FINANCIAL ANALYSIS AND MARGINAL ABATEMENT COSTS

The actions require investments now and over time to implement. Starting immediately, they result in savings and, in the case of local energy production, in revenues. Incremental expenditures in buildings, vehicles, and other energy-related equipment and infrastructure increase costs in the short-term but result in long-term savings.

Detailed financial analysis was undertaken for each action in the LEC Plan Scenario to identify the investment required, the net present value, the return on investment, marginal abatement costs, and employment impacts.

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 cost per 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.

The following figure below summarizes the MAC analysis for the LEC Plan. Not all actions modelled in the LEC Plan are included, as some would severely skew the scale of the graph (e.g. the renewable energy procurement action results in massive emissions reductions at massive costs, which would dwarf most actions on the graph). All but nine of the LEC Plan actions result in savings in present dollars, discounted at 3%, over the period from 2020 to 2050.

Note that the wider a bar is, the greater emissions reductions it provides, while the length of the bar depicts the total cost or savings of the action. A taller bar on the right of the graph means an action costs more per tonne, while a taller bar on the left side of the graph means an action has a larger cost savings or return on investment.

According to the model, investment in emissions reducing actions now and in the near future will result in massive energy savings and financial returns for government, industry and households.

The actions with the greatest savings per tonne of emissions reduced include:

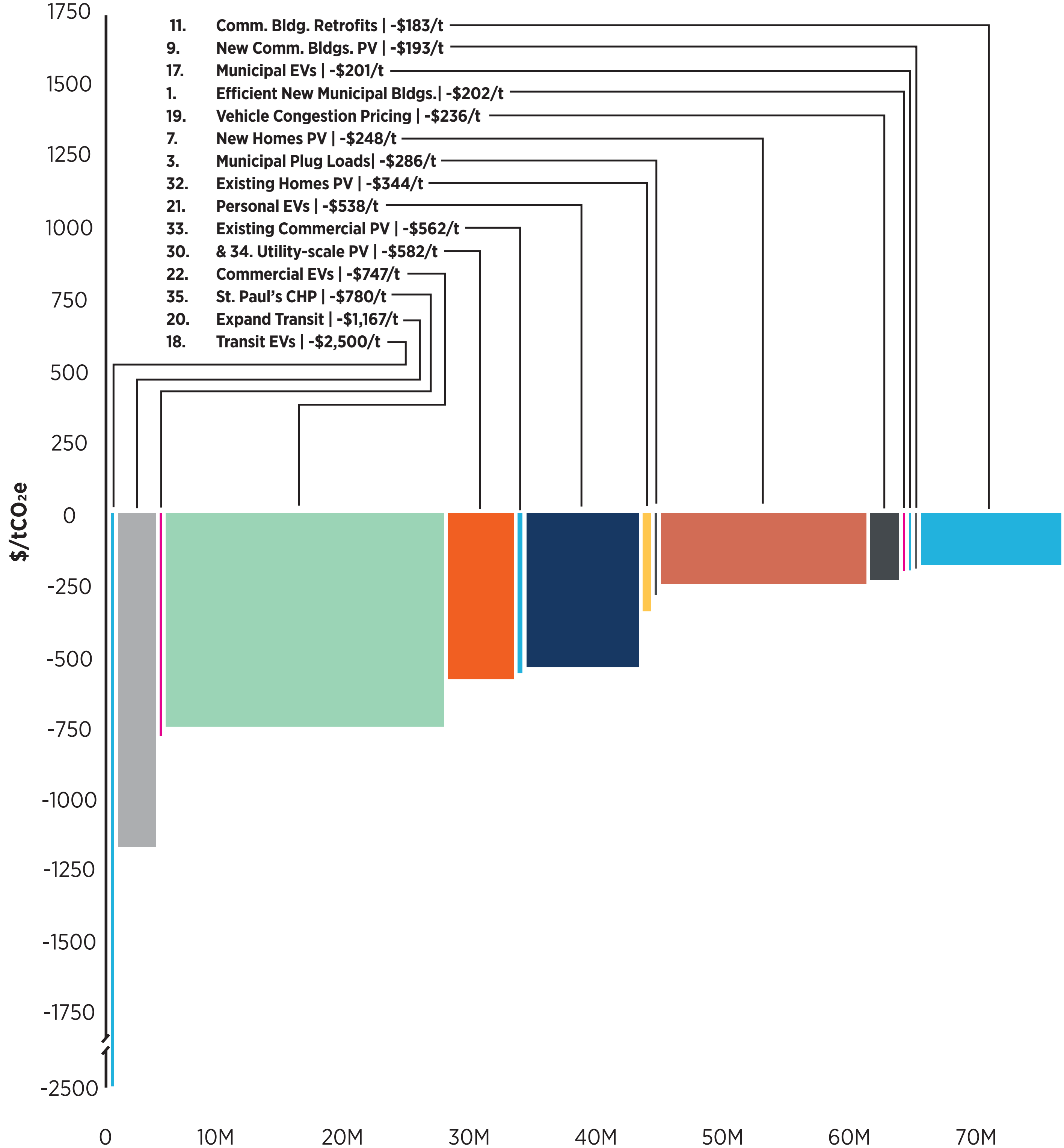
- personal and commercial electric vehicles;
- on-building and utility-scale solar photovoltaic systems;
- efficient new buildings; and
- building retrofits.

