APPENDIX B: Net-Zero Modelling Results

July 2021

Purpose of this Document

This document reports the energy use and greenhouse gas (GHG) emissions modelling results for the Town of Halton Hills in a net-zero-by-2030 scenario. The series of assumptions that make up the net-zero scenario are outlined in Appendix A.

The modelling results are shown in comparison to the reference scenario energy use and GHG emissions projections, which are detailed in Appendix E.

Disclaimer

Reasonable skill, care, and diligence has 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 the associated factors are subject to changes that are beyond the control of the author. The information provided by others is believed to be accurate but has not been verified.

This analysis includes strategic-level estimates of energy efficiency and greenhouse gas reduction potential represented by the proposed Low-Carbon Transition Strategy (LCTS). The intent of this analysis is to help inform project stakeholders about the potential reductions represented by the LCTS in relation to the modelled reference scenario. It should not be relied upon for 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 do not accept responsibility to any third party for the use, in whole or in part, of the contents of this document.

This analysis applies to the Town of Halton Hills and cannot be applied to other jurisdictions without further analysis. Any use by the Town of Halton Hills, its sub-consultants, or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

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Acronyms

CDD	cooling degree day
CO2e	carbon dioxide equivalent
EF	emissions factor
EV	electric vehicle
GHG	greenhouse gas
GJ	gigajoule
GWP	global warming potential
HDD	heating degree day
ICE	internal combustion engine
Kt	kilotonne
Mt	megatonne
NZS	net-zero scenario
PUV	personal-use vehicle
RNG	renewable natural gas

Units

GHG emissions

1 ktCO2e =	1,000 tCO2e
1 tCO2e =	1,000 kgCO2e
1 kgCO2e =	1,000 gCO2e

Energy

1 MWh =	1,000 kWh
1 MWh =	3.6 GJ
1 GJ =	278 kWh
1 GJ =	1,000,000 J
1 MJ =	0.001 GJ
1 TJ =	1,000 GJ
1 PJ =	1,000,000 GJ

Introduction

This document highlights the key results from the net-zero scenario model. The model was developed using CityInSight, SSG's energy, emissions, land-use, and finance model. The model estimates likely energy use and emissions trends between 2016 and 2030 across the following sectors: buildings, industry, transportation, waste, agriculture, and fugitive emissions.

Whereas the reference scenario, whose results are presented in a separate report, represents a continuation of current trends and policies in these sectors, the net-zero scenario (NZS) includes detailed actions to improve the efficiency of existing buildings and industrial processes, implement higher energy efficiency standards for new buildings, switch from fossil fuels to low-carbon alternatives, increase renewable energy consumption and local generation, enhance transit and active transportation, and increase waste diversion.

The modelling time frame is from 2016 to 2030, with 2016 as a base year. The census of 2016 is a key data source used to establish the base year. Model calibration for the base year uses as much locally observed data as possible.

Method

CityInSight is an energy, emissions, and finance model developed by SSG and whatIf? Technologies. It 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). Energy and greenhouse gas (GHG) emissions values are derived from a series of connected stock and flow models, and evolve based on current and future geographic and technology decisions/assumptions (e.g., EV uptake rates). The model accounts for physical flows (e.g., energy use, new vehicles by technology, VKT) as determined by stocks (e.g., buildings, vehicles, heating equipment, etc.).

CityInSight incorporates and adapts concepts from the system dynamics approach to complex systems analysis. For any given year, CityInSight traces the flows and transformations of energy from sources through to energy currencies (e.g., gasoline, electricity, hydrogen) to end uses (e.g., personal vehicle use, space heating) to energy costs and 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.

The CityInSight workflow models the actions according to the "Reduce-Improve-Switch" philosophy, where avoiding energy consumption in the first place is the top priority, followed by energy efficiency improvements and, finally, switching to low-carbon energy sources for the remaining demand. The workflow also prioritizes improvements to long-lasting infrastructure that can "lock in" energy consumption patterns for many decades and takes advantage of opportunities to align proposed investments with the natural turnover of infrastructure and buildings.

The model supports the use of scenarios as a mechanism to evaluate potential futures for communities. A scenario is an internally consistent view of what the future might turn out to be—not a forecast, but one possible future outcome. Scenarios must represent serious considerations defined by planning staff and community members. They are generated by identifying population projections into the future, identifying how many additional households are required, and then applying those additional households according to existing land-use plans and/or alternative scenarios.

Additionally, the municipal greenhouse gas inventory baseline development and scenario modelling approach correlate with the Global Protocol for Community-Scale GHG Emissions Inventories (GPC).

For further information on modelling methodology, see the Reference Scenario, Part 2: Data, Methods and Assumptions (Feb. 2021).

Part 1: Net-Zero Scenario Results

Net-Zero Scenario: Overall Energy and Emissions Outcomes

Energy Reduction, Energy Efficiency, and Fuel Switching

In order to reduce GHG emissions in a manner that reduces overall financial and environmental costs, it is essential to first reduce energy use and then switch remaining fuel consumption from fossil fuels towards clean energy sources. Prioritizing energy efficiency helps reduce the need for additional electricity capacity, renewable natural gas (RNG) feedstock, and the purchase of renewable electricity certificates.

The net-zero scenario for Halton Hills provides significant energy efficiency improvements (see Figure 1), reducing the overall energy consumption by 33% compared with 2016, and slightly more in comparison to the 2030 reference scenario.

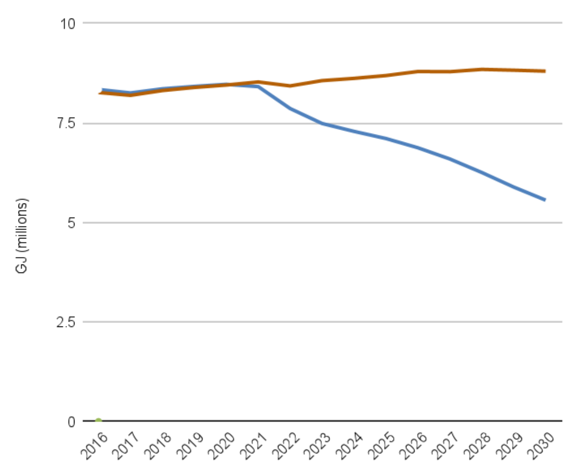

Figure 1. Net-zero scenario (blue) versus the reference scenario (orange), total community energy use, 2016-2030.

Along with reducing energy consumption, the shift in the energy sources must be aggressive to meet the 2030 emissions targets. Whereas natural gas in 2016 accounted for more than one third of energy use in the town (37%), by the end of the evaluation period it is completely removed from Halton Hills' energy matrix through efficiency, fuel switching, and replacement with renewable natural gas. On the other hand, gasoline and diesel consumption, which combined account for 34% of total energy consumption in 2016, are only reduced to 20% in 2030. Grid electricity is almost completely replaced with local renewable electricity and renewable energy certificates.

See Table 1 in the Appendix for a more comprehensive set of data.

