%	1,788,759	20.55%	394,196	8%	-87%	-78%
Geothermal	0	0.00%			331,030	7%		
Hydrogen	0	0.00%	0	0.00%	157,092	3%		
Imported Electricity	1,495,360	14.54%	1,588,043	18.24%	14,053	0%	-99%	-99%
Local Electricity	51	0.00%	51	0.00%	2,838,467	58%	5616330%	5615374%
Marine Diesel	3,090,107	30.05%	3,090,107	35.49%	615,721	13%	-80%	-80%
OnRoad Diesel	877,078	8.53%	647,475	7.44%	141,453	3%	-84%	-78%
Other	0	0.00%			7,800	0%		
Propane	139,832	1.36%	131,287	1.51%	31,688	1%	-77%	-76%
RNG	0	0.00%			60,000	1%		
Wood	549,533	5.34%	470,072	5.40%	72,256	1%	-87%	-85%
Total	10,282,591		8,706,057		4,909,935		-52%	-44%
Energy per capita (GJ/cap)	208		180		107		-49%	-41%

Table A2. Community emissions by sector and fuel, for 2016 BAU, and 2050 BAU and LE

EMISSIONS BY SECTOR (TCO2E)	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Commercial	147,143	14%	86,396	11%	4,001	3%	-97%	-95%
Industrial	87,433	8%	54,659	7%	20,407	16%	-77%	-63%
Marine Transportation	243,893	23%	243,893	31%	49,122	38%	-80%	-80%
On Road Transportation	263,760	25%	168,567	22%	36,703	28%	-86%	-78%
Residential	314,043	29%	214,226	27%	14,483	11%	-95%	-93%
Waste	11,147	1%	12,549	2%	6,201	5%	-44%	-51%
Total	1,067,419		780,289		130,918		-88%	-83%
EMISSIONS BY SOURCE (TCO2E)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Fuel Oil	213,822	20%	187,915	24%	34,733	27%	-84%	-82%
Gasoline	200,792	19%	118,998	15%	26,224	20%	-87%	-78%
Imported Electricity	311,887	29%	150,170	19%	1,329	1%	-100%	-99%
Marine Diesel	243,893	23%	243,893	31%	48,597	37%	-80%	-80%
On Road Diesel	62,959	6%	46,480	6%	10,155	8%	-84%	-78%
Other	11,147	1%	12,549	2%	6,201	5%	-44%	-51%
Propane	8,552	1%	8,030	1%	1,938	1%	-77%	-76%
Wood	14,366	1%	12,255	2%	1,741	1%	-88%	-86%
Total	1,067,419	1	780,289		130,918	100%	-88%	-83%
Emissions per capita (tCO_2e/ person)	21.6		16.2		2.7		-87%	-83%

Table A3. Building sector energy tabulated results, 2016, 2050 BAU and 2050 LE.

BUILDINGS ENERGY (GJ) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Residential	1,957,206	59%	1,793,242	56.98%	846,032	45%	-57%	-53%
Commercial	784,496	23.80%	792,005	25.17%	358,392	19%	-54%	-55%
Industrial	555,112	16.84%	561,805	17.85%	658,750	35%	19%	17%
Total	3,296,814		3,147,052		1,863,174		-43%	-41%
BUILDINGS ENERGY (GJ) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**

Fuel Oil	1,112,083	34%	990,264	31%	246,180	13%	-78%	-75%
Geothermal	0	0%	0	0%	331,030	18%		
Imported Electricity	1,495,316	45%	1,555,380	49%	5,069	0%	-100%	-100%
Local Electricity	51	0%	50	0%	1,176,953	63%	2329116%	2377102%
Propane	139,832	4%	131,287	4%	31,688	2%	-77%	-76%
Wood	549,533	17%	470,072	15%	72,256	4%	-87%	-85%
Total	3,296,814		3,147,052		1,863,174		-43%	-41%
BUILDINGS ENERGY (GJ) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Industrial Manufacturing	507,546	15%	506,833	16%	630,090	34%	24%	24%
Lighting	226,353	7%	226,353	7%	123,320	7%	-46%	-46%
Major Appliances	194,955	6%	194,955	6%	97,905	5%	-50%	-50%
Plug Load	418,486	13%	416,236	13%	232,559	12%	-44%	-44%
Space Cooling	59,709	2%	144,336	5%	84,252	5%	41%	-42%
Space Heating	1,389,499	42%	1,162,191	37%	540,902	29%	-61%	-53%
Water Heating	500,266	15%	496,147	16%	154,147	8%	-69%	-69%
Total	3,296,814		3,147,052		1,863,174		-43.5%	-40.8%

Table A4. Building sector emissions tabulated results, 2016, 2050 BAU and 2050 LE.

