Thunder Bay Community Energy Emissions Plan:

Net Zero GHG Emissions Financial and Economic Analysis Summary

December 2020

Purpose of this Document

This document provides a summary of the projected costs, revenues, and savings represented by the low-carbon pathway modelled for Thunder Bay's Community Energy and Emissions Plan.

The pathway's financial impacts are assessed as a whole and on an action-by-action basis. Associated economic development opportunities and employment impacts are reviewed in the previously provided best practices paper.

A detailed analysis of the low-carbon scenario modeled as the basis of the CEEP is provided in a separate report.

CONTENTS

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 capital investments and related revenues, energy savings, and avoided costs of carbon represented by the proposed Community Energy and Emissions Plan. The intent of this analysis is to help inform project stakeholders about the potential costs and savings represented by the CEEP in relation to the modeled Business-as-Planned 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 City of Thunder Bay and cannot be applied to other jurisdictions without further analysis. Any use by the City of Thunder Bay, 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.

Overview

The following table highlights the key findings from the financial analysis of the low-carbon scenario modelled for Thunder Bay's Community Energy and Emissions Plan (CEEP). Further details about what is captured in each financial estimate is provided in the body of the report, as indicated in the right-hand column.

Table 1. Summary of high-level financial analysis of Thunder Bay's CEEP.

Financial estimate	Key results	Where to find further details
Total incremental capital investment, 2020-2050	*$3.8 billion, NPV. (Undiscounted total is $5.1 billion)*	Part 2, NPV and MAC Values
Total savings, 2020-2089[1]	*$3.3 billion, NPV. (Undiscounted total is $5.3 billion)*	Part 2, Cash Flow Analysis
Total revenue, 2020-2089	*$2.2 billion, NPV. (Undiscounted value is $3.5 billion)*	Part 2, Cash Flow Analysis
Net benefit of the CEEP investments, 2020-2089	*$1,705 million, NPV. (Undiscounted value is $3.7 billion)*	Part 2, Table 3
Average cost to reduce each tonne of GHG	*$102 in savings, NPV.*	Part 2, Table 3
Most cost-effective GHG-reduction action ($/ tonne CO2e)	*1. Transit expansion and electrification: $6 thousand in savings* *2. Car-free zones: $4.5 thousand in savings* *3. Denser housing: $1 thousand in savings* *4. Personal electric vehicles: $5 hundred in savings* *5. Industrial building retrofits: $5 hundred in savings*	Part 2, Table 3
Household savings on energy, 2020-2050	*$3,500 avg/year*	Part 2, Cost Savings for Households

[1] While the capital investments in the low carbon scenario all occur by 2050, the savings and revenue from many of those investments continue well beyond 2050 and are tracked in this analysis to the year 2089. This also accounts for why the gap between the NPV and undiscounted totals is higher for the non-capital categories.

Part 1. Key Financial Analysis Concepts

The direct financial impacts of Thunder Bay's Community Energy and Emissions Plan (CEEP) provide important context for local decision-makers. However, it is important to note that the direct financial impacts are a secondary motivation for undertaking actions that reduce greenhouse gas (GHG) emissions. First and foremost, GHG reductions are a critical response to the global climate emergency. In addition, most measures included in the CEEP also provide social goods to the community, such as net job creation and positive health outcomes, which are only marginally captured in this financial analysis via the cost of carbon.

The following are key concepts that are used to analyze the financial impacts of the CEEP.

Costs are relative to the BAP

This financial analysis tracks projected costs and savings associated with low-carbon measures that are above and beyond the assumed 'business-as-planned' costs.

Discount Rate

The discount rate is the baseline growth value an investor places on their investment dollar. A project is considered financially beneficial by an investor if it generates a real rate of return equal to or greater than their discount rate.

An investor's discount rate varies with the type of project, duration of the investment, risk and the scarcity of capital.

The social discount rate is the discount rate applied for comparing the value to society of investments made for the common good and as such it is inherently uncertain and difficult to determine. Some argue that in the evaluation of climate change mitigation investments a very low or even zero discount rate should be applied. In this project, we evaluate investments in a low-carbon future with a 3% discount rate.

Net Present Value

The net present value of an investment is the difference between the present value of the capital investment and the present value of the future stream of savings and revenue generated by the investment.

Five aggregate categories are used to track the financial performance of the low-carbon actions in this analysis: capital expenditures, energy savings (or additional costs), carbon cost savings (assuming the carbon price reaches $50/tonne CO2e in 2023 and is held constant thereafter), operation and maintenance savings, and revenue generation (associated with renewable energy production facilities and some transit actions). What is NOT included are administrative costs associated with implementing programs, as well as any energy system infrastructure upgrades that may be required. Similarly, the broader social costs that are avoided from mitigating climate change are not included in the financial analysis.

Abatement Cost

The abatement cost of an action is the estimated cost for that action to reduce one tonne of greenhouse gas emissions ('GHG') and is calculated by dividing the action's net present value ('NPV') by the total GHG emissions it reduces (tCO2e) over its lifetime. For example, if a project has a net present value of $1,000 and generates 10 tCO2e of savings, its abatement cost is $100 per tCO2e reduced.

Amortization

The costs of major capital investments are typically spread over a period of time (e.g. a mortgage on a house commonly has a 25- year mortgage period). Amortization refers to the process of paying off capital expenditures (debt) through regular principal and interest payments over time. In this analysis we have applied a 25-year amortization rate to all investments.