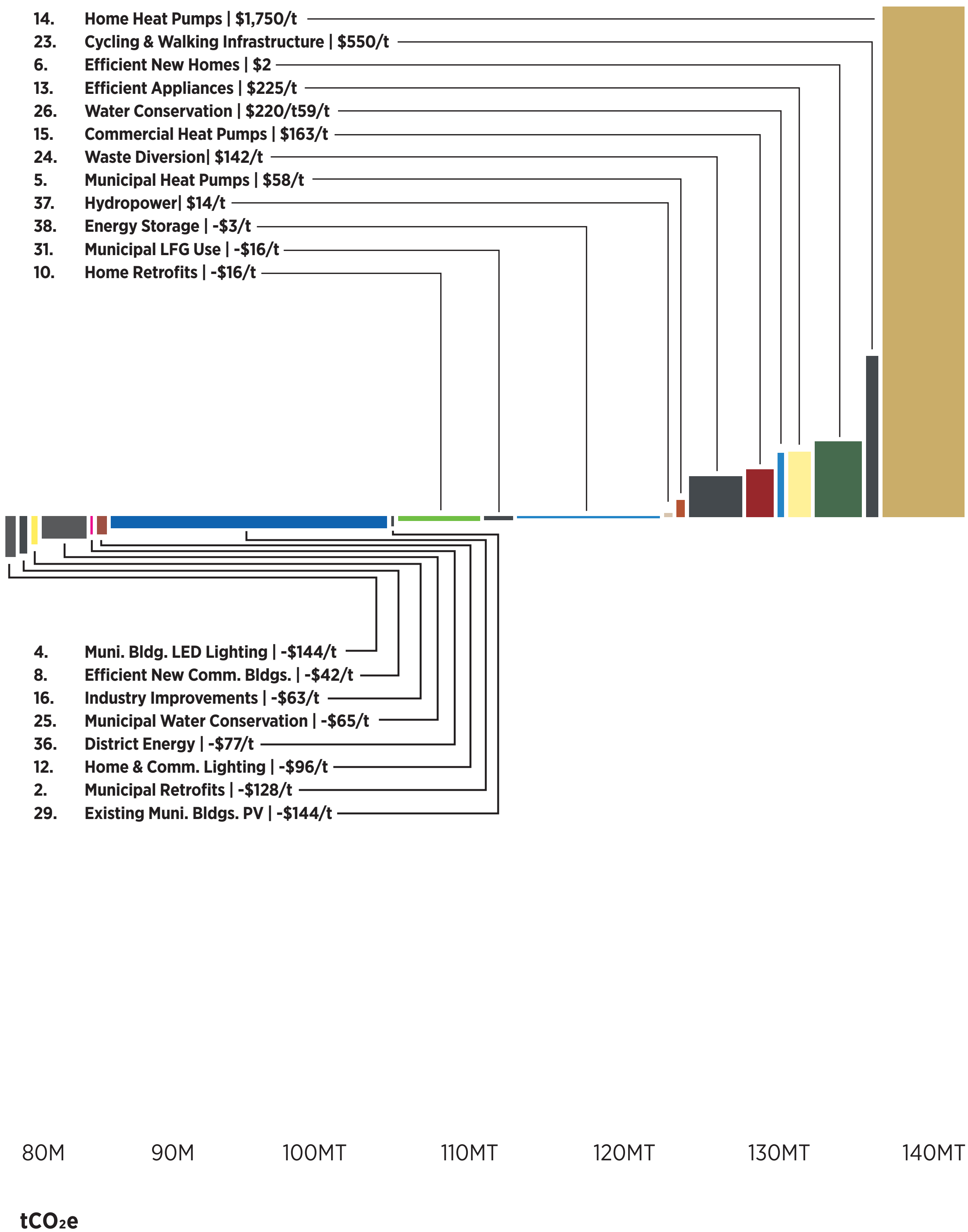
Although there are also considerable emissions savings with installing heat pumps, building efficient new homes, and upgrading appliances, these come at a net cost per tonne of emissions reduced.