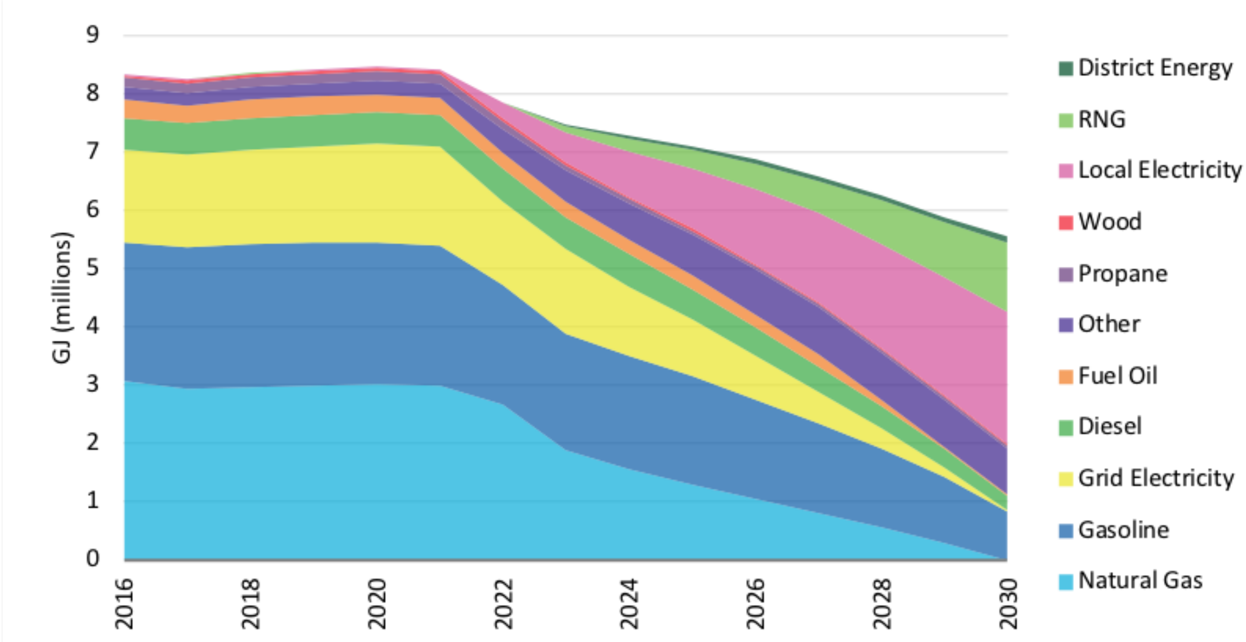

Figure 2. Halton Hills' energy consumption by source in the net-zero scenario (gigajoules), 2016-2030.[1]

Where and How Energy Is Used

The transportation sector reduces its energy demand by 46% by 2030, despite significant population growth (Figure 3). This is mostly due to the transformation of personal vehicles to electric ones and the impressive energy efficiency of electric vehicles (EVs).[2] It is also due to the reduced need for personal vehicles due to an increase in transit use, walking, and cycling, as well as the introduction of an autonomous EV carshare.

On the other hand, residential buildings use 24% less energy in 2030 than in 2016, while commercial buildings use 46% less. The municipal sector accounts for a small proportion of overall energy consumption in 2016 representing 1% of the total, which is reduced to 0% in 2030.

[1] 'Other' includes steam, waste heat, biofuels, and ambient heat for heat pumps.

[2] Electric vehicles convert over 77% of the electrical energy from the grid to power at the wheels, whereas the internal combustion energy vehicles convert about 12%–30%. US Department of Energy (n.d.) All-electric vehicles. Retrieved from: fueleconomy.gov/feg/evtech.shtml.

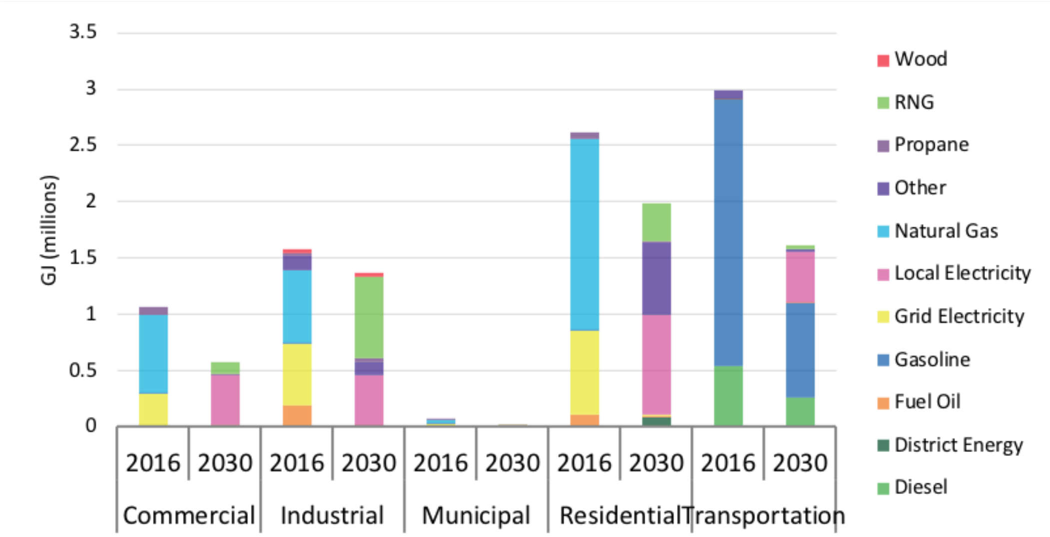

Figure 3 Net-zero scenario community energy use by sector and fuel (gigajoules), 2016-2030.[3]

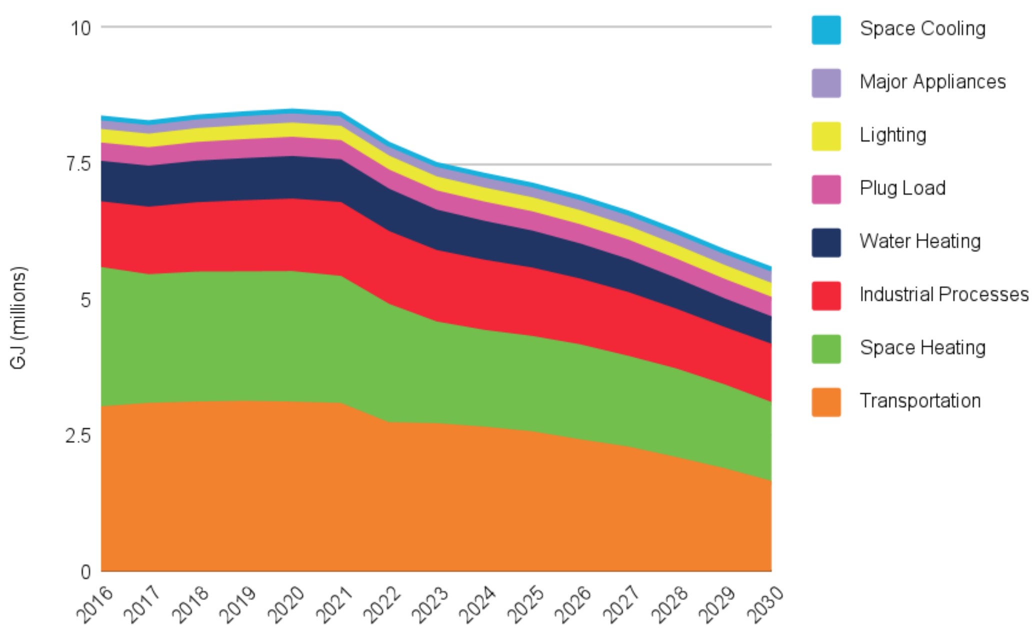

Figure 4. Net-zero scenario community energy use by end use (gigajoules), 2016-2030.

Emissions Reduction

Implementation of the net-zero scenario dramatically alters Halton Hills' emissions compared to 2016 and compared to the 2030 reference scenario, as illustrated in the chart below (Figure 5). By 2030, the net-zero scenario reduces greenhouse gas emissions by 74% compared to 2030 reference scenario levels. This is an impressive outcome over an eight-year period in an energy supply market currently dominated by fossil fuels.

[3] "Other" includes steam, waste heat, biofuels, and ambient heat for heat pumps.