Industrial Emissions

Financial analysis of the industrial sector includes only the low-carbon investments for secondary manufacturing. Primary industry (e.g. pulp and paper) comprises about 80% of industrial gas and electricity sales in Thunder Bay and emission reduction costs for that sector have not been estimated in this analysis.

Energy and Carbon Cost Projections

The energy cost projections displayed in Figure 1 underlie the financial analysis. These projections were derived from:

- the Independent Electricity System Operator's Long-Term Energy Plan (electricity),
- the US Energy Information Administration (propane), and
- the National Energy Board (all other fuels).

The financial analysis is sensitive to electricity and natural gas costs. Electricity costs are projected to increase more rapidly than natural gas; if natural gas costs increase more rapidly, then the financial benefit of many of the actions increases.

An escalating cost of carbon based on federal regulation was applied out to 2023, then held constant.

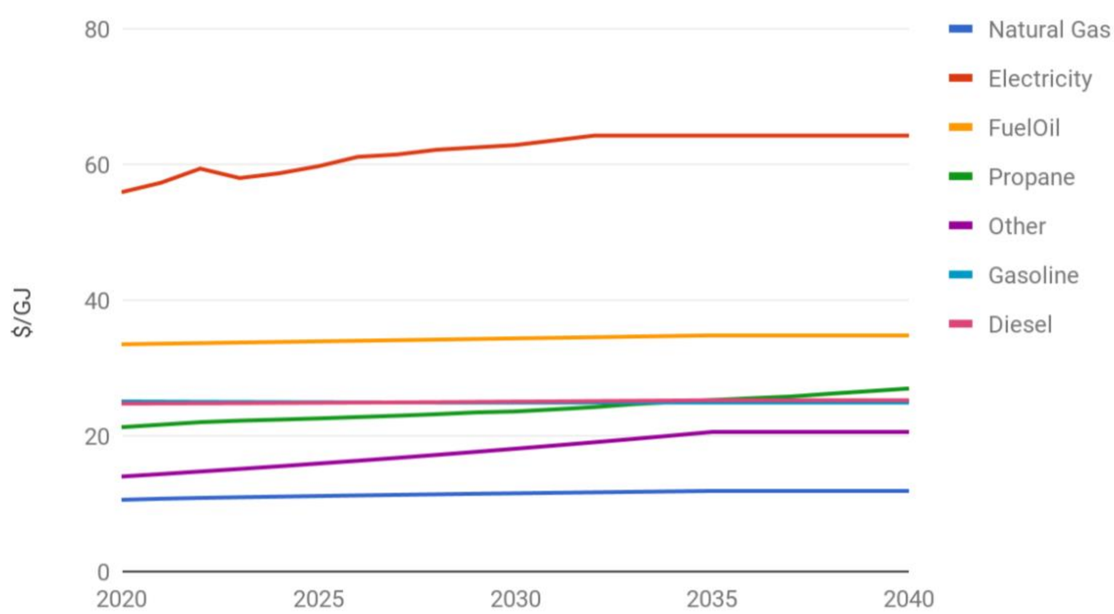

Figure 1. Project energy costs

Part 2. Thunder Bay's CEEP Financial Analysis Results

Abatement Costs

As outlined in Table 2, the investments included in the low carbon pathway presented here actually yield a negative cost of carbon; that is, the net savings and revenues they generate yield a positive financial return that translates to a weighted average *benefit* of $102/tonne of CO2e reduced.[2] The values for the individual measures are included in Table2; all measures that have a positive abatement cost are highlighted in red, all measures with a negative abatement cost are highlighted in green.

The highest cost reduction for one tonne of GHG emissions is the shift to non-vehicle transport (walking and biking) at $1,677, followed closely by heat pumps in new residential buildings, at $1,405. This high cost is primarily due to the time sequencing of the model; in both cases these actions occur after significant GHG-reductions to the source GHG being addressed have already occurred. In the case of walking and biking, this action is sequenced in the model to follow electrification of vehicles. In the case of heat pumps in new homes, these are homes that are already quite energy efficient.

The lowest cost tonne of GHG reduction applies to expanding transit, at an estimated $6,266 of fuel savings and revenue. Again, this benefit is due to model sequencing. These new buses are electric, and are replacing fossil-fuel intensive buses (and not electric buses).

As such, reviewing the following table action-by-action requires understanding the action's sequencing in the model (i.e. what is if offsetting). For this reason, what is most important when looking at the following table is the abatement cost for the entire plan, as well as identifying which actions are considered to have a positive versus negative abatement cost. Measures with a *positive* net present value (i.e. where the investment has a positive return of at least 3%) will therefore have a *negative* abatement cost (i.e. they would be worth doing even without consideration of the carbon benefits), whereas measures with a *negative* net present value will have a *positive* abatement cost (i.e. these are measures with returns less than 3%).

[2] The net present value of the measures includes credit for the avoided costs of carbon ($50/tonne CO2e); if that credit were excluded, the net savings per tonne of GHG mitigated would be correspondingly lower.

Table 2. Net present value and abatement costs by action.

