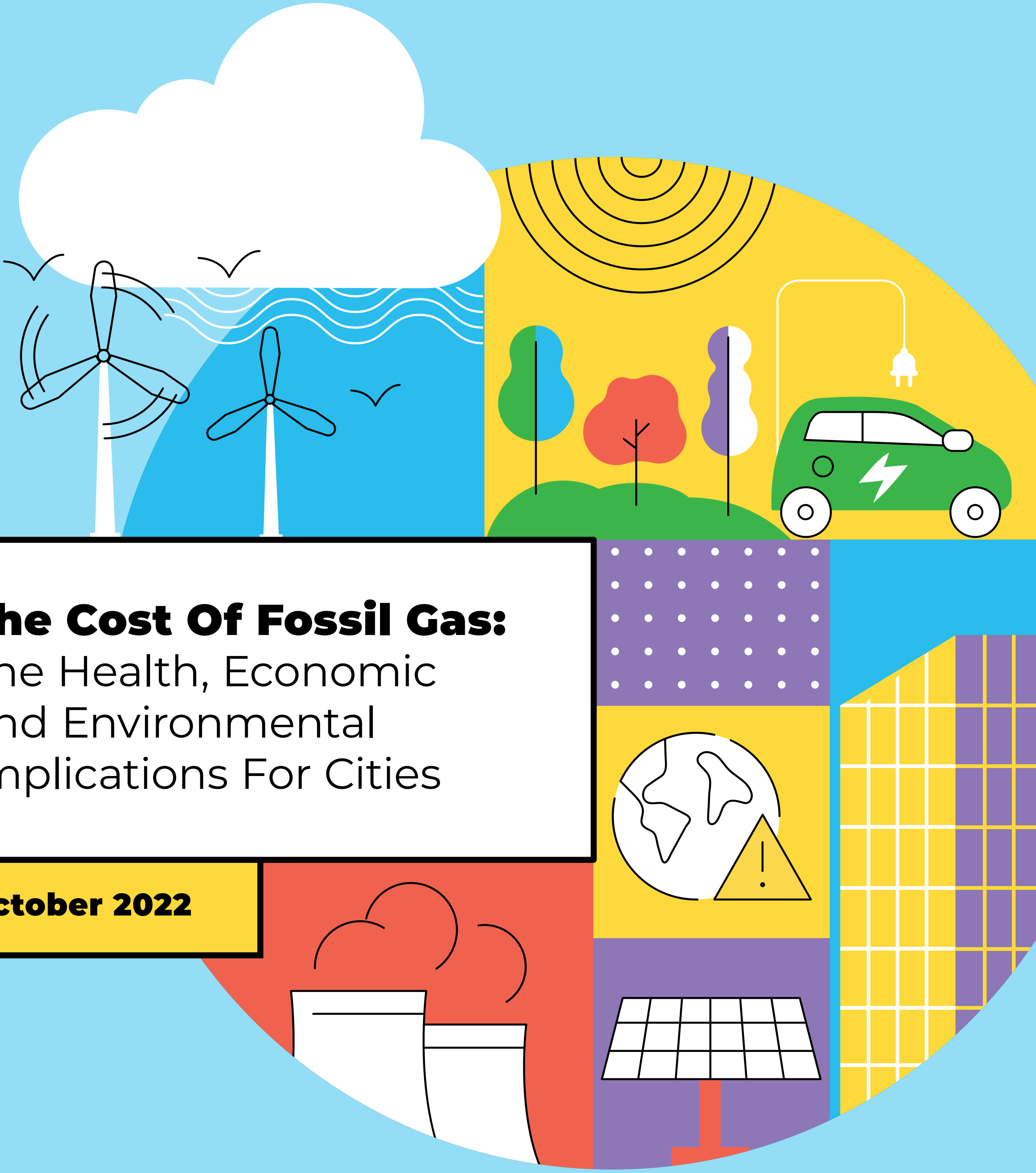

The Cost Of Fossil Gas: The Health, Economic And Environmental Implications For Cities

October 2022

C40 CITIES

C40 cities

C40 is a network of nearly 100 mayors of the world's leading cities who are working to deliver the urgent action needed right now to confront the climate crisis and create a future where everyone, everywhere can thrive. Mayors of C40 cities are committed to using a science-based and people-focussed approach to help the world limit global heating to 1.5°C and build healthy, equitable and resilient communities. Through a Global Green New Deal, mayors are working alongside a broad coalition of representatives from labour, business, the youth climate movement and civil society to go further and faster than ever before. The current Chair of C40 is Mayor of Los Angeles Eric Garcetti; and three-term Mayor of New York City Michael R. Bloomberg serves as President of the Board. C40's work is made possible by our three strategic funders: Bloomberg Philanthropies, Children's Investment Fund Foundation (CIFF) and Realdania. To learn more about the work of C40 and our cities, please visit our website or follow us on

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Wellcome supports science to solve the urgent health challenges facing everyone. It supports discovery research into life, health and well-being and is taking on three worldwide health challenges: mental health, global heating and infectious diseases.

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The Centre for Research on Energy and Clean Air (CREA) is an independent research organisation focussed on revealing the trends in, causes and health impacts of, and solutions to, air pollution.

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The Center for Global Sustainability (CGS) at the University of Maryland takes a collaborative, interdisciplinary approach to delivering research, education and engagement for policy impact. CGS was created in response to the global need for integrated analytics and engagement to support higher ambition in achieving climate, development and sustainability goals.

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Buro Happold is an international, integrated consultancy of engineers, consultants and advisers with a presence in 31 locations worldwide. For over 45 years, it has built a world-class reputation for delivering creative, value-led solutions for an ever-challenging world. It values human well-being and curiosity, embraces mutual responsibility and is committed to acting with the urgency required to tackle the climate and ecological emergency.

Contents

Glossary

1.5°C scenario: A scenario that is aligned with limiting global temperature change to 1.5°C over pre-industrial levels by the end of the 21st century. The scenario is implemented as regional and/or national net-zero targets, based on existing literature of different fair share approaches where higher-, middle- and lower-income cities reduce their emissions in line with net-zero targets at different points in time according to capability and responsibility for mitigating emissions.

Air pollution: In this report, particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2).

Asthma: A lung disorder characterised by a narrowing of the airways, causing shortness of breath, wheezing and coughing.

Carbon capture and storage: The process of capturing CO_2 before it enters the Earth's atmosphere and sequestering it indefinitely.

Cardiovascular disease: A disease relating to the heart and circulatory system, including stroke and problems with arteries or veins.

Current pledges scenario: A scenario that takes into account countries' unconditional nationally determined contributions (NDCs) and long-term net-zero targets. For regions without long-term net-zero target, the implied decarbonisation rates from the NDC pledges are extended in the post-2030 period.

Clean energy solutions: For the purposes of this study, clean energy refers to renewable energy, energy efficiency and energy demand measures.

Downstream emissions: Greenhouse gas (GHG) emissions that relate to burning a fossil fuel.

Fossil gas: This study adopts the term 'fossil gas' to reflect the fossil origin of what is usually called 'natural gas' or just 'gas'. Fossil gas comprises both liquified natural gas (LNG) and pipeline gas.

Green hydrogen: Hydrogen created through electrolysis using renewable electricity.

Integration costs: The costs that will be incurred by the electricity grid as a result of transitioning to renewable power sources.

Levelised cost of electricity (LCOE): The LCOE is the ratio of the cost to produce electricity over a generation project lifecycle, including capital expenditure and operational expenditure, to the megawatt-hours (MWh) expected to be generated over the project's lifecycle.

Ozone: Ground-level ozone is a harmful secondary pollutant that is produced when nitrogen oxides (NO_x) and volatile organic compounds react. Ground-level ozone is a key ingredient in smog.

NO_x: The collective term for the nitrogen oxides that are most relevant to air pollution, namely, nitric oxide (NO) and nitrogen dioxide (NO_2). These gases contribute to the formation of smog and acid rain and affect the ozone layer and human health.

$PM_{2.5}$: Fine, inhalable particles in the air, known as particulate matter, with diameters generally of 2.5 micrometres or less. These particles are a particular threat to human health, as they can travel deep into the lungs.

Respiratory disease: An illness relating to the lungs.

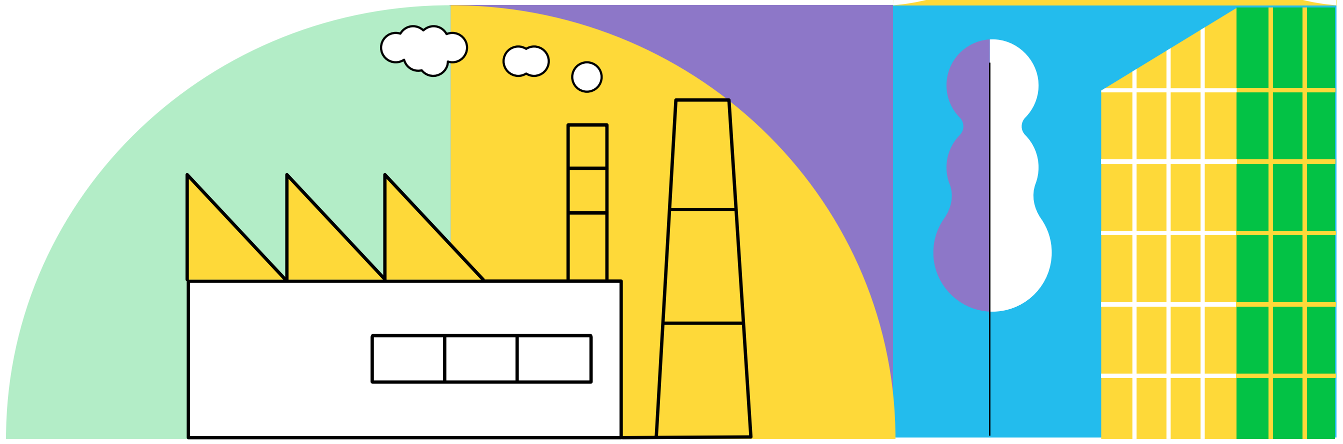
Smart grid: A national power network that uses information technology to deliver electricity efficiently, reliably and securely.

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

Upstream emissions: Upstream emissions are generated through the production, processing, transmission and distribution of a fossil fuel.

Acronyms

CCGT	Combined Cycle Gas Turbine
CCS	Carbon capture and storage
CGS	Center for Global Sustainability
CHP	Combined heat and power
CREA	Centre for Research on Energy and Clean Air
EJ	Exajoule
EU	European Union
GCAM	Global Change Analysis Model
GHG	Greenhouse gas
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LCOE	Levelised cost of electricity
LNG	Liquified natural gas
MW	Megawatt
NDC	Nationally determined contributions
PV	Photovoltaic
UK	United Kingdom
US	United States of America



Executive Summary

Fossil gas is not green – it is incompatible with a 1.5°C goal

The climate advantage of fossil gas over coal is greatly negated once methane leakages and upstream emissions are accounted for. Hence fossil gas, like all fossil fuels, is a key contributor to GHG emissions that are pushing us over safe limits of global heating. It is responsible for 10% of the emissions gap between current national climate pledges and our mid-century net-zero goal.

Our research shows we need to swiftly reduce fossil gas use by 30% by 2035 to stay on course for 1.5°C, but instead planned expansions will add 86% to fossil gas use capacity. Of these planned expansions, 33% are already under construction.

Fossil gas is not clean – it causes significant air pollution and damages health

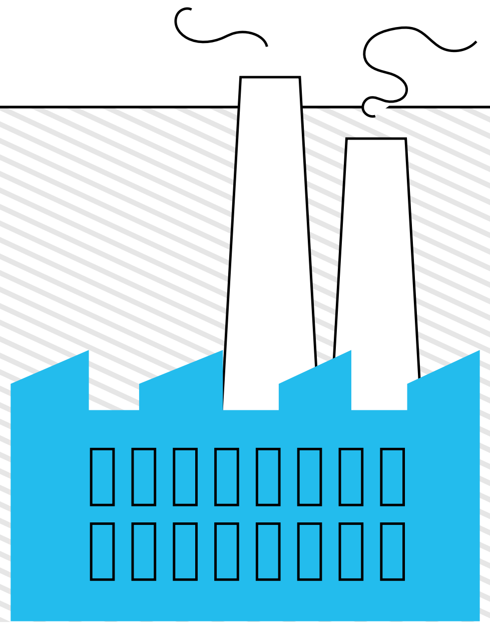
Our model shows that fossil gas use for electricity generation, heating and cooking in buildings as well as industry contributed almost as much as coal power plants to premature deaths in C40 cities in 2020. Fossil gas air pollution caused 35,987 premature deaths in 2020 across C40 cities, 40,327 new cases of asthma in children and 3,317 pre-term births. Our modelling shows that a swift clean energy transition away from gas could avoid as many as 217,045 premature deaths in C40 cities by 2035 and some 776,190 premature deaths by 2050.

These negative health effects also come at a financial cost. By 2050, a swift transition from fossil gas would avoid USD 7.5 billion in costs associated with childhood asthma, USD 7.2 billion in costs from early births, USD 11.3 billion from lost work and USD 3.9 trillion economic losses from premature deaths.

Renewables are cheaper and less volatile than fossil gas

While fossil gas prices are soaring, the cost of renewable energy technologies continues to decline. As of 2022, solar and wind are already cheaper than new fossil gas electricity generation in countries where 95 out of 96 C40 cities are located, including major fossil gas consumers such as the United States of America (US), the European Union (EU), the United Kingdom (UK), China and Canada.

The international price of fossil gas is volatile, putting supply at risk, as evidenced this year by the war on Ukraine. Diverse renewable supply mixes, combined with energy efficiency, battery storage and smart grids, offer a more economic, long-term and stable solution to the current energy crisis than gas expansion, offering shorter lead times and less price volatility.



A SWIFT CLEAN ENERGY TRANSITION AWAY FROM GAS COULD AVOID AS MANY AS 217,045 PREMATURE DEATHS IN C40 CITIES BY 2035

Clean energy creates more jobs and is an opportunity for a just transition

Urban clean energy action can drive employment. Every USD 1 million investment in utility-scale solar photovoltaic (PV) and wind energy would generate 1.7 times as many jobs as fossil gas power plants. And investment in residential retrofit and solar PV would generate six times as many jobs as the same investment in fossil gas.

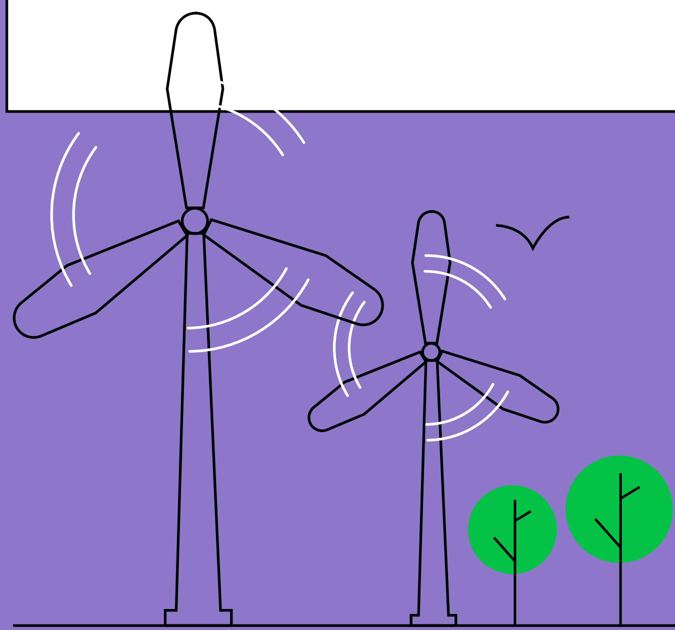
The transition to clean energy is an opportunity for a just transition and greater equality in terms of access to good, green jobs. For example, women already have a far stronger presence in the renewable energy sector than in fossil energy, making up 32% of the workforce compared with 22%. Concerted efforts will still be needed, however, to tackle skills gaps, to address barriers and historic inequities, and to ensure decent wages and conditions through regulatory action, participatory processes and collective bargaining.

Moreover, energy and fuel poverty are acute issues in many cities. Some 759 million people still live without electricity. Switching to renewables, combined with energy efficiency improvements and electrification, will help to make energy more affordable and accessible – alleviating cost of living pressures.

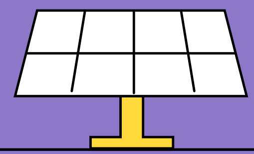
Cities are at the centre of the global energy transition

Cities account for two-thirds of global primary energy use,[1] meaning they both influence and are influenced by the shift from fossil fuels – including fossil gas – to clean energy. They are on the frontlines of both the climate and energy crisis and at the heart of the just transition. Cities around the world are already leading the transition by legislating and litigating for fossil gas phase-out, reducing demand, expanding renewables and decarbonising heating and cooling. And while they have varying power to act against fossil gas, cities are boldly leveraging their leadership – increasing municipal powers over energy and utilising city purchasing power and assets. They are setting the direction of travel through clean energy commitments and creating new market mechanisms to incentivise and accelerate the transition.

Throughout this report, we use the term 'fossil gas' to refer to fossil methane, including LNG and pipeline gas, but not including liquefied petroleum gas (LPG). We avoid referring to 'natural gas' to underscore the fact that it is a fossil fuel and to put an end to the misleading idea that gas is a 'natural' and 'clean' source of energy. The combustion of fossil gas still results in GHG emissions and air pollution.



INVESTING IN RESIDENTIAL RETROFIT AND SOLAR PV GENERATES 6 TIMES AS MANY JOBS AS FOSSIL GAS



Key findings

1 Cities are central to a swift, just transition away from fossil gas

2/3
Cities account for two-thirds of global primary energy use.

20%
of the world's energy-related CO² emissions is **associated with fossil gas.**

3/4
of global fossil gas consumption occurs in countries where C40 cities are located.

2 Fossil gas is not green – it is incompatible with a 1.5°C scenario

The planned expansion will increase fossil gas capacity by

+ 86%
in and around C40 cities by 2035

... when it **needs to reduce by**

–30%
to comply with a 1.5°C scenario.

Between 2019 and 2050, this **reduction** represents

1.9 $GtCO_2e$
from gas use in buildings, electricity and industry in C40 cities.

