Part 3: The Opportunities

9. Financial Analysis

9.1 FINANCIAL CONCEPTS

The direct, community-wide, financial impacts of Toronto's net zero pathways provide important context for local decision-makers. However, direct financial impacts should be seen as a secondary benefit of reducing GHG emissions. First and foremost, GHG reductions are a critical response to the global climate emergency. In addition, most measures included in the pathways provide economic and social goods to the community, such as net job creation and positive health outcomes, which are only reflected in this financial analysis as the cost of carbon emitted.[91]

Key concepts that are used to analyze the financial impacts of the pathways are summarized below.[92]

COSTS ARE RELATIVE TO THE DO NOTHING SCENARIO

This financial analysis tracks projected costs and savings associated with low-carbon measures that are above and beyond the costs in the Do Nothing scenario.

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 a very low or even zero discount rate should be applied in the evaluation of climate change mitigation investments. In this project, we evaluate investments in a low-carbon future with a 3% discount rate.[93]

91 The Social Cost of Carbon is an estimate of the damage caused to society by climate change, including impacts on health and lost jobs.

92 Detailed financial assumptions are described in the Data, Methods and Assumptions Manual.

93 Environment and Climate Change Canada. (2016). Technical update to Environment and Climate Change Canada's social cost of greenhouse gas estimates. Retrieved from http://ec.gc.ca/cc/BE705779-0495-4C53-BC29-6A055C7542B7/Technical%20Update%20to%20Environment%20and%20Climate%20Change%20Canadas%20Social%20Cost%20of%20Greenhouse%20Gas%20Estimates.pdf

NET PRESENT VALUE

The net present value (NPV) 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 $170/tonne CO_2e in 2030 and is held constant thereafter), operation and maintenance savings, and revenue generation (associated with renewable energy production facilities and some transit actions). Administrative costs associated with implementing programs are excluded, 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 this financial analysis, such as avoided health costs, or avoided damages from climate change.

ABATEMENT COST

The abatement cost of an action is the estimated cost for that action to reduce one tonne of GHG emissions, which is calculated by dividing the action's NPV by the total GHG emissions reductions (tCO_2e) resulting from the action. For example, if a project has a NPV of $1,000 and generates 10 tCO_2e of savings, its abatement cost is $100 per tCO_2e 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.

ENERGY AND CARBON COST PROJECTIONS

Energy cost projections were derived from:[94]

- the Independent Electricity System Operator's (IESO) Long-Term Energy Plan (electricity);
- the US Energy Information Administration (propane); and
- the Canada's Energy Regulator (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 2030, then held constant.

94 For more details on the financial assumptions see the TransformTO Data, Methods and Assumptions Manual.

A PROSPEROUS CITY

Economic prosperity is the capability to flourish, according to a definition developed by the UK Sustainable Development Commission.[95] In articulating this definition, the authors cite broad questions posed by the economist Amartya Sen about how people are able to function: Are they well nourished? Are they free from avoidable morbidity? Do they live long? Can they take part in the life of the community? Can they appear in public without shame and without feeling disgraced? Can they find worthwhile jobs? Can they keep themselves warm? Can they use their school education? Can they visit friends and relations if they choose?[96] The notion of the capability to flourish as a definition of economic prosperity is consistent with the intention of key City documents, such as One Toronto and TO Prosperity: Toronto Poverty Reduction Strategy. It is complementary to the categories on health and social equity discussed elsewhere in this report, and, as the UK Sustainable Development Commission argued, is also consistent with the intention of preventing dangerous levels of climate change.

In considering potential co-benefits and co-harms of efforts to reduce GHG emissions, the aspects of economic prosperity which will be considered include employment, household incomes, enterprises, public finance, environmental capital, and social capital.

9.2 THE BIG PICTURE

Table 15. Summary of financial results.

	BAP	NZ50	NZ40
Net impacts over the period, *$ billions*			
Total incremental capital investment, 2020-2050	$31.40	$139.63	$145.86
Total savings, 2020-2050[97]	-$32.02	-$107.64	-$114.00
Revenue losses, 2020-2050[98]	$3.35	$25.41	$25.40

95 Jackson, T. (2009). p.21 *Prosperity without growth: economics for a finite planet*. London ; Sterling, VA: Earthscan.

96 Nussbaum, M., Sen, A., & Research, W. I. for D. E. (1993). *The Quality of Life*. Oxford University Press.

97 While the capital investments in the NZ scenarios 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.

98 Revenue losses are a result of mode shifts to walking and cycling, and, in the NZ Pathways, from making transit free. See Figure 51 and its description for a more detailed explanation of this.

	BAP	NZ50	NZ40
Net cost, 2020-2050	$2.74	$57.40	$57.26
Financial indicators, $			
Capital cost (undiscounted) to reduce each tonne of GHG	$827	$969	$827
Abatement cost (NPV) per tonne of GHG	$35	$262	$216
Average annual household savings on home energy (undiscounted), 2050 over 2016	$555	$1,258	$1,268
Investment $/person-year of employment			$145,000

The financial impacts of the scenarios were explored in detail. At a high level, the investments in NZ40, which has the highest near-term investments, hover around 5% of annual GDP for a decade before declining to 2% in the subsequent decades. Figure 45 illustrates the scale of investments relative to a projection of the annual GDP, which is escalated at 1% to illustrate the scale of investments is relatively small in comparison to the overall GDP of the city.

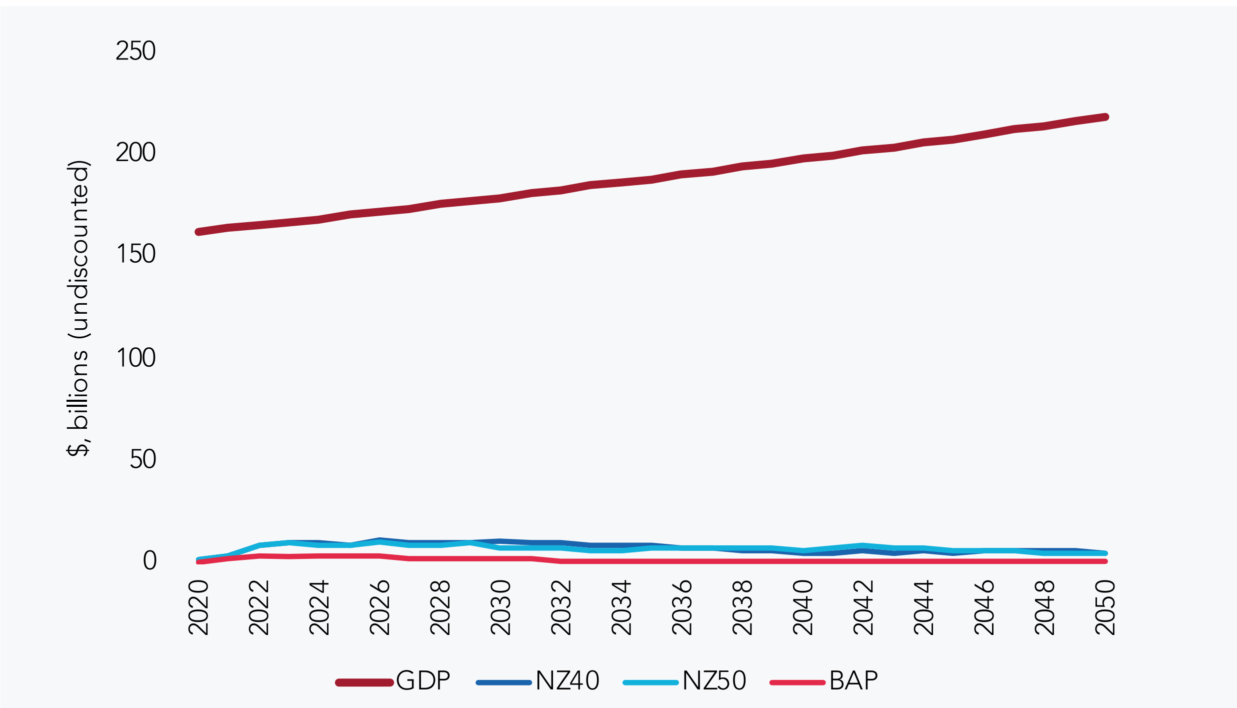

Figure 45. Investments relative to projected GDP (annual growth of 1%).

The investments in the NZ scenarios generate financial returns, the net impact of which is illustrated in Figure 46. Notably, the NZ40 generates financial returns (beginning in 2040) prior to the NZ50 scenario (beginning in 2045), while the BAP generates financial benefits by 2032. The suite of actions in the BAP scenario generate financial returns because investments are low and returns are relatively high, but the BAP is not a viable scenario in terms of achieving the City's GHG targets.

Table 16. Pivot points: Year in which the scenario starts to generate annual savings.

	NZ40	NZ50	BAP
Year that annual savings begin	2040	2045	2032

Each of the lines in Figure 46 represent the addition of investments and savings. For illustrative purposes, in an early year in a net zero scenario, investments might total $7 billion, while savings total $1 billion. This results in a net cost of $6 billion (7-1=6). Later in the study period, investments might total $5 billion, while savings total $6 billion, resulting in net savings of -$1 billion (5-6=-1). There are many underlying dynamics at play that result in these curves. Both the NZ40 and NZ50 scenarios have higher initial investments and NZ40 has higher investments in vehicles than NZ50. As a result of the earlier investments in EVs, greater savings occur in NZ40 earlier, pushing the NZ40 line down to zero earlier than the NZ50 line. The investments in NZ40 and NZ50 generate greater savings than the BAP post 2050. In the post-investment period after 2050, the benefits continue for as long as the measures deliver savings.

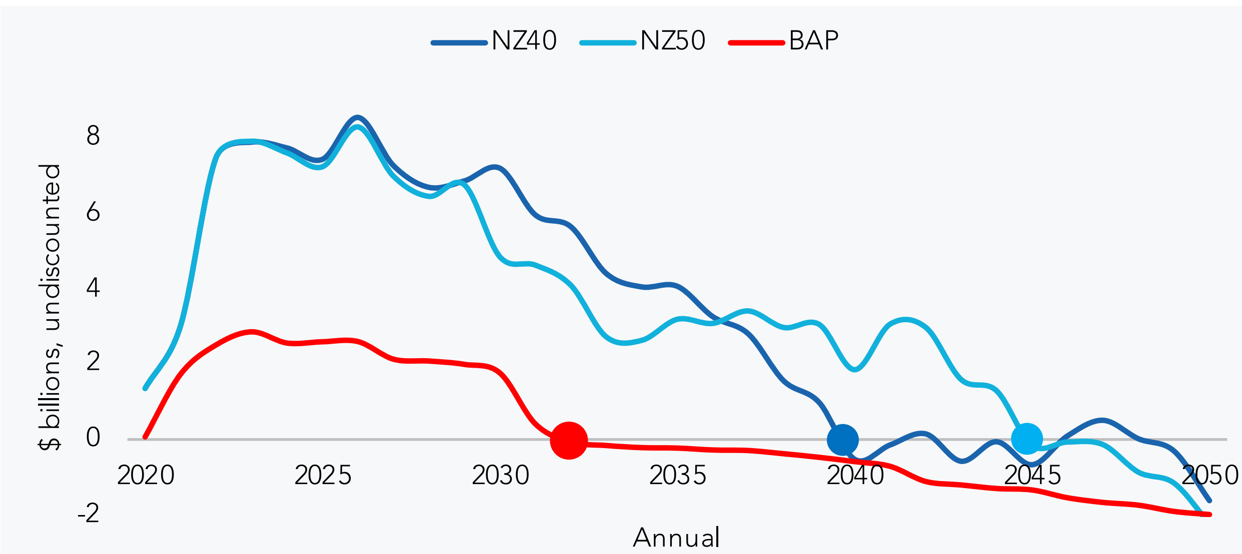

Figure 46. Net annual community-wide costs/savings for the three scenarios (costs are positive, savings are negative).

9.3 A MIX OF ABATEMENT COSTS AND SAVINGS

Abatement costs provide an indication as to whether a measure generates financial returns over its lifetime. A negative abatement cost indicates an action generates financial returns, while a positive abatement cost indicates the cost of an action that exceeds financial returns. The width of each bar on the x-axis indicates the amount of GHG emissions that it saves.

The marginal abatement cost for the NZ40 actions are provided in Figure 47. Active transit infrastructure has the highest marginal abatement cost at $14,567 for every tonne of GHG reduced. Increasing tree canopy follows with a marginal abatement cost of $6,506. Both of these are interesting examples because, unlike other actions, GHG emission reductions are not always the primary motivator for these projects. In addition, these actions deliver significant benefits (improved health in the case of active transportation and ecology and shade in the case of trees) that are not factored into the calculation as financial benefits.

More compact buildings have the lowest cost, generating financial returns (savings) $10,474 per tonne of GHG reduced. Electrification of vehicles consistently generate savings including personal vehicles (savings of $205/t), transit (savings of $566/t), and the City fleet (savings of $592/t). These measures deliver a third of the GHG reductions while generating financial savings that could help to pay for building retrofits.

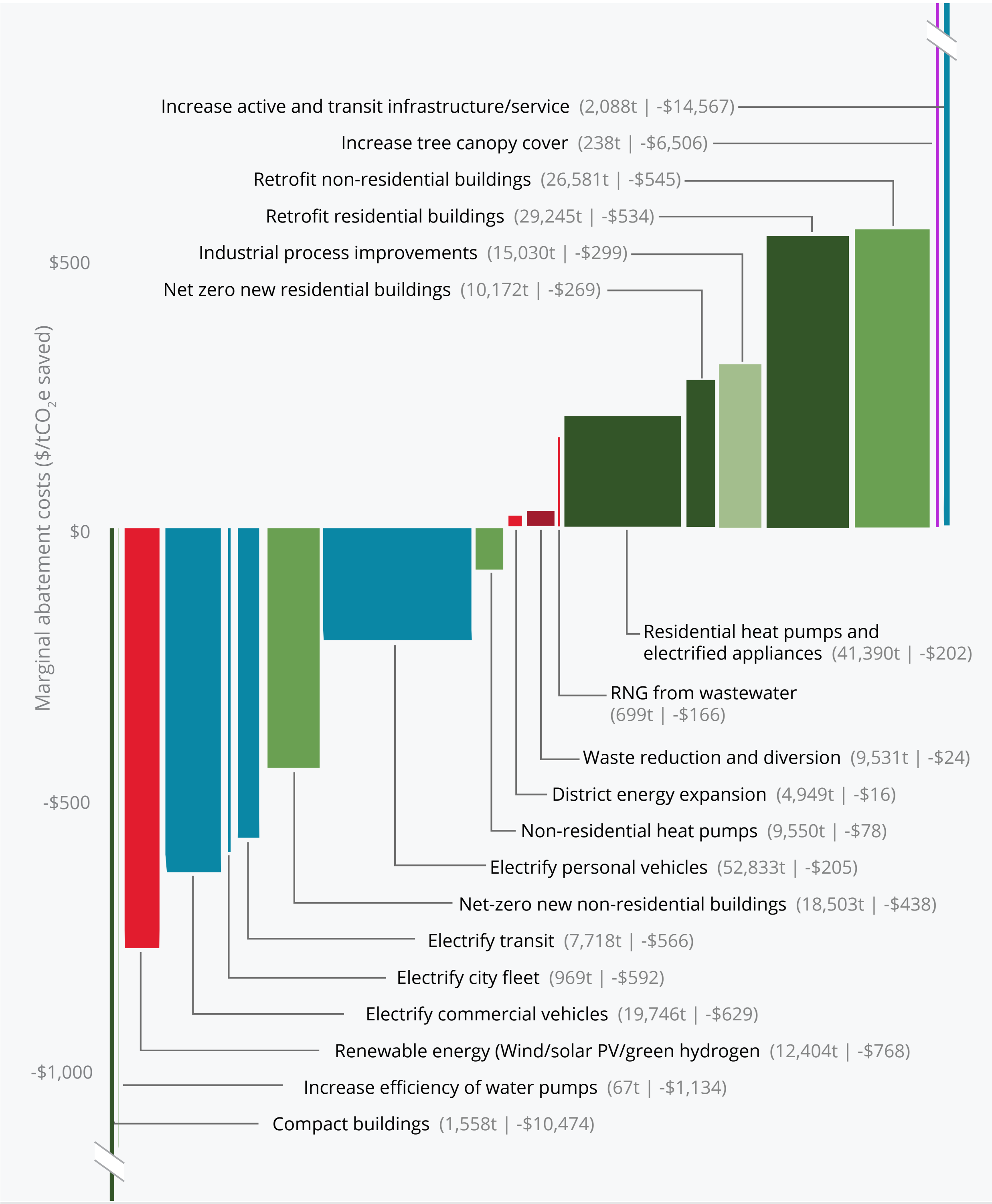

Figure 47. Marginal abatement cost curve (MACC) for the City's net zero by 2040 actions.

THE CRITICALITY OF A SYSTEMS APPROACH

The abatement costs provide an important insight: the electrification of transportation generates financial savings, which, given the deployment of appropriate financial mechanisms, can be used to finance building retrofits, which are more costly. Building retrofits are critical to minimizing the burden on the grid to enable electrification of transportation.

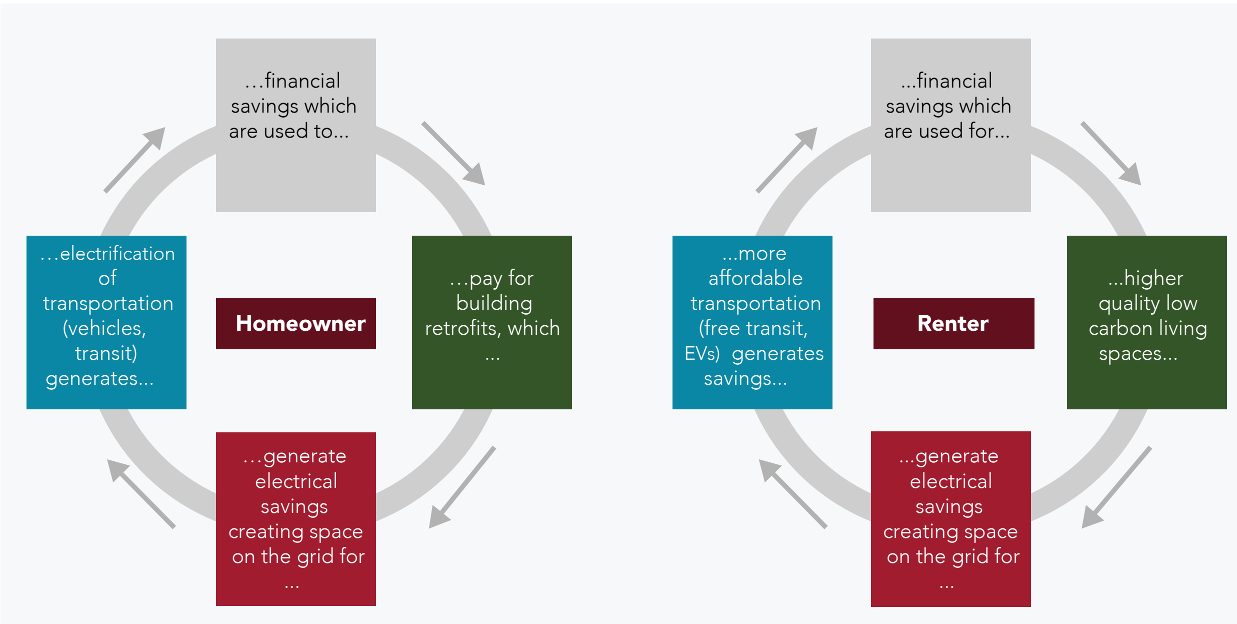

Figure 48. The electrification feedback cycle.