Of course, the MAC does not provide the complete justification for whether or not to implement an action, as each of these actions is required in order to meet our GHG reduction targets, but it is a powerful tool to demonstrate the return these investments can have per tonne of GHG reduction and may be used as one of many factors in deciding which actions to take over the short-, medium-, and longer-tem.

City of Saskatoon Energy and Emissions Actions Marginal Abatement Cost Curve

y-axis: tonnes CO2e reduced by the action (taller bars = greater reductions)
x-axis: net financial return or cost of the action (wider bars = greater return/cost)




14. Home Heat Pumps | $1,750/t
23. Cycling & Walking Infrastructure | $550/t
6. Efficient New Homes | $2
13. Efficient Appliances | $225/t
26. Water Conservation | $220/t59/t
15. Commercial Heat Pumps | $163/t
24. Waste Diversion| $142/t
5. Municipal Heat Pumps | $58/t
37. Hydropower| $14/t
38. Energy Storage | -$3/t
31. Municipal LFG Use | -$16/t
10. Home Retrofits | -$16/t
4. Muni. Bldg. LED Lighting | -$144/t
8. Efficient New Comm. Bldgs. | -$42/t
16. Industry Improvements | -$63/t
25. Municipal Water Conservation | -$65/t
36. District Energy | -$77/t
12. Home & Comm. Lighting | -$96/t
2. Municipal Retrofits | -$128/t
29. Existing Muni. Bldgs. PV | -$144/t
80M
90M
100MT
110MT
120MT
130MT
140MT
tCO2e

Capital Investment & Returns

Total LEC Plan investment and return were evaluated including capital investments, operating costs (including for fuel and electricity), carbon credits, and revenues from investments in local generation. The following table summarizes the categories of investments evaluated.

Table 3: *Categories of investments evaluated.*

Category	Description
Residential buildings	Cost of dwelling construction; operating and maintenance costs (non-fuel)
Residential equipment	Cost of appliances and lighting, heating and cooling equipment
Personal use vehicles	Cost of vehicle purchase; operating and maintenance costs (non-fuel)
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; 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.
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. This is treated as a negative expenditure in the analysis.

The Plan shows that by 2050 total annual residential energy expenditures are $440 million per year lower than in the business as planned scenario

The following table illustrates the undiscounted and present value of the City and Community investments associated with the low emissions pathway. The negative balance represents initial expenditures and the positive balances represent savings, new revenues or returns.

Table 4: *Summary of financial metrics resulting from the low emissions actions and pathway*

	Low Emissions Community ($ Billions)	
	Cumulative, incremental expenditures and savings to 2050	**Net Present Value** (Discount Rate of 3%)
Capital investments	($19.0)	($11.5)
Operations and Maintenance savings	6.1	3.2
Energy savings	13.2	6.9
Carbon price savings	4.7	2.4
Revenue from local generation	9.6	5.2
Net return of program	**$14.6**	**$6.2**

** In this table, income and savings are positive, expenditures are negative*

By 2050, cumulative City and Community capital investment in the low emissions community actions totals $19 billion with a present value of $11.5 billion, using a discount rate of 3%.The municipality is directly responsible for approximately 32% of these total capital investments and can expect to see approximately 35% of the returns.

Table 5: *Summary of financial metrics directly attributable to City of Saskatoon*

	Low Emissions Community ($ Billions)	
	Cumulative, incremental expenditures and savings to 2050	**Net Present Value** (Discount Rate of 3%)
Capital investments	($6.1)	($3.7)
Savings & New Revenues	11.8	6.2
Net return of program	**$5.7**	**$2.5**
* In this table, income and savings are positive, expenditures are negative		

On the other side of the ledger are operations and maintenance savings (e.g. from electric vehicles requiring less maintenance than internal combustion engine vehicles, from buildings' electrical systems that have lower operating costs), energy (fuel and electricity) cost savings from energy efficiency improvements, the monetary value of the carbon reductions resulting from carbon pricing, and the revenues from locally generated energy. One large contribution to the value of the LEC Plan is lower energy bills; by 2050, total annual residential energy expenditures are $440 million per year lower than in the BAP scenario.

