THE FUTURE OF URBAN CONSUMPTION IN A 1.5°C WORLD

C40 CITIES

HEADLINE REPORT

UNIVERSITY OF LEEDS | ARUP | C40 CITIES

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Acronyms

Abbreviation	Full term
BECC	Bio-energy Carbon Capture and Storage
CBE	Consumption-Based Emissions
CCS	Carbon Capture and Storage
D2020	Deadline 2020
EEIO	Environmentally Extended Input-Output Model
ETS	Emissions Trading Scheme
EU	European Union
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Inventories
GTAP	Global Trade Analysis Project
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Co-operation and Development
NDCs	Nationally Determined Contribution
UN	United Nations

Key terms

Term	Description
Ambitious target	Target level of ambition for consumption interventions that is more 'ambitious', based on a future vision of resource-efficient production and extensive changes in consumer choices. This level was typically informed by expert judgement rather than existing research.
Aviation	Consumption category covering full supply chain emissions associated with the operation of planes due to city residents' personal flights. This category excludes the embodied emissions of planes and associated equipment.
Bio-energy carbon capture and storage	Carbon capture and storage (CCS) is a set of technologies that can keep CO_2 from entering into the atmosphere, typically from sources with concentrated and high CO_2 emissions such as power plants or industrial processes. Bio-energy with CCS (BECCS) is a potential greenhouse gas mitigation technology which removes CO_2 from the atmosphere by combining bio-energy (energy from biomass) use with geological capture and storage.
Buildings and infrastructure	Consumption category encompassing full supply chain emissions from the construction of new buildings and infrastructure as well other works associated with refurbishment, retrofit etc. It excludes operational emissions during a building's lifetime. The methodology for determining a city's buildings and infrastructure emissions is based on downscaling expenditure at a national level to the associated urban population on a pro-rata basis. This is based on the assumption that new construction benefits the national population irrespective of where people live.
City residents	Refers to residents living within a city, i.e. excluding visitors.
Clean production	The sequence of processes involved in the production of a commodity are associated with low emissions.
Clothing and textiles	Consumption category encompassing full supply chain emissions from all apparel, footwear and other textile products (e.g. rugs, curtains, bedding, fabric) purchased by city residents.
Consumption-based emissions	Consumption-based GHG accounting is an alternative to the production-based approach to measuring city GHG emissions. It focuses on the consumption of goods and services (such as food, clothing, electronic equipment) by residents of a city, and GHG emissions are reported by consumption category rather than GHG emission source category. For the purposes of this report, the PAS 2070 methodology was adopted.

Consumption category	Category of products and services covered by consumption-based emissions. These are aggregated categories based on EEIO model categories.
Consumption intervention	A change in production or consumption that in most cases leads to a direct reduction in consumption-based emissions. One example would be a reduction in vehicle ownership.
Deadline 2020	Deadline 2020 is a routemap for achieving the Paris Agreement, which outlines the pace, scale and prioritisation of actions needed by C40 member cities to reduce their production-based emissions over the next five years and beyond. The report was delivered through a collaboration between Arup and C40.
Electronics and household appliances	Consumption category encompassing full supply chain emissions from electronics (e.g. smart phones and laptops) and household appliances (e.g. refrigerator, toaster, microwave) purchased by city residents.
Environmentally Extended Input-Output Model (EEIO)	This model provides environmental indices associated with financial flows. For the purposes of this report, the Environmentally Extended Input-Output Model was used to analyse spending from households and government, and business capital expenditure, based on financial flow data from national and regional economic accounts. It estimates GHG emissions using average GHG emission factors for each consumption category depending on where the goods and services consumed in a city are produced.
Food	Consumption category referring to full supply chain emissions from all products for human consumption, including beverages and tobacco.
Global Trade Analysis Project	The Global Trade Analysis Project is one of several multi-regional input-output models available and was chosen for producing the C40 cities consumption-based emissions inventories due to its global reach.
Greenhouse Protocol for Community-scale Greenhouse Gas Inventories	The World Resources Institute, C40 and Local Governments for Sustainability (ICLEI) have partnered to create a GHG protocol standard for cities known as the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. This establishes a methodology for city GHG emissions reporting based on the production-based emissions accounting framework.
GHG budget	The quantity of GHG emissions that can be emitted in total over a defined period of time defined by the probability of avoiding a specific global average temperature increase.
Nationally Determined Contribution	A commitment made by each signatory country to the Paris Agreement outlining the climate action it will take to contribute towards the agreement's aims.
On-site (emissions)	Emissions occurring on the site of a specific industry e.g. emissions from on-site agricultural facilities.

Planetary boundary	A boundary that provides a safe operating space for humanity within which it is possible to continue to thrive in a long-term perspective.
Production-based emissions	An approach to producing emissions inventories that focuses on activities occurring within a boundary as opposed to a population's consumption within that boundary. This methodology was developed by the Intergovernmental Panel on Climate Change for national emissions reporting. Note the terms production-based emissions and production emissions are used interchangeably within this report.
Private transport	Consumption category referring to full supply chain emissions associated with privately owned transport modes primarily private vehicles. In this case, it covers embodied emissions of vehicles as well as operational emissions in running vehicles.
Progressive target	Target level of ambition for consumption interventions determined through research on currently available technologies and evidence of feasibility for progressive changes in consumer choices (e.g. historic evidence of consumer habit change or alignment with other consumer priorities such as health).
Rest of Nation	Term used to refer to source emissions of a city's consumption-based emissions that occur within that city's host nation.
Rest of World	Term used to refer to source emissions of a city's consumption-based emissions that occur outside that city and its host nation's borders. Note this does not preclude the emissions occurring within one of the C40 cities where these relate to a different city.
Supply chain	The sequence of processes involved in the production and distribution of a commodity.
Urban stakeholders	The broader group of stakeholders, such as city governments, businesses and residents, whose decisions contribute to the emissions intensity of an economy. For example, building contractors' use of cement is arguably a consumer choice that ultimately leads to emissions associated with construction.

Forewords

C40

C40 is delighted to publish this pioneering piece of thought leadership, *The Future of Urban Consumption in a 1.5°C World.* The report demonstrates that mayors have an even bigger role and opportunity to help avert climate emergency than previously thought. But to grasp that opportunity, city leaders need to be even more entrepreneurial, creating and shaping markets and engaging in sectors that may not previously have been considered within the domain of city government, and working out how to support their citizens and businesses in achieving a radical, and rapid, shift in consumption patterns.

Cities drive the global economy, and urban decisions have an impact well beyond city boundaries. In this case, the impact we are considering is the greenhouse gas (GHG) emissions resulting from urban consumption of building materials, food, clothing & textiles, private transport, electronics & household appliances, as well as private aviation travel.

This report is the product of a detailed analysis by a team of leading experts and presents the scientific evidence on the climate impact of urban consumption. The work charts entirely new territory for C40, but also for the world at large.

What is the true scope and scale of urban impacts on the environment? What is the role of mayors and other urban stakeholders in addressing them? How can we fairly and equitably address consumption-based emissions if many citizens in C40 cities still do not meet their basic needs? Is it possible to avert climate breakdown given

Cities drive the global economy, and urban decisions have an impact well beyond city boundaries.

that the current rules of the global economy encourage ever-increasing consumption?

This report helps unpack some of those questions.

While the analysis addresses big global questions, its purpose is to inspire practical action. *The Future of Urban Consumption in a 1.5°C World* carefully outlines what changes that are needed to reduce the impact of urban consumption in line with limiting global heating to 1.5°C. The work also shows that there are huge health and cost benefits in doing so. A world with low-impact consumption will be more prosperous and happy than the over-consuming, polluted alternative that we are currently heading for.

C40 recognises that the full environmental consequences of twenty-first century consumption are only beginning to be understood and that the findings of this report will make uncomfortable reading for many mayors, businesses and citizens. As a result, C40 cities will need time to develop the partnerships, strategies and actions that can deliver the necessary changes. C40 is committed to supporting that process.

As always, C40 has adopted a science-based approach and that science is clear: average consumption-based emissions in C40 cities must halve within the next 10 years. In our wealthiest and highest consuming cities that means a reduction of two thirds or more by 2030. There is no time to lose and the C40 team looks forward to working with mayors and our partners to find solutions and take action to address this crucial issue, so that C40 cities can help put the world on track to climate safety and a prosperous future.

Mark Watts, ***Executive Director of C40***

Arup

We are proud of our partnership with C40 Cities and the work we have done together to help cities take action on climate change. As time passes and the evidence continues to mount, however, it becomes clearer that we must do more, and with greater urgency.

Our *Deadline 2020* report, which was published in 2016, established the pace and scale required for climate action in the C40 cities. The scope of that report was defined by a 'production-based' approach to emissions accounting. While the actions being taken by cities under their *Deadline 2020* commitments are necessary, we have turned our attention in this report to consider emissions from a consumption perspective.

Urban residents, myself included, drive greenhouse gas emissions through consuming goods and services. It is now clear that action to reduce consumption will be necessary as part of the global effort to mitigate climate change.

The good news is that these actions have the potential to realise wider economic and social benefits, including health and lifestyle benefits.

This report considers actions that can be taken across six priority areas of the global economy: food; clothing and textiles; electronics and household appliances; buildings and infrastructure; private transport, and; aviation. The actions set out in the report are challenging and they will be confronting for many, but we think they are necessary. We want to work with our partners to bring about the change that is needed – Arup is engaged on projects across most of the sectors covered by this report and as individuals we all make choices about what we eat, what we wear and how we travel.

Leadership and collaboration are essential to effect the kinds of changes that will be required in international supply chains. City Mayors can set a vision and convene actors to bring about the changes we describe. Leadership will also be needed from national governments, businesses and from individual people.

The work reported here forces a focus on what a sustainable urban future might look like and helps us to consider what policies, regulations, incentives and behavioural changes will be necessary to transition to a zero-carbon world.

Gregory Hodkinson, ***Former Chairman of Arup***

It is now clear that action to reduce consumption will be necessary as part of the global effort to mitigate climate change.

University of Leeds

There is a growing consensus, based on compelling evidence, that the world is facing a climate crisis and rapid action to reduce greenhouse gas emissions is a necessity. Historically, decision-makers and academics have discussed a range of options that can reduce our carbon footprint over the long-term. However, recent evidence demonstrates that choosing between one option and another is no longer compatible with rapid and significant emission reductions. Increasingly, all options are required, and this involves multiple actors exploring how they can respond to the current climate crisis; including national government, cities, business and civil society.

Cities have a unique opportunity to deliver mitigation options in addition to national action. Cities can clearly reduce their direct emissions from heat, electricity, mobility and waste, that occurs inside the city, as well as have a role in reducing the emissions that occur outside the city boundary, as a consequence of urban consumption patterns. Providing city authorities with the evidence needed to reduce the impact of consumption has led to major advances in methodologies that can measure the embodied emissions of supply chains. This report documents one of the most advanced applications to date, since it both documents the carbon footprint of key global cities, projects urban emissions into the future and analyses a range of strategies and policies that can be implemented at the city level to reduce consumption-based emissions.

Projecting future emissions is never easy as no one has perfect foresight. However, the methodology in this report provides a transparent approach that we hope will be more widely adopted by cities beyond the C40 network. It clearly highlights that options are available to cities and that more sustainable consumption patterns can achieve rapid reductions in global emissions.

Professor John Barrett, ***Chair in Energy and Climate Policy at the University of Leeds***

Cities have a unique opportunity to deliver mitigation options in addition to national action.

Acknowledgements

This report was generously supported with funding from Citi Foundation

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THE FUTURE OF URBAN CONSUMPTION IN A 1.5°C WORLD

1 Executive summary

This report by C40, Arup and the University of Leeds assesses the impact of urban consumption on climate breakdown and explores the type and scale of changes needed to ensure that C40 cities reduce their GHG emissions in line with internationally agreed, climate-safe limits.

Main takeaways

1 • ***New ways of measuring the climate footprint of C40 cities show that urban consumption is a key driver of global GHG emissions.*** *C40 cities can have a significant impact on GHG emissions beyond their geographic borders by influencing global supply chains.*

2 • ***C40 cities alone represent 10% of global GHG emissions when accounting for consumption-based emissions.***

3 • *While C40 cities have strong action plans in place to significantly cut emissions produced directly within their geographic boundaries,* ***emissions measured by what is consumed within C40 cities are rising and, left unchecked, will nearly double by 2050*** *(+87%).*

4 • *To avoid climate breakdown, emissions from global urban consumption must halve by 2030. For this to be achieved,* ***emissions from consumption in high-income cities must decrease by two thirds within the next decade.*** *At the same time, rapidly developing economies need to adopt sustainable consumption patterns when growing.*

5 • ***Cities are already leading on addressing climate breakdown by setting science-based targets and taking meaningful action to reduce local emissions from buildings, energy, transport and waste.*** *However, it is crucial that emissions from consumption are measured when considering how to reduce a city's full impact on climate change.*

6 • ***Urban action on consumption can significantly reduce emissions from key consumption categories*** *such as buildings and infrastructure (26% by 2030; 44% by 2050), food (36% by 2030; 60% by 2050), private transport (28% by 2030; 39% by 2050), clothing and textiles (39% by 2030; 66% by 2050), electronics and household appliances (18% by 2030; 33% by 2050) as well as aviation (26% by 2030; 55% by 2050).*

7 • ***Cutting consumption-based emissions will deliver wider benefits for a city and its residents. Individuals, businesses and city governments all stand to gain if changes are delivered in the right way.*** *This analysis shows that a city that consumes sustainably can also be a city where residents' health is improved and mortality rates are lowered, where it is safer to walk and cycle, where there is more public space, where there is cleaner air, where water and land are used effectively, and where housing is more affordable.*

What the science says about where we are

Cities are leading on tackling climate breakdown by setting ambitious targets and taking impactful action to reduce their local emissions.

This work has mostly focused on transport, buildings, energy and waste, which reduces GHG emissions that are emitted within the city, or production-based emissions. Production-based emissions have already peaked in 27 C40 cities.[1]

Cities are at the centre of the world economy and decisions made in them have a significant impact on emissions beyond their boundaries.

New information shows that fast-growing urban consumption is a key driver of climate change. When a product or service is bought by an urban consumer in a C40 city, resource extraction, manufacturing and transportation have already generated emissions along every link of a global supply chain. Together these consumption-based emissions add up to a total climate impact that is approximately 60% higher than production-based emissions.

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C40 cities have already peaked in terms of production-based emissions

It is crucial that emissions from consumption are measured when considering how to reduce a city's full impact on climate change.

Consumption-based emissions account for the total climate impact accumulated around the world of a good or service, allocated to the place where an end-product is used or consumed. Take a pair of jeans, for example. Its climate impact includes the GHG emissions that resulted from growing and harvesting the cotton used for the fabric, the CO_2e emitted by the factory where it was stitched together, and the emissions from ships, trucks or planes that transported it to the store. Its impact also includes the emissions from heating, cooling or lighting the store the jeans were bought in and the CO_2e emitted by the end-consumer washing and drying it over its lifetime.

[1] C40 Cities (2018) Available at: https://www.c40.org/press_releases/27-cities-have-reached-peak-greenhouse-gas-emissions-whilst-populations-increase-and-economies-grow

A consumption-based inventory gives a fuller picture of a city's climate impact.

An assessment of cities' consumption-based emissions takes into account the total emissions associated with goods and services produced and consumed within the city, plus emissions from goods and services imported from the rest of the nation or the world, minus emissions from goods and services produced within the city but exported elsewhere. This differs from a production-based approach – the standard methodology used by national governments – which accounts for emissions from activities within a geographic boundary, such as heating up a building or driving a vehicle. A production-based methodology is less suitable for cities than countries, because many cities consume a far greater quantity of CO_2e-emitting products than they produce.

By compiling consumption-based inventories for all C40 cities, C40 has been able to develop an understanding of what sustainable urban consumption looks like.

In 2016, C40 launched Deadline 2020, the first routemap that showed how cities could deliver on the Paris Agreement from the point of view of production-based emissions.[2] Since then, Deadline 2020 has established the pace and scale of climate action in C40 cities. However, the scope of this work was defined by a production-based approach to emissions accounting. In 2018, C40 published a consumption-based GHG emissions inventory for a cohort of cities, which highlighted the global climate impact that cities have as centres of consumption.[3] In this new report, we take this analysis one step further by examining previously unconsidered urban opportunities for climate action and analysing how effective a number of interventions to stimulate more sustainable consumption can be, in terms of reducing emissions, alongside a continued delivery of Deadline 2020 commitments to reduce emissions from production.

An assessment of cities' consumption-based emissions takes into account the total emissions associated with goods and services produced and consumed within the city, plus emissions from goods and services imported from the rest of the nation or the world, minus emissions from goods and services produced within the city but exported elsewhere.

[2] The Paris Agreement commits signatories to "holding the increase in the global average temperature to well below 2 degrees above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees above pre-industrial levels"
[3] C40 Cities: Consumption-based GHG Emissions of C40 cities

This report shows that tackling urban consumption gives C40 cities a greater scope to influence global emissions. Consumption-based emissions in C40 cities have been estimated to account for 4.5 $GtCO_2e$ out of a global total of 45 GtCO2e in 2017.

C40's 94 member cities can therefore influence roughly 10% of global emissions. By contrast, the total production-based emissions of C40 cities in 2017 are estimated to be 2.9 $GtCO_2e$. When considering C40 cities' consumption-based emissions, mayors, businesses and urban residents can influence an approximately 60% larger share of global GHG emissions than previously thought. Cities and urban consumers have a huge impact on emissions beyond their own borders since 85% of the emissions associated with goods and services consumed in C40 cities are generated outside the city; 60% in their own country and 25% from abroad.

85%

of the emissions associated with goods and services consumed in C40 cities are generated outside the city

What the science says about where we need to get to

In order to stay within established GHG budgets and limit global warming to 1.5°C – the internationally agreed upper-limit for a climate-safe future[4] – the average per capita impact of urban consumption in C40 cities must decrease by 50% by 2030 and 80% by 2050.

Therefore, C40 cities' consumption-based emissions need to peak by 2020, then decrease by half by 2030, before halving once again by 2036, and finally stabilising at 0.7tCO_2e per capita by 2050. This transition to a low-carbon economy will require a rapid alignment of climate policies on global, national and local levels in order to deliver this unprecedented level of climate action by individuals, business and government.

[4] *IPCC: Special Report on Global Warming of 1.5°C*

By 2030, the average per capita impact of urban consumption in C40 cities must decrease by 50%

Without further climate action, C40 cities' consumption-based emissions will nearly double (+87%) by 2050.

Under such a scenario, C40 cities will use up their entire 1.5°C-compliant GHG budget in just 14 years.

High-income cities must immediately steeply reduce the climate impact of their consumption by two thirds within the next decade.

Much of this reduction will take place in Europe, North America and East Asia, and climate action over the coming decade will decide whether C40 cities, and the world at large, can reduce consumption-based emissions in line with a 1.5°C trajectory.

At the same time, rapidly-developing economies need to adopt sustainable consumption patterns as they grow.

For C40 cities in Latin America, South and West Asia, South-East Asia and Africa, the challenge is to prevent further increases in per capita consumption-based emissions after 2020, before steadily reducing emissions in line with a 1.5°C trajectory.

City governments and urban stakeholders can deliver 35% of the necessary emission reductions on their own, by committing to Deadline 2020 (an emissions trajectory consistent with a 1.5°C scenario for production-based emission) and by working with local and global partners to meet the consumption targets set out in this report.

C40 cities that are already delivering on their Deadline 2020 commitments will simultaneously be addressing 25% of their consumption-based emissions, due to an overlap between production-based and consumption-based emissions. However, urban stakeholders can go a step further and address their full consumption-based emissions by taking additional climate actions on *food; buildings and infrastructure; private transport; aviation; clothing and textiles; and electronics and household appliances.*

[5] *Flight Emission Map*

Wealth is an important factor. Greater levels of disposable income in wealthy cities allow consumers to buy more goods and services, which result in higher levels of consumption-based emissions.