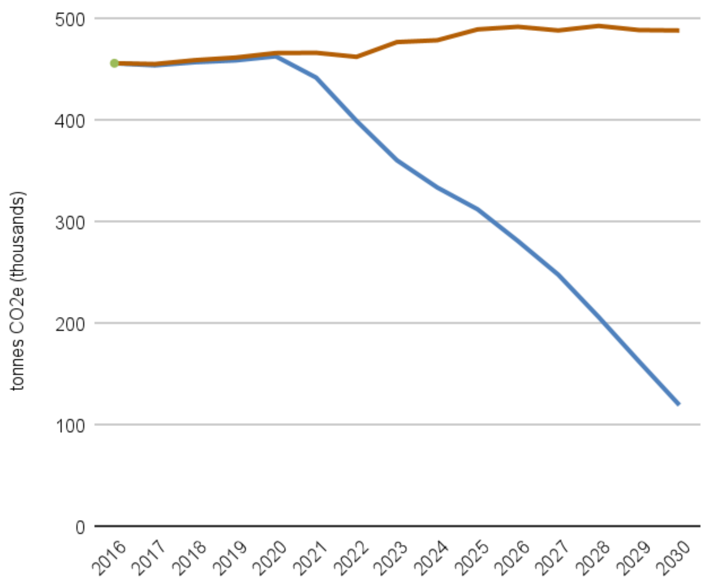

Figure 5. Total community GHG emissions, net-zero scenario (blue) versus the reference scenario (orange) (tCO2e), 2016-2030.

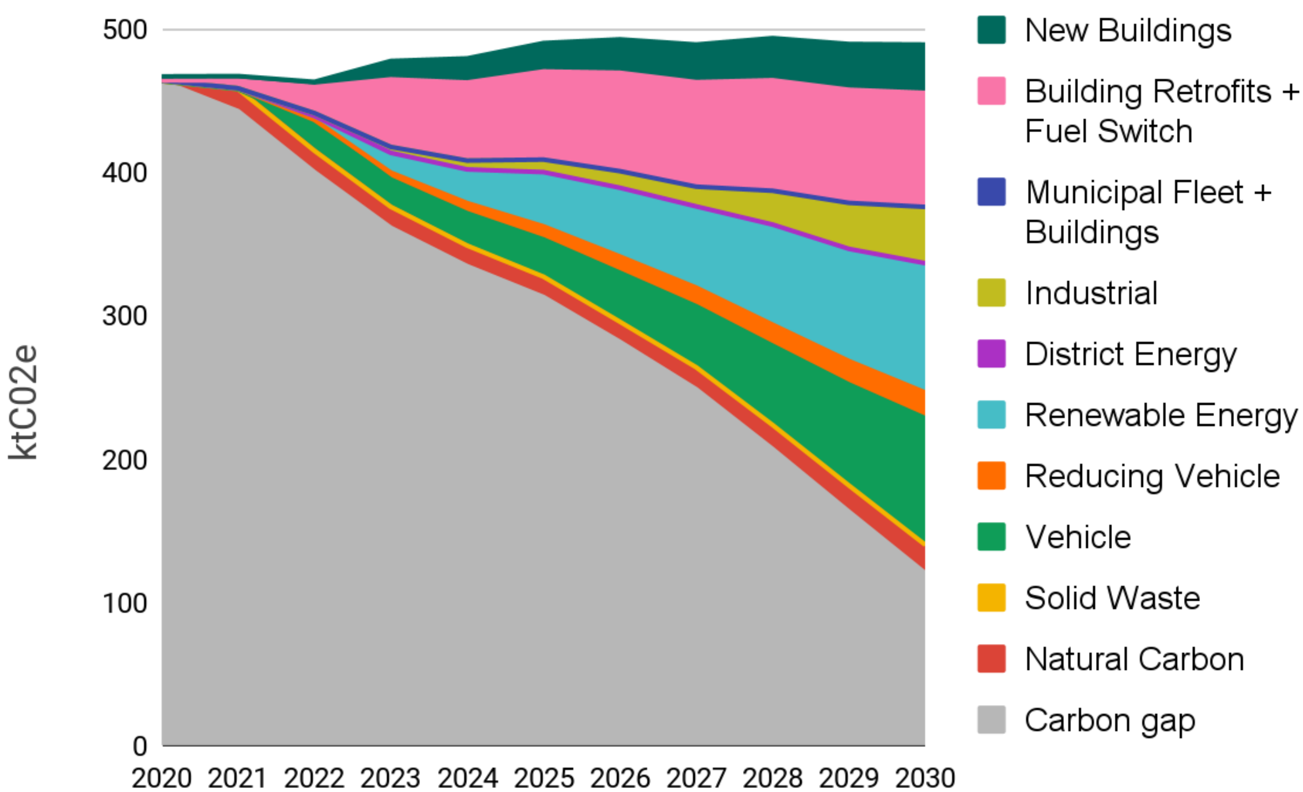

*Figure 6. Wedge diagram illustrating the emissions reductions associated with the net-zero scenario actions (some have been aggregated for visual clarity). **Note:** The emissions reduction of each action is interdependent with the other actions. The wedges diagram shows the emissions reduction effect of implementing all actions considered. Only implementing some will affect the emissions reduction effectiveness of the others.*

Residential retrofits account for the biggest GHG reduction in the net-zero scenario, followed by commercial and personal-use vehicle electrification, and then local renewable energy production (ground mount solar and district energy).

These low-carbon actions result in the widespread reduction of fossil fuel consumption—chiefly natural gas in buildings and gasoline in vehicles (see Figure 7). The dramatic expansion of renewable/low-carbon energy use in the community ensures that the remaining energy consumption generates as few emissions as possible. This is consistent with the "Reduce-Improve-Switch" philosophy described in the Method section.

As a result of the trends in energy use, natural gas emissions are reduced completely by 2030, while emissions from gasoline, diesel, and grid electricity are reduced by 64%, 51%, and 98%, respectively, compared with 2016 (see Figure 7). At the same time, the increase in RNG and renewable electricity consumption does not translate into higher emissions for those energy sources as they are low- or net-zero emissions.

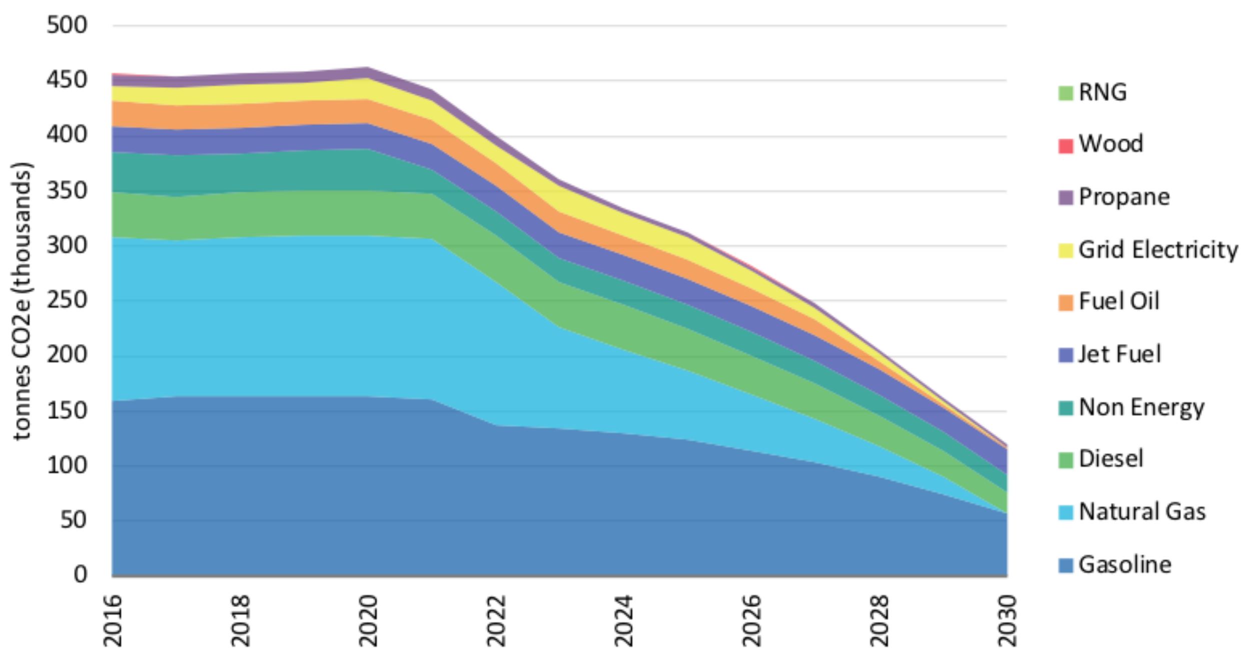

Figure 7. Net-zero scenario emissions by source (ktCO2e), 2016-2030.