Carbon pricing effectively increases the value of fuel and electricity savings , modestly in the first half of the program but more significantly in the later years as the effective carbon price increases. In 2050, the carbon "premium" from the low emissions scenario reaches $373 million and the cumulative premium over the 2018–2050 period totals $4.7 billion, with a present value of $2.4 billion.

Finally, the LEC Plan includes investments in local energy generation facilities (solar photovoltaics, hydropower, and district energy) that create a steadily growing revenue stream that averages over $300 million over the 2020-2050 time period, reaching over $660 million in 2050. Local generation's cumulative total is $9.6 billion with a present value of $5.2 billion.

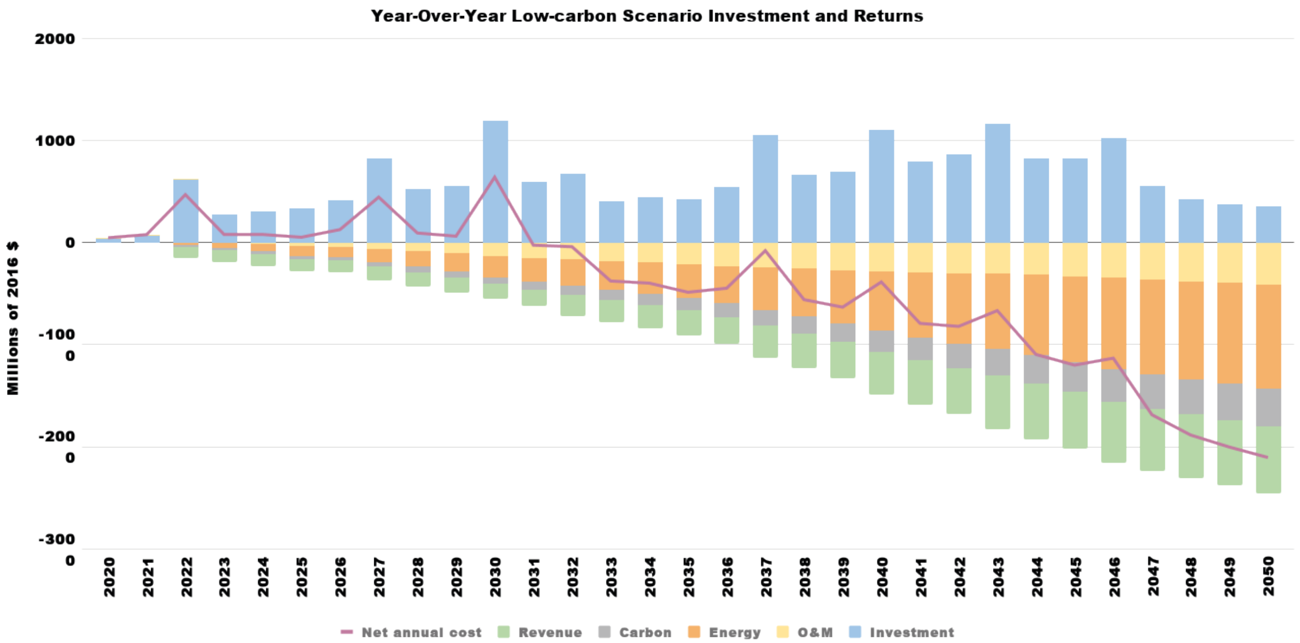
The figure below displays the investment and returns for the low emissions community when compared to the business as planned option. Above the x-axis are investments - the incremental expenditures required to implement the LEC Plan actions over BAP investments. The average annual investment over the 2020-2050 time period is $600M. There are a few years where the investment is notably higher:

- 2027: Downtown district energy expansion and investment in the weir hydropower plant.
- 2030: Purchase of electric public transit buses.
- 2027, 2032, 2037, 2040, 2043, 2046: Lump procurements of external solar PV generated electricity.

Below the x-axis are savings and revenues. Annual total investments exceed total savings and revenues until the breakeven point in 2031, beyond which gains begin to consistently exceed costs. As discussed above, by 2050 the net payback from the plan reaches $14.6 billion.