While a marginal abatement cost curve (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 must 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.

USING ABATEMENT COSTS TO GUIDE POLICY

Figure 49 illustrates an abatement curve of actions. Actions on the left save money and are therefore financially interesting to investors. Actions in the middle have a net present value that is either slightly negative or slightly positive and may require credit enhancements to be compelling. Finally, on the right, those actions which are NPV negative will require subsidies. A capital-constrained public sector must concentrate on the expensive projects while relying on the private sector for the rest. A capital-rich public sector can invest in projects that are more expensive and those that may generate more interesting financial returns.

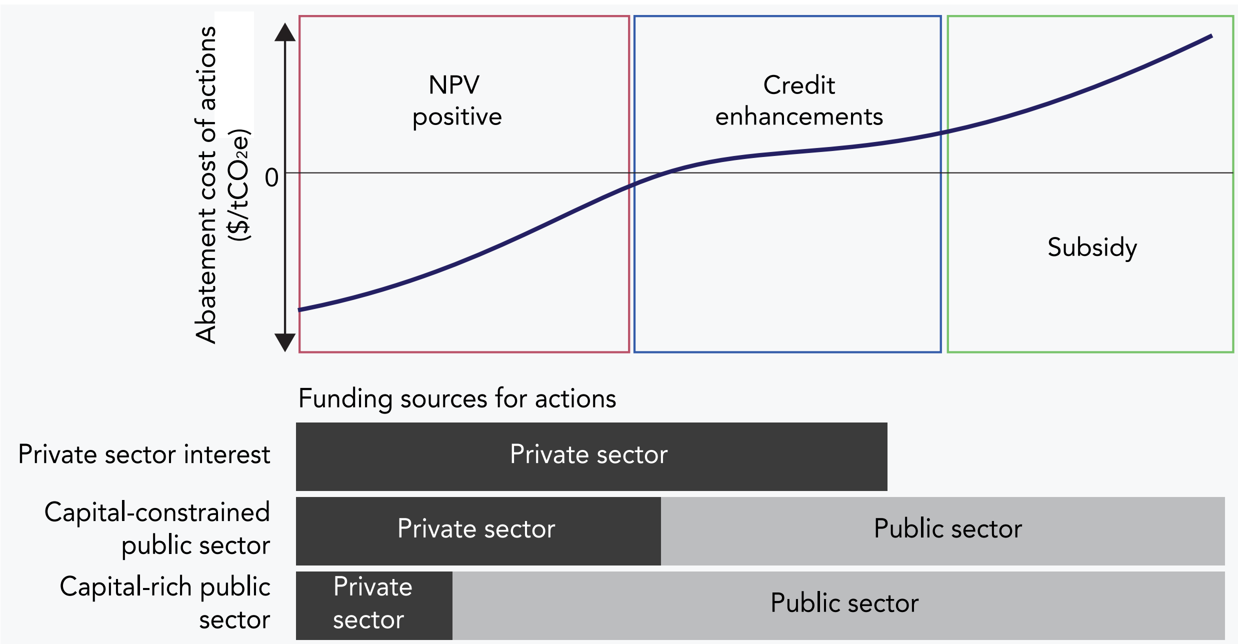

Figure 49. Aligning the abatement costs with investor interest.

Many of the actions in the NZ scenarios have positive net present values. Figure 50 shows the present value of the major components of the three scenarios: 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 both NZ scenarios have a present value of $57 billion (the light green bar), meaning there is no substantial financial difference between these two scenarios. 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.

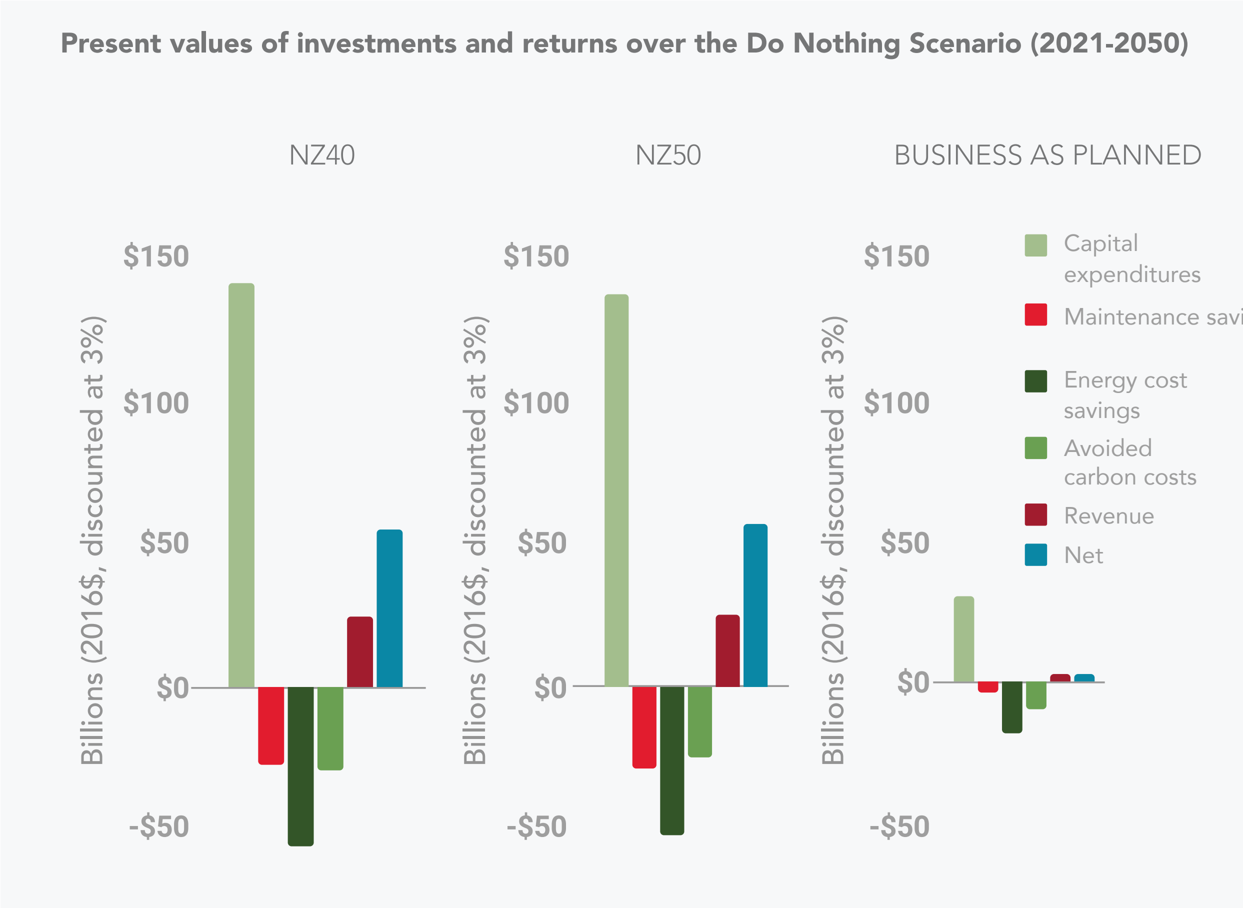

Figure 50. Present values of investments and returns for the three scenarios over the Do Nothing scenario (2021-2050). Costs appear above the x-axis, while revenue and savings appear below it.

The annual costs, savings, and revenue associated with fully implementing the actions in the NZ scenarios are shown in detail in Figure 51, with capital expenditures shown in full for 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, and by 2040 savings are beginning to exceed investments in the NZ40 scenario.

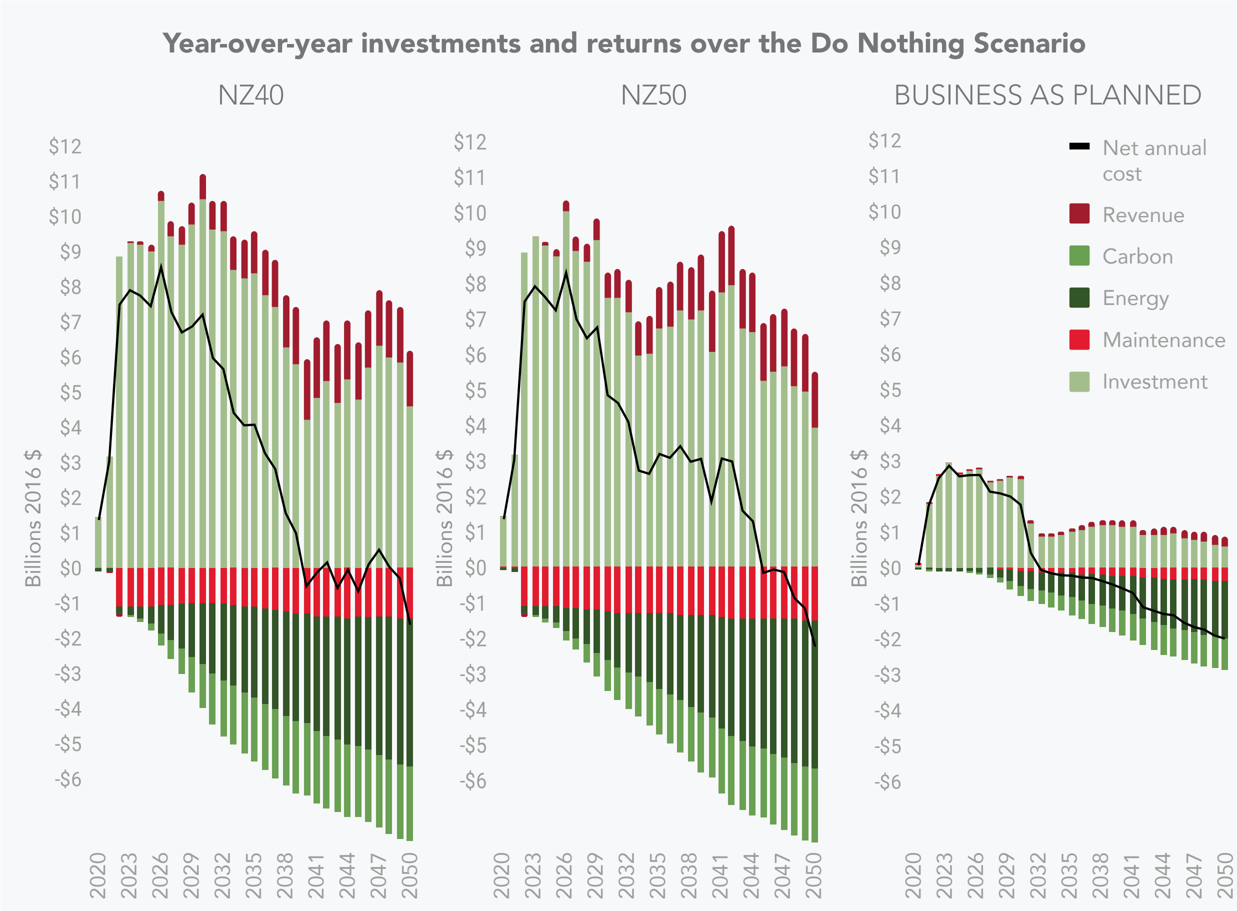

Figure 51. Year-over-year investments and returns over the Do Nothing scenario, 2020-2050.

Note that revenues show up as a cost (positive numbers), rather than as savings (negative numbers), contrary to what would be expected with the significant additions of renewable energy and district energy that generate new revenues. This outcome results because the reduction in revenues from transit relative to the Do Nothing scenario (as transit is free) exceeds the new revenues from renewable energy and district energy systems, generating a net cost (Figure 52).

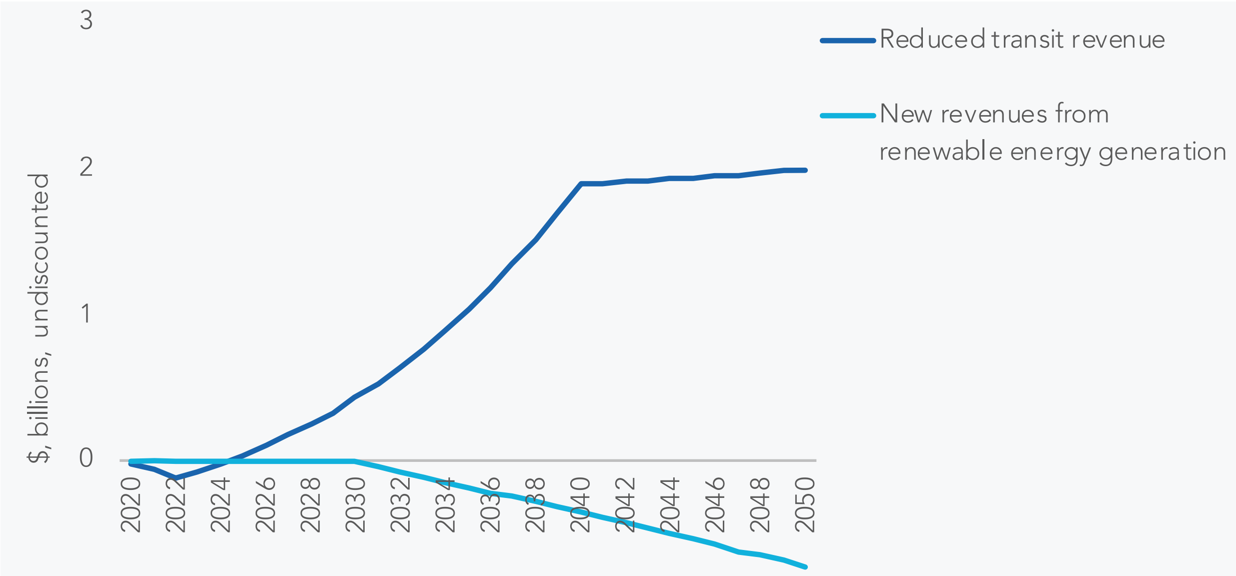

Figure 52. Impact of free transit on avoided annual revenues, relative to revenues from renewable electricity generation, NZ40.

In addition to the reduced revenue as a result of making transit free, transit investments are also one of the three major capital investment areas in the NZ scenarios, totalling $92 billion over the period. Transit plays a similar role to building retrofits by reducing the overall energy demand on the grid resulting from the electrification of transportation, as transit is more efficient than personal vehicles. Residential and non-residential buildings are the other major sources of investment, accounting for $74 and $42 billion, respectively (Figure 53).

The stacked area charts in Figure 53 represent the investments in the year in which they are made, which results in spikes and peaks depending on which actions are implemented in which year. For example, there is a spike in local energy investments in 2027 when renewable energy capacity is added. There is also an incremental capital expenditure relative to the Do Nothing scenario in 2030 when EVs are added, reflecting the early retirement of ICE vehicles. Expenditures on vehicles are greater in the NZ40 scenario than the background replacement rate in the Do Nothing scenario. Because of the early replacement, fewer vehicles are purchased in the NZ40 scenario than the Do Nothing scenario between 2038 and 2044, resulting in a reduction in capital expenditures in this category. Similar blips can be observed in the NZ50 scenario but later on in the time period. The investment in transit and the building stock in the NZ scenarios is apparent relative to the BAP scenario.

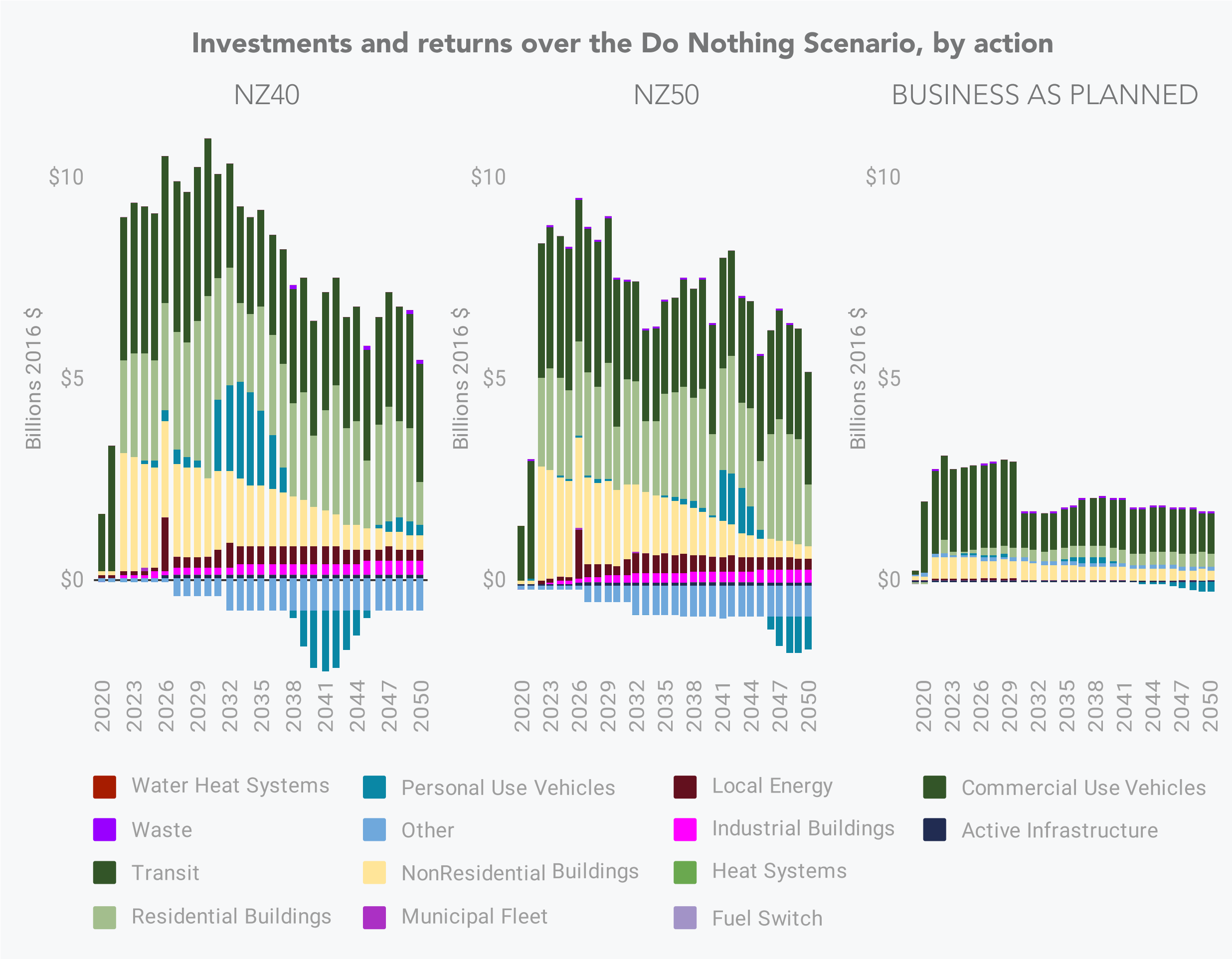

Figure 53. Capital investments over the Do Nothing scenario by action area, undiscounted.