3 Fossil gas is not clean

Fossil gas use for electricity generation, heating and cooking in buildings as well as industry **contributed almost as much as coal power plants to premature deaths in C40 cities in 2020.**

35,987
premature deaths

40,327
new cases of asthma in children

3,317
pre-term births

4 A clean energy transition is necessary and viable – renewables are cheaper and less volatile than fossil gas

In 2022,
solar and wind are already cheaper
than new fossil gas electricity generation **in countries where 95 out of 96 C40 cities** are located, and costs continue to decrease.

5 A clean energy transition brings economic gains and generates more jobs

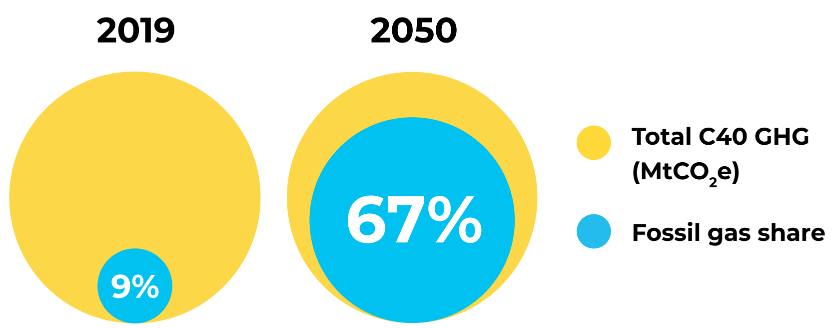
A 1.5°C scenario would avoid more than
USD 3.9 trillion
in health-related economic losses between 2020 and 2050.

Every USD 1 million investment in utility-scale solar PV and wind energy would generate
1.7 times as many jobs
as fossil gas power plants.

Investment in residential retrofit and solar PV would generate
6 times as many jobs
as the same investment in fossil gas.

6 National climate pledges current pledges are not enough

If C40 cities work to meet their 1.5°C targets but maintain the same levels of fossil gas consumption as under the current pledge scenario, the share of fossil gas will grow from 9% of C40 cities total GHG emissions in 2019 to **67% in 2050.**



Introduction

A swift, just energy transition excludes fossil gas

The combustion of fossil gas, often touted as a 'clean' alternative to coal, results in significant air pollution and GHG emissions and has harmful social, economic and environmental impacts. Fossil gas accounts for around a quarter of global energy supply and a fifth of carbon dioxide (CO_2) emissions from energy.[2] It is, therefore, a key part of the world's fossil-fuel problem.

Fossil gas consists largely of methane, a potent GHG. The climate advantage of fossil gas over coal becomes marginal if just 3.2%–3.4% escapes into the atmosphere before being burned[3] – in other words, at some point in the fossil gas supply chain, from extraction to transmission and distribution. Current research suggests that methane leaks may be more substantial than previously thought. Studies have found leakage rates of up to 17%[4] and estimated averages of 3.3% to 4.7% in cities – such rates negate the fossil gas GHG benefit.[5]

Fossil gas use results in air pollution and negative health outcomes. Our analysis shows that it contributed almost as much as coal power plants to premature deaths in C40 cities in 2020.[i] By contrast, we estimate that a swift, clean energy transition away from fossil gas could avoid as many as 217,045 premature deaths in C40 cities by 2035 and 776,190 premature deaths by 2050.[ii]

Moreover, the economic arguments for gas do not stack up. New renewable capacity already costs less than gas in almost every country and is on course to be cheaper than gas globally within the next few years. Renewable energy prices are also more stable than gas prices, which are highly volatile. Investing in gas creates fewer jobs than equivalent spending on renewable energy.

Consequently, decision-makers should focus on shrinking the role of gas in the energy mix and embrace the diverse rewards of a renewable future.

Despite its negative impacts, fossil gas consumption has been growing, not declining, over the past decade and this trend is set to continue. Several countries intend to increase their reliance on fossil gas – in contradiction to their national climate pledges and many C40 cities' ambitions – by constructing additional fossil gas infrastructure.

Cities are central to the energy transition. Fossil gas use and upstream emissions currently account for 9% of all GHG emissions in C40 cities. Of this 40% are from electricity generation, 39% are from buildings and 13% are from industry.[iii]

Urban households and businesses are key consumers. For example, urban consumption of fossil gas is now the main driver of gas demand in China – between 2006 and 2017, the share of urban gas consumption grew from 41.7% to 53.9%.[6] As key consumers, cities can have a huge impact across the fossil gas supply chain. The American Gas Association, for example, estimates that 90% of revenue from the sale of fossil gas in the US comes from the buildings sector, with residential gas sales accounting for nearly 70% of total revenue.[7] Cities are already using this consumer power and taking bold climate action, banning and reducing demand for fossil gas and increasing renewables – leading the way for a swift transition from fossil gas to clean energy globally.

i Across C40 cities, population-weighted premature deaths from coal-generated electricity in 2020 were 4.81 per 100,000, while the corresponding figure for fossil gas consumption was 4.06 per 100,000.

ii Due to the complexity of modelling indoor air pollution globally, this report only analyses the health impact of fossil gas-related outdoor air pollution. As such, the consequences of air pollution are probably an underestimate for many C40 cities.

iii The remaining 8% is from 'other' sources, such as transport.

To inform city action on fossil gas, we have undertaken a ground-breaking analysis of the climate, air quality and health impact of fossil gas use in C40 cities. Our research models the climate and health burden of this fossil gas use across electricity, buildings (heating and cooking) and industry on C40 cities and their citizens. The analysis looks at the fossil gas use required to limit global heating to 1.5°C compared with current national climate pledges and expansion plans to show the scale of the emissions gap and to highlight how investing in fossil gas is incompatible with climate goals.

Our analysis is clear: national pledges are insufficient and greatly worsened by expansion plans. Relying on fossil gas as a transition fuel is incompatible with our 1.5°C goal. Rather than supporting cities through an energy transition, fossil gas creates far more problems than it solves.

Transition pathways

The 1.5oC scenario takes into account different regional transition pathways based on existing literature of different fair share approaches, whereby total GHG emissions decline immediately after 2020 and reach net zero by 2040, 2050 and 2075 in different regions, depending on capacity and responsibility to act. We have also considered the quickest way of phasing out gas while maintaining a rapid coal phase-out, maximising clean energy and meeting forecast growth in global energy demand. Therefore, the 1.5°C scenario shows a slight increase in fossil gas consumption in some middle- and low-income countries until the late 2030s – within the overall global decline.

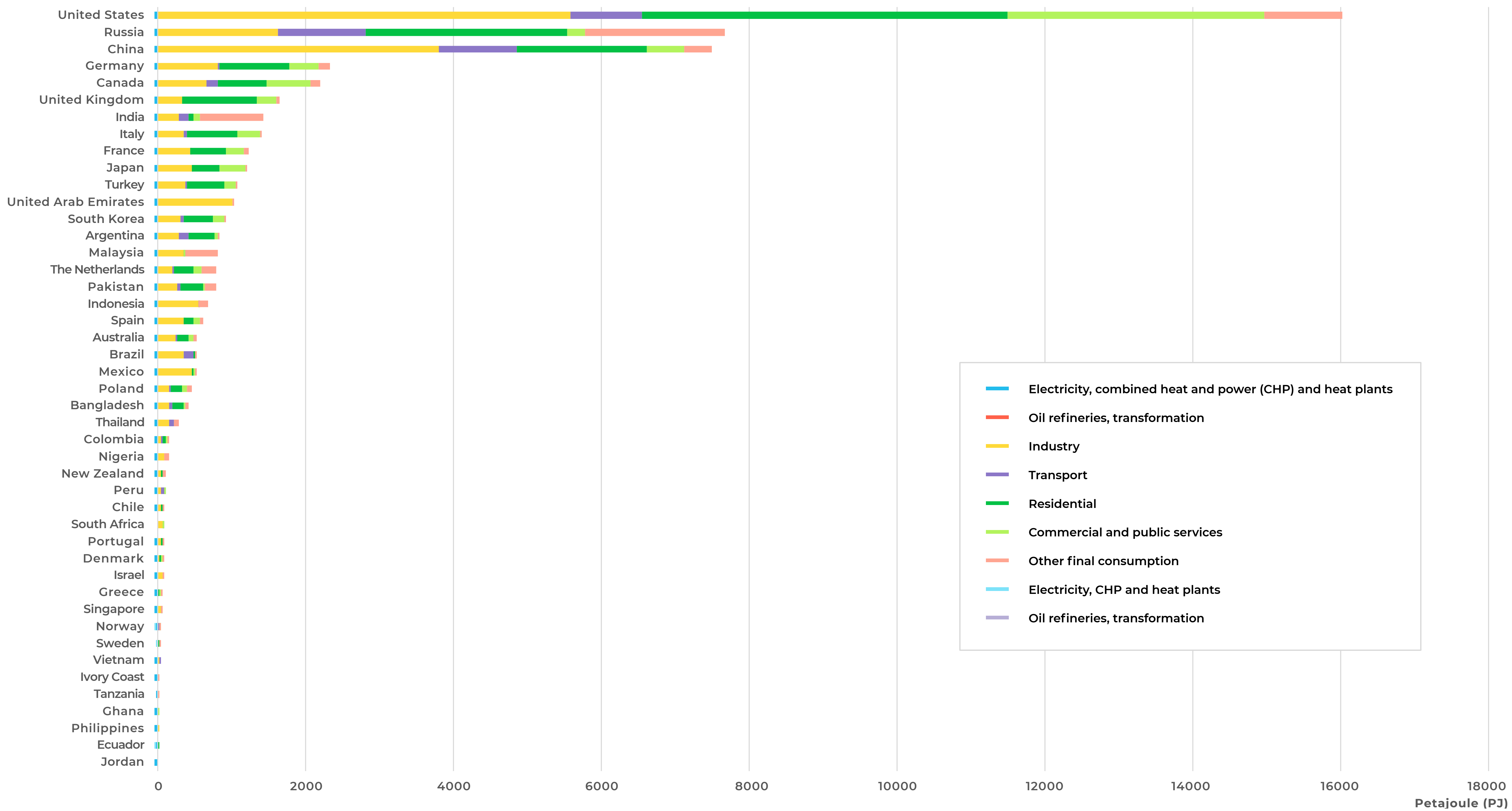
However, investing in new gas infrastructure should be avoided wherever possible. Even where fossil gas has scope to increase slightly during the 2020s and 2030s, usage needs to decline everywhere within 15 years, making fossil gas investments very short-lived. Additional investment risks locking in emissions, leading to missed climate targets and intensified climate change, as well as stranded assets and correspondingly high debt burdens, particularly in low- and middle-income countries. Around USD 1.4 trillion in global oil and gas assets are at risk of becoming stranded during the energy transition – about 44% of them gas.[8] Furthermore, our research covers the economic and employment impacts of fossil gas, showing how a swift transition to clean energy is not only critical for climate and health, but offers a cheaper, more secure and more equitable energy solution. Gas is no longer a good investment from a climate, health or economic perspective.

Consequently, we explore three transition pathways using detailed city use-cases: a rapid phase-out of fossil gas; a swift transition with a near-term switch to clean energy; and the opportunity to leapfrog from coal directly to clean energy without investing in gas. These case studies are underpinned by numerous examples of actions that cities around the world are already taking in order to transition from fossil fuels to a renewable future.

Three-quarters of global gas consumption occurs in countries where C40 cities are located, with the largest consumers being the US, Russia, the EU, the UK, China, Japan, Canada and the United Arab Emirates (UAE). These countries and regions, with the exception of China, are also near the top in terms of per capita consumption. Bangladesh, Pakistan and Argentina stand out when it comes to gas as a share of total (commercial) energy consumption.

Figure 1 | Fossil gas consumption in C40 city countries

Source: International Energy Agency (IEA) energy balance.[9]



Methodology summary

Developing scenarios

Our modelling is based on two main scenarios, the 'current pledges scenario' and the '1.5°C scenario', developed using a global integrated assessment model, the Global Change Analysis Model (GCAM).

The **current pledges scenario** is based on countries' current unconditional NDC pledges and long-term net-zero targets. For regions without long-term net-zero targets, the implied decarbonisation rates from the NDC pledges are extended in the post-2030 period.

The **1.5°C scenario** is based on fossil gas use in a world where GHG emissions decline rapidly to keep global warming within 1.5°C of pre-industrialised levels. This includes regional net-zero targets on three different timelines, based on existing literature of different fair share approaches and different equity principles, with regions grouped according to capability and responsibility for mitigating emissions.[10, 11] Higher current, historical and per capita gas usage in Global North cities, coupled with higher levels of income per capita, means that cities in high-income countries in Europe, North America, Oceania and East Asia rapidly phase out fossil gas to reach net zero by 2040. Cities in middle-income countries in Asia, Europe and Latin America swiftly transition to renewables to reach net zero by 2050. Developing countries in Asia, Africa and Latin America, meanwhile, reach net zero by 2075.

The 1.5°C-scenario shows one pathway to achieve the global 1.5°C goal. It is featured with limited temperature overshooting, limited carbon capture and storage (CCS) (based on current levels of deployment), limited biomass with CCS (for air quality reasons), limited nuclear sources, minimised fossil fuels, maximised renewables (solar and wind) and high electrification. It also reflects a reasonable increase in energy efficiency and shows growing total energy consumption in emerging country regions.

We have also developed a simplified scenario to assess the impact of currently planned fossil gas expansion. This **'expansion scenario'** is based on proposed gas power, gas pipeline and LNG import terminal projects.[12,13] Such projects are generally only planned up to ten years ahead, so we are only able to assess the impacts of the expansion until 2030. We assume that the expanded fossil gas capacity will be kept online until 2050, a reasonable assumption, as gas-fired power plants have a conventionally assumed lifespan of at least 30 years.[14]

Our analysis comprises both downstream and upstream emissions associated with fossil gas use in cities. Upstream emissions from extraction, production, processing, transmission and distribution account for 7% (0.36 $GtCO_2e$) of C40 cities' cumulative fossil gas-related emissions to 2050 under the current pledges scenario. While these emissions tend to fall outside cities' GHG inventories, as they occur beyond city boundaries, it is important to include them to understand the full impact of fossil gas. If a city consumes fossil gas with significant upstream methane leakages, this could mean that the climate impact of the city's fossil gas is considerably larger than locally released emissions would suggest.

For further details see the full methodology.

Air pollution and health modelling

The majority of the health impact from fossil gas operations stems from NO_x emissions, which influence ground-level NO_2, ozone and $PM_{2.5}$ concentrations through photochemical reactions and pollutant dispersion. To model these impacts across C40 cities, we have used a global chemistry-transport model (GEOS-Chem) that can simulate the combined influences of physical and chemical processes. We have analysed the impact of concentrated air pollutants on public health using well-established concentration response functions that relate the concentration of pollutants to mortality and morbidity risks.

Time frames

Our analysis looks at two time periods, 2035 and 2050, to compare short-term and long-term climate action, as well as short-term and long-term climate and health impacts. For GHG and air pollutants, we take 2019 as our baseline year, as due to the COVID-19 pandemic, 2019 is a more representative year than 2020 or 2021. We assess the health impacts of air-pollution concentration from 2020.

Jobs modelling

The jobs multipliers analysis was based on previous C40 work for the Green and Just Recovery research.[15] The analysis used IEA 'Sustainable Recovery World Energy Outlook Special Report' data across six C40 model cities. For this report, we created a global average from the six model cities' data. For the full details on the methodology, see the **Green and Just Recovery report.**

Developing city use-cases

To complement our global analysis, we have also developed city use-cases where we analyse how 1.5°C-compliant fossil gas transition pathways can play out in three C40 cities with different political contexts, varying levels of income and types of gas use. These cities are Montréal, Bogotá and Johannesburg. For this analysis, we have used C40's Pathways tool to develop climate mitigation strategies, together with a literature review and interviews with city officials and local energy experts, to better understand each city's unique context.

Cities included in the analysis

All C40 cities were included in this analysis. This was 97 member cities at the time of analysis, but though membership has dropped to 96 since then. Updates were made where feasible: the number of cities and countries where fossil gas is cheaper than renewables (during the time of analysis this was 95 out of 97 cities, and two C40 city countries where gas was cheaper). The rest of the report reflects C40 city membership at the time of analysis.

Chapter 1

Fossil gas is not green

Chapter 1.

Fossil gas is not green

Fossil gas is not green. To demonstrate the magnitude of the fossil gas climate problem, we have modelled GHG emissions based on current national climate pledges and compared these with the emissions cuts required to keep global warming within 1.5°C of pre-industrialised levels. This shows the scale of the emissions gap and highlights the role fossil gas plays in contributing to this gap. We have then explored how plans to expand gas production will widen this gap even further.

Fossil gas's contribution to the emissions gap

Our analysis shows that current climate pledges are not yet aligned with 1.5°C, as seen in Figure 2. The emissions gap between current national climate pledges and 1.5˚C is 6.1 $GtCO_2e$ in 2035 and grows to 19.5 $GtCO_2e$ by 2050. Fossil gas use in electricity, buildings and industry is responsible for 6% of this emissions gap to 2035, growing to 10% of the gap by 2050, making it a substantive source of GHG emissions that cities need to tackle if they are to align with a 1.5˚C scenario.

This indicates that phasing out gas is crucial alongside key actions such as phasing out coal-fired power. Relying on gas as a transition fuel will only preserve and expand the emissions wedge between current climate pledges and a 1.5°C scenario as the years go by. And while a very limited amount of gas use (for backup electricity, hard-to-decarbonise industrial processes, and cooking where it replaces more polluting fuels) is currently required, the findings are clear: relying on fossil gas as a transition fuel is incompatible with a 1.5°C scenario.

Figure 3 illustrates the emissions gap between announced fossil gas expansion, current pledges and a 1.5°C scenario globally and for the 20 C40 city countries with the biggest emissions gaps.