Low-Carbon Action	Cumulative Emissions Reduction (kt CO2eq)	Net Present Value of Action ($ millions)	Abatement Cost ($ / t CO2 eq)
Intensification and Demolitions	825	$325	-$394
Denser Housing	39	$40	-$1,017
New Residential Buildings Heat Pumps	79	-$112	$1,405
New Residential Buildings	81	-$17	$216
New Res Rooftop Solar	25	-$15	$587
New Non-Residential Buildings Heat Pumps	140	-$23	$167
New Non-Residential Buildings	241	$104	-$431
New Industrial Buildings	0.48	$1	-$1,571
New NonRes Rooftop Solar	43	-$26	$612
Residential Retrofits	1,880	-$893	$475
Heat Pumps in Retrofitted Buildings	1,594	-$507	$318
Water Heaters in Retrofitted Buildings	762	-$320	$420
Municipal Retrofits	157	$13	-$84
Municipal Equipment Retrofits	142	$26	-$185
Municipal Rooftop Solar Retrofit	69	-$47	$680
NonRes Retrofits	1,394	$73	-$52
NonRes Heat Pumps in Retrofits	900	-$63	$70
NonRes Water Heaters in Retrofits	86	-$31	$363
Industrial Building Retrofits	23	$11	-$460

Industrial Process Improvement	675	$231	-$341
Existing Rooftop Solar Retrofit	211	-$142	$672
Clean District Energy	96	-$43	$449
Transit Electrification	113	-$29	$259
Transit Expansion	104	$651	-$6,266
Transportation Marketing - Work at Home	54	-$7	$124
Shift to Non-Vehicle Transport	127	-$213	$1,677
Commercial Use Vehicle Electrification/Shift to H2	1,038	$1,037	-$999
E-Bikes	54	-$67	$1,237
Car Free	215	$973	-$4,533
Municipal Fleet Electrification	31	$14	-$442
Personal Use Vehicle Electrification	1,761	$876	-$498
Solid Waste Reduction and Water Conservation	818	$101	-$124
Wastewater Process Efficiency	13	-$2	$159
Waste to Energy (RNG)	104	-$11	$110
Renewable Natural Gas	20	-$2	$105
Hydrogen Displacement of Natural Gas	574	-$168	$292
Ground Mount Solar	869	-$82	$94
Wind Generation	825	$48	-$58
Sequestration (tree planting/intensification)	454	-$2	$5
TOTAL	**16,638**	**$1,705**	**AVERAGE: $102**

*This total does not include primary industry GHG reductions

Marginal Abatement Cost Curve

Figure 2 shows the marginal abatement cost curve (MACC) for measures included in Thunder Bay's CEEP.

While a MACC illustrates the financial profile of the suite of actions, it is an imperfect indicator. The presentation of the MACC implies that the actions are a menu from which individual actions can be selected. In fact, many of the actions are dependent on each other, for example, the district energy cost increases without retrofits. Another important message is that in order to achieve the City's target all the actions need to be undertaken, as soon as possible. While there can be a tendency to wait for technological improvements, this has the effect of reducing the value of the savings that can be achieved for households and businesses, and the new employment opportunities that can be created.

The MACC provides useful insights that guide implementation planning, for example:

- Can high cost and high savings actions be bundled to achieve greater GHG emissions reductions?
- How can the City help reduce the costs of the high cost actions by supporting innovation or by providing subsidies?
- Which actions both save money and reduce the most GHG emissions? These can be considered the big moves.
- Which actions are likely to be of interest to the private sector, assuming barriers can be removed or supporting policies introduced?

