Canada: The case for an urban green and just recovery

Technical report April 2021

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This report has been produced by the C40 Cities Climate Leadership Group, with support from a number of organisations.

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Glossary

Green Recovery
A modelled scenario in which COVID-19 recovery stimulus funding supports expenditure on climate action that prioritises the rapid creation of jobs and ensures that cities are on track to limit global warming to 1.5°C.

Business as usual (BAU)
A modelled scenario that projects current levels of climate action into the future based on urban population growth. It does not take into account potential advances in technology or changes in policy, nor does it account for any policy change as a result of stimulus funding. In effect, it is a pre-COVID-19 BAU scenario.

Slow Green Recovery
A modelled Green Recovery scenario in which capital stimulus funds are spent more slowly and any associated climate actions (and impacts of those actions) occur over the next 15 years, to the end 2035.

Building retrofits
Advanced upgrades of building wall, roof and window-system technologies.

Canadian model cities:
The results of this analysis are based on two types of Canadian model city, which are identical except for the composition of the electricity grid in 2020, the starting point of the analysis. One model city has a low-carbon grid in 2020, while the other model city has a carbon-intensive grid in 2020. The two models are to account for the fact that sources of electricity currently vary significantly between Canadian provinces. Throughout the report, they will be referred to as the lower-carbon city and the higher-carbon city.

Carbon budget (or GHG budget)
The total quantity of greenhouse gas (GHG) emissions that can be emitted over a fixed period of time, determined by the probability of avoiding a specific global average temperature increase.

Cardiovascular disease
Disease related to the heart and circulatory system, including stroke and problems with arteries or veins in other parts of the body.

Concentration response function
The quantitative relationship between the concentration of a pollutant and the increased risk of an effect on health (in this case, mortality and morbidity).

Deadline 2020
Commitment from the world's leading cities to implement climate actions that deliver on the objectives of the Paris Agreement by limiting an increase in global average temperatures to 1.5°C.

Jobs multiplier (or employment multiplier)
The number of jobs created per CAD 1 million of expenditure or per CAD 1 million spent on final product.

Job year
One full-time job for one year. Five job years can be made up of five different jobs, each lasting one year, or one job, lasting five years.

Life expectancy at birth
Average number of years a newborn could be expected to live if he or she were to pass through life subject to the age-specific mortality rates of a given period.

Nitrogen oxides (NO_x)
Poisonous gases that stem mainly from transport emissions and other combustion processes, such as electricity generation.

Pathways tool
The Pathways Tool is a customisation of the World Bank's Climate Action for Urban Sustainability (CURB) tool, which assesses the impact of climate mitigation strategies in the context of C40 cities and generates the outputs needed to inform the Climate Action Planning process. In practical terms, the tool allows the user to set the penetration levels of climate actions across a number of key sectors.

Particulate matter ($PM_{2.5}$)
Particulate matter (PM) is the mixture of solid particles and liquid droplets in the air. $PM_{2.5}$ is the mass concentration per cubic metre (m^3) of air particles with a diameter of less than 2.5 micrometres (μm). Often called 'fine particulate matter', they can penetrate deep into the lungs.

Total jobs
The number of full-time jobs available in a given year. For example, five job years in one year equal five total jobs; five job years over five years equal one total job.

Value of statistical life (VSL)
The benefit of preventing a fatality, defined as the additional cost that individuals would be willing to bear for improvements in safety or reductions in risk that reduce the expected number of fatalities by one.

Years lived with disability (YLD)
The burden of living with a disease or disability in terms of number of years.

Acronyms and abbreviations

AFOLU	Agriculture, forestry and other land use
BAU	Business as usual
CAD	Canadian dollar
CAP	Climate Action Planning
Capex	Capital expenditure
CDC	Centers for Disease Control and Prevention
COVID-19	Coronavirus Disease 2019
CURB	Climate Action for Urban Sustainability tool (World Bank)
EV	Electric vehicle
GDP	Gross domestic product
GHG	Greenhouse gas
ICE	Internal combustion engine
IEA	International Energy Agency
IPPU	Industrial processes and product use
NBS	Nature-based solutions
NO_x	Nitrogen oxides
O&M	Operating and maintenance
PM	Particulate matter
PV	Photovoltaic
R&D	Research and development
VSL	Value of statistical life
WHO	World Health Organization
U.S.	United States of America
USD	United States dollar

Introduction

C40 has analysed and modelled what could happen if Canada's major cities collectively prioritised a green and just recovery consistent with limiting global heating to less than 1.5° Celsius. A recovery based on the principles of a Global Green New Deal would see COVID-19 stimulus funds channelled to expenditure in key areas, such as building retrofits, mass transit, walking and cycling infrastructure and clean energy.

Such a green recovery approach would have transformational economic and health benefits for Canadian cities and put Canada on track to keep global heating to less than 1.5°C compared with a business-as-usual (BAU) scenario.

Key modelling conclusions

- A green and just recovery could see a **two-thirds reduction in greenhouse gas emissions by 2030** compared with BAU, making it possible to deliver on efforts to keep the global temperature rise to less than 1.5°C.

- A return to BAU would lock in over-heating of more than 1.5°C.

- A green and just recovery could create and support more than **2.9 million good, sustainable jobs by 2030** across a dozen major Canadian cities and their supply chains, more than 2.5 times the number of jobs that would be created and supported by BAU.

- A green and just recovery could **reduce air pollution by as much as 32%** in major Canadian cities over the next 10 years compared with a return to BAU. Such improvements could **prevent up to 3,950 premature deaths over the next decade**.

- An increase in active mobility, due to a shift away from car trips to active modes of transport, such as walking and cycling, could **prevent up to 2,200 premature deaths over the next decade**. Such increases in active mobility could **increase the life expectancy of commuters by up to 3.6 months** and **reduce the risk of diseases such as stroke and coronary heart disease by 12%**.

- Across major Canadian cities, the economic value of premature deaths avoided by a reduction in air pollution would be **CAD 24 billion,** while for increased active mobility it would be **CAD 13 billion**, based on the value of statistical life (VSL).

The timing of the recovery is key. By modelling the impacts of rapid stimulus spending, enabling a Green Recovery over the next 10 years compared with a Slow Green Recovery over the next 15 years, the case for early expenditure by nimble governments, including cities, is clear:

- A Green Recovery could create and support more than 2.9 million good, sustainable jobs by the end of 2030, across a dozen major Canadian cities and their supply chains, more than 1.35 times the jobs created in a Slow Green Recovery scenario.
- A Green Recovery could avert almost double (1.9 times) the number of premature deaths between 2020 and 2030 of a Slow Green Recovery, with associated economic benefits from reduced health costs.
- In Canadian cities with a lower-carbon grid, a Green Recovery could lead to 30% fewer per capita GHG emissions than a Slow Green Recovery, and fewer than 50% of the per capita BAU emissions by 2030.
- In Canadian cities with a higher-carbon grid, a Green Recovery could lead to 35% fewer per capita GHG emissions than a Slow Green Recovery and fewer than 40% of per capita BAU emissions by 2030.

The aim of the analysis

The goal of the analysis was to understand the multiple benefits of pursuing a green and just recovery between 2020 and 2030, with a specific focus on the potential to create jobs and improve health in Canadian cities while limiting warming to 1.5°C. We undertook the research in response to the COVID-19 stimulus packages being developed and deployed in Canada at the moment.

Unfortunately, most stimulus packages globally have failed to avail of this public expenditure opportunity to achieve long-term economic, environmental and social targets.[1] As of March 2021, the proportion of global COVID-19 stimulus classified as 'green' ranged from 2.5%[2] to 7%.[3] According to a recent report by the United Nations Environment Programme and Oxford University,[4] Canada's recovery package shows 'early promise', in terms of its size and the proportion of funding projected to be spent on a green recovery. However, Canada does not yet qualify as a leading nation when it comes to support for a green recovery. While Canada's national government is off to a good start, it could do more to build back better.

This C40 research shows that allocating more stimulus funding to a green and just recovery could help Canadian cities to reduce their emissions in line with a 1.5°C trajectory while being a good use of public funds.

A green recovery creates and supports many jobs and has a significant impact on emissions, thus improving urban health by significantly improving air quality and encouraging active mobility.

The report showcases how various recovery scenarios affect GHG emissions, health impacts and job creation. We examine a Green Recovery scenario and a Slow Green Recovery scenario and compare them with a BAU scenario.

- We modelled GHG emission reductions under the BAU and Green Recovery scenarios using the C40 Pathways Tool, which captures a range of climate actions and associated GHG emission reductions.

- To showcase potential job creation, we estimated the level of expenditure needed to deliver the Green Recovery scenario.[5] This was translated into job creation using employment multipliers from the current body of relevant literature and research.

- To illustrate how a Green Recovery could affect health, we modelled the impact on air quality ($PM_{2.5}$). These changes were translated into potential health impacts using concentration response functions from the current body of literature and research. We also modelled how a shift to more active modes of transport in major Canadian cities could lead to more walking and cycling as well as better health outcomes.

- To highlight how the timing of a Green Recovery would affect key indicators, we modelled a Green Recovery and a Slow Green Recovery scenario for capital expenditure (capex), whereby all capex would be spent by the end of 2025 and 2027, respectively. They would bring about associated climate actions to be implemented by the end of 2030 (Green Recovery) and 2035 (Slow Green Recovery). Here, we assumed that expenditure would have to precede the full implementation of a climate action, hence the time lag between expenditure and implementation. The Green Recovery and Slow Green Recovery scenarios are designed to provide a high-level illustration of the impact of timing on GHG emissions, health impacts and job creation.

The results presented in this report are based on two model cities that represent different types of Canadian city, depending on how carbon-intensive a city's grid was in 2020. The BAU and Green Recovery scenarios were created using these two model cities to provide illustrative results that reflect the variation in carbon intensity of electricity grids in Canada's provinces.

We have scaled up the results from these model cities to cover a dozen major Canadian cities, to give a sense of the potential GHG, health and job benefits across the country. This scaling exercise assumes a correlation between GHG emission reductions and job creation, as well as a similar relative reduction in air pollution for all cities in each province.

We say 'illustrative results' because the purpose of this analysis is not to show exactly how a green recovery will play out in a specific Canadian city. As Canadian cities do not have much time to react to proposed national stimulus packages, the C40 research team has modelled a number of scenarios they can use as order-of-magnitude benchmarks when evaluating them.[6] The idea is for policymakers to use the GHG emission, health impact and job-creation results of our analysis as a guide for decision-making. We believe it is highly important to provide policymakers with this evidence at this point in time, when large-scale funding decisions are being made that will affect Canada for decades, and when the climate risks associated with those decisions could not be higher.