Figure 2 | illustrates the GHG emissions gap between current pledges and 1.5°C scenario, as well as showing the impact of announced gas expansion

Source: C40 Cities

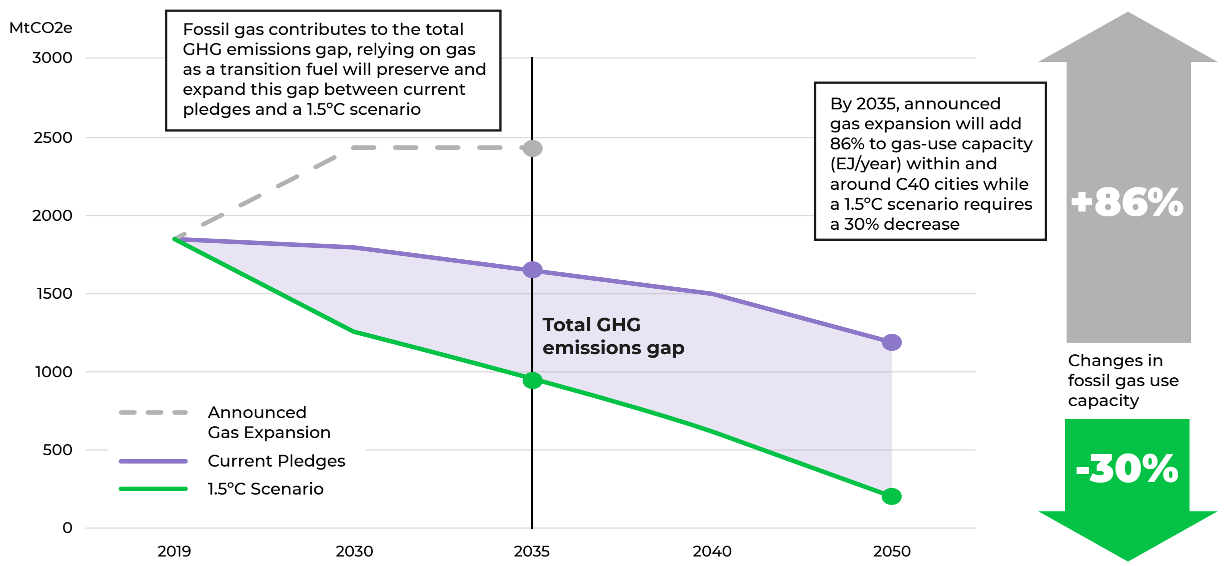
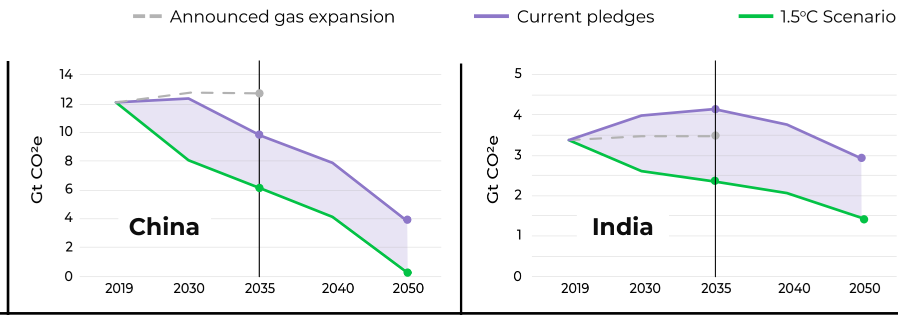


Figure 3 | National emissions gaps between current pledges and 1.5°C scenario

Graphs are ordered based on the cumulative $GtCO_2e$-size of the emissions gap



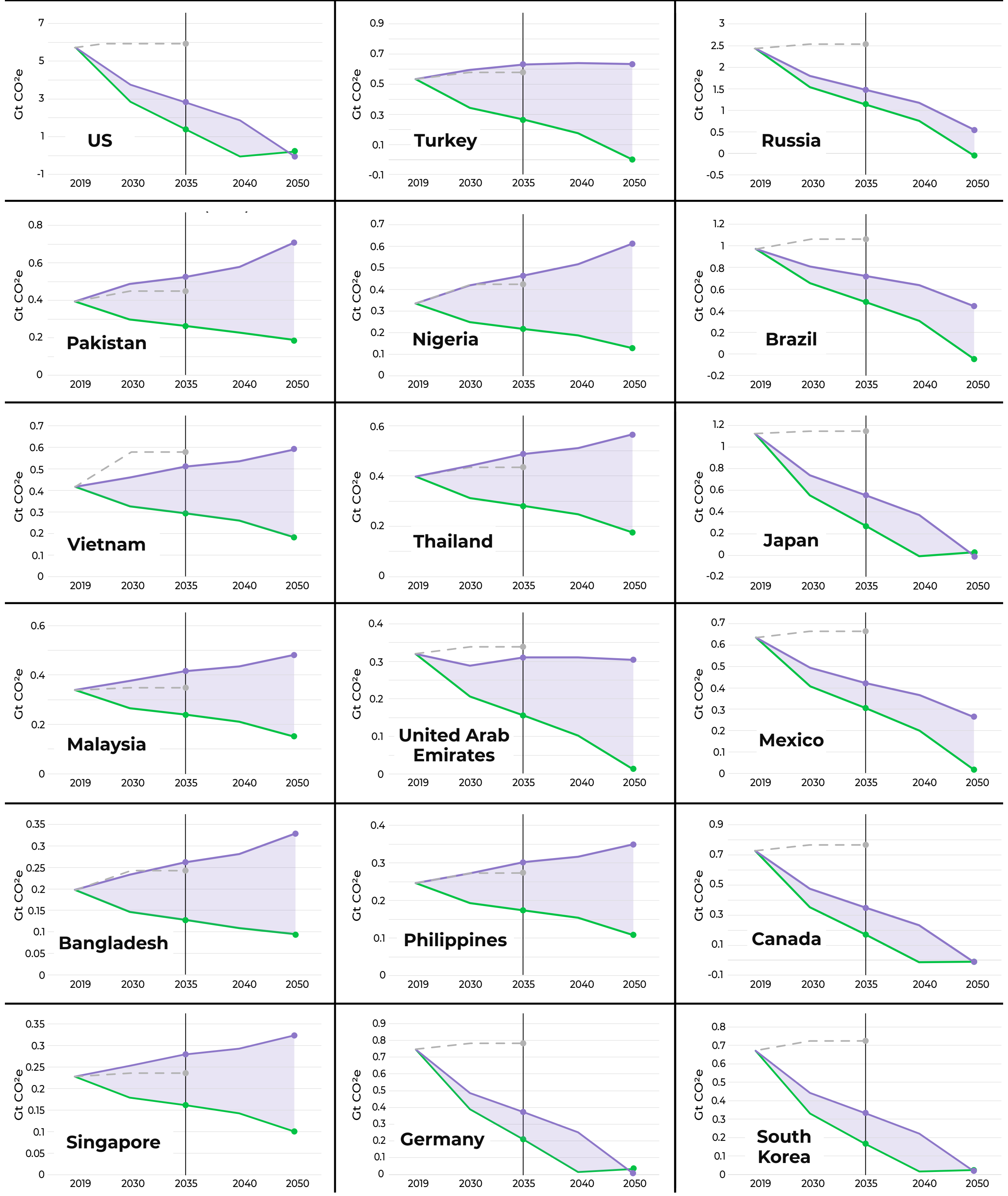
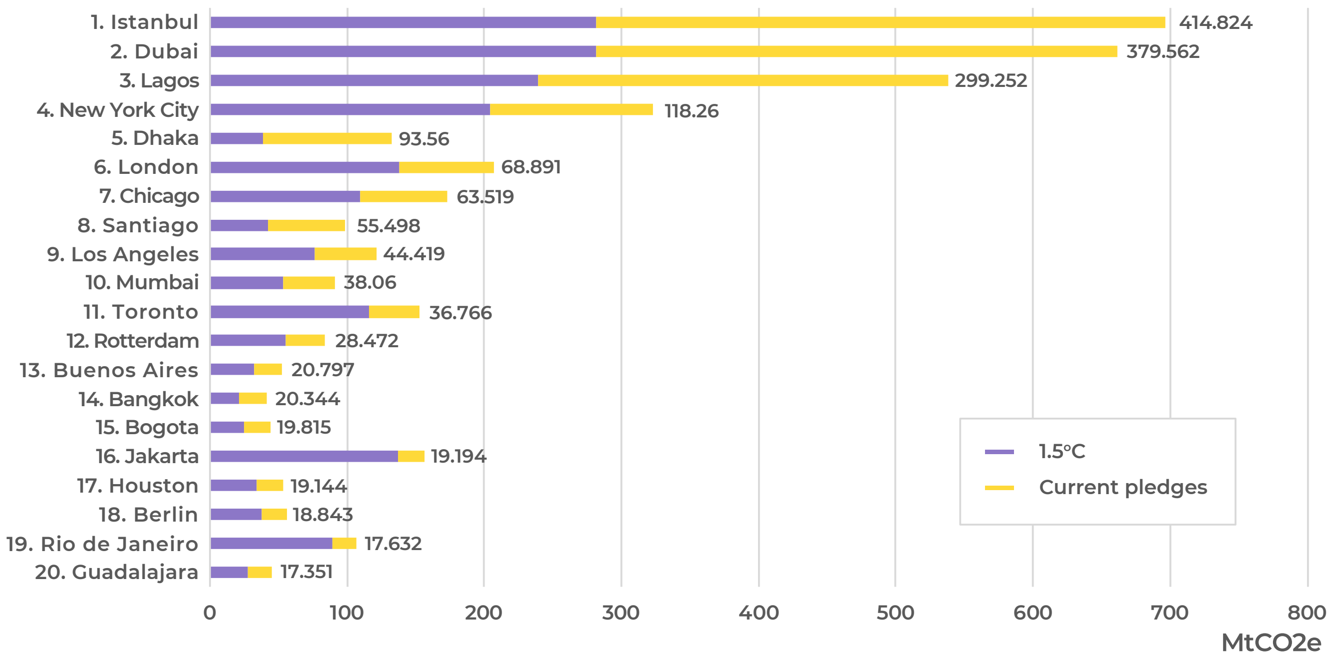


Figure 4 | Cumulative fossil gas-based GHG emissions by 2050 under a 1.5°C scenario and additional emissions under current pledges in the 20 C40 cities with the greatest emissions gap



Expansion plans are exacerbating the emissions gap

The total growth in fossil gas consumption over the past decade is set to continue, not decline. We have compiled data on proposed gas power projects[16] and infrastructure,[17] spanning planned power plants, CHP plants and infrastructure within and around C40 cities, but also new pipelines, terminals and gas fields connected to the gas transmission networks and power grids that supply them.[vi] The data show that several countries plan to increase, not reduce, their reliance on fossil gas by constructing or proposing to construct additional fossil gas infrastructure (see Figure 5). This expansion is already underway, with 33% of the projects and infrastructure under construction. The 19 C40 cities' countries with the largest expansion plans will create the capacity for additional 42 exajoule (EJ)/year, which is more than the world's biggest fossil gas consumer – the United States – used in 2019 (31.08 EJ/year).

This fossil gas expansion is even incompatible with current national climate pledges. Of the 49 C40 city countries that have pledged to reduce their GHG emissions from 2019 to 2050, 44 will end up with higher emissions due to the gas expansion they have announced or have under construction. These expansion plans will make it even more difficult for C40 cities to achieve the ambitions stated in their current pledges.

Unless C40 cities and other stakeholders take active measures to counteract this planned expansion, 83 C40 cities will be at risk of increasing fossil gas consumption rather than reducing it by 2035. In the same period, these plans will add 86% to gas-use capacity within and around C40 cities, while a 1.5°C scenario requires a 30% decrease. This fossil gas expansion is totally incompatible with a global 1.5°C scenario. It would mean 323 $MtCO_2e$ more GHG emissions from gas in 2035 than under a 1.5°C-compliant scenario. That is equivalent to 33% of C40 cities' total GHG emissions for that year under a 1.5°C scenario. The world simply cannot afford to increase fossil gas use on this scale.

vi These data are based on an update from Global Energy Monitor that includes many of the expansion plans announced or reactivated after the start of the Ukraine war.

Figure 5 | Current and planned fossil gas infrastructure projects in countries and regions with the greatest gas expansion plans

Source | CREA modelling for C40 Cities

Chapter 2

Fossil gas is not clean

Chapter 2.

Fossil gas is not clean

Advocates of fossil gas expansion and its use as a 'transition fuel' often emphasise how clean it is compared to coal. However, fossil gas is not a low-polluting energy source.

Our model shows that fossil gas use in power plants (for electricity generation), buildings (for heating and cooking) and industry in and around C40 cities resulted in nearly as many premature deaths per capita as coal plants in 2019. Replacing coal with fossil gas merely replaces one source of air pollution with another.

Air pollution from fossil gas combustion is all-pervasive in many C40 cities. It can originate within a city (from power plants, residential- and commercial-building boilers and industrial facilities) or blow in from afar, crossing jurisdictional and geographical boundaries. It is responsible for, on average, 8% of NO_x and 2% of $PM_{2.5}$ concentrations in C40 cities. Of this, industry contributes 35% of fossil gas-related NO_x emissions and 32% of $PM_{2.5}$, electricity contributes 42% of NO_x and 37% of $PM_{2.5}$ and buildings contribute 19% of NO_x and 22% of $PM_{2.5}$. It is critical to bear these sectoral contributions in mind when formulating a city's fossil gas reduction plan, as it should ideally take into account both GHG emissions and air pollution and plan sectoral approaches that maximise climate and health benefits.

Most of the health impact from fossil gas stems from NO_x emissions, which react with other chemicals in the air to form ground-level ozone and $PM_{2.5}$. These pollutants are harmful to inhale, as they can penetrate deep into the lungs and are linked to respiratory and cardiovascular morbidity and mortality, even at low concentrations. Fossil gas-related air pollution can lead to premature deaths from respiratory infections and diseases, pre-term births and long-term health issues associated with asthma, diabetes, stroke and chronic respiratory problems.

Fossil gas air pollution is not confined to the external environment. It permeates our homes. Studies in several countries show that the use of gas stoves in poorly ventilated buildings causes hourly safe exposure thresholds to NO_2 to be exceeded in minutes.[18] In the US, homes with gas stoves were found to have higher levels of indoor NO_2 than outdoor NO_2, no matter the season, and higher levels of NO_2 than households with electric stoves.[19] Of course, where fossil gas replaces more heavily polluting fuels such as charcoal, wood or kerosene for cooking, it brings substantial health benefits,[20] and such targeted application is considered a legitimate near-term use of fossil gas. However, this usage should be reconsidered as electric alternatives become increasingly viable and avoid the indoor air pollution from fossil gas.

It is important to note that our analysis only models the impact of fossil gas on outdoor air pollution and the consequent health burden. Due to the complexity of modelling indoor air pollution globally, this was excluded from the analysis. As such, the consequences of air pollution are probably an underestimate for many C40 cities.

The health impact of fossil gas use

Air pollution kills. We estimate that fossil gas use caused 35,987 premature deaths in C40 cities in 2020.

Air pollution exposure can contribute to the development of asthma, a chronic lung condition that affects a person's health and wellbeing over their lifetime. It resulted in 40,327 new childhood asthma cases in children and 10,676 asthma-related emergency-room visits in 2020 alone. Air pollution exposure significantly increases the likelihood of pre-term births and low birthweights, exacerbating the risk of infant death, lifelong health damage, diabetes and cardiovascular disease. In 2020, 3,317 pre-term births in C40 cities can be attributed to fossil gas use.

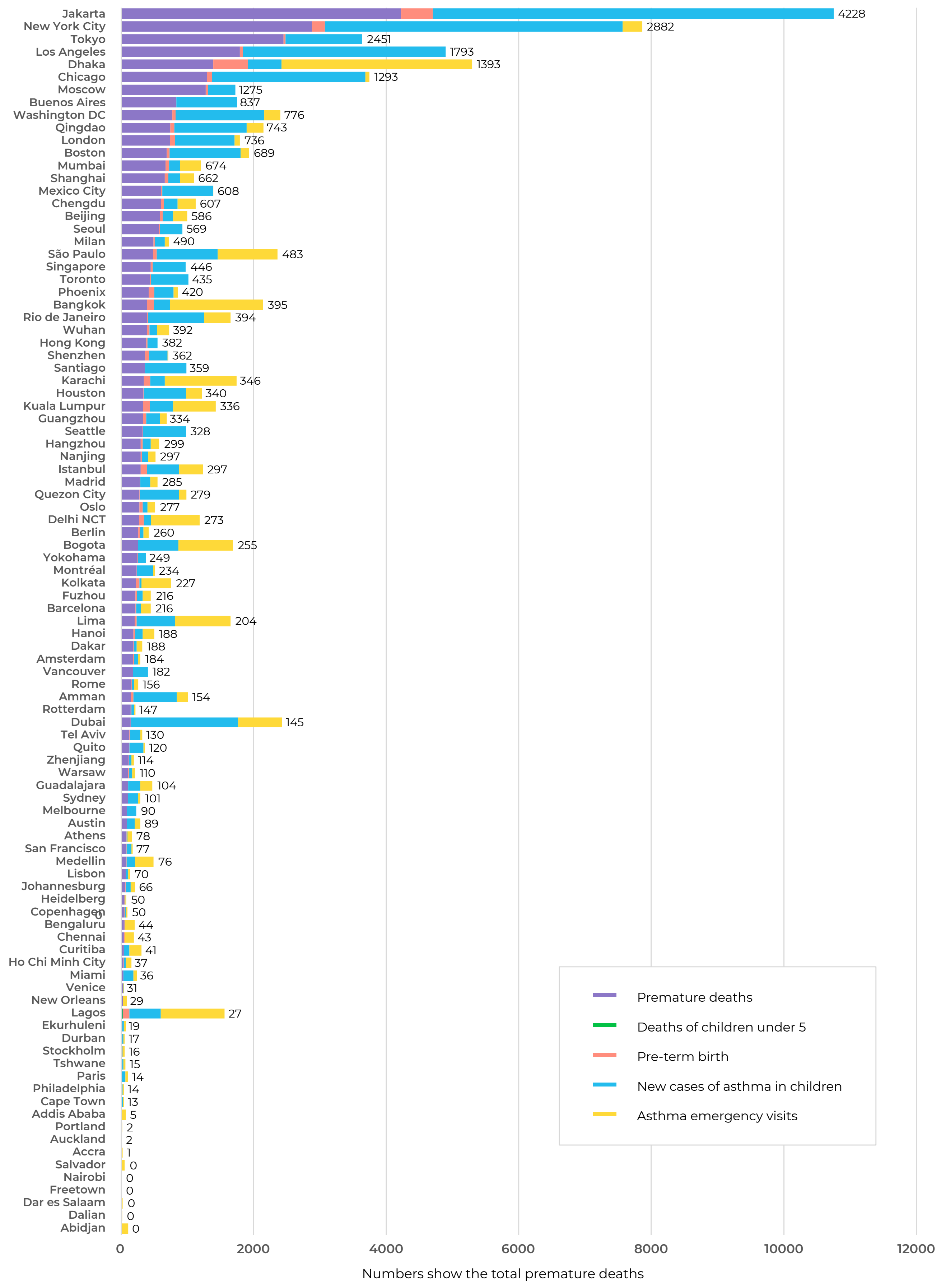
Air pollution also increases the risk of diseases such as diabetes and stroke and chronic respiratory illness, as well as complications for patients with such conditions and those facing existing inequalities. In 2020, non-communicable diseases due to air pollution from fossil gas may have extinguished 10,972 years of life in C40 cities.