BUILDINGS EMISSIONS (TCO2E) BY BUILDING TYPE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Residential	314,043	57%	214,227	60%	14,483	37%	-95%	-93%
Commercial	147,143	27%	86,396	24%	4,001	10%	-97%	-95%
Industrial	87,433	16%	54,659	15%	20,407	52%	-77%	-63%
Total	548,619		355,281		38,891		-93%	-89%
BUILDINGS EMISSIONS (TCO2E) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Fuel Oil	213,822	39%	187,915	53%	34,733	89%	-84%	-82%
Imported Electricity	311,878	57%	147,081	41%	479	1%	-100%	-100%
Propane	8,552	2%	8,030	2%	1,938	5%	-77%	-76%
Wood	14,366	3%	12,255	3%	1,741	4%	-88%	-86%
Total	548,619		355,281		38,891		-93%	-89%

BUILDINGS EMISSIONS (TCO2E) BY END USE	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Industrial Manufacturing	77,512	14%	50,520	14%	21,781	56%	-72%	-57%
Lighting	47,209	9%	21,404	6%	49	0%	-100%	-100%
Major Appliances	40,660	7%	18,435	5%	39	0%	-100%	-100%
Plug Load	85,988	16%	39,066	11%	401	1%	-100%	-99%
Space Cooling	12,453	2%	13,648	4%	34	0%	-100%	-100%
Space Heating	192,949	35%	138,483	39%	5,556	14%	-97%	-96%
Water Heating	91,848	17%	73,725	21%	11,033	28%	-88%	-85%
Total	548,619		355,281		38,891		-93%	-89%

Table A5. Transportation sector energy tabulated results, 2016 & 2050 (BAU).

TRANSPORTATION ENERGY (GJ) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Biodiesel	0	0.0%	0	0%	7,800	0%		
Gas	3,018,548	43.2%	1,788,759	32%	394,196	13%	-87%	-78%
Hydrogen	0	0.0%	0	0%	157,092	5%		
Imported Electricity	44	0.0%	32,663	1%	8,984	0%	20429%	-72%
Local Electricity	0	0.0%	1	0%	1,661,514	55%	112264470146%	159813124%
Marine Diesel	3,090,107	44.2%	3,090,107	56%	615,721	20%	-80%	-80%
OnRoad Diesel	877,078	12.6%	647,475	12%	141,453	5%	-84%	-78%
RNG	0	0.0%	0	0%	60,000	2%		
Total	6,985,777		5,559,005		3,046,760		-56%	-45%
TRANSPORTATION ENERGY (GJ) BY VEHICLE TYPE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**% +/- (2016-2050)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Car	1,807,361	26%	994,268	18%	471,568	15%	-74%	-53%
Ferry	675,721	10%	675,721	12%	668,019	22%	-1%	-1%
Fishing	2,414,386	35%	2,414,386	43%	1,203,989	40%	-50%	-50%
Heavy truck	433,663	6%	315,226	6%	153,973	5%	-64%	-51%
Light truck	1,651,388	24%	1,156,145	21%	548,397	18%	-67%	-53%
Urban bus	3,259	0%	3,259	0%	815	0%	-75%	-75%
Total	6,985,777		5,559,005		3,046,760		-56%	-45%

Table A6. Transportation sector emissions tabulated results, 2016, 2050 BAU and 2050 LE.

TRANSPORTATION EMISSIONS (TCO2E) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Gas	200,792	39.6%	118,998	29%	26,224	31%	-87%	-78%
Imported Electricity	9	0.0%	3,089	1%	850	1%	9207%	-72%
Marine Diesel	243,893	48.0%	243,893	59%	48,597	57%	-80%	-80%
OnRoad Diesel	62,959	12.4%	46,480	11%	10,155	12%	-84%	-78%
Total	507,653		412,459		85,825	100%	-83%	-79%
TRANSPORTATION EMISSIONS (TCO2E) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Car	121,537	24%	67,543	16%	14,746	17%	-88%	-78%
Ferry	53,333	11%	53,333	13%	47,989	56%	-10%	-10%
Fishing	190,560	38%	190,560	46%	1,132	1%	-99%	-99%
Heavy truck	30,866	6%	22,434	5%	4,943	6%	-84%	-78%
Light truck	111,129	22%	78,362	19%	17,014	20%	-85%	-78%
Urban bus	228	0%	228	0%	0	0%	-100%	-100%
Total	507,653		412,459		85,825	100%	-83%	-79%

Appendix B. Detailed Financial Modelling Results

Table B1. Total energy expenditures tabulated results, 2016, 2050 BAU and 2050 LE.