In reality, because of the significant variations in city context, there will be variations in GHG emission, health impacts and job creation from city to city. The results, therefore, are an illustration of the potential benefits, not a precise estimate. Ideally, an analysis such as this would use local and provincial data for all of Canada's cities to estimate more accurately the individual 1.5°C emission trajectories, health impacts, associated expenditure and job-creation opportunities.

The models: BAU and the Green Recovery

- The **Green Recovery** is a scenario in which COVID-19 recovery stimulus funding supports expenditure on climate action that prioritises rapid job creation and ensures that Canadian cities are on track to limit global heating to 1.5°C. We modelled two variations of the Green Recovery scenario: (1) a **Green Recovery**, in which capital expenditure occurs over the next five years and climate action occurs from 2020 to 2030, and (2) a **Slow Green Recovery**, in which delayed capex causes climate action to occur more slowly, between 2020 and 2035. The purpose of these variations is to see how the timing of the stimulus funding impacts emissions, jobs and health.

When developing the Green Recovery scenarios for each of the two model cities, the level of climate action was set to ensure that the city aligned with its 1.5°C-compliant target trajectory. The scale of the climate actions was reviewed by a subject-matter expert for Canada to check that it was realistic, both overall and by sector. Having set the model city's trajectory in line with 1.5°C 2030 emissions targets, we estimated the level of expenditure needed and associated number of jobs created.

Further details on the climate actions that constitute the Green Recovery scenario are included in the appendix.

- The **BAU scenario** takes current levels of climate action and projects them into the future based on urban population growth. The BAU scenario in this analysis does not take into account GDP growth, potential advances in technology or policy changes. Importantly, it does not include any policy changes resulting from stimulus funding; in effect, it is a pre-COVID-19 BAU. While some individual BAU spending items (for example, on expanded transit networks) may help to reduce emissions, the overall effect is likely to be marginal compared with the amount of expenditure required to align with a 1.5°C trajectory.

GHG and air quality

- We have compared the reductions in GHG emissions and air pollution of a Green Recovery with those of a BAU scenario. This baseline is not entirely accurate, as stimulus funding will support either a greener or less green recovery and alter the BAU itself. However, for practical reasons to do with a lack of available data (the emissions future that the current stimulus package has set in motion is not yet fully visible in the data) and modelling limitations, we have compared GHG emissions and air-quality impacts against BAU.

Employment

- We have compared the Green Recovery employment with that of a BAU Recovery in a few places in this report. The purpose of this comparison is to show that jobs are also created under normal conditions as well, but that a Green Recovery can - through an increase in expenditure aimed at reducing emissions - boost job creation in Canadian cities. To evaluate different spending policies, we would ideally have liked to compare the Green Recovery employment impacts with actual and planned Canadian stimulus spending, but translating a broad stimulus package (that may still develop) into easily modelled data would require a range of assumptions on C40's part.

Therefore, rather than providing our interpretation of the carbon impacts of specific Canadian stimulus decisions, we have opted to just present the employment impact of a 1.5°C trajectory achieved under a Green Recovery scenario. In particular, we have explored how the timing of expenditure has a significant impact on GHG emissions, health impacts and job creation.

1. Results of the GHG analysis

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Lower-carbon and higher-carbon model cities

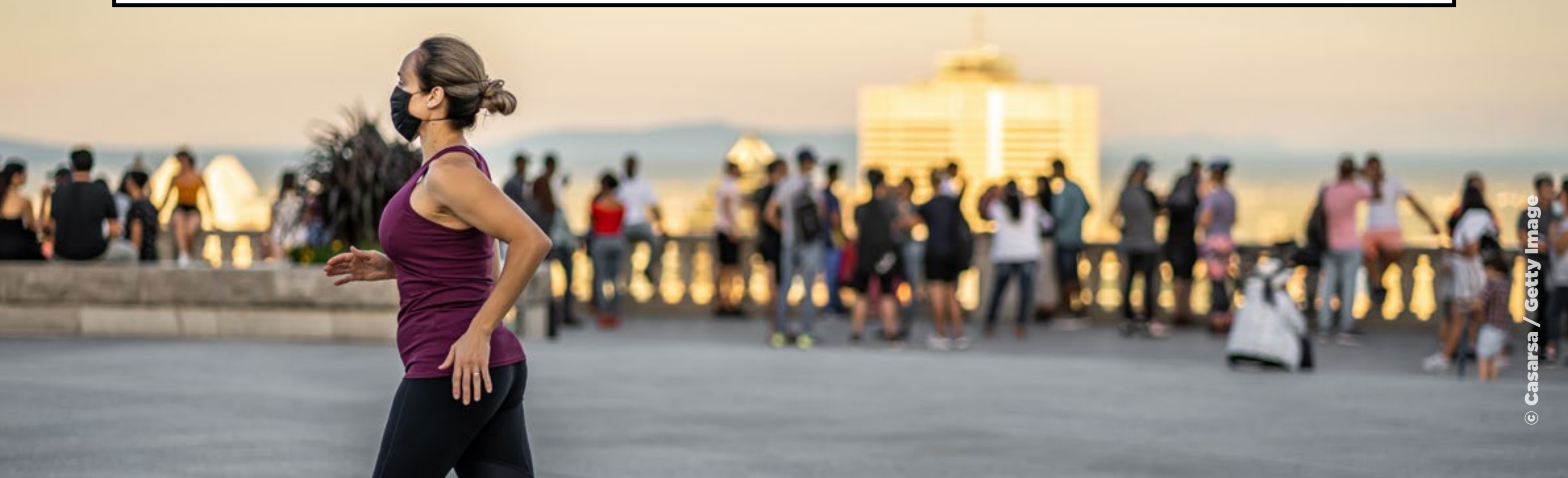
In our analysis, we have created two different types of Canadian city in order to understand the scale and ambition of climate action necessary to reduce emissions in line with a 1.5°C trajectory, as well as what the associated benefits would be if a city delivered that scale of climate action.

We created one lower-carbon and one higher-carbon model city for the purposes of our analysis. These model cities share identical characteristics in all sectors, apart from the carbon intensity of their electricity grids. In 2020, the lower-carbon model city starts out with a low-carbon electricity grid, while the higher-carbon city starts out with a high-carbon-intensity electricity grid.

Of course, cities within Canada's cities differ considerably when it comes to population density, public transport use, sources of electricity, age of building stock, energy sources for heating, and other important aspects, informing the type and scale of climate action they need. However, after analysing the urban emissions profiles of Canadian cities, it became clear that the carbon intensity of the respective provincial electricity grids had a particularly significant impact on urban emissions from city to city. For example, while clean hydroelectric power supplies nearly all of Quebec's electricity (Quebec's grid carbon intensity was 1.8g CO_2e/kWh in 2019), Ontario relies on a greater share of nuclear power and natural gas (Ontario's grid carbon intensity was 31g CO_2e/kWh in 2018)[7] and Alberta is heavily dependant on polluting fossil fuels, such as coal and natural gas (Alberta's grid carbon intensity was 694g CO_2e/kWh in 2019).[8] Therefore, this is the main differentiating variable we considered between the two model cities.

- The lower-carbon electricity model city is characterised by a relatively high population density (in a Canadian context), a high proportion of transport emissions and a clean electricity grid. The model city's per capita emissions in 2020 were at the lower end of the emissions spectrum compared with other major Canadian cities. This model city bears more of a resemblance (but is not identical) to Canadian cities such as Vancouver, Toronto or Montreal. We will refer to this city as the **lower-carbon city** throughout this report.

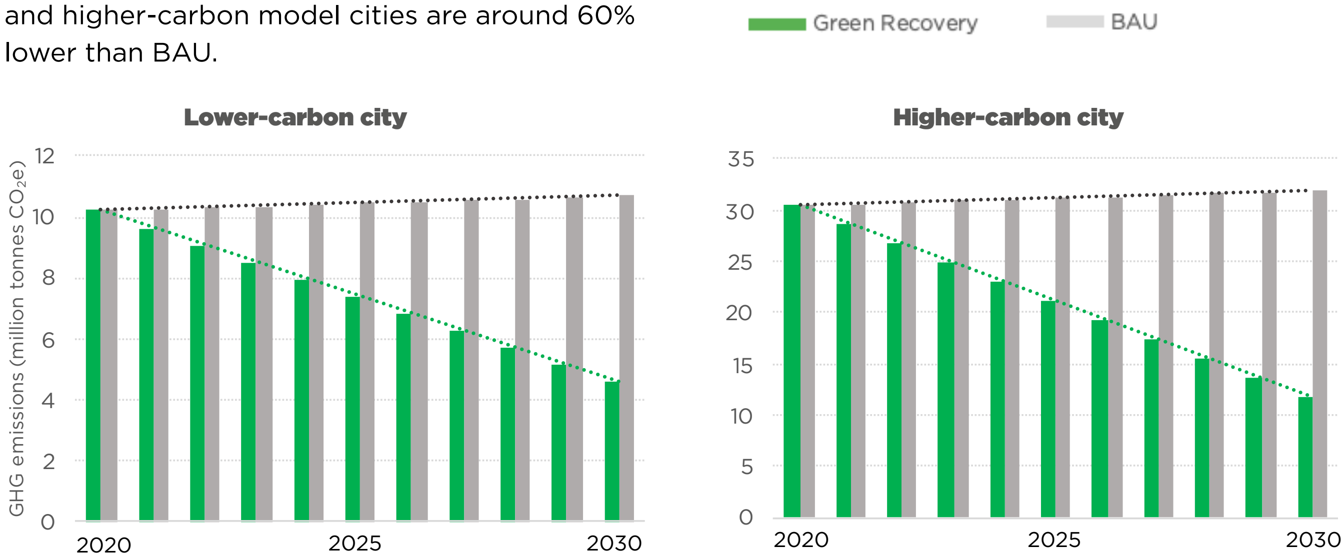
- The higher-carbon electricity model city has the same features as the lower-carbon city, except for its sources of electricity. This model city has a carbon-intensive electricity grid, which means that its electricity grid accounts for more than 60% of total emissions and its emissions in 2020 were at the higher end of the emissions spectrum compared with other major Canadian cities. This type of model city bears greater resemblance (but is not identical) to Canadian cities such as Edmonton or Calgary. We will refer to this city as the **higher-carbon city** throughout this report.



Global GHG emission trajectories (2020–2030)

In Figure 1.1, we compare the Green Recovery and BAU emissions trajectory for the two model cities. Under a Green Recovery scenario in 2030, the GHG emissions of the lower-carbon and higher-carbon model cities are around 60% lower than BAU.