Fossil gas-induced cumulative health impacts

	2020-2035	2020-2050
Premature deaths	217,045	776,190
New childhood asthma cases	198,478	532,587
Asthma emergency visits	105,045	409,912
Pre-term births	17,499	55,086
Years lived with disability	127,419	444,389
Sick days	23,590,237	95,505,313

Figure 6 | The health consequences of fossil gas-based air pollution in C40 cities, 2020

Source: C40 Cities



The health burden of not meeting 1.5°C targets

Our modelling shows that under the current climate pledge scenario, by 2035, air pollution from fossil gas could result in 217,045 more premature deaths in C40 cities than under a 1.5°C scenario. This increases to 776,190 more premature deaths by 2050.

The health burden of fossil gas expansion plans

Some 88 C40 cities are located in countries where fossil gas consumption is scheduled to increase beyond what current climate pledges would allow, however. If realised, this will lead to even more premature deaths.

The socio-economic costs of fossil gas

Phasing out fossil gas will have huge social and economic benefits. Our modelling shows that a 1.5°C scenario would avoid more than USD 3.9 trillion in health-related economic losses between 2020 and 2050. This figure spans economic losses from disability, premature death, reductions in labour productivity and increased work absences.

We have estimated these economic impacts based on the health effects of gas use for electricity generation, heating and cooking in buildings, as well as industry, across C40 cities. Compared with the current pledges scenario, a 1.5°C scenario would save:

- **USD 7.5 billion from childhood asthma**, taking into account direct and indirect costs, including medical bills and loss of income to the child's caregiver.
- **USD 91.3 million from asthma emergency room visits**, considering hospital care costs for both children and adults.
- **USD 30.7 billion from years lived with disability.** Diabetes, chronic respiratory diseases and stroke significantly reduce the quality of life and economic productivity of those affected and entail substantial healthcare costs.
- **USD 7.2 billion from premature births**, taking into account the healthcare costs and parental economic losses associated with an increase in pre-term births.
- **USD 11.3 billion from lost work**, as a result of forced absence, which can greatly affect individuals' ability to earn a salary and support their families, especially among informal workers and the self-employed. Even among the formally employed, social insurance schemes often fail to compensate for lost wages.
- **USD 3.9 trillion from premature deaths.**

Fossil gas air pollution also has an impact in terms of lost productivity. The health impacts of fossil gas resulted in 6.1 million sick days across C40 cities in 2020, by our estimates.

The unequal health burden of fossil gas-fuelled air pollution

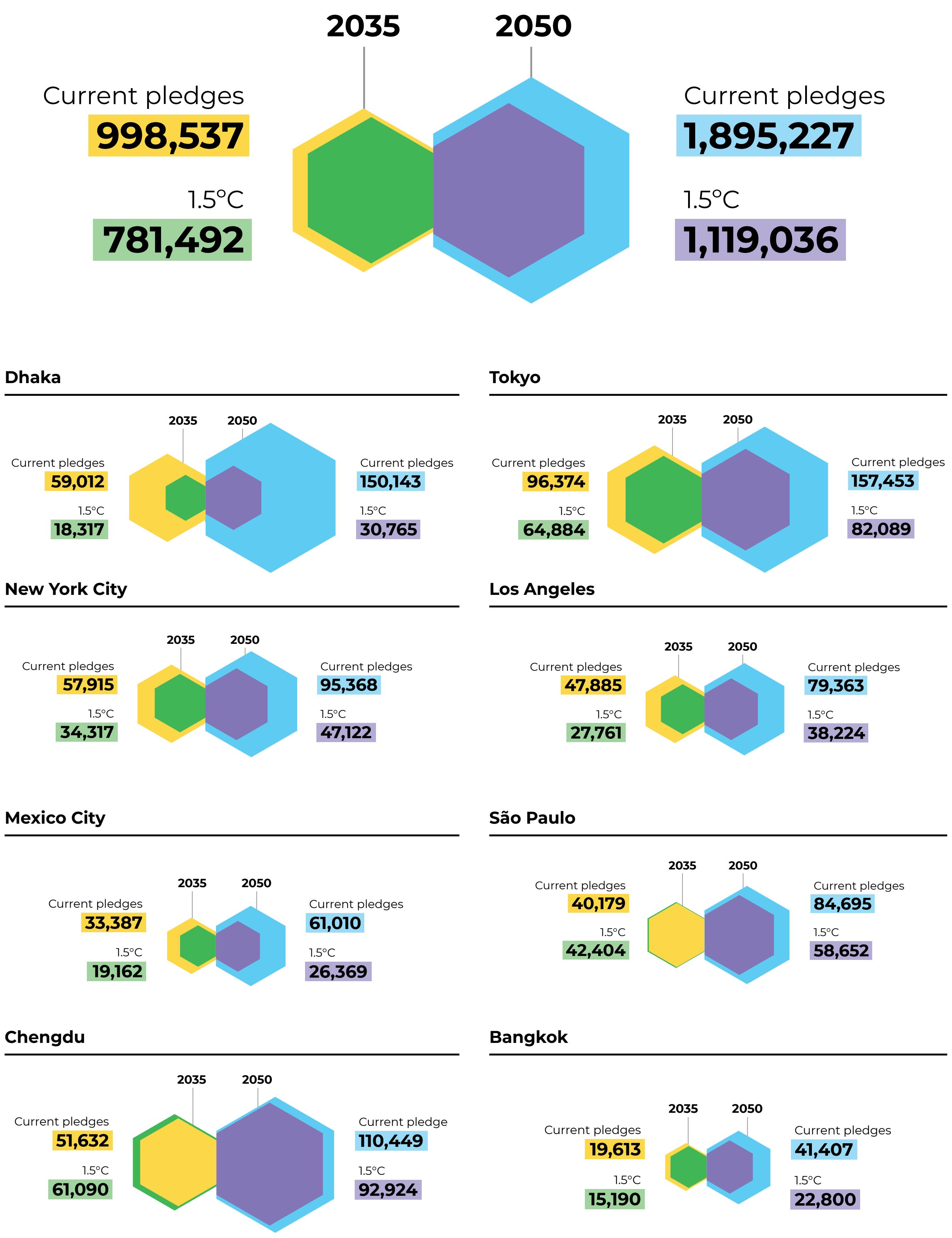
Children are at particularly high risk of developing respiratory illnesses due to methane and nitrogen oxides.[21] In Germany, higher white blood-cell counts and respiratory symptoms and infections have been recorded in children living in households with gas appliances,[22] while a cross-literature review links indoor particulate matter and NO_2 levels to higher cases of asthma in children.[23]

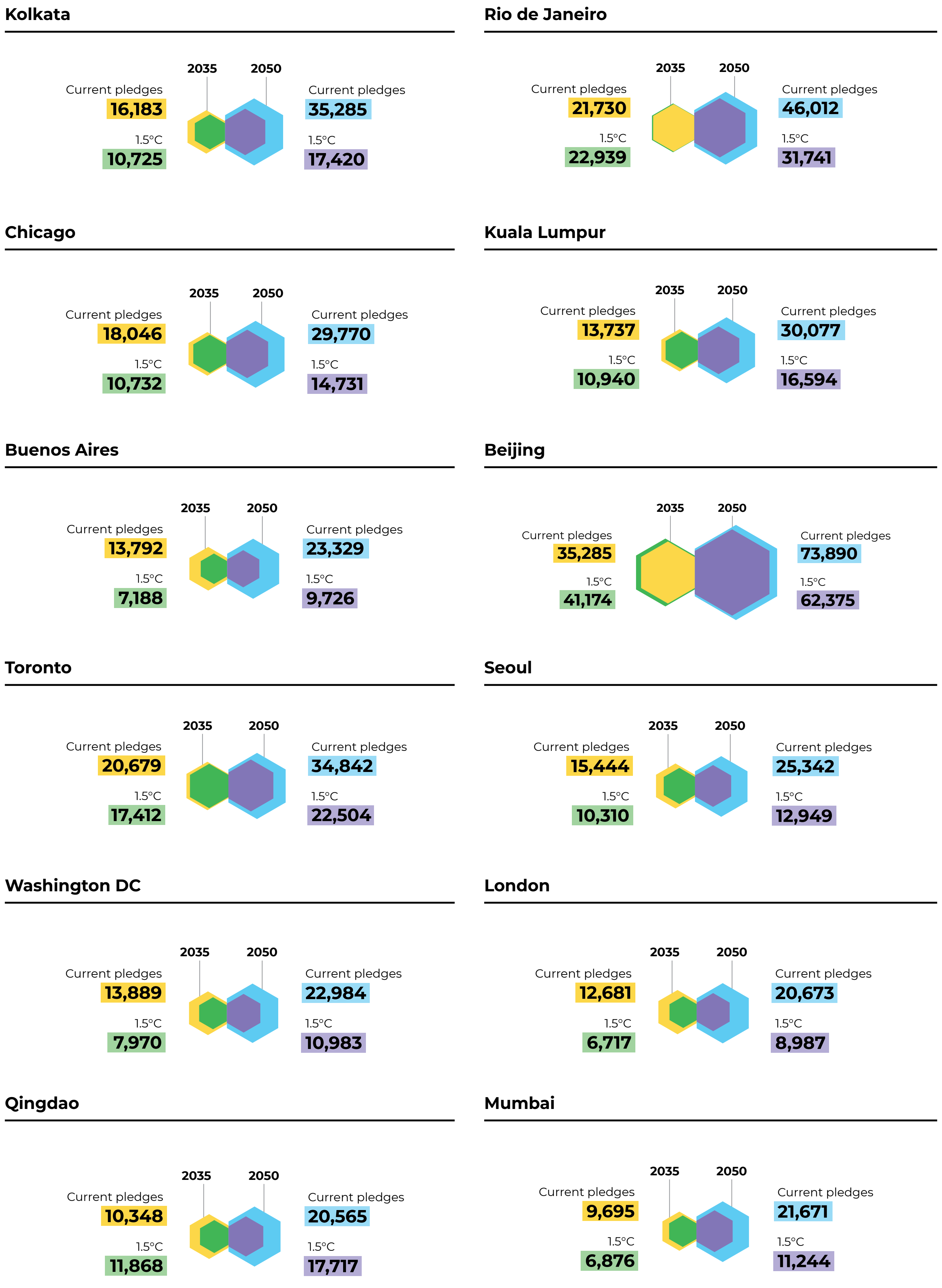
Lower-income households in cities bear greater risk of illness from air pollution, as they are more likely to live in areas with higher concentrations of outdoor air pollutants and smaller homes with less air circulation and ventilation.[24]

In many cities in the Global North, this translates into a disproportionate impact on people of colour. In the US, for example, African-American children experience asthma at more than double the rate of white children.[25]

C40 cities should take a holistic approach to reducing fossil gas that cuts GHG emissions in line with a 1.5°C scenario and minimises the negative health impacts of air pollution from gas use. While one sector, such as electricity, may be a major contributor to both GHG emissions and air pollution in one city, for instance, that may not be the case in another.

Figure 7 | The health burden of fossil gas, cumulative deaths from fossil gas consumption under current pledges and 1.5°C scenario





Chapter 3

A swift clean energy transition is a good investment

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A swift clean energy transition is a good investment

The consequences of policy and investment decisions made today will last for years and be decisive in whether or not we avoid a climate catastrophe. We've seen that the choice of gas as a transition fuel is not wise from a climate and health perspective; here, we show whether it makes sense from an economic perspective.

Renewable electricity is getting cheaper.BloombergNEF reports that onshore wind energy saw a 51% decline in the LCOE, while utility-scale solar PV underwent an 85% reduction from 2009 to 2021.[vii] As of 2022, **new solar and wind are already cheaper than new fossil gas combined cycle gas turbines (CCGT). In all C40 city countries except one,** as seen in Figure 8. Soon, BloombergNEF estimates, it will be cheaper everywhere.

Gas is no longer a good investment

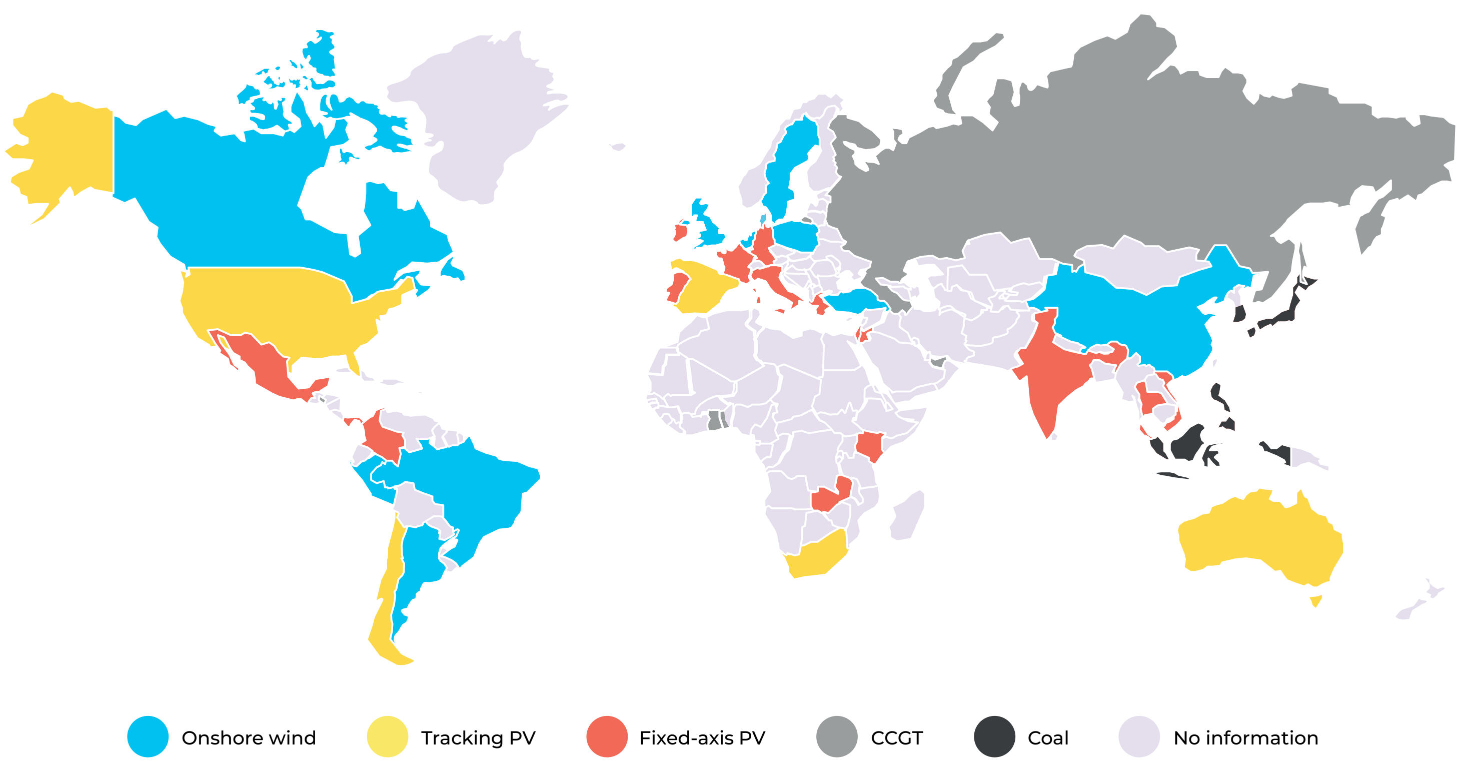


Figure 8 | The cheapest sources of new-build bulk generation, 2022

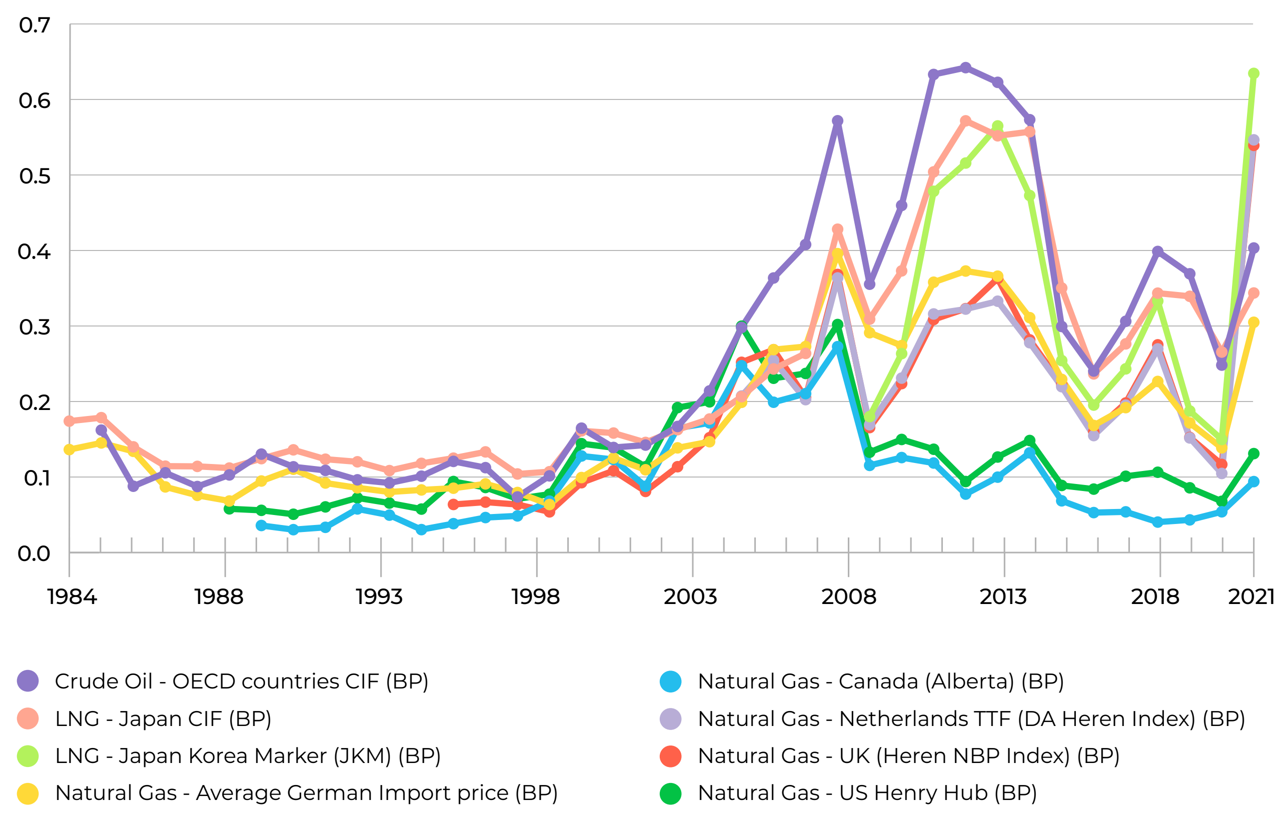
Source: BloombergNEF

vii Based on data shared by BloombergNEF for this research.