Additionally, the net-zero scenario reduces emissions in all sectors. The greatest decrease in terms of net emissions are obtained in the transportation, residential, industrial, and then commercial sectors with reductions of 1.2, 1, 0.5 and 0.4 MtCO2e respectively. In 2030, transportation represents the largest source of GHG emissions, resulting in about 1 Mt CO2e of emissions—55% less emissions compared to 2016. Waste emissions are reduced by 18%.

See Table 3 in the Appendix for more details on community emissions.

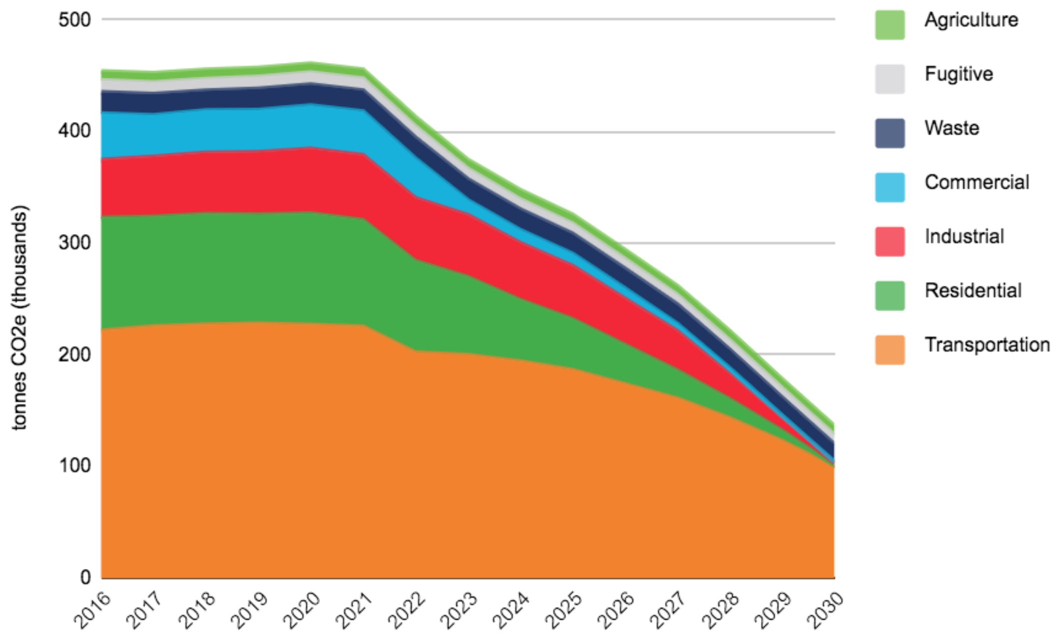

Figure 8.Net-zero scenario emissions by sector (tCO2e), 2016-2030.

Net-Zero Scenario: Sector-by-Sector Energy and Emissions Outcomes

Transportation

Though transportation remains the town's largest source of emissions, the transportation sector transforms dramatically over the 2016-2030 time period, resulting in reduced emissions of 55% from 2016 (Figure 9).

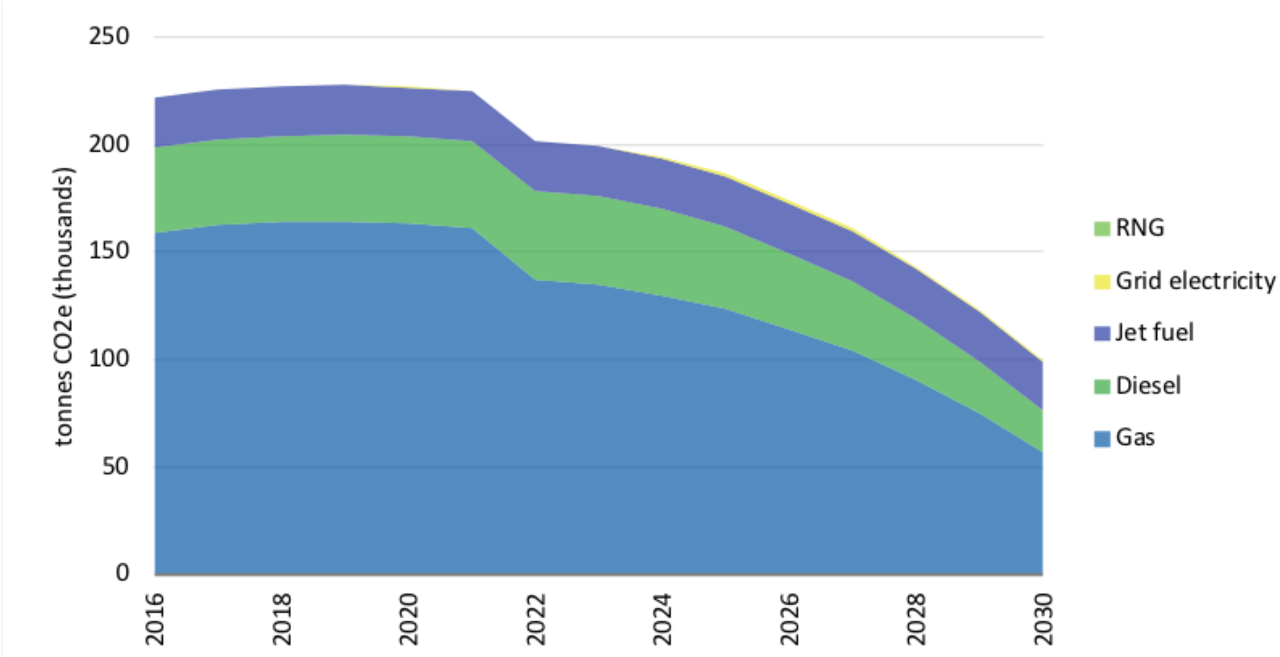

Figure 9. Transportation emissions by fuel type, in 2016 and 2030 in the net-zero scenario (tC02e).

The main driver of this decrease is the shift from internal combustion engines (ICE) to electric vehicles, especially the electrification of cars and light trucks. While the Ontario grid powers electric transportation to start, this electricity is increasingly replaced by local solar and renewable electricity procured from sources outside the town boundaries.

Additionally, increasing walking and cycling infrastructure as well as increasing local transit options, among other actions, help reduce vehicle trip generation and trip distance. The resulting reduction in vehicle kilometres travelled also helps reduce energy consumption and GHG emissions in Halton Hills.

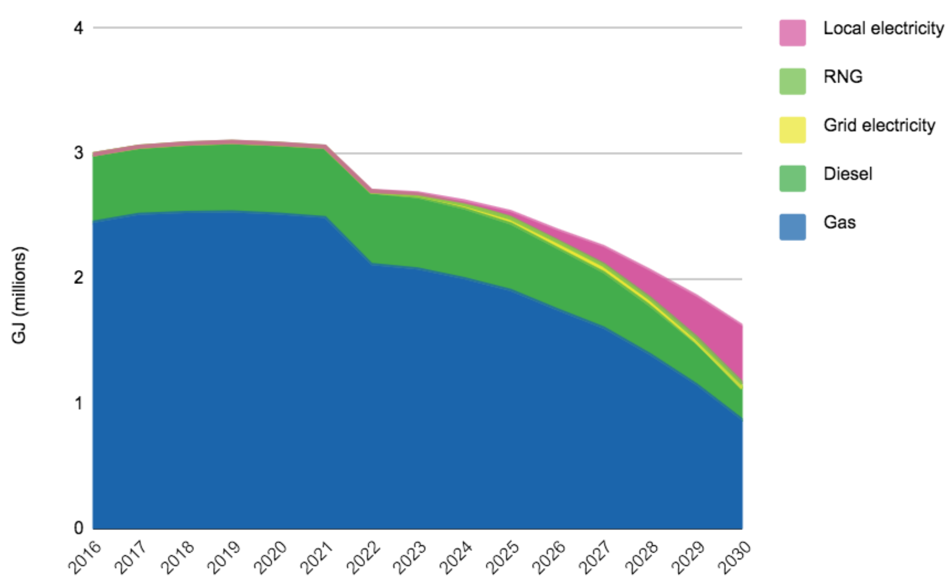

Figure 10. Transportation energy consumption (gigajoules) for the net-zero scenario by fuel type, 2016-2030.