Figure 1.1: GHG emission trajectories of the two model cities under a Green Recovery and BAU scenario, 2020–2030.



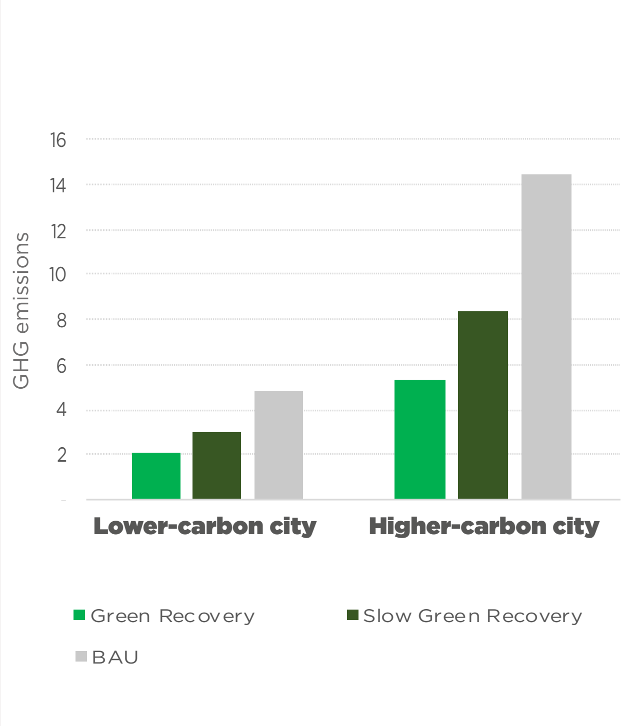
GHG emissions per capita (2030)

Figure 1.2 shows GHG emissions per capita for the lower-carbon and higher-carbon cities in 2030 under the three modelled scenarios. In 2030, the Green Recovery results in 30% to 36% fewer per capita GHG emissions than the Slow Green Recovery in the lowe- and higher-carbon model cities, respectively.

There is also a difference in per capita emissions in 2030 between the lower-and higher-carbon cities, as illustrated in Figure 1.2. The reason for this is that the higher-carbon city continues to source more than half of its electricity from natural gas in 2030. If both model cities are to achieve net-zero emissions by 2050, the higher-carbon city will eventually need to phase out its natural gas consumption (as will Canada as a whole).

Canadian cities that are currently transitioning from coal to natural gas should opt to transition to renewable energy sooner, eliminating the risk of stranded assets and creating greater potential for emission reductions and other benefits.

Figure 1.2: 2030 per capita GHG emissions under the three modelled GHG scenarios.



Carbon budgets and cumulative emissions (2020–2030)

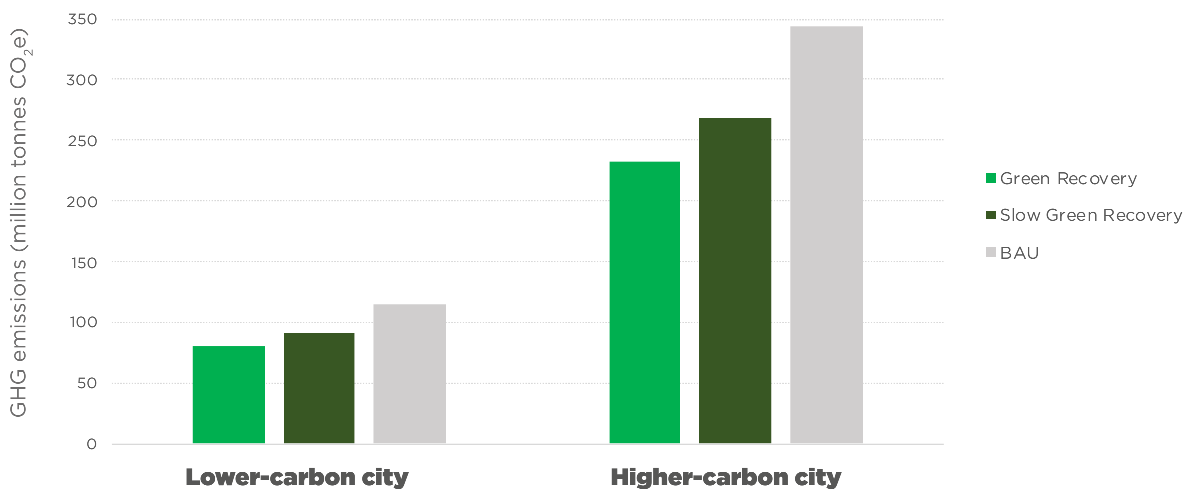
Under Deadline 2020, each C40 city is assigned a 1.5°C-compliant carbon budget that sets out the cumulative emissions a city is permitted between 2020 and 2030 to stay within its carbon budget. Figure 1.3 shows cumulative emissions from 2020 to 2030 for the lower- and higher-carbon cities under the two Green Recovery and BAU scenarios. Both the lower- and higher-carbon cities follow their Deadline 2020 trajectory over the decade, but there is a difference in cumulative emissions observed in Figure 1.3, due to the two model cities having different starting emissions in 2020, as outlined in Figure 1.1.

- **Lower-carbon city:** A Slow Green Recovery results in cumulative GHG emissions that are 13% higher by 2030 than under a Green Recovery. This difference illustrates how meeting climate targets depends on both the ambition of a city's climate actions and the speed at which they are implemented. If a city postpones key climate actions, or simply implements climate actions at a slower pace, the city may miss its cumulative emissions targets or find it necessary to compensate for a lack of early action by initiating more drastic emission reductions a few years down the line.

- **Higher-carbon city:** A Slow Green Recovery results in cumulative GHG emissions being 15% higher by 2030 than under a Green Recovery. As the higher-carbon city starts out with higher emissions in 2020, slow implementation of climate actions will create a greater discrepancy in total cumulative emissions between the Green Recovery and Slow Green Recovery scenarios. It is, therefore, even more critical for the higher-carbon city to deliver significant cuts to emissions as early and quickly as possible to stay within its carbon budget.

This same logic applies to Canada more generally. In a global context, Canada has some of the world's highest per capita emissions in 2020, meaning that cumulative emissions will continue to grow at a rapid pace unless Canada makes significant cuts to its emissions as soon as possible, including in its major cities.

Figure 1.3: Cumulative GHG emissions by model city, 2020–2030.



Cumulative emission reductions by sector

A city's sectoral emissions profile in 2020 will determine the type and scale of climate action required to meet a 1.5°C-compliant emissions trajectory in 2020–2030. The difference between the lower-carbon and higher-carbon cities is the carbon intensity of their electricity grids.

Higher-carbon city

The higher-carbon city had a highly carbon intensive grid in 2020, which means that a large share of its emission reductions will come from electricity decarbonisation, as shown in Figure 1.4. Transitioning from a 90% fossil-fuel grid to almost 50% renewable sources by 2030, primarily through the complete phase-out of coal, accounts for more than 40% of emission reductions over the decade. In this scenario, the share of natural gas for electricity generation was kept constant from 2020 to 2030, while natural gas use in residential and commercial buildings was decreased by 78% and 52%, respectively, by switching to electric heat pumps. We have based our analysis on currently viable technologies and excluded technologies such as renewable natural gas (RNG), which is not available at the necessary scale, and hydrogen, which is too costly.

After significant grid decarbonisation, the deep retrofit of existing buildings and greater new building efficiency will account for nearly 40% of emission reductions. A shift to electric vehicles and higher rates of mass transit and active mobility will account for 15% of emission reductions.

Lower-carbon city

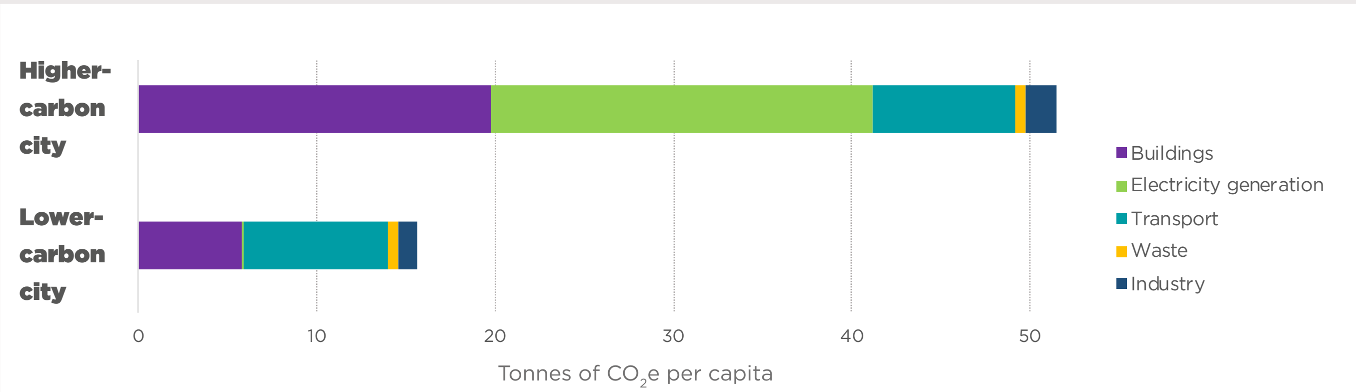
In the lower-carbon city, a shift to electric vehicles and higher rates of mass transit and active mobility will account for 50% of emission reductions. This is followed by retrofitting and upgrading existing buildings and increasing new building efficiency, which will account for nearly 40% of emission reductions.

Comparison

The fact that transport actions account for just 15% of emission reductions in the higher-carbon city and more than 50% of reductions in the lower-carbon city is not down to the implementation of less ambitious transport actions. By 2030, for both model cities, we assume a relative electrification of 75% of all private vehicles compared with 2020, as well as a reduction in passenger automobile mode share from 66% to 44%. The emission reductions in the transport sector are similar for both model cities, but the emission reduction from transport in the higher-carbon city is lower than the reduction from electricity generation.

This underscores the fact that the higher-carbon city needs to take all of the challenging climate actions in all sectors that the lower-carbon city takes between 2020 and 2030, in addition to the decarbonisation of its grid.

Figure 1.4: Cumulative per capita emission reductions under a Green Recovery by model city, 2020–2030.



GHG analysis: Upscaled scenario

Figure 1.5 shows the projected emissions for a dozen major Canadian cities in 2030 under a Green Recovery and BAU scenario. These emissions were scaled up based on the relative sectoral emission reductions achieved in the two model cities.