Consumption patterns and consumption-based emissions are not uniform across all cities. Within the C40 network, consumption-based GHG emissions vary from 1.2 to 39.7 tCO_2e per capita per year, a difference that is equivalent to 20 return flights between London and New York City.[5]

This report outlines six consumption categories (food; buildings and infrastructure; private transport; aviation; clothing and textiles; and electronics and household appliances) that cities can focus on, as well as the emission-reduction impact of selected consumption interventions.

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consumption categories: food; buildings and infrastructure; private transport; aviation; clothing and textiles; and electronics and household appliances

The benefits of getting there

Cutting consumption-based emissions will deliver wider benefits for a city and its residents.

Individuals, businesses and city governments all stand to gain if the changes are delivered in the right way. Some benefits include:

- Using existing buildings more efficiently and avoiding new construction would save London, for example, more than $11 billion over the next five years.
- Eating less red meat and more vegetables and fruits could prevent annually 160,000 deaths associated with diseases such as cancer, heart disease, diabetes and stroke in C40 cities.
- By reducing vehicle ownership, 170 million m^2 of on-street parking could be released back to the public realm in C40 cities, providing enough space for 2.5 million trees and 25,000 km of cycle lanes.
- By buying fewer new clothes and textiles, residents in all C40 cities could collectively save $93 billion in one year.
- Reducing flights and adopting sustainable aviation fuels could collectively avoid $70 million in damages from air pollution that would impact human health, buildings, infrastructure and agricultural production.

Eating less red meat and more vegetables and fruits could prevent annually 160,000 deaths associated with diseases such as cancer, heart disease, diabetes and stroke in C40 cities.

The changes that need to happen to get us there

This study finds that leaders in the C40 cities network can exert influence over global emission reductions by promoting changes in the production and consumption of food, buildings and infrastructure, private transport, aviation, clothing and textiles, and electronics and household appliances.

Individuals, businesses and governments in C40 cities can affect what and how goods and services are bought, sold, used, shared and re-used all over the world. The network of C40 cities can use their global spending power to speed up a transition to low-carbon production.

Consumption category	Consumption interventions	Emission reductions per consumption category between 2017 and 2030	Emission reductions per consumption category between 2017 and 2050
	• Reduce the number of new clothing items bought every year • Reduce supply chain waste	**39%** (Reducing the number of new clothing items alone accounts for 37%)	**66%** (Reducing the number of new clothing items alone accounts for 64%)
	• Dietary change: eat in line with health recommendations and lower meat and dairy consumption • Reduce household waste • Reduce supply chain waste	**36%** (Dietary change alone accounts for 27%)	**60%** (Dietary change alone accounts for 45%)
	• Reduce number of flights • Increase adoption of sustainable aviation fuel	**26%** (Reducing number of flights alone accounts for 18%)	**55%** (Reducing number of flights alone accounts for 31%)
	• Improve materials efficiency • Enhance building utilisation • Switch to lower carbon materials • Adopt low-carbon cement • Reuse building components	**26%** (Improving materials efficiency and enhance building utilisation together account for 18%)	**44%** (Improving materials efficiency and enhance building utilisation together account for 29%)
	• Reduce car ownership • Increase car lifespans • Increase material efficiency	**28%** (Reducing car ownership alone accounts for 24%)	**39%** (Reducing car ownership alone accounts for 31%)
	• Optimise lifetimes of IT equipment	**18%**	**33%**

Immediate and ambitious action on consumption-based emissions is needed from everyone to achieve a swift transition to a low-carbon economy.

Mayors, national governments, business and individual consumers have to work together to decarbonise global supply chains and shift to sustainable consumption practices. An accelerated transition to cleaner production will require much more ambitious national targets than the Nationally Determined Contributions (NDCs) nations have committed to under the Paris Agreement.

Reducing consumption-based emissions will require significant behavioural changes.

Individual consumers cannot change the way the global economy operates on their own, but many of the interventions proposed in this report rely on individual action. It is ultimately up to individuals to decide what type of food to eat and how to manage their shopping to avoid household food waste. It is also largely up to individuals to decide how many new items of clothing to buy, whether they should own and drive a private car, and how many personal flights to take. As this report shows, these are some of the most impactful consumption interventions that can be taken to reduce consumption-based emissions in C40 cities. Furthermore, businesses and elected leaders often respond to consumer demands and voter priorities. Signs of broad behavioural change will therefore support low-carbon corporate and political action. If C40 cities are to cut their consumption-based emissions in half by 2030 and reduce them by 80% by 2050, it is critical that large-scale behavioural changes occur as soon as possible, and that governments and businesses support a swift transition to more sustainable consumption through policy incentives and new business models.

However, achieving the necessary emission reductions will also require greater international action than is currently planned.

Compared to a future scenario with no further climate action, this report demonstrates that a global transition to low-carbon production of goods and services, in line with current national government targets, could reduce emissions significantly. If, in addition, Deadline 2020 commitments are also met and a series of ambitious consumption interventions are carried out, C40 cities could reduce their consumption-based emissions by 70% over the period up to 2050. This is a significant reduction, but it still leaves an emissions gap in C40 cities, compared to a 1.5°C scenario.

Individual consumers cannot change the way the global economy operates on their own, but many of the interventions proposed in this report rely on individual action.

To fully reduce emissions in line with a 1.5°C trajectory, an accelerated global transition to cleaner production must take place, supported by national targets that go well beyond current nationally-determined commitments.

These developments must initiate sweeping decreases in the carbon-intensity of industrial processes such as the making of steel, cement and petrochemicals.

If C40 cities can reduce their consumption, under a scenario with an accelerated transition to cleaner production, global, national and city action will close 95% of C40 cities' consumption-based emissions gap by 2050.

If cities then develop additional bespoke consumption interventions, for a wider set of diverse goods and service categories that have not been the focus of this report, C40 cities could close their full consumption-based emissions gap by 2050.

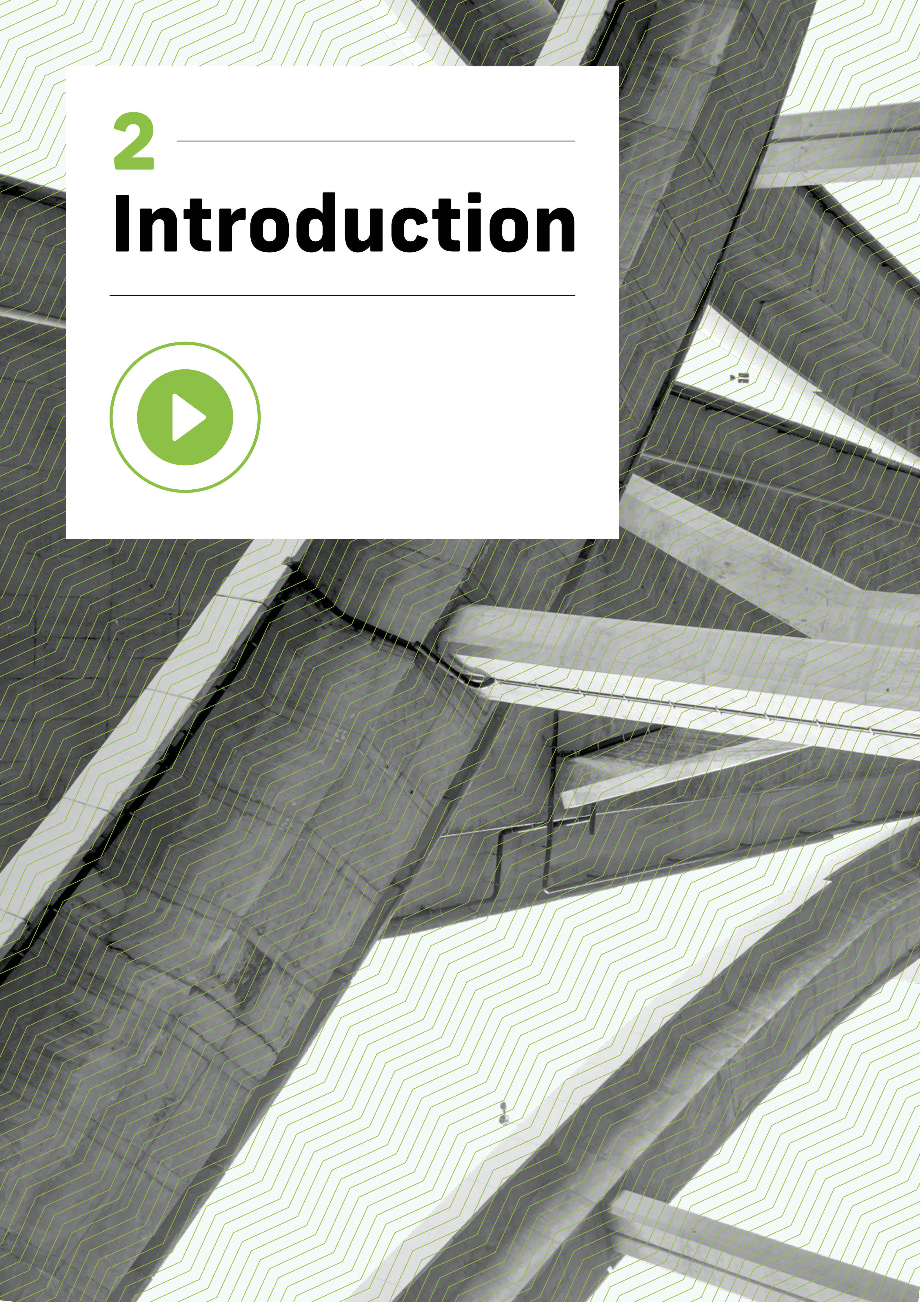
While national action is necessary, C40 cities do not have to wait for it.

The C40 network represents 25% of the global economy, and vast amounts of goods and services are produced around the world in order to meet consumer demands in C40 cities. Mayors and city governments are well-positioned to bring together urban residents, businesses, civil society groups and national governments to collaborate on the delivery of transformative climate solutions.

To achieve necessary emission reductions, we need deep shifts in the way that economies and societies operate.

The wide range of action required to achieve a 1.5°C scenario leaves little room for delay or failure over the coming decade; other broad, supporting policies can provide a safety net by bringing about complimentary emission reductions. Examples of such policies are a wide deployment of carbon capture and storage (CCS), particularly in industries that emit direct emissions, and carbon pricing mechanisms that can underpin action across entire economies and markets. However, even deeper paradigmatic shifts may be relevant, such as adopting more useful measures of societal development than just economic growth. In practice, no one city or nation will follow the exact same emissions reduction pathway, but this report provides direction on the type, scale and timescale of policies that will need to be implemented.

The wide range of action required to achieve a 1.5°C scenario leaves little room for delay or failure over the coming decade.



2 Introduction

2.1 Broadening cities' climate action by considering consumption-based emissions

In 2016, C40 launched Deadline 2020, the first significant routemap for cities to deliver on the Paris Agreement.

Deadline 2020 commits signatories to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

Deadline 2020 established the pace and scale required for climate action in C40 cities, and set out a list of priorities. It is based on an analysis of each C40 city's emissions using the UN's production-based methodology to measure each nation's GHG emissions. This methodology provides an accurate assessment of emissions produced by physical processes within a given geographical boundary, but does not account for emissions from products and services bought in a different place from where they were manufactured or serviced.

In 2017, C40 published consumption-based greenhouse gas (GHG) emissions inventories for a significant cohort of C40 cities. This work highlighted the impact of cities as centres of consumption and set an important challenge to reduce emissions.

This project combines the action focus of Deadline 2020 with the broader scope of tackling consumption-based emissions in cities.

[6] *GHG Protocol (2014) Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. Available at: https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf*

[7] *C40 Cities (2018) Consumption-based GHG emissions of C40 cities.*

2.2

What can cities and mayors do to support action on consumption?

C40, Arup and the University of Leeds have collaborated on research and analysis to better understand the scale of consumption-based emissions and explore what cities can do to reduce them.

This report sets out a series of future scenarios to show how consumption-based emissions in C40 cities may evolve if no action is taken, if limited action is taken and if ambitious action is taken. It presents previously untapped opportunities for emissions reduction in six key consumption categories - food; buildings and infrastructure; private vehicles; aviation; clothing and textiles; and electronics and household appliances - and quantifies the wider benefits of acting on consumption.

Opportunities for action were analysed in the context of different levels of urban consumption across the C40 network. Further detail on the differentiated targets over time will be published in a series of accompanying focused reports on the six priority areas for city consumption intervention referred to as In Focus Category Reports.

Future scenarios are set against updates of the GHG budgets for C40 cities based on consumption, rather than production. This new analysis provides a fresh perspective of the scale of climate efforts required to reduce emissions in line with cities' commitments to keep global warming to 1.5°C and offers insights about where in the world action should be focused.

Changing consumer and producer choices is a challenging task, which is why this report uses a mapping framework to identify stakeholders with the greatest ability to influence different interventions on consumption. The accompanying method report also presents a set of consumption indicators designed to support city governments in predicting their consumption-based emissions and to help cities to reduce these over time.

This report is aimed at the member cities of the C40 network. It calls on mayors and their advisers to reflect on how their city development plans can help reduce global emissions while delivering multiple benefits for residents. However, the reduction of consumption-based emissions is a shared responsibility. This report should therefore serve as a catalyst for collaboration between government, business, NGOs and communities. Mayors can play an important role as leaders and convenors in this.

Changing consumer and producer choices is a challenging task, which is why this report uses a mapping framework to identify stakeholders with the greatest ability to influence different interventions on consumption. The accompanying method report also presents a set of consumption indicators designed to support city governments in predicting their consumption-based emissions and to help cities to reduce these over time.

2.3

Continuing the collective journey to leverage cities' role in global mitigation efforts

This report attempts to map the extent of C40 cities' consumption-based emissions as well as what cities can do to reduce their climate impact.

However, this research is evolving. This report is based on the best currently available evidence, but more and better data will become available over time, allowing the goals and approaches to be refined. The findings presented in this report constitute the first step of an ongoing process of measurement and prioritisation that C40 will lead over the next few years to better understand what cities can do to reduce their consumption-based emissions in line with a 1.5°C scenario. We have published the evidence, methods and assumptions within an accompanying method report, and welcome suggestions for improvements. An overview of the research approach is shown on the next page.

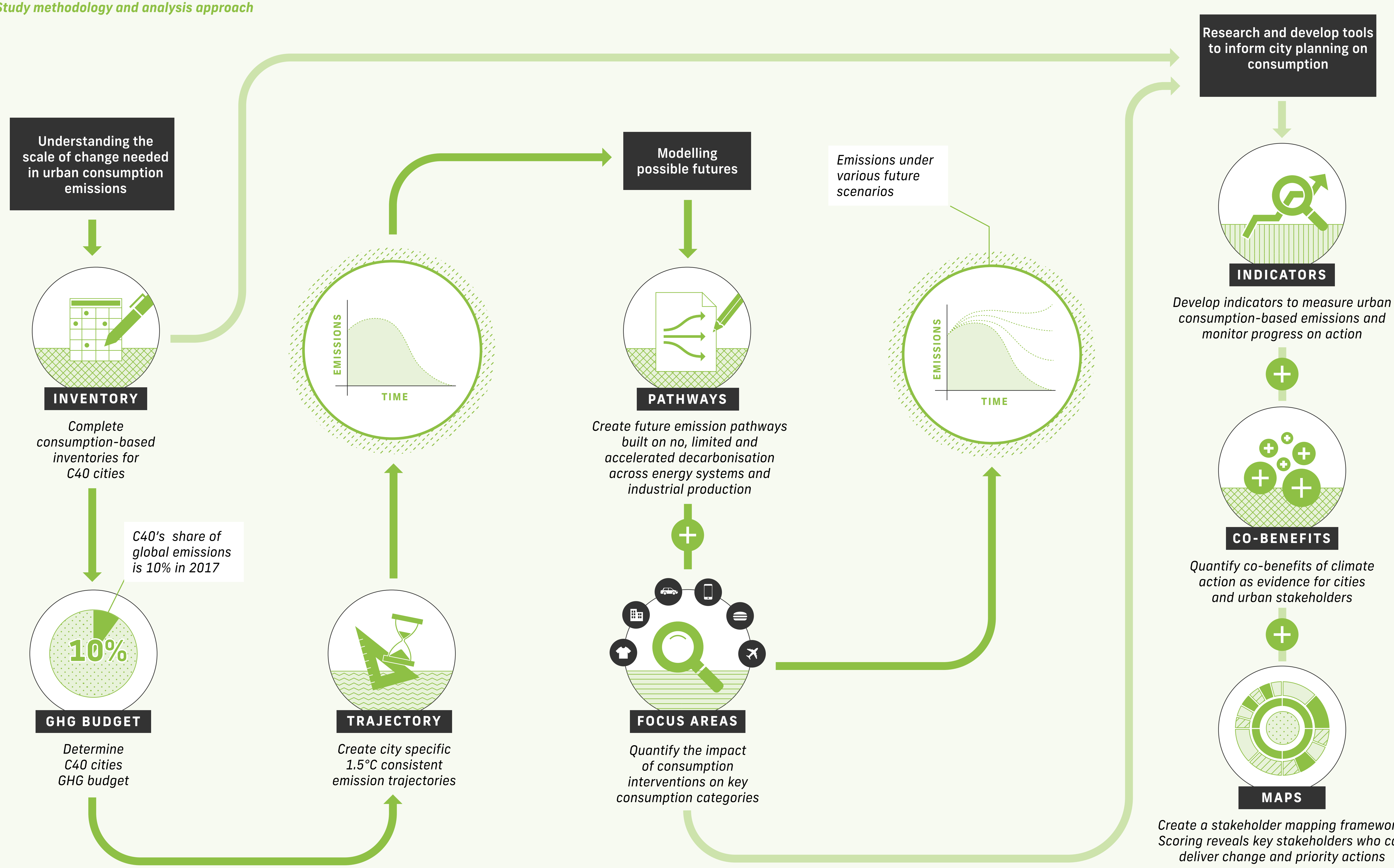
Call for Evidence: A work in progress seeking your review and input

Homepage: www.C40.org/research

The method report, evidence base and limitations of the research are published in a technical paper. Additionally six focus reports for each priority consumption category will be provided, which will include the rationale and evidence for the interventions and their target levels, further details of the benefits these could deliver to cities, and the description of key stakeholders and actions to deliver on the most impactful interventions.

We invite all partners to read and review these, and provide comments and recommendations for improvement, as well as providing links to other relevant work and data.

Study methodology and analysis approach



*Note that the indicators are not presented within this report. Instead these can be found in the method report (C40.org)

3 Why do we need to act?

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) published its Special Report on Global Warming of 1.5°C.[8] This showed that an average of 1.5°C of warming is the only viable target to preserve a hospitable global living environment.

“Limiting global warming to 1.5°C instead of 2°C could result in around 420 million fewer people being frequently exposed to extreme heatwaves, and about 65 million fewer people being exposed to exceptional heatwaves.”[9]

The unequivocal conclusion from this finding is that the Paris Agreement should take on the lower limit of 1.5°C warming above pre-industrial levels. C40 Cities is adopting this level of ambition.