Gas prices, in contrast, are soaring. Even before Russia's invasion of Ukraine in February 2022, which sparked a five-fold increase in gas futures prices, fossil gas prices were volatile and rising. Volatile gas prices affect everyone – from governments to companies and individuals – and have knock-on effects on consumption.

Figure 9 | Global fossil gas prices, US dollars per million British thermal unit, 1984-2021

Source: Statistical Review of World Energy – BP/Our World in Data (2022).[26]
Note: The significant effects of the Russian invasion of Ukraine in February 2022 are not captured here as data are only available to 2021.



Moreover, rising fossil gas prices will only intensify the acute energy and fuel poverty[viii] suffered by many residents in cities. Some 759 million people globally still live without electricity.[27] Choosing renewables over fossil gas, combined with energy efficiency improvements and electrification, will help to make energy more affordable and accessible.

In addition to reducing the cost of energy production, a transition to clean energy – including energy efficiency and demand reduction – will lower household costs. Our modelling shows a reduction in final energy consumption of 18%, thus saving on energy bills and helping to alleviate energy poverty.

viii There is no standard definition of energy poverty. Some definitions relate to spending anything more than 10% of take-home income on energy while others consider a more complex assessment of capacity. Broadly, we use this term to refer to an inability to heat and cool homes adequately and buy clean cooking fuels at an affordable cost.

A transition from more volatile fossil fuels to clean energy solutions (both on the supply and demand sides) can protect cities from global shocks and their knock-on impacts, while efforts to increase fossil gas can have the reverse effect. For example, as Europe tries to address its demand for gas in response to the Ukraine war, there is rising energy poverty in the region.[28] At the same time, LNG deliveries are also being rerouted from countries such as Bangladesh and Pakistan to Europe, as Europe is willing to pay more for those resources. This is resulting in massive disruptions to those countries' energy systems, including blackouts that have affected economic activity, as well as health and well-being when fridges, air conditioners and electric fans have stopped working during record-breaking heat waves.[29] Choosing renewables over fossil gas, combined with energy efficiency improvements and electrification, will help to make energy more affordable, accessible and secure.

Investing in the clean energy transition

Of course, there are costs involved in transitioning to clean energy. Decarbonising buildings, electricity generation and industrial production will all require investment, though many of these costs apply to fossil gas energy options as well. For example, both renewable and gas-fuelled grids require grid reinforcement, digitalisation and infrastructural upgrades.

Storage and continuity of supply are a particular consideration in the energy transition and renewable systems require short-term storage to help cope with system variability.[30] There are many types of storage technologies available, such as chemical batteries (biomass, biogas and hydrogen), electrical batteries (gravity storage and lead acid/lithium-ion batteries) and heat storage (district heat tanks) and there is much innovation and investment in this area.[31] Overall investment in battery storage increased by almost 40% to USD 5.5 billion in 2020, while spending on grid-scale batteries rose over 60%.[32] As a result, costs for short-term electricity storage are falling and could drop by up to two-thirds from 2017 to 2030.[33]

Note that investment in storage is required for fossil gas as well, however. For instance, gas requires long-term physical storage for seasonal heating use, for up to 10%-30% of winter demand in the EU.[34]

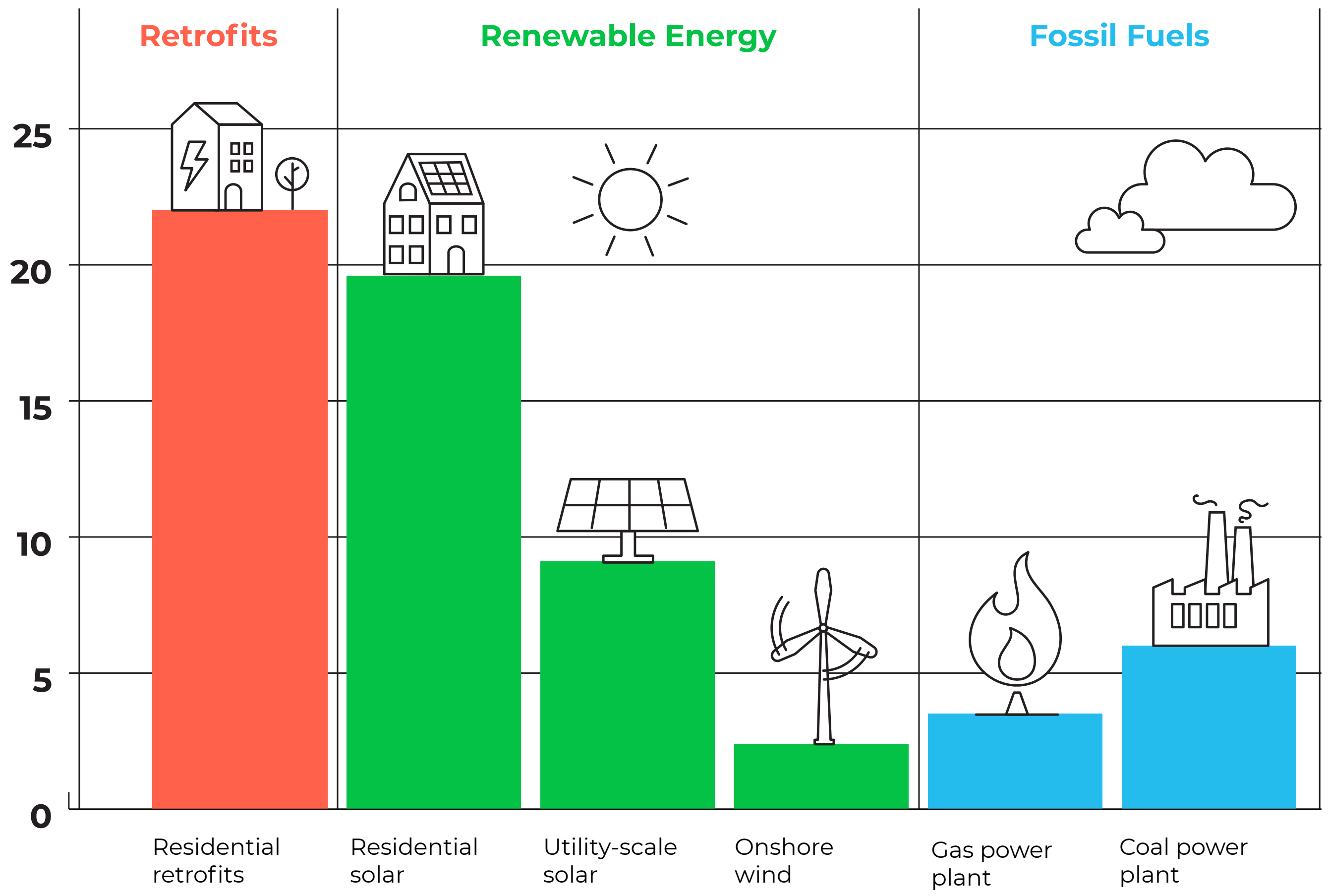
What's more, investments in infrastructure to support a clean energy transition have wider benefits. The connection of new renewables to the grid boosts energy security, for example, by upgrading existing infrastructure or building interconnectors to nearby countries. Costs can be minimised through greater systems flexibility and the use of smart systems.

A clean energy transition creates jobs

As of September 2022, the IEA estimated that more than 50% of the world's total energy employment was in clean energy industries.[35] The transition to clean energy will generate many more jobs over the coming decades. Our analysis shows that every USD 1 million invested in utility-scale solar PV and wind generates 1.7 times as many jobs as fossil gas power plants. And for residential retrofit and solar, the employment potential is even higher, generating six times as many jobs as investing the same amount in fossil gas. This high employment potential of retrofit and decentralised solar PV is particularly relevant as these aspects of the clean energy transition are located within cities, and often within the municipal authority. Cities can use their purchasing power and policymaking to drive these investments and create good green jobs that are well suited to urban environments.

Figure 10 | Number of jobs per million USD invested

Source: C40 Cities



A just transition is critical

While more jobs will be created as a result of the clean energy transition, it is imperative that cities ensure a just transition for those affected by the phase-out of fossil fuels. Investment in training will be needed, but many skills will be transferable – particularly those based in cities.

Many people working on national grids are likely to be able to transfer their skills to cleaner technologies with little retraining. The same applies to many employees in the main offices of energy companies, which tend to be located in cities, as these jobs are often more technical and knowledge-intensive, implying skills that are transferable to other industries and job functions. People working directly in extraction and refinement, in contrast, are likely to require significant retraining, and while these jobs are rarely located in cities, it is still important to ensure a just transition for those workers.[36]

A just transition is also an opportunity to ensure a more equitable workforce and energy distribution. For example, women already have a far stronger presence in the renewable energy sector than in fossil energy, at 32% of the workforce compared with 22%, and this is set to continue. Furthermore, renewable energy is well suited to cooperative, community-led and locally directed ownership structures that enable cities to ensure profits can be spent locally rather than directed and controlled by multinational companies.

A just transition needs to be well planned and organised, so that the benefits of moving away from fossil gas are shared widely and equitably and the burdens of changing livelihoods are managed.[37]

Chapter 4

Modelling a phase-out from fossil gas

Chapter 4.

Modelling a phase-out from fossil gas

How can C40 cities reduce their fossil gas emissions?

We have modelled gas phase-outs in line with a 1.5°C scenario for all C40 cities, producing a 1.5°C transition pathway for each. These transitions are impacted by regional, national and local contexts, as well as sectoral patterns of fossil gas use.

Regional analysis

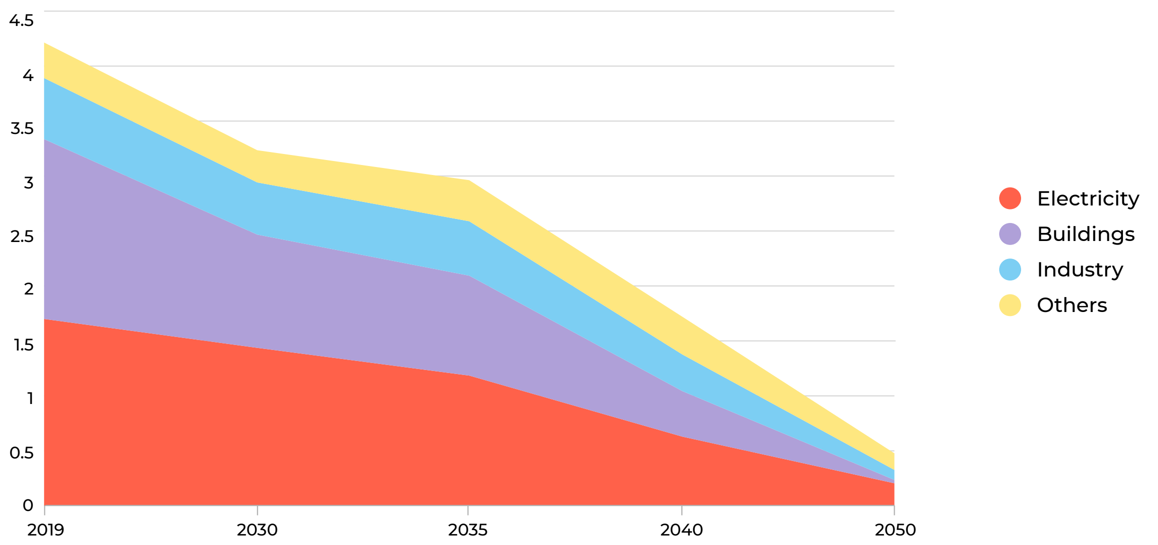
Fossil gas accounted for 9% of C40 cities' GHG emissions, on average, in 2019. Regionally there is wide variation in the level of fossil gas use. The majority of fossil gas use is in C40 cities in Europe and North America, where C40 cities' fossil gas accounts for 40% and 23% of gas consumption respectively. In Latin America, it accounts for 7%, Southeast Asia and Oceania, 5%, East Asia, 5%, Africa, 4%, and South and West Asia, 2% (excluding the outliers Dhaka and Dubai, which are big consumers).

As previously outlined, the 1.5°C transition pathway reflects fair share approaches, accounting for cities' degree of responsibility and capacity to reduce fossil gas use. We also considered the quickest way of phasing out gas while rapidly doing away with coal, maximising clean energy and meeting forecast growth in global energy demand. This results in an immediate decline in high-income cities that are responsible for 69% of C40 fossil gas consumption (Europe, North America and East Asia). And allows for a slight increase and then decline in the late 2030s for low- and middle-income countries that are responsible for 31% of total gas consumption (Latin America, Southeast Asia and Oceania, Africa and South and West Asia).

Again, here it is important to note that while a fair share approach allows for a phased transition in some regions, building new gas infrastructure is not a good investment. Indeed, given the climate, health and economic impacts, in particular the risk stranded assets and correspondingly high debt burdens, such investment has its own equity considerations.

Figure 11 | C40 fossil gas use per sector in a 1.5°C scenario, 2019-2050

Source: C40 Cities



To achieve the required energy transition, fossil gas for final energy consumption should be replaced by renewable electricity and the electrification of buildings.

Sectoral analysis

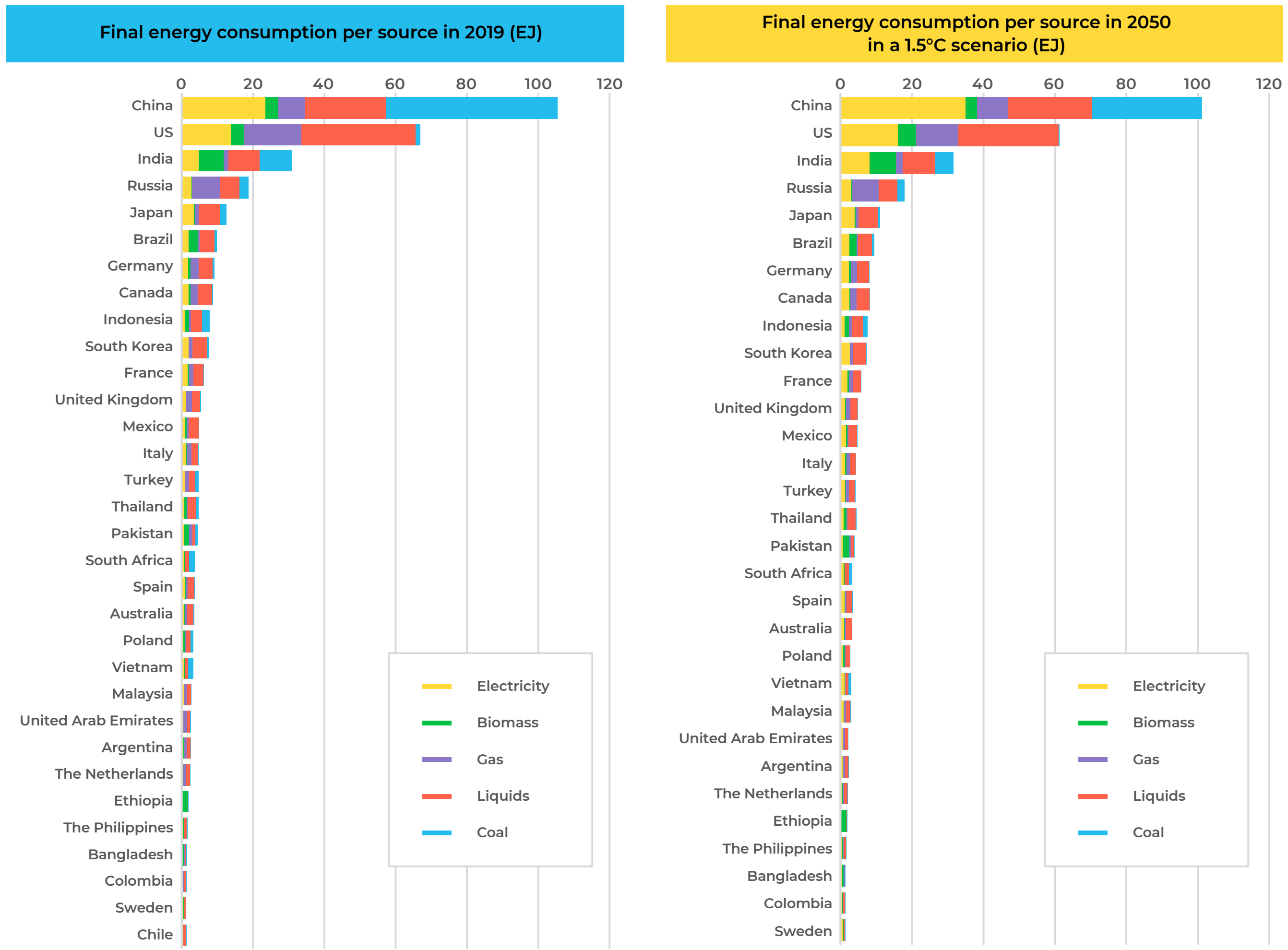
Under a 1.5°C scenario, C40 cities will need to reduce their fossil gas use for electricity, buildings and industry to a combined 0.32 EJ/year in 2050 from 3.9 EJ/year in 2019.