The emissions of a dozen major Canadian cities in 2030 could be around two-thirds lower (than BAU) under a Green Recovery scenario, avoiding the emission of 77 megatonnes (Mt) of CO_2e that year. An annual reduction of 77 Mt in 2030 is equivalent to cutting around 10% of Canada's total annual emissions in 2020.[9]

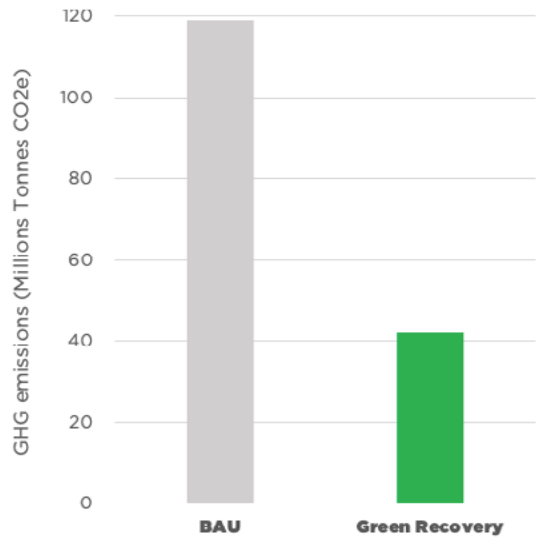


Figure 1.5: Projected emissions in 2030 for a dozen major Canadian cities under a BAU scenario and a Green Recovery scenario.

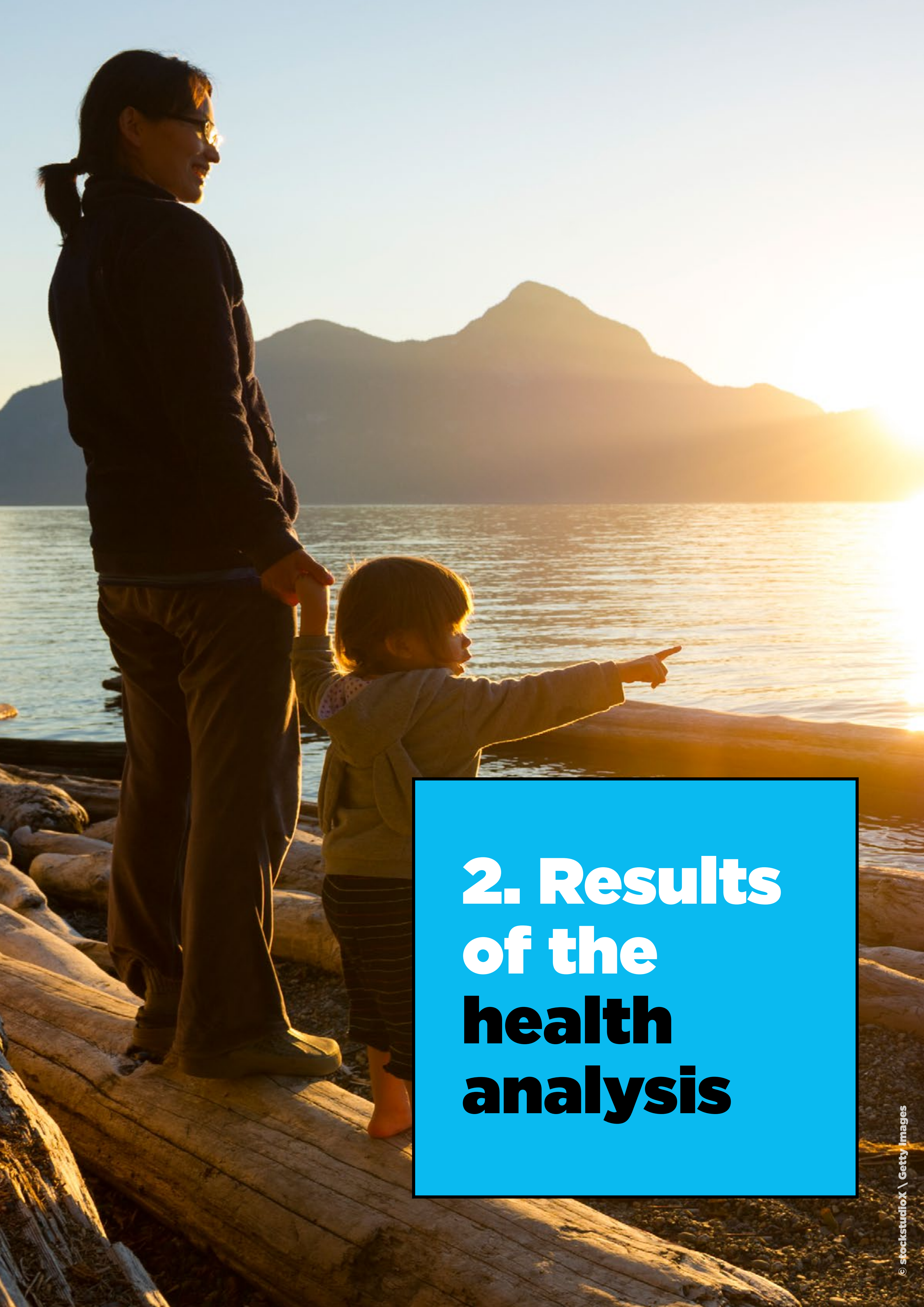
GHG emissions inventory

In our modelling, we opted to use the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) BASIC emissions inventory approach, as it is more commonly available than BASIC+ (summarised in Table 1.1). Consequently, emissions from industrial processes and product use (IPPU) and agriculture, forestry and other land use (AFOLU) have been excluded. IPPU covers industrial processes (including those associated with industrial chemical processes, such as steel and cement manufacturing) and product use (for example, the release of potent GHG emissions from refrigerants, foams or aerosol cans).

Reducing emissions in major emitting industries (often called hard-to-abate industries), such as steel, cement and fertiliser, will require more research and development (R&D) and there is a clear role for more government investment in R&D. This type of research is commonly funded by national governments around the world due to the uncertainty and cost involved. The benefits of such research could be enormous, in that it would enable the world to reduce hard-to-abate emissions while governments could support industrial breakthroughs in product areas where there is a huge global market.

By 2050, some estimates say that the world will consume 2.8 billion tonnes of steel[10] and 4 billion tonnes of cement each year.[11] This steel and cement needs to be green if the world is to be on track for net zero emissions. Countries that are home to green producers will reap the benefits in terms of job creation.

Sector	BASIC	BASIC+
Stationary energy: Residential buildings, commercial and institutional buildings and facilities, manufacturing industries and construction, and energy industries	✔	✔
Transportation: On-road, railways, waterborne, aviation, off-road	✔	✔
Waste: Solid, biological, incineration, wastewater	✔	✔
Industrial processes and product use (IPPU)	✖	✔
Agriculture, forestry and other land use (AFOLU)	✖	✔



2. Results of the health analysis

Results of the health analysis

The Lancet's *2019 Burden of Disease* study estimates that every year, in Canada, 4,380 premature deaths (estimates range from 2,200-6,620) are attributable to current levels of air pollution.[12] There is a growing body of evidence on the increased risk of detrimental COVID-19 outcomes resulting from exposure to air pollution, even at low levels. Populations that are affected by respiratory and cardiovascular diseases are at greater risk of suffering from more severe COVID-19 infection.[13,14,15,16]

Furthermore, in 2018, 26.8% (around 7.3 million people) and 36.3% (about 9.9 million people) of adult Canadians were classified as obese or overweight, respectively. This brings the total population with increased health risks due to excess weight to 63.1%, up from 61.9% in 2015.[17] Of growing concern is the fact that one in three children between the ages of 6 and 17 is now overweight or obese.[18] Urbanisation, change in diet and low physical activity are all contributing to the decline in health. The causes of and contributors to obesity are complex and go beyond individual behaviours and attitudes. However, encouraging a healthier diet and greater levels of physical activity can help to reduce the risks associated with obesity, excess weight and comorbidities.

Canadian cities need to take action to improve the health of their citizens by transitioning to renewable energy, improving building and industrial efficiency, increasing the share of mass transit and active mobility, and switching passenger trips to electric vehicles.

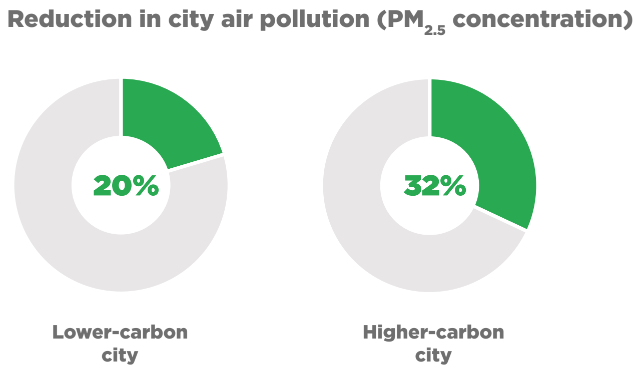
Results of the air quality analysis

- We have compared the difference in life expectancy, mortality and morbidity of Canadian citizens under the BAU and Green Recovery scenarios for the two model cities, specifically looking at air-quality and physical activity improvements. The assessment only explored the impact on $PM_{2.5}$ concentration, but there would be additional benefits from reducing exposure to nitrogen oxides (NO_x) and other air pollutants.

- The two model cities suggest that a Green Recovery would reduce total $PM_{2.5}$ concentration by 20% to 32% compared with the BAU in 2030. This reduces most sources of $PM_{2.5}$ within the cities themselves. Around 60% of $PM_{2.5}$ in cities comes from external sources, such as natural sources, neighbouring cities or provinces.

- The majority of the modelled reduction in $PM_{2.5}$ concentration is achieved by switching from fossil fuels to renewables in the building, transport and energy sectors. The greatest reduction in $PM_{2.5}$ concentration is achieved in the buildings sector, in large part due to the reduction of residual fuel oil use in 2030. While residual fuel oil only accounts for a small share of building energy use, it accounts for the majority of sectoral emissions in the lower-carbon city, followed by natural gas. For urban areas of Canada that use a smaller share of residual fuel oil for heating than the two model cities, our analysis may overestimate the reduction in $PM_{2.5}$ concentration achieved due to switching to renewable sources.

- A modelled reduction in energy use in buildings and improved industrial efficiency, as well as an increase in mass transit and active mode share, deliver smaller – though not negligible – reductions in $PM_{2.5}$.