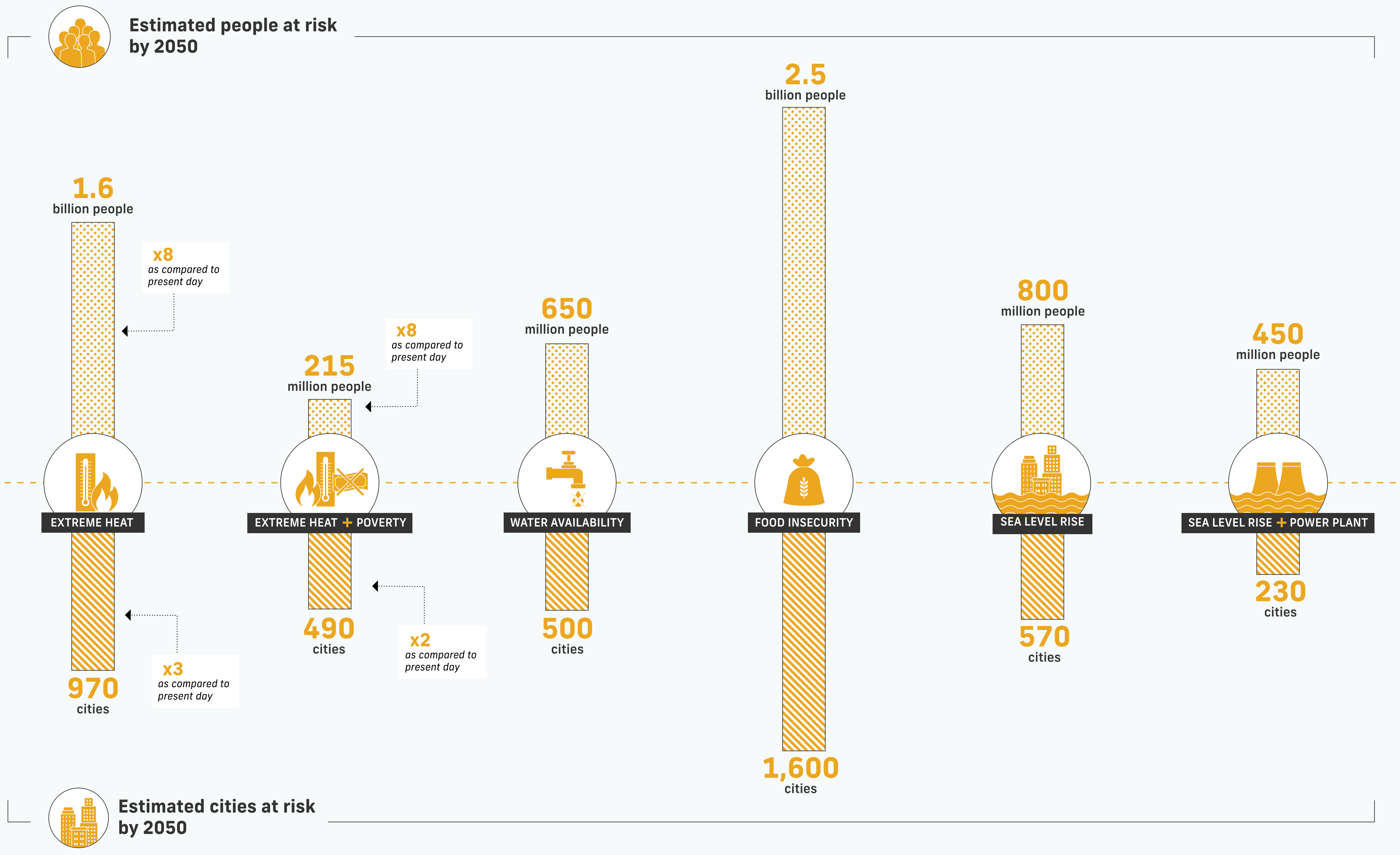
C40’s research *The Future We Don’t Want* investigated urban vulnerability to six climate hazards by 2050 and found that unmitigated climate change poses an existential threat to some of the world’s greatest cities. People who live in cities are increasingly vulnerable to climate extremes, including more frequent, longer and more intense heatwaves, exacerbated inland flooding from rainfall and extended coastal flooding due to sea level rise. Cities need to plan with these impacts in mind to reduce risks for their citizens, physical infrastructure and economies.

[8-9] *IPCC (2018) Global warming of 1.5°C Summary for Policy-makers. Available at: https://www.ipcc.ch/sr15/*

WHY DO WE NEED TO ACT?
PART — 3

fig.1 A summary of critical risks

A summary of critical risks that cities and their residents will encounter as a result of climate change.



4

Why is it important to measure consumption-based emissions?

4.1

City emissions from production-based and consumption-based inventories

Many cities have already adopted the Global Protocol for Community-Scale Greenhouse Gases (GPC) to measure their climate impact.[9]

This framework, often described as production-based or territorial accounting, captures GHG emissions associated with major urban activities within physical city boundaries, i.e. transport; buildings and industries; agriculture; forestry and other land uses (where applicable); as well as waste disposal and wastewater treatment. The total emissions of C40 cities measured using this methodology were estimated to be 2.9 $GtCO_2e$ in 2017.

This production-based approach to measuring and reporting GHG emissions has successfully driven mitigation efforts on urban activities within C40 cities' boundaries. Under C40's Deadline 2020 programme, more than 70 cities have committed to achieve an early peak in emissions, collectively halve emissions by 2030 and achieve net carbon neutrality by 2050 through the use of the GPC territorial boundary definitions.

[9] GHG Protocol (2014) Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. Available at: https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf

In 2017, the total production-based emissions of C40 cities were approximately

2.9 $GtCO_2e$

However, this accounting framework does not fully reflect the impact that cities have on global emissions, since 85% of emissions associated with goods and services consumed in C40 cities are imported from elsewhere. Nor does the production-based accounting approach direct focus on the influence that city governments can have if they enable citizens and businesses to shift to more sustainable consumption. This shift can affect emissions well beyond cities' geographical and political boundaries.

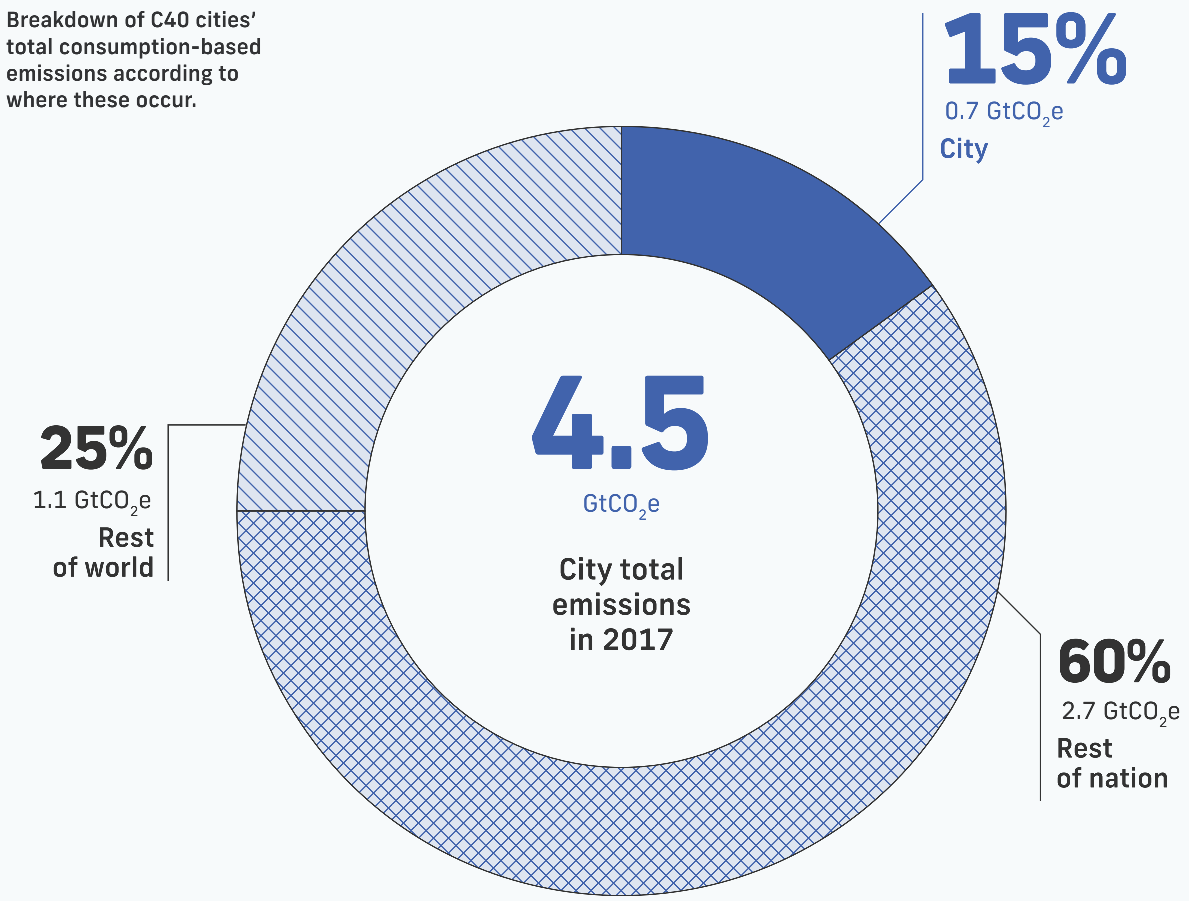
When using a production-based methodology, emissions produced through the extraction of raw materials, industrial processes, transportation and the energy that all of these activities require are predominantly accounted for at the place of production. A production perspective can therefore significantly underplay the impact that urban residents, businesses and governments have on global emissions, especially in cities where carbon-intensive production

85%

of emissions associated with goods and services consumed in C40 cities are imported from elsewhere

fig.2

Breakdown of C40 cities' total consumption-based emissions according to where these occur.



of material goods and services has largely has been outsourced, either to other regions of the nation, or to other countries.

To better understand the climate impact of goods and services consumed in cities, it is possible to examine their emissions using a consumption-based accounting framework. This framework allocates all GHG emissions associated with the production and distribution of goods and services to the end-consumer, allowing for the full GHG emissions associated with city residents and, by association, the businesses and government activities serving them, to be determined.

A city's consumption-based based GHG inventory can be defined as: production-based emissions[15], minus the GHG emissions of exported goods and services (i.e. those that are produced in the city but consumed in other locations), plus the emissions of imported goods and services.

In 2017, consumption-based emissions in C40 cities were estimated to account for 4.5 $GtCO_2e$ emissions, or roughly 10% of global GHG emissions. This means that C40 cities' consumption-based emissions are approximately 58% larger than the network's production-based emissions (Figure 3).

A city's consumption-based based GHG inventory can be defined as: production-based emissions[15], minus the GHG emissions of exported goods and services (i.e. those that are produced in the city but are consumed in other locations), plus the emissions of imported goods and services.

[10] The term 'Goods and Services' is used in this context to mean consumption of public transport, utilities, food, stationary fuel/energy, personal transport and purchased goods and services

[11] The GPC accounting framework sets two levels of reporting - BASIC and BASIC + - which incorporate a level of out-of-city boundary emissions such as emissions from electricity consumed in the city but produced elsewhere and waste generated in the city but disposed elsewhere

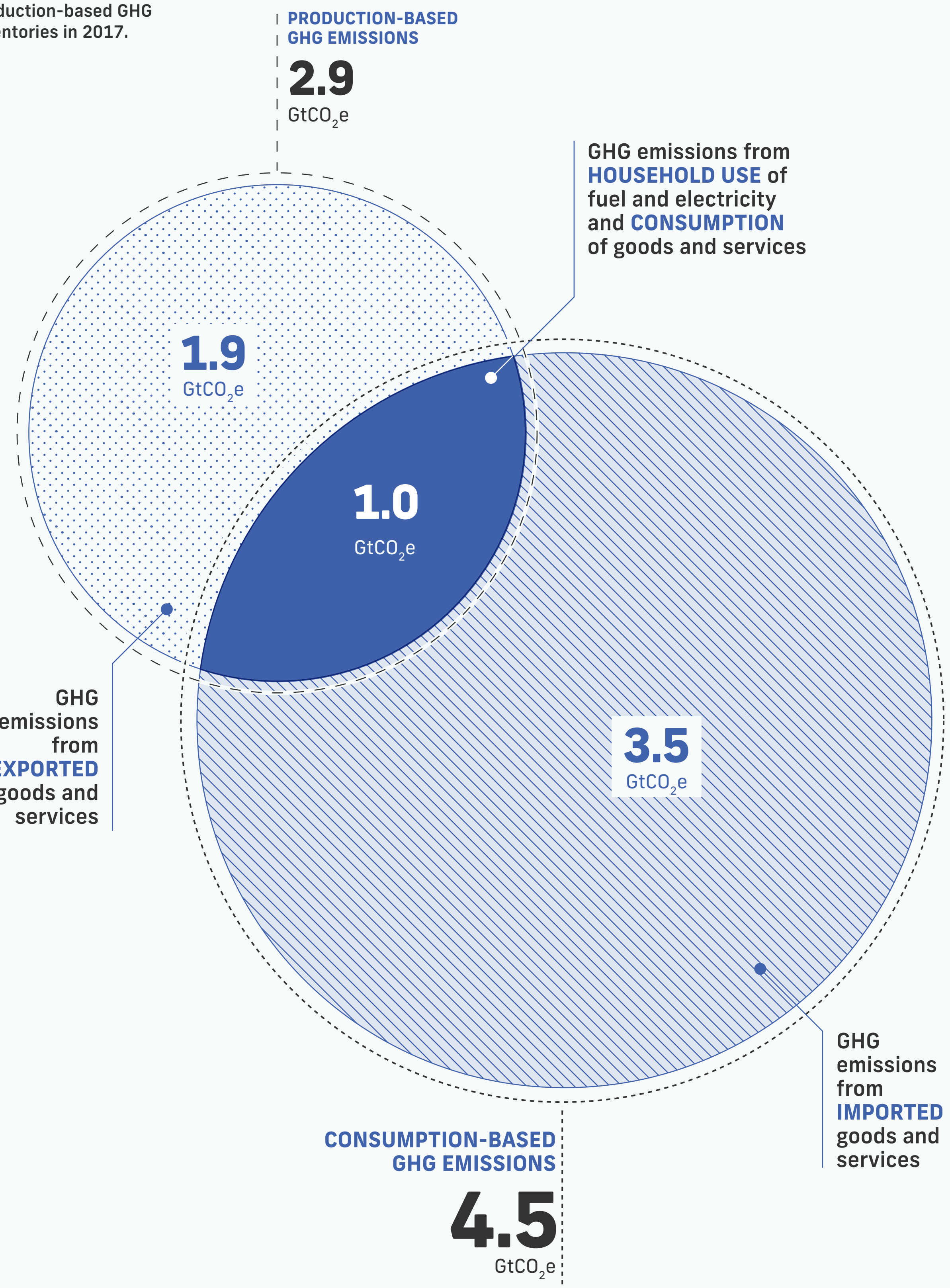
[12] The exception to this is emissions associated with waste disposal and treatment which are captured within the GPC framework

[13] UNEP (2019) Global Resources Outlook 2019. Available at: https://wedocs.unep.org/handle/20.500.11822/27519

[14] Within this document, the term 'city residents' refers specifically to residents living within the city, i.e. excluding visitors. By contrast, the term 'urban consumers' refers to the broader group of stakeholders e.g. city governments, businesses and residents whose consumption decisions contribute to the emissions intensity of the economy. For example, building contractors' use of cement is arguably a consumer choice which ultimately leads to the emissions associated with construction

[15] GPC inventory according to BASIC level

fig.3
Comparison of C40 consumption-based and production-based GHG inventories in 2017.



4.1.1 Consumption-based emissions by category

As Figure 3 shows, there is an overlap between cities' production-based and consumption-based emissions. About a quarter of consumption-based emissions relate to goods and services that are both produced and consumed within the city boundary (such as public transportation, municipal government services and certain consumer goods) as well as the burning of fossil fuels for transport and energy used in buildings. Moreover, emissions common to the two accounting frameworks are not exclusively limited to those occurring within the city boundary (see Figure 2) but also include emissions from grid electricity consumption that are covered within basic GPC reporting.

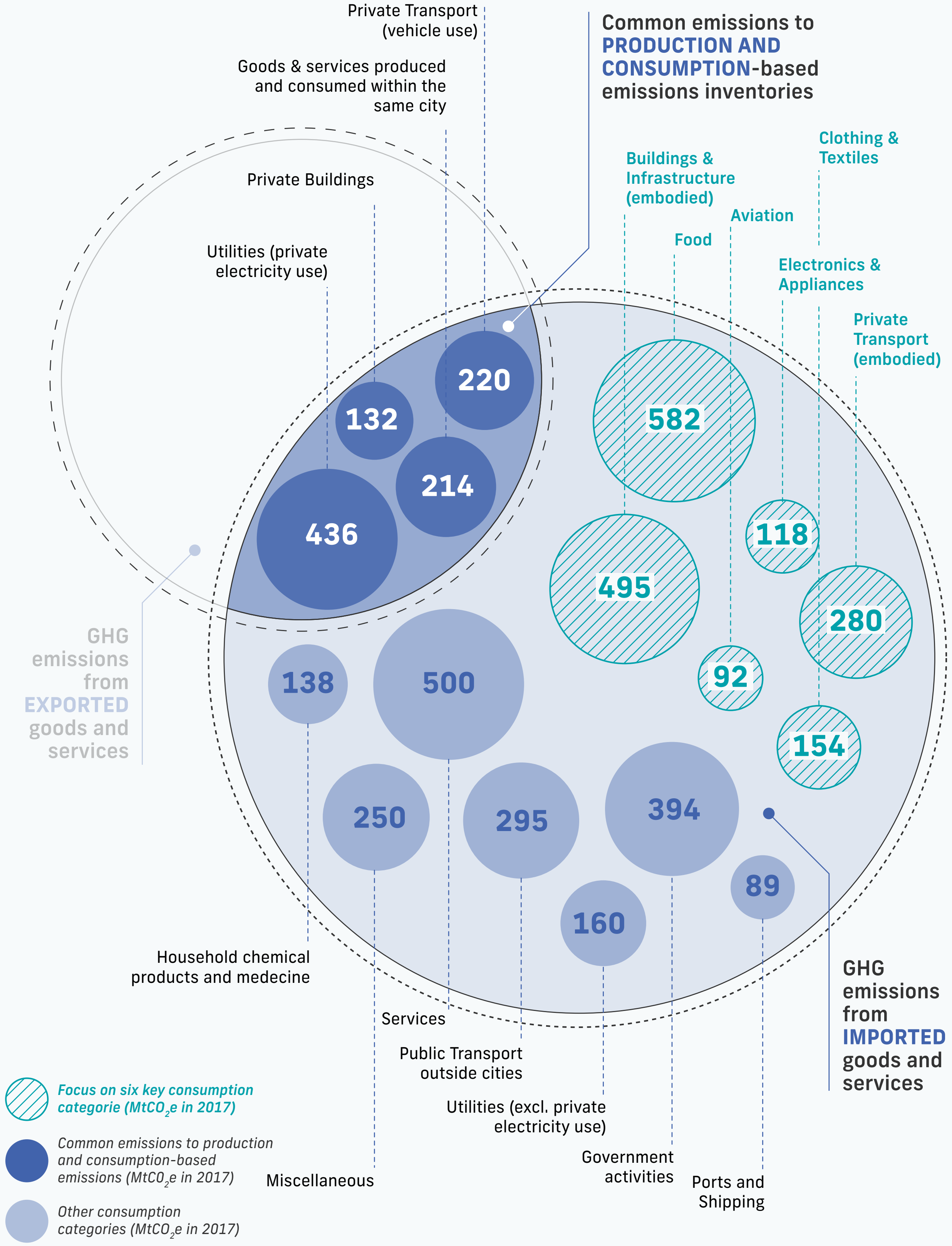
Consumption-based emissions represent a broad range of categories, with many different goods and services that contain varied source emissions and require different interventions.

By focusing on consumption-based emissions, this study also examines previously unconsidered urban opportunities for climate action. Consumption-based emissions represent a broad range of categories, with many different goods and services that contain varied source emissions and require different interventions. To help prioritise action on urban consumption, this study concentrates on six categories which represent the greatest opportunity for significant emission reduction in cities, and have not been exploited to date: food, buildings and infrastructure, clothing and textiles, electronics and household appliances, private transport and aviation.