Figure 54 presents costs and revenues, but with the capital expenditures amortized over 25 years with 3% interest. 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 NZ scenarios have an annual deficit, and annual savings only exceed annual costs by a small amount after 2070, as illustrated by the black line.

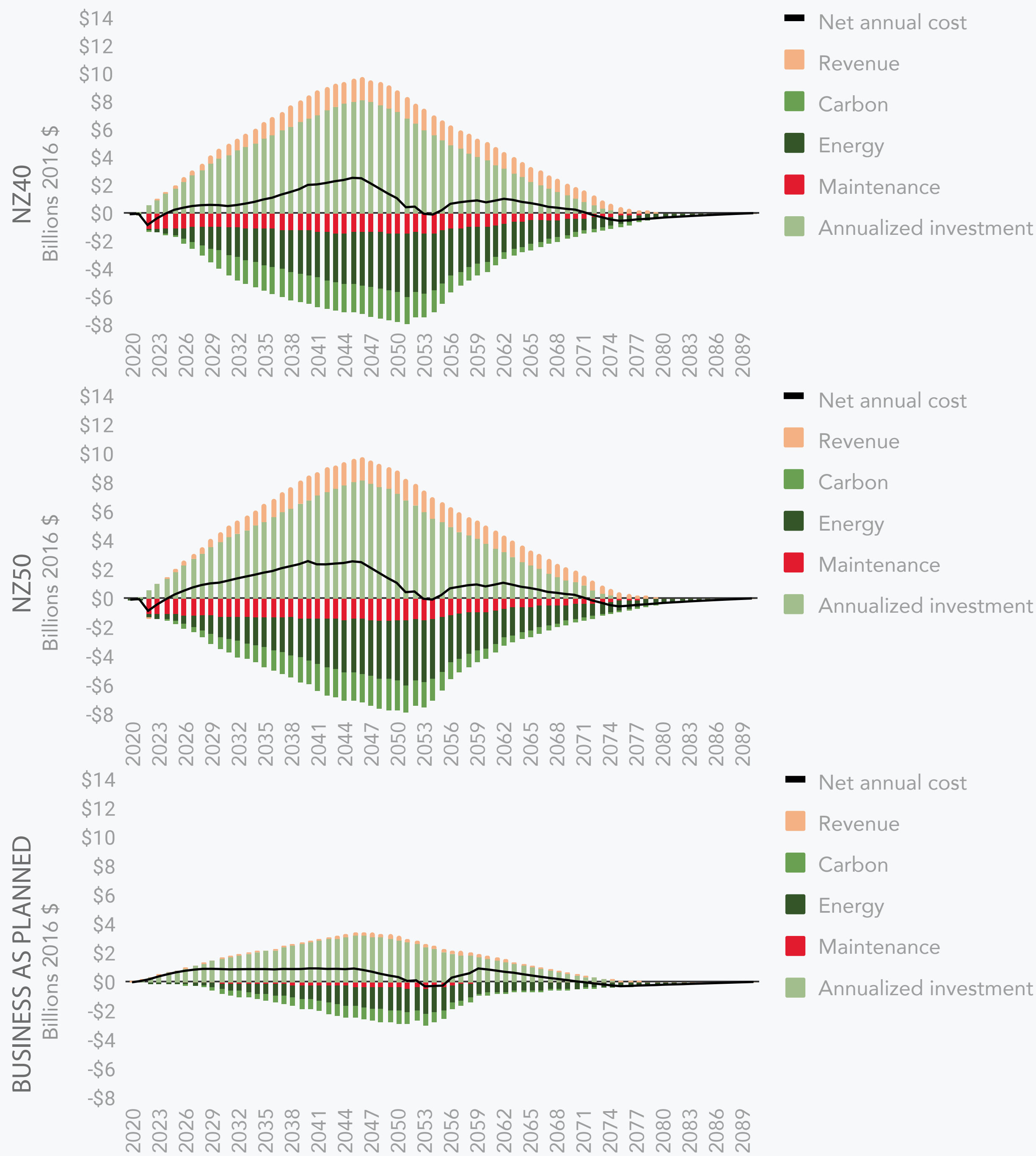

Figure 54. Investments amortized over the period for each of the three scenarios over the Do Nothing scenario.

Amortization reduces the requirement for capital in the short term and smoothes out the trajectory, resulting in a longer tail of payments out until 2070 (Figure 55).

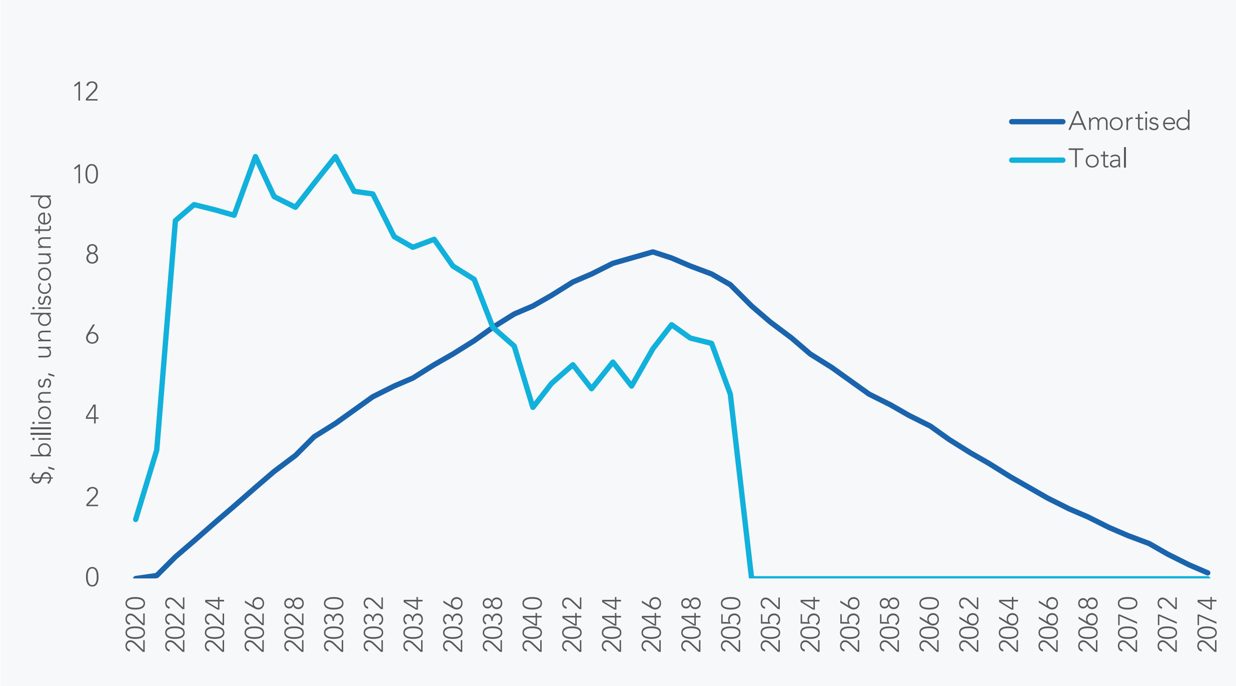

Figure 55. Impact of amortization on capital requirements for the NZ40 scenario.

Household expenditures on energy—natural gas, electricity, gasoline, and diesel—are projected to decline slightly in the BAP and decline significantly in the net zero scenarios (Figure 56). 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 hotter due to climate change. The net zero scenarios involve shifting away from natural gas and gasoline to electricity, a more costly energy source. The increased cost, 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 scenarios, an average household in 2050 spends less on fuel and electricity (household energy and transportation expenditures) than they would have in the Do Nothing scenario. 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.

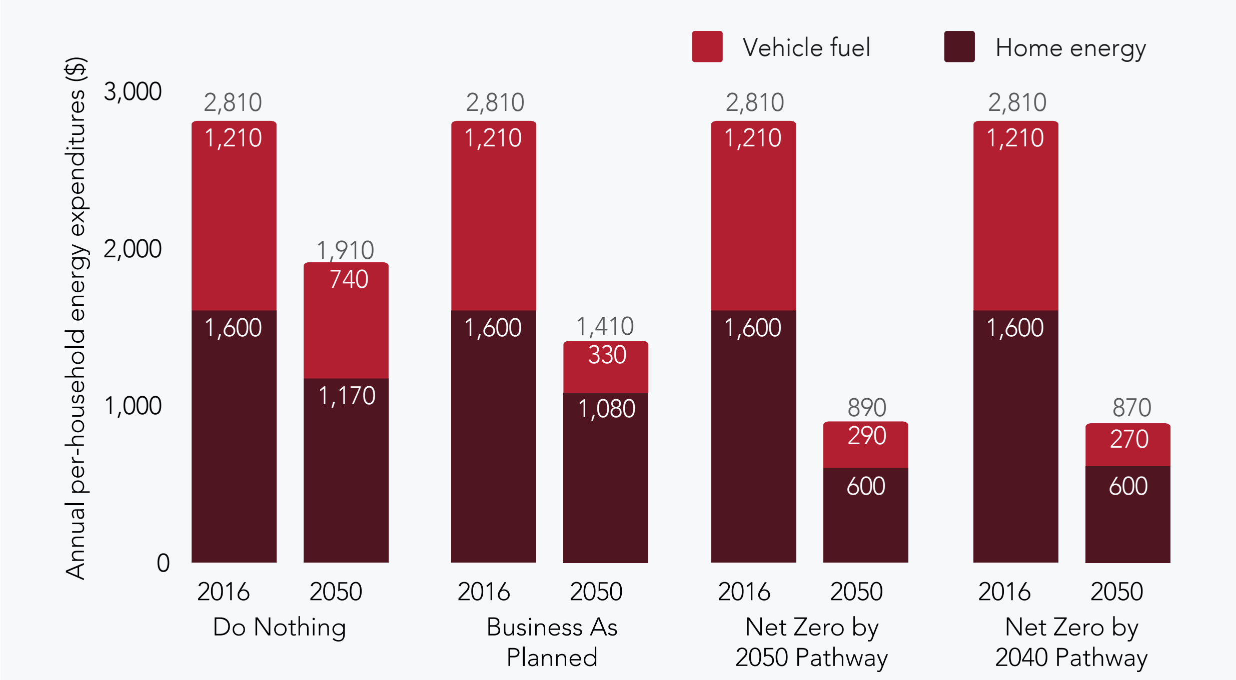

Figure 56. Average annual household expenditures on residential energy for each scenario.

THE IMPACT OF THE CARBON TAX

The carbon price is currently projected to climb to $170/t$CO_2$e by 2030. This has the impact of increasing the cost of gasoline and natural gas relative to electricity. As a result, gasoline is more expensive than electricity on a per-unit-of-energy basis by 2028 (note that the carbon price has not been factored into the electricity cost as it is negligible). This benefit is compounded by the fact that electric vehicles can go further per unit of energy than gasoline vehicles. Natural gas is still more affordable than electricity on a per unit basis over the period. Heat pumps, however, are three times more efficient than natural gas heating and home heating with an electric heat pump becomes more affordable than heating with natural gas in 2027 (Figure 57).

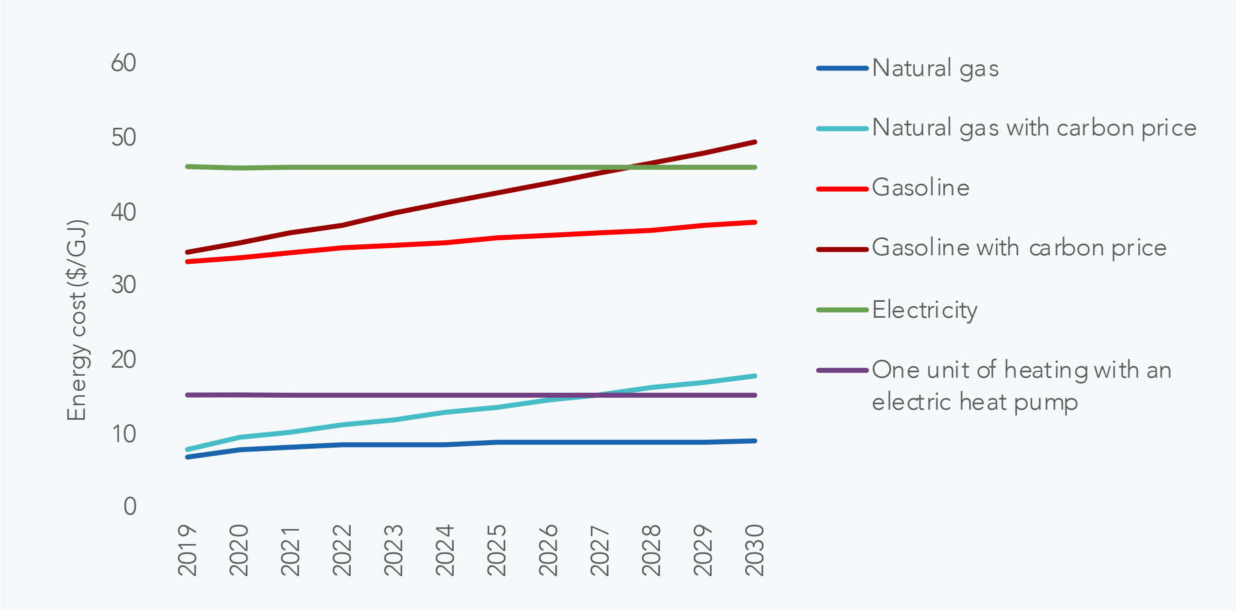

Figure 57. Projections of relative energy costs for gasoline, electricity, and natural gas.

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. The NZ40 scenario adds 1.5 million person-years of employment over the Do Nothing Scenario between 2020 and 2050 (Figure 58). As seen in the figure, this amounts to approximately 40,000-60,000 jobs annually with the majority in residential and commercial building retrofits and infrastructure investments, averaging 10,000-20,000 in each of these three areas.

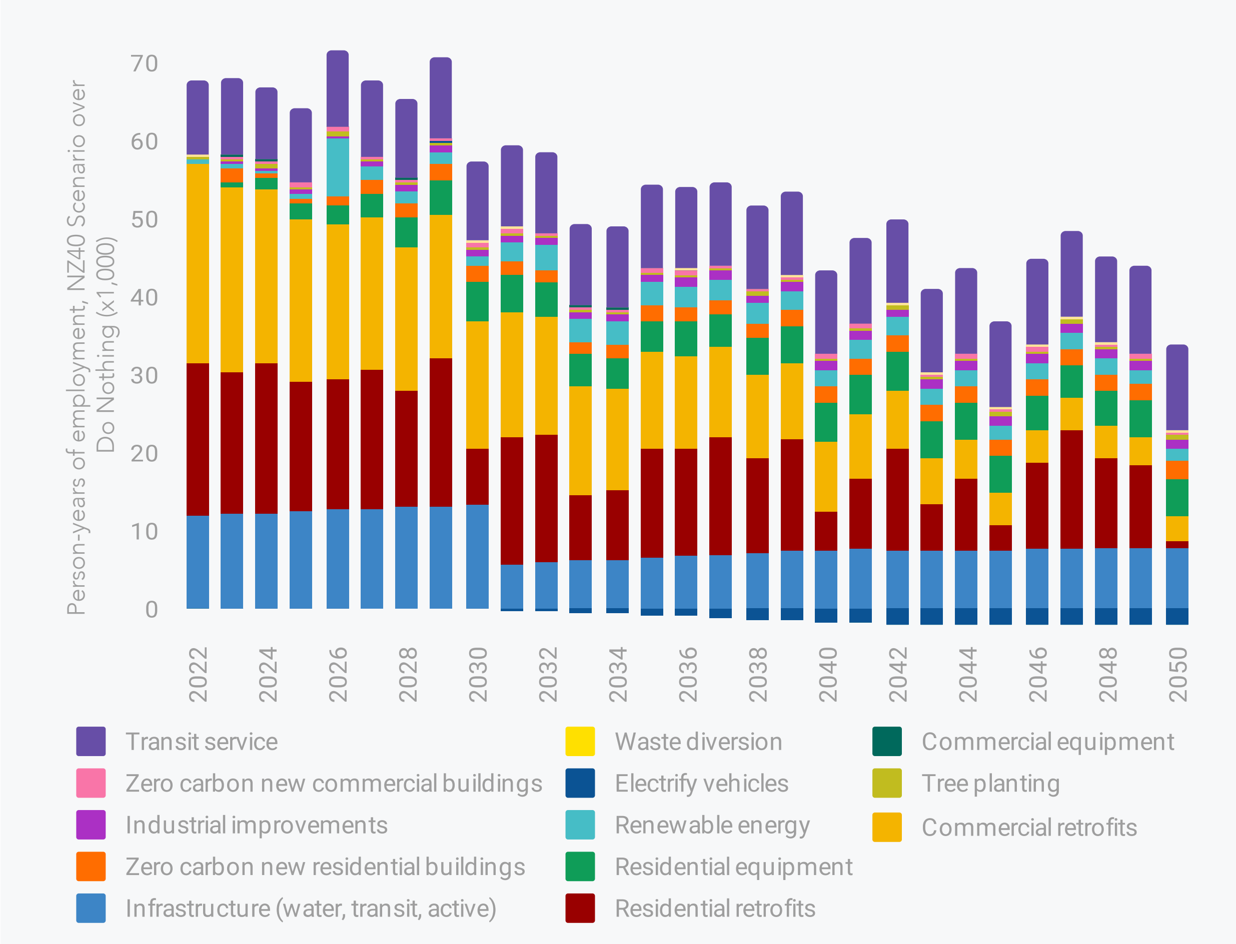

Figure 58. Annual person years of employment generated in the NZ40 scenario.

