Technical report: The case for a green and just recovery

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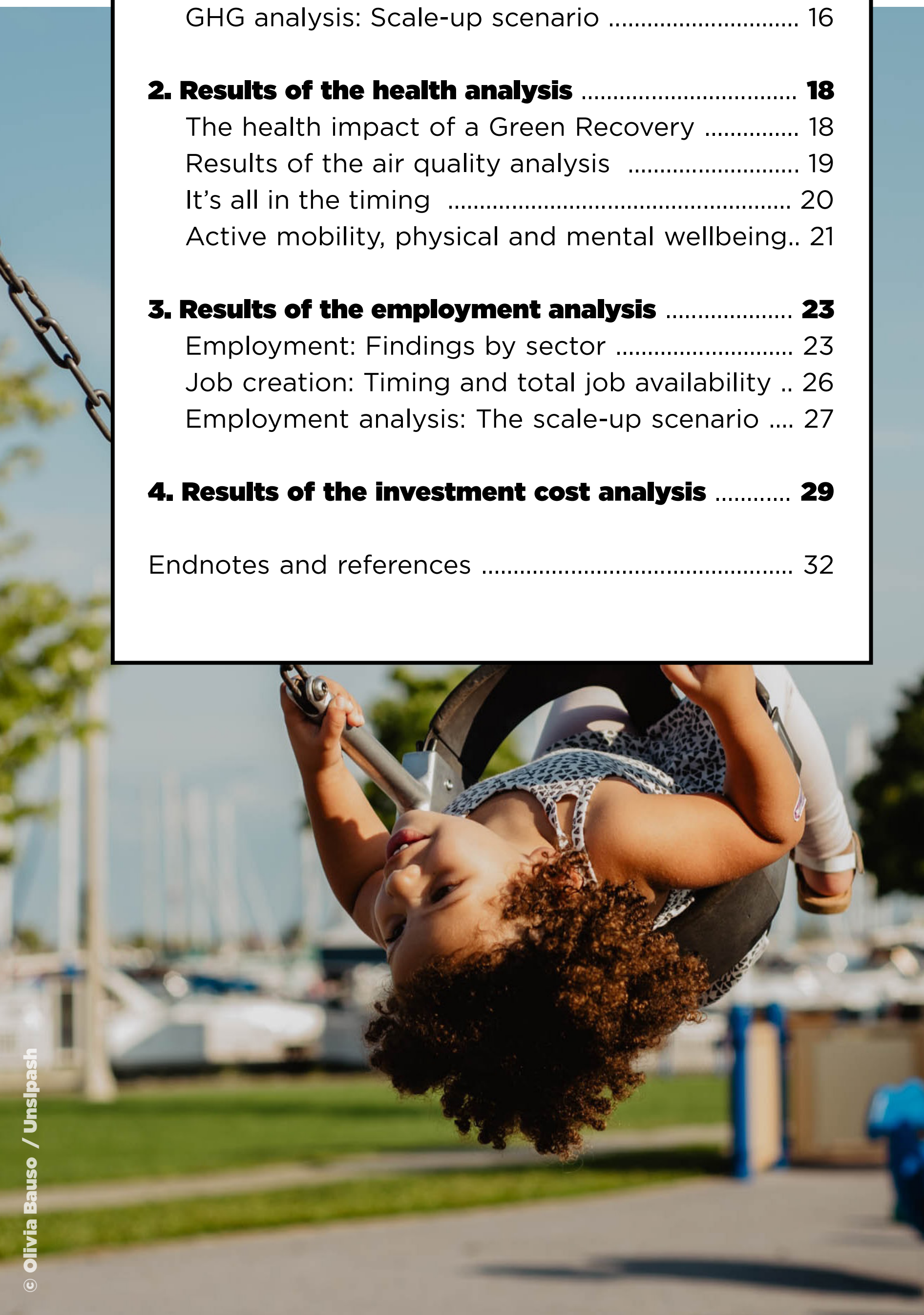

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Glossary

Green Recovery
A modelled scenario in which COVID recovery stimulus funding supports investment in climate action that prioritises the rapid creation of jobs and ensures that C40 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 and gross domestic product (GDP) growth. Note that the BAU scenario 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.

High-carbon Recovery
A modelled scenario in which an amount equal to the COVID-19 stimulus funding required for a Green Recovery is spent on maintaining and enhancing existing urban infrastructure, most of which is carbon-intensive. This scenario is based on the BAU scenario, but with an artificial increase in investment to match the Green Recovery scenario. Investment has been increased proportionally based on BAU and does not mimic any specific stimulus.

Accelerated Green Recovery
A modelled scenario in which capital stimulus funds are spent over the next three years, to end 2023, and any associated climate actions (and the impacts of these actions) occur over the next five years, to end 2025.

Standard Green Recovery
A modelled scenario in which capital stimulus funds are spent over the next five years, to end 2025, and any associated climate actions (and impacts of these actions) occur over the next 10 years, to end 2030.

Slow Green Recovery
A modelled scenario in which capital stimulus funds are spent over the next seven years, to end 2027, and any associated climate actions (and impacts of these actions) occur over the next 15 years, to end 2035.

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 USD 1 million spent on final product.

Job year
One full-time job for one year. Five job years can comprise 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.

Mortality rate
Number of deaths in the population.

Morbidity rate
Rate of disease in the population.

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

Pathways Tool
A customisation of the World Bank's Climate Action for Urban Sustainability (CURB) tool to address the specific needs of C40's Climate Action Planning (CAP) programme.

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.

Regional model cities: North America, Europe, Latin America, East and Southeast Asia, South and West Asia and Africa
The results are based on six model cities that represent different city types around the world. The BAU, Green Recovery and High-carbon Recovery scenarios were created based on these six model cities, to provide illustrative results for most of the regions in which there are C40 Cities members (Central East Asia was excluded due to a lack of Pathways Tool data).

Respiratory disease
A disease related to the lungs.

Sulphur dioxide (SO_2)
A toxic gas and major air pollutant derived from burning sulphur-containing fossil fuels.

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.

Volatile organic compounds (VOCs)
Organic chemicals emitted as gases from certain solid or liquid products, some of which can have short- and long-term adverse health effects.

Urban nature-based solutions
Actions to protect, sustainably manage and restore natural or modified ecosystems that effectively and adaptively address societal challenges while providing human wellbeing and biodiversity benefits, such as green roofs, parks and open spaces.

Acronyms and abbreviations

AQ	Air quality
BAU	Business as usual
CAP	Climate Action Planning
Capex	Capital expenditure
CDC	Centers for Disease Control
COVID-19	Coronavirus Disease 2019
CURB	Climate Action for Urban Sustainability tool (World Bank)
GDP	Gross domestic product
GHG	Greenhouse gas
HEI	Health Effects Institute
ICE	Internal combustion engine
IEA	International Energy Agency
ILO	International Labour Organization
O&M	Operating and maintenance
PM	Particulate matter
PV	Photovoltaic
WHO	World Health Organization
U.S.	United States of America
USD	United States dollar

Introduction

The C40 Mayors Task Force has analysed and modelled what could happen if the world'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 investments in key areas, such as mass transit, walking and cycling infrastructure and clean energy. Such a Green Recovery approach would have transformational economic and health benefits for C40 cities and their supply chains and put the world on track to keep global heating to less than 1.5°C compared with a business-as-usual (BAU) scenario.

The findings show that:

- Only a green and just recovery will allow for emission reductions. A green and just recovery, especially an accelerated one, could **more than halve greenhouse gas emissions by 2030**, making it possible to deliver on efforts to keep global warming below 1.5°C.

- A return to business as usual will lock in over-heating above 1.5°C.

- A green and just recovery could create **over 50 million good, sustainable jobs by 2025** across the nearly 100 cities in the C40 network and their supply chains, over a third more than investing equivalent funds into a High-carbon Recovery'.

- A green and just recovery could save hundreds of thousands of lives by **reducing air pollution as much as 29%** in cities around the world over the next 10 years, compared with a return to business as usual. Such improvements could **prevent over 270,000 premature deaths over the next decade** in C40's nearly 100 member cities.

- Improvements in air quality across C40's member cities alone could lead to over **USD 1.4 billion savings in health costs** resulting from reduced hospital admissions from respiratory and cardiovascular diseases and wider economic benefits of **USD 275 billion over the next 10 years** from the value of premature deaths averted. This is particularly valuable at a time when healthcare systems and public-sector budgets are facing unprecedented pressure.

- The timing of the recovery is key. By modelling the impacts of faster stimulus spending, enabling an accelerated green recovery over the next five years compared with a Slow Green Recovery over the next 15 years, the case for early investment by nimble governments, including cities, is clear:

    - An Accelerated Green Recovery could create over 80 million good, sustainable jobs to end of 2023, across the nearly 100 cities in the C40 network and their supply chains, more than double a Slow Green Recovery. At a time of mass unemployment and economic hardship in many parts of the world, generating jobs now will benefit millions of families.

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- An Accelerated Green Recovery could avert almost twice the number of premature deaths (over 1.8 times as many) between 2020 and 2030, with associated economic benefits from reduced health costs.

- An Accelerated Green Recovery could lead to half the per capita greenhouse gas (GHG) emissions of a Slow Green Recovery, and approximately a third of the per capita business-as-usual emissions by 2030.