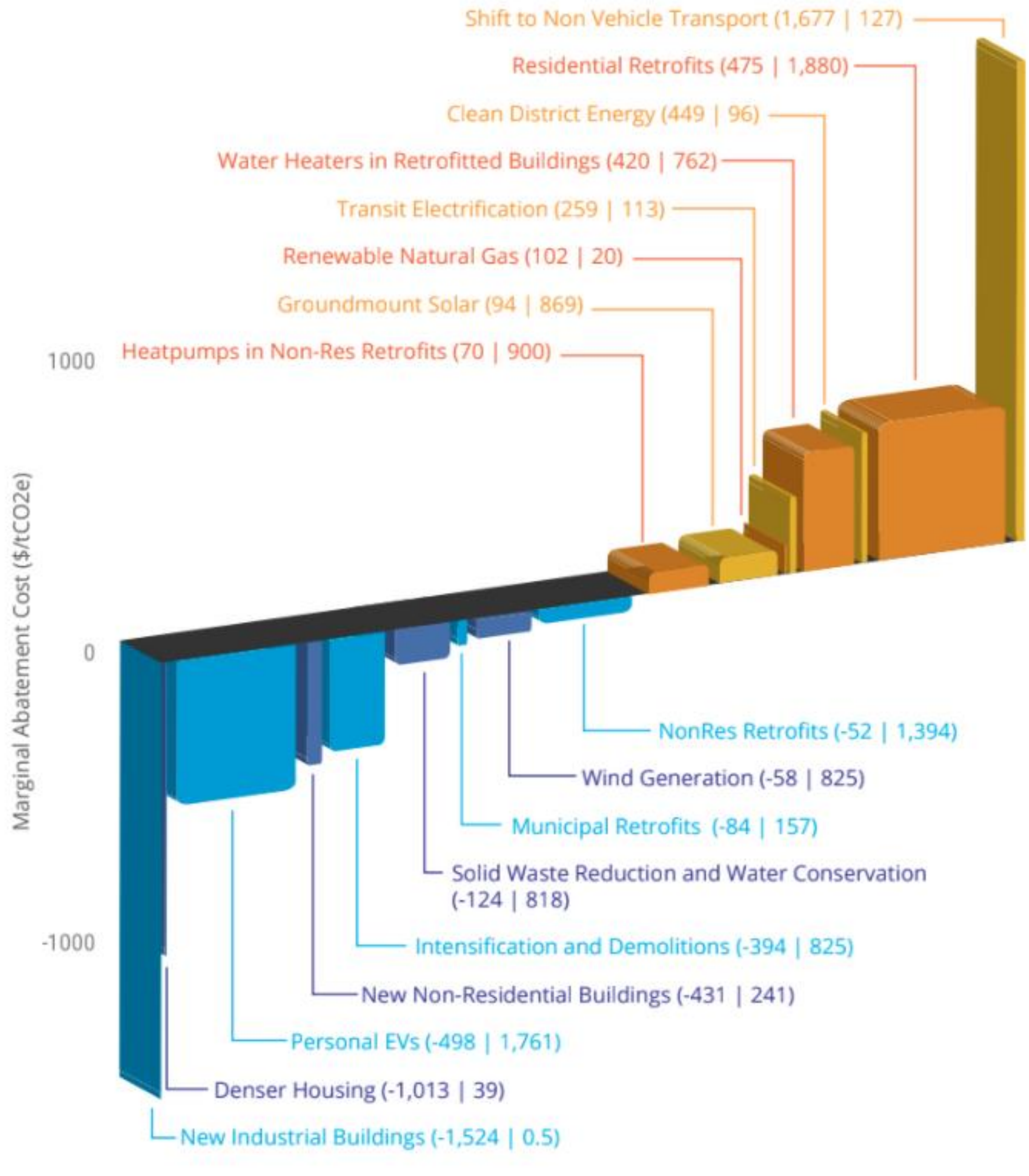

Figure 2. Marginal abatement cost curve for low-carbon actions included in Thunder Bay's CEEP.

These are exemplified in a sample Figure 3 MACC.

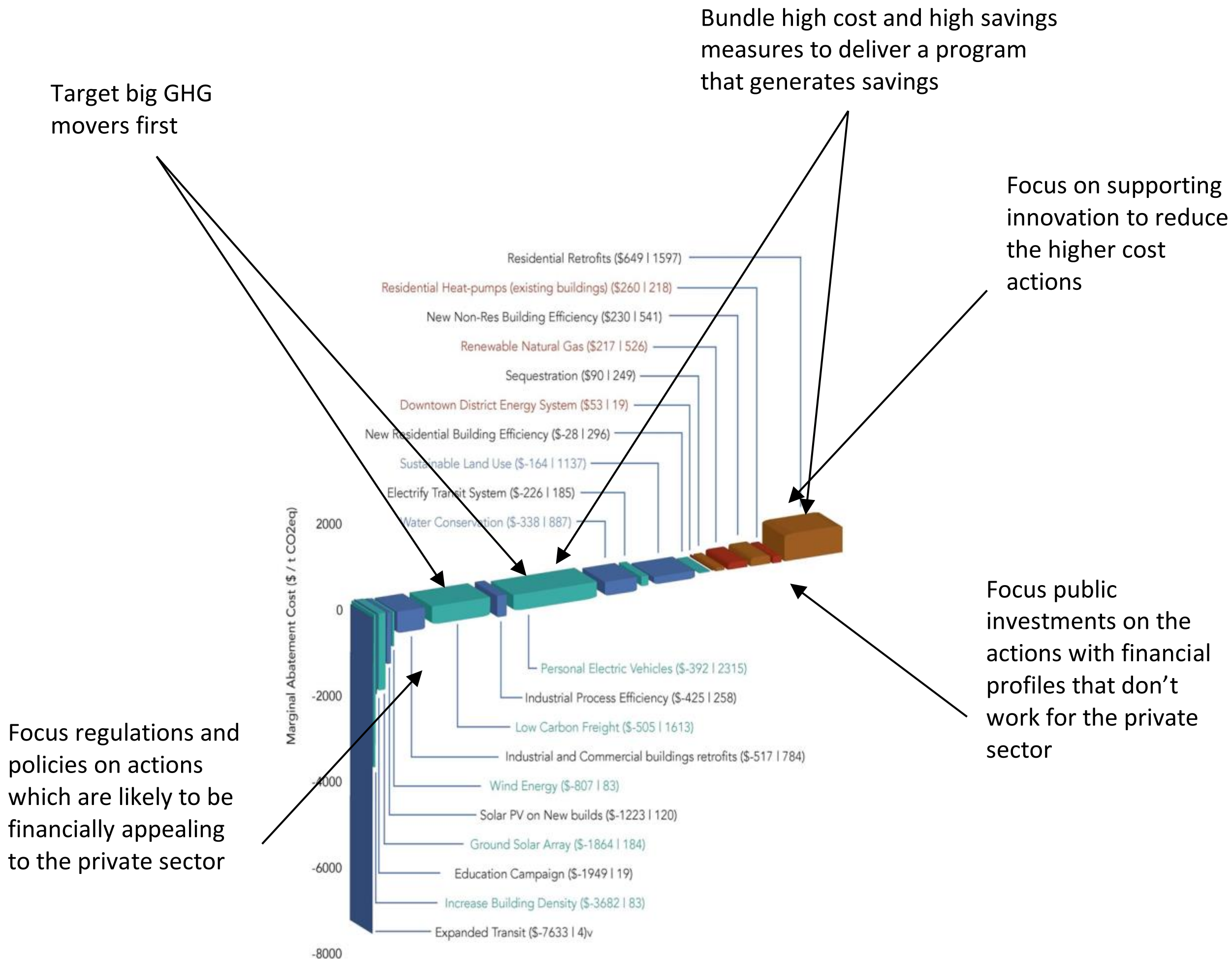

Figure 3. Examples of the strategic uses of a marginal abatement cost curve analysis.