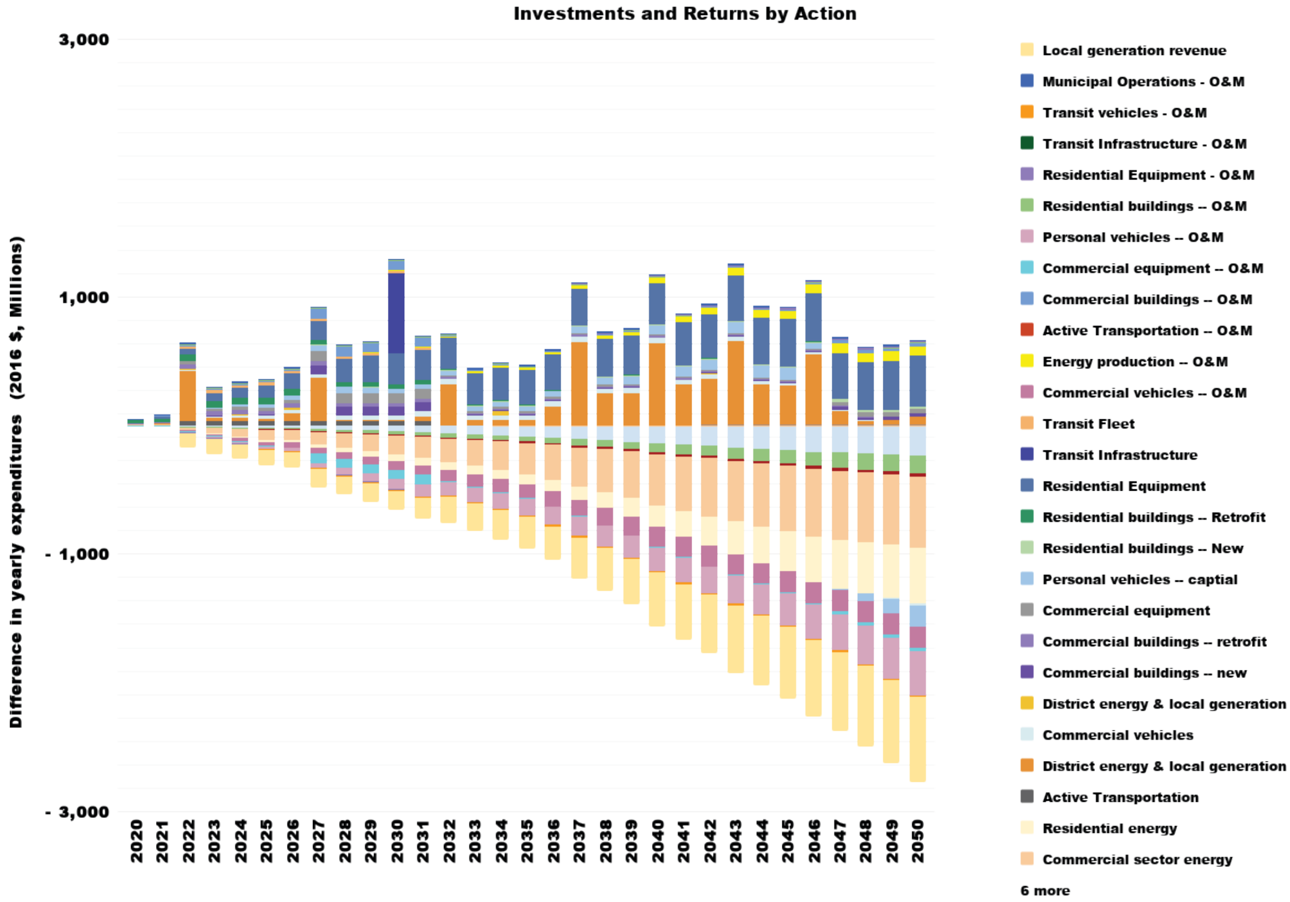
Figure 37: *Expenditures, savings and revenues from the LEC Plan relative to BAP Scenario.*

**Values are presented as costs in this figure, so expenditures are above the x-axis line and savings and revenue are below the x-axis line. Incremental capital costs are shown in the year they are incurred.*



The following figure provides a detailed year-by-year breakdown of the investments, fuel and electricity savings, carbon premiums, and generation revenue in the LEC Plan. The value of the cost savings increases as time progresses.

Figure 38: *LEC Plan annual incremental expenditures over BAP scenario by action.*
**Incremental capital costs are shown in the year they are incurred.*