It is also important that C40 cities address consumption-based emissions from other consumption categories as well, such as services, government activities and public transport outside the city boundary. These categories encompass diverse goods and services for which meaningful and specific interventions are difficult to determine and may not have a significant impact. For example, services is a broad category covering services from financial, legal and hospitality.

[16] C40 Cities (2018) Consumption-based GHG emissions of C40 cities. [17] For further information on how they relate to GPC categories, see accompanying method report.
[18] 'Buildings and infrastructure' refers to embodied emissions in new construction, as opposed to 'Private buildings' which refers to emissions from in-use energy consumption in private buildings only
[19] Within Figure 3, the consumption category 'Private transport' is split according to embodied and in-use emissions. However, the category is treated as one in the context of city consumption interventions, see Section 7

fig.4
Production-based and consumption-based emissions by category.



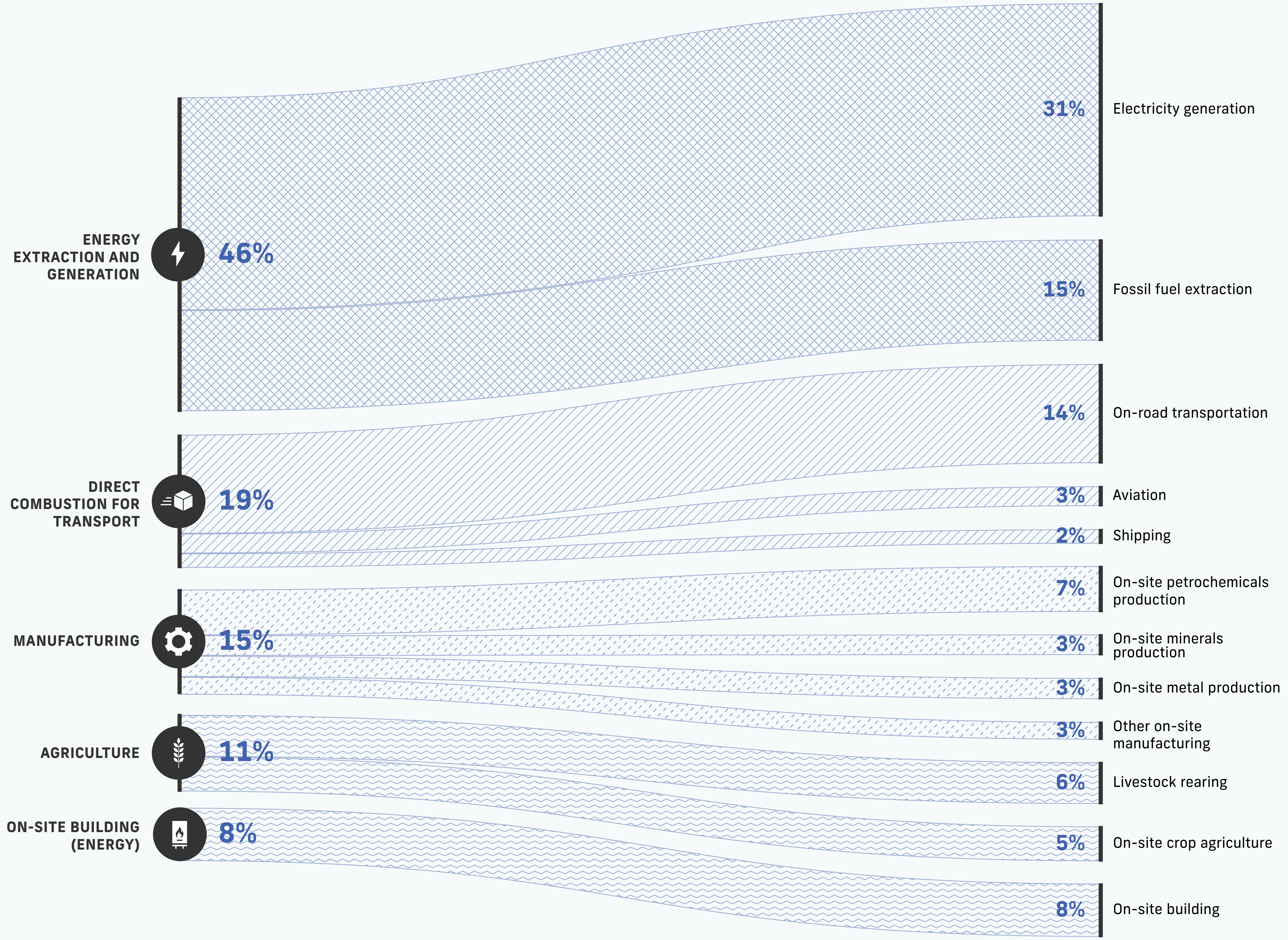
THE FUTURE OF URBAN CONSUMPTION IN A 1.5°C WORLD

4.1.2
Consumption-based emissions by source

Having a better understanding of where emissions are released can help target efforts to cut them. Figure 5 shows the varied range of sources that contribute to consumption-based emissions, which accounts for the direct emissions occurring within different industrial activities. Emissions from fossil fuel extraction, for example, include those produced at the site to power the process of extraction and direct methane leaks as a by-product of mining. They do not include the burning of those extracted fuels (for energy) further down the supply chain. Emissions from the use of extracted fossil fuels are allocated to the processes that consumed the fuel, such as on-site manufacturing of metals or electricity generation.

fig.5

Breakdown of 2017 direct sources of C40 consumption-based emissions.



Main takeaways

→ *Many cities currently use a production-based approach to measure their emissions. While a production-based approach is helpful when focusing mitigation efforts on urban activities that take place within a city's territorial boundary, the approach does not fully reflect the impact that cities have on global emissions.*

→ *85% of the emissions that are associated with the goods and services that are consumed in C40 cities are in fact imported from beyond city boundaries. Due to this, consumption-based emissions in C40 cities were approximately 58% larger than the network's production-based emissions in 2017.*

→ *By focusing on consumption-based emissions this study examines a range of opportunities for climate action across six key consumption categories: food, buildings and infrastructure, clothing and textiles, electronics and appliances, private transport and aviation. These climate actions differ from previous C40 efforts by targeting new drivers of emissions such as food consumption as well as embodied emissions in construction and private transport.*

→ *If C40 cities take action to reduce their consumption-based emissions, it will affect emissions and activities that take place well beyond their geographical and political boundaries.*

Switching from a production-based to a consumption-based approach to measuring emissions provides additional opportunities for reducing emissions.

85%
of emissions associated with goods and services consumed in the C40 group are imported from elsewhere.

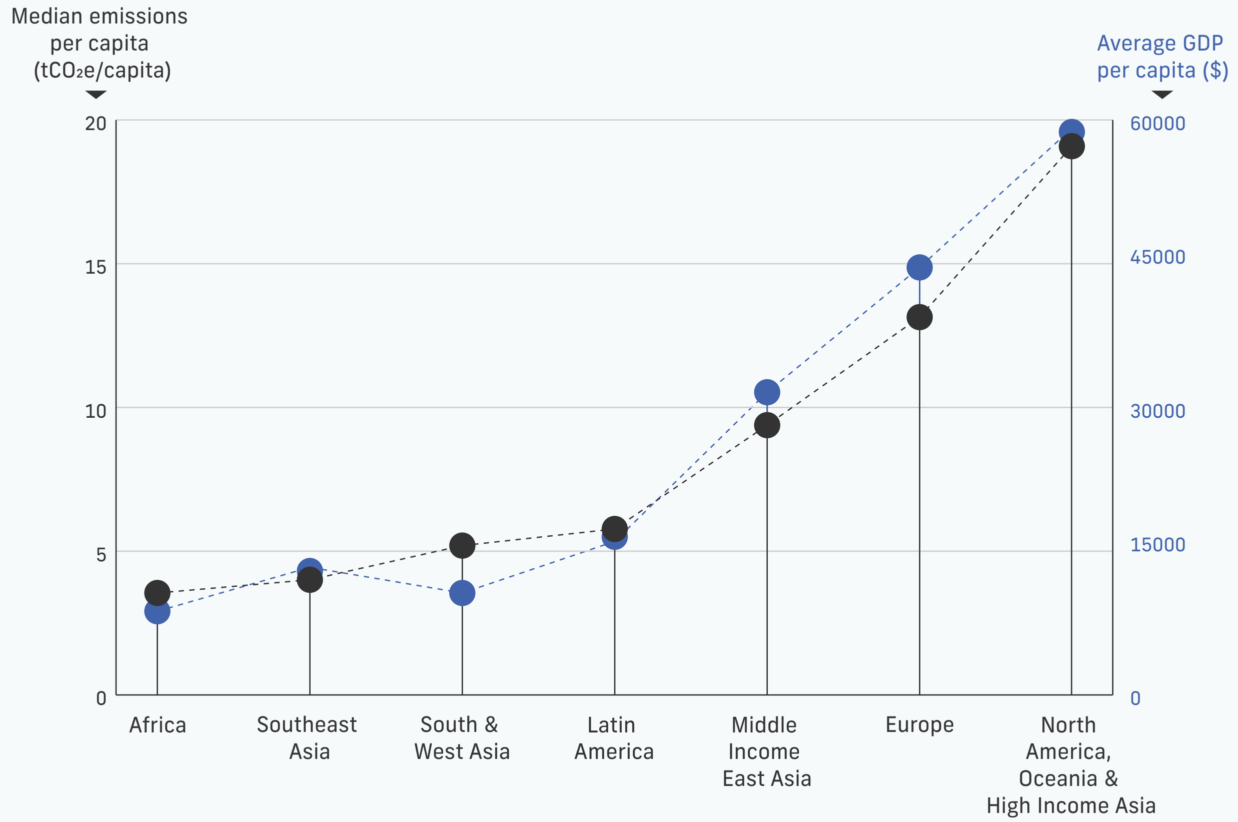
6
key consumption categories: food; buildings and infrastructure; clothing and textiles; electronics and appliances; private transport and aviation.

4.1.3
City consumption-based emissions by region

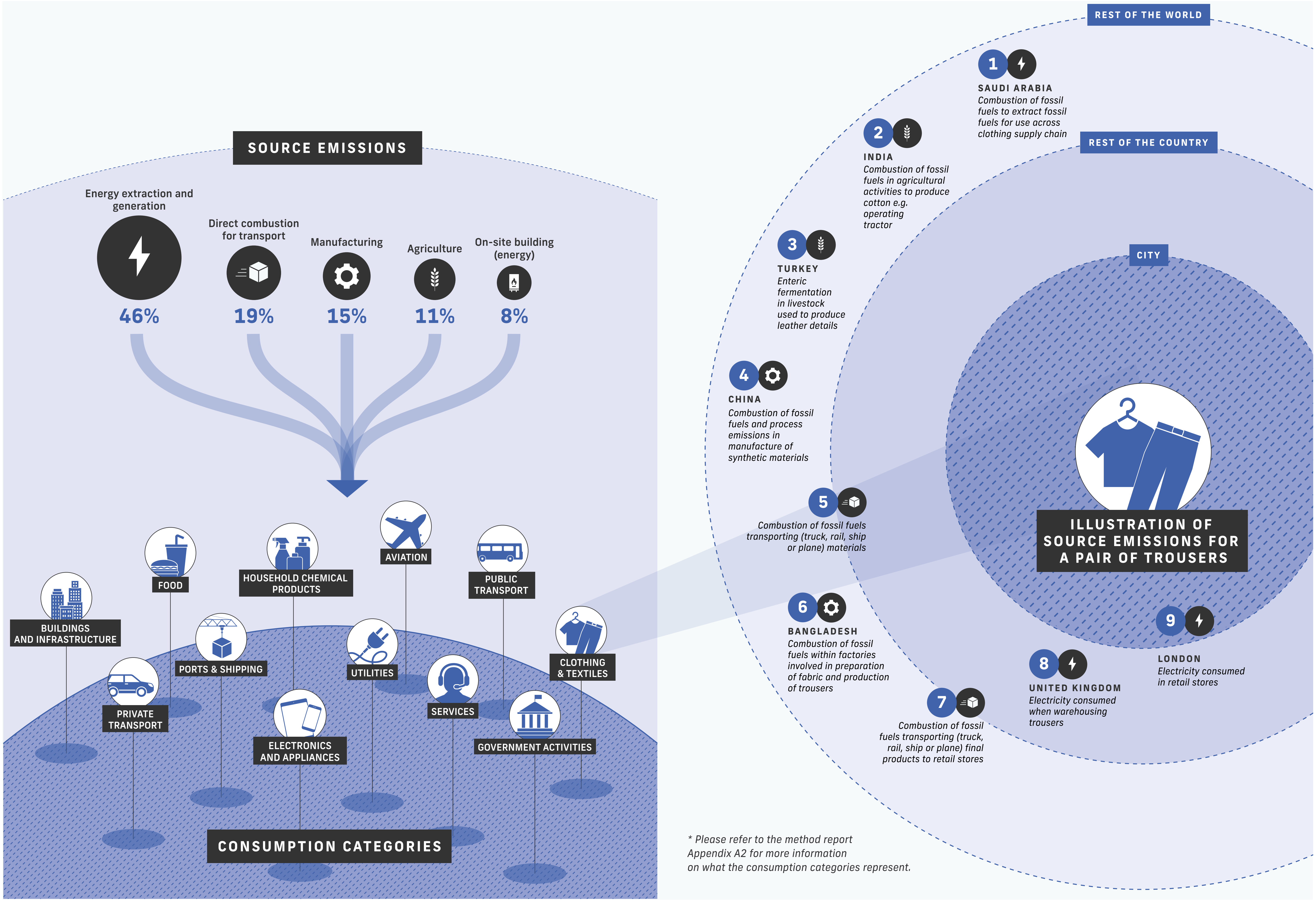
Within the cities in the C40 network there is a huge range in levels of consumption-based emissions, varying from 1.2 tCO_2e to 39.7 tCO_2e per capita, with a median value of 9.6 tCO_2e per capita. This emissions range is highly correlated to differences in GDP, as seen in Figure 6, although cities' wider cultural and developmental contexts also play a role.

Wealth is an important factor. Greater levels of disposable income in high-income cities allow consumers to buy more goods and services, which result in higher levels of consumption-based emissions. C40 cities in Europe, North America, Oceania and high-income parts of Asia have the highest median consumption-based emissions, at 13-20 tCO_2e per capita. Conversely, C40 cities in Africa, South and West Asia and South-East Asia have median consumption-based emissions below 6 tCO_2e per capita. Indeed, 34% of emissions stem from cities with a GDP per capita above $50,000, despite accounting for just 17% of the population living in C40 cities. If we include cities with a GDP per capita above $30,000, these account for 52% of emissions while representing just 34% of the network's population.

fig.6
Consumption-based emissions against GDP per capita by C40 city typology.



WHY IS IT IMPORTANT TO MEASURE CONSUMPTION-BASED EMISSIONS?
PART — 4



* Please refer to the method report Appendix A2 for more information on what the consumption categories represent.

THE FUTURE OF URBAN CONSUMPTION IN A 1.5°C WORLD

4.2

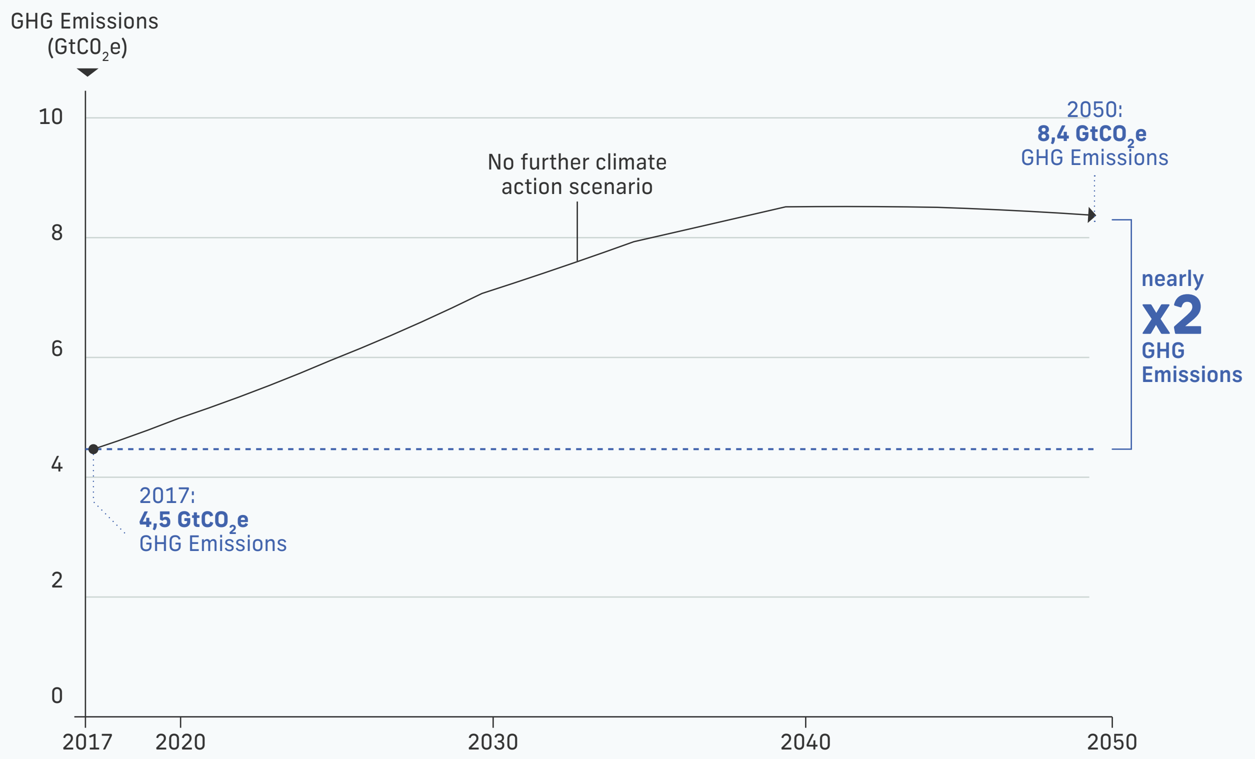
What happens to consumption-based emissions in C40 cities if no further climate action is taken?

This report looks at several potential future scenarios to explore how social, economic and technical changes may affect C40 cities' consumption-based emissions.

If no further climate action is taken to improve production processes or consumption patterns, C40's total consumption-based emissions are projected to nearly double between 2017 and 2050 – from 4.5 $GtCO_2e$ to 8.4 $GtCO_2e$ per year. Despite technological efficiencies that improve the emissions intensity of the global economy by 1% per year, growing urban populations[20] and doubling of expenditure (due to higher incomes) will increase consumption emissions by 87% by 2050 (Figure 7).

fig.7

C40 consumption-based emissions 2017-50, if no further climate action is taken.



4.3

C40 cities' GHG budgets

To account for varying levels of GDP and regional differences among C40 cities, as shown in Figure 6, this report used a contraction-and-convergence approach to estimate a fair share allocation of C40's total 1.5°C GHG budget of 82 $GtCO_2e$ – see more in Figure 9. Once this total budget was estimated, it analysed what regional emission reduction trajectories are needed for cities to align with a 1.5°C emissions trajectory, while accounting for individual city characteristics and development.