10. Co-Benefits

As has been discussed, the benefits of GHG mitigation actions go well beyond emissions reductions, also helping to advance City objectives around health, equity, prosperity, and climate resilience. Recognizing this, in 2019 the City's Environment and Energy Division commissioned three reports to explore how these benefits from climate actions could be quantified. This section draws on this work, analyzing metrics related to health, equity, and resilience and comparing them across the four scenarios to shed light on the relative impacts of each. The analysis shows that, across the board, the City could expect to see demonstrable improvements in the NZ scenarios over the BAP and Do Nothing scenarios.

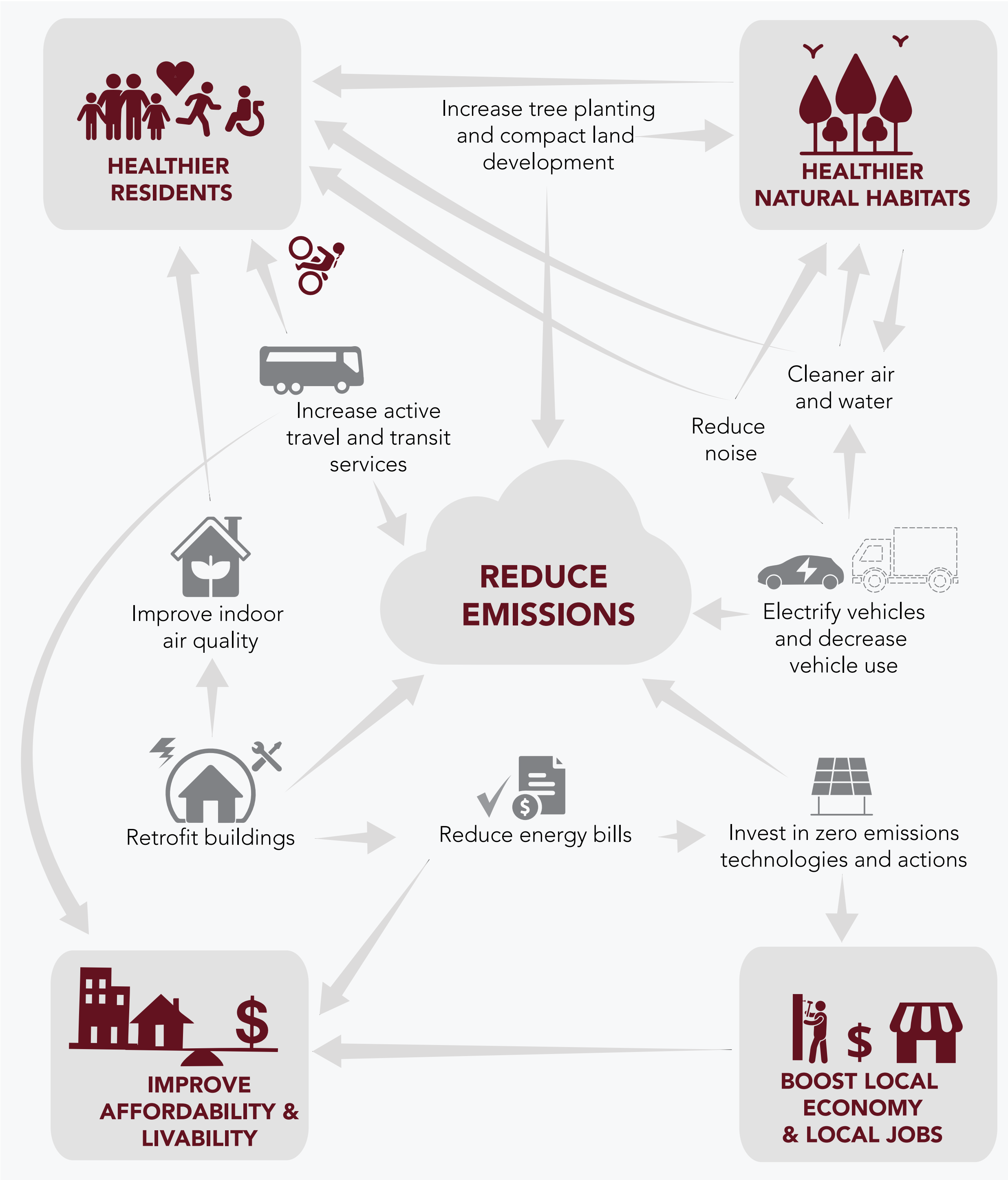

Figure 59. Illustration of some of the key co-benefits of emissions reductions actions.

10.1 ADVANCING HEALTH

CLEANER AIR

In 2020, approximately 232 GJ of fossil fuels were combusted in the City of Toronto. The combustion of these fossil fuels releases air pollutants, such as sulphur dioxide, nitrogen oxides, particulate matter, carbon monoxide, volatile organic compounds, and others, and can create ground-level ozone, all of which have adverse impacts on human health. Air pollution from traffic has resulted in cases of neurological disorders including Parkinson's disease, Alzheimer's disease and other dementias,[99] acute bronchitis in children, asthma and respiratory illnesses, among other impacts.[100] In addition, low income residents experience a greater burden of air pollution.[101] Toronto Public Health estimates that 1,300 premature deaths and 3,550 hospitalizations for heart and lung disease in Toronto can be attributed to air pollution each year.[102] According to one study, "eliminating tailpipe emissions, especially in large metropolitan areas, represents a unique opportunity to reduce the health burden of PM2.5 in the U.S."[103] The study quantified the benefit at between US$0.02 and US$0.12 per mile; at $0.056 per mile, the reduced air pollution can be valued at $750 million per year, or $7.5 billion between 2040 and 2050 when ICEs are phased out. The actual value per mile for Toronto would be higher, due the benefits between 2025 and 2040 when EVs are phased in, cleaner electricity to power the vehicles than in the study (less air pollution), and the exposure levels due to the urban environment of Toronto.

There is also increasing evidence about the impacts of using natural gas stoves and fireplaces indoors on health impacts, particularly on children.[104] In the NZ scenarios, natural gas appliances are phased out and replaced with electric appliances. Reducing the combustion of fossil fuels can help alleviate a wide range of air quality health impacts and result in a more livable indoor and outdoor environment in Toronto.

By 2050, the NZ scenarios see a 99% reduction in local fossil fuels combusted compared to the Do Nothing scenario, primarily from switching vehicles and building heating systems to electric sources.

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99 Shi, L., Wu, X., Yazdi, M. D., Braun, D., Awad, Y. A., Wei, Y., ... & Zanobetti, A. (2020). Long-term effects of PM2· 5 on neurological disorders in the American Medicare population: a longitudinal cohort study. The Lancet Planetary Health, 4(12), e557-e565.

100 City of Toronto. (2014). Path to healthier air: Toronto air pollution burden of illness update.

101 Giang, A., & Castellani, K. (2020). Cumulative air pollution indicators highlight unique patterns of injustice in urban Canada. Environmental Research Letters, 15(12), 124063.

102 City of Toronto. (2017). Avoiding the TRAP: Traffic-Related Air Pollution in Toronto and Options for Reducing Exposure. Technical Report. Retrieved from: https://www.toronto.ca/legdocs/mmis/2017/pe/bgrd/backgroundfile-108667.pdf

103 Choma, E. F., Evans, J. S., Hammitt, J. K., Gómez-Ibáñez, J. A., & Spengler, J. D. (2020). Assessing the health impacts of electric vehicles through air pollution in the United States. Environment International, 144, 106015.

104 Seals, B. and Karasner, A. (2020). Health effects from gas stove pollution. Retrieved from: https://rmi.org/insight/gas-stoves-pollution-health

NZ40 cumulatively achieves a 10% greater reduction in fossil fuels than NZ50 due to early action.

Table 17. Comparison of fossil fuels combusted in Toronto across the four scenarios.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Local fossil fuels combusted					
GJ fossil fuels combusted in 2050 (millions)	**197**	**120**	**2**	**1**	
% improvement from Do Nothing	-	-39%	-99%	-99%	
Cumulative GJ of fossil fuels combusted (2020-2050) (millions)	**6,445**	**5,130**	**2,855**	**2,095**	
% improvement from Do Nothing	-	-20%	-56%	-67%	

PHYSICAL ACTIVITY

Actions in both NZ scenarios result in increased active travel. They increase bike lanes and pedestrian infrastructure, increase the number of transit trips through promotional campaigns, and encourage alternative forms of travel over vehicle use through road tolls and e-bike programs. With active transportation being the most common form of physical exercise, increasing walking and biking has been identified as one of the most significant ways to improve a city's public physical health.[105] Health benefits from routine physical exercise include reductions in incidence of diabetes,[106] cancer, and heart-related illnesses, as well as improvements to mental health.[107]

The NZ scenarios result in a doubling of average walking kilometers per person per year and sixfold increase in average yearly cycling kilometers per person annually by 2050 compared to the Do Nothing scenario.

105 CSEP (2019). Canadian 24-Hour Movement Guidelines. Canadian Society for Exercise Physiology. Retrieved from: https://csepguidelines.ca/

106 Sampasa-Kanyinga, H., Colman, I., Hamilton, H. A., & Chaput, J. P. (2020). Outdoor physical activity, compliance with the physical activity, screen time, and sleep duration recommendations, and excess weight among adolescents. Obesity science & practice, 6(2), 196-206.

107 Ruegsegger, G. N., & Booth, F. W. (2018). Health benefits of exercise. Cold Spring Harbor perspectives in medicine, 8(7), a029694.

Table 18. Change in active kilometers travelled in 2050 across the scenarios.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Active travel per capita					
Yearly walking kms/person (2050)	**74**	**83**	**150**	**150**	
% improvement from Do Nothing	-	+12%	+103%	+103%	
Yearly cycling kms/person (2050)	**109**	**405**	**626**	**626**	
% improvement from Do Nothing	-	+273%	+477%	+477%	

While nearly every neighbourhood experiences increases in active transportation, the increases are not evenly distributed. For example, neighbourhoods in a ring around the downtown experience increases 2-4 times higher than other parts of the city, due to their proximity to services. Large areas of geography experience increases that average 0.5 to 1 km per person per day, while a smaller number of zones experience little or no growth. These walking and cycling deserts require more targeted interventions.

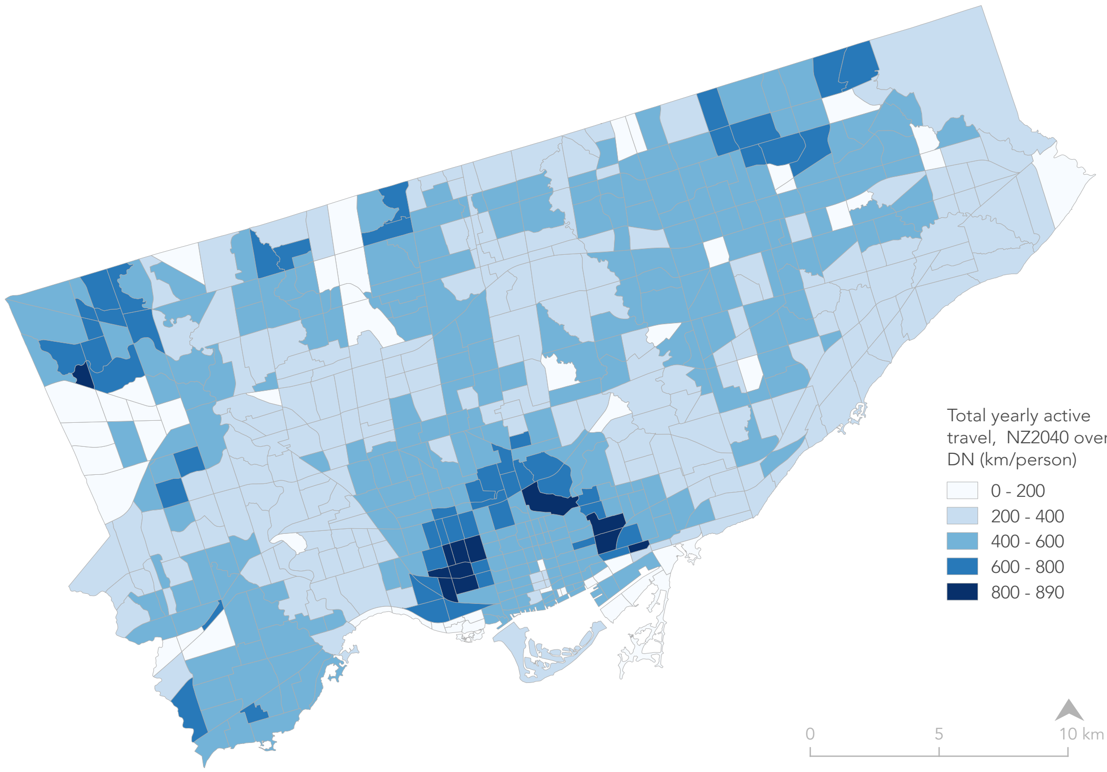

Figure 60. Increase in yearly kilometres per capita of active travel for commuting in the NZ40 scenario compared to the Do Nothing scenario, 2050.

NOISE POLLUTION AND TRAFFIC

Noise pollution is reduced in the NZ Scenarios, in part through reduced vehicle kilometers travelled (14% fewer than Do Nothing in 2050), but primarily through conversion of internal combustion engine vehicles to quieter electric vehicles. By 2050, in the NZ scenarios, there are approximately 1.3 million fewer internal combustion engine vehicles and 125,000 fewer commercial internal combustion engine vehicles on Toronto's roads compared to Do Nothing. Noise pollution from traffic has been associated with a number of health impacts including cardiovascular disease,[108] annoyance,[109] sleep disturbance, and heart attacks.[110]

108 Biel, R., Danieli, C., Shekarrizfard, M., Minet, L., Abrahamowicz, M., Baumgartner, J., ... & Weichenthal, S. (2020). Acute cardiovascular health effects in a panel study of personal exposure to traffic-related air pollutants and noise in Toronto, Canada. Scientific reports, 10(1), 1-12.

109 Miedema, H. M. E., & Oudshoorn, C. G. M. (2001). Annoyance from Transportation Noise: Relationships with Exposure Metrics DNL and DENL and Their Confidence Intervals. Environmental Health Perspectives, 109(4), 409–416.

110 De Nazelle, A., Nieuwenhuijsen, M. J., Antó, J. M., Brauer, M., Briggs, D., Braun-Fahrlander, C., … Lebret, E. (2011). Improving health through policies that promote active travel: A review of evidence to support integrated health impact assessment. Environment International, 37(4), 766–777.

Table 19. Change in personal use VKT (vehicle kilometres travelled) in 2050, by scenario.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Vehicle use					
Yearly personal use VKT (billions) (2050)	**20.2**	**19.4**	**17.3**	**17.3**	
% improvement from Do Nothing	-	-4%	-14%	-14%	
ICE vehicles on roads					
ICE personal use vehicles (2050)	**1,272,000**	**31,000**	**0**[111]	**0**	
% improvement from Do Nothing	-	-98%	-100%	-100%	
ICE commercial vehicles (2050)	**125,000**	**79,000**	**2,000**	**0**	
% improvement from Do Nothing	-	-37%	-98%	-100%	

Figure 61 illustrates that the decrease in VKT in the NZ40 scenario due to mode shifting and changing transportation patterns is not concentrated in one area of the City but rather is widespread. Figure 62 shows how VKT is reduced by 30% in some zones, from 50 million VKT per year to 35 million VKT, for example. The benefits are multiple in terms of reduced air pollution, noise, increased safety, reduced social isolation, and other factors.

111 The actual number of ICE vehicles is not zero but it is negligible, and was therefore represented as 0.

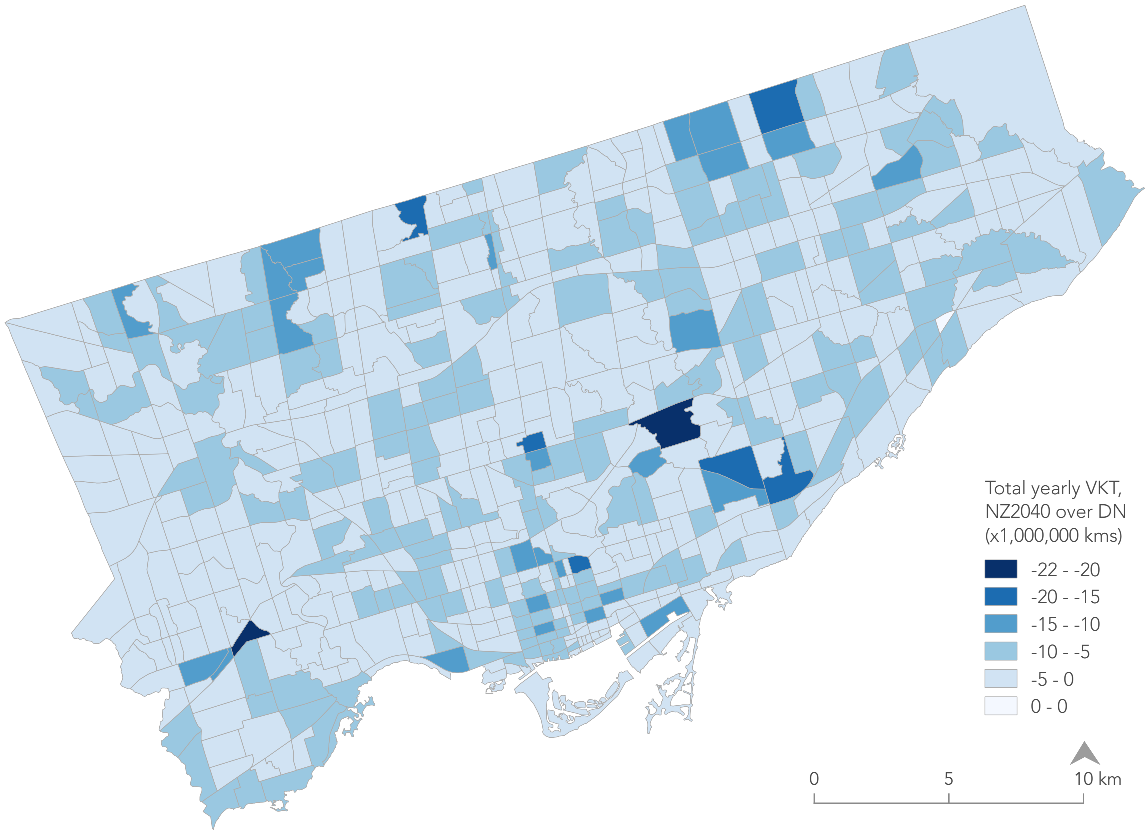

Figure 61. Decrease in total yearly VKTs (for trips within Toronto's boundaries) in the NZ40 scenario compared to Do Nothing, 2050. Darker blue means a greater decrease in VKTs in the NZ40 scenario.