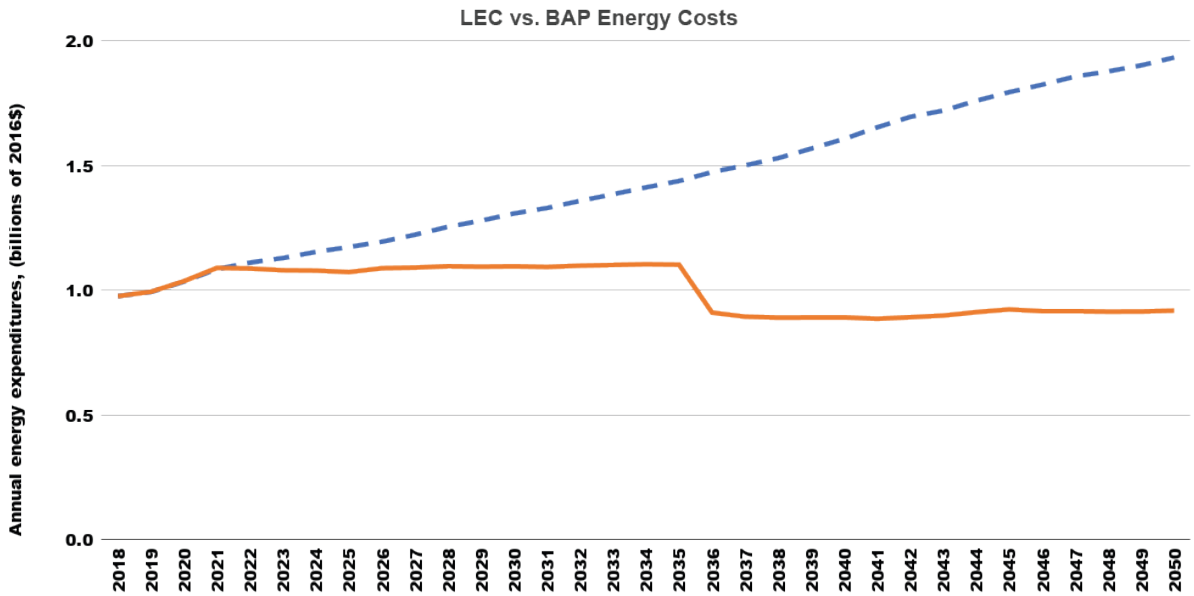
The majority of investments (above the x-axis) are in local energy generation, transit, and residential retrofits and equipment (e.g. heat pumps). The majority of returns (below the x-axis) are in residential and commercial avoided emissions, residential and commercial energy savings, personal and commercial vehicle operating and maintenance costs, and local energy generation.

Energy Costs

The following graph depicts the expected total energy (fuel and electricity) costs for the BAP scenario and LEC Plan.

In the BAP scenario shown with the blue dashed line, costs increase for all types of energy, with gasoline and electricity rising the most, as shown in the following graph.

Figure 39: *Estimated total annual energy expenditures for the BAP scenario (blue) and LEC Plan (orange).*



In 2016, total energy costs paid out by households, businesses and other organizations in Saskatoon totalled $866 million. Electricity accounted for 28%, gasoline sales accounted for 35%, and natural gas use accounted for 10% of expenditures. In the BAP scenario, energy prices are projected to increase, although ongoing improvements in vehicle and building efficiency offsets some of the increase, resulting in a 2% average annual energy spending increase, reaching almost $2 billion in total energy expenditures in 2050.