The aim of the analysis

The objective of the analysis was to understand the multiple benefits of pursuing a green and just recovery between 2020 and 2030, specifically, the potential to create jobs and improve health in 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 countries around the world at the moment. Unfortunately, the majority of these stimulus packages have failed or are failing to use this public investment opportunity as a means to achieve long-term economic, and environmental and social targets.[1] This Mayoral Task Force research shows, however, that allocating stimulus funding to a Green Recovery that helps cities to reduce their emissions in line with a 1.5°C trajectory is a good use of public funding. It generates many jobs and has a significant impact on emissions, thus improving urban health by significantly improving air quality.

The report showcases how various recovery scenarios affect GHG emissions, jobs and health. We examine a Green Recovery scenario, an Accelerated Green Recovery scenario and a Slow Green Recovery scenario and compare them with a BAU scenario and High-carbon Recovery scenarios.

- 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 investment needed to deliver the Green Recovery scenario.[2] This was translated into job creation using employment multipliers from the available body of relevant literature and research. We created a High-carbon Recovery scenario for job creation by

proportionately scaling the estimated level of investment under the BAU scenario to the estimated level of investment in a Green Recovery. The High-carbon Recovery scenario allows us to make a balanced comparison of *how* the stimulus is invested, when the same amount is invested, but the funds go to different sectors or actions than in a Green Recovery scenario.

- 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.

- To highlight how the timing of a Green Recovery would affect key indicators, we modelled Accelerated, Standard and Slow scenarios for capital investment (capex), where all capex would be spent to end of 2023, 2025 and 2027, respectively, to bring about associated climate actions to be implemented by end 2025 (Accelerated), 2030 (Standard) and 2035 (Slow). Here, we assumed that investments needed to precede the full implementation of a climate action, hence the time lag between investment and implementation. The Accelerated, Standard and Slow scenarios are designed to provide a high-level illustration of the impact of timing on GHG emissions, job creation and air pollution. The Accelerated Recovery scenario, in particular, is more of a 'moon shot' in terms of ambition, assuming all capex investments are deployed swiftly, that sufficient green projects are 'shovel ready' and that there is sufficient capacity to implement them.

The results presented in this report are based on six model cities that represent the different types of city around the world. The BAU, Green Recovery and High-carbon Recovery scenarios were created using these six model cities to provide illustrative results for the regions of most C40 Cities members: North America, Europe, Latin America, South East Asia, South West Asia and Africa.[3] We have scaled the results from these model cities to cover all C40 cities, to give a sense of the potential GHG, job and health benefits across the C40 city network. This scale-up 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 region. In reality, however, because of the significant variations in city context, there will be variations in GHG-emission, job and air-pollution impacts 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 or regional data for all 96 C40 cities[4] to estimate more accurately the individual 1.5°C emission trajectories, associated investment costs, job-creation opportunities and air-quality impacts. To quote French historian Fernand Braudel, "real figures would be better but they do not exist".[5]

As C40 cities don't 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] Using this report as guidance, it will be possible to gauge whether national spending packages will have a big or small, positive or negative impact on a C40 city's emissions trajectory. The results can then be used in advocating for greener stimulus that would result in a world with lower emissions, more jobs and cleaner air.


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The models: BAU, the Green Recovery and the High-carbon Recovery

- The **Green Recovery** is a scenario in which COVID-19 recovery stimulus funding supports investment in climate action that prioritises rapid job creation and ensures C40 cities are on track to limit global warming to 1.5°C. We modelled three variations of the Green Recovery scenario: (1) a **Standard Green Recovery**, in which capital investment occurs over the next five years and climate action occurs from 2020 to 2030; (2) an **Accelerated Green Recovery**, in which a step-up in capex over the next three years enables all climate action to occur between 2020 and 2025; and (3) 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.

- The **BAU scenario** takes current levels of climate action and projects them into the future based on urban population and GDP growth. The BAU scenario does not take into account potential advances in technology or changes in policy. 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 investments (for example, in expanded transit networks) may help to reduce emissions, the overall effect may be marginal compared with the amount of investment required to align with a 1.5°C trajectory.

Selecting comparisons - 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 Green or a High-carbon Recovery and alter the BAU. However, for practical reasons (current data and modelling limitations) and conservative reasons (the BAU scenario underestimates stimulus benefits, as the majority of planned spending goes to support carbon-intensive infrastructure), we have compared GHG emissions and air-quality impacts against this baseline.

- In the **High-carbon Recovery** scenario, we assume the amount of COVID-19 recovery stimulus funding required for a Green Recovery goes to maintaining and enhancing existing city infrastructure, most of which is carbon intensive. This recovery scenario is based on the BAU scenario, but with a proportionate, artificial scale-up in investment to match the Green Recovery scenario, so we can compare how two very different but equally sized stimulus packages (one green, one not) affect job creation. The High-carbon Recovery scenario is not based on actual national stimulus packages (due to insufficient data), but is a high-level representation of the situation in which the world currently finds itself: where the vast majority of planned stimulus spending is being pumped into BAU, with an estimated 3–5% going to green investments (see methodology report for the description of the estimate).

Selecting comparisons - employment

- We have compared Green Recovery employment impacts with those of a High-carbon Recovery. As job creation depends on investment, the High-carbon Recovery scenario provides a more balanced comparison than the BAU scenario, which foresees lower total investment. Our decision was for practical reasons (investment, unlike climate actions and the associated GHG and air pollution, can be relatively easily scaled) and balance (comparing with the BAU scenario, devoid of stimulus investment, would have overestimated Green Recovery benefits).

1. Results of the GHG analysis

Results of the GHG analysis

The four scenarios modelled in this section are the:

- Accelerated Green Recovery (with climate action taking place in 2020–2025).
- Standard Green Recovery (with climate action taking place in 2020–2030).
- Slow Green Recovery (with climate action taking place in 2020–2035).
- Business as usual

When developing the Green Recovery scenarios for each of the six model cities, we first considered whether pre-populated data for model cities aligned with a Deadline 2020 trajectory.[7] We took into account the different regional emission trajectories set out in C40's Deadline 2020 report (namely, the Steep Decline, Accelerated Peak, Steady Decline and Slow Peak). If a model city's Pathways trajectory emitted more than its 1.5°C-compliant target trajectory, or if there was more scope to deliver more climate actions associated with high employment multipliers, we increased its scale of ambition, assuming that this would be supported by global stimulus focused on climate and equity. Once the model city's Pathways trajectory had met its Deadline 2020 emissions targets, while generating a significant number of jobs, we created its Standard Recovery scenario, setting the level of climate action and associated investment needed to prevent it from exceeding the level of emissions allowed by a 1.5°C trajectory.

We also modelled what could happen to GHG emissions if the model cities invested the same amount as the Standard Green Recovery scenario, but at a faster or slower pace. The purpose of these additional Accelerated and Slow scenarios was to show how the timing of investment and climate action is critical.

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Model cities

The model cities in this report represent a range of emission profiles, from high to low, and vary in terms of the composition of their emissions in 2020 (which will affect the actions chosen and the ambition of their targets). Of course, cities within a given region differ considerably, so these model cities should be treated as illustrations, not representations. We have listed the typical characteristics of the model cities, for analytical context. It is important to note that the populations of the model cities vary from less than 1 million to almost 10 million and that GDP ranges from around USD 30 billion to nearly USD 500 billion. These variations in size and wealth have a direct effect on the results, so absolute comparisons should be avoided.

- The **North American model city** is characterised by urban sprawl, a low share of mass transit and a relatively carbon-intensive grid.

- The **European model city** is characterised by medium density, with a lower share of public transit than the European average and a grid mix that is still relatively carbon intensive.

- The **East, Southeast Asian model city** is characterised by high density, significant building and waste emissions and a relatively carbon-intensive grid mix.

- The **Latin American model city** is characterised by medium density, a relatively high share of renewables in the grid mix and high shares of public transit and active mobility.

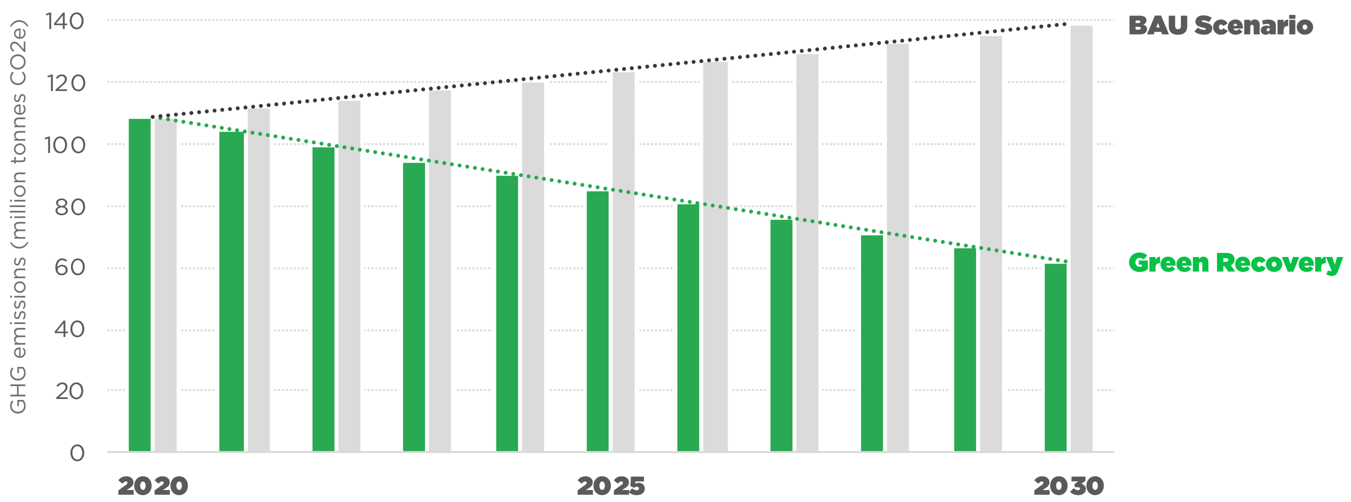
- The **South and West Asian model city** is characterised by high density, a carbon-intensive electricity grid, low share of private automobiles and rapidly growing building stock.