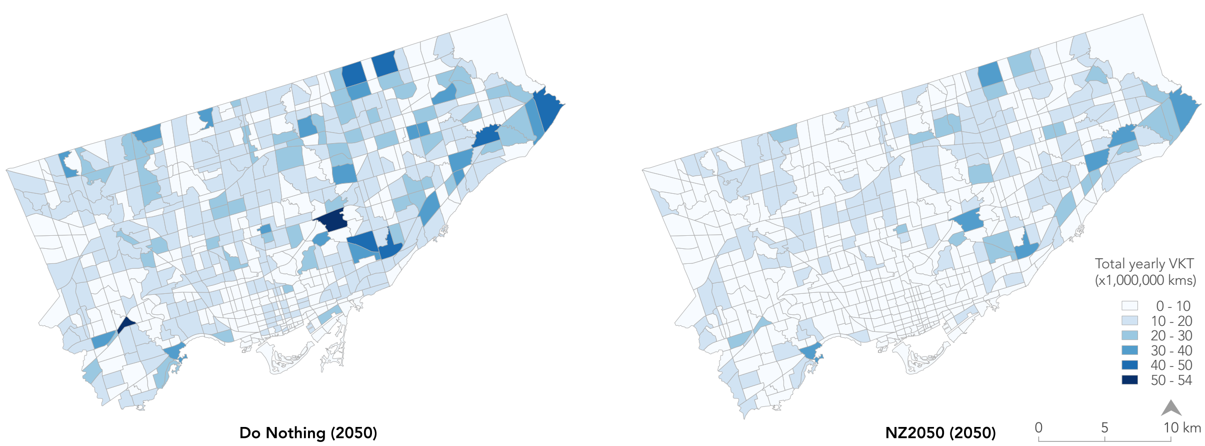

Figure 62. Total yearly VKTs (for trips within Toronto's boundaries) in the NZ40 scenario compared to Do Nothing, 2050.

INDOOR ENVIRONMENTAL QUALITY

According to the City's buildings projections, over 80% of the floorspace that will exist in 2050 has already been built. With people typically spending 90% of their time indoors,[112] the condition of these spaces significantly impacts the physical and mental health of residents. Retrofits to reduce GHGs include improvements to building envelopes, as well as to heating, ventilation, and air conditioning systems. These retrofits can reduce indoor air pollutants (i.e., NOx, CO, and VOCs), reduce mould and dampness, and improve thermal comfort of buildings. Health benefits from these changes can include reduced risks of cardiovascular, endocrine, respiratory, cancer, and cardiopulmonary illnesses, as well as decreased mental disorders and improvements to mental health.[113,114,115]

In the NZ Scenarios,100% of buildings are retrofitted by 2050, water and space heating systems are all converted to heat pumps, and all natural gas appliances are phased out. By 2050, approximately 804,000 more dwelling units and 10,000 more square meters of non-residential floor space have been retrofitted in the NZ Scenarios compared to Do Nothing. These retrofits result in 93% fewer GJ of fossil fuels being used in residential buildings, and 97% fewer in non-residential buildings.

Table 20. Residential and non-residential buildings retrofit by scenario.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Dwelling units retrofit					
Dwelling units retrofit (2020-2050) (thousands)	**66**	**182**	**870**	**870**	
% improvement from Do Nothing	-	+175%	+1,200%	+1,200%	

112 U.S. Environmental Protection Agency (EPA). 1989. Report to Congress on Indoor Air Quality — Vol. II: Assessment and Control of Indoor Air Pollution. EPA/400/1-89/001C. Washington, D.C.: US EPA.

113 Wu, F., Jacobs, D., Mitchell, C., Miller, D., & Karol, M. H. (2007). Improving Indoor Environmental Quality for Public Health: Impediments and Policy Recommendations. Environmental Health Perspectives, 115(6), 953–957. https://doi.org/10.1289/ehp.8986.

114 Barton, A., Basham M., Foy C., Buckingham, K., and Somerville, M., on behalf of the Torbay Healthy Housing Group. 2007. The Watcombe Housing Study: the short term effect of improving housing conditions on the health of residents. Journal of Epidemiol Community Health, 61(9):771e7.

115 Bonnefoy, X. 2007. Inadequate housing and health: An overview. International Journal of Environment and Pollution, 30(3/4), 411. doi: 10.1504/IJEP.2007.014819

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Total GJ of fossil fuels used in residential buildings (2050) (millions)	**78**	**70**	**6**	**6**	
% improvement from Do Nothing	-	-10%	-93%	-93%	
Non-residential buildings retrofit					
Square meters of non-residential building floor space retrofit (2020-2050)	**1,274**	**3,298**	**11,469**	**11,469**	
% improvement from Do Nothing	-	+159%	+800%	+800%	
GJ of fossil fuels used in non-residential buildings (2050) (millions)	**60**	**44**	**2**	**2**	
% improvement from Do Nothing	-	-27%	-97%	-97%	

SOCIAL INTERACTIONS

In the Net Zero Scenarios, people spend approximately 80 hours walking and cycling annually in 2050.[116] This is just over three times greater than the 26 hours spent in the Do Nothing Scenario in 2050. Time spent outside walking and cycling increases the number of conversations and connections amongst residents, which can increase individuals' mental health, sense of community within a neighbourhood, and neighbourhood safety.[117]

10.2 ECONOMIC PROSPERITY

LOCAL ECONOMY

Economic impacts of the NZ Scenarios have been discussed in detail in the Financial Analysis section. Overall, the NZ Scenarios result in $140 billion (NZ50) and $146 billion (NZ40) in investments over the next 30 years compared to the Do Nothing Scenario. These lead to 1.25 million and 1.26 million new person years of employment, respectively. In addition to this, local businesses see a 32% decrease in fuel costs to heat and cool their buildings due to efficiency

116 This estimate is calculated based on a walking rate of 4 km/h and a cycling rate of 15 km/h.

117 Shliselberg, R., & Givoni, M. (2018). Motility as a policy objective. Transport reviews, 38(3), 279-297.

improvements, freeing up money for other purposes such as improving business competitiveness or for reinvestment in the economy.

Reduced household costs for energy and transportation also represent opportunities for residents to spend money locally, resulting in more resilient neighbourhoods. Other benefits to the local economy are seen from changing travel patterns and modes in the NZ scenarios, resulting in more visits and spending at local shops.[118] Providing free transit, as is done in the NZ scenarios, has been shown to result in an increase in leisure and shopping trips,[119] while businesses have also seen increased retail sales from the addition of nearby bike lanes.[120]

Table 21. Comparison of local economy metrics across the four scenarios.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Capital investments					
Capital investments over Do Nothing (NPV at 3%) (2020-2050)		**$31 billion**	**$140 billion**	**$146 billion**	
Jobs added					
Person years of employment generated over Do Nothing (2020-2050)		**0.66 million**	**1.25 million**	**1.26 million**	
Non-residential buildings fuel costs					
$/m2 non-residential floor space yearly fuel costs (2050)	**$30**	**$26**	**$22**	**$22**	
% improvement from Do Nothing	-	-21%	-32%	-32%	

118 Klemmer, K., Brandt, T., & Jarvis, S. (2018). Isolating the effect of cycling on local business environments in London. PloS one, 13(12), e0209090.

119 Bull, O., Muñoz, J. C., & Silva, H. E. (2021). The impact of fare-free public transport on travel behavior: Evidence from a randomized controlled trial. Regional Science and Urban Economics, 86, 103616. https://doi.org/10.1016/j.regsciurbeco.2020.103616

120 New York City Department of Transportation. 2012. Measuring the Street: New Metrics for 21st Century Streets. Department of Transportation, City of New York, NY. https://nacto.org/wp-content/uploads/2015/04/measuring_the_street_nyc_dot.pdf

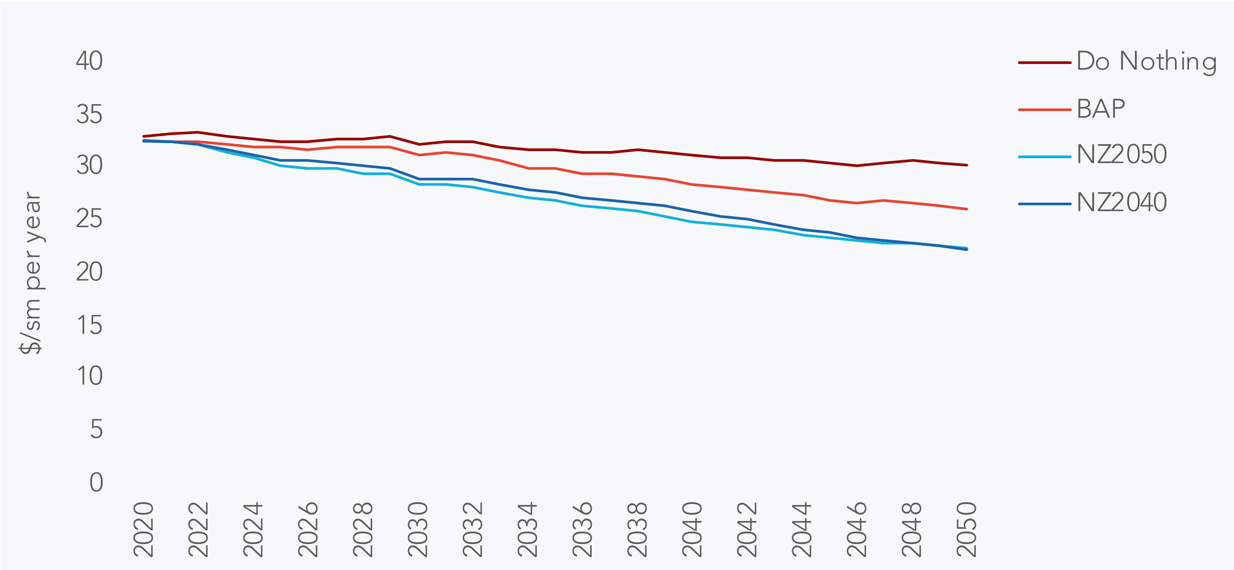

Figure 63. Yearly fuel costs per m2 of floor space for non-residential buildings, 2020-2050.

COST OF LIVING

GHG reduction measures result in reduced household energy costs as buildings are built and retrofitted to be more energy efficient. NZ Scenario household energy costs are nearly 50% less in 2050 compared to the Do Nothing Scenario. Transportation costs are also reduced in the NZ Scenarios, as more automobile trips are replaced by walking, cycling, and transit trips and as transit becomes free. Transportation costs decrease from $214 per household per month in the Do Nothing Scenario to just $23 per month in the NZ40 Scenario. Taken together, this results in a 77% decrease in household monthly energy expenditures in the NZ Scenarios compared to Do Nothing by 2050, an average reduction of nearly $2,850 per household per year when transit fares are considered, or $1,030 per household per year when transit fares are not considered.

Table 22. Comparison of household fuel expenditures in 2050, across the scenarios.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Household energy and transportation costs					
Household average monthly energy expenditures (2050)	**$97**	**$90**	**$50**	**$50**	
% improvement from Do Nothing	-	-8%	-48%	-48%	

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Household average monthly travel costs (transit plus vehicle fuel)	**$214**	**$167**	**$24**	**$23**	
% improvement from Do Nothing	-	-22%	-89%	-89%	
Household total monthly travel and energy expenditures	**$311**	**$257**	**$74**	**$73**	
% improvement from Do Nothing	-	-17%	-76%	-77%	

Households across the city experience a reduction in annual household (dwelling) energy costs (home energy and vehicle fuel) of between $500 and $1,000 by 2050, with a small number of zones experiencing reductions between $1,000 and $2,000. Figure 64 indicates that household energy cost reductions (dwelling) are generally between $500 and $1,500 per year by 2050 in the city.

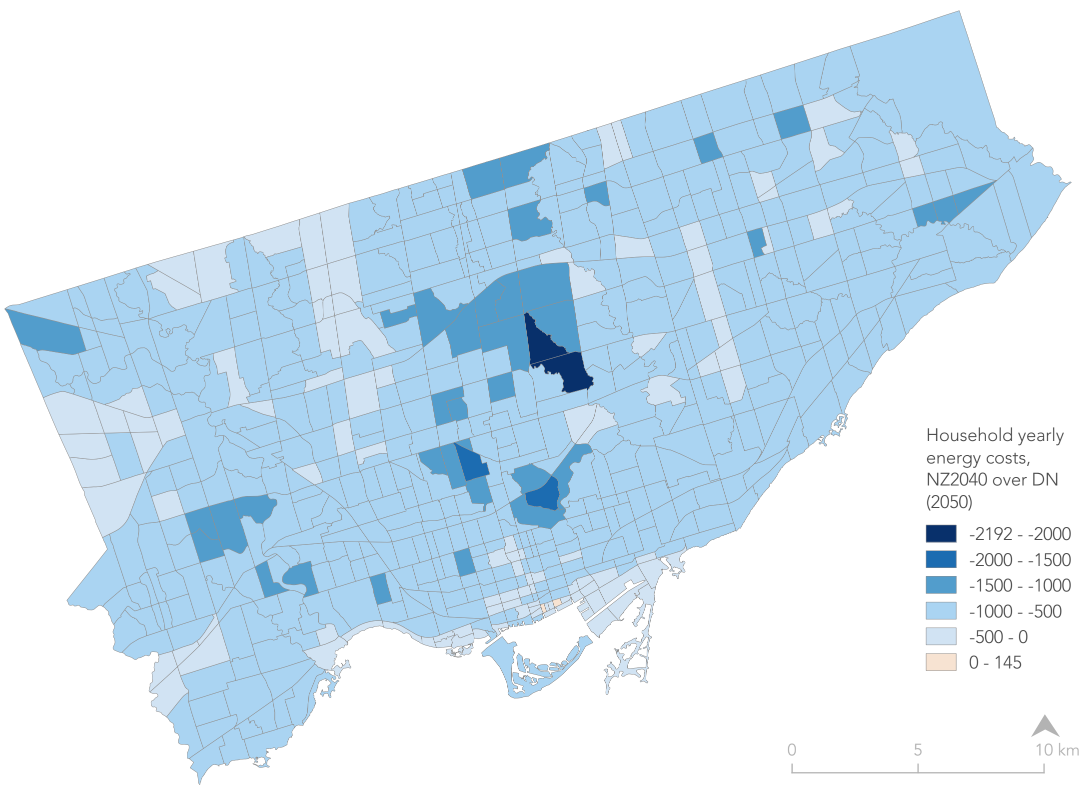

Figure 64. Change in household yearly energy costs (home energy and vehicle fuel) in the NZ40 Scenario over the Do Nothing Scenario (2050). The darkest zones show the greatest decrease.

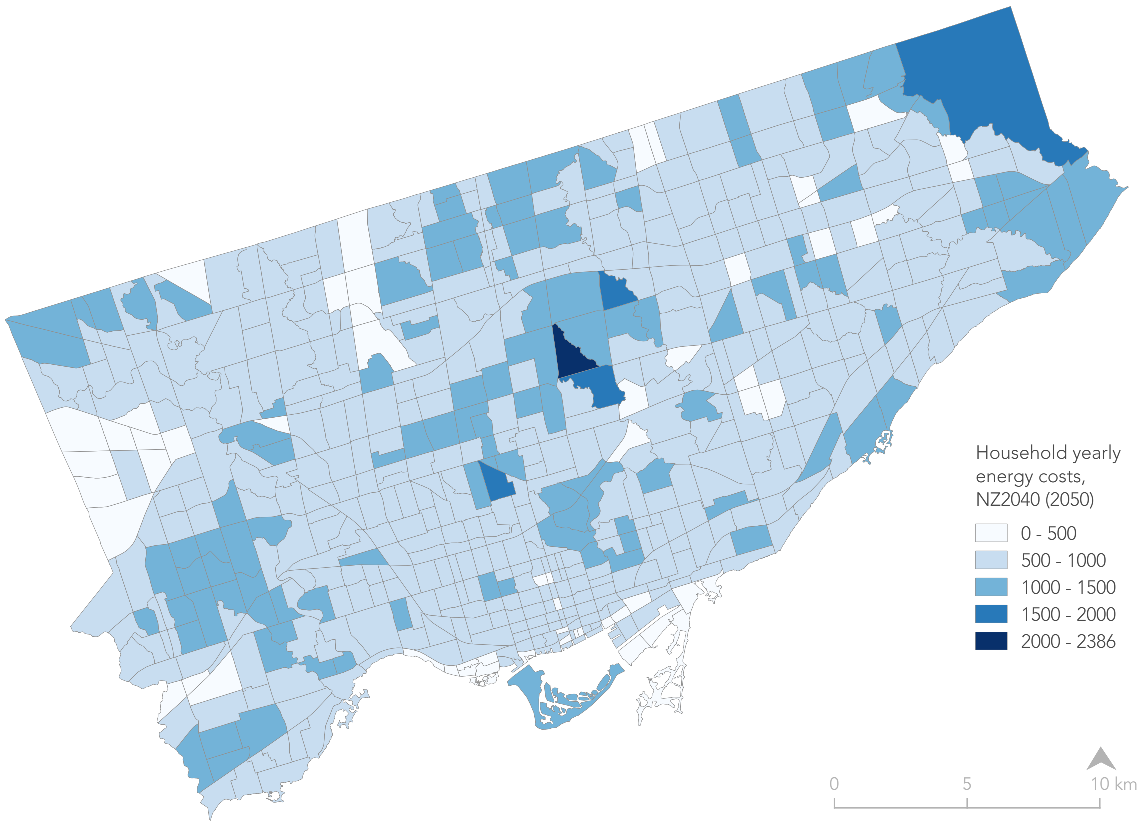

Figure 65. Household yearly energy costs in the NZ40 Scenario (2050).

MUNICIPAL FINANCES

The table below summarizes net municipal costs across the four scenarios. It is important to note that these numbers were drawn from a city-wide analysis and thus are broad estimates. A detailed analysis of corporate actions, investments, and savings should be undertaken to gain further insights. The costs included in this calculation of municipal finances are: transit infrastructure capital costs (assuming 27% of total investments are incurred by the City, the rest are from Provincial, Federal or other sources), transit bus maintenance and fuel costs, transit revenues, transit vehicle capital costs, wastewater and water treatment, waste management, and road toll revenues. Costs and savings related to new buildings, building retrofits, and renewable energy investments are not included (these are aggregated into the city-wide commercial numbers), nor are costs for staff time for development and deployment of programs to deliver the actions. By 2050, costs increase by approximately $2.2 billion in the Net Zero Scenarios compared to Do Nothing.