In addition, energy consumption decreases because electric vehicles are much more efficient than their ICE counterparts.

Industry and Buildings

In 2016, residential buildings in Halton Hills accounted for 31% of energy consumption and 22% of GHG emissions, while commercial and industrial buildings accounted for 32% of energy consumption and 20% of GHG emissions. Reduction of energy consumption is the main priority in this sector in the net-zero scenario, with implementation of new building energy performance requirements, deep energy retrofits of existing buildings, and the incorporation of highly energy-efficient heat pumps for space and water heating. These actions combine to reduce energy consumption from buildings by 26% between 2016 and 2030 (see Figure 11).

The transition to low-emissions or zero-emissions fuels is dramatic in the commercial and residential buildings sectors. Whereas in 2016 the dominating energy source is natural gas and the electricity from the Ontario grid, by 2030 renewable electricity and renewable natural gas will become the predominant sources. Given this shift in the energy mix, the sector experiences a 98% reduction in emissions by 2030 compared with 2016 levels (see Figure 12).

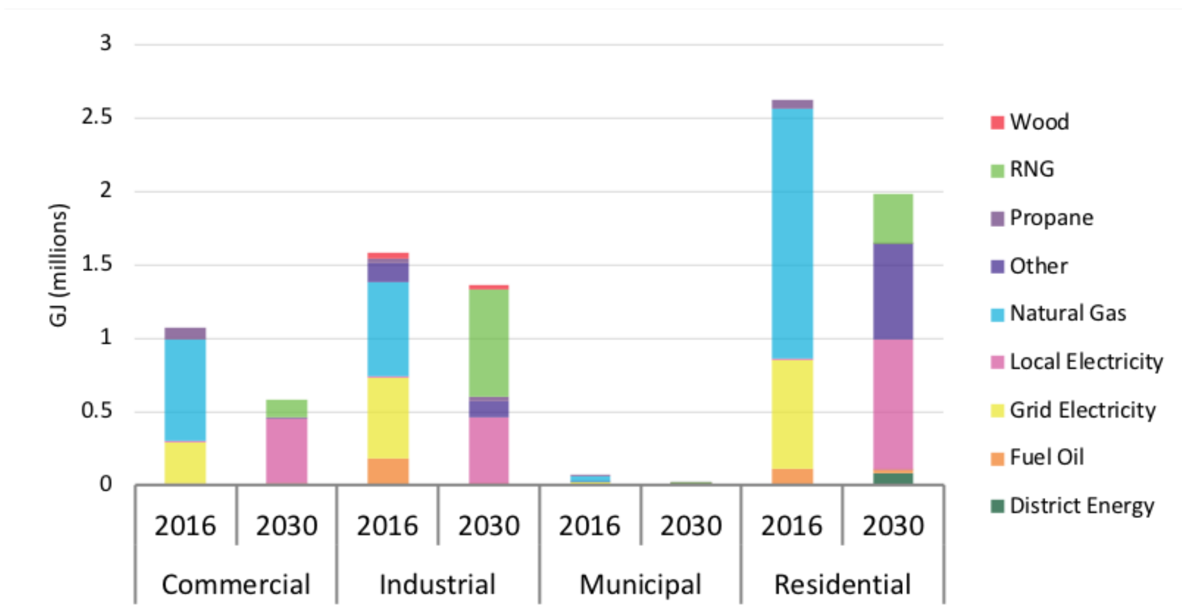

Figure 11. Buildings and industry energy consumption (gigajoules) by sector and fuel type, 2016-2030.[4]

[4] "Other" includes steam, waste heat, biofuels, and ambient heat for heat pumps.

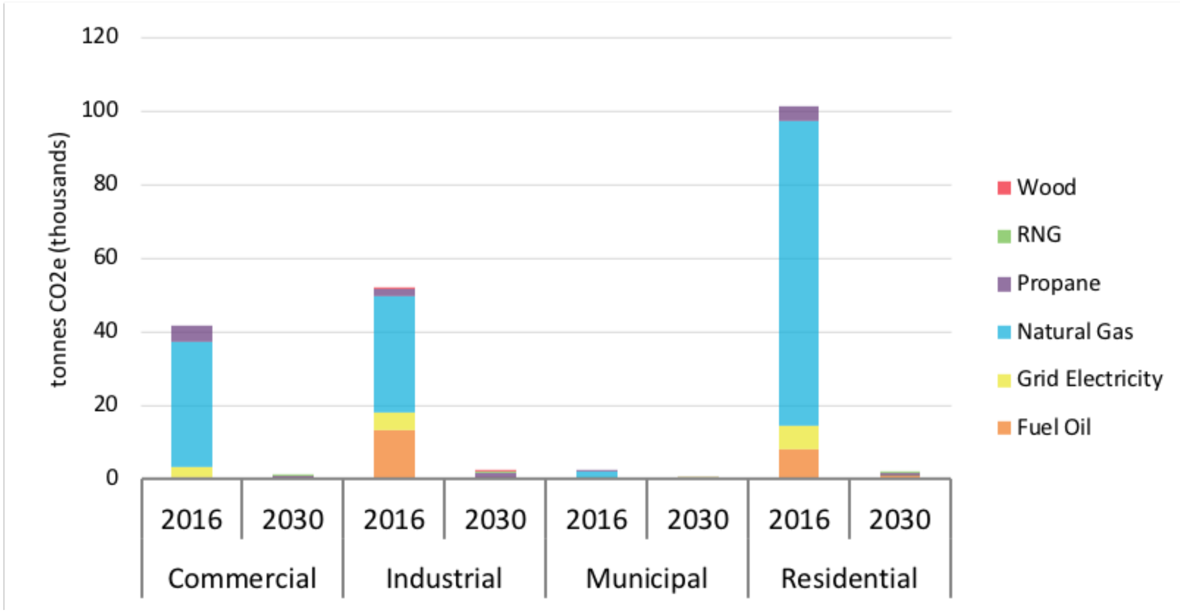

Figure 12. Buildings and industry emissions (tC02e) by sector and fuel type, 2016-2030.

The residential sector was the main energy consumer and emitter in Halton Hills in 2016. This sector will have to deal with important transformations in the way energy is used.

The Town has prioritized industry energy efficiency process improvement targets, assuming an improvement of 50%. Industrial emissions, in turn, show a more dramatic reduction by 2030 (dropping 97% below 2016 levels). The shift is driven by the decrease in energy consumption, as well as reliance on new energy sources that are zero emissions or low emissions.

Figure 13 shows the three areas where building and industrial energy use are centred in the Town in 2016: Acton, Georgetown, and the commercial hub at the turn off from highway 401. Figure 14 shows the emissions associated with these same energy sources in 2016.