- The **African model city** is characterised by medium density, a carbon-intensive grid mix, a low share of active transport and high waste emissions.

Global GHG emission trajectories (2020-2030)

In Figure 1.1, we compare the Standard Green Recovery emissions trajectory and the BAU emissions trajectory for all six model cities. Under a Standard Green Recovery scenario, in 2030, the combined GHG emissions of the six model cities are 55% lower than under a BAU scenario.

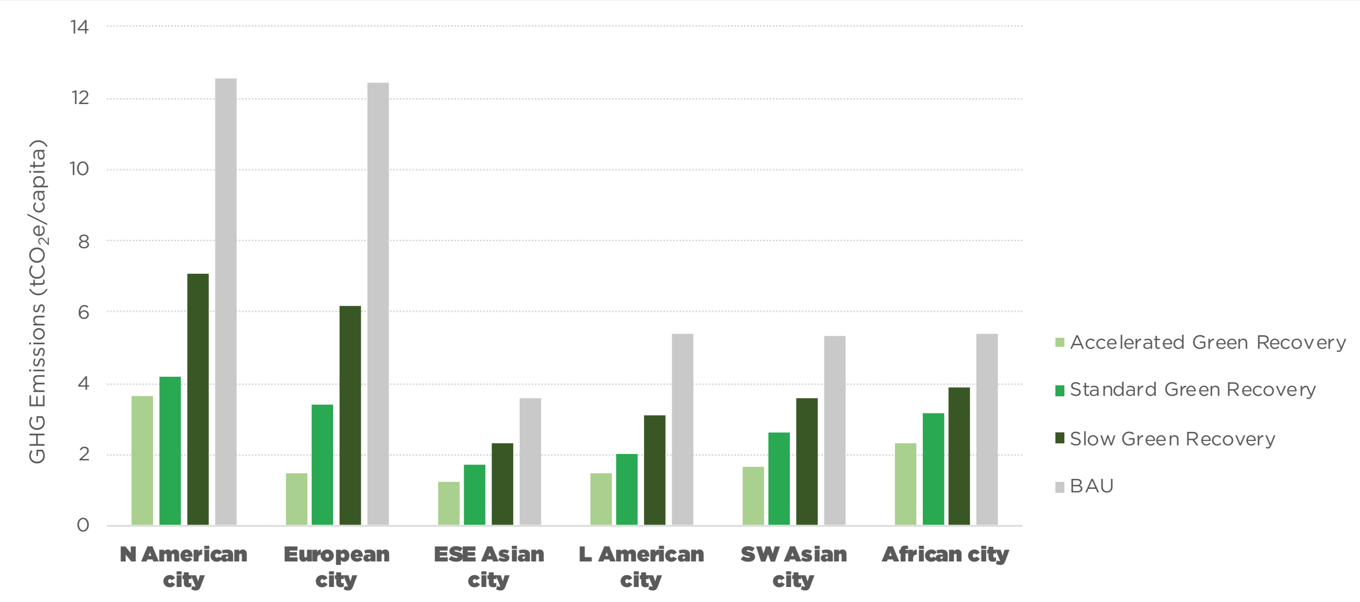
Figure 1.1: Combined GHG emission trajectories of the six model cities under a Standard Green Recovery scenario and a BAU scenario, 2020–2030.



GHG emissions per capita (2030)

Figure 1.2 shows GHG emissions per capita in 2030 for the four modelled scenarios. In 2030, the Accelerated Green Recovery results in around half the per capita GHG emissions of the Slow Green Recovery across the six model cities, on average.

Figure 1.2: 2030 per capita GHG emissions under the four 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. If the cumulative emissions exceed the Deadline 2020 target (denoted by the black dotted line in Figure 1.3), this means a city is not staying within its carbon budget and is not on track to keep warming to 1.5°C.

Figure 1.3 shows cumulative emissions reductions from 2020 to 2030 by model city under the three Green Recovery scenarios and the BAU scenario. It also shows which scenarios stay within the Deadline 2020 cumulative emissions targets through 2030 to illustrate the impact of an Accelerated, Standard and Slow Green Recovery on a city's ability to meet its Deadline 2020 commitment.

- **North American model city:** Both the Accelerated and Standard Green Recovery scenarios ensure that the North American model city's 2030 GHG emissions align with its Deadline 2020 target. A Slow Green Recovery leads to significantly higher GHG emissions in 2030, meaning the city would exceed its Deadline 2020 target.

- **European model city:** All three Green Recovery scenarios meet the Deadline 2020 target for the European model city. An Accelerated Green Recovery would reduce cumulative emissions by more than the city's Deadline 2020 target, increasing the probability of the European model city meeting its net zero target by 2050.

- **East, Southeast Asian model city:** All Green Recovery scenarios meet the Deadline 2020 target for the East, Southeast Asian model city, meaning that even a Slow Green Recovery would increase the city's probability of meeting its net zero target by 2050.

- **Latin American model city:** Both the Accelerated and Standard Green Recovery scenarios ensure that the Latin American model city's 2030 GHG emissions align with its Deadline 2020 target. A Slow Green Recovery would exceed its Deadline 2020 target, while an Accelerated Green Recovery would reduce cumulative emissions by more than the city's

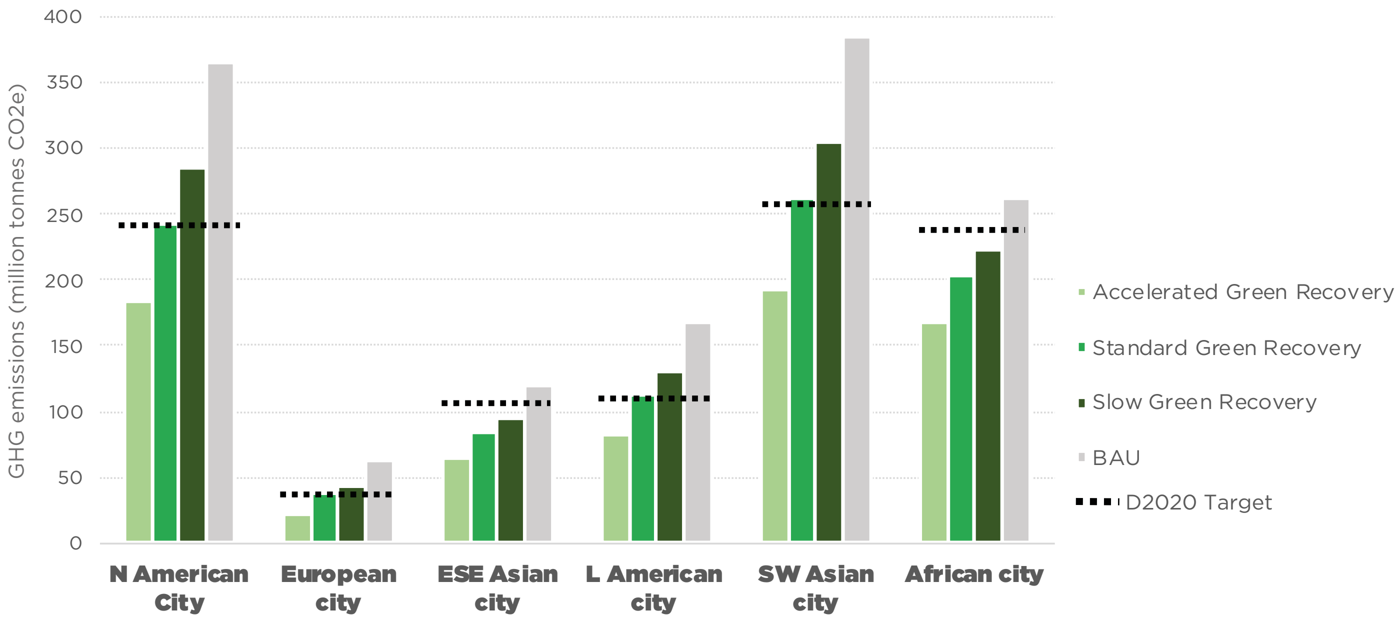


Figure 1.3: Cumulative GHG emissions by model city, 2020–2030.

Deadline 2020 trajectory required and increase its probability of meeting its net zero target by 2050.

- **South and West Asian model city:** Both the Accelerated and Standard Green Recovery scenarios ensure that the Southwest Asian model city's 2030 GHG emissions align with its Deadline 2020 target. A Slow Green Recovery leads to significantly higher GHG emissions in 2030, which means that the city would exceed its Deadline 2020 target. An Accelerated Green Recovery would reduce cumulative emissions by more than the city's Deadline 2020 requirement and increase the city's probability of meeting its net zero target by 2050.

- **African model city**: All three Green Recovery scenarios in the African model city ensure that it meets its Deadline 2020 target, meaning that even a Slow Green Recovery would increase the city's probability of meeting its net zero target by 2050.