Table 23. Comparison of net municipal costs across the scenarios.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Municipal costs					
Net municipal costs ($billions) (2050)	**-0.08**	**0.8**	**2.16**	**2.16**	
Net municipal costs ($billions) (2020-2050)	**5.3**	**25.6**	**41.3**	**41.0**	

10.3 BIODIVERSITY

ECOSYSTEM ENCROACHMENT

All forms of energy generation—including renewables—require land[121] that could otherwise be used to maintain biodiversity or for agriculture or forestry. This land, known as the energy footprint, is required for exploration, fuel extraction, generation, transmission, and distribution, and is primarily located outside of Toronto's geographic borders. For example, the energy footprint traces the land use impact of gasoline to the oil sands, or the source of natural gas to shale formations, or the source of electricity to wind farms. Through reduced fossil fuel consumption and efficiency gains, the latter of which reduces the capacity required, the NZ scenarios result in an energy footprint 1,392 km^2 smaller than that of the Do Nothing scenario—an area more than double the size of the City of Toronto.

Table 24. Comparison of energy footprint associated with the different scenarios, 2050.[122]

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Energy footprint					
Land area associated with energy production (km^2) (2050)	**2,292**	**1,645**	**911**	**900**	
% improvement from Do Nothing	-	-28%	-60%	-61%	

121 Calculated using factors from: *McDonald, R. I., Fargione, J., Kiesecker, J., Miller, W. M., & Powell, J. (2009). Energy Sprawl or Energy Efficiency: Climate Policy Impacts on Natural Habitat for the United States of America. PLoS ONE, 4(8), e6802.*

122 Note that this is a rough approximation and does not include district energy or hydrogen in the calculation.

HABITAT CONNECTIVITY

As development continues throughout the GTA, so too does the importance of preserving and restoring local habitats and biodiversity. The BAP and NZ Scenario targets align with the City's Strategic Forest Management Plan goal of increasing tree canopy cover in the city from 30% to 40%. Additional benefits of increased tree canopy and greenery in cities can include improvements to mental health, reduced heat island effect, improved air quality, and improved stormwater infiltration during extreme rainfall events.[123]

Table 25. Comparison of tree canopy cover across the scenarios.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Tree cover					
Tree canopy cover (2050) % improvement from Do Nothing	**30%** -	**40%** +33%	**40%** +33%	**40%** +33%	

10.4 EQUITY

While consideration of equity is woven through the sections above, this section addresses specific equity considerations.

INTERGENERATIONAL EQUITY

Climate change represents a burden on future generations that increases the longer that action is delayed. Recent years have seen increased demand from youth for government action on climate change, including school walk-outs, protests, and lawsuits against their governments for inaction on climate change.[124]

The social cost of carbon (SCC) has been used in regulatory processes in Canada and the US to reflect the impacts of climate change on society. The SCC attempts to add up the quantifiable costs and benefits of a tonne of carbon dioxide on society, incorporating assumptions around future conditions such as population size, economic growth, rate of climate change, and the impact of climate change on these conditions.

123 Santamouris, M., & Osmond, P. (2020). Increasing green infrastructure in cities: Impact on ambient temperature, air quality and heat-related mortality and morbidity. Buildings, 10(12), 233.

124 Our Children's Trust. (2016). Landmark US federal climate lawsuit. Retrieved November 14, 2016, from https://www.ourchildrenstrust.org/us/federal-lawsuit/

The cumulative cost of the Do Nothing Scenario between 2020 and 2050 using the Social Cost of Carbon (SCC) is $94 billion. Under the BAP, this declines to $76 billion. Under the NZ40, it declines to $35 billion, as illustrated in Figure 68.[125]

IMPACTS ON LOW-INCOME POPULATION

Climate change is affecting individuals and communities at varying rates and to varying degrees.[126] Climate change is amplifying vulnerability and hindering adaptive capacity of persons with low incomes, Aboriginal Peoples, LGBTQ2S communities, undocumented individuals, immigrants and refugees, diverse women, seniors, children, persons with disabilities, and racialized groups. These groups often lack power as well as access to resources, adequate urban services, and reliable infrastructure. For example, poverty and marginalization not only leave people vulnerable to rising food, water, and energy prices, but also limit their ability to invest in resources and prepare for the impacts of climate change. Following a disaster, it is much harder for low-income and marginalized communities to rebuild, as these groups are less likely to have the social capital and resources to do so.

The figure below shows the decrease in household energy costs, which occurs in nearly every zone across the city. Neighbourhoods with the greatest populations of low-income individuals are highlighted. These areas see reductions of up to $2,000 in yearly household energy costs in the NZ40 Scenario compared to Do Nothing Scenario. Ensuring that the benefits of these savings reach low-income populations (e.g., renters rather than building owners), however, is dependent on policies to ensure that this occurs. Similarly, programs to provide or assist with capital for renewable energy and energy efficient construction and retrofits for low-income earners and housing will also be important to ensure that they can participate in and reap the benefits of the low-carbon transition.

125 All values used the 3% discounting rate, 95th percentile which reflects higher than expected economic damages from climate change. Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

126 Rudolph, L., Gould, S., and Berko, J. "Climate Change, Health and Equity: Opportunities for Action." Oakland, CA: Public Health Institute, 2015. https://www.phi.org/uploads/application/files/h7fjouo1i38v3tu427p9s9kcmhs3oxsi7tsg1fovh3yesd5hxu.pdf.

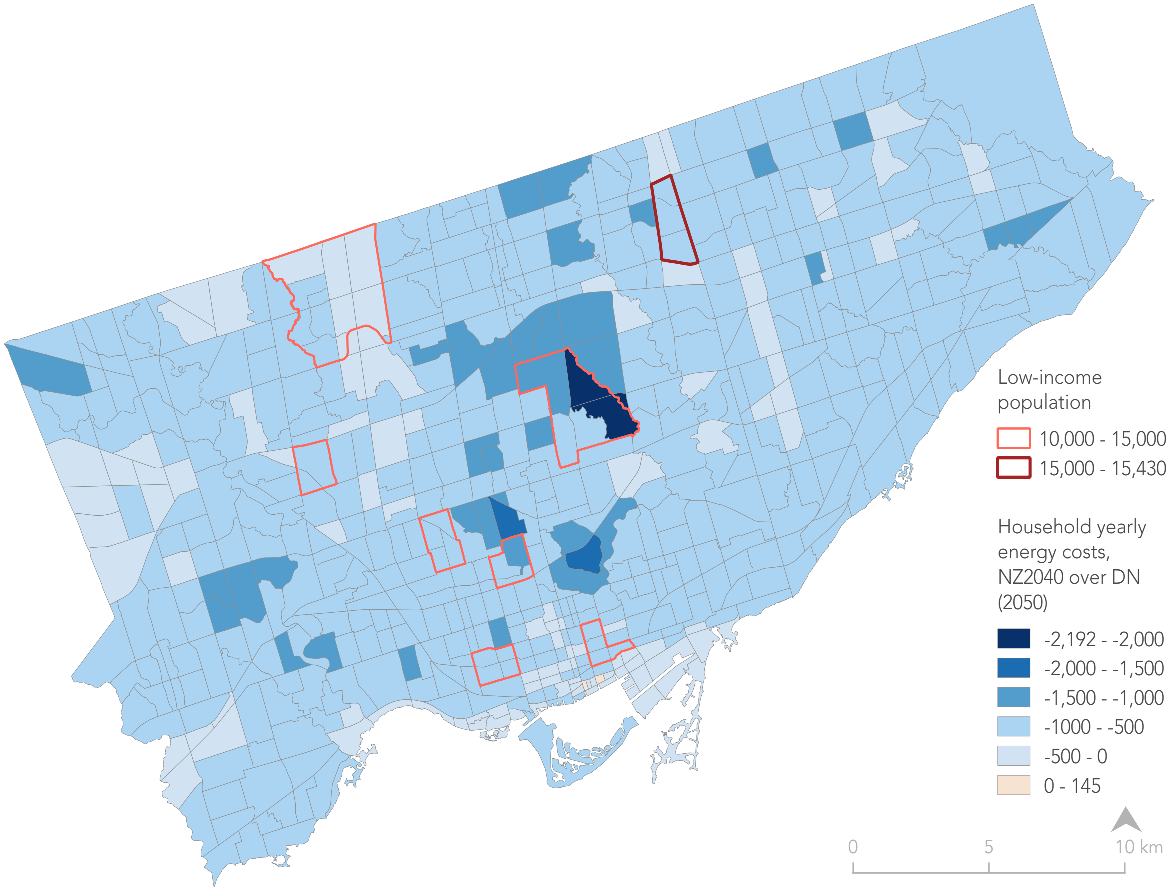

Figure 66. Change in yearly household energy costs (vehicle fuel and home energy) in the NZ40 scenario compared to Do Nothing in 2050. Neighbourhoods housing low-income populations greater than 10,000 people are highlighted. In nearly every zone, energy costs decrease, to a maximum of $2,192/year saved, which occurs in a low-income neighbourhood. Savings are even greater when the impact of free transit is also considered.

TRANSIT AND ACTIVE TRAVEL ACCESSIBILITY

The NZ Scenarios call for significant investments in transit, including converting one lane of traffic to exclusive bus lanes on all arterials, increased service frequency on all transit routes (bus by 70%, streetcar by 50%, subway off-peak service to every 3 minutes), and expanding the rapid transit network. The cost of making transit free in the NZ Scenarios is partially offset by tolls of $0.66/km on all arterial roads. As a result, alongside increases in active transportation (see the previous section on physical activity), per-household transportation costs decrease by 76%. This is even more significant for people who do not own a car and for whom costs are reduced by 100%. From an equity perspective, this is significant, as it frees up money for low-income populations to meet other needs and provides them with access to services and job opportunities that might have otherwise been out of reach. Infrastructure investments need to be distributed and directed to low-income areas to ensure that these benefits do in fact reach low-income residents.

QUALITY AFFORDABLE HOUSING

In 2010, 44% of renter households and 28% of owner households faced affordability issues in the City of Toronto.[127] Households facing energy poverty or energy insecurity face challenges such as "pay the rent or feed the kids," "heat or eat," or "cool or eat."[128] Low-income households stand to benefit greatly from the improved housing quality and energy cost savings resulting from the NZ Scenario actions. Affordable housing units and units occupied by low-income earners in Toronto are more likely to be in need of repair,[129,130] with these buildings often being older, less energy efficient, and lacking proper ventilation.

In the NZ Scenarios, 100% of dwelling units are retrofit to net zero standards, presenting opportunities for improved health and living conditions for residents, and energy savings for households. Prioritizing the retrofit of affordable and low-income housing, particularly that which is in need of repair, can help to improve the living conditions of Torontonians who need this most. Energy retrofits can result in improved thermal satisfaction, fewer reported financial difficulties, increased satisfaction among participants with the repair of their homes, fewer reported housing-related problems and more social interactions.[131] Care will need to be taken to ensure that adverse impacts from these efforts, such as increased housing costs or rents, are managed or avoided. Focussing retrofit initiatives on low-income households will mean the financial and health benefits from the NZ actions are seen sooner for those in need.

Retrofits can also increase the resilience of affordable housing by incorporating measures for extreme heat and power outages. Relative death rates can begin to increase at temperatures as low as 20°C, rates which are influenced by pre-existing health conditions, social isolation, living conditions and other factors.[132] A 2010 survey found that 15% of Toronto residents do not have air conditioning, and for those with low incomes, 33% did not have air conditioning.[133] Deep retrofits can increase the passive survivability of the dwelling while the installation of electric heat pumps provides cooling.

127 City of Toronto. (2016). Housing and health: Unlocking opportunity.

128 Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., … Cutts, D. B. (2008). A brief indicator of household energy security: Associations with food security, child health, and child development in US infants and toddlers. *PEDIATRICS*, *122*(4), e867–e875. https://doi.org/10.1542/peds.2008-0286

129 Pagliaro, J, 2017. Half of Toronto Community Housing homes to hit 'critical' status within five years. Toronto Star. https://www.thestar.com/news/city_hall/2017/05/23/half-of-toronto-community-housing-homes-to-hit-critical-status-within-five-years.html

130 Paradis, E., Wilson, R., Logan, J., 2014: Nowhere Else to Go: Inadequate Housing & Risk of Homelessness Among Families in Toronto's Aging Rental Buildings. University of Toronto Cities Centre. https://www.homelesshub.ca/sites/default/files/Paradis%20Homelessness%20Executive%20summary.pdf

131 Poortinga, W., Rodgers, S. E., Lyons, R. A., Anderson, P., Tweed, C., Grey, C., … Winfield, T. G. (2018). The health impacts of energy performance investments in low-income areas: a mixed-methods approach. Public Health Research, 6(5), 1–182. https://doi.org/10.3310/phr06050

132 Health Canada. (2012). Extreme heat events guidelines: technical guide for health care workers. Ottawa.

133 City of Toronto. (2015). *Reducing health risk from extreme heat in apartment buildings.*

GLOBAL EQUITY

Climate change is directly killing people.[134] A recent paper in Nature developed a new metric, the mortality cost of carbon (MCC), which quantifies the number of deaths per ton of GHG emissions released in 2020.[135] Adding 4,434 tons of carbon dioxide in 2020 causes one excess death globally in expectation between 2020-2100. Using this number, the NZ40 scenario results in 59,539 fewer deaths globally than the Do Nothing scenario. As the authors point out, not all people have an equal impact—the lifetime emissions of 3.5 Americans cause one excess death globally in expectation between 2020 and 2100, the same impact that results from the lifetime emissions of 100 Indians.

10.5 SAFETY & RESILIENCE

RESILIENCE TO OUTAGES AND CLIMATE IMPACTS

Many GHG mitigation efforts have been shown to increase adaptive capacity to the impacts of climate change. These synergies exist at many levels.[136] While all these benefits are not captured here, some key improvements to resilience in the city from the NZ scenarios include:

- safer buildings during extreme weather events (flooding, extreme heat/cold) from older buildings having been retrofitted;
- decreased impacts of power outages from homes having been fitted with renewable energy and storage systems;
- decreased impacts of power outages for homes that are connected to district energy systems;
- decreased stress on water and wastewater systems from retrofits and more stringent efficiency standards for new buildings;
- decreased heat island effect and flood stress from greater tree canopy cover; and
- increased back-up power from EVs.

134 Mitchell, D. (2021). Climate attribution of heat mortality. Nature Climate Change, 11(6), 467-468.

135 Bressler, R. D. (2021). The mortality cost of carbon. Nature Communications, 12(1), 1-12.

136 Klein, R.J.T., S. Huq, F. Denton, T.E. Downing, R.G. Richels, J.B. Robinson, F.L. Toth, 2007: Inter-relationships between adaptation and mitigation. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 745-777.

Table 26. Residential and non-residential buildings retrofit by scenario.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Dwelling units retrofit					
Dwelling units retrofit (2020-2050) (millions) % improvement from Do Nothing	**0.39** -	**0.99** +156%	**4.6** +1,090%	**4.6** +1,090%	
Non-residential buildings retrofit					
Non-residential buildings retrofit (2020-2050) % improvement from Do Nothing	**1,274** -	**3,298** +159%	**11,469** +800%	**11,469** +800%	
Backup power					
MW of storage with solar PV (2050) % improvement from Do Nothing	**0.1** -	**0.1** 0%	**2,000** >1,000%	**2,000** >1,000%	
# of EVs (2050) % improvement from Do Nothing	**0.35 million** -	**1.62 million** +363%	**1.65 million** +371%	**1.65 million** +371%	
Decentralized energy					
#of district energy systems / m2 of floor space served by DE (2050) % improvement from Do Nothing	**6** **9.5M m²** -	**8** **9.8M m²** +33% +3%	**8** **10.8M m²** +33% +14%	**8** **10.8M m²** +33% +14%	

CYCLING AND PEDESTRIAN SAFETY

Cycling and pedestrian safety is improved in the NZ Scenarios by:

- increasing cycling and pedestrian infrastructure to provide safer travel and crossings;
- reducing opportunities for collisions with vehicles as VKT decrease; and
- increasing the "safety in numbers" effect from a greater prevalence of pedestrians and cyclists on roads.[137]

The table below shows that the NZ Scenarios result in 2,140 more kilometers of cycling/multi-use trails and 108 more kilometers of sidewalks compared to the Do Nothing Scenario.

Table 27. Kilometers of cycling lanes and sidewalks added by scenario, 2020-2050.

	DO NOTHING	BAP	NZ50	NZ40	ALL SCENARIOS
Cycling lane kilometers added					
Kilometers of cycling/multi-use paths added (2020-2050)	-	**1,200**	**2,140**	**2,140**	
Kilometers of sidewalks added					
Kilometers of sidewalks added (2020-2050)	-	**90**	**108**	**108**	

11. Implementation

This section provides key insights for the City as it begins implementing its Net Zero Strategy. These insights have been used in the development of the Net Zero Strategy, which details the City's key implementation actions and targets over the next decade.

137 Fyhri, A., Sundfør, H., Bjørnskau, T., & Laureshyn, A. (2017). Safety in numbers for cyclists—conclusions from a multidisciplinary study of seasonal change in interplay and conflicts. Accident Analysis & Prevention, 105, 124–133. https://doi.org/10.1016/j.aap.2016.04.039

11.1 THE QUESTION OF FEASIBILITY

The City has posed the question as to whether or not achieving net zero by 2040 is feasible. Broadly speaking, feasibility is defined as whether something can be made, done, or achieved. The modelling demonstrates that there is a pathway for Toronto to achieve NZ40 in physical terms. The pathway also provides a number of insights with respect to feasibility:

1. **The pathway is technologically feasible:** The core of the actions evaluated rely on current technologies; in other words, there are no magic or untested solutions that contribute to the NZ40 pathway. Note that some emerging technologies are included, such as green hydrogen, but they are not critical to the pathway, and technological developments could speed up the pathway even more.

2. **The financial resources can be mobilized:** The investment required is approximately 5% of the City's GDP for a decade, or significantly less if the investments are amortized. In addition, many of these investments generate returns. The mechanisms for mobilizing these investments and which entity makes the investment will influence the timing and scale of funds that can be raised.

3. **Political will is required:** The implementation of the NZ40 pathway will require new and innovative policies which will disrupt the status quo. Given the lag time to develop and deliver policies, there is no time to delay.