The importance of GDP growth assumptions

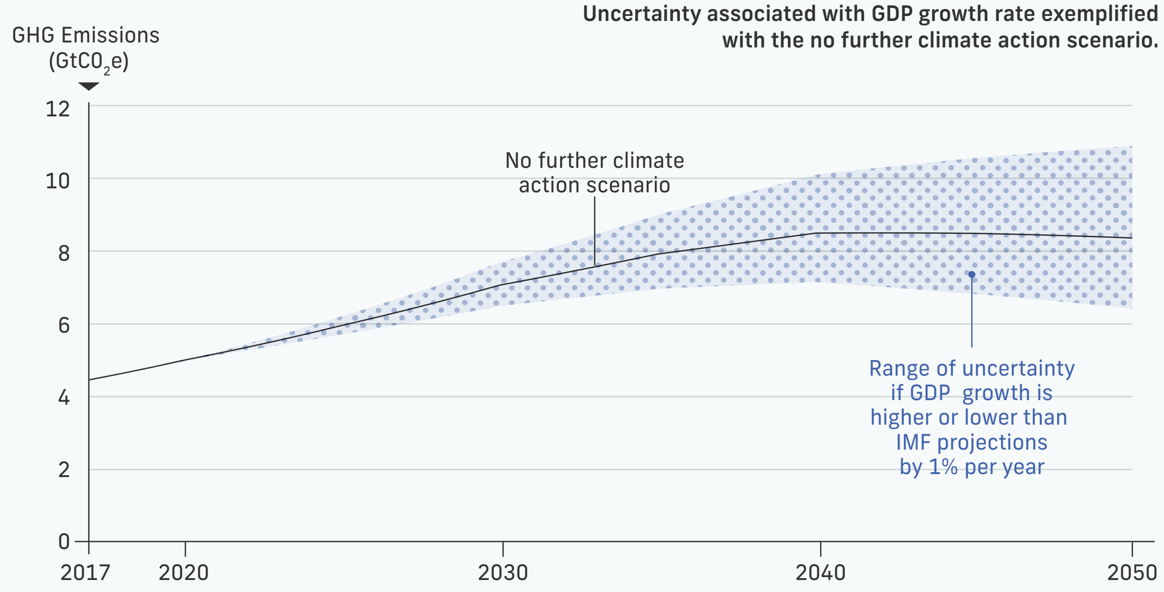
The level of GDP growth features as a key driver of consumption-based emissions in the modelling framework that has been used in this report. As seen in Figure 6, there is a strong correlation between GDP per capita levels and medium emissions per capita in C40 cities. The annual GDP growth that is assumed to occur between 2017 and 2050 will therefore have a significant impact on the future growth of consumption-based emissions.

This impact can be exemplified by varying the GDP growth rate by an additional 1% per year between 2017-2050 (base rate projections of 2.9% meaning a high of 3.9% and low 1.9% per year). With a reduced GDP growth rate, C40 cities' cumulative emissions would decrease by 30 $GtCO_2e$, between 2017-2050. The scale of the climate challenge will therefore vary significantly depending on the rate of GDP growth over the next few decades.

It is also important to note that long-term GDP growth forecasts are highly uncertain. For the purposes of this study we have opted to base the scenarios on the regional long-term GDP growth forecasts by the International Monetary Fund (IMF) and International Energy Agency (IEA).

fig.8

Uncertainty associated with GDP growth rate exemplified with the no further climate action scenario.

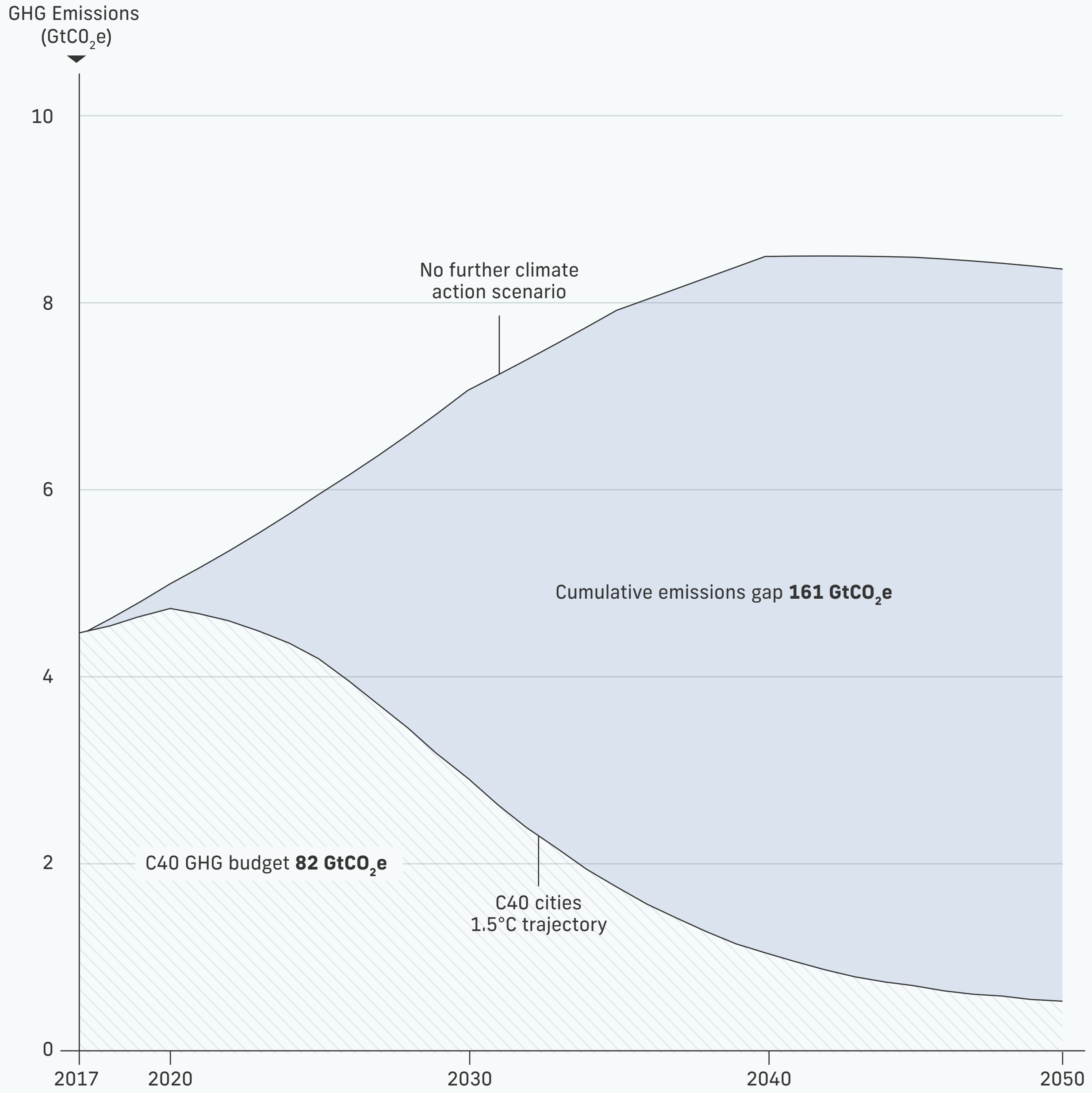


To achieve this, more than 161 $GtCO_2e$ of cumulative consumption-based emissions would need to be avoided between 2017 and 2050, compared to a future scenario where there is no further climate action, as shown in Figure 9. This value, which means cutting current emissions by two thirds, represents the starting emissions gap against which further climate action can be referenced to determine whether it is sufficient to align with the 1.5°C goal. Not doing anything would result in C40's GHG budget of 82 $GtCO_2e$ to mid-century being fully consumed within just 14 years.

fig.9

Difference in consumption-based emissions between a '1.5°C trajectory' (bottom line) and a 'no further climate action' trajectory (top line) in C40.

[20] C40 cities' population is anticipated to grow from 523 million to 753 million between 2017 and 2050 according UN growth projections
[21] See Method Report



4.3.1
Regional emission trajectories

For most C40 cities the challenge is to drastically reduce current emissions. However, for a small number of cities, it is possible for consumption-based emissions to grow slightly, before starting to come down, and still stay within the 1.5°C budget. Cities in North America, Oceania and high-income Asia as well as Europe need to reduce their current per capita consumption-based emissions immediately and rapidly. In middle-income Asia (largely Chinese cities in this context) it is possible to model a trajectory that sees emissions continue to rise a little for the next few years, but then they need to fall steeply. For C40 cities in Latin America, South and West Asia, South-East Asia and Africa,the challenge is to prevent further increases in per capita consumption emissions after 2020, before slowly reducing emissions in line with a 1.5°C trajectory. Start, interim and final emissions targets per region are set out in the table below.

For the purposes of this model, the first three years of emissions reductions, between 2017-2020, are based on mitigation targets made by national governments under the Paris Agreement, known as NDCs. These commitments were made by both developed and developing countries.[22]

[22] The Paris Agreement stipulates that developed countries shall provide assistance to developing countries to finance mitigation and adaptation activities. The success of climate change mitigation is therefore contingent on developed countries around the world delivering on this commitment

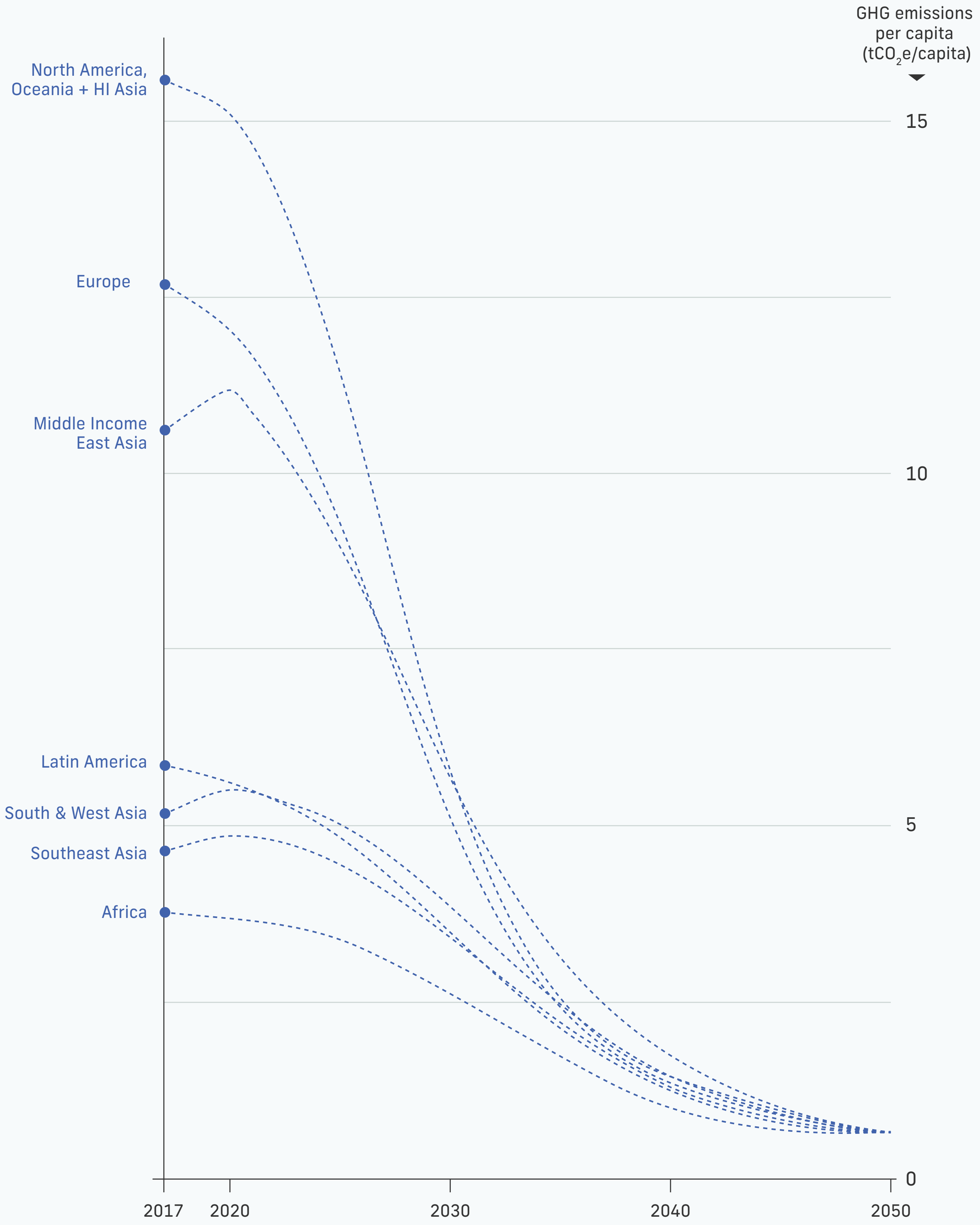
Tab.1

Start, interim and final consumption-based emissions per capita targets per region (in tCO_2e/capita)-

Per capita emissions per regional typology	2017	2030	2050
North America, Oceania & High Income Asia	15.6	5.9	0.7
Europe	12.7	5.2	0.7
Middle Income Asia	10.7	5.8	0.7
Latin America	5.9	3.5	0.7
South & West Asia	5.2	3.9	0.7
Africa	3.8	2.7	0.7

fig.10

1.5°C compliant per capita consumption-based emissions trajectories by C40 city typology.



Cities included in the study

This research drew on data for 96 cities, the C40 cities network membership at the start of the research project in June 2018. The cities were grouped into typologies on the basis of common characteristics in their consumption-based emissions.

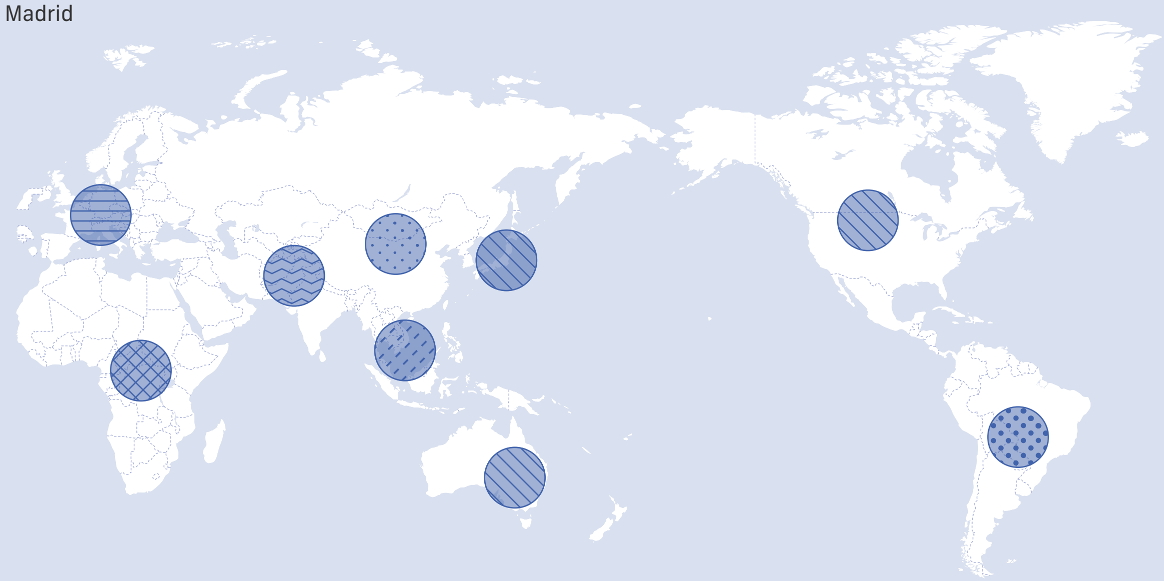
Map

C40 cities included within study by typology

EUROPE
Amsterdam, Athens, Barcelona, Basel, Berlin, Copenhagen, Heidelberg, Istanbul, London, Madrid, Milan, Moscow, Oslo, Paris, Rome, Rotterdam, Stockholm, Venice, Warsaw

MIDDLE-INCOME EAST ASIA
Beijing, Changwon, Chengdu, Dalian, Fuzhou, Guangzhou, Nanjing, Qingdao, Shanghai, Shenzhen, Singapore, Wuhan, Yokohama, Zhenjiang

LATIN AMERICAN
Bogotá, Buenos Aires, Curitiba, Guadalajara, Lima, Medellín, Mexico City, Quito, Rio de Janeiro, Salvador, Santiago de Chile, São Paulo

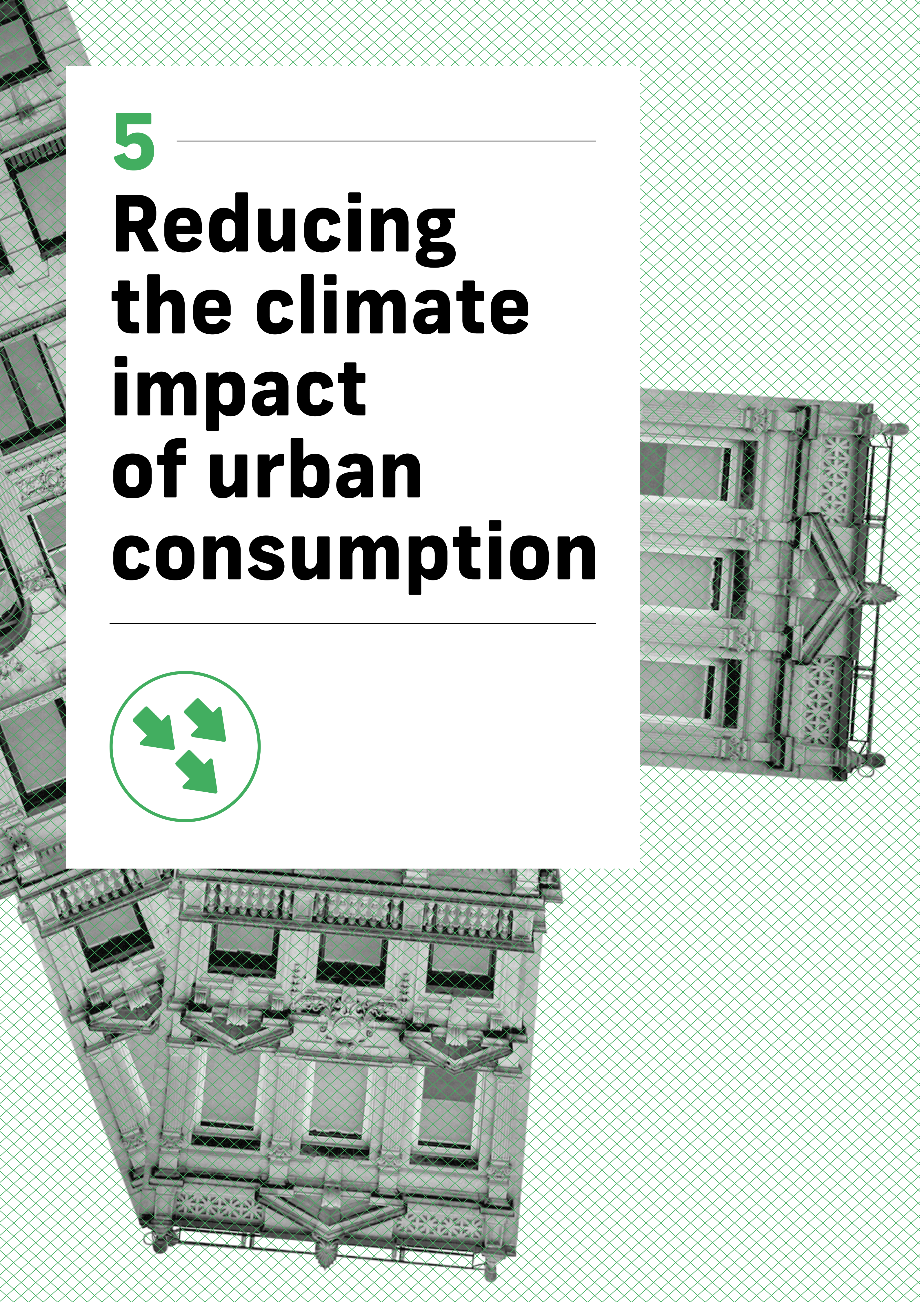


AFRICA
Abidjan, Accra, Addis Ababa, Cairo, Cape Town, Dakar, Dar es Salaam, Durban, Johannesburg, Lagos, Nairobi, Tshwane

SOUTH & WEST ASIA
Amman, Bengaluru, Chennai, Delhi, Dhaka, Dubai, Jaipur, Karachi, Kolkata, Mumbai, Tel Aviv

SOUTHEAST ASIA
Bangkok, Hanoi, Ho Chi Minh, Jakarta, Kuala Lumpur, Quezon City

NORTH AMERICA, OCEANIA & HIGH-INCOME ASIA
Austin, Auckland, Boston, Chicago, Hong Kong, Houston, Los Angeles, Melbourne, Montreal, New Orleans, New York, Philadelphia, Portland, San Francisco, Seattle, Seoul, Sydney, Tokyo, Toronto, Vancouver, Washington



5 Reducing the climate impact of urban consumption

Consumer goods are still largely made of extracted raw materials, assembled in facilities that are not powered by renewables and transported across the world by ships, trains, trucks and aircrafts powered by fossil fuels.