Present and Net Present Values

As noted in the previous section, most of the actions in the low-carbon scenario have positive net present values, as does the program of investments taken as a whole. Figure 4 shows the present value of the major components of CEEP: investments, operations and maintenance savings, fuel and electricity savings, avoided costs of carbon, and revenue from transit and local energy generation. After discounting at 3%, the investments in the program have a present value of $3.8 billion and the savings and revenue have a present value of $5.5 billion, for a NPV of the whole scenario of $1,705 million.

It is important to highlight the fact that capital investment for the plan ends in 2050, however the NPV includes the energy, maintenance, and carbon costs savings as well as revenue projected over the full life of the measure, which in some cases extend as far as 2089.

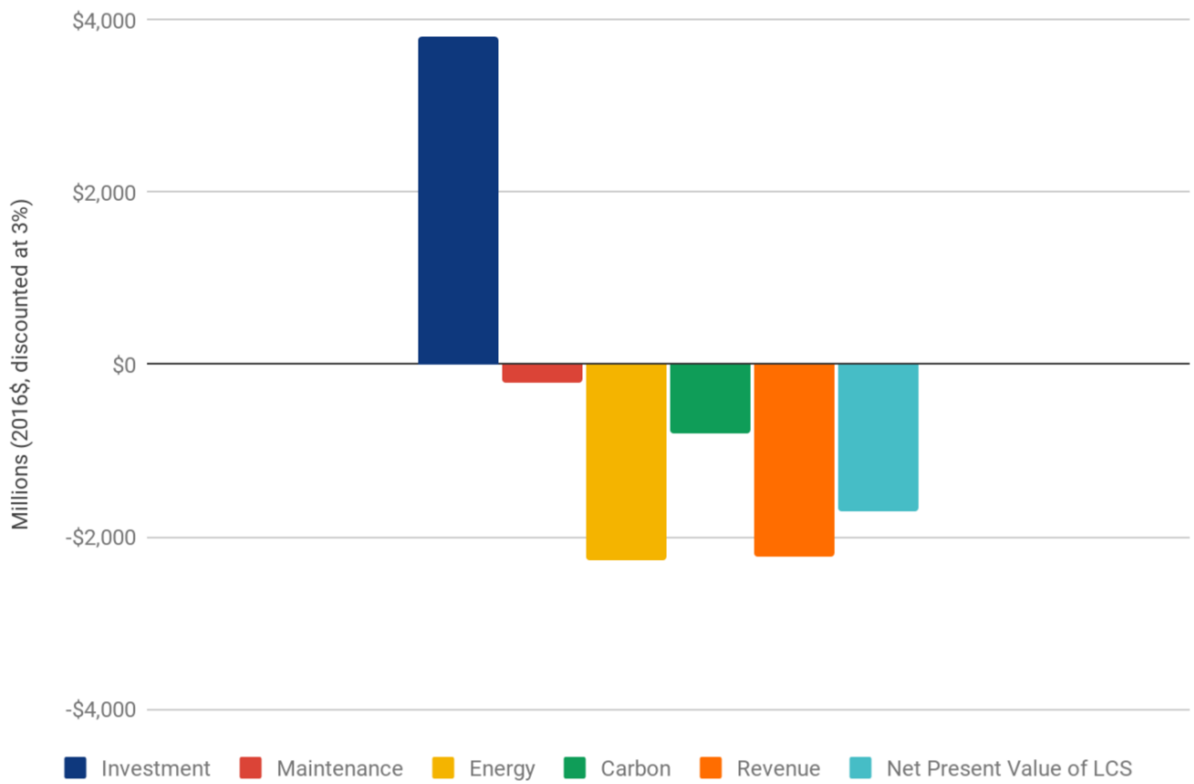

Figure 4. Present values of low-carbon scenario costs, savings, and net present value of the scenario.

Cash Flow Analysis

The annual costs, savings and revenue associated with fully implementing the actions in the CEEP are shown in detail in Figures 5, with capital expenditures shown in full in the years in which they are incurred. As is characteristic of low-carbon transitions, the capital expenditures in the early years of the transition are significantly greater than the savings and revenues generated, but by 2032 the annual benefits exceed the annual investments and the cumulative benefits are greater than the cumulative costs by mid-2040.