ENERGY EXPENDITURES BY SECTOR (MILLION $)	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LE)	SHARE 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Residential	24,521,614	8%	28,323,681	7%	9,408,134	6%	-62%	-67%
Commercial	9,680,315	3%	13,162,921	3%	13,751,133	8%	42%	4%
Industrial	54,586,651	17%	60,978,919	16%	17,641,843	10%	-68%	-71%
On-road transportation	125,408,039	38%	116,824,344	30%	50,477,671	30%	-60%	-57%
Marine- fishing	87,956,071	27%	129,652,515	34%	43,487,123	26%	-51%	-66%
Marine-passenger	24,616,524	8%	36,286,230	9%	33,758,810	20%	37%	-7%
Total	326,769,213		385,228,610		168,524,713		-48%	-56%
ENERGY EXPENDITURES BY FUEL (MILLION $)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LE)**	**SHARE 2050**	**% +/- 2016-2050 LE**	**% +/- 2050 BAU-2050 LE**
Biodiesel	0	0.00%	0	0.00%	418,860	0%		
Diesel	144,524,553	44.23%	200,708,127	52.10%	40,660,238	24%	-72%	-80%
District Energy	0	0.00%	0	0.00%	0	0%		
Electricity	55,255,136	16.91%	61,312,244	15.92%	92,144,287	55%	67%	50%
Fuel oil	25,071,430	7.67%	32,289,465	8.38%	6,484,889	4%	-74%	-80%
Gasoline	93,454,249	28.60%	80,619,378	20.93%	17,766,407	11%	-81%	-78%
Propane	0	0.00%	0	0.00%	8,247,342	5%		
Wood	2,749,968	0.84%	3,623,631	0.94%	861,481	1%	-69%	-76%
Total	5,713,877	1.75%	6,675,766	1.73%	833,008	0%	-85%	-88%

Table B2. Household energy expenditures tabulated results, 2016 & 2050.

Household energy expenditures by fuel ($)	2016	share 2016	2050 (BAU)	share 2050	2050 (LE)	share 2050	% +/- 2016-2050 LE	% +/- 2050 BAU-2050 LE
Diesel	$ 99	2%	$ 100	2%	$ 22	1%	-78%	-78%
Electricity	$ 1,365	23%	$ 1,464	27%	$ 1,386	66%	2%	-5%
Fuel oil	$ 851	15%	$ 1,046	19%	$ 105	5%	-88%	-90%
Gasoline	$ 3,261	56%	$ 2,564	47%	$ 569	27%	-83%	-78%
Propane	$ 18	0%	$ 21	0%	$ 1	0%	-93%	-94%
Wood	$ 248	4%	$ 290	5%	$ 16	1%	-93%	-94%
Total	$ 5,842		$ 5,486		$ 2,100		-64%	-62%

Table B3. Capital investments (2016$) by 5 year interval for the Clean Energy Scenario

ACTION	2020-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	TOTAL
Retrofit single-family residential homes	100,184,000	334,961,100	3,158,900	10,708,900	9,433,500	7,106,300	465,552,700
Retrofit multi-unit residential buildings	272,700	1,059,200	0	10,000	8,600	1,500	1,352,000
Retrofit commercial buildings	1,996,600	6,788,700	505,600	405,200	383,800	330,100	10,410,000
Retrofit institutional buildings	1,561,800	4,911,700	312,400	244,100	218,200	89,700	7,338,000
Retrofit municipal buildings	1,952,200	6,123,600	385,600	292,800	254,500	99,100	9,107,700
Retrofit industrial buildings	923,100	916,300	77,500	71,100	65,500	38,600	2,092,000
Industry process motors/ efficiency improvements	3,394,100	9,796,000	12,396,600	11,777,700	11,188,900	10,629,400	59,182,700
Residential space heating	12,170,300	31,548,100	30,187,700	29,873,100	30,455,200	30,041,500	164,276,000
Residential water heating	2,719,300	3,073,900	5,444,600	3,782,100	4,403,600	4,153,200	23,576,700
Non-residential space heating	1,190,700	831,600	0	0	0	0	2,022,300