Fossil gas use will, therefore, have to decrease dramatically across all sectors. By 2050, it will have been effectively phased out in buildings (a 98% reduction to 0.03 EJ/year), other than for cooking, where it replaces more polluting fuels in developing countries. Only limited amounts of fossil gas will be used in industrial processes that lack clear alternatives (an 84% reduction to 0.09 EJ/year) and limited amounts will be used for peak demand for electricity (an 88% reduction to 0.2 EJ/year).

The effective phase-out in buildings allows for the use of LPG gas to replace more polluting fuels for indoor use in countries in developing contexts. While the health benefits of less polluting gas stoves go without saying, cooking with non-GHG-emitting electricity is likely to become increasingly viable in the near future and should be embraced. All remaining fossil gas use for electricity and industry should be with CCS and these uses should be phased out as quickly as possible as innovations and new technologies become available and affordable.

Figure 12 | The change in energy consumption per source in the home countries of C40 cities, 2019-2050

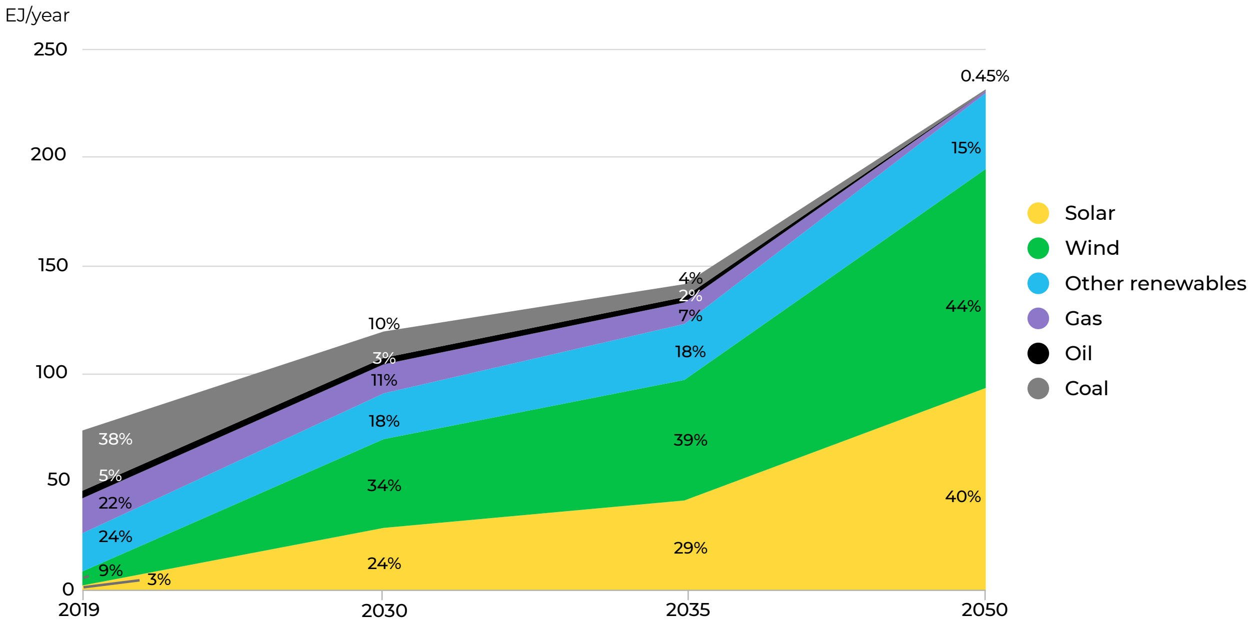
Source: C40 Cities



Under a 1.5°C scenario, the electricity grid will be powered mostly by renewable sources in 2050 (99% by solar, wind, biomass, hydropower, geothermal and nuclear). Figure 12 illustrates how, under a 1.5°C scenario, the solar share will grow from 3% in 2019 to 40% in 2050 and the wind share from 9% to 44%, while fossil gas will plunge from 22% to 0.5%.

Figure 13 | Global electricity generation by source, 2019–2050

Source: C40 Cities



As all fossil fuels are phased out, renewable electricity consumption is forecast to increase 767% to 229.8 EJ by 2050. Meeting this growth in demand for renewable electricity will be extremely challenging. Energy efficiency will play a critical role in the transition, reducing overall demand and, hence, the scale of the challenge.

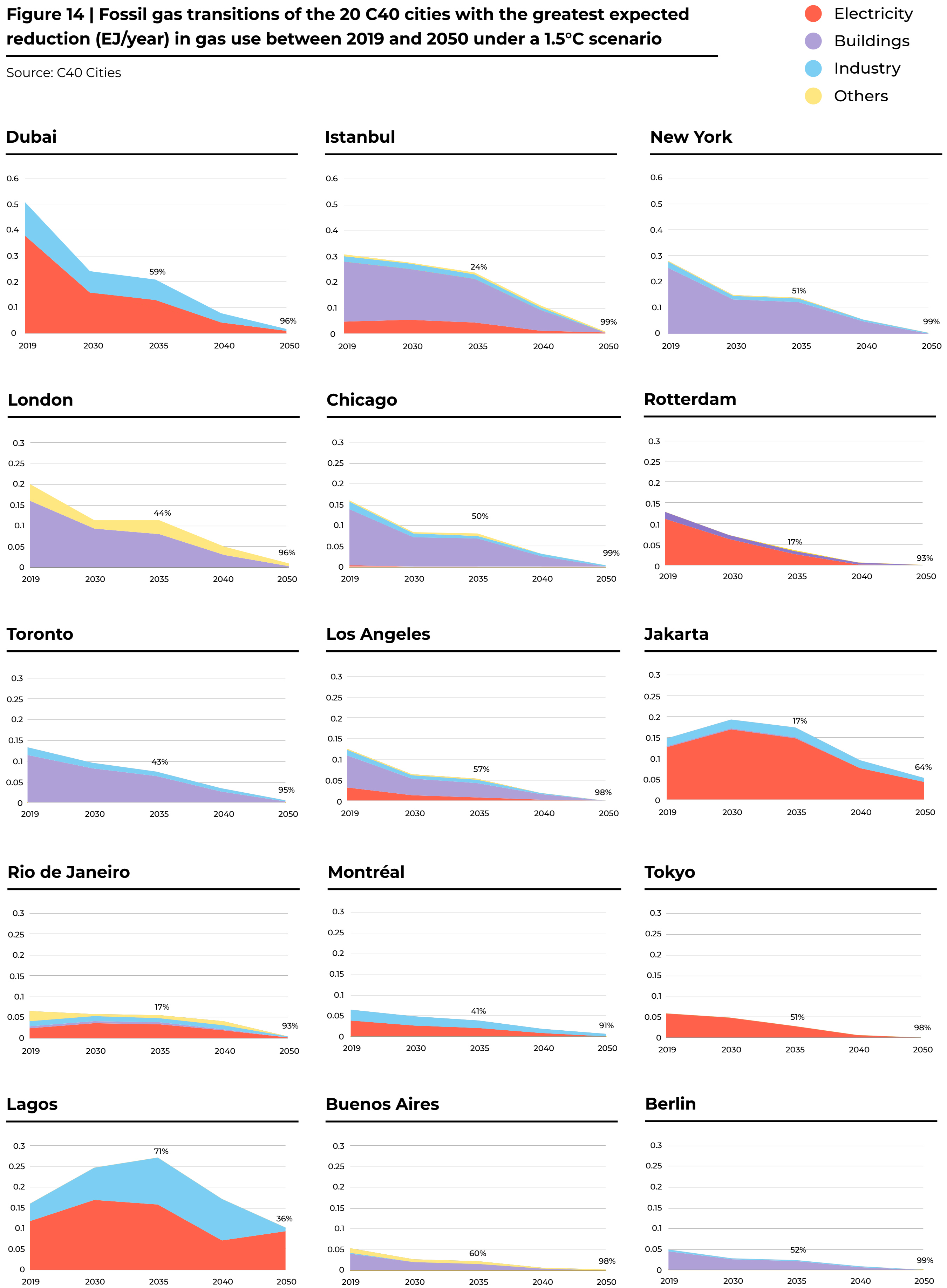
RETROFIT AND EFFICIENCY MEASURES REDUCE OVERALL ENERGY CONSUMPTION BY 18% FROM 2019 TO 2050.

City pathways

C40 cities' fossil gas phase-out will vary depending on their regionally related transition pathway, as well as whether they primarily use gas for electricity, in the buildings sector or for industry, or a mix of all three. To illustrate the variety of city pathways, Figure 14 shows the fossil gas transitions of the 20 C40 cities with the greatest expected reduction (EJ/year) in gas use between 2019 and 2050.

Figure 14 | Fossil gas transitions of the 20 C40 cities with the greatest expected reduction (EJ/year) in gas use between 2019 and 2050 under a 1.5°C scenario

Source: C40 Cities



Chapter 5

The urban transition to clean energy – three city use-cases

Chapter 5.

The urban transition to clean energy – three city use-cases

To root our 1.5°C scenario in urban reality, we have developed city use-cases in which we analyse how a 1.5°C-compliant reduction in fossil gas might look in three C40 cities with differing gas contexts – Montréal, Bogotá and Johannesburg.[ix]

Montréal: A rapid phase-out of fossil gas

Background

Canada's second-largest city, Montréal, is currently home to 1.9 million people. The city is expected to grow to 2.1 million people by 2050. Average winter temperatures are about –9°C (January), so buildings require heating systems. Peak energy demand occurs in winter.

GHG emissions and air pollution

Montréal's GHG emissions amounted to 9 $MtCO_2e$ in 2019. Fossil gas accounted for 40% of emissions.

Current gas use

Buildings. Thirty-five percent of residential buildings use fossil gas for heating (31% for water heating), with the majority (55%) using electric heating. In contrast, 86% of commercial buildings are connected to fossil gas networks for heating. Cooking is largely electric in both buildings segments.

Electricity. Montréal's grid is 99.8% renewable. At peak times, fossil gas is used for electricity generation to reduce pressure on the grid.

Industry. Fossil gas accounts for 62% of all fuel consumed for manufacturing and construction.

Current energy plans

Montréal's Climate Plan 2020-2030[38] and the Energir Climate Resiliency Report[39] (Energir is a private fossil gas provider that is the sole distributor of fossil gas in Montréal) do not mention any plans to expand the gas network. However, Energir's Climate Resiliency Report does note the aim to continue replacing more polluting energy with fossil gas, especially in the industrial sector, where electrification may not be viable or is costly.

The municipality plans to ban the use of fossil fuels (fossil gas, heating oil, propane) in all municipal buildings. At the provincial level, the adoption of Bill 21 will end oil and gas exploration in Quebec. Oil-powered heating is banned in all new construction projects across Quebec.

ix The baseline data on GHG emissions and energy consumption were sourced from cities GHG emissions inventories and the C40 Pathways model.

What would a clean energy transition look like in Montréal?

	Fossil gas use	Today	1.5°C Fossil Gas Phase-out Pathway Model		
			Target	Date	City Action
Buildings	Heating in existing buildings	35% residential; 86% commercial	Fossil gas use reduced to 0%	2037	Montréal is already taking ambitious action by phasing out oil in all existing buildings by 2030, as well as committing new buildings to be 'zero-emission' by 2025. Montréal can use its by-laws to adopt more stringent standards than provincial requirements for certain new-build and renovation elements, such as insulation. One challenge is peak energy for space heating during winter. The existing capacity of the grid cannot meet these peaks and further storage would be required if more appliances were electrified in the city.
	Cooking in existing buildings		Fossil gas use reduced to 0%	2030	
	Heating in new buildings		Ban heating systems powered by fossil fuels	2030	
	Cooking in new buildings		Ban cooking systems powered by fossil fuels	2030	
	Energy efficiency		60% of buildings with fabric retrofits and double glazing	2030 (and 100% of buildings by 2050)	
Electricity	Renewables	99.8%; fossil gas used as backup during peak demand	Increase wind to 23% and solar to 5%	2050	Montréal's electricity grid is already nearly 100% renewable. Montréal's transition will, therefore, focus on how distributed renewables can be added to the grid to support hydrogeneration and deal with peak demand. Rapidly expanding solar and wind could displace the use of fossil gas as a backup fuel. Montréal has a history of collaborating with the provincial and national government, as well as key energy players, such as Hydro-Quebec and Energir. Typically large flat roofs in Montréal are ideally suited to integrating PV. Quebec is a sunny region whose solar power potential, depending on the region, is comparable to that of Barcelona in Spain.
	Fossil gas		Fossil gas usage eliminated as backup fuel	2050	
	Other fossil fuels		None		
	Rooftop PV	None	50% of rooftops with solar PV	2050	
Industry	Energy mix	62% of energy is fossil gas	Gas reduced to 9%, rest electrified	2050	Most industry in the city is 'light' (including food and tobacco; paper, pulp and print; and non-ferrous metals), which mainly use fossil gas for low- and medium-temperature heat demand. This type of heat demand is less complicated to electrify. However, the 9% fossil gas remaining in 2050 represents the current industrial lock-in to gas. Any remaining gas is used for intensive industrial processes rather than for electricity. Bioenergy may also make up the remaining 9% in 2050.
	Energy efficiency		20% increase in efficiency	2030 (and 65% by 2050)	

Bogotá: A swift transition away from fossil gas

Background

Colombia's capital, Bogotá, is currently home to 8 million people and expected to grow to 13 million by 2050.

GHG emissions and air pollution

Bogotá's GHG emissions amounted to 10.2 $MtCO_2e$ in 2019. Fossil gas accounted for 20% of emissions.

Current gas use

Buildings. In both the residential and commercial sectors, gas is the main source of fuel for space and water heating and cooking. Building heating and cooling requirements are limited, however, due to mild average temperatures.

Electricity. Most fossil gas consumed in Colombia is for electricity generation. Electricity is primarily generated using renewables: hydropower (67.94%), solar PV (0.37%), wind (0.07%), other renewables (1.45%). Fossil fuels account for the remainder: fossil gas (16.78%), coal (7.25%) and other fossil fuels (6.14%).

Industry. Bogotá's industry is predominantly fossil fuel-powered. Fossil gas accounts for just over one-quarter of that (26.7%).

Current energy plans

There are both local and national plans to expand the use of fossil gas in electricity generation and industry, largely due to energy security concerns, given the vulnerability of the country's hydropower generation to climatic changes. However, there are also plans to increase the amount of installed renewable capacity at both the national and city level.

What would a clean energy transition look like in Bogotá?

	Fossil gas use	Today	1.5°C Fossil Gas Phase-out Pathway Model		
			Target	Date	City Action
Buildings	Heating in existing buildings	Fossil gas is primary fuel source	Fossil gas use reduced to less than 5%	2040 (commercial) 2050 (residential)	There are already ambitious building-sector policies in place at both the local and national level. To provide further support, Bogotá can support building retrofits and a solar PV expansion by providing building owners with data, planning guidance and regulatory and fiscal incentives. The city can also take a leading role by phasing out fossil gas use in municipal buildings and by accelerating retrofit and PV deployment programmes on municipally owned properties and land.
	Cooking in existing buildings		Fossil gas use reduced to less than 5%	2040 (commercial) 2050 (residential)	
	Heating in new buildings		Fossil gas use reduced to 0%	2040	
	Cooking in new buildings		Fossil gas use reduced to 0%	2040	
	Energy efficiency		Fabric retrofits and double glazing to 100% of buildings	2050	
Electricity	Renewables	Hydropower supplies over 60% of electricity, 16.78% is from fossil gas	Maintain hydropower, increase wind and solar to replace fossil fuels	2050	The electricity grid in Colombia does not rely heavily on fossil gas today, which is a good starting point. Bogotá also owns a majority share in the Grupo Energía Bogotá, the country's largest power-generation company. Thus, the city can explore, together with private minority partner Enel, whether they can increase the pace and scale of renewable electricity production as a part of their alliance to pursue renewable energy. The city can also collaborate with the energy sector on battery storage. Here, solar and hydroelectricity generation can complement each other and facilitate a balancing of supply and demand.
	Fossil gas		Gas usage reduced to 0%	2050	
	Other fossil fuels		None		
	Rooftop PV	None recorded	50% of rooftops with solar PV	2050	
Industry	Energy mix	50% of fuel used is oil, gas used for 27% and the remainder electricity	Gas and oil reduced to <5%, biomass increased to 12.5%, rest electrified	2050	The city's industry is primarily light, where processes tend to be less complex to decarbonise. Decarbonisation options largely involve changing fuels, such as waste heat (from industrial sites) for low-temperature, and biomass, biogas or electricity for medium-temperature heat. Industry is generally regulated by the national government in Colombia, but the city can establish regulatory and fiscal incentives for energy efficiency in industry, as well as consider industrial regulations that improve air quality and health or that help Bogotá meet GHG goals.
	Energy efficiency		71% increase in efficiency	2050	

Johannesburg: The opportunity to leapfrog fossil gas

Background

South Africa's largest city, Johannesburg, is currently home to 5.6 million people.

GHG emissions and air pollution

Johannesburg's GHG emissions amounted to 10 $MtCO_2e$ in 2019. Fossil gas accounted for 2% of emissions.

Current gas use

Buildings. In residential buildings, electricity is the primary fuel source for space and water heating and cooking (83%-93%). There is some use of fossil gas boilers, mainly in higher-income households. In commercial buildings, both fossil gas (55%) and electricity (40%) are used for space heating. Water heating is predominantly fuel-oil powered. The use of fossil gas for water heating and cooking in commercial buildings is less common and only reported in hotels and hospitals.

Electricity. South Africa's electricity is primarily generated using coal (84.4%). Nuclear power is the second-largest fuel source (5.3%), with only very limited fossil gas used for generation (0.8%). Just over 5% of residents get their electricity from solar (2%) or wind generators (3.4%), with higher-income households most likely to have such installations.[40]

Industry. The primary energy source is electricity (84.2%). The fossil fuels used are coal (11%) and fossil gas (4.6%). There is a limited pipeline distribution network managed by Egoli Gas, a company supplying industrial areas around the city, as well as residential and commercial consumers.

Current energy plans

There are plans both nationally and within the city to increase the use of fossil gas and to exploit local resources of fossil gas, mainly to replace coal-powered plants for electricity generation. The Integrated Resource Plan envisages 3,000 megawatt (MW) of fossil gas generation by 2030, with an allocation of 1,000 MW in 2023 and 2,000 MW in 2027. The Risk Mitigation Independent Power Producer Procurement Programme (RMI4P), an emergency measure aimed at bringing new generation capacity online as fast as possible, plans to install 1,418 MW of gas-to-power projects. The increased use of fossil gas is planned for large utilities and industrial usage, not for mass adoption as a fuel for heating and cooking in buildings.