4. **The grid needs to decarbonize:** The emissions intensity of the provincial electricity grid is currently projected to increase. For the city to get to zero, the grid needs to become clean by 2040. Failing this, the city can rely on the "net" part of the target and purchase carbon offsets or renewable energy certificates, both of which add to the costs of the pathway and deliver limited co-benefits.

There are other conditions that will need to be satisfied in order to implement the NZ40 pathway:

1. **Action must begin now:** The NZ40 pathway requires ambitious action to begin as early as 2021. Swift action not only allows financial benefits to accrue sooner and results in fewer GHG emissions released in the long run, but also sets the stage for ambition to ramp up as the target year approaches and for the City to ultimately meet it by 2040.

2. **The electricity system needs to be adapted:** In addition to decarbonizing the grid, the electricity system needs to be able to adapt to new loads as heating and transportation are electrified. At a high level, the NZ40 scenario mitigates

this challenge by emphasizing efficiency first to minimise the increase in annual electricity consumption; however, hourly peaks will vary.

3. **The labour market must shift:** The skills mix and capacity of the labour force will need to scale up rapidly in order to deliver the actions in NZ40.

4. **New and innovative delivery mechanisms must be adopted:** Conventional delivery mechanisms are likely too slow and costly to deliver the transformation envisioned in NZ40. For example, the model of delivering retrofits one house at a time will need to be replaced by a bulk retrofit program.

5. **Impacts on material and land resources should be accounted for:** The economy will need to produce large numbers of electric vehicles and deliver building retrofits and renewable energy in short order. In addition to supplying or manufacturing these resources, there are also material requirements for concrete, wood, insulation, batteries, and land. The environmental, social, and economic implications will need to be carefully considered to ensure that there is not a negative feedback that stimulates additional GHG emissions.

11.2 A CARBON BUDGET FOR THE CITY OF TORONTO

The historical practice of carbon management has been to identify GHG emissions reduction targets for specific years, such as targets set for 2030 and 2050. The more recent emerging paradigm, however, indicates that every tonne of GHG matters and, therefore, the trajectory of GHG emissions, not just the end point, must be managed. The City of Toronto's Climate Emergency Declaration (2019.MM10.3) also includes direction to investigate and report back on the feasibility of creating a carbon budget for the City of Toronto to aid in the implementation of TransformTO.[138]

A carbon budget provides a theoretical limit to the total GHG emissions that a community or organization can produce; the budget is directly aligned with the remaining global carbon budget for 1.5°C of warming. Governments and cities around the world, such as the United Kingdom, the City of Oslo, and several Canadian cities, are implementing self-imposed carbon budgets.

138 Declaring a Climate Emergency and Accelerating Toronto's Climate Action Plan. MM10.3. October 2, 2019. Retrieved from: http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2019.MM10.3

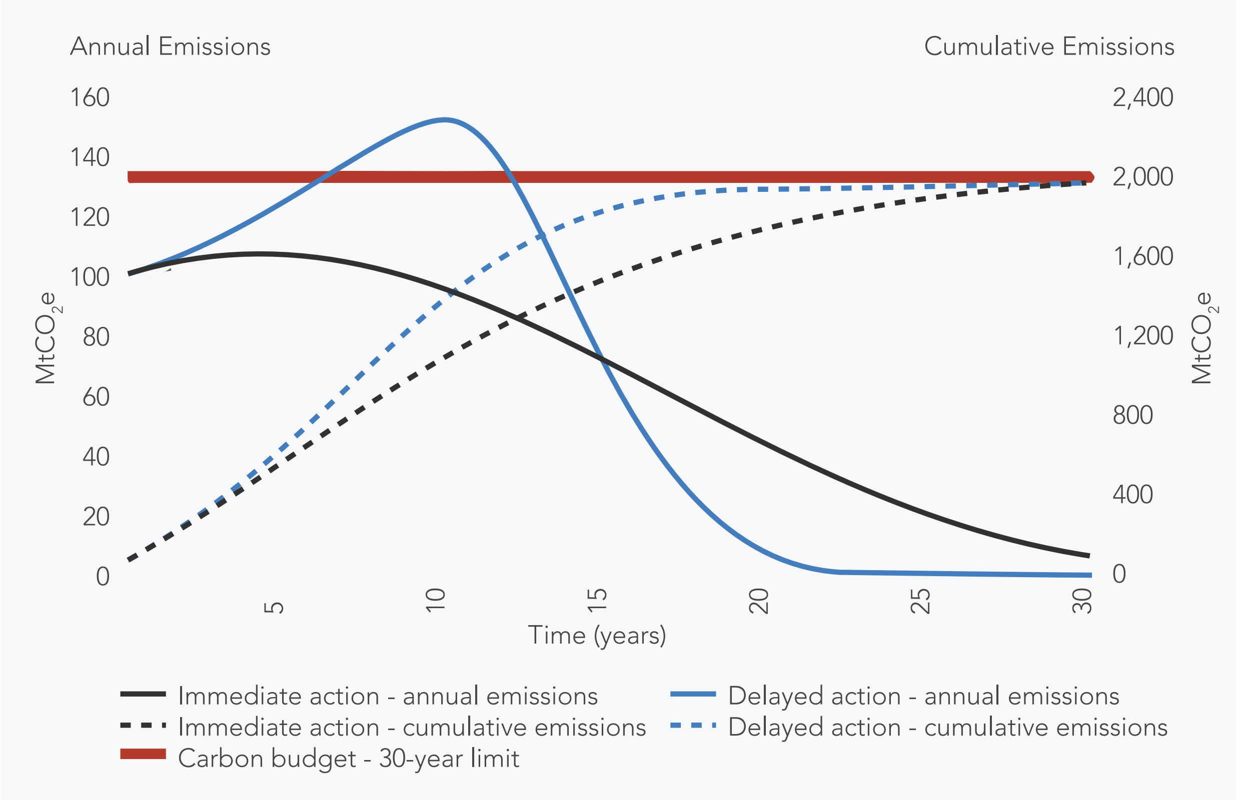

Figure 67. Hypothetical illustration for delayed versus immediate GHG mitigation reductions towards meeting a carbon budget.

Figure 67 demonstrates how a carbon budget can act as a key climate action planning tool. Both pathways result in the same cumulative emissions over the 30-year period; however, by year 15, the delayed action pathway has spent 90% of the carbon budget compared to only 70% for the pathway with immediate action. The delayed mitigation scenario results in GHG emissions continuing to grow until they peak around Year 11, at which time steep reductions are required to stay within the carbon budget. The scenario with significant immediate mitigation action, on the other hand, results in a more gradual transition.

TORONTO'S CARBON BUDGET

While Council has set 1.5°C-aligned targets and directed for the investigation into a similarly aligned carbon budget, the City of Toronto has not yet quantified a carbon budget for itself.

There are different methods for quantifying local and global carbon budgets and there is not yet consensus on a single one that should be used. There is consensus, however, that there is a finite amount of GHG emissions that can be released into the atmosphere to avoid catastrophic climate change, and, as discussed above, a carbon budget allows for accountability and transparency in efforts to reach net zero emissions. The NZ40 scenario results in 178 $MtCO_2e$, which can be used as a proxy for the city's carbon budget. At 2019 levels of emissions, this total would be exceeded in

12 years. The total remaining consumption of gasoline and natural gas ("gasoline and natural gas budgets") can also be quantified in the NZ40 scenario. Remaining natural gas and gasoline equals less than 9 years of consumption of gasoline and natural gas at current rates.

Table 28. Carbon and energy budgets.

BUDGETS (2021-2050)	TOTAL CUMULATIVE EMISSIONS	NUMBER OF YEARS LEFT AT CURRENT RATES	NATURAL GAS	GASOLINE
Do Nothing	442 $MtCO_2e$		4.01 billion GJ	1,616 million GJ
Business as Planned	364 $MtCO_2e$		3.50 billion GJ	972 million GJ
Carbon (NZ50 scenario)	224 $MtCO_2e$		1.49 billion GJ	856 million GJ
Carbon (NZ40 scenario)	178 $MtCO_2e$	12.5	1.15 billion GJ	520 million GJ
Remaining natural gas	1.15 billion GJ	8.3		
Remaining gasoline	520 million GJ	8.8		

11.3 INTEGRATING CLIMATE RESILIENCE

The City's 2019 Resilience Strategy recommended that future TransformTO updates bring together climate mitigation and adaptation more systematically to maximize efficiencies and cost effectiveness. Climate resilience is often used interchangeably with adaptation; however, the City's framework views climate resilience as a state, ability, or capacity to anticipate, reduce, accommodate, or recover from the effects of climate-related events, stresses, and acute shocks. Adaptation is the process by which the City can build climate resilience.

Climate adaptation and mitigation are inherently integrated in the sense that mitigation efforts to reduce emissions will help moderate climate impacts now and into the future. As such, investing in mitigation today lowers the costs and extent of adaptation and resilience in the future. Immediate and near-term policy decisions will determine the level of climate risk that the City of Toronto and jurisdictions around the globe will be exposed to. Similarly, planning and investing in adaptation action now will reduce further impacts and costs as the City's climate changes.

The City can integrate climate mitigation and adaptation efforts and investments to maximize effectiveness and minimize overall risks. There are four types of adaptation-mitigation interactions:

1. **Mal-investments:** Actions that can be undone or are made less effective by the impacts of climate change if they do not create sufficient resilience (e.g., building new infrastructure in an area prone to flooding).
2. **Trade-offs:** Actions with conflicting effects on mitigation and adaptation (e.g., diesel back-up power or increased air-conditioning units).
3. **Piggybacking:** Actions that are complementary when designed and implemented together (e.g., adding adaptation measures to a mitigation initiative).
4. **Synergies:** Actions that reduce both GHG emissions and climate risk (e.g., investments in new and enhanced green or natural infrastructure).

There are many opportunities for linking the City's Net Zero Strategy and the Resiliency Strategy, including investments in green infrastructure and resilient local energy systems. For example, diversified community energy planning not only reduces GHG emissions, it can also reduce the risk of system failure during extreme storm events.

Toronto's Resilience Strategy recommendations should be integrated into the planning and implementation of its Net Zero Strategy as follows:

1. **Neighbourhood resilience, community energy systems, and energy efficiency:** Develop a bottom-up community resilience approach to enhance and build the capacity of communities to become more resilient to climate impacts and more energy efficient. This approach should include an equity lens that identifies the City's most climate-vulnerable neighbourhoods.
2. **Emergency management and infrastructure planning:** Emergency management and risk reduction strategies should be implemented into infrastructure planning during the implementation of new climate mitigation actions.
3. **Climate resilience and retrofitting initiatives:** Integrate climate resilience into ongoing building and tower retrofitting by including resilience to heat, flooding, and extreme events as core components of retrofit objectives.
4. **Critical infrastructure risk and vulnerability:** The city depends upon a complex network of urban infrastructure, including energy, telecommunications, transportation, water supply, wastewater treatment, solid waste management, buildings, and food systems. This complex network will be transformed as the City implements the Net

Zero Strategy. At the same time, investment will be required to ensure that these networks can withstand the impacts of the growing frequency of extreme climate events, as well as the impacts of longer-term climate change.

5. **Codes and standards:** Update existing codes and standards for buildings and infrastructure with climate mitigation and adaptation considerations. These updates can be based on the City of Toronto's Future Weather and Climate Drivers Study and the more recent Climate Atlas of Canada, which provides an updated and common set of future climate projections.

6. **Land-use planning:** Integrate climate mitigation actions, such as energy efficiency and active transportation, as well as actions to build climate resilience, such as restricting development in high-risk areas and enhancing natural land cover, into land-use planning policies and processes. Adapting land-use planning tools for climate mitigation and resilience is one of the most effective ways to enhance climate resilience and implement GHG reductions in the urban landscape.

7. **Asset management:** Integrate climate resilience and mitigation measures into the City's corporate-wide Asset Management Framework and Integrated Asset Management Plan to align with Ontario Regulation 588/17. This regulation requires that municipalities consider climate change in the development of asset management policies and planning.

8. **Climate mitigation and resilience lens for capital planning:** Develop and apply a comprehensive guideline for applying a climate lens for capital planning that demonstrates how to implement a climate mitigation and adaptation lens for all City capital projects. The lens could include spatial risk and vulnerability mapping, climate resilience design considerations, equitable distribution of infrastructure, and full lifecycle assessment for GHGs and costs.

9. **Green and blue infrastructure city-wide strategy for climate mitigation and resilience:** Develop a coordinated and comprehensive city-wide strategy that builds on current City efforts and plans to significantly expand green and blue infrastructure. Green and blue infrastructure play a significant role in reducing heat and flooding impacts by increasing infiltration, reducing runoff, reducing the heat island effect, and providing shading. They also contribute other social and environmental benefits, such as improved air and water quality, space for recreation, physical activity and social interaction, reduced noise pollution, reduced energy demand for cooling, and habitat for biodiversity, beauty, and in some cases food. Significant expansion of green and blue infrastructure is needed to address heat and flooding, as well as outdoor spaces for the City's growing population.

10. **Indigenous knowledge:** Integrate Indigenous knowledge systems and collaborate with Indigenous peoples to ensure diverse perspectives and approaches are included in climate action planning.

In 2010, the City developed the Toronto Climate Change Risk Assessment Tool to prioritize actions across the City's divisions with a consistent and robust approach. This was followed by a streamlined version used by the City for a High-Level Risk Assessment exercise undertaken in 2016. According to the City's Resilience Strategy, this process was successful in identifying a preliminary list of risk reduction activities. The Strategy recommended the City undertake a more detailed spatial risk and vulnerability assessment that would include an interdependencies analysis for critical infrastructure systems. This would ideally be undertaken as soon as possible so it can be integrated into the implementation of the Net Zero Strategy actions. For example, Table 29 provides a preliminary list of potential considerations and actions for the NZ40 scenario actions.

Table 29. Examples of climate resilience considerations for NZ40 scenario actions

WEDGE	WEDGE DESCRIPTION	CLIMATE RESILIENCE ACTIONS AND CONSIDERATIONS
Buildings- residential		
Decrease size of new dwellings	30% increase in floorspace intensity from 2016 by 2040 (for all new dwellings).	Integrate climate resilience into policies, codes, and standards for new residential buildings. Integrate climate adaptation actions into land-use planning. Ensure that policies and codes for retrofits of existing buildings include measures for climate resilience based on the impacts of the changing climate.
High-performance new residential buildings	100% Tier 2 by 2021. 100% Tier 3 by 2022. 100% Tier 4 by 2027.	
Retrofit residential buildings by 2040	Retrofit 100% of existing buildings by 2040. Savings of 15% electricity and 75% thermal energy consumption.	
Residential heat pumps by 2040	Convert 100% of residential water and space heating to heat pumps by 2040.	Appliances and water and space heating should be located in low-risk areas within buildings.
Electrify residential appliances by 2040	Phase out residential natural gas appliances by 2040.	

WEDGE	WEDGE DESCRIPTION	CLIMATE RESILIENCE ACTIONS AND CONSIDERATIONS
Buildings- industrial		
New industrial buildings improved performance	Industrial new build energy intensity reduction (45% from base year) reached by 2031 and applies to lighting, space heating, and water heating end uses.	New industrial buildings should be located in low-risk areas. Retrofits and new building performance standards should include climate adaptation and resilience measures.
Industrial building retrofits	Retrofit all industrial buildings by 2040 to achieve 50% reduction of industrial energy use intensities for lighting and space and water heating end uses.	
Hydrogen for process heating by 2040	Reduce natural gas consumption by 30% by 2030 and 60% by 2050. Convert 100% of remaining natural gas for process heat to hydrogen by 2040. Capture 90% of waste heat from industry.	
Buildings- commercial		
Decreased office space per employee	Reduced office floorspace per employee by a "mobility factor" of 1.7 (i.e., 20 people per 12 desks), then allocated new commercial floorspace along lines of employment projection. Results in reduced growth in commercial/office floorspace (for new office).	New commercial buildings should be located in low-risk areas. Retrofits and new building performance standards should include climate adaptation and resilience measures.
High performance new commercial buildings	100% Tier 2 by 2021. 100% Tier 3 by 2022. 100% Tier 4 by 2027.	

WEDGE	WEDGE DESCRIPTION	CLIMATE RESILIENCE ACTIONS AND CONSIDERATIONS
Retrofit non-residential buildings by 2050	Retrofit 100% of existing buildings by 2040. Electricity consumption decreases by 15% while thermal energy consumption decreases by 75% compared to 2016 performance.	
Non-residential heat pumps by 2040	100% electric heat pumps for space and water heating in non-residential buildings by 2040.	
Energy		
District energy	All DE systems are 100% renewable by 2030—natural gas and electric cooling are replaced by RNG and cold water. All of the City's currently planned DE expansions are installed.	District energy systems should incorporate redundancy so they can continue to operate in the event of grid disruptions.
Renewable energy	Wind capacity scaled up to 200 MW by 2050. Onsite battery storage scaled up to 2000 MW by 2050. Ground mount PV on 50% of parking lots. 100% of buildings have solar PV installed by 2050, where feasible.	Energy storage should be integrated with renewable energy generation to provide localised resilient grids.
Transportation		
Electrify transit by 2040	50% of fleet electric by 2030; 100% by 2040. 100% electrification of GO by 2025.	Develop and apply a climate lens for capital planning that includes spatial risk and vulnerability mapping, climate resilience design considerations, equitable distribution of

WEDGE	WEDGE DESCRIPTION	CLIMATE RESILIENCE ACTIONS AND CONSIDERATIONS
City fleet 45% electric by 2030	Transition 45% of City-owned fleet to low-carbon vehicles by 2030; 65% GHG reduction by 2030 (from 1990 levels).	infrastructure investments that prioritize climate-vulnerable populations, and full lifecycle assessment for GHGs and costs. Develop a bottom-up community resilience approach to enhance and build the capacity of communities to become more resilient to climate impacts and more energy efficient. This approach should include an equity lens that identifies the City's most climate-vulnerable neighbourhoods. Integrate climate mitigation actions, such as energy efficiency and active transportation, as well as actions to build climate resilience, such as restricting development in high-risk areas and enhancing natural land cover, into land-use planning policies and processes. Ensure climate risk and vulnerability assessment is integrated into transportation policies, GHG mitigation, and planning.
Electrify personal vehicles by 2040	Electrify 100% of personal vehicles by 2040.	
Electrify commercial vehicles by 2040	Electrify 100% of commercial vehicles by 2040.	
Increased bus lanes and service frequency	Convert one lane of traffic to exclusive bus lanes on all arterials. Increase service frequency on all transit routes: bus by 70%, streetcar by 50%, subway off-peak service increased to every 3 mins.	
Road tolls	Tolls of $0.66/km on all arterial roads.	
Free transit	No transit fares.	
Work from home	50% of professional/management/technical and general office/clerical workers in the GTHA work from home on any given day.	
E-bikes	Shift 75% of car and transit trips under 5km to ebikes by 2040.	
Increase walking and cycling	Shift 75% of trips under 2km to walking by 2040.	