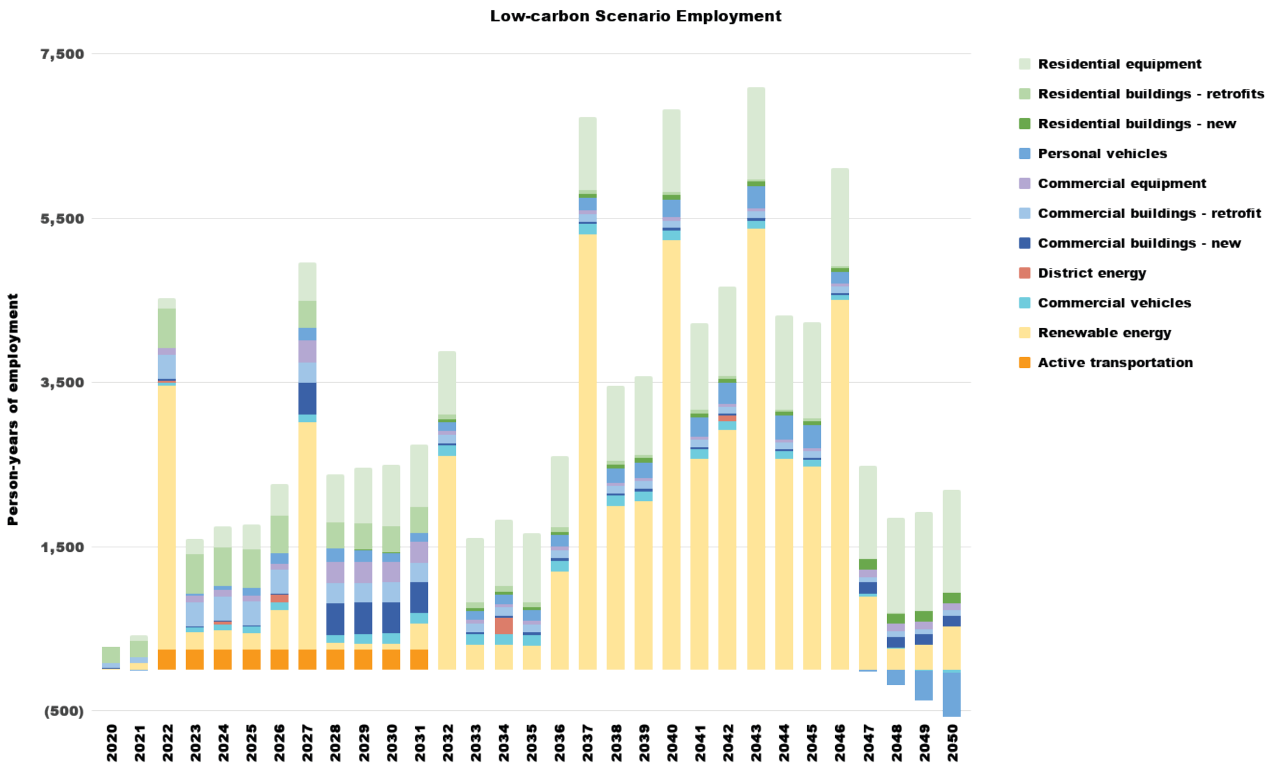
Employment

The LEC Plan capital expenditures are expected to result in increased employment.

Employment factors for each sector were used to translate each million dollars of activity into full-time equivalent jobs. The LEC Plan is estimated to generate over 100,000 person years of employment between 2020 and 2050, or an average of over 3300 per year compared to the BAP scenario. Many jobs are in the energy sector, with solar PV, DE systems, and heat pumps to install. Many are also related to home retrofits and new construction.

The LEC Plan includes investments in local energy generation facilities (solar photovoltaics, hydropower, and district energy) that create a steadily growing revenue stream that averages over $300 million over the 2020-2050 time period, reaching over $660 million in 2050.

Figure 40: *Employment generated by LEC implementation.*



The financial analysis shows there would likely be many economic and employment benefits to implementing the LEC Plan actions. Although significant investments are required by the City, the private sector, industry, and not-for-profits, the long-term cost savings and revenues far outweigh the investments. It is important to note that there is some flexibility in the timing of action implementation. Implementation timelines for the recommended actions can be adjusted slightly depending on funding, public/political desire to complete some actions before others, and advances in technology.

However, the overall recommended timelines should not be disregarded, as delaying the implementation of these impactful actions will undermine our ability to: achieve our GHG reduction targets; reduce negative environmental impacts; and gain the co-benefits that come from taking early action on climate change.

Delaying action also delays (and in some cases, reduces) financial benefits, which could impact our City's and community's ability to achieve the savings, revenues, returns, and employment outcomes as projected in the LEC Plan.

There are significant benefits of adopting the actions set out in the LEC Plan Similarly, the risks of doing nothing are also significant. In the context of this analysis, risks include the following:

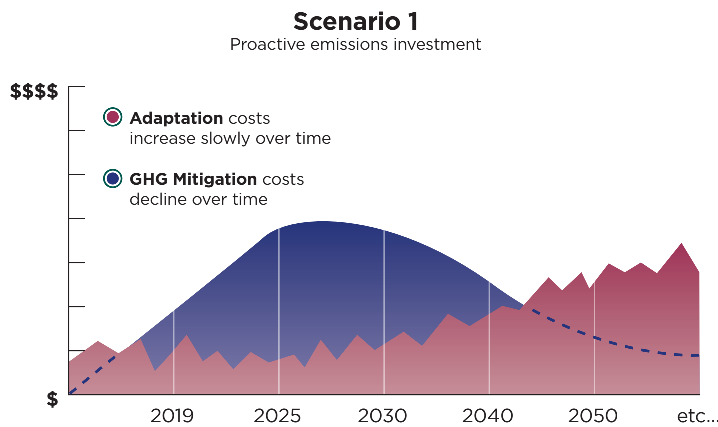
- A slower response to mitigation and therefore more severe impacts of climate change;
- A missed opportunity to transition to low carbon urban systems and therefore an increased burden on the City households and the private sector to support the transition;
- A missed opportunity for leadership in the 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 LEC Plan energy and emissions outcomes.

The Link between Mitigation & Adaptation Investment

Investment in emissions reduction activities will impact our adaptation costs over the next 80 years. This is illustrated through reviewing two climate change investment scenarios below.