What would a clean energy transition look like in Johannesburg?

	Fossil gas use	Today	1.5°C Fossil Gas Phase-out Pathway Model		
			Target	**Date**	**City Action**
Buildings	**Heating in existing buildings**	Fossil gas used for heating in 3%-15% of residential buildings and 45%-55% of commercial buildings. Commonly used for cooking in commercial buildings.	Fossil gas use reduced to less than 1%	2050	In Johannesburg, existing fossil gas infrastructure is very limited. Therefore, the city faces a comparatively lighter logistical and financial burden when it comes to phasing out gas to meet its climate goals. Though, it is important to note is that where gas replaces more polluting forms of indoor cooking, it brings substantial health benefits and can be considered a legitimate near-term option. As electric alternatives become increasingly viable, these should be the preference. The municipality can update local construction regulations to ban the installation of gas systems and appliances in all new buildings, as well as the replacement of gas systems or appliances in existing buildings.
	Cooking in existing buildings		Fossil gas use reduced to less than 1%	2050	
	Heating in new buildings		Fossil gas use reduced to 1%	2030	
	Cooking in new buildings		Fossil gas use reduced to 1%	2030	
	Energy efficiency		Double glazing to 40% of residential buildings and 100% of commercial buildings, together with advanced wall/roof insulation	2050	
Electricity	**Renewables**	Very little fossil gas use	35% solar PV; 43.5% wind; 8.4% hydro; bioenergy, concentrated solar power and geothermal 3.1%	2050	Johannesburg is the sole shareholder of City Power, which distributes 80% of the city's electricity. Recent reforms to the energy sector have enabled the city to purchase and control its own energy networks. Therefore, the city has the opportunity to influence its own future pathways. Johannesburg has high solar radiation. As the average residential rooftop PV capacity is around 5 kWh, it should cover the entire electricity uses of a household in a year and more. We recommend that the city increasingly exploit this huge potential.
	Fossil gas		Gas usage reduced to 0%	2050	
	Other fossil fuels		Reduced to 5.5%	2050	
	Rooftop PV	Just over 2% of residents get their electricity from solar	50%-55% of rooftops with solar PV	2050	
Industry	**Energy mix**	84% of fuel is electricity, gas used for 8.6% and the remainder is coal	Coal and fossil gas usage reduced to 0%	2050	Cleaner and innovative technologies, such as biogas and hydrogen, should be deployed. Whereas biogas production is an established process, with several plants already installed in the region, hydrogen is a long-term solution for now, due to its high production costs.
	Energy efficiency		30% increase in efficiency	2050	

How other cities can use these cases to reduce existing fossil gas consumption and avoid future use

Montréal, Bogotá and Johannesburg present three different fossil gas-use profiles, along with varying regional and city contexts. However, the cities' transition pathways can be summed up in two broad statements: avoid expanding fossil gas consumption for electricity generation, new buildings and new industrial uses and avoid replacing existing fossil gas appliances with new ones.

These sentiments are echoed by others. For example, in the IEA's roadmap for a net-zero global energy sector by 2050, it is suggested that a worldwide ban of new fossil-fuel boilers in buildings be introduced by 2025.[41]

Montréal can lead a rapid phase-out of fossil gas. Hydroelectricity should be complemented by solar and wind power. New buildings should stop installing fossil gas boilers soon and gas stoves for cooking should be phased out in existing buildings over the next few years. The city's gas boilers can largely be used until their end of life, after which they should not be replaced. In industry, new gas consumption should not be added, while existing companies should find other sources of energy to meet demand, leaving only some hard-to-decarbonise facilities with CCS by 2050.

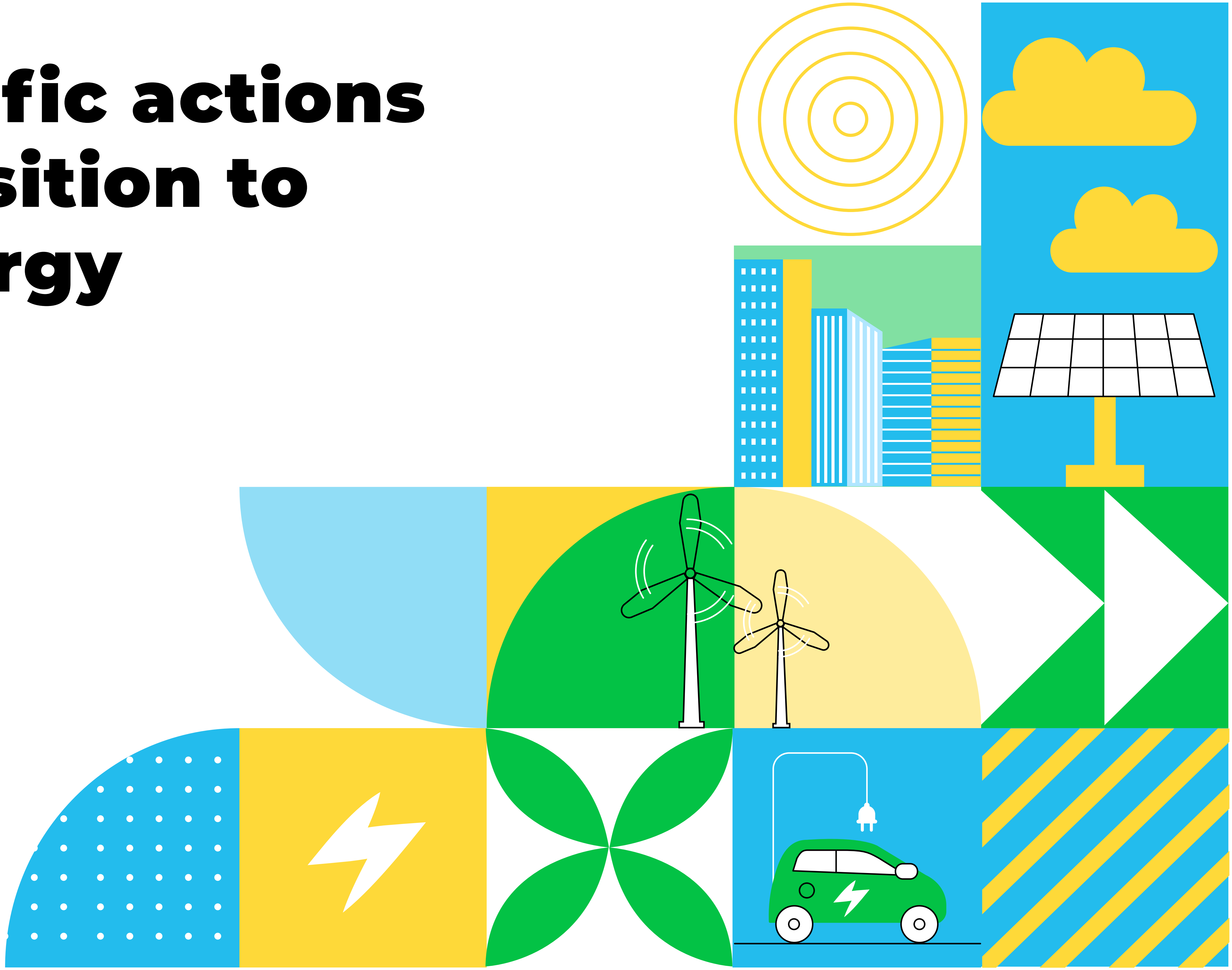
In Bogotá, a swift transition can take place if renewable energy, rather than fossil gas, is used to complement Colombia's significant hydro resources. New buildings are recommended to stop installing gas boilers as soon as possible (but by 2040, at the very latest) while current building owners should replace their existing fossil gas boilers with clean alternatives as soon as possible, but at the very latest by 2050. New industrial facilities should not expand gas consumption, while existing companies are encouraged to use other sources of energy to meet their heat demand. This transition still leaves limited room for post-2050 gas use in extremely hard-to-decarbonise industries. However, the city should require CCS for remaining gas uses.

Johannesburg is facing the challenge of rapidly phasing out coal, and decisions about what to replace it with. Our analysis highlights the opportunity to leapfrog directly from coal to clean energy, and bypass a costly investment in polluting fossil gas infrastructure. Clean energy offers a better economic, health and climate investment. If the city ensures that gas use does not expand, it can work together with a limited number of households, commercial building-owners and industrial facilities to phase out existing appliances and machinery by 2050.

A swift transition from fossil gas to clean energy will not be easy for cities, but these use-cases demonstrate that decisions made today that restrict current and future gas usage will make the transition manageable.

Chapter 6

City-specific actions for a transition to clean energy



Chapter 6.

City-specific actions for a transition to clean energy

Cities are already leading the transition to clean energy by banning and divesting from fossil gas, reducing demand and increasing energy security, investing in renewables and decarbonising heating and cooling. While they have varying power to act against fossil gas, cities are leveraging their leadership by increasing municipal powers over the energy system and using city demand and assets, providing a clear direction of travel through clean energy roadmaps and creating new market mechanisms to incentivise the transition. Here, we show how cities are playing a central role in the energy transition.

Phasing out fossil gas

Cities are already taking action to phase out fossil gas by using legislation and regulation to outlaw its use, using their financial might to divest from fossil gas and by developing clean energy and net-zero targets. Starting with municipal buildings and infrastructure is a great first step, as this is where cities have most power to act and can lead by example.

Close down or ban fossil gas

Where cities have powers and ownership, they can close down fossil gas infrastructure or introduce legislation to end the use of fossil gas.

- The Los Angeles Department of Water and Power is phasing out three coastal fossil gas power plants, which together account for 38% of the city's natural gas portfolio, by 2029. This will accelerate the city's transition to 100% renewable energy and its 2050 carbon-neutral target.
- Zurich is shutting down the fossil gas supply network in parts of the city that are connected to, or will be connected to, district heating, with a plan to phase out gas completely by 2040.
- Dozens of cities have banned gas in new buildings: for example the city councils of Vienna, San Francisco, San Jose and Palo Alto do not allow gas in new buildings.
- Amsterdam banned the advertising of fossil fuels in its metro in 2021. Instead, incentives are offered for renewables ads. This has affected roughly 10% of adverts that promoted high-carbon products and services. The municipality hopes to extend the ban citywide in future.
- California will ban the sale of new fossil gas-fuelled space and water heaters by 2030. **Utilities** are no longer allowed to pass on to customers part of the cost of extending fossil gas infrastructure to new residential or commercial buildings.

Divest from fossil gas

By divesting from fossil fuels and increasing sustainable investments in climate solutions, cities around the world can help to ensure a swift transition from fossil gas to clean energy.

- **Auckland, Berlin, Bristol, Cape Town, Copenhagen, Durban (eThekwini), Glasgow, London, Los Angeles, Milan, New Orleans, New York, Oslo, Paris, Pittsburgh, Rio de Janeiro, Seattle and Vancouver** have signed up to the **Divesting from Fossil Fuels, Investing in a Sustainable Future** Accelerator. This commits them to: taking all possible steps to divest city assets from fossil fuels and increase investments in climate solutions; calling on pension funds to do the same; and advocating for fossil-free and sustainable finance by other investors and all levels of government.
- Oslo's pension fund has developed a climate strategy based on two strands: consideration of climate risk and a goal to reduce the carbon footprint of its equities portfolio by 40% by 2030. As a result, the fund has not had any direct equity investments in oil and gas companies since 2016.

Develop and adopt clean energy and net-zero targets

Set targets that are accompanied by a clear pathway for the phase-out of fossil gas. This should encompass all sectors, including those that are the most challenging and most often excluded today, such as industry. Targets signal intent and allow stakeholders and consumers to plan for change. They also enable cities to push for more ambitious national pledges.

- At least **834 city governments** in 72 countries had adopted a renewable energy target in at least one sector as of the end of 2020. More than 600 of those cities had targets for 100% renewables. The majority of targets relate to power, but there are also targets for heating/cooling and transport, as well as some cross-sector targets. While most targets are voluntary, some are **legally binding commitments**: more than 60 cities are proposing or passing complete or partial bans on fossil-fuel use by 2020.
- Cities including Atlanta, Paris and Vancouver have joined global campaigns such as **Cities Race to Zero**, the C40 **Renewable Energy Declaration** (open to all cities) and national or regional campaigns, such as that **led by the Sierra Club in the US.**
- In Japan and South Korea, local governments have been instrumental in pushing national governments to adopt net-zero targets through multilevel dialogues and collective alliances. This is a particularly important action in regions where cities do not always have control over the energy system.

Reduce demand

Critical to the clean energy transition will be energy efficiency, limiting use and reducing overall energy demand.

Support building retrofit programmes and energy efficiency standards

Cities can curb demand by supporting retrofits, introducing building performance and emissions standards, and replacing natural gas appliances.

- Toronto has set up a building retrofit accelerator as a part of its Atmospheric Fund, where the city provides expert services and collaborates with building owners, utilities, residents and other stakeholders to maximise the climate, social and health benefits of deep energy retrofits. Demand for these services was so high that the city created an offshoot, **Efficiency Capital**, to drive commercial retrofits.
- Innsbruck subsidises the extra cost involved in constructing all new social housing to meet passive house standards. It also supports the energy upgrades of existing housing, but only if the renovations meet deep retrofit requirements. The city may also finance partial retrofits, but these measures need to enable and not prevent a full deep retrofit of buildings later on.

- By 2030, Vancouver's green building regulations foresee a 50% reduction in building carbon emissions from 2007 levels and a 40% reduction in embodied carbon for new buildings from 2018 levels. The city is prioritising the electrification of new and existing buildings and exploring ways to eliminate gas for cooking, fireplaces and other uses in new residential buildings.

- Washington DC's building performance standards set efficiency standards for the district's buildings, which account for 70% of the city's emissions.

- New York City's Local Law 97 aims to tackle the 70% of the city's emissions that come from buildings by requiring those over 25,000 sq ft to meet strict energy efficiency standards, with stricter limits coming into effect in 2030. The law provides less stringent emissions cuts, low-cost retrofit measures and financing support for affordable housing owners and renters to incorporate equity concerns.

- Philadelphia's Energy Authority's Built to Last programme helps homeowners in high-poverty neighbourhoods access housing repair services. It combines low-income home repair programmes with electrification and solar power installation, leading to home restorations that include a transition away from gas to clean energy.

Introduce energy use restrictions

In response to the current energy crisis in Europe, several cities and countries are introducing restrictions on energy use. These offer a fast and effective way to reduce demand. Cities can introduce measures themselves, where possible, and/or support regional and national governments in introducing and enforcing such measures.

- The Berlin city government has committed to reducing its energy consumption by 10%, for example, by turning off the lights around monuments such as the Brandenburg Gate at night.

- In Paris, the city has introduced fines for businesses that leave their doors open when the air conditioning or heating is on. The measure was proposed by the citizens' convention for climate.

- Hanover has introduced energy-saving measures, such as limiting the indoor temperature to 20°C and turning off hot water for handwashing in public buildings, as well as switching off public fountains and nightly illuminations of the town hall and museums, in order to reduce energy consumption.

- In Spain, businesses can no longer cool their premises below 27°C in summer or heat them above 19°C in winter to preserve energy.

Increase energy security and manage supply and demand

Continuity of energy supply is a priority. Uncertainty over renewables and perceptions of fossil gas as critical to peak demand are major concerns. Cities can take action to improve energy security by investing in supply-and-demand management measures.

- Cape Town suffers from frequent power outages, but its Small-Scale Energy Generation programme improves energy security by promoting rooftop solar and small wind turbines for businesses and residents. Energy consumers become 'prosumers', selling excess electricity to the grid.

- Los Angeles has developed the largest solar and battery energy storage system in the US, enough to power 283,330 homes. Two large-scale solar facilities will capture 400 MW of solar energy and store up to 1,200 megawatt-hours to help meet peak demand.

- Newstead has introduced 'solar sponge' tariffs that offer much lower rates to customers during daytime hours, when solar power is abundant.

- The City of Yokohama Virtual Power Plant building project includes installing storage batteries in elementary and junior high schools that are designated local disaster shelters. The project will help to deal with peak electricity demand and increase resilience to disaster.

Prepare for the transition

Cities should prepare for the energy transition by pushing for greater powers, designing new infrastructure strategies, collaborating and sharing data, and creating new market mechanisms.

Increase municipal powers over the energy system

'Re-municipalisation' campaigns have encouraged more cities to take control of local power suppliers and grids, giving them and their residents more say over their energy provision and the design of their decarbonisation policy.

- At least 1,408 cases of the re-municipalisation of critical infrastructure had been recorded as of late 2020, including 369 energy-related cases. Eighty percent were in Germany, followed by Spain, the UK and the US.

- London, in collaboration with the Octopus Energy company, has created London Power, a municipal utility that aims to provide affordable energy options while using profits to support net-zero projects.

- The Metropolitan Municipality of Cape Town took the national government to court to contest procurement rules that prevent the city from buying its own renewable energy. It has also explored innovative energy measures, including decoupling electricity demand from economic growth in the city's plans.

- Re-municipalisation took place in the Palestinian city of Hebron, where the publicly owned Hebron Electric Power Company is developing solar PV on all municipal buildings.

Design clean energy roadmaps and infrastructure strategies

Local plans are needed to understand future energy demand, alternative uses for fossil gas infrastructure and accompanying energy efficiency, renewables and grid reinforcement needs. Such plans might be integrated into city or local-area development or zoning plans.

- Durban developed and evaluated several renewable energy scenarios with different technological combinations from inside and outside the city that could be included in the energy mix. Through this process, the city determined that solar technology was the primary way for it to meet a growing proportion of energy demand from in-city renewables over the coming decades.

- The Jakarta local action plan aims to help achieve Indonesia's national emission reduction target of 29% by 2030. The city also is developing a Regional Energy Plan, to help achieve the targets set in the National Energy General Plan and the National Energy Policy.

- London mapped heat demand and supply across the city to support district heating deployment as part of its goal to generate 25% of its energy supply from decentralised sources by 2030. The city uses the London Heat Map to determine where market-competitive heat networks could be located, and the tool is publicly available for use by local authorities, developers and community advocates.

Accelerate renewables and decarbonise

Accelerating renewables is fundamental to replacing fossil gas with low-carbon, sustainable alternatives. Cites should maximise their purchasing power and catalyse action through new market mechanisms.