Cumulative emissions reductions per sector

As a general point on Figure 1.4, a city's sectoral emissions profile in 2020 will determine the type and scale of climate action required to meet a Deadline 2020-compliant emissions trajectory in 2020–2030. If a city has a highly carbon-intensive grid in 2020, a large share of its emission reductions will be associated with energy decarbonisation. If a city is characterised by car-dependent urban sprawl in 2020, a large share of its emission reductions will stem from shifting to mass transit, walking and cycling. If a city has a relatively clean grid and high degree of mass transit, walking and cycling in 2020, then a large share of its emission reductions are likely to come from retrofitting the building stock. In almost all C40 and non-C40 cities, however, the level and profile of emissions will require significant action in all sectors to align with a 1.5°C-compliant emissions trajectory over the coming decade.

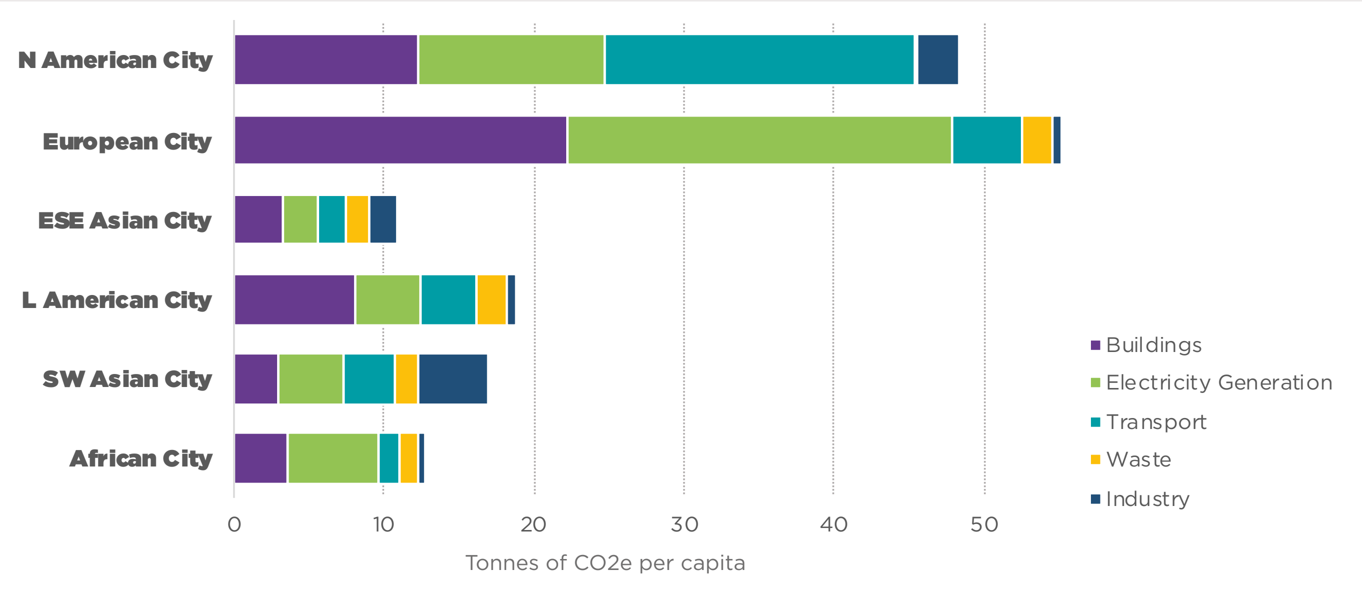


Figure 1.4: Cumulative per capita emissions reductions under a Standard Green Recovery by model city, 2020–2030.

• The model of per capita cumulative emission reductions from 2020 to 2030 under a Standard Green Recovery scenario shows that energy accounts for 34% of reductions, buildings 32% and transport 22%. This shows that Green Recovery investments in these sectors have high emission-reduction potential.

• Decarbonizing the energy grid is the driver of emission reductions from electricity generation. In the building sector, emission cuts are primarily achieved by enhancing the efficiency of new buildings and retrofitting the existing residential and commercial building stock. In the transport sector, decreases stem from the transition from private vehicles to mass and active transport, as well as the simultaneous electrification of passenger and transit vehicles using decarbonised power. In the waste sector, emission reductions are achieved by diverting and treating food waste, capturing landfill gas and improving recycling.

• **North American model city**: Significant emission reductions are achieved in the transport sector through measures to reduce the high auto share of a city characterised by urban sprawl. Energy efficiency and retrofit measures also lead to significant emission reductions in the building sector, while a decarbonisation of the grid, with a move away the current high dependency on coal and natural gas, leads to similar reductions from electricity generation.

• **European model city:** Significant emission reductions are achieved by increasing the share of renewable technologies, as the model city grid mix is slightly more carbon intensive than Europe as a whole. In European cities where the grid mix is cleaner, building emissions are likely to represent a larger share of cumulative emission reductions. Baseline transportation emissions are also relatively low compared with the European average, so reductions in this sector are less pronounced than in many other European cities.

• **East, Southeast Asian model city:** The building sector accounts for the greatest emission reductions due to the projected expansion of the building stock and far-reaching retrofit goals. Continued rapid urban growth is expected throughout the region over the coming decades. Buildings aside, moderate emission reductions are achieved in the transport, energy, waste and industrial sectors.

• **Latin American model city:** Significant emission reductions are achieved in the building sector thanks to new construction efficiency and retrofit measures. The model city has a high proportion of renewable energy in its baseline, reducing the potential for further energy emission reductions. As the grid mix and renewable targets vary from country to country and city to city in Latin America, this model is representative of some cities in the region, but not all.

• **South and West Asian model city:** The model city has high baseline of industrial emissions, so there are significant emission reductions in this sector. As the model city has a relatively carbon-intensive grid, increasing the share of renewable energy by 2030 leads to large emission reductions from electricity generation.

• **African model city:** The model city has a carbon-intensive electricity grid that is not representative of the region as a whole. Consequently, emission reductions from electricity generation dominate this model city. High emission reductions are also achieved in the building sector through new building efficiency and retrofit measures.

GHG analysis: Scale-up scenario

- Figure 1.5 shows the projected emissions for all C40 cities by region in 2030 under a BAU scenario and a Standard Green Recovery scenario. Note that the Standard Green Recovery scenario is based on Deadline 2020 trajectories.

- The emissions of all C40 member cities in 2030 could be more than halved (compared with BAU) under a Green Recovery scenario, avoiding the emissions of over 2.3 gigatonnes CO2e in 2030.

- The reduction is highest in high-income countries, as the original carbon budget analysis underpinning the Deadline 2020 programme assumes that these cities will shoulder a greater share of the emission-reduction burden in 2020–2030, based on their historically and/or currently high levels of emissions.

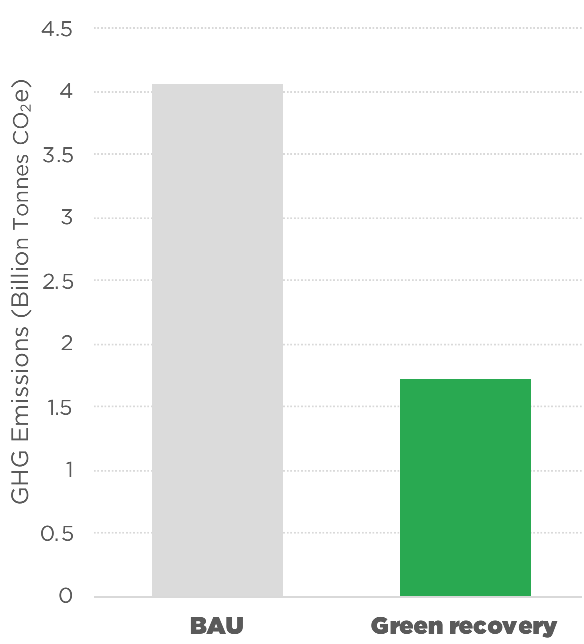


Figure 1.5: Projected emissions in 2030 for all C40 cities under a BAU scenario and a Standard Green recovery scenario.

2. Results of the health analysis

Results of the Air Quality analysis

Ninety-five percent of people in C40 cities are exposed to poor air quality that exceeds World Health Organization (WHO) recommended limits for air pollution. In 2019, total air pollution ($PM_{2.5}$, ozone and household air pollution) contributed to 6.67 million deaths globally, accelerating 1 in every 9 deaths.[8] Deaths from exposure to air pollution in 2020 are likely to outpace those resulting from COVID-19 in 2020. Moreover, there is growing evidence to suggest a link between exposure to air pollution and greater severity of COVID-19 infection in many areas,[9] making improvements in air quality even more critical for a post-COVID recovery.

Cities need to take action to improve the health of their citizens by increasing their mass-transit and active-mobility shares, switching the remainder of their trips to electric vehicles, improving building and industrial efficiency, and transitioning to renewable energy.

The health impact of a Green Recovery

- We have compared the difference in life expectancy, mortality and morbidity of citizens under BAU and Green Recovery scenarios for the six model cities.

- Results have been scaled up on the assumption that all C40 cities could achieve the same percentage reduction in air pollution as their regional model cities by taking ambitious climate action as part of a Green Recovery.

- In reality, the percentage reduction in air pollution will vary from city to city depending on its emissions and air-pollution profile and because factors other than local emissions 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 air pollution. The scale-up analysis, therefore, provides an illustration of the magnitude of the health impact a Green Recovery could have.