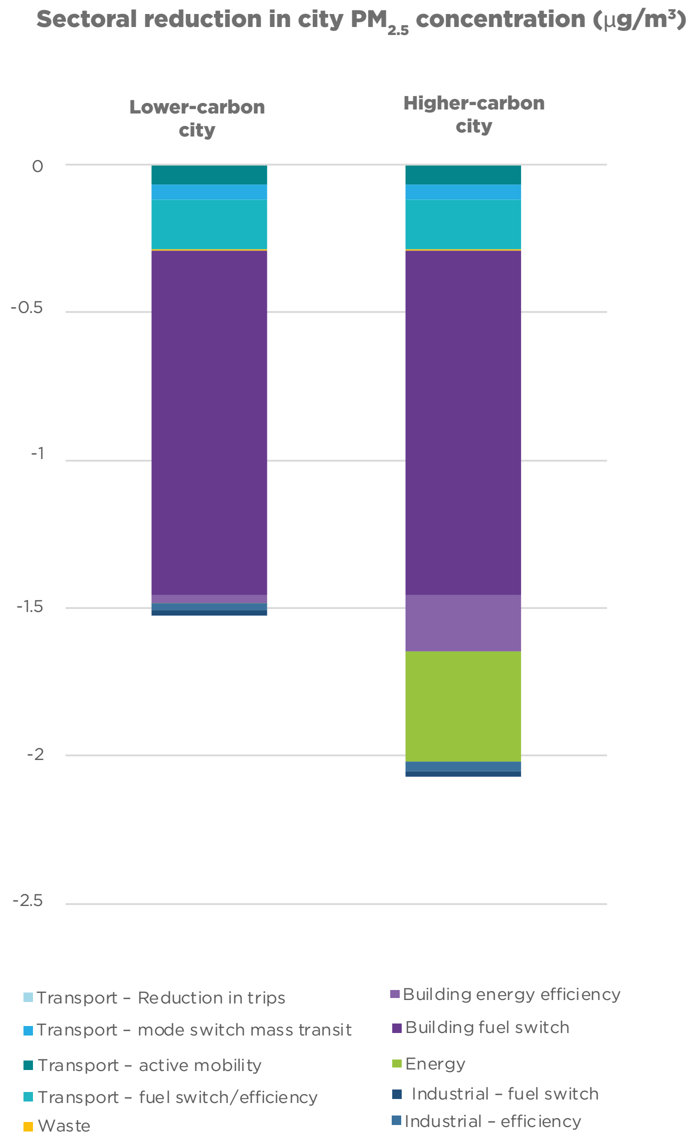


Figure 2.2: Overall and sectoral reduction in $PM_{2.5}$ concentration in the lower-carbon and higher-carbon model cities under a Green Recovery.

The health impact of a Green Recovery

The results have been scaled up to a dozen major Canadian cities based on the assumption that they could achieve the same percentage reduction in $PM_{2.5}$ concentration and increase in physical activity as their model counterparts, by taking ambitious climate action as part of a Green Recovery. These upscaled results are presented in Figure 2.1.

In reality, the percentage reduction in $PM_{2.5}$ concentration will vary from city to city, depending on its emissions and $PM_{2.5}$ profile, as well as factors that affect a city's air quality. Sources of emissions beyond a city's boundary (such as factories, power plants and agriculture), geographical features and natural phenomena all affect a city's $PM_{2.5}$ concentration. Similarly, local characteristics may change the profile of commuters. The upscaled analysis, therefore, only illustrates the magnitude of the health impact a Green Recovery could have.

If we assume that the dozen major Canadian cities included in this analysis could achieve the same percentage reduction in air pollution as the two model cities, a Green Recovery could prevent more than 3,950 premature deaths between 2020 and 2030 (including 790 premature deaths in 2030 alone) compared with a BAU scenario.

Reducing $PM_{2.5}$ concentration has a positive impact on citizens' health, with a resulting benefit on healthcare costs. Across a dozen major Canadian cities, the model suggests that a Green Recovery could prevent premature deaths with an economic value of CAD 24 billion between 2020 and 2030, based on the VSL. The high-level assumptions made in this upscaled analysis mean that the figures are merely illustrative of the magnitude of potential health savings compared with a BAU scenario, rather than precise estimates.

The findings we have outlined are particularly pertinent in light of the ongoing global COVID-19 pandemic. Populations with existing respiratory and cardiovascular diseases are at increased risk of severe illness from the virus. Improving air quality could reduce both the number of people vulnerable to COVID-19 and the number of patients admitted to hospital for non-COVID-19-related diseases in peak episodes.

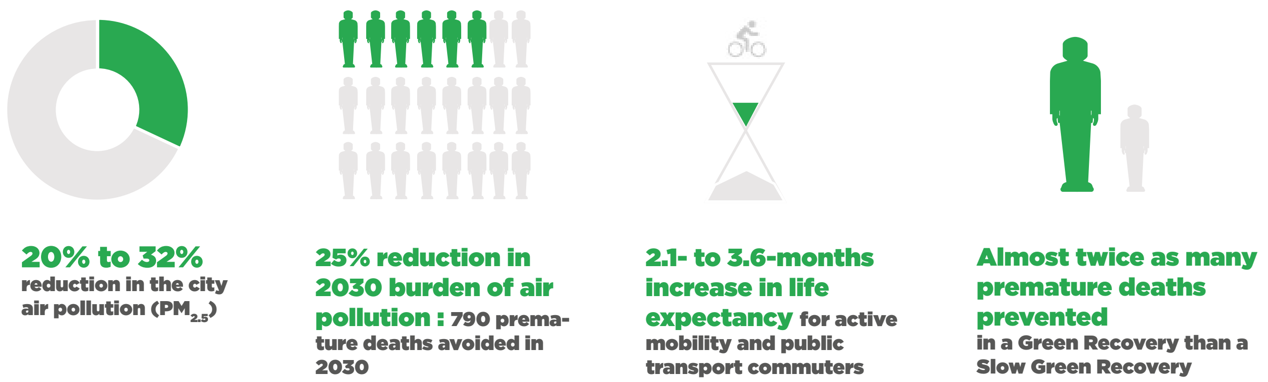


Figure 2.1: Summary of the health impacts modelled under the Green Recovery scenario.

Increase in life expectancy due to active mobility

- Just a few minutes walking to or from the station as part of a daily commute can bring about a significant increase in life expectancy and combat obesity, diabetes, stroke, cardiovascular diseases, breast and colon cancer, depression and dementia. Six-minute walks to and from transit stations as part of the daily commute (for a total of 24 minutes per day) could increase an average commuter's life expectancy by 2.1 months.

- Where commuters have a longer walking or cycling commute - such as the two 20 minute trips, on average, reported in Vancouver[19] - this could lead to as much as a 3.6-month increase in life expectancy, in addition to reducing the risks of developing type 2 diabetes and stroke by 10% and 15%, respectively.

- Across the 12 Canadian cities, the increase in active mobility and public transport use could reduce premature deaths by 2,200 from 2020 to 2030 (including 440 for 2030 alone). The reduction in disease rate corresponds to a decrease in years lived with disabilities (YLDs) of 15,700 from 2020 to 2030 (including 3,140 for 2030 alone)), such as the illnesses included in our analysis, from 2020 to 2030 (including 3,140 for 2030 alone). Those scaled-up figures assume a similar shift to active and public modes of transport across all 12 cities, so should only be viewed as an illustration of the potential results trajectory.

- The impact of active mobility on cardiovascular disease and diabetes is particularly relevant in the context of the ongoing global COVID-19 pandemic. According to the United States Centers for Disease Control and Prevention (CDC), populations with existing high incidences of cardiovascular disease and/ or type 2 diabetes are at greater risk of severe illness from COVID-19. Preventing disease, therefore, has the potential to reduce the number of people vulnerable to COVID-19.[20]

2.1-month increase in life expectancy **for public transport commuters on the basis of six-minute walks to and from transit for weekday commuting (24 minutes in total).**

3.6-month increase in life expectancy **for cyclists and pedestrians on a 20-minute commute to and from work every weekday (40 minutes in total).**

Reduction in disease risk:

Coronary heart disease & stroke by 10 to 15%
Dementia by 4 to 7%
Type 2 diabetes by 6 to 10%
Depression by 6 to 9%
Breast cancer by 5 to 8%
Colon cancer by 3 to 5%

Figure 2.3: Modelled health impacts of increased active mobility under a Green Recovery scenario.

It's all in the timing

Another finding from our research is that timing matters. It is essential to act now. The earlier a Green Recovery is realised, the greater the number of lives that can be improved and premature deaths avoided.

A Green Recovery could avert nearly double (1.9 times) the premature deaths of a Slow Green Recovery between 2020 and 2030, while the associated economic value of those avoided premature deaths would be CAD 17 billion higher.

Figure 2.4 shows the impact of the Green Recovery and Slow Green Recovery scenarios on the cumulative number of premature deaths avoided per year due to improved air quality and enhanced physical activity across the 12 major Canadian cities in this analysis, based on a similar relative reduction in $PM_{2.5}$ concentration and increase in public and active modes of transport in all cities.

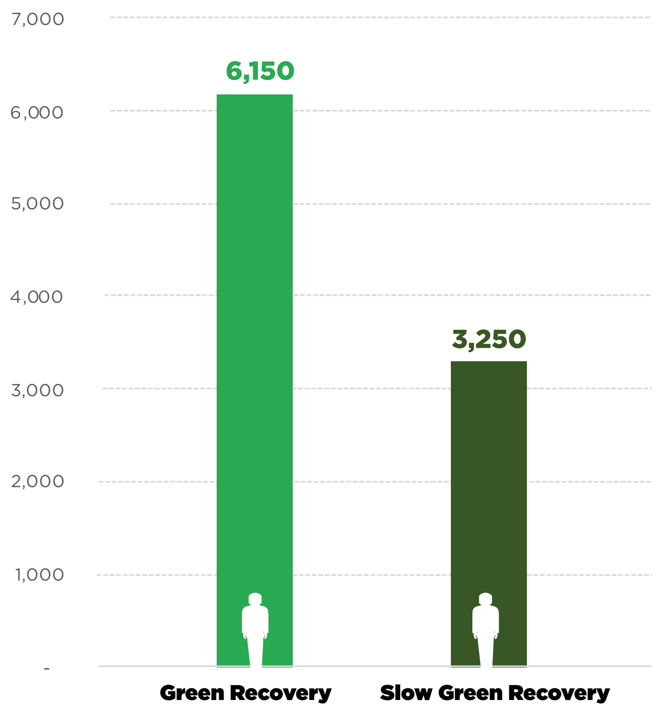


Figure 2.4: Total number of premature deaths avoided due to improved air quality and physical activity in 12 major Canadian cities under different Green Recovery scenarios compared with BAU, 2020–2030

3. Results of the employment analysis

Results of the employment analysis

• The Green Recovery scenario could generate 1.6 million and l.7 million job years across the lower-carbon and higher-carbon model cities and their supply chains, between 2020 and 2030. The sectoral job years created are presented in Figure 3.1.