Scenario 1

Figure 41: *Adaptation and mitigation spending with pro-active investment in mitigation*



In scenario 1, substantial investment is spent for emissions reduction activities such as renewable energy projects, education programs, and financing alternatives within the next 5-10 years. Although this investment is of a higher cost now, it will eventually peak and decline as emissions reduction activities are normalized and technology becomes more accessible and less expensive. This scenario creates co-benefits for both emissions reductions (mitigation) and resiliency (adaptation) activities. An additional benefit is the reduction in the severity of climate change impacts experienced by citizens. For example, as GHG emissions are reduced and previous emissions are mitigated, the severity of changes in annual temperature, precipitation, and extreme weather event patterns is also reduced over time, which limits risk to civic infrastructure, programming and service delivery.

In scenario 1, there is still a need for some adaptation investment, as climate change impacts are already being experienced in Saskatoon and around the world due to emissions previously emitted into the atmosphere. However, this scenario provides time for municipalities to build climate change impact preparedness programming and add adaptation costs to budgets over time as part of their asset management and program planning practices. This creates a more gradual and controlled rise in the cost of adaptation efforts following the principle that $1 of proactive mitigation spending saves $6 of reactive emergency spending.[10]

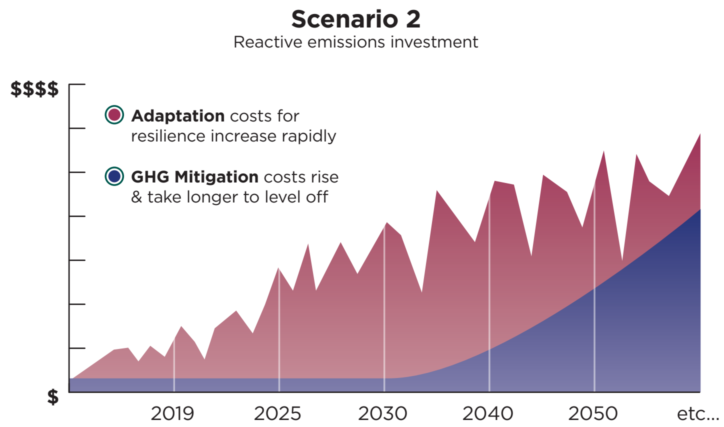
Assuming the time value of money principal, which states the value of money is constantly decreasing over time, investing in emissions reduction projects now will cost less over the long term than investing 20 or 50 years in the future. This is because $1 today is worth more than $1 in 20 years.

Accelerated investments have the added benefit of preventing further degradation of the environment and slowing the degradation-increased cost cycle.

10 National Institute of Building Sciences Issues New Report on the Value of Mitigation, National Institute of Building Sciences, 2018

Scenario 2

Figure 42: *Adaptation and mitigation spending with minimal investment in mitigation.*



In scenario 2, if minimal investment dollars are spent on mitigation (emissions reductions activities) in the immediate future, then climate change impacts such as flooding, drought, and severe storms will increase more rapidly. This will create large spikes in adaptation costs through a reactive approach that cannot be reliably planned or budgeted for, as we will be addressing emergencies as they are occurring. As these large expenditures for repairs or services will be needed on short notice, there is a high likelihood they will create service disruptions to citizens and require debt financing and associated additional costs. At the same time, investment in mitigation will continue to rise as laying the groundwork for projects has not been completed and the time-value of money takes effect.

The National Institute of Building Sciences issued a report that communicates the value of risk reduction spending and cited that for every $1 invested in proactive actions $6 in reactive and unplanned spending is saved.[11] This ratio should be considered when evaluating the amount of funding resources allocated between mitigation and adaptation to the new climate reality; in the near term, 6 times more investment in mitigation will reduce the need for adaptation spending in the long term.

Investing funds for future benefit is not a new concept; investing in emissions reductions is similar to saving for retirement. Investing for retirement at age 20 results in substantial compounded gains by age 60, and large investment downturns are mitigated over time. In contrast, retirement investment started at age 55 is more vulnerable to large swings in the market and does not have sufficient time to recover before being withdrawn. Similar to retirement investment, there are always alternatives for present day spending such as a new vehicle, a down payment for a home, or a vacation, but those short-term demands do not diminish the importance of investing for the future.

Although significant investments are required by the City, the private sector, industry, and households, the long-term cost savings and revenues far outweigh the investments.

11 National Institute of Building Sciences Issues New Report on the Value of Mitigation, National Institute of Building Sciences, 2018