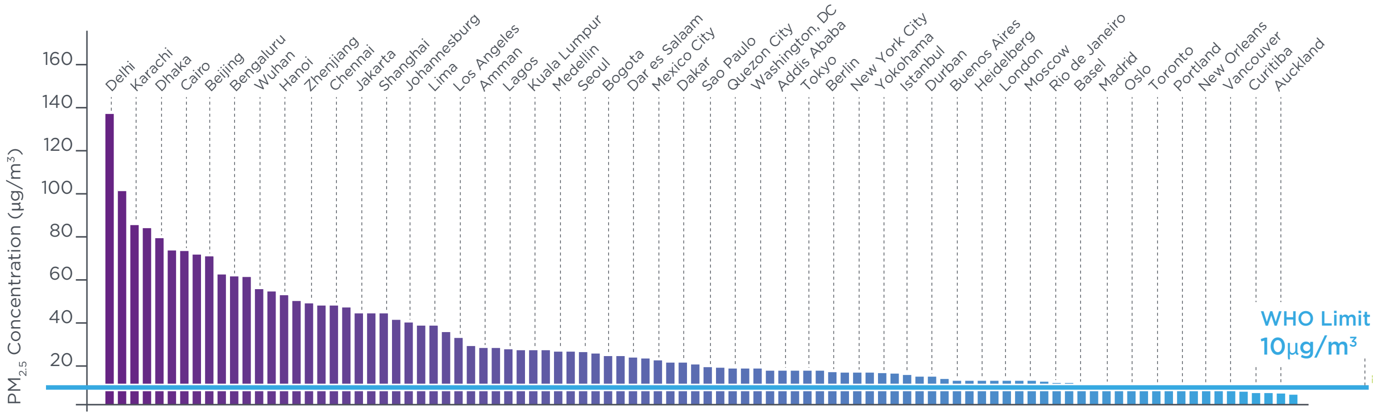


Figure 2.1: 2018 $PM_{2.5}$ annual concentration in C40 cities. For more information on air pollution and the health impact of climate action, see C40's Benefits of Air Quality report and the Air Quality Explorer.

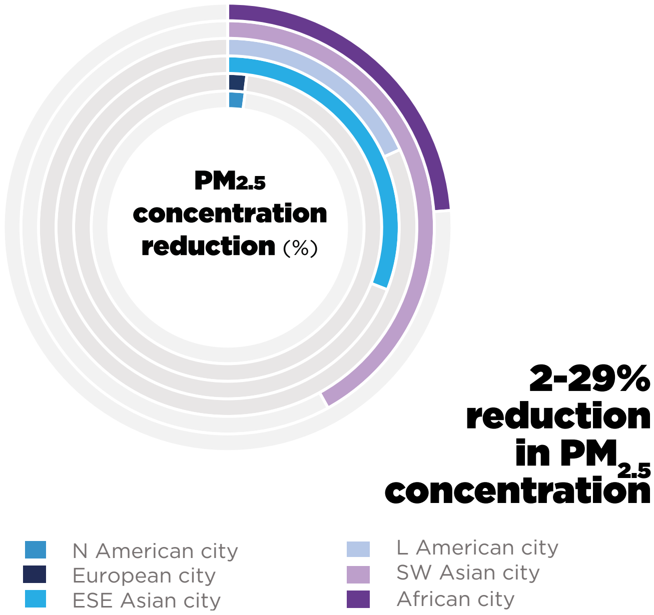
Results of the air-quality analysis

- The six regional city models suggest a Green Recovery will reduce air pollution by between 2% and 29% compared with BAU in 2030.

- The North America and European model cities show very small reductions in air pollution. This is probably due to source data from the Pathways AQ (Air Quality) Tool, which estimates $PM_{2.5}$ concentrations based on GHG emission inventories, which vary and can exclude key pollutants. Compared with other sources, the Pathways AQ results appear to underestimate $PM_{2.5}$ concentrations (for example, for Europe, the Pathways AQ tool only models 5% of the air pollution level measured by the city). Consequently, the air-quality results are likely to be underestimated for some regions.

- If we assume that all C40 cities could achieve the same percentage reduction in air pollution as the model cities in their regions, a Green Recovery could avoid more than **270,000 premature deaths between 2020 and 2030 (including 55,000 premature deaths in 2030 alone)** compared with BAU. This underscores the significant potential health benefits of a Green Recovery, but should be treated with caution. The high-level assumptions of the scale-up exercise mean that the figures merely illustrate the magnitude of potential benefits and are not a precise estimate. Limited source information also means the results could underestimate $PM_{2.5}$ concentrations for North America and Europe.

- Reducing emissions and air pollution has a positive impact on health, with knock-on benefits for healthcare costs. Using the same assumptions as before for all C40 cities, the models suggest that a Green Recovery could save **USD 1.4 billion (including USD 275 million in 2030)** in healthcare costs from avoided respiratory and cardiovascular hospital admissions between 2020 and 2030. This finding, too, should be treated with caution, however. A Green Recovery offers significant potential health savings compared with BAU,



Increase in citizens' life expectancy

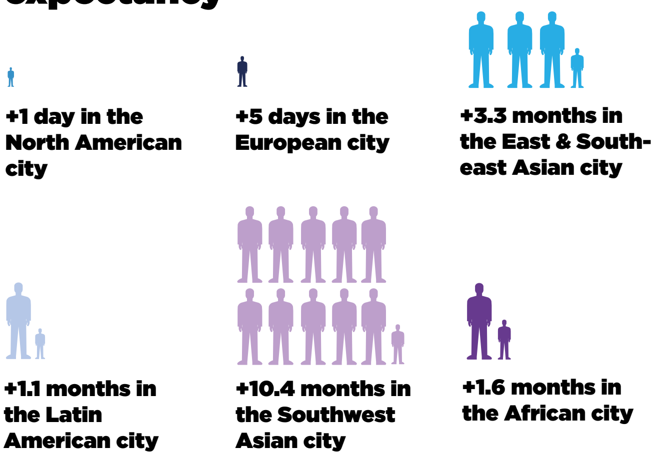


Figure 2.2: Relative reduction in $PM_{2.5}$ concentration in model cities versus BAU in 2030 (above) and increase in life expectancy (months) in 2030 versus BAU in model cities (below). For more information on air pollution and the health impact of climate action, see C40's Benefits of Air Quality report.

but this figure is an illustration of the scale of potential benefits, not a precise estimate. Note also that we assumed a constant reduction in the risk of hospital admissions, irrespective of the $PM_{2.5}$ baseline and decrease, so this may overestimate results in high-pollution contexts.

- The findings we have outlined are particularly pertinent right now 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.

It's all in the timing

- Another finding from the research is that timing matters. It is essential to act now. The earlier a Green Recovery is launched, the more lives can be improved and the more premature deaths can be averted.

- An Accelerated Green Recovery would avert almost twice (1.8x) as many premature deaths between 2020 and 2030 as a Slow Green Recovery. The economic value of the premature deaths averted would be more than USD 175 billion higher in an Accelerated Green Recovery than a Slow Green Recovery.

- Figure 2.3 shows the impact of an Accelerated, Standard and Slow Green Recovery on the number of premature deaths averted per year. The graph is based on a scale-up of the six model cities. As mentioned, we assume a similar relative reduction in air pollution can be achieved by all cities in a Green Recovery, but in reality, the percentage reduction will vary.

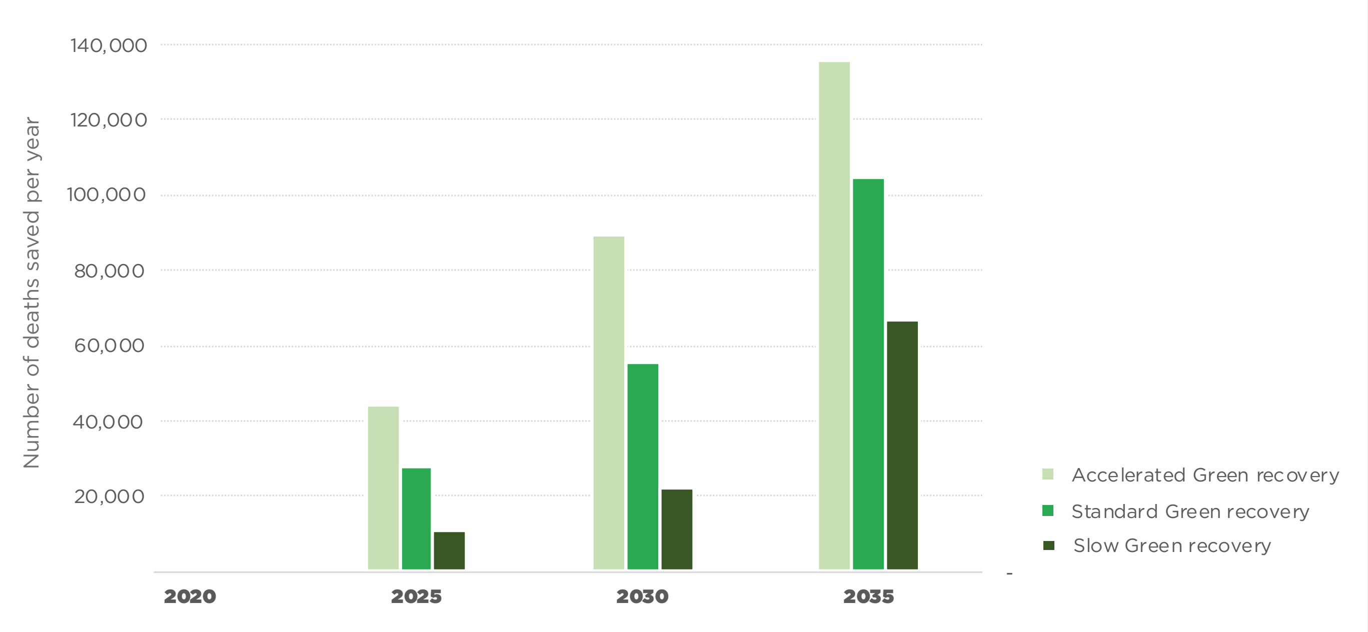


Figure 2.3: Modelled total number of premature deaths averted per year across all C40 cities in different Green Recovery scenarios compared to a BAU scenario over the period of 2020 to 2035.