• The employment potential was calculated using employment multipliers. Two types of mutliplier were used, namely jobs per USD 1 million expended (for example, expenditure on energy generation) and jobs per USD 1 million spent on final goods (for example, spending on new vehicles).[A]

• Our analysis mainly looks at job years. A job year is defined as one full-time job for one year. Five job years, for example, can be made up of five different jobs, each lasting one year, or one job lasting five years. While most of the employment analysis looks at job years, we have translated these job years into 'total jobs' for some results both because 'jobs' is a term more readily understood and because 'jobs' better reflects the total employment opportunities available at any one time. Here, 'total jobs' refers to the number of full-time jobs available in a given year. For example, five job years in one year equals five total jobs, while five job years over five years equals one total job.

• The jobs reported relate to constructing, manufacturing and O&M jobs (for example, activities to support proper operation of a plant). Together, they cover the direct (on-site) and indirect (supply chain) jobs associated with expenditure.

• It is important to note that not all jobs generated by investments in a Green Recovery will be local (city-based) jobs. As a general rule, Green Recovery expenditure generates more local jobs if the activity being funded requires a substantial amount of on-site labour, whereas, the location of jobs associated with the purchase of products will depend on the geography of that product's supply chain.

• As supply chains are global, expenditure on distributed solar panels, for example, may result in a number of installation and maintenance jobs in the city where they are fitted, but some of the associated jobs will be elsewhere, such as in factories outside Canada.

A For the purposes of this report, all employment multipliers and cost outputs have been converted from USD into CAD.

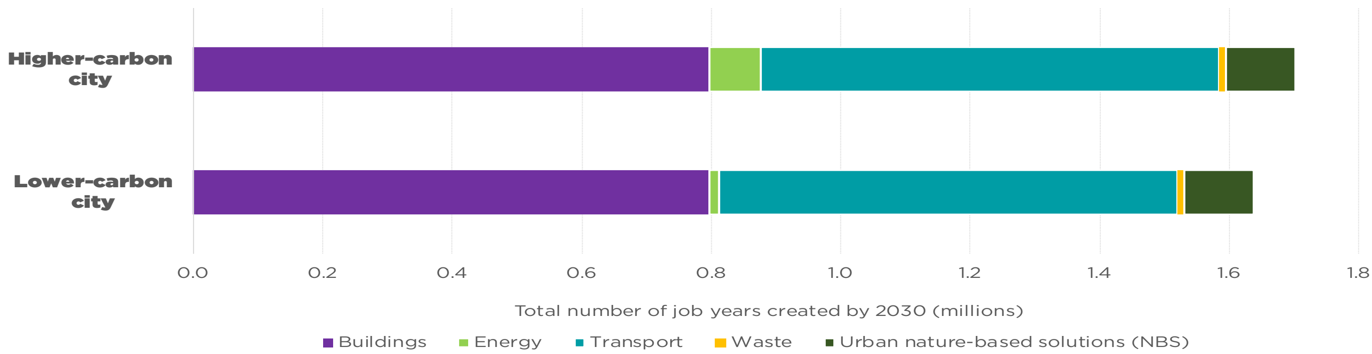


Figure 3.1: Job years created under a Green Recovery scenario, by sector, 2020-2030.

According to the IEA, at least 80% of jobs from investing in rooftop solar PV will be local as these are linked to delivery and fitting on site, while the remaining 20% are associated with manufacturing all necessary equipment, so will be more widely distributed geographically across Canada and beyond.[B]

- The total job years estimated from a Green Recovery represent both supported and created jobs. We have compared a Green Recovery with BAU as an indication of new job creation as a result of additional expenditure in a Green Recovery. It is important to acknowledge that any green and just recovery will entail local- and/or industry-specific job gains and losses.

While the results of this analysis show a greater gain in employment opportunities under a Green Recovery scenario than under a BAU scenario (which is to be expected due to the higher levels of expenditure under a Green Recovery), employment losses may still occur in some industries, such as the fossil-fuel industry, because of reduced demand for carbon-intensive products and services. Provisions must, therefore, be made to ensure a just transition for workers within industries that would be phased-out under a Green Recovery.

- We have not modelled job losses that may occur in specific cities due to a transition to a low-carbon economy, for example, due to a reduction in fossil-fuel employment. However, research from the Centre for Future Work indicates that direct employment in fossil-fuel industries accounted for less than 1% of Canada's total employment in 2019 and that this share has been declining since 2014. In fact, there are only 18 communities in Canada (including Calgary) where fossil-fuel employment accounts for more than 5% of total employment.[21]

- **Buildings**: Residential and commercial building deep retrofits and new energy-efficient construction are the most significant job-creating actions in the two model cities, accounting for more than 45% of all jobs created in both the lower-carbon and higher-carbon cities. Such deep retrofits entail advanced upgrades to the wall, roof and window-system technologies of residential and commercial buildings. The significant job-creation potential is down to the large expenditure that must be made by both the public and private sector in cities to align with a 1.5°C trajectory, combined with the relatively high jobs multiplier (the number of jobs generated per CAD 1 million invested) for building retrofits and new construction. Exact multipliers differ from city to city, but according to the International Energy Agency (IEA), the multiplier for building retrofits in Canada is 11 and 10 for the construction of new, efficient buildings.[22] Moreover, these jobs tend to be generated relatively quickly, as many building proposals and retrofit projects can move rapidly from the planning to the construction phase and a large share of them are local (as you can only retrofit a property where it is located). What's more, the jobs are often in small and medium-sized enterprises that cover a range of income brackets and skill levels. However, there may not be enough trained labour available in the current workforce, so additional training is likely to be required.

B These values are based on the constrution and manufacturing employment multipliers applicable for new residential PV installations. They do not take into account maintenance over the lifecycle of the plant.

- **Transport**: Expenditure in transport actions is also a key creator of job years in both the lower-carbon (43%) and higher-carbon (42%) model cities. The jobs multipliers vary for different types of transport expenditure. For example, the IEA estimates new mass-transit infrastructure (rail) at 4.7 and new electric vehicle (EV) charging infrastructure at 11.7,[23] while the North American multiplier for new cycling infrastructure has been estimated as 5.2.[24]
The greatest number of transport job years stems from replacing most of the current vehicle fleet with EV vehicles between 2020 and 2030. The IEA estimates the multiplier for EVs in advanced economies at 6.2.[25]

- **Energy**: Energy expenditure in utility-scale infrastructure tends to generate relatively few jobs per CAD 1 million spent because the sector is highly capital-intensive, with a greater share of funds going on infrastructure and machinery than labour. Therefore, even though the energy transition in the higher-carbon city brings about significant emission reductions as coal is replaced with renewable electricity, this spending only generates 4.5% of the total Green Recovery job years. According to the IEA, building new hydropower has a jobs multiplier of 1.6, new nuclear power infrastructure, 4.4, and new on-shore wind power, 1.8. By way of comparison, new gas power sees the creation of 2.5 jobs per CAD 1 million spent.

Distributed solar power is the energy exception when it comes to job creation, as it has a high jobs multiplier of 12.5[26] owing to the installation requirements involved (many units in many places throughout a city). While utility-scale energy expenditure tends to have long lead timelines, distributed solar photovoltaic (PV) panels also generate jobs more quickly, as installations require less planning and less upfront capital expenditure. We have assumed that 4% of buildings could have solar PV installed by 2030. If this were increased, more jobs would be created. While the energy sector, more generally, is not a significant job creator, it is absolutely critical to our climate.
It is also important to note that the fossil-fuel transition can avoid a loss of jobs if measures are put in place to achieve a just transition from fossil fuels.

- **Urban nature-based solutions (NBS)**:
Ecosystem service-related jobs can be created quickly and offer accessible employment at various skill levels. Many of the jobs associated with NBS are long-term jobs in operations and management, such as park wardens and gardeners. Expenditure on urban NBS generates 6% of the job years in both model cities. The New York State Office of Parks, Recreation, and Historic Preservation's estimate of 9.9 jobs per CAD 1 million.[27]

- **Waste**: The waste-related employment effect will vary from city to city, depending on the current waste-management system and level of waste in 2020. The scale of spending required is lower than in the buildings, transport or energy sectors, resulting in a lower number of waste-related job years, at less than 1% of all job years generated in both model cities. According to the IEA, waste recycling infrastructure in advanced economies has a jobs multiplier of 11.3.[28]

Job creation: Timing and total job availability

- In this section, we have converted job years to total jobs in order to show how the timing of expenditures affects annual job availability. Figure 3.2 shows the total number of jobs associated with capital expenditure in the Green Recovery and Slow Green Recovery scenarios. Note that the total number of job years is the same for both scenarios. It is the total number of jobs created per year and the duration of those jobs that varies, with the Green Recovery scenario creating more jobs per year over a shorter timespan with the Slow Green Recovery scenario. The 'total jobs' figure is calculated by dividing the number of capital expenditure-generated job years by the timeframe (years) over which the capital is spent.

- The Green Recovery and Slow Green Recovery scenarios are based on increasing or decreasing the five-year timeframe for capital expenditure by two years (see glossary). It is important to note that our analysis is for illustrative purposes: it shows that it is better to invest as much as possible as early as possible to generate maximum employment opportunities, emission reductions and health benefits near-term. However, it is important to acknowledge that it is challenging to enact some urban climate action quickly due to the fixed planning and development periods involved in major projects (such as a new metro line) or their reliance on consumer decisions (for example, on replacing a vehicle that may be new or working just fine).

As can be seen in Figure 3.2, the swifter expenditure of a Green Recovery scenario results in 50% more total jobs per year than the Slow Recovery scenario. This means that a greater number of employment opportunities are created early on – an ideal strategy when seeking to usher in an immediate economic recovery from the pandemic.