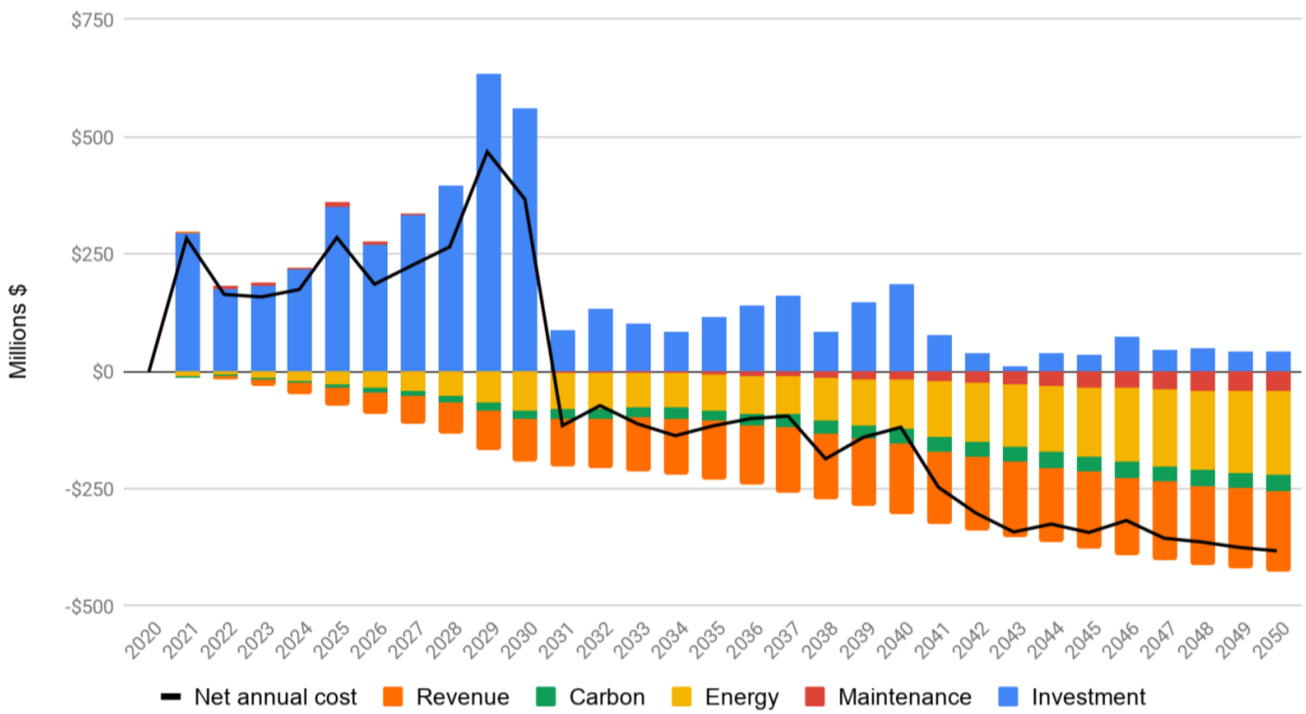

Figure 5. Capital expenditures vs. savings and revenues from the low-carbon scenario, 2020-2050.

Figure 6 presents the same costs and benefits, but with the capital expenditures amortized over 25 years at 3%. With this approach, which presumably would reflect actual approaches for financing the transition, the annualized capital payments are about equal to the savings and revenue generation, right from the beginning of the program. By 2045 the annualized capital payments begin to decline as the earliest investments are paid off. On an annual basis, the program never has a significant annual deficit; there is a net annual benefit that grows steadily throughout the 2030's and 2040's. By 2050, the annual net benefit is over $200 million. After 2050, the annualized capital investments continue to taper off, reaching zero by 2075, while the benefits and revenues continue, resulting in continuing growth in the net annual benefit in the post 2050 period.

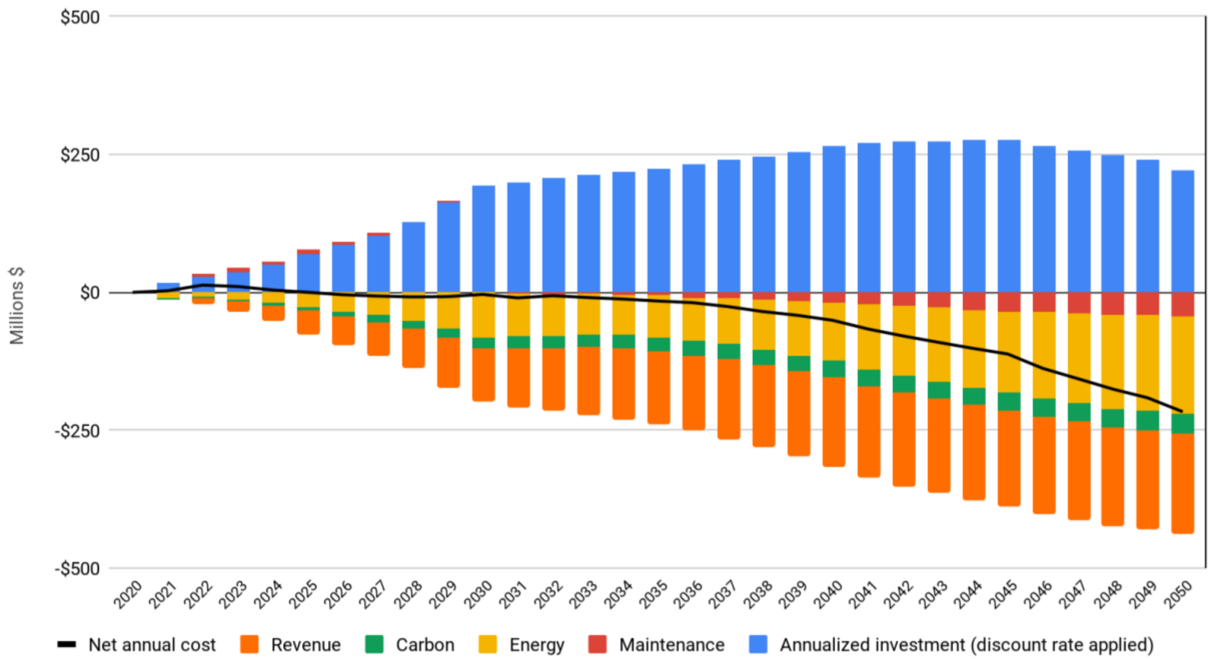

Figure 6. Annualized capital expenditures vs. savings and revenue from the low-carbon scenario, 2020-2050.