When a good or service is purchased, resource extraction, production and transportation processes have already generated emissions along every link of the global supply chain that brought it to the end-consumer.

To reduce consumption emissions in C40 cities, the whole system of production needs to be rapidly transformed while also altering consumer decision-making. That means significant changes to how the world uses and manages natural resources such as fossil fuels, metals, minerals and biomass to produce goods and services, as well as changing consumer demand.

5.1

The impact of national government commitments (NDCs)

Overall, 85% of emissions associated with goods and services consumed in C40 cities are produced beyond their borders; 60% occur within the same country (see Figure 2).

Overall, 85% of emissions associated with goods and services consumed in C40 cities are produced beyond their borders; 60% occur within the same country (see Figure 2). This means a city's level of consumption emissions is strongly affected by national and global clean production developments such as grid decarbonisation and the deployment of new energy and process-efficient technologies. These national and global clean production developments are, in turn, influenced by national climate policies, such as the NDCs that countries committed to under the Paris Agreement. The ambition of national climate targets will therefore, to a large extent, affect the level of consumption-based emission-reductions that C40 cities can achieve.

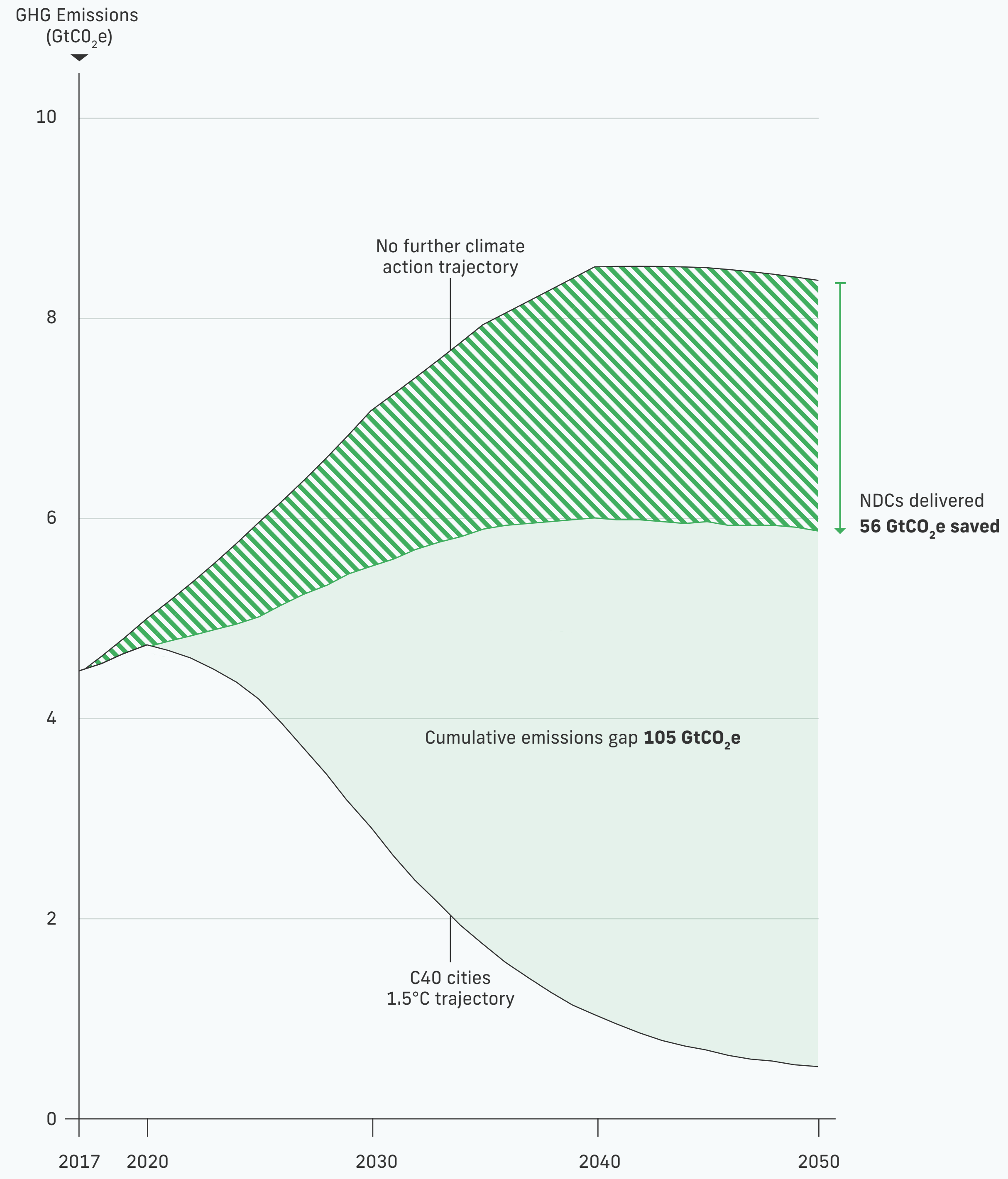
Global developments such as the growing proportion of electricity that comes from renewable sources, decreasing carbon intensity of steel and cement production and improvements in fuel efficiency will set the baseline for what level of additional consumption emission reductions is necessary in C40 cities to align with a 1.5°C trajectory. If there is rapid and significant climate action in the wider world, the carbon footprint of C40 consumption-based emissions will decrease.

If we consider a future scenario where climate action occurs in line with current NDCs[23], a transition to clean energy and low-carbon production processes will reduce C40 cities' consumption-based emissions by approximately 56 $GtCO_2e$ between 2017-50 (Figure 11). That reduces the consumption-emissions gap in C40 cities by 35%, compared to a future scenario with no further climate action.

[23] *Further detail on what this scenario entails, in terms of low-carbon production-side developments, is in Section 10.1*

fig.11

Emissions reduction potential of delivering the NDCs against a 'no further climate action' scenario.



THE FUTURE OF URBAN CONSUMPTION IN A 1.5°C WORLD

5.2

The impact of Deadline 2020 commitments

City production-based emissions and consumption-based emissions are interlinked and overlap to some extent, as shown in Figure 4.

Both accounting frameworks include electricity consumption, private transport, the burning of fuels in homes for heating and cooking, and the manufacturing of products consumed by residents of the same city where they are produced. This means that C40 cities that are already delivering on their Deadline 2020 commitments will automatically have an impact on 25% of their consumption emissions (see Figure 3).

Consequently, there are substantial synergies between tackling production-based emissions and reducing consumption-related emissions. A more explicit focus on urban emissions from a consumption perspective does not supplant previous C40 efforts to reduce production-based emissions; the two agendas are complementary.[24]

In terms of overall emission reductions, delivering on Deadline 2020 commitments will reduce consumption emissions in C40 cities by 25 $GtCO_2e$ between 2017 and 2050.[25]

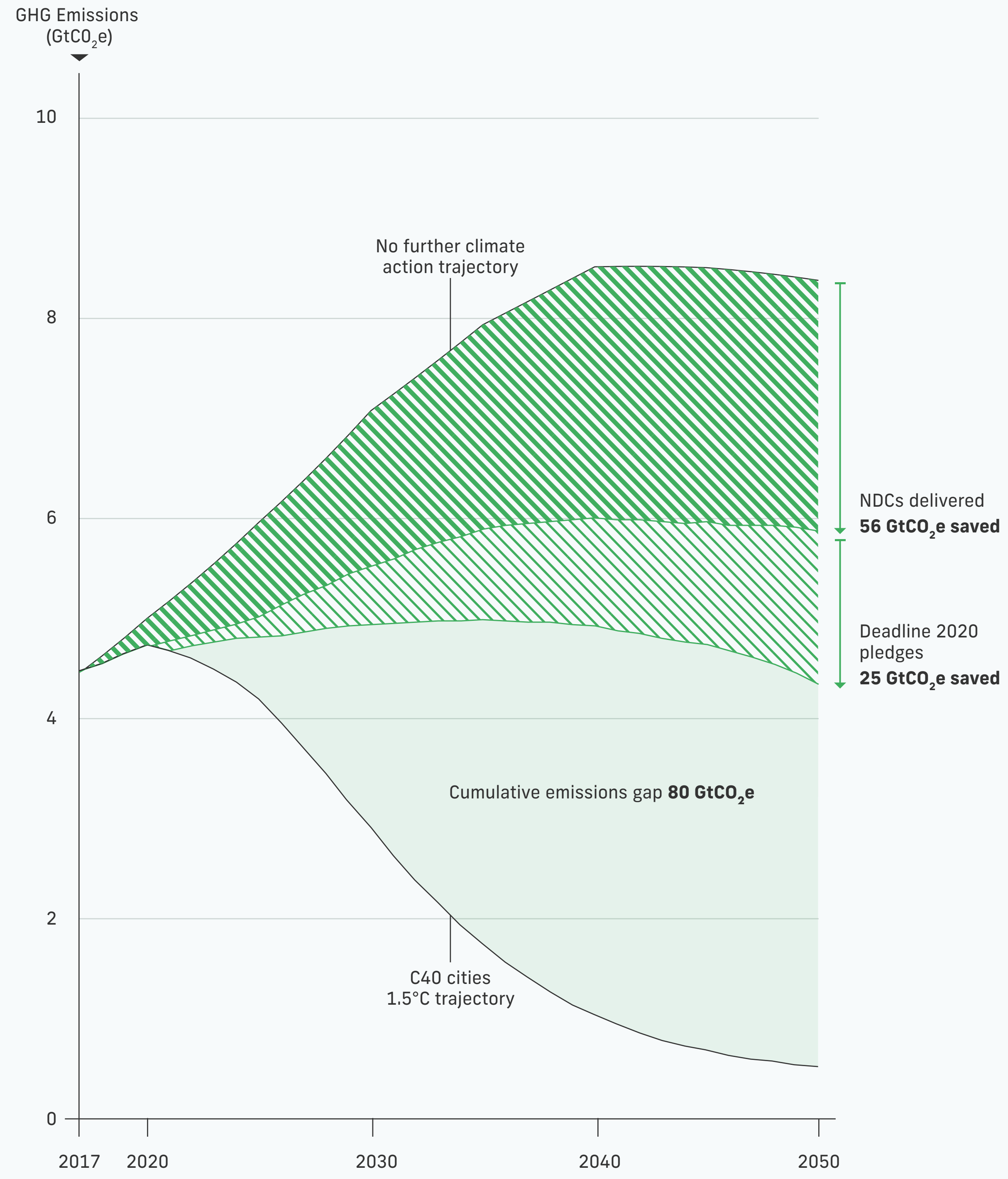
In a future scenario where a global low-carbon transition of production occurs in line with NDC targets, and where C40 cities deliver on their Deadline 2020 commitments, C40 cities' consumption emissions will decrease by 81 $GtCO_2e$ between 2017-2050. Altogether, that reduces the consumption-emissions gap in C40 cities by half compared to a future scenario with no further climate action. It follows that additional action will be needed to reduce the emissions intensity of supply chains as well as change urban consumption.

[24] *Complementary efforts will be highlighted within Chapter 7*

[25] *Assuming these go beyond NDC commitments to achieve carbon neutrality on production-based emissions*

fig.12

Emissions reduction potential of NDCs and Deadline 2020 pledges against a 'no further climate action' scenario.



5.3

The impact of consumption interventions

This report focuses on six consumption categories: food; buildings and infrastructure; clothing and textiles; private transport; aviation; and electronics and appliances.

This report focuses on six consumption categories: food; buildings and infrastructure; clothing and textiles; private transport; aviation; and electronics and appliances. For these categories, 18 interventions were developed and tested for their emissions reduction impact, details of which are provided in Chapter 6.

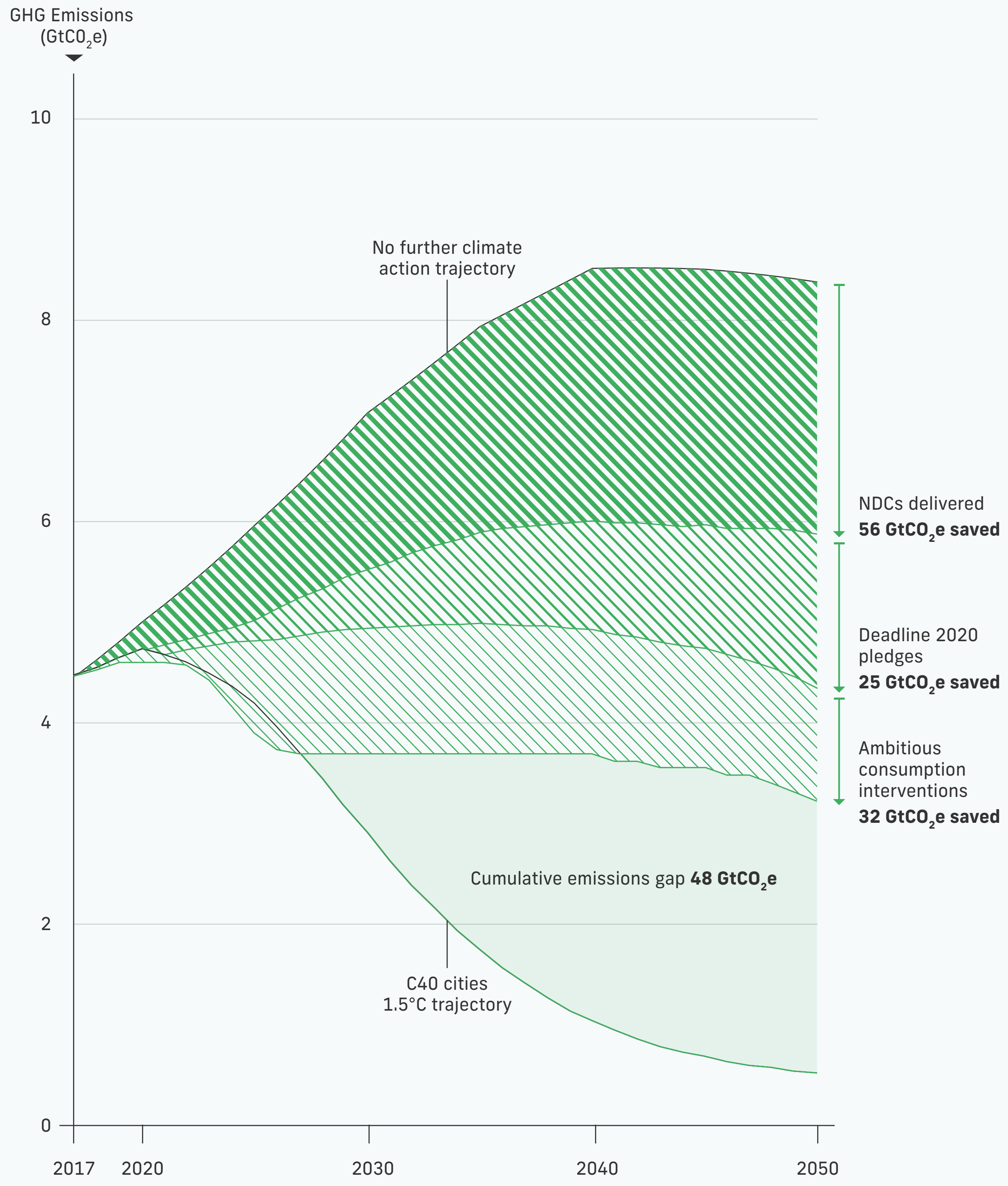
In a future scenario where C40 cities implement the identified interventions across these categories, alongside global delivery of NDC targets and Deadline 2020 commitments, C40 cities' consumption-based emissions would decrease by an additional 32 $GtCO_2e$ between 2017-2050. Altogether, NDC, Deadline 2020 and consumption interventions reduce the consumption-based emissions gap in C40 cities by 70%, compared to a scenario with no further climate action (Figure 13).

Altogether, NDC, Deadline 2020 and consumption interventions reduce the consumption-based emissions gap in C40 cities by

70%

fig.13

Emissions reduction potential of NDCs, Deadline 2020 commitments and consumption interventions against a 'no further climate action' scenario.



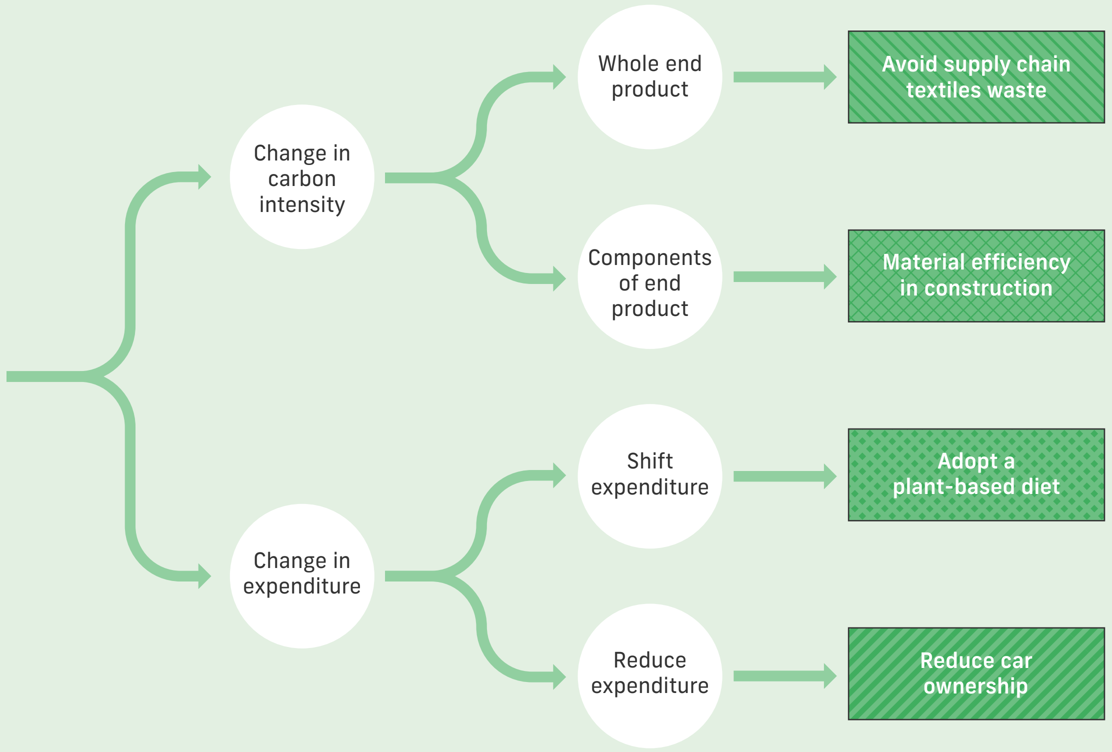
How consumption interventions are modelled

The various consumption interventions are implemented within the model in different ways. The most important distinction between consumption interventions are whether these involve changes in the carbon intensity of end-products (through improved production) or changes in expenditure (that shifts or reduces expenditure on end-products). A few examples of the changes modelled are shown in the diagram below.