ACTION	2020-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	TOTAL
Non-residential water heating	95,700	86,900	0	0	0	0	182,600
Solar PV - existing residential	35,710,100	40,800,300	8,697,600	0	0	0	85,208,000
Solar PV - existing non-res	35,463,500	16,112,200	7,770,300	0	0	0	59,346,000
Energy storage - residential	7,839,400	6,066,200	1,162,400	0	0	0	15,067,900
Energy storage - non-res	7,786,900	2,528,100	1,038,500	0	0	0	11,353,400
Electrify transit	1,393,700	1,471,000	0	937,000	1,168,600	0	4,970,400
Electrify municipal fleets	29,200	98,200	99,300	48,700	14,300	0	289,800
Electrify personal vehicles	1,867,600	5,076,100	0	0	0	0	6,943,700
Electrify commercial vehicles	5,400	56,800	176,500	362,900	526,500	568,100	1,696,100
Waste diversion	0	0	0	0	0	0	0
Water & WW energy	135,000	0	0	0	0	0	135,000
Marine vehicles fuel switch	17,350,000	0	22,500,000	112,500,000	90,000,000	0	242,350,000
Utility-scale solar PV - ground mount	0	0	56,261,900	56,444,200	56,621,000	56,803,300	226,130,500
Onshore wind	0	0	87,670,700	83,770,000	79,714,700	75,504,600	326,660,100
Energy storage - utility ground mount solar pv	0	0	6,476,900	6,476,900	6,476,900	6,476,900	25,907,600
Energy storage - wind	0	0	12,956,100	12,956,100	12,956,100	12,956,100	51,824,500
Total	234,041,100	472,306,000	257,279,200	330,660,900	303,890,000	204,798,400	1,802,975,500

Appendix C. Renewable Energy Site Selection

Siting for large-scale renewable energy systems requires careful consideration to maximize the environmental and financial benefits while minimizing the potential landscape and land-use impacts.

Site selection should involve two parts: the first is a technical analysis to identify the most suitable locations for the renewable energy installation, and the second is a community engagement and discussion to identify concerns or land-use conflicts, to prioritize the technically-suitable sites.

A guidebook for geospatial mapping for renewable energy installations has been prepared for Ontario, and is a useful starting point for the Western Region.[52]

The Union of Nova Scotia Municipalities has developed a fact sheet to assist municipalities in making decisions about wind generation developments.[53]

CONSIDERATIONS FOR WIND TURBINE SITE SELECTION

Wind generation development is regulated by the Province, and by municipalities in Nova Scotia. The Department of Energy sets policies to regulate and support wind energy, and the Province requires environmental assessments for wind energy projects 2 MW or larger. Provincial permits will also be required for any site-specific alterations to watercourses, or for stream crossings.

Land-use planning for wind turbines and associated infrastructure is regulated by municipalities in Nova Scotia, and varies by municipality.

Selection criteria for potential wind generation sites include:

- A wind assessment, to determine if the wind generating potential is appropriate for the size of turbine
- Proximity to homes, developed areas, and sensitive land-use types
- Accessibility of the site by road for construction and maintenance
- Proximity to the transmission grid, or to electricity storage
- Municipal by-laws and zoning requirements, which often depend on the size of the turbine.
- Land ownership

Steps for a wind generation project include a risk assessment to evaluate the feasibility of the project, both technically and financially, a wind resource assessment, where the Nova Scotia Wind Atlas[54] can provide useful preliminary data, and an environmental assessment.

Screening criteria for wind turbine installations include:

[52] CEKAP, 2019. Mapping opportunities for land-based renewable energy generation in Ontario: a primer. https://www.cekap.ca/PDF/resources-mapping-opportunities-for-renewable-energy-a-guidebook-primer.pdf

[53] Union of Nova Scotia Municipalities, 2015. Wind Energy Fact Sheets for Nova Scotian Municipalities: Supporting municipalities in making informed decisions of wind energy. https://www.nsfm.ca/members-only-content/sustainability/1199-unsm-s-wind-energy-fact-sheet-3/file.html

[54] http://www.nswindatlas.ca/

- Avoid areas with a slope above 35%;
- Avoid land-use types such as
- Urbanized areas
- Roads
- Railways
- Waterbodies and wetlands
- Airports
- Aggregate extraction areas
- Areas smaller than 1 ha

CONSIDERATIONS FOR SOLAR PV SITE SELECTION

While specific site assessments will be required for solar installations, land-use and geographic mapping can help to identify areas for further exploration. Some screening criteria for solar installations include:

- Avoid areas with a slope above 35%;
- Avoid north-facing slopes above 10 degrees;
- Avoid land-use types such as
- Urbanized areas
- Roads
- Railways
- Waterbodies and wetlands
- Airports
- Aggregate extraction areas
- Areas smaller than 4 ha

Municipal regulations will regulate specifics about the solar generation installation, including allowable proximity to developed land, and land-use restrictions. These vary by municipality across Nova Scotia.

Provincial regulations may trigger an Environmental Impact Assessment, which will include a review of listed species that could be impacted by development, and permits would be required for any watercourse alterations or stream crossings.