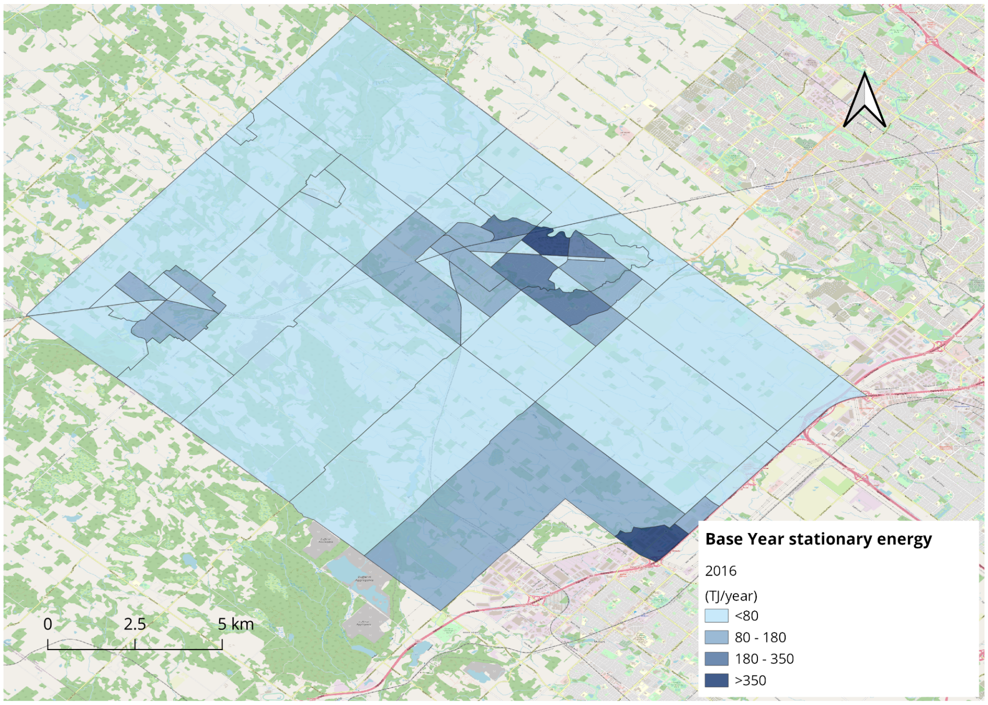

Figure 13. Building and industry energy use ('stationary energy') in 2016.

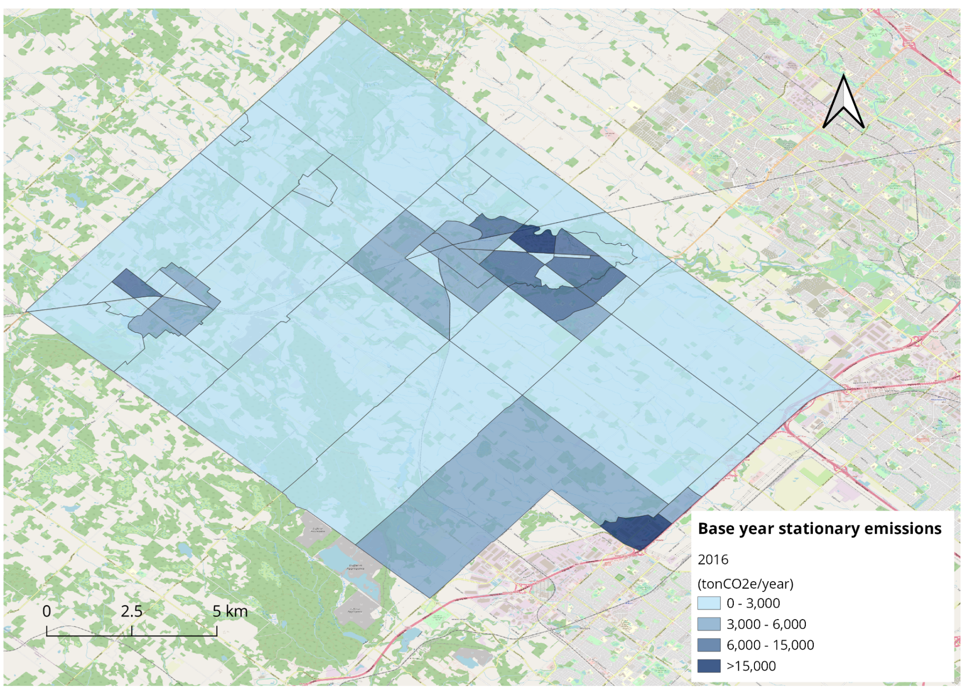

Figure 14. Building and industry emissions ('stationary emissions') in 2016.

Figures 15 and 16 show how the net-zero scenario affects building and industry energy use and emissions in space as a result of energy efficiency and fuel switching measures.

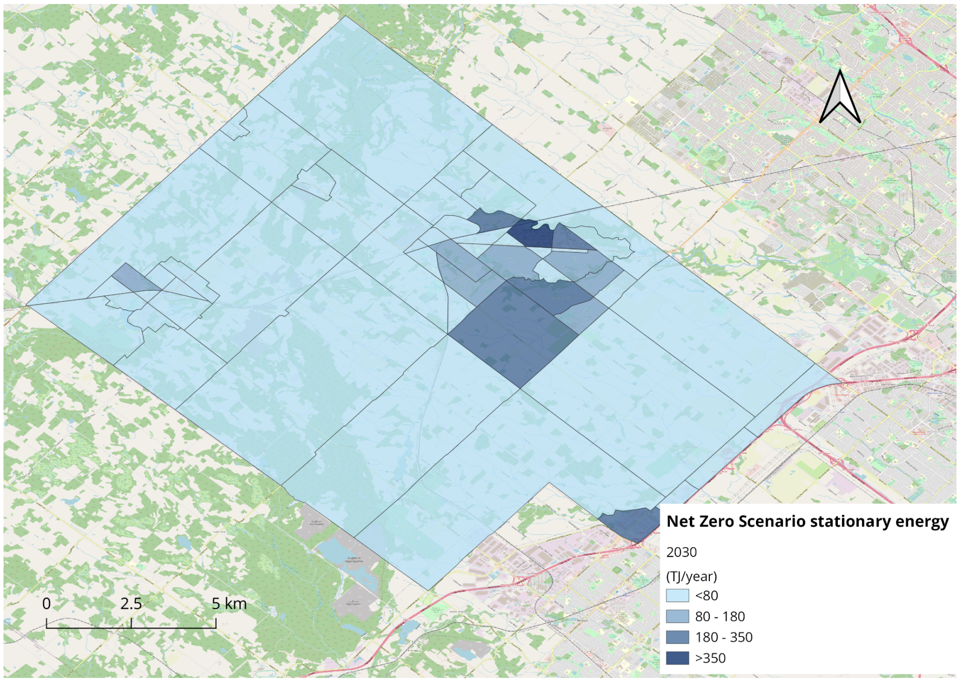

Figure 15. Building and industry energy use ('stationary energy') in 2030.

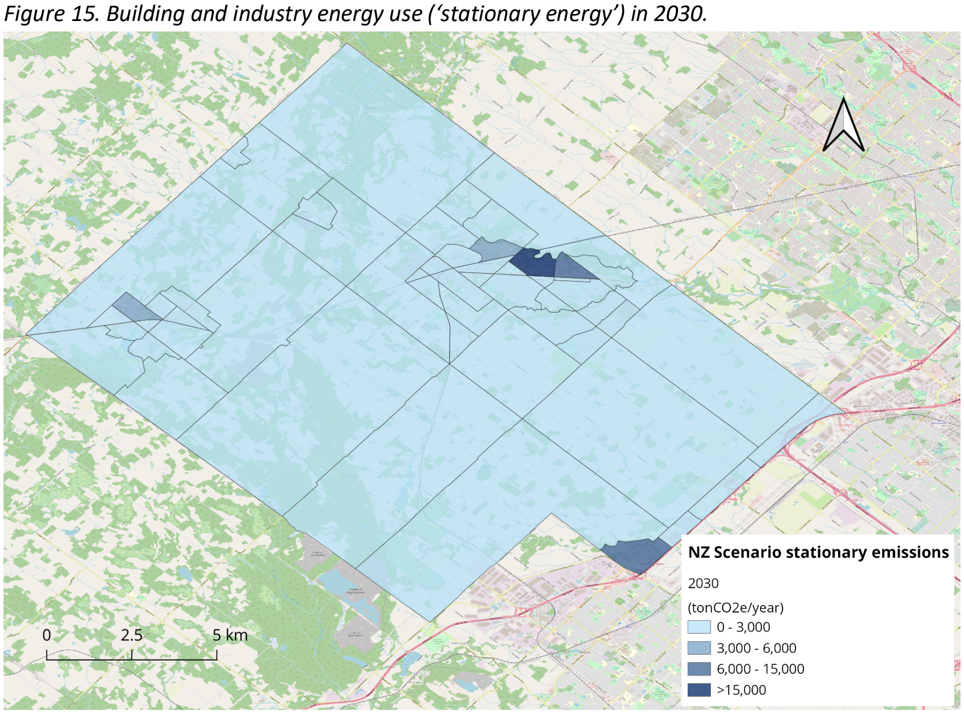

Figure 16. Building and industry emissions ('stationary emissions') in 2016.