Within the change in carbon intensity there are two types of emission reductions. One by which the entire emissions of the product are reduced due to the avoidance of manufacture of the product e.g. supplying the same quantity of food to the consumer market, but by eliminating waste in the supply chain being able to reduce base food production. Alternatively, production improvements may result in the same quantity of products being produced but with a reduced carbon footprint, through substituting carbon-intensive materials with lower impact components, such as swapping steel for timber in building construction.

Changes in expenditure are also modelled in two ways; either consumption is shifted from one product to another, such as when substituting meat with plant-based foods; or by a wholesale reduction in consumption of an entire product category, for instance if fewer new cars are purchased.

fig.14
Diagram explaining how consumption interventions are modelled.



Accounting for the rebound effect

One of the risks in changing consumption habits is that monetary savings, due to a consumer buying less of one good, could then be spent on other products and services which have a GHG emissions footprint. This is known as "the rebound effect." Rebound can occur in the form of a re-allocation of household expenditure from savings, referred to as the "micro-rebound effect," or a change in industrial activity due to shifting consumer purchasing decisions, referred to as the "macro-rebound effect".

The rebound effect poses a significant challenge as it can reduce the effectiveness of policies aimed at reducing carbon emissions. In the case of the saving options consumption interventions considered within this study, a conservative micro- rebound effect was found to offset approximately a third of the emission savings over the period 2017 to 2050. This estimate was based on the assumption that city residents continue to allocate their spend-mix as before.

Estimating the rebound effect is difficult given a large uncertainty, across socio-economic groups, around how consumers will choose to use monetary savings as well as what effect price changes will have on consumer decisions, due to market fluctuations and political decisions (such as taxes and subsidies). Empirical studies that estimate rebound are rare and estimates of micro-rebound effects fail to consider the broader economic implications. Indeed, most carbon projections models do not account for this the rebound effect at all.

In practice, managing the rebound effect will be critical to the effectiveness of city consumption action. These effects can be mitigated, with the appropriate action, requiring a combination of educational programmes to inform consumers of choices, product labelling and government-led intervention to create pricing signals; for instance via carbon pricing. The latter mechanism is described in more detail in Chapter 9.

One of the risks in changing consumption habits is that monetary savings, due to a consumer buying less of one good, could then be spent on other products and services which have a GHG emissions footprint. This is known as "the rebound effect."

6 What can cities do? Consumption interventions by category

This section examines the six categories that represent new opportunities for cities to reduce their consumption-based emissions.

Across these categories, 18 consumption interventions were developed, focusing on demand-led changes that can be facilitated by cities. Two of these, relating to packaging, were found to have a negligible impact on emissions and are therefore omitted from this report. The interventions are targeted at making goods and services less carbon-intensive without compromising their function and the adoption of low-carbon consumer choices without compromising quality of life.

The results of these interventions are presented in terms of the cumulative emissions reduction between 2017 and 2050 against a scenario in which NDC and Deadline 2020 commitments are delivered.

6.1

Targets for consumption climate action

Two target levels were established for each intervention. The progressive target level is based on research that identifies the threshold of resource efficiency and behavioural change potential, as defined by current technology and progressive changes in consumer choices.

The second, more 'ambitious', target level is based on a future vision of resource-efficient production and extensive changes in consumer choices. This report does not advocate for the wholesale adoption of these more ambitious targets in C40 cities; rather, they are included to provide a set of reference points that cities, and other actors, can reflect on when considering different emission-reduction alternatives and long-term urban visions.

The specific consumption interventions and targets have been developed through a dual process of desk research and engagement with subject-matter specialists to validate assumptions. Opportunities for action were analysed in the context of different levels of urban consumption across the C40 network. However, it is recognised that local context (financial capacity, availability of technologies and cultural context) will heavily dictate which interventions may be suitable and will dictate the feasibility of rapidly scaling their adoption. Details of the rationale and evidence base for the interventions and their target levels will be outlined in a series of focus reports covering six consumption categories and the accompanying method report.

The second, more 'ambitious', target level is based on a future vision of resource-efficient production and extensive changes in consumer choices.

6.2

Summary of emissions reduction potential across focus consumption categories

The consumption interventions set out in this report could significantly reduce urban emissions (Figure 15 shows the potential emissions reduction assuming ambitious target levels).

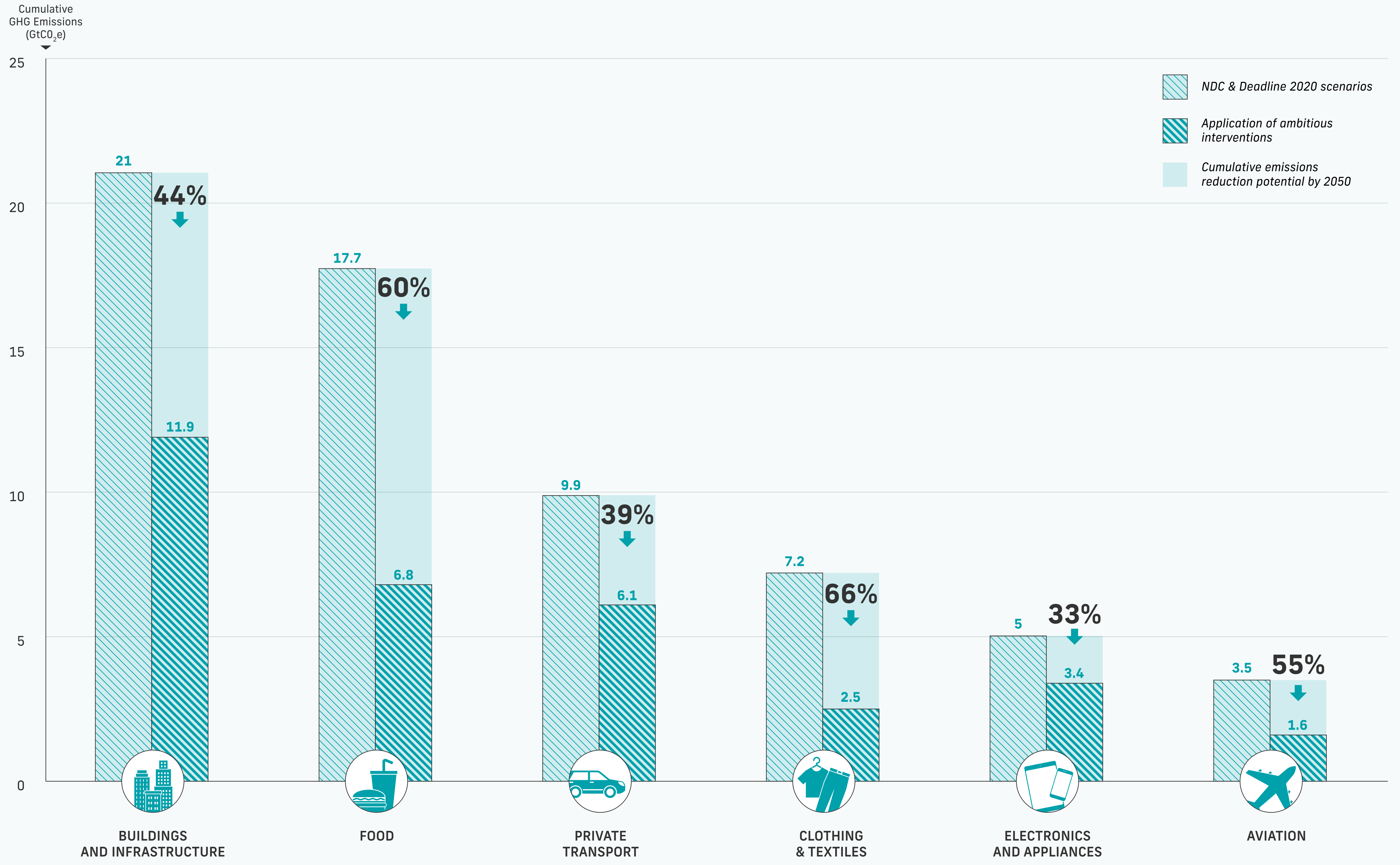
The emissions reduction potential is predicated on a rapid scaling of interventions to 2030 so that these changes can facilitate an accelerated low-carbon transition. Interventions such as material efficiency, reduced consumption and adoption of low-carbon alternatives are complementary and arguably necessary in certain cases to enable production processes to transform.

Achieving these targets will be difficult, both socially and economically. The consumption interventions will require significant changes to consumer patterns and individual behaviours as well as usher in structural changes across entire supply chains and industries. To successfully transition to a low-carbon economy, it is important that the transition actively addresses the ways in which certain businesses and workers can be negatively affected (see section 7.2 'A just transition to a low-carbon economy').

The consumption interventions will both require significant changes to consumer patterns and individual behaviours as well as usher in structural changes across entire supply chains and industries.

fig.15

Cumulative emissions reduction potential by 2050 across six consumption categories.

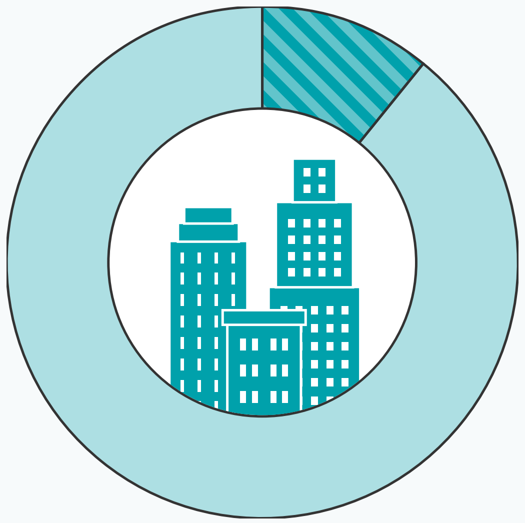


6.3

Buildings and infrastructure

In 2017, C40 cities' emissions associated with construction and refurbishment of buildings and infrastructure accounted for 0.45 $GtCO_2e$, representing 11% of emissions in that year.

These emissions are not only associated with construction within C40 cities; city residents are also beneficiaries of buildings and infrastructure across their host country, such as public and commercial buildings, railways, bridges, highways, water and sewerage infrastructure. Emissions from construction of such national infrastructure is included within C40 cities' consumption-based emissions. [27]

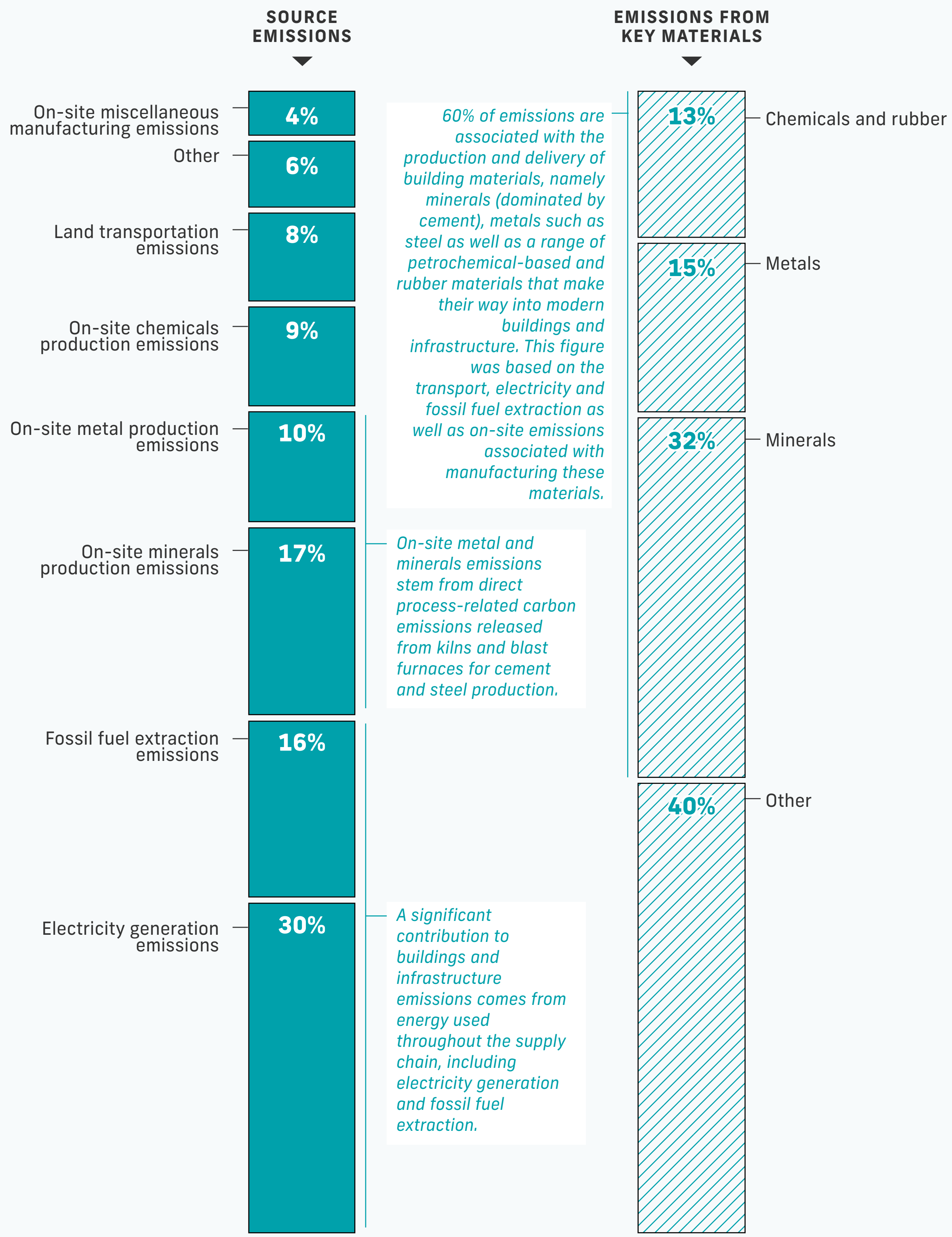


11%
of total emissions of C40 cities in 2017

[26] This consumption category becomes the largest of the consumption categories when cumulative emissions between 2017 and 2050 are considered

[27] The methodology for determining a city's buildings and infrastructure emissions is based on down-scaling expenditure at a national level to the associated urban population on a pro-rata basis. This is based on the assumption that new construction benefits, and is likely used by, the national population irrespective of where they live. For example, Parisians might use bridges across the whole of France

fig.16
Source emissions of buildings and infrastructure from 2017-2050 under an NDC scenario.



6.3.1
Buildings and infrastructure: consumption interventions

This study models five interventions that could reduce consumption-based emissions from new buildings and infrastructure in C40 cities (table 2).

[28] CCS is not included here. However, if infrastructure for CO_2 transport and storage is available and CCS were used to capture the cement process emissions in cement and steel production, these could be further reduced by 2050. The same goes for steel as well as for many chemical products

table 2

Consumption interventions for buildings and infrastructure and associated targets.[28]

CONSUMPTION INTERVENTION	PROGRESSIVE TARGET IN 2030	AMBITIOUS TARGET IN 2030
Material efficiency	Reduction in steel and cement use of **20% and 32%** respectively	Reduction in steel and cement use of **35% and 56%** respectively
Enhance building use	**10%** reduction in demand for new buildings	**20%** reduction in demand for new buildings
Material switching	**75%** of residential and **50%** of commercial are timber buildings	**90%** of residential and **70%** of commercial are timber buildings
Low-carbon cement	**50%** of cement replaced with low-carbon alternatives	**61%** of cement replaced with low-carbon alternatives
Reuse of building components	**11%** reduction in virgin metal and petrochemical-based materials	**22%** reduction in virgin metal and petrochemical-based materials

6.3.2
Buildings and infrastructure: effect of consumption interventions

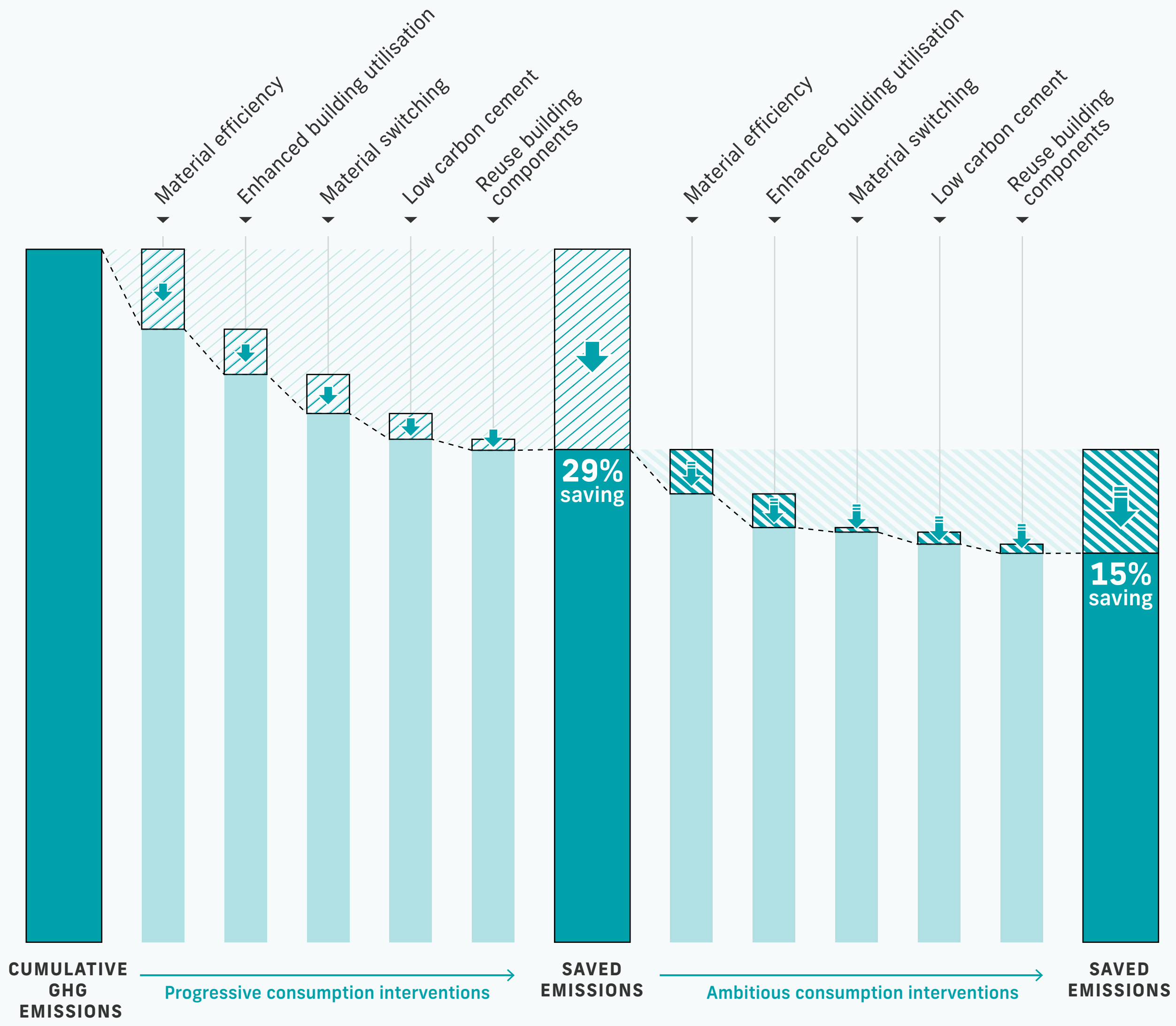
If all C40 cities make the changes set out in table 2, emissions from buildings and infrastructure could be cut by 29% between 2017 and 2050. The adoption of ambitious targets would enable a 44% reduction.

Material efficiency has the highest emissions reduction impact (Figure 17), followed by enhancing building utilisation, material switching and low-carbon cement. While the potential saving associated with reuse of building components is smaller than the rest, it still represents an important reduction opportunity.

Construction site emissions is also a key area of climate action. Emissions can for example be reduced by shifting from petroleum-fuelled to electric machinery. However, the impact of such a shift is categorised as local energy emissions in this report.

fig.17

Buildings and infrastructure emissions reductions broken down by consumption intervention and target ambition.