Use municipal demand to drive the transition

Cities are using their purchasing power and municipal projects to drive renewable energy demand.

- Melbourne has facilitated a number of power purchase agreements for businesses across the city that join forces to increase the demand for renewable electricity. Recently, the Melbourne Renewable Energy Project brought together seven large energy users (universities, property and retail companies and others) to jointly procure 110 GWh of renewable electricity per year over 10 years.
- Houston's Sunnyside Solar Project is expected to become the largest landfill solar project in the US. The project's 52 MW of solar panels will be able to power 5,000 homes and offset about 55,000 tonnes of CO_2 each year.
- Chicago signed a USD 422.2 million agreement with Constellation Energy to provide renewable energy to municipal buildings by 2025 in an effort to help the city meet its goal of reducing its emissions 62% by 2040.

Create new market mechanisms

Feed-in tariffs, auctions, heat incentives and other financial mechanisms are all powerful drivers of utility and distributed renewable development. Cities can work with energy system stakeholders to design simple, accessible policies that make it quick, cheap and easy for individuals, businesses and renewable energy developers to add renewable electricity to the grid or use renewable power for their own consumption.

- **Municipal-level feed-in tariffs** are present in numerous cities, including **Canberra, Fukushima, Gainesville, Harare, Hong Kong, Rajkot and Recoleta.**
- Mexico City's government is installing 787,000 m2 of solar panels in residential and commercial buildings by 2024 as part of its Ciudad Solar programme. Mandatory targets will help, but the city is also providing grants of up to 30% of the initial investment, combined with a soft loan. The city is partnering with a range of organisations to support the scheme, including the Inter-American Development Bank and the World Bank.
- The Stuttgart municipal utility, Stadtwerke Stuttgart, is offering households the option to buy or lease solar PV panels. Consulting, installation and servicing are provided, as well as the option to integrate storage or electric vehicle charging. Householders pay a monthly leasing fee rather than upfront investment costs and receive the energy produced, as well as a feed-in tariff for any surplus energy. The city undertakes any repairs and after the lease expires, the householders can keep the panels.
- Delhi has introduced virtual net metering to allow residents and businesses without suitable roof space to invest in solar energy systems. The systems are generally collectively owned, measure the power consumed and exported, and offer credits on electricity bills.
- Salvador, Brazil, has developed two tax-incentive programmes to promote energy sustainability in building construction and solar PV energy generation. Tax is reduced by up to 10% for buildings that adopt sustainability measures such as the installation of solar PVs.

Decarbonise heating and cooling systems

Cities should lead the way by converting the heating and cooling of individual buildings to renewable technologies and promoting clean district heating and cooling networks powered by renewable energy. The decarbonisation of heating and cooling should be implemented in tandem with building energy efficiency measures to make the transition more manageable and cost-effective.

- **Barcelona** has a **solar-thermal ordinance** that requires new buildings using more than 0.8MWh per day for hot water production and those undergoing major renovations to source at least 60% of their hot water from solar-thermal collectors. The policy successfully supported the growth of solar-thermal systems from 1,650 square metres in 2000 to 87,600 square metres in 2010.
- Silkeborg, Denmark, installed the world's largest solar-thermal plant in 2016. The plant generates 80,000MWh/year and has brought about a 20% increase in energy efficiency and 15,000 tonnes/year of CO_2 savings. Solar collectors are the most cost-effective technology (helped by Danish taxes on fossil fuels) and the plant is forecast to save DKK 127 million over the next 20 years. Importantly, the plant improves heat-price stability and buffers against fossil gas price fluctuations.
- In **Hong Kong**, the **Kai Tak Development low-carbon district cooling system** uses seawater to supply 284 MW of centralised cooling to buildings from schools and hotels to shopping centres and railway stations, achieving 35% greater efficiency than standard air-cooling systems. Air conditioning constitutes 30% of electricity demand in Hong Kong, and the district cooling system is expected to save 85 million kWh of electricity and 59,500 tonnes of CO_2 annually.

A just and equitable transition

The energy transition will only succeed if the economic and social benefits are enjoyed equitably by all. This includes helping communities and workers dependent on fossil fuels to switch to new energy sources and sustainable jobs. With gas still a major energy source for urban cooking and heating, this is a challenge that local leaders are recognising and addressing. Much of what has been learnt from the global transition from coal is relevant to enabling investment in renewables and addressing cities' reliance on fossil gas. However, this also needs to be adapted to city-specific context, housing stock, industries and reliance on costly and volatile fossil gas.

Establish inclusive and transparent social dialogue and partnerships

A well-planned and just transition to clean, renewable energy sources is critical to maximise the transformative potential in jobs and minimise the impact on workforces. While much energy policy is set at national level, mayors are showing that they can play a critical role in supporting just transitions for communities and workers. Cities are creating inclusive and participatory governance models and ensuring that those most impacted – workers (and their unions) and communities – have an equal voice in decision-making processes.

- Seattle's Green New Deal Oversight Board advises the mayor and City Council on the city's Green New Deal policies. It comprises a diverse group of stakeholders, including representatives from frontline groups, labour unions, environmental justice organisations, workforce training institutions and climate specialists.
- South African cities are establishing a dialogue and partnerships with a range of stakeholders, including the national government and unions, to better understand their stances and plans with regard to a just transition and to position themselves among the main players in the process.
- Accra is engaging with informal-sector workers to better understand their needs and to institutionalise collaboration with them, to safeguard and improve livelihoods.

Maximise job creation and invest in upskilling and reskilling programmes

Bold action to deliver renewable energy and energy efficiency projects will create new jobs and require new skills. Cities should work with unions, workers, key institutions and industry partners on just transition plans, offering retraining and ensuring that opportunities are accessible to all and offer decent jobs. Cities should also support these communities and individuals in navigating their changing careers and cultures, acknowledging the importance of industrial heritage and identity.

- **Austin** is building on existing recruitment initiatives to encompass green jobs and create opportunities for low-income groups. As well as providing training, the **Green Workforce Accelerator programme** aims to build employers' capacity to provide pathways into green jobs.
- **London** has committed to doubling the size of the city's green economy to GBP 100 billion (USD 112 billion) by 2030 and creating 1,000 new skilled jobs for Londoners from the first GBP 10 million (USD 11.2 million) Green New Deal fund, with a focus on low-income residents and black, Asian and minority ethnic and female-led entrepreneurs.
- **Denver** is working with historically disadvantaged communities and to ease the energy transition for fossil-fuel employees to ensure they have jobs that provide family-supporting wages, good work standards and benefits.
- **Buenos Aires** is mapping sectors with the greatest green job potential, helping to generate reliable and accurate data for the city's **Registry of Green Employment**.
- **Tshwane**, home to the executive branch of South Africa's national government, is integrating just transition interventions in its Integrated Development Plan in order to earmark funds and ensure that there is institutional financial support for just transition activities.

Implement a clean energy transition that improves energy access

A clean energy transition away from fossil fuels is an opportunity to address long-standing inequities, in particular energy access. Around 176 million urban residents, three-quarters of whom are in sub-Saharan Africa, have no access to electricity.[42] Energy access is particularly limited for the growing number of people living in urban and peri-urban slums and informal settlements.

- **Johannesburg** created an ambitious electrification plan to increase energy access for its 180,000 households in informal settlements, where illegal connections cause frequent power losses and fatal electrocutions. Where an extension of the grid was not possible, the city installed independent power grids running on renewable energy, electrifying more than 12,850 homes in its first year.
- In **Rio de Janeiro**, a shared solar power-generation system is being brought to one of the city's poorest communities, the Babilonia favela, where residents suffer high electricity prices and poor grid services. So far, the generation of more than 100,000 kWh of renewable energy has avoided more than 10 tonnes of CO_2, generated more than BRL 90,000 (~USD 20,000) savings on energy bills, and trained dozens of locals as electricians and solar installers in the process.
- In **Seoul**, solar PV systems have been deployed for low-income housing as part of the city's target to install more than 1 million individual systems on city rooftops by 2022.
- The city of **Vienna** has partnered with Austria's largest energy provider to reduce energy poverty, helping to safeguard the energy supply of precarious populations, for example, by reducing additional costs and interest payments.
- **Barcelona** undertook energy assessments and installed energy efficiency measures in homes experiencing energy poverty, reducing the cost of their utility bills by 19%, and saving homes EUR 225 (USD 219) per year on electricity bills.

Support the transition to clean cooking fuels.

More than 2.6 billion people globally still do not have access to clean cooking facilities.[43] Cooking with traditional polluting fuels such as biomass costs the world more than USD 2.4 trillion each year in poor health, climate impacts and lost productivity, especially for women.[44] Children and elderly people are also particularly vulnerable to the health impacts of unsafe domestic fuels. Many of the largest barriers pertain to specific social and economic context, not technological shortcomings.

LPG is currently the most common fuel alternative, as electric cooking requires quality electrical appliances and affordable electricity.[45] Cooking with electricity, however, is likely to become increasingly viable in the near future,[46] and it can achieve efficiency levels of 85% – double those of LPG and five times those of traditional biomass stoves – without the GHG emissions.[47] Research from peri-urban Nepal suggests that electrification will not only improve household welfare, but increase residential demand for electricity, thereby accelerating and sustaining energy generation and distribution infrastructure.[48]

For more examples of how cities are leading the clean energy transition, see Chapter 3 of C40 Cities' report **Coal-free cities: the health and economic case for a clean energy revolution.**

Key takeaways

Fossil gas is not green – it is incompatible with a 1.5°C goal

- Fossil gas consists largely of methane, a potent GHG. The climate advantage of fossil gas over coal becomes marginal if just 3.2%-3.4% escapes into the atmosphere before being burned.
- Fossil gap is a key contributor to global heating. The emissions gap between current national climate pledges and 1.5°C is 6.1 $GtCO_2e$ in 2035 and grows to 19.5 $GtCO_2e$ by 2050. Fossil gas causes 6% of this emissions gap in 2035, growing to 10% in 2050.
- We need to swiftly reduce fossil gas use by 30% by 2035 to stay on course for 1.5°C, but instead planned expansions will add 86% to fossil gas use capacity. Of these planned expansions, 33% is already under construction. Fossil gas is not a transition fuel.

Fossil gas is not clean – it causes significant air pollution and damages health

- Fossil gas use for electricity generation, heating and cooking in buildings as well as industry contributed almost as much as coal power plants to premature deaths in C40 cities in 2020.
- Our modelling shows that a swift clean energy transition away from gas could avoid as many as 776,190 premature deaths in C40 cities by 2050.

Renewables are cheaper and less volatile than fossil gas

- Renewables are becoming more cost competitive as the costs of energy generation and battery storage fall. Solar and wind are already cheaper than new fossil gas electricity generation in countries where 95 out of 96 C40 cities are located.
- The international price of fossil gas is also highly volatile, putting supply at risk. Diverse renewable supply mixes, combined with energy efficiency, battery storage and smart grids, offer a more economic, long-term and stable solution to energy crises than gas expansion.

Clean energy creates more jobs and is an opportunity for a just transition

- Phasing out fossil gas will have huge social and economic benefits. Our modelling shows that a 1.5°C scenario would avoid more than USD 3.9 trillion in health-related economic losses between 2020 and 2050.
- Urban clean energy action can drive employment. Retrofit and distributed PV power, in particular, have high employment potential, generating six times as many jobs as similar investment in fossil gas. For utility-scale solar PV and wind every USD 1 million invested would create 1.7 times as many jobs as fossil gas.
- Some 759 million people still live without electricity. Switching to renewables, with energy efficiency improvements and electrification, could help to make energy more affordable and accessible – alleviating cost-of-living pressures.
- The transition to clean energy is an opportunity for a just transition and greater equality, both in terms of good, green jobs and energy access and affordability.

City action and leadership for a clean energy transition

- Cities are central to a clean energy transition. Different cities will have different transition pathways, but they can be summed up in two broad statements: avoid expanding fossil gas consumption for electricity generation, new buildings and new industrial uses, and avoid replacing existing fossil gas appliances with new ones.
- Cities around the world are already leveraging their leadership by increasing municipal powers over energy and utilising city purchasing power and assets. They are acting to legislate and litigate for a fossil gas phase-out, reduce demand, expand renewables and decarbonise heating and cooling.

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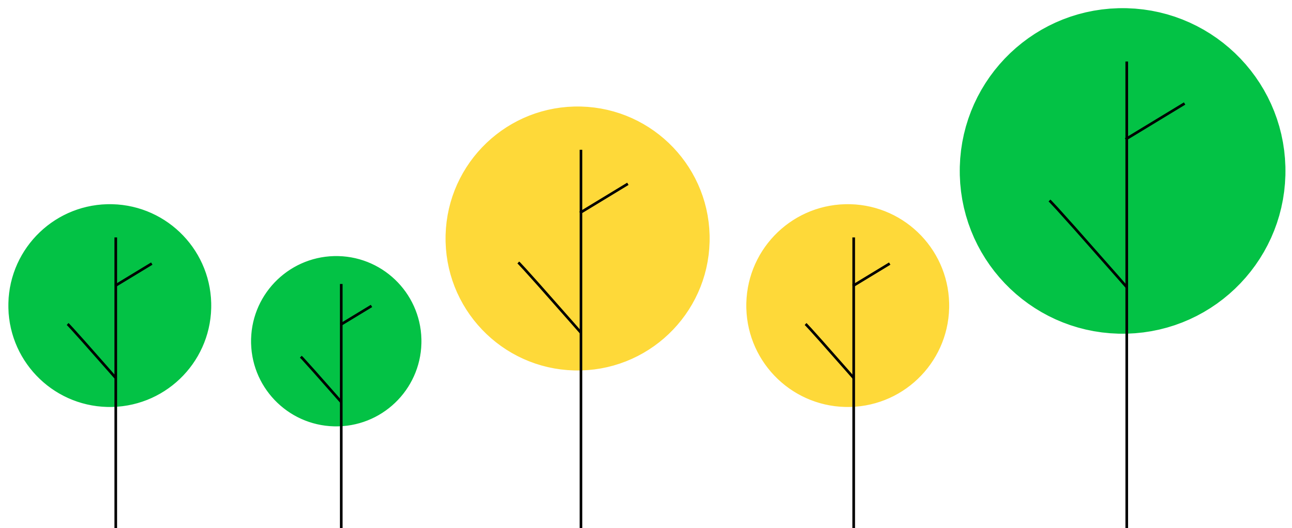

Authors

C40
Rachel Huxley
Markus Berensson
Mariana Nicolletti
Honorine van den Broek d'Obrenan
Lauren Sellers
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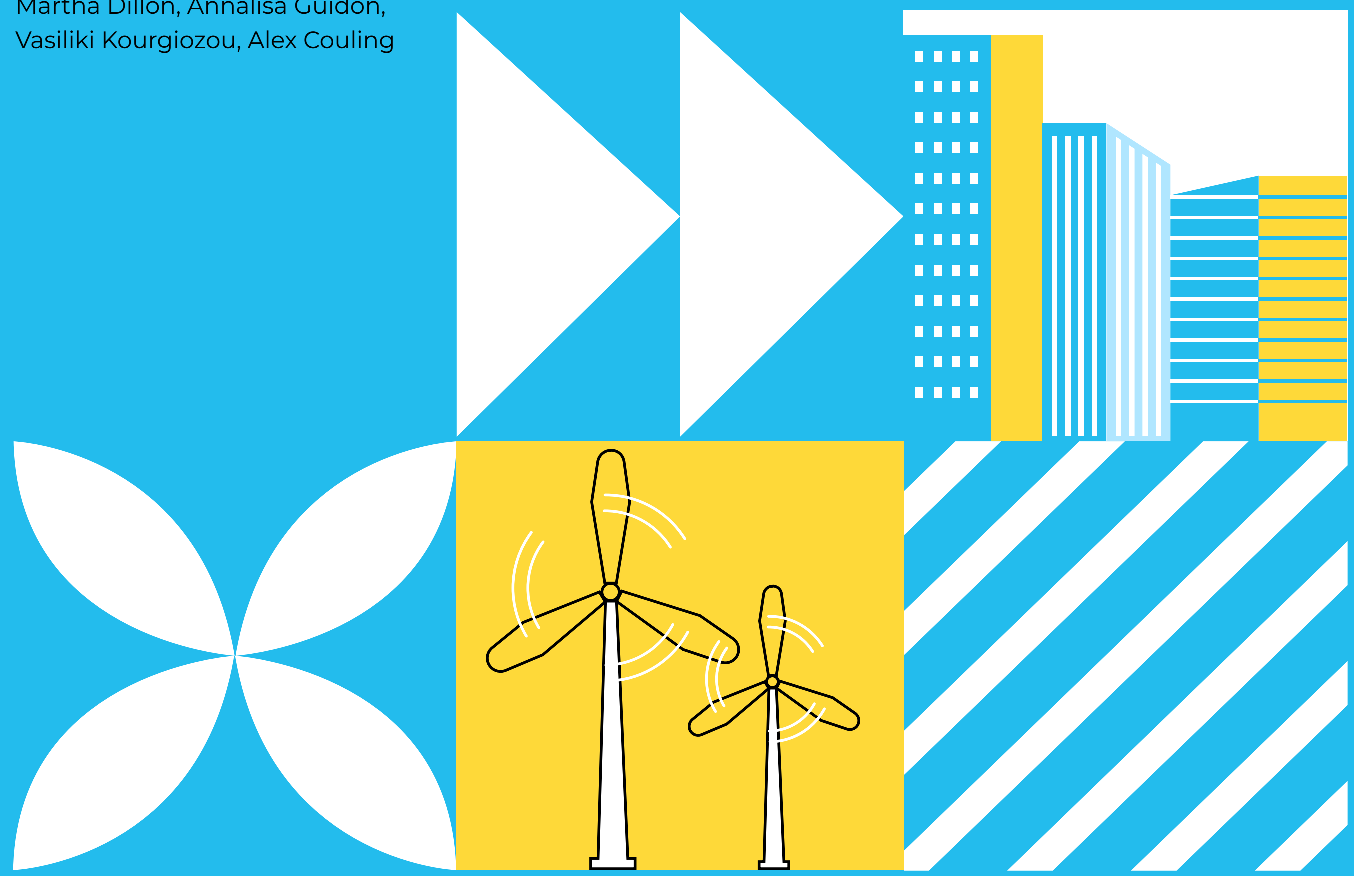

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