Sensitivity Analysis

Uncertainty is inherent in modelling future scenarios and the projection of future emissions. A sensitivity analysis was conducted to examine how these uncertainties could affect the overall results.

The following chart shows how changing key parameters in the model will affect the net-zero scenario for Halton Hills.

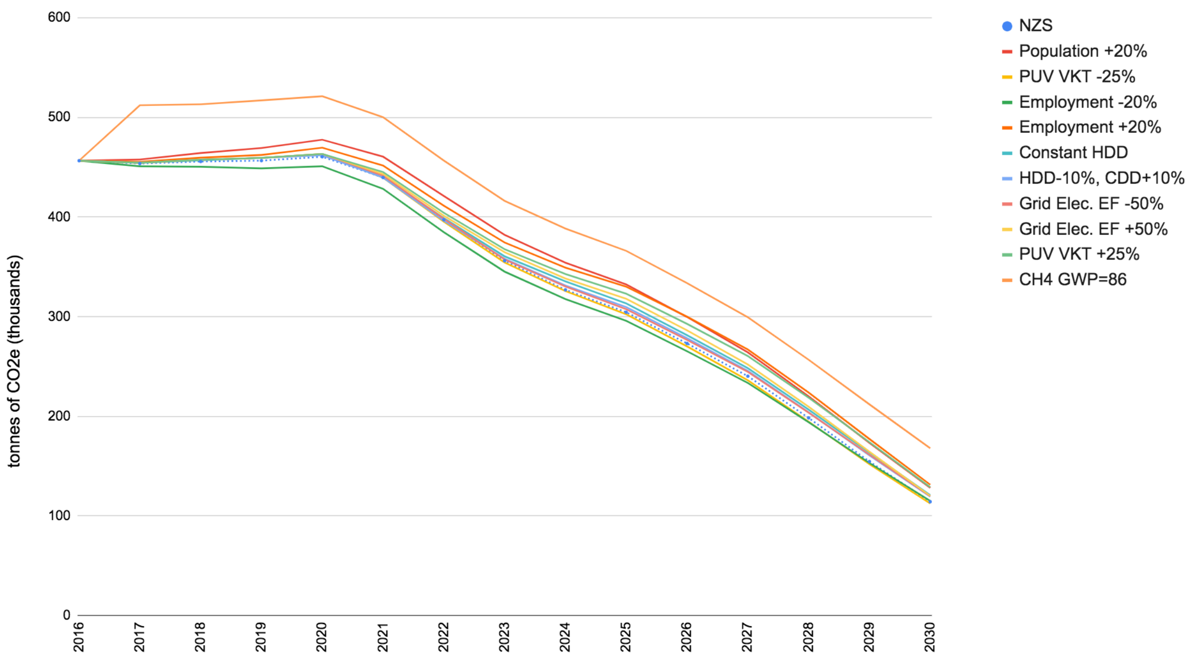

Figure 17. Variations in NZS emissions due to a sensitivity analysis of eight key assumptions (ktCO2e), 2016-2030.

This sensitivity analysis shows what happens when you change the inputs of one of several key inputs, namely:

- Population (increasing and decreasing by 20%),
- Employment (increasing and decreasing by 20%),
- Methane (CH4) global warming potential (GWP) (from 34 to 86),
- Heating and cooling degree days (HDD and CDD) (decreasing and increasing by 10%, respectively),
- Provincial electricity grid emissions factor (increasing and decreasing by 50%), and
- Personal-use vehicle (PUV) vehicle kilometre travelled (VKT) (increasing and decreasing by 25%).

All of the above changes are modelled individually in comparison to the net-zero scenario.

The maximum variation in the net-zero scenario in the sensitivity analysis—a 40% increase in emissions—results from adjusting the methane global warming potential from 100 years (the politically accepted accounting methodology) to 20 years (the scientifically accepted accounting methodology). In other words, if the methane GWP were 86 instead of 34, then the NZS would result in an overall emissions reduction of 63% against the base year, whereas it currently reduces emissions by about 74%.

All other variables assessed in the sensitivity analysis result in a less than 10% impact on overall emissions.

The data illustrated in Figure 17 is provided in Table 10 of the Appendix.

Appendix: Data Tables

Community Energy

Table 1. Community energy consumption tabulated results in the net-zero scenario (NZS), 2016 & 2030.

Energy by sector (GJ)	2016	share 2016	2030 (NZS)	share 2030	% +/ 2016-2030
Commercial	1,071,601	13%	579,317	10%	-46%
Industrial	1,584,413	19%	1,366,510	25%	-14%
Municipal	72,446	1%	13,077	0%	-82%
Residential	2,620,586	31%	1,983,637	36%	-24%
Transportation	2,992,639	36%	1,618,728	29%	-46%
Total	8,341,685		5,561,269		-33%
Energy by fuel (GJ)	**2016**	**share 2016**	**2030 (NZS)**	**share 2030**	**% +/ 2016-2030**
Diesel	537,183	6%	257,284	5%	-52%
District Energy	0	0%	95,463	2%	100%
Fuel Oil	313,369	4%	19,691	0%	-94%
Gasoline	2,369,554	28%	841,847	15%	-64%
Grid electricity	1,601,633	19%	13,747	0%	-99%
Local electricity	18,058	0%	2,255,677	41%	12391%
Natural Gas	3,081,390	37%	0	0%	-100%
Other	214,901	3%	787,148	14%	266%
Propane	168,676	2%	46,264	1%	-73%
RNG	0	0%	1,211,548	22%	100%
Wood	36,920	0%	32,600	1%	-12%
Total	8,341,685	100%	5,561,269	100%	-33%
Energy per capita (GJ/cap)	132		61		-54%

Community Emissions

Table 2. Per capita emissions, 2016 and 2030 (NZS).

Emissions by sector (tCO2e)	2016	2030 (NZS)	% +/- 2016-2030
Emissions per capita (tCO2e/person)	7.2	1.3	-82%

Table 3. Community emissions tabulated results, 2016 & 2030 (NZS).

Emissions by sector (tCO_2e)	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Agriculture	8,083	2%	8,083	7%	0%
Commercial	41,721	9%	955	1%	-98%
Fugitive	10,754	2%	8,487	7%	-21%
Industrial	51,683	11%	2,176	2%	-96%
Municipal	2,411	1%	21	0%	-99%
Residential	101,151	22%	1,697	1%	-98%
Sequestration	0	0%	-16,671	-14%	100%
Transportation	221,704	49%	99,679	83%	-55%
Waste	19,064	4%	15,544	13%	-18%
Total	456,571	100%	119,970	100%	-74%
Emissions by fuel (tCO_2e)	**2016**	**share 2016**	**2030 (NZS)**	**share 2030**	**% +/- (2016-2030)**
Diesel	39,613	9%	19,228	16%	-51%
Fuel Oil	22,291	5%	1,399	1%	-94%
Gasoline	158,853	35%	56,860	47%	-64%
Grid electricity	14,330	3%	290	0%	-98%
Jet Fuel	23,238	5%	23,238	19%	0%
Natural Gas	149,970	33%	0	0%	-100%
Non Energy	37,900	8%	15,443	13%	-59%
Propane	10,317	2%	2,830	2%	-73%
RNG	0	0%	631	1%	100%
Wood	58	0%	51	0%	-13%
Total	456,571	100%	119,970	100%	-74%

Building Sector

Table 4. Buildings sector energy tabulated results, 2016 & 2030 (NZS).