Active mobility, physical and mental wellbeing

While our research has focused on modelling the impact of a 1.5°C-compliant Green Recovery on air quality and health, it is also important to note that a Green Recovery scenario has additional health benefits, as it promotes active mobility.

Obesity has tripled worldwide since 1975. Sedentary, indoor lifestyles coupled with increased calorie consumption pose a major threat to health. In 2016, more than 1.9 billion adults and 340 million children were overweight or obese.[10]

- Active mobility, by walking, cycling or taking other forms of exercise, improves physical and mental health and reduces the risk of dementia, depression, stroke, cardiovascular disease and type 2 diabetes, according to the WHO.[11]

- Switching from driving to an active commute (walking at a brisk pace or cycling 30 minutes a day, five days a week) can deliver the following health benefits:

  - A 23% reduction in the risk of heart disease.
  - A 23% reduction in the risk of stroke.
  - A 5% reduction in the risk of type 2 diabetes.
  - A 14% reduction in the risk of depression.
  - A 12% reduction in the risk of breast cancer.
  - An 11% reduction in the risk of dementia.
  - An 8% reduction in the risk of colon cancer.

- The impact of active mobility on cardiovascular disease and diabetes is especially pertinent in the context of the ongoing global pandemic. According to the Centers for Disease Control, populations with already high incidences of cardiovascular disease and/or type II diabetes are at greater risk of severe illness from COVID-19.[12] Preventing disease has the potential to reduce the number of people vulnerable to COVID-19.[13]

Walking or cycling 30 minutes per weekdays could reduce:

Risk of heart disease and stroke by 23%

Risk of type 2 diabetes by 5%

Risk of depression by 14%

Risk of dementia by 11%

3. Results of the employment analysis

Results of the employment analysis

• The Green Recovery scenario generates more job years than the High-carbon Recovery scenario in the six model cities. On average, 8-17 job-years are likely to be created by USD 1 million of investment in the High-carbon Recovery scenario, while 10-21 job-years are likely for the same amount of investment under the Green Recovery scenario. The main explanation for this results is that the Green Recovery scenario assumes more investment in climate actions that have greater employment potential than the High-carbon Recovery scenario (based on a review of relevant employment literature).

• This 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. 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.

• 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, a Green Recovery investment generates more local jobs if the activity being funded requires a substantial amount of on-site labour. As supply chains are global, investments in 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 the city.

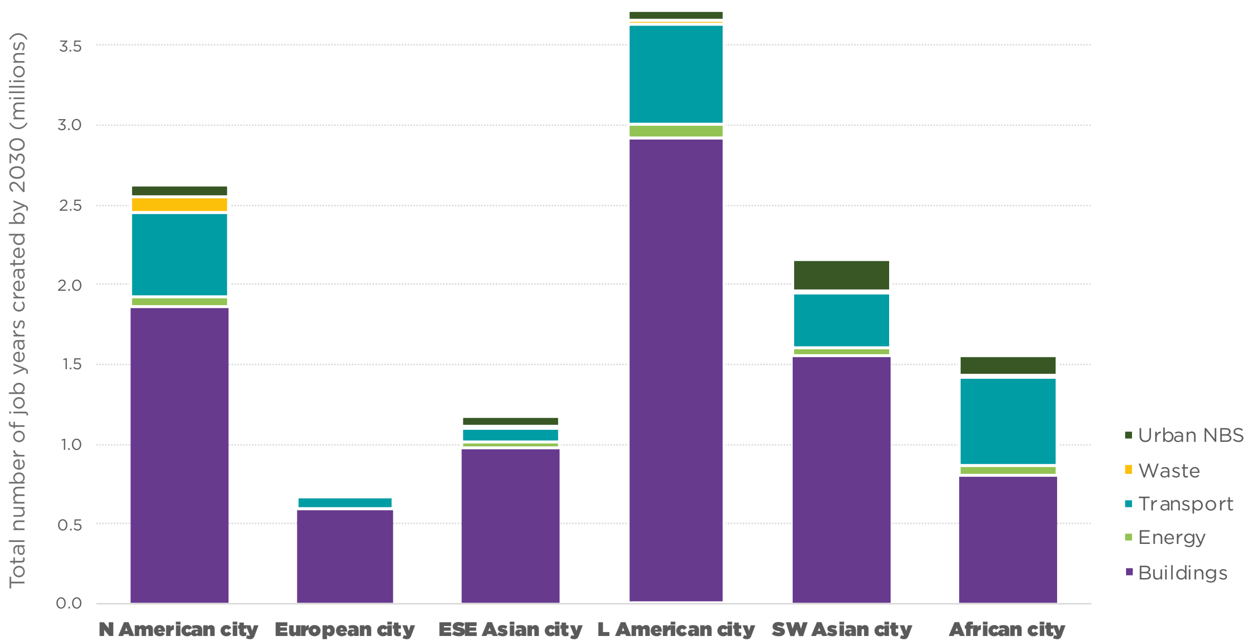


Figure 3.1: Job years created under a Standard Green Recovery scenario, by sector, 2020-2030.

- The sizeable variations in the populations and economies of the six model cities has a direct effect on the results of the employment analysis, so absolute comparisons should be avoided.
- Note, too, that while a Green Recovery scenario focuses on low-carbon infrastructure, capital investments will include the replacement of some existing infrastructure or systems, such as roads, over time.

- **Buildings**: Residential and office building retrofits and new energy-efficient construction are by far the biggest job-creating actions in all six model cities, as can be seen in Figure 3.1. This is down to the large investments cities must make in the building sector to align with a 1.5°C trajectory, combined with the relatively high jobs multiplier (defined as the number of jobs generated per USD 1 million invested) for new construction and building retrofits. Exact multipliers differ from city to city, but the International Energy Agency's (IEA) average global jobs multiplier is 14.8 for building retrofits and 15.2 for the construction of new, efficient buildings.[14] Moreover, these jobs tend to be generated relatively quickly, as many building proposals and retrofit projects can move rapidly from the planning phase to construction 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.

- **Transport**: The global average jobs multipliers vary for different types of transport investment. For example, the IEA estimates new mass-transit infrastructure (rail) at 6.6, new cycling infrastructure at 12.5 and charging infrastructure at 12.[15]

It is also worth noting that the Green Recovery scenario assumes fewer personal vehicles by 2030 than the BAU or High-carbon Recovery scenarios. A Green Recovery, therefore, sees less investment in new personal vehicles and and road infrastructure than the BAU or High-carbon Recovery scenarios, in addition to a transition to electric vehicles. These lower levels of investment affect employment in the auto industry, while the production of electric vehicles generally requires less manufacturing, maintenance and repair work than internal combustion engine (ICE) vehicles, according to the International Labour Organization.[16] It is, therefore, important that a Green Recovery also support the re-training and re-skilling of individuals who currently work in these fields. Jobs multipliers vary from country to country, too, however. The IEA estimates that the multiplier for electric vehicles is higher in less advanced economies (9.2) than in advanced economies (6.4).[17]

The net transport-related employment created in a city will depend on the number of people working in that city's ICE sector at the beginning of the 2020s and the number of people working on building, maintaining and providing mass transit services, electric vehicles and walking and cycling infrastructure.

- **Energy**: Energy investments in utility-scale infrastructure tend to generate fewer jobs per USD 1 million invested than building-related actions in the six model cities, as it is a highly capital-intensive sector, with a greater share of funds going on infrastructure and machinery than labour costs. According to the IEA, constructing new grids has an average jobs multiplier of 5.5, building new hydropower, 1.6, new nuclear power infrastructure, 1.5, and new wind power, 1.6. Distributed solar power is the exception, as it has a high jobs multiplier of 12.2 [18] thanks to the installation requirements involved (many units in many places throughout a city). While utility-scale energy investments tend to have long lead timelines, distributed solar photovoltaic (PV) panels also generate jobs more quickly, as installations require less planning and less upfront capital investment.

- **Urban nature-based solutions**: Most of the jobs associated with nature-based solutions are long-term jobs in operations and management. Moreover, ecosystem service-related jobs can be created quickly and offer accessible employment on various skill levels. We were not able to identify a global average jobs multiplier for urban nature-based solutions, but the New York State Office of Parks, Recreation, and Historic Preservation estimates the U.S.-specific jobs multiplier of investments in parks at 11.9.[19]

It is important to note that as well as variations in jobs multipliers from sector to sector, the size of a model city's population and GDP, its policy context, choice of climate action and level of investment will impact its results. Therefore, the employment analysis provides examples of how a green and just recovery could look in different cities and contexts. Direct comparison between the six model city or direct extrapolation of these findings to other cities should be avoided.

- **Waste**: The net waste-related employment effect will vary from city to city, depending on the current waste management system and level of waste. A city may, for example, transition from open dumping to waste processing at a landfill site, with an increase in recycling and composting. This would have a greater impact in terms of number of jobs than if a city already had a landfill site and some recycling and composting in place in 2020. Depending on the extent and type of investments necessary, and the level of waste being generated due to population growth and patterns of waste-generation, the net waste-related employment may be lower under a Green Recovery than a High-carbon Recovery scenario.