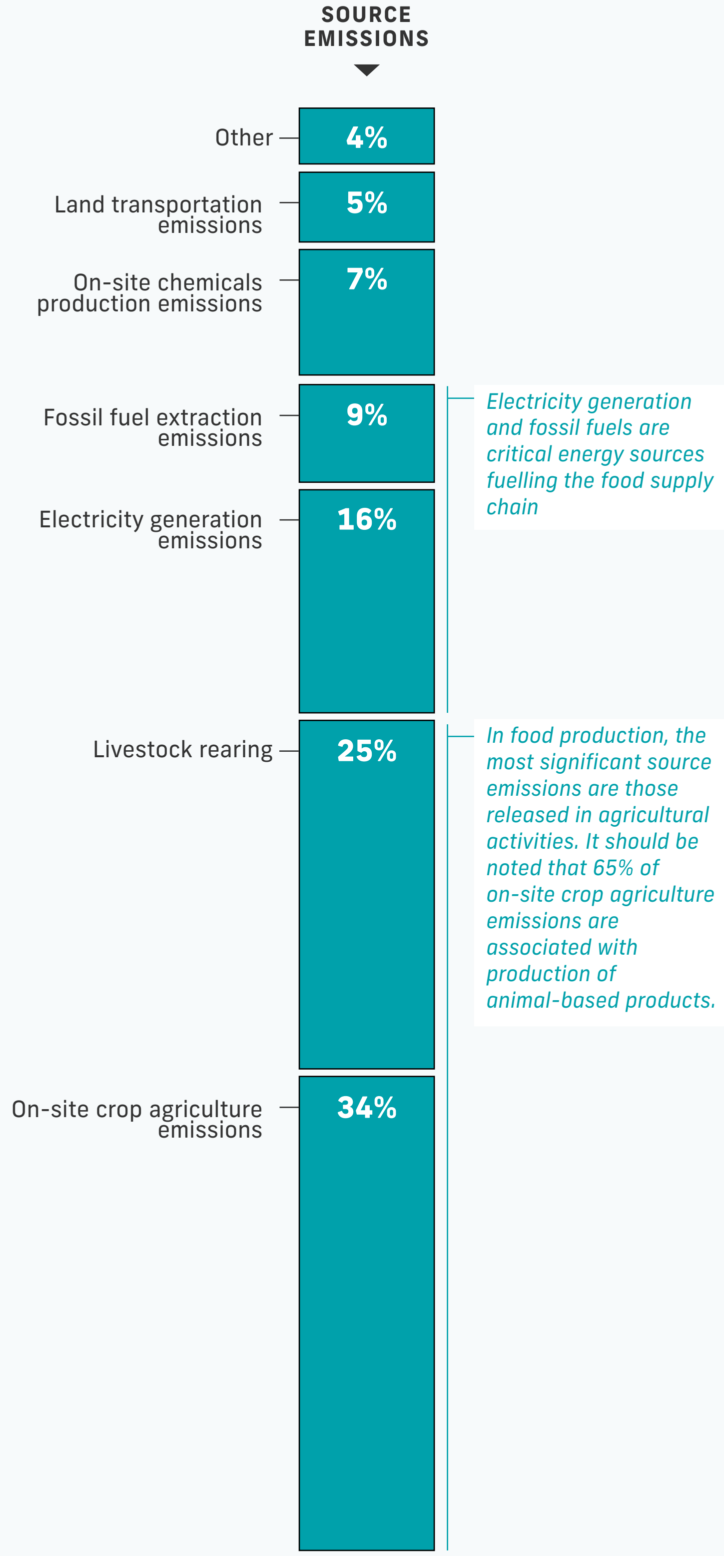
6.4
Food

In 2017, emissions associated with food were estimated to account for 13% of total consumption-based emissions across C40 cities.[30] Roughly three quarters of these emissions stem from consumption of animal-based foods, with the remaining 25% from consumption of plant-based foods.

13%
of total emissions of C40 cities in 2017

[30] Note that emissions are excluding impacts from land-use change, which are not included within the consumption-based emissions inventories

fig.18
Source emissions of food products from 2017-2050 under an NDC scenario.



6.4.1
Food: Consumption interventions

The study modelled five food-related consumption interventions as shown in table 3.

Table 3

Consumption interventions for food and associated targets.

CONSUMPTION INTERVENTION	PROGRESSIVE TARGET IN 2030	AMBITIOUS TARGET IN 2030
Dietary change (this intervention is characterised by three major changes which are described in more detail)	**16 kg** of meat per person per year[31]	**0 kg** meat consumption
	90 kg dairy consumption (milk or derivative equivalent) per person per year[32]	**0 kg** dairy consumption (milk or derivative equivalent) per person per year
	2,500 kcal per person per day	**2,500 kcal** per person per day
Reduce household waste	**50%** reduction in household food waste	**0%** household food waste
Avoid supply chain waste	**50%** reduction in supply chain food waste	**75%** reduction in supply chain food waste

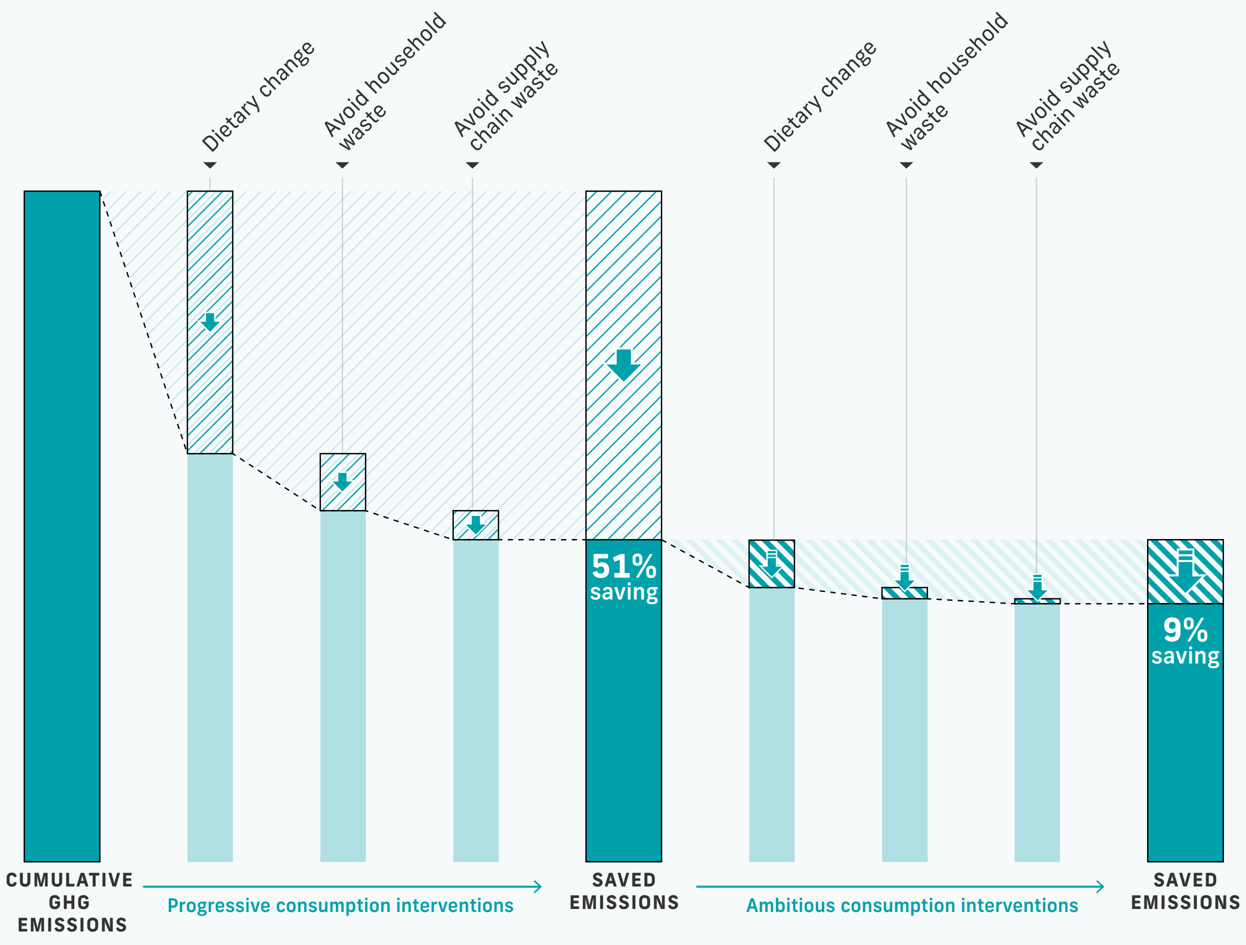
6.4.2
Food: effect of consumption interventions

If C40 cities change their food consumption habits in line with the identified progressive targets, the category's emissions could be cut by 51% between 2017 and 2050 (Figure 19). The adoption of ambitious targets would enable an additional 9% reduction.

Adopting dietary change is the consumption intervention with the greatest potential for emissions reductions. Adopting a healthy diet (i.e. lowering meat and dairy intake) would contribute 60% of the emissions reduction (43% and 17% respectively), while the remainder is likely associated with reduced calorie intake, in line with health guidance, as well as the recommended alternatives[33]. Additionally, avoiding household food waste and supply chain food waste would reduce current food-related emissions by 10% and 5%, respectively.

fig.19

Food emission reductions broken down by consumption intervention and target ambition.

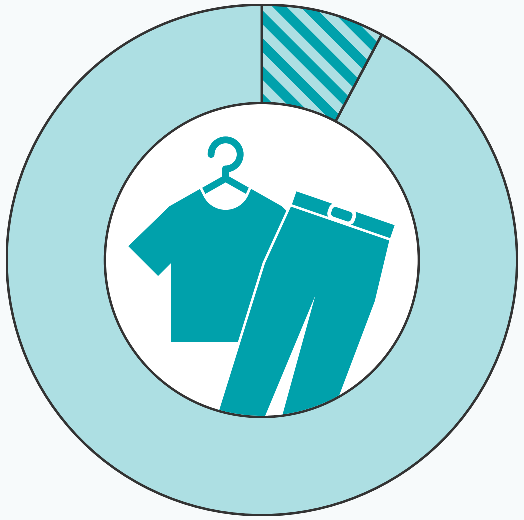


[31] Current average meat consumption in C40 cities is 58 kg per person, three times the target
[32] Current average dairy consumption in C40 cities is 155 kg per person, 1.7 times the target. This target includes dairy derivatives, such as cheese in terms of raw-milk equivalent: for example it takes roughly ten times the amount of milk to make a specified quantity of cheese so this target could also be expressed as 90 kg of milk or 10 kg of cheese
[33] See accompanying method report for further details on developing dietary changes

6.5

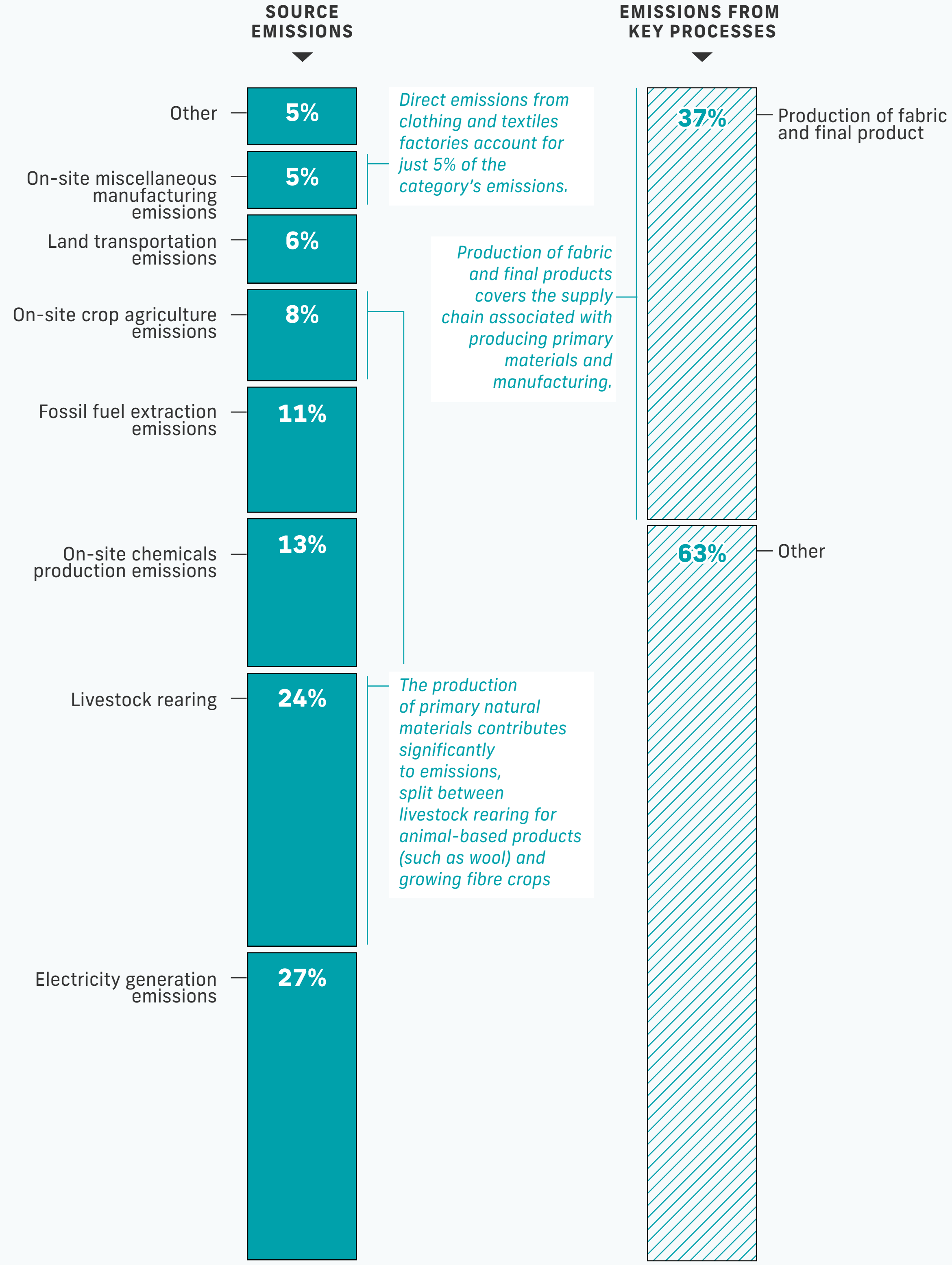
Clothing and textiles

The clothing and textile industry plays a significant part in the global economy. The industry is undergoing a transformation as growth rates are increasingly driven by expanding markets in rapidly-developing nations. Emissions from clothing and textiles made up 4% of C40 cities' consumption-based emissions in 2017.



4%
of total emissions of C40 cities in 2017

fig.20
Source emissions of clothing and textiles during the period 2017-2050 under an NDC scenario.



6.5.1
Clothing and textiles: consumption interventions

This study modelled two interventions that could reduce consumption-based emissions from clothing and textiles across C40 cities.

Table 4

Consumption interventions for clothing and textiles and associated targets.

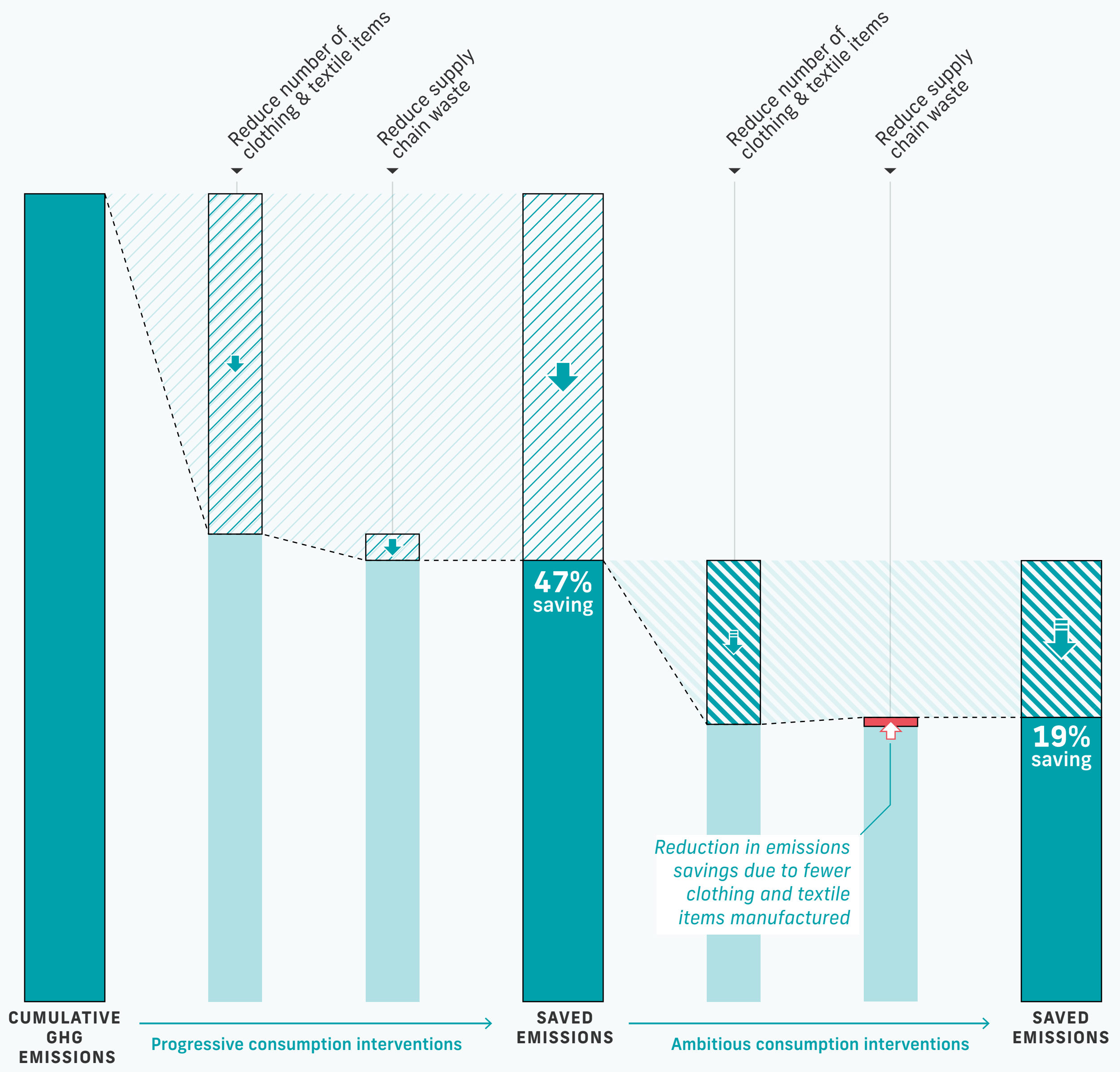
CONSUMPTION INTERVENTION	PROGRESSIVE TARGET IN 2030	AMBITIOUS TARGET IN 2030
Reduce number of clothing and textile items	8 new clothing items per person per year	3 new clothing items per person per year
Reduce waste in the supply chain	50% reduction in supply chain waste	75% reduction in supply chain waste

6.5.2
Clothing and textiles: Effect of consumption interventions

If all C40 cities make the changes set out in table 4, the emissions of the clothing and textiles category could be cut by 47% between 2017 and 2050. The adoption of ambitious targets would enable a further 19% emissions reduction. It is notable that the impact of reducing the number of new clothing and textile items people buy significantly exceeds the impact of cutting supply chain waste. In the ambitious scenario, the limited number of items being produced means that there are lower savings to be made through supply chain waste reductions.

fig.21

Clothing and textile emissions reductions broken down by consumption intervention and target ambition.