Cost Savings for Households

Household expenditures on energy—natural gas, electricity, gasoline and diesel—are projected to increase in the BAP and decline in the net zero scenario. In the BAP, household energy expenditures are relatively flat because vehicles become more efficient due to national fuel efficiency standards and because of decreased heating requirements as the climate becomes milder due to climate change. The net-zero scenario involves shifting away from natural gas and gasoline to electricity, a more costly energy source. The increased cost of electricity, however, is offset by the increased efficiency of homes as required by building codes and in the case of electric vehicles by the high efficiency of the electric motors as compared to internal combustion engines. The carbon price also adds to the cost of using fossil fuels for heating and transport. In the net-zero scenario, an average Thunder Bay household in 2050 spends $3,476 less on fuel and electricity (household energy and transportation expenditures) then they would have in a BAP scenario, over 60% less than what people spent in 2016 and will spend in the 2050 BAP scenario. Between 2020 and 2050, the LC scenario saves the average Thunder Bay household about $55 thousand on fuel and electricity expenditures. Depending on the business, policy and financing strategies used in the implementation of the actions, these savings will be partly offset by the incremental capital expenditures required.

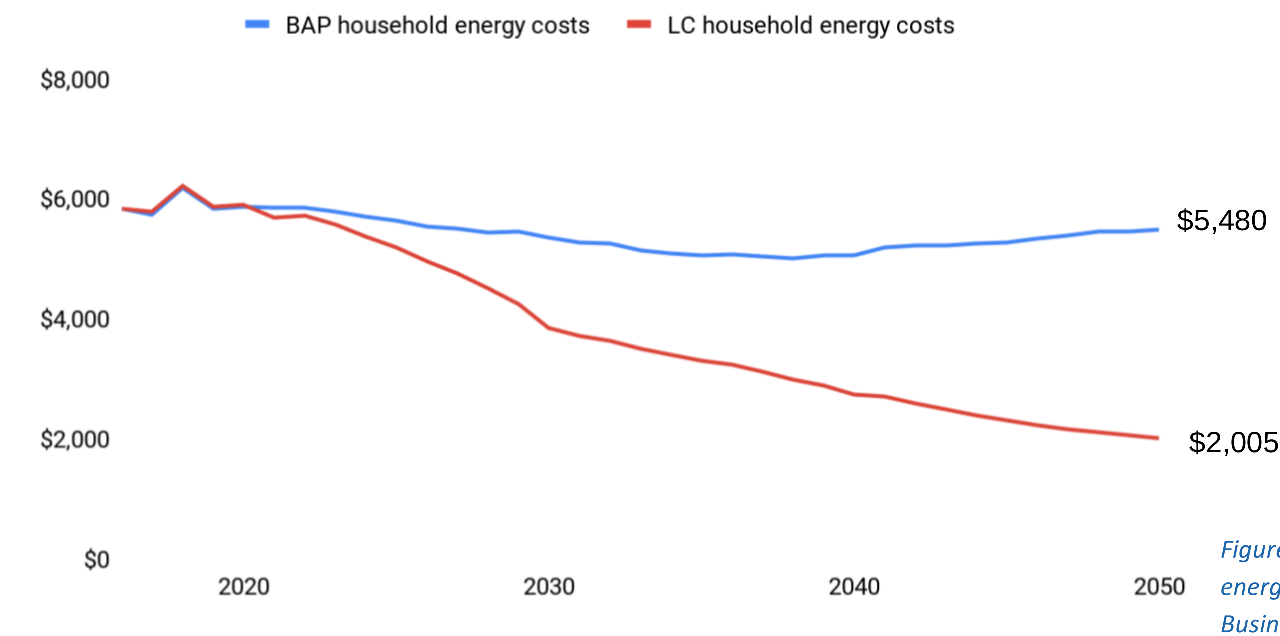

Figure 7. Average annual household energy costs in the Low-Carbon and Business-as-Planned scenarios, 2020-2050.

New Job Opportunities

Transitioning to a low- or zero-carbon economy is expected to have four categories of impacts on labour markets: additional jobs will be created in emerging sectors, some employment will be shifted (e.g. from fossil fuels to renewables), certain jobs will be reduced or eliminated (e.g. combustion engine vehicle mechanics), and many existing jobs will be transformed and redefined.