Investments in solid waste management are associated with relatively high jobs multipliers across all six model cities, especially those in developing countries. However, the magnitude of investment required is lower than in the buildings, transport or energy sectors, resulting in lower 'total jobs' figures for waste. According to the International Energy Agency, waste recycling infrastructure in advanced economies has a jobs multiplier of 13.1, while the jobs multiplier for non-advanced economies can be as high as 45.8.[20]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Job creation: Timing and total job availability

• Figure 3.6 shows the total number of jobs associated with capital investment in a Standard, Accelerated and Slow Green Recovery scenario. Note that the total number of job years is the same for all three. It is the total number of jobs created per year and the duration of those jobs that varies, with the Accelerated Recovery scenario creating more jobs per year over a shorter timespan. 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 Accelerated and Slow Green Recovery scenarios are based increasing or decreasing the five-year timeframe for capital investment by two years (see glossary). The purpose of this approach is to show how the timing of capital investments affects job creation. This analysis is solely for illustrative purposes; in reality, many urban investments cannot be carried out on such rapid timescales 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).

• What the modelling does show is that it is better to invest as much as possible as early as possible in Green Recovery actions from an emissions, air-quality and job-creation perspective. As can be seen in Figure 3.6, speeding up investments under an Accelerated scenario almost doubles the number of total jobs per year compared with the Slow investment scenario. This means that a greater number of job opportunities are created early on – an ideal strategy when seeking to usher in an immediate economic recovery from the pandemic.

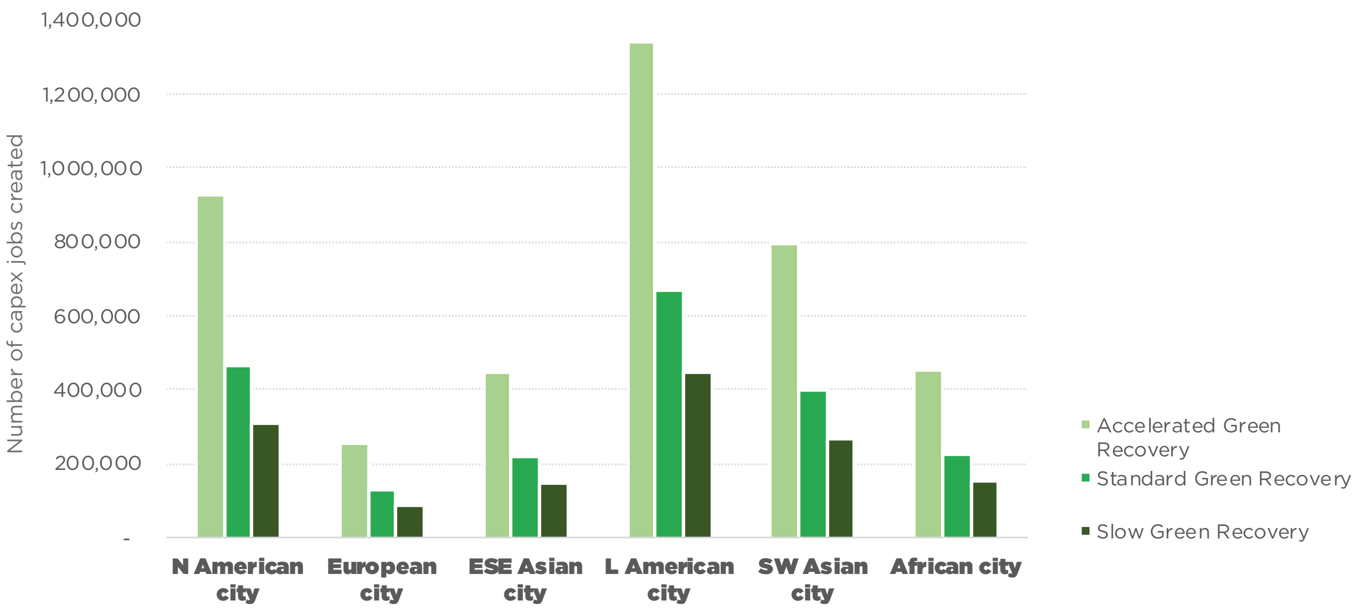

Figure 3.2: Total number of jobs associated with capital expenditure under the Standard, Accelerated and Slow Green Recovery scenarios.

An Accelerated Recovery will generate a higher number of total jobs, as large capital investments 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 scale-up scenario

- Table 3.1 shows the results of scaling up the Green Recovery employment analysis for all of the C40 cities. We did this by scaling them in line with the cumulative emission reductions required to bring each region in alignment with a 1.5°C (Deadline 2020) trajectory.

- Job generation is dominated by the buildings and energy sectors, which account for 74% of all jobs that would be generated under a Green Recovery scenario.

- Transport is the next-largest source of job creation, accounting for 20% of all jobs that would be created in a Green Recovery.

- The waste sector and jobs associated with urban nature-based solutions account for a more marginal share of employment, at 6% and less than 1%, respectively. While they may not be major job creators, ambitious action in these sectors is key to reducing GHG emissions in cities, as well as to 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 investment creates more jobs per year, underpinning the post-pandemic employment recovery.

Table 3.1: Number of jobs created under a Green Recovery scenario (million, across all regions).

	Buildings & energy	Transport	Waste	Urban nature-based Solutions	Total job in a Green Recovery
Jobs created (million)	**38.8**	**10.4**	**2.9**	**0.2**	**52.3**

Table 3.2: Number of job years (million) and total jobs (million) under an Accelerated, Standard and Slow Green Recovery Scenarios.

	Accelerated (capex over 3 years, O&M over 10 years)	Standard (capex over 5 years, O&M over 10 years)	Slow (capex over 7 years, O&M over 10 years)
Capex job years	239.9	239.9	239.9
O&M job years	43.3	43.3	43.3
Total job years	**283.2**	**283.2**	**283.2**
Capex jobs	80.0	48.0	34.3
O&M jobs	4.3	4.3	722.5
Total jobs	**52.7**	**39.0**	**10.6**

4. Results of the investment cost analysis

Results of the investment cost analysis

• 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. Investment costs are based on a city's baseline sectoral profiling data in the 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 investment 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 C40 city. All costs are reported in USD for the year 2020. As industrial initiatives and the associated investments can be highly specific and vary significantly from one sector or facility to the next, it was not possible to develop cost estimates for industrial projects.

• The investment cost calculations cover new investments in infrastructure and systems (such as vehicles or heating systems), the replacement and rehabilitation of infrastructure and systems and annual operating 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 the Mayoral Task Force is only indicative; a full cost analysis would require more time and resources. It is particularly difficult to identify cost benchmarks for cities in developing countries; in many cases, we had to rely on cost benchmarks from North America or Europe, or costs otherwise disaggregated by economic

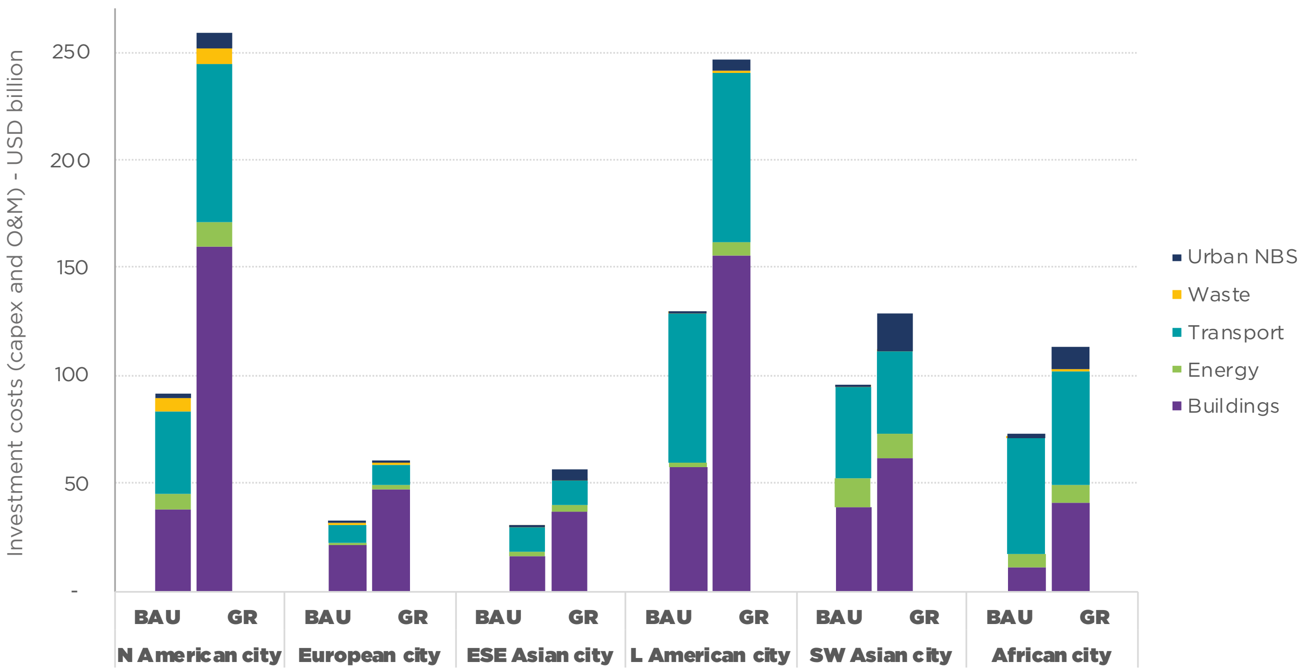

Figure 4.1: Investment costs under BAU and Green Recovery scenarios by sector, 2020–2030.

classification. The operational lifetimes of and commitments to fixed O&M costs may differ from city to city as a result, which may exaggerate the investment cost in those locations. That said, this cost exercise has provided a few interesting insights that can inform future research and discussions.