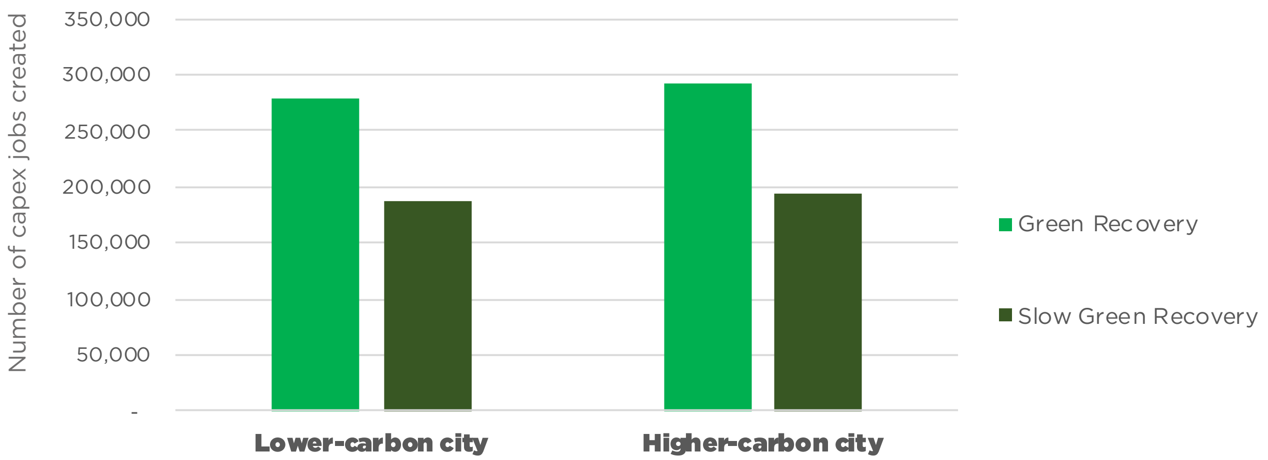


Figure 3.2: Total number of jobs associated with capital expenditure under the Green and Slow Green Recovery scenarios.

A Green Recovery will generate a higher number of total jobs, as large capital expenditures are made over a shorter period. For example, if 10 houses are built in one year and each house generates one construction job for a full year, then building 10 houses will generate 10 construction jobs that year. If the same 10 houses are built over 10 years, the pace of construction will only generate one construction job per year. The first scenario would see 10 people working for one year, the second, one person working for 10 years.

Employment analysis: The upscaled scenario

- Table 3.1 shows the results of scaling up the Green Recovery employment analysis for a dozen major Canadian cities. We did this by scaling up the results of the model cities in line with the cumulative emission reductions required to bring each region into alignment with a 1.5°C trajectory. We then compared job creation by sector under a Green Recovery and BAU scenario to arrive at the number of new jobs created.

- Job generation is dominated by the buildings and energy sectors, which together account for 56% of all jobs generated under a Green Recovery scenario (67% of new jobs created). Transport is the next-largest source of job creation, accounting for 39% of all jobs created (26% of new jobs created).

- Jobs associated with urban NBS are moderate, accounting for 4% of all jobs (7% of new jobs created). This is based on the assumption that cities target the creation of public green spaces and gardens on more than 30% of city area. The waste sector accounts for a small share of employment, at less than 1% of all jobs created (less than 1% of new jobs created). While these sectors are not as significant as the buildings, energy and transport sectors when it comes to job creation, they are key to reducing GHG emissions in cities, as well as creating safe ecosystems for humans and other species.

- Table 3.2 shows how timing affects the number of jobs available (though the total number of job years remains the same). We can see that speeding up capital expenditure creates more jobs per year, underpinning the post-pandemic employment recovery.

Table 3.1: Total number of jobs created under a Green Recovery scenario in 2020-2030 and number of new jobs created compared with BAU (million, across a dozen major Canadian cities).

	Buildings & energy	Transport	Waste	Urban NBS	Total jobs in a Green Recovery
Jobs created and supported	**1.7**	**1.2**	**0.016**	**0.13**	**2.9**
Jobs created	**1.2**	**0.47**	**0.01**	**0.12**	**1.8**

Table 3.2: Number of job years (million) and total jobs (million) under Green Recovery and Slow Green Recovery scenarios.

	Standard (capex over 5 years, O&M over 10 years)	Slow (capex over 7 years, O&M over 10 years)
Capex job years	13.8	13.8
O&M job years	2.2	2.2
Total job years	**16.0**	**16.0**
Capex jobs	2.8	2.0
O&M jobs	0.2	0.2
Total jobs	**2.9**	**2.2**

4. Results of the expenditure cost analysis

Results of the expenditure cost analysis

In this section, our analysis looks at the financing of a Green Recovery compared with a BAU scenario in the two model cities. While the expenditure costs are significant, the cost of inaction is also great. The ability to achieve climate targets will be more costly and more difficult to achieve, if climate action and associated expenditure are delayed, as GHGs will accumulate in the atmosphere, requiring future mitigation actions to be more stringent and therefore, more costly.[29]

To estimate the number of jobs created under different scenarios, it was first necessary to assess how much a specific scenario was likely to cost. Expenditure costs are based on C40's Pathways Tool. Pathways models what needs to happen in the buildings, energy, transport, waste and industrial sectors to reduce emissions in line with a 1.5°C trajectory. Based on this, it is possible to gather data on average total expenditure costs for a particular action in a particular location and, for example, to estimate the total cost of retrofitting a certain number of residential buildings in a Canadian city.

As industrial initiatives and the associated expenditure can be highly specific and vary significantly from one sector or facility to the next, and due to an absence of good data, it was not possible to develop cost estimates for industrial projects.

The expenditure cost calculations cover new expenditure in infrastructure and systems (such as vehicles or heating systems), the replacement and rehabilitation of infrastructure and systems and annual operation and maintenance (O&M) costs. These costs are quantified and described in more detail in the appendix.

To establish exactly how much a 1.5°C-compliant Green Recovery scenario would cost in a particular city, it is necessary to have extensive local data on the cost of goods, services and labour. Consequently, the high-level research conducted for this report is only indicative; a full cost analysis would require more time and resources.

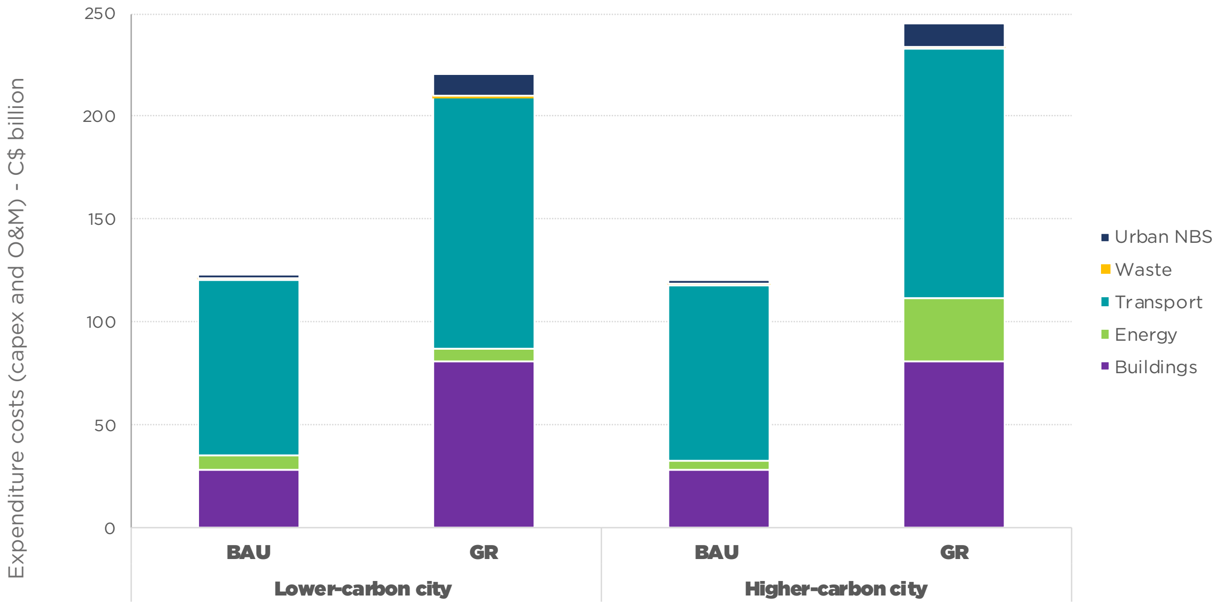


Figure 4.1: Expenditure costs under BAU and a Green Recovery scenario by sector, 2020–2030.

- Figure 4.1 shows how a Green Recovery that aligns with a 1.5°C trajectory will require almost twice as much expenditure as a BAU scenario, on average, in both the lower- and higher-carbon cities. The most significant sectoral finding was that in the higher-carbon city required more than six times the expenditure on the energy sector was required for a Green Recovery than the BAU scenario. This is due to the considerable expansion of renewable infrastructure needed to decarbonise the grid and align it with a 1.5°C trajectory. In the lower-carbon city, where the grid is already low-carbon, expenditure costs in the energy sector are slightly lower under a Green Recovery scenario than BAU, as energy consumption is lower in 2030 under the Green Recovery scenario.

- Achieving a 1.5°C trajectory will require significant expenditure in cities across Canada. It will generally cost more to transform cities that have comparatively high emissions today, but the emission savings will be higher.

- It is not solely up to city governments to shoulder this expenditure. A significant share of the necessary expenditure will be private rather than public, and the public-sector costs will be shared between local, regional and national governments.

- It is also worth noting that the costs associated with a product or service tend to decrease over time due to better processes and the economies of scale and scope. This pattern has been repeated across industries over time.[30] The costs of solar PVs fell by 82% between 2021 and 2019, for instance, due to technological improvements and more efficient production processes.[31] Similarly, the costs of lithium-ion battery packs, commonly used in EVs, fell by 87% in the same time period.[32] If we were to have estimated the costs of rapidly expanding solar PV generation or EVs in Canada in 2010 or 2015, C40 would have arrived at significantly higher total costs than today. When it comes to deep building retrofits, the situation is more similar to that of solar PVs or lithium-ion battery packs in 2010 than in 2019; an increase in scale and scope has yet to occur. If Canada is able to rapidly scale up its deep energy retrofits, the construction sector will be motivated to develop new approaches and processes to support it.