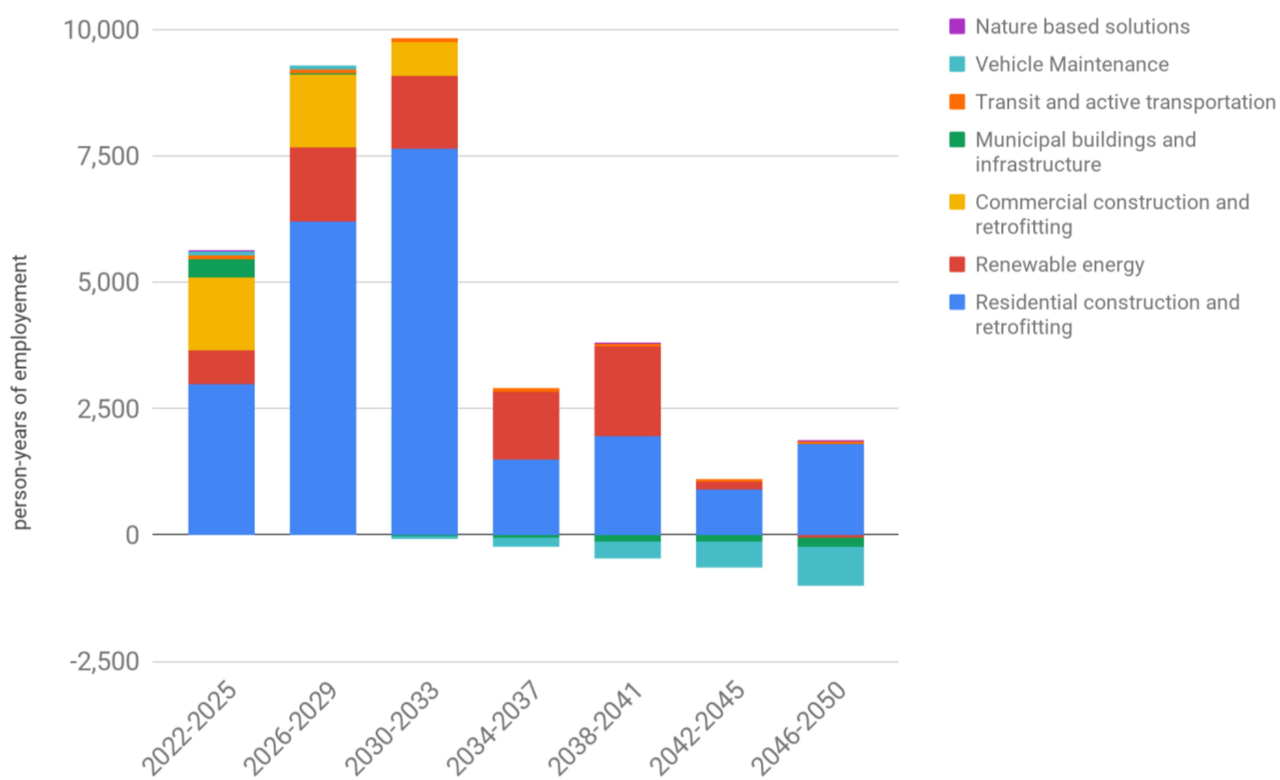

Figure 8: Additional person-years of employment associated with LCS actions.

APPENDIX A - Key Financial Assumptions

Program 1 : Land Use	Capital Investment Assumption
Land use intensification	- Capital costs associated with land use intensification encompass standard investment in the community such as new housing developments - Generally speaking with more infill development new infrastructure spending decreases.
Reduce avg. dwelling size	
Decrease share of single-detached housing	
Program 2: New Buildings	

New res. buildings w/ heat pumps	- The cost for new construction of buildings on a $\$/m^2$ is estimated to be:
	  - Single-detached: $1,722 / m^2
	  - Double: $1,372 / m^2
	  - Apt 1-4 storey: $2,476 / m^2
	  - Apt 5-14 storey: $2,664 / m^2
	  - Apt > 15 storey: $2,778 / m^2
	- The premium associated with meeting high-efficiency building standards is assumed to average 10%.
	- Energy savings associated with high-efficiency buildings is calculated to be 80-90% over existing building stock.
	- A residential heat pump has a capital cost of approximately $6,000 (non-res is ~$10,000 and scaled to the heating requirement), with approximately $160 annually to operate (~$400 annually for non-res)

New res. buildings w/ solar PV	
New industrial building standards (TGS)	
New commercial building efficiency	
Commercial buildings w/ solar PV	

Program 3: Existing Buildings	
Retrofit homes / energy efficiency Residential electric water heaters Heat pump as part of residential retrofits Retrofits industrial buildings Retrofits of commercial and industrial Industrial Improvements (process motors/efficiency)	- 80% of buildings are retrofit, both residential and non-residential. - The average cost of retrofits was assumed to be (per GJ of energy saved): - Residential: $600-2500 - Non-Res: $500-$1,500 - A residential heat pump has a capital cost of approximately $6,000 (non-residential is ~$10,000), with approximately $160 annually to operate (~$400 annually for non-residential)
Program 4: Renewable Energy	
Solar PV- net metering all and new buildings 155 MW Ground Solar Farm 150 MW Wind Farm Organic Waste to RNG Hydrogen introduced to natural gas networks	- Solar PV, wind, and storage have a capital cost of approximately $2,360 per kW. The capital cost is expected to decrease towards 2050 - The lithium ion battery for energy storage is anticipated to decrease by as much as %50 by 2050.

Program 5: Transport	
Expand bus service	- The cost of an electric vehicle is approximately $55,000 in 2016 and below $34,000 by 2050. 90% of personal car sales are electric by 2050. - Fuel cost of gasoline per litre goes up to 26% with carbon tax and market factors added by 2040 .
Electrify transit system	
Increase/improve cycling & walking infrastructure	
E-Bikes	
Car Free Zones	
Electrify municipal fleets	
Electrify personal vehicles	
Low carbon commercial transport activity	
Program 6: Waste & Wastewater	
25% less water use (technology & behaviour change)	- Behaviour change programs are a cost of staff and communications from the city - Improving wastewater process efficiency will cost an estimated $5.8 million over 30 years, and will represent $3.8 million in energy and carbon cost savings
Wastewater process efficiency	

Program 7: Municipal Buildings	
Retrofit municipal buildings	- See retrofit and solar PV figures in Programs 1 & 3
Solar PV on municipal buildings	
Program 8: Natural Environment & Sequestration	
Tree planting	- Behaviour change programs are a cost of staff and communications from the city - Total cost of tree planting is valued over $2.3 million