• Figure 4.1 shows how a Green Recovery that aligns with a 1.5°C trajectory will require twice as much investment as a BAU scenario, on average. However, in certain sectors and regions, such as transport (excluding the North American example), the costs under a Green Recovery scenario are fairly similar to those of a BAU scenario – the key difference being that Green Recovery investments meet climate targets and improve air quality.

• Figure 4.2 shows total investment cost as a percentage of city GDP. This is higher for cities in developing countries, which is to be expected, as investments, particularly in globally traded goods, carry similar costs no matter where they are and are inevitably more expensive on a relative basis for developing economies. In the North American and European model cities, investment costs are 5% and 3%, respectively, and deliver the largest emission reductions. The fact that Green Recovery investments are relatively more expensive for developing countries as a share of GDP underscores the need for financial support from developed countries, as stated in the outcomes of the 2009 United Nations Climate Change Conference (COP15) and in the outcomes of the 2015 United Nations Climate Change Conference (COP21), which produced the Paris Agreement. To date, the full scale of the pledged climate aid, of USD 100 billion a year by 2020, has not yet been realised. [21]

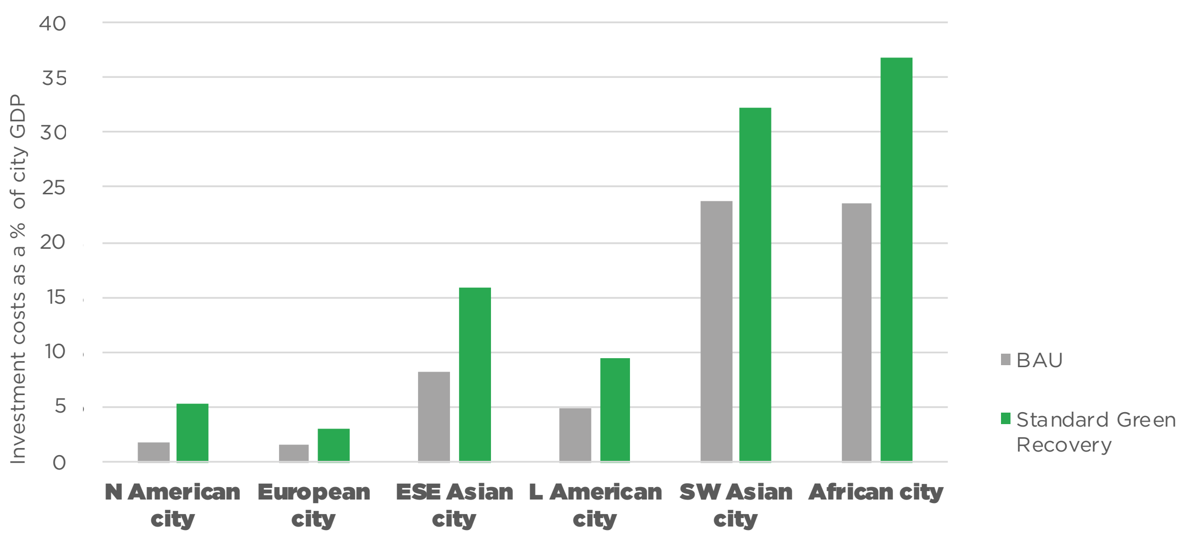

Figure 4.2: *Total investment costs as a share of city GDP under BAU and a Green Recovery scenario.*

- Achieving a 1.5°C trajectory will require significant investment in cities around the world. It will generally cost more to transform the buildings, transport, waste and industrial sectors in cities that have comparatively high emissions today.

- However, it is worth noting that it is not solely up to city governments to undertake this investment. A significant share of the necessary investment will be private rather than public and, among the public investments, the costs will be shared between local, regional and national governments.

- In the buildings sector, the government 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 equipment and appliances in buildings.

- In the energy sector, investments in infrastructure for distributed PVs, centralised renewables and nuclear power generally generate revenue streams from paying customers that cover the cost of the investments and also net a profit. Consequently, most of these investments will probably be made by private companies and publicly owned, profit-driven entities.

- In the transport sector, 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 these investments 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 investment costs relate to vehicle replacement. Under a BAU scenario, many 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 electric vehicles. In both instances, replacing vehicles will largely be financed by private investment, even though governments can provide subsidies for electric vehicles to reduce purchase costs, increase demand and incentivise the technological development and economies of scale that result in electric-vehicle cost reductions over time.

- Electric charging infrastructure is another key Green Recovery action that will require substantial investment. While an electric charging station is an asset that can generate a revenue stream, which may attract private investment, the experience of cities and countries around the world suggests that the public sector may need to incentivise or subsidise the initial construction of electric charging infrastructure before the electric-vehicle fleet is big enough to support a private market.

- In the waste sector, expanding waste and recycling infrastructure will largely require public investment, some of which can be funded by fees and taxes.

- When it comes to nature-based solutions, the expansion of green roofs may be a largely private investment 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.

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2 | This analysis is based on C40 cities' production-based emissions. These stem from activities that occur within a city's boundaries, rather than the population's consumption within those boundaries. This methodology was developed by the Intergovernmental Panel on Climate Change for national emissions reporting.

3 | Note that due to lack of data for the Pathways Tool, the Central East Asian region was not included in the six model city analysis. It was included in the scaled-up analysis.

4 | This analysis was completed before Ekurhuleni joined the C40 network.

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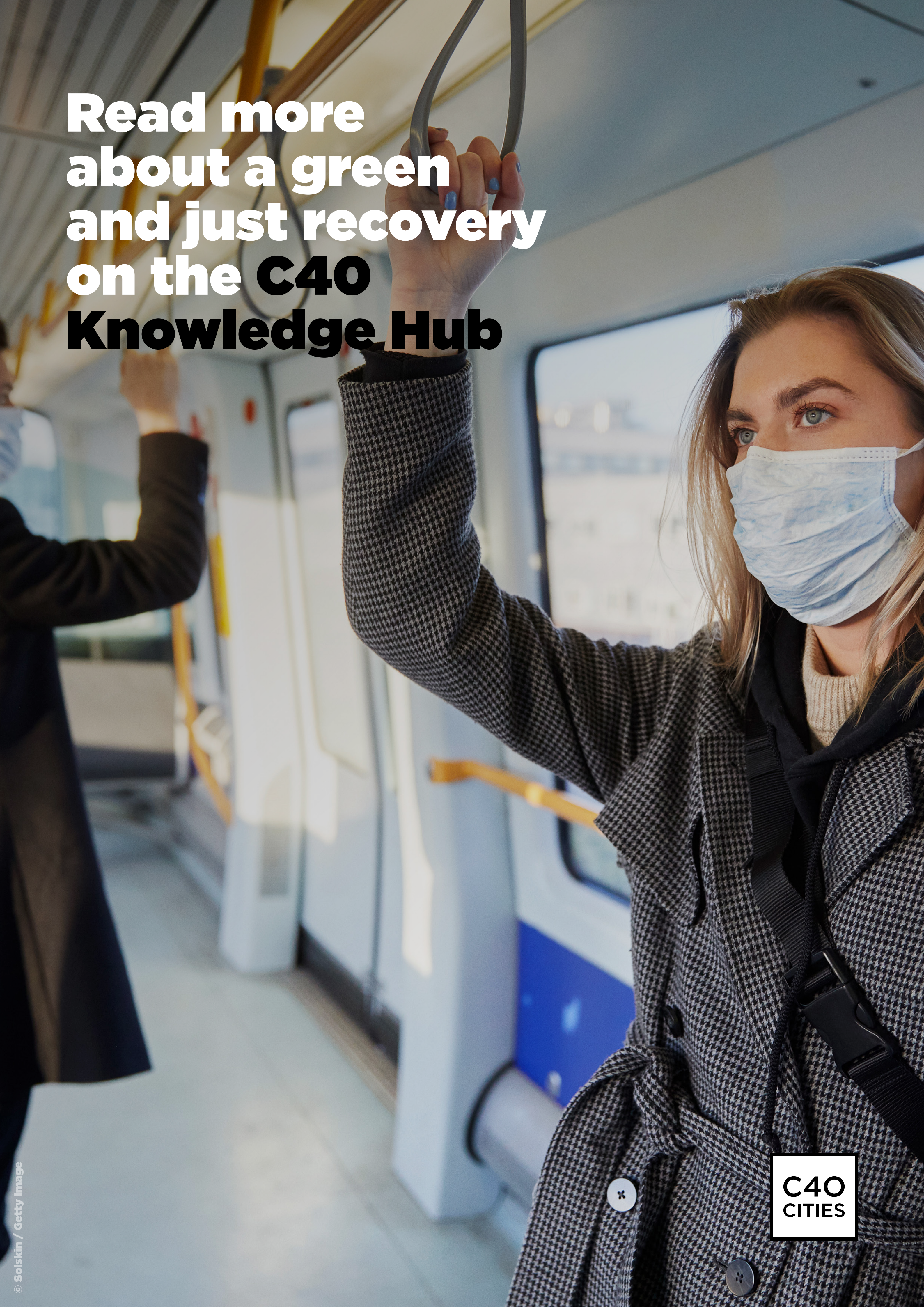

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