WEDGE	WEDGE DESCRIPTION	CLIMATE RESILIENCE ACTIONS AND CONSIDERATIONS
Biofuels city fleet	In 2025, begin purchasing renewable diesel for diesel vehicles and equipment (30% renewable diesel for city fleet).	
Biofuel aviation	Aviation runs on 100% low emissions fuels by 2040.	
Biofuel rail	Rail runs on 100% biofuel by 2040.	
Waste/water/ wastewater		
Increase efficiency of water pumps	Increase efficiency of water distribution pumps.	Emergency management and risk reduction strategies should be integrated into infrastructure planning during the implementation of new climate mitigation actions. Ensure climate risk and vulnerability assessment is integrated into waste, water, and wastewater management.
Waste diversion Zero by 2050	Increase waste diversion rates beyond the 70% by 2026 target to 95% by 2040.	
Ban landfill organics	Zero organics in landfills by 2025.	
Nature-based solutions/ carbon sequestration		
Increase tree canopy cover	Increase city-wide tree canopy cover to 40% by 2040.	Develop a coordinated and comprehensive city-wide strategy to significantly expand green and blue infrastructure that builds on current City efforts and plans.

11.4 THE COST OF INACTION

The impacts and costs of climate change will be determined by how quickly actions are implemented and by how deeply GHG emissions are reduced over the next few years prior to 2030. This is because the cumulative GHGs emitted to the atmosphere determine the degree of global average temperature increase. Over the past several decades, the cost of inaction to address climate change by limiting and reducing GHG emissions has now locked the world into at least a 1.5–2.0°C temperature increase.

Already, the costs of weather-related disasters, such as floods, storms, and wildfires, have risen in Canada from an average of $8.3 million per event in the 1970s to $112 million per event between 2010-2019. This change represents a staggering 1,250% increase.[139] During the latter time period (2010-2019), total insured losses for catastrophic weather events totalled over $18 billion.

Climate change is driving more extreme weather patterns, resulting in more frequent and more expensive impacts than previous decades. For example, in the last decade, disaster costs have grown from about the equivalent of 1% of Canada's gross domestic product (GDP) growth to between 5%–6% of annual GDP growth.[140]

These costs demonstrate some of the impacts that previous decades of inaction are now placing on economic growth and well-being today and into the future.

The cumulative cost of the Do Nothing Scenario between 2020 and 2050 is $94 billion based on the Social Cost of Carbon (SCC). In comparison, the SCC declines to $76 billion in the BAP scenario and to $35 billion in the NZ40 scenario, as illustrated in Figure 68.[141]

139 Canadian Institute for Climate Choices. 2020. Tip of the Iceberg: Navigating the Known and Unknown Costs of Climate Change for Canada. Retrieved from: https://climatechoices.ca/wp-content/uploads/2020/12/Tip-of-the-Iceberg-_-CoCC_-Institute_-Full.pdf

140 Ibid.

141 All values used the 3% discounting rate, 95th percentile which reflects higher than expected economic damages from climate change. Interagency Working Group on Social Cost of Greenhouse Gases, United States Government (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

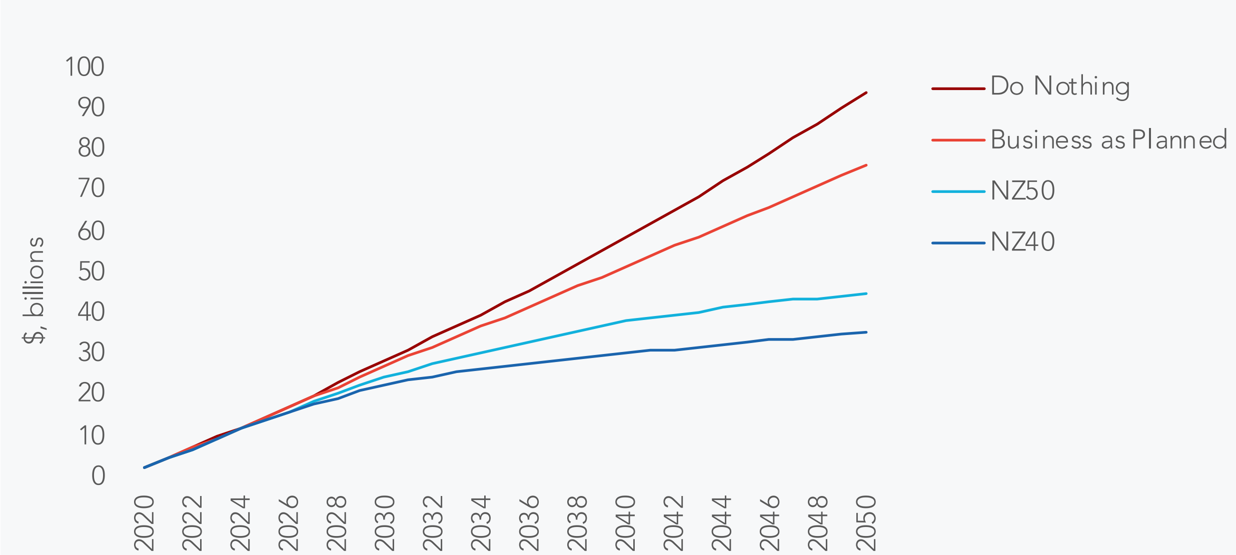

Figure 68. The Social Cost of Carbon (SCC) for all four scenarios, 2020-2050.

The cumulative financial benefits of implementing the NZ40 scenario, with regard to the avoided damage costs of climate change, total $41 billion compared to the BAP scenario. And, the cumulative benefits of implementing the NZ40 scenario rather than the NZ50 scenario result in savings of $9 billion in avoided damage costs (Figure 69).

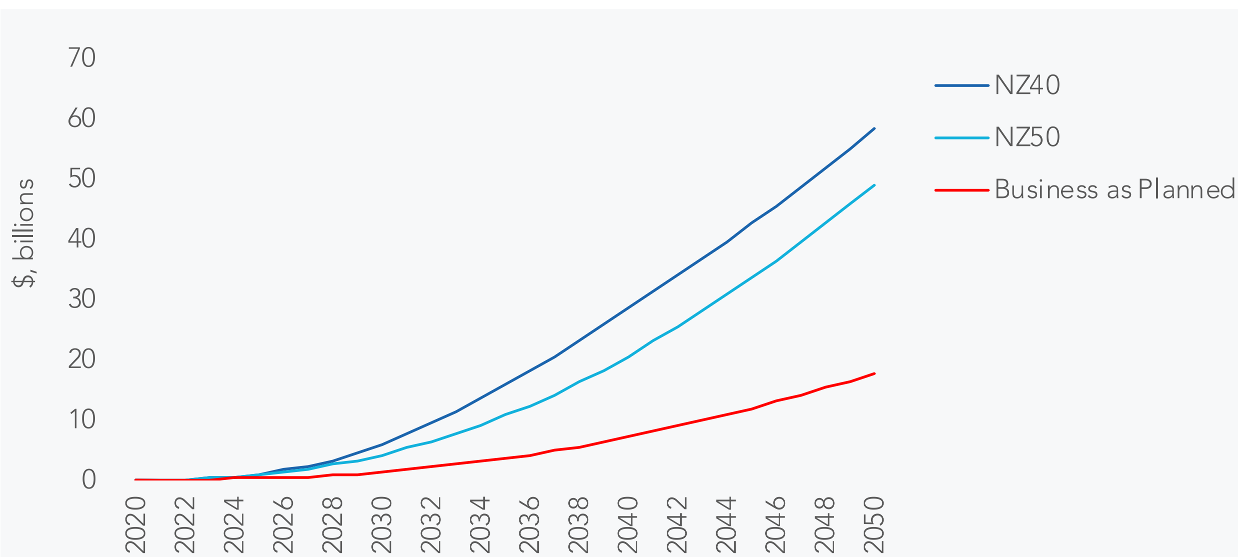

Figure 69. Cumulative benefit of Social Cost of Carbon (SCC), as an indicator of avoided damages of climate change for BAP, NZ40, and NZ50.

THE SOCIAL COST OF CARBON

The social cost of carbon (SCC) has been used in regulatory processes in Canada and the US to reflect the impacts of climate change on society. The SCC attempts to add up the quantifiable costs and benefits of a tonne of carbon dioxide. While the estimates of SCC are highly uncertain, it is one of the best ways to reflect future damages to ensure that decision-making that has implications for future emissions accounts for those implications. The SCC includes assumptions around future conditions, including population size, economic growth, rate of climate change, and the impact of climate change on those conditions, drawing on the results of integrated assessment models. The discount rate is a significant assumption within the models. Discounting reflects the idea that people would rather have $100 now than $100 in ten years. From an ethical perspective, a higher discount rate indicates that future generations are worth less than current generations; for this reason, the Stern Review recommended a discount rate of 1.4%, well below traditional discount rates. As Stern pointed out in a subsequent article "A 2% pure-time discount rate means that the life of someone born 35 years from now (with given consumption patterns) is deemed half as valuable as that of someone born now (with the same patterns)." The Government of Canada recommends 3% in circumstances where environmental and human health impacts are involved and 3% was used for Toronto's NZ modelling. In addition, the Government of Canada reports on estimated damage associated with lower probability, high-cost damages, again using a 3% discounting rate. The SCC in this analysis reflects less likely impacts of increased temperatures that result in greater damage, as described within the 95th percentile of the SCC frequency distribution

11.5 SENSITIVITY

The NZ pathways illustrate how the City of Toronto could achieve its GHG targets, and are built on the assumptions described above in this report. In that light, they reflect what is anticipated to occur in the future if the actions are implemented as described.

Sensitivity analysis involves adjusting certain selected variables within the model in order to identify those that have the most significant impact on the model outcomes. It is not a process of "scenario analysis," as the variables tested do not represent internally consistent scenarios. The approach to sensitivity analysis is to adjust those variables that were identified as having a higher potential to "move the curve," (i.e., the factors that appear to be contributing significantly to the NZ scenarios), in order to be better informed about the implications of future options.

The process applied a judgement-based "one-at-a-time" exploration of variables within the NZ50 scenario. The results should not be viewed as an evaluation of fully considered alternative futures. Rather, it is an exploration revealing how a selected output (i.e. emissions) responds to changes in selected inputs (e.g. VKT).

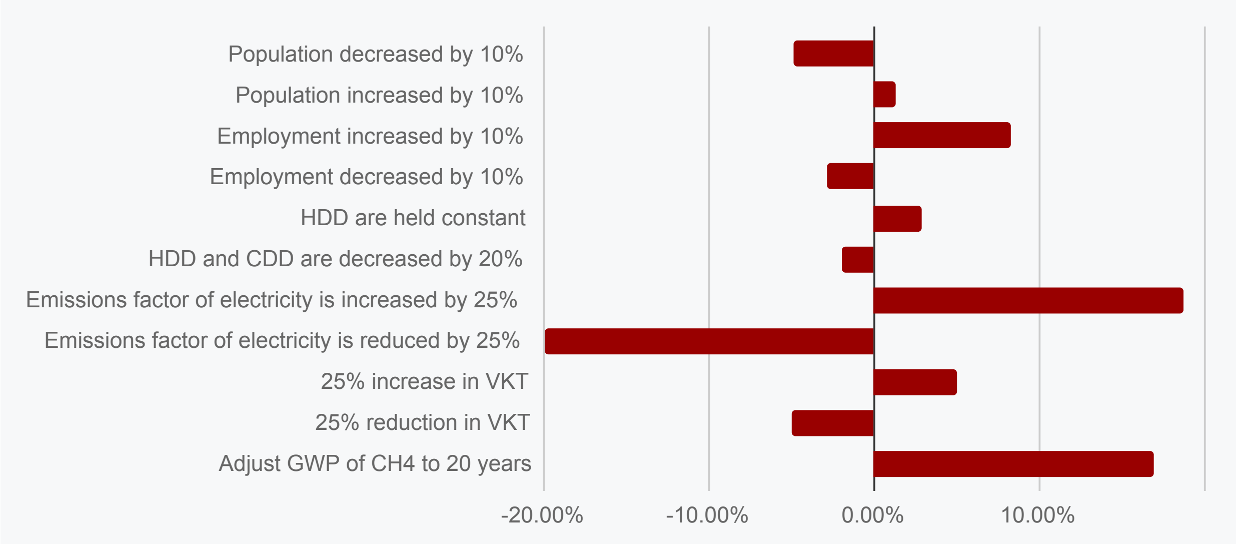

Figure 70. Percent change in 2050 emissions as a result of adjustments to the variables.

Applying a GWP to methane for 20 years instead of 100 years increases total GHG emissions by more than 1 $MtCO_2e$ per year, while decreasing the emissions factor of electricity reduces emissions by 400 $kTCO_2e$ by 2050. Variation in the emissions factor of electricity defines the outer limits of the variation evaluated, resulting in an overall uncertainty of 37 $MtCO_2e$, or 15% of the cumulative 241 $MtCO_2e$ emissions under the NZ50 pathway.

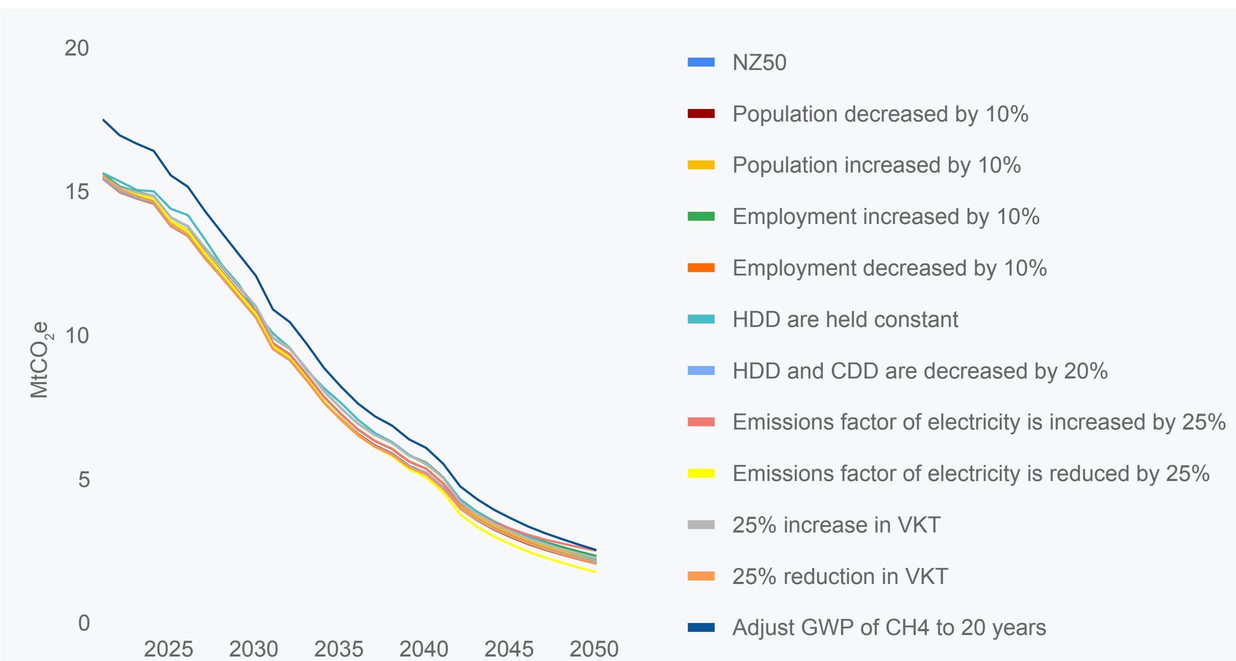

Figure 71. Impact on the NZ40 pathway of adjusting each of the key variables.

Based on this investigation the pathway is sensitive to methane emissions, particularly if a 20 year GWP is applied. The emissions factor of electricity is also critical to accelerating the reduction in GHG emissions, which follows from the electrification of heating and transportation.

12. Conclusion: Time is of the Essence

"We basically have three choices: mitigation, adaptation, and suffering. We're going to do some of each. The question is what the mix is going to be. The more mitigation we do, the less adaptation will be required and the less suffering there will be."

John Holdren, Professor of Environmental Policy and former Director of the White House Office of Science and Technology Policy

In May 2021, the International Energy Agency (IEA) released a milestone report titled **Net Zero by 2050**.[142] Globally the IEA found that the path to net-zero is narrow, requiring the massive deployment of all available clean energy technologies, including renewables, EVs, and energy efficiency building retrofits between now and 2030. IEA's key findings echo those of the TransformTO analysis, notably: the net zero pathway can bring jobs and growth; huge leaps are needed in clean energy innovation and a rapid shift away from fossil fuels; electricity becomes the core of the energy system; and new low-emissions industries flourish. Similar to the IEA, the Technical Report describes a pathway to completely transform the energy system.

142 IEA (2021). Net Zero by 2050. Retrieved from: https://www.iea.org/reports/net-zero-by-2050

As a viable pathway to substantively address climate change, TransformTO is a beacon of hope. The urgency to act on climate change grows every day, and the technologies and processes required to decarbonize become more accessible and affordable. Decarbonizing sooner rather than later is compelling in order to maximize societal benefits that include reducing GHG emissions more quickly, delivering health benefits, enhancing resilience, enabling a green recovery from COVID, and improving quality of life. From this perspective, delay constitutes forfeited opportunities.

Every new investment that advances decarbonization of the energy system is additional infrastructure that doesn't need to be retrofitted down the road, decreasing the cost of transformation. Investments in fossil fuel equipment, on the other hand, are likely to become stranded assets, resulting in financial and social liabilities that will be prematurely replaced in order to limit climate change.

The NZ pathways modelled in this analysis reduce household transportation and energy costs, which, depending on how these actions are implemented, can benefit lower-income households. In particular, the expanded and free transit modelling in the NZ pathways advances equity objectives by improving accessibility.

The financial industry will play a key role in enabling the NZ scenarios, first by avoiding investments that result in increased emissions and second by facilitating access to capital for emissions reduction investments. Given access to capital, governments and other organizations will need to coordinate their efforts in order to mobilize the workforce that can rapidly deliver retrofits, renewable energy, and related actions.

The net zero scenarios represent a transformation of the energy system and the built environment, which will require a coordinated mobilization of the City and society at large for which there are few precedents. This analysis demonstrates that the technology is available, the financials are viable, and the broader societal benefits are extensive. The pathway to net zero by 2040 has no downsides for the current and, in particular, future generations of the residents of Toronto, and of the world.