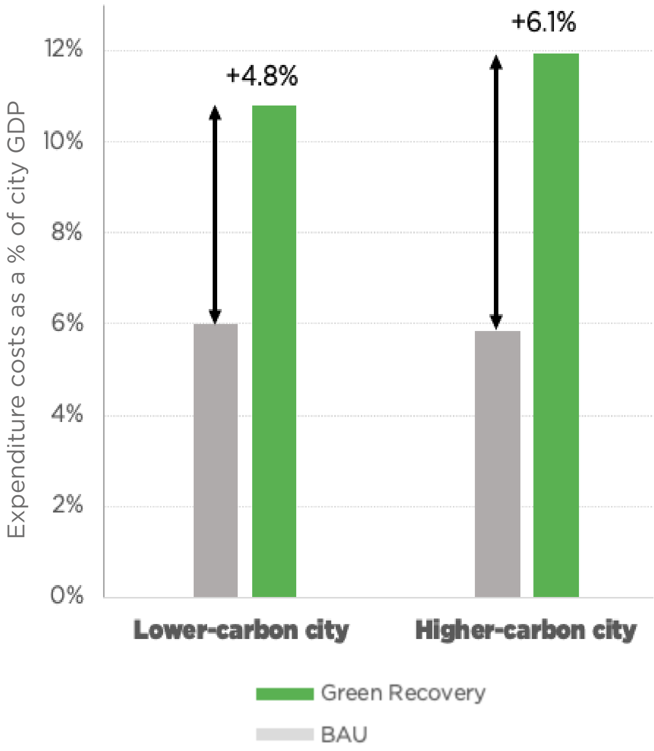


Figure 4.2: Total expenditure costs as a share of city GDP under BAU and a Green Recovery scenario.

For example, if a thousand units of a specific type of housing, common to a specific neighbourhood or city were to be retrofitted at the same time, the private sector could develop a streamlined and cost-efficient approach for that type of deep retrofit. Under such conditions, the unit cost of a retrofit would fall as the output of retrofits increased. Consequently, we hope that we have overestimated a number of costs in our analysis and that time will prove us wrong, based on what economic historian Alfred D. Chandler called "*the dynamic logic of growth and competition that drives modern industrial capitalism*".[33]

- In our analysis, we have looked at the total costs associated with a specific climate action, namely, building a new, highly energy-efficient dwelling. For certain climate actions, where an action will take place under both BAU and a Green Recovery scenario, but where the action can be green or non-green, it is appropriate to consider the incremental cost associated with that climate action. For example, if a new apartment would be built under any scenario, how much more would it cost to build a highly energy-efficient dwelling compared with a standard apartment? In our analysis, a new highly energy-efficient apartment would cost 4.2% more than a standard dwelling.

The following sectoral analysis covers which actors will be responsible for meeting the costs of a Green Recovery, the incremental cost compared with BAU and the current funding gap based upon announced stimulus packages.

- **Buildings:** Governments can incentivise low-energy new builds or the retrofit of residential and commercial buildings with subsidies, tax rebates or other measures, but individual building developers and owners will be responsible for a lot of the construction and retrofit costs. The same applies to upgrades and replacements of building equipment and appliances. In December 2020, the Canadian federal government published a climate plan detailing CAD 15 billion of spending. The largest share – just over CAD 4 billion – has been set aside for energy-efficiency projects, of which CAD 2.6 billion (or 0.12% of Canada's GDP in 2019) will comprise grants for residential housing retrofits, spread over seven years.[34] The retrofit expenditure will be spread out over seven years and BloombergNEF estimates that the funding will cover retrofits of 0.2-0.3% of Canada's housing stock on an annual basis.[35] In contrast, C40 estimates that the rate of deep retrofits in major Canadian cities needs to reach 6.5% of the urban housing stock every year between 2020 and 2030.

- **Energy:** In the energy sector, expenditure on energy generation, such as centralised renewables and nuclear power, generally generate revenue streams from paying customers that cover the cost of the expenditure and also net a profit. Consequently, most of this expenditure will probably be made by private companies and publicly owned entities with mandates for financial returns. Currently, Canada's green stimulus allocates 9% to clean power, which is just over CAD 1.35 billion (0.06% of GDP in 2019).[36] By way of comparison, the higher-carbon city in C40's model would need to invest 25 times as much in just one city to reduce its energy emissions between 2020 and 2030.

- **Transport:** The public sector is largely responsible for building and maintaining new road, rail, walking and cycling infrastructure, as well as operating transit services. Some of this expenditure may generate a revenue stream in the form of road tolls or transit fares. Under both the BAU and Green Recovery scenarios, some of the biggest expenditure costs relate to vehicle replacement. Under a BAU scenario, many internal combustion engine (ICE) vehicles will be replaced by other ICE vehicles and more vehicles will be sold due to the growing urban population. Under a Green Recovery scenario, there will be a general reduction in the number of vehicles and a replacement of ICE vehicles with EVs. In both instances, replacing vehicles will largely be financed by private expenditure, even though governments can provide subsidies for EVs to reduce purchase costs, increase demand and incentivise the technological development and economies of scale that result in EV cost reductions over time. Replacing ICE vehicles with EVs is a pertinent area in which to consider the incremental cost associated with a given climate action. How much more would it cost to replace an average ICE vehicle with an average EV rather than another ICE vehicle? We estimate that the cost of replacing an average ICE vehicle with an average EV is 12% higher than replacing it with another ICE vehicle.

When it comes to the electrification of mass transit, the Canadian federal government's CAD 2.75 billion support to procure 5,000 electric buses is promising and part of a wider CAD 14.9 billion of transit spending over the next eight years.[37] However, under C40's Green Recovery scenario, a dozen major Canadian cities would need roughly 20,000 new electric buses over the next 10 years[A], alongside significant expenditure in other transit infrastructure.

- **Waste:** In the waste sector, expanding waste and recycling infrastructure will largely require public expenditure, some of which can be funded by fees and taxes. Canada's green recovery package does not currently include any specific funding for urban waste and recycling infrastructure.[38]

- **Urban NBS:** When it comes to NBS, the expansion of green roofs may be a largely private expenditure made by building owners, but one that is incentivised or subsidised by the public sector. Expanding parks and open spaces will generally be a public cost. The Canadian government has currently pledged to invest more than CAD 4 billion to plant 2 billion trees, as well as to conserve and restore natural spaces.[39] It is key that funding for NBS also benefit cities, so as to increase urban climate resilience, health and well-being.

A We were not able to account for the existing bus fleet in Canadian cities and therefore the value could be marginally lower.

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6 C40 welcomes comments and contributions to support further development of this research.

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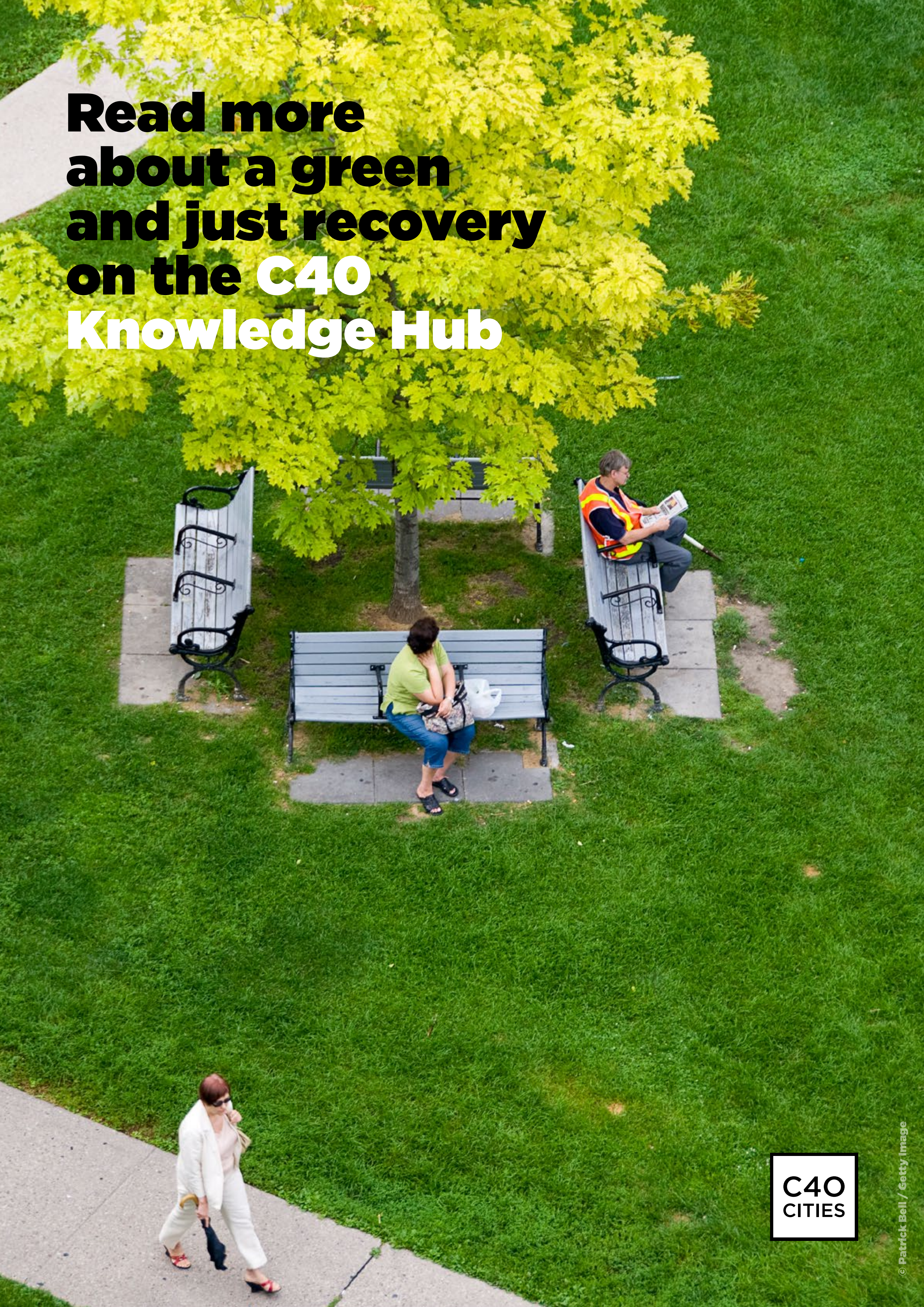

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Appendix

Appendix

2030 climate actions	**% of house-holds with rooftop PV**	**% of grid generated by renewable energy**	**% of new build to high energy efficiency standrd**	**% of resi-dential and commercial deep retrofit**	**% of house-holds in-stalling heat pumps**	**Walking and cycling mode share**	**Mass tran-sit mode share**	**% of passen-ger automo-biles that are BEVs**	**% of organic waste di-verted for compost**	**% of paper/ plastic waste recycle**
Lower-car-bon city	4%	**100%**	100%	65%	35%	20%	34%	75%	72.5%	95%
Higher-car-bon city	4%	**48%**	100%	65%	35%	20%	34%	75%	72.5%	95%

Table 1: Examples of the 2030 climate actions included in our Green Recovery scenario. These actions are modelled in C40's Pathways tool and provide the basis for our GHG, health impacts and jobs modelling. Note that the all climate actions are the same for the lower-carbon and higher-carbon cities, except for the percentage of renewable energy in the grid that characterises the two different model cities.