Buildings energy (GJ) by building type	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Commercial	1,071,601	20%	579,317	15%	-46%
Industrial	1,584,413	30%	1,366,510	35%	-14%
Municipal	72,446	1%	13,077	0%	-82%
Residential	2,620,586	49%	1,983,637	50%	-24%
Total	5,349,046	100%	3,942,541	100%	-26%
Buildings energy (GJ) by fuel	**2016**	**share 2016**	**2030 (NZS)**	**share 2030**	**% +/- (2016-2030)**

District Energy	0	0%	95,463	2%	100%
Fuel Oil	313,369	6%	19,691	0%	-94%
Grid electricity	1,601,596	30%	10,705	0%	-99%
Local electricity	18,058	0%	1,798,408	46%	9859%
Natural Gas	3,081,390	58%	0	0%	-100%
Other	129,035	2%	762,440	19%	491%
Propane	168,676	3%	46,264	1%	-73%
RNG	0	0%	1,176,971	30%	100%
Wood	36,920	1%	32,600	1%	-12%
Total	5,349,046	100%	3,942,541	100%	-26%

Buildings energy (GJ) by end use	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Industrial Processes	1,207,854	23%	1,071,268	27%	-11%
Lighting	250,545	5%	256,190	6%	2%
Major Appliances	167,168	3%	228,569	6%	37%
Plug Load	336,133	6%	358,958	9%	7%
Space Cooling	80,262	2%	73,931	2%	-8%
Space Heating	2,562,879	48%	1,450,242	37%	-43%
Water Heating	744,205	14%	503,383	13%	-32%
Total	5,349,046	100%	3,942,541	100%	-26%

Table 5. Buildings sector emissions tabulated results, 2016 & 2030 (NZS).

Buildings emissions (tCO_2e) by building type	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Commercial	41,721	21%	955	20%	-98%
Industrial	51,683	26%	2,176	45%	-96%
Municipal	2,411	1%	21	0%	-99%
Residential	101,151	51%	1,697	35%	-98%
Total	196,966	100%	4,848	100%	-98%

Buildings emissions (tCO_2e) by fuel	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Electricity	14,329	7%	226	0%	-98%
Fuel Oil	22,291	11%	1,399	0%	-94%
Natural Gas	149,970	76%	0	0%	-100%
Propane	10,317	5%	2,830	1%	-73%
RNG	0	0%	342	0%	100%

Wood	58	0%	51	0%	-12%
Total	196,966	100%	4,848	100%	-98%

Buildings emissions (tCO_2e) by end use	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Industrial Processes	40,274	20%	1,626	34%	-96%
Lighting	2,217	1%	31	1%	-99%
Major Appliances	2,162	1%	32	1%	-99%
Plug Load	3,475	2%	376	8%	-89%
Space Cooling	1,112	1%	10	0%	-99%
Space Heating	115,818	59%	1,321	27%	-99%
Water Heating	31,907	16%	1,451	30%	-95%
Total	196,966	100%	4,848	100%	-98%

Transportation Sector

Table 6. Transportation sector energy tabulated results, 2016 & 2030 (NZS).

Transportation energy (GJ) by fuel	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
RNG	0	0%	34,576	2%	100%
Diesel	546,370	18%	260,988	16%	-52%
Gas	2,446,232	82%	862,851	53%	-65%
Grid electricity	37	0%	3,043	0%	8218%
Local electricity	0	0%	457,270	28%	100%
Total	2,992,640	100%	1,618,728	100%	-46%

Transportation energy (GJ) by vehicle type	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Car	1,136,787	38%	410,784	25%	-64%
Heavy truck	204,729	7%	126,078	8%	-38%
Light rail	316	0%	1,580	0%	400%
Light truck	1,030,948	34%	605,540	37%	-41%
Off road	601,473	20%	459,111	28%	-24%
Rail	7,475	0%	7,475	0%	0%
Urban bus	10,911	0%	8,159	1%	-25%
Total	2,992,640	100%	1,618,728	100%	-46%

Table 7. Transportation emissions, tabulated results, 2016 & 2030 (NZS).

Transportation Emissions (tCO_2e) by fuel	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
RNG	0	0%	289	0%	100%

Diesel	39,613	18%	19,228	19%	-51%
Gas	158,853	72%	56,860	57%	-64%
Grid electricity	0	0%	64	0%	19503%
Jet fuel	23,238	10%	23,238	23%	0%
Total	221,704	100%	99,680	100%	-55%

Transportation Emissions (tCO2e) by vehicle type	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Aviation	23,238	10%	23,238	23%	0%
Car	73,354	33%	16,893	17%	-77%
Heavy truck	14,205	6%	5,252	5%	-63%
Light truck	66,541	30%	23,527	24%	-65%
Off road	43,000	19%	29,775	30%	-31%
Rail	601	0%	699	1%	16%
Urban bus	765	0%	295	0%	-61%
Total	221,704	100%	99,680	100%	-55%

Waste Sector

Table 8. Waste Sector Emissions, 2016 & 2030 (NZS).

Waste Emissions (tCO_2e) by fuel	2016	share 2016	2030 (NZS)	share 2030	% +/- (2016-2030)
Biological	1,584	8%	2,247	14%	42%
Landfill	16,648	87%	12,180	78%	-27%
Wastewater	832	4%	1,117	7%	34%
Total	19,064	100%	15,544	100%	-18%

Land Use

Table 9. Land-Use Change Emissions 2021-2030 (NZS).

	(tCO_2e/yr)		
	2021	2026	2031
1. Forest land: remaining forest land	-93,828	-93,638	-93,504
1. Cropland: remaining cropland	124	-172	-466
1. Settlements: remaining settlements	-19,748	-25,664	-31,674
2.1 Forest land converted to settlements	27,997	6,588	4,666
2.2 Cropland converted to settlements	502	2,920	2,325
Total carbon sequestered	-84,953	-109,966	-118,651

Sensitivity Analysis

Table 10. NZS sensitivity analysis results.

	ENERGY Impact: relative to NZ Scenario in 2030		EMISSIONS Impact: relative to NZ Scenario in 2030	
	[+/-] GJ	[+/-] %	[+/-] tonnes CO2e	[+/-] %
Demographics				
Decrease population -20%	-297,153	-5.3%	-5,769	-4.8%
Increase population 20%	487,200	8.8%	8,139	6.8%
Employment				
Decrease employment -20%	-369,171	-6.6%	-4,963	-4.1%
Increase employment 20%	538,343	9.7%	11,324	9.4%
Heating degree days (HDD)				
Hold HDD fixed	121,094	2.2%	922	0.8%
Decrease HDD + increase CDD by 10%	-258,239	-4.6%	-548	-0.5%
Grid electricity emissions factor (EF)				
Decrease grid emissions factor 50%	0	0.0%	-145	-0.1%
Increase grid emissions factor 50%	0	0.0%	145	0.1%
Vehicle kilometres travelled (VKT)				
Decrease VKT 25% by 2030	-190,198	-3.4%	-7,549	-6.3%
Increase VKT 25% by 2030	190,198	3.4%	8,875	7.4%
Methane				

Adjust methane global warming potential (GWP) from 100-yr to 20-yr GWP (i.e., 86)	0	0.0%	47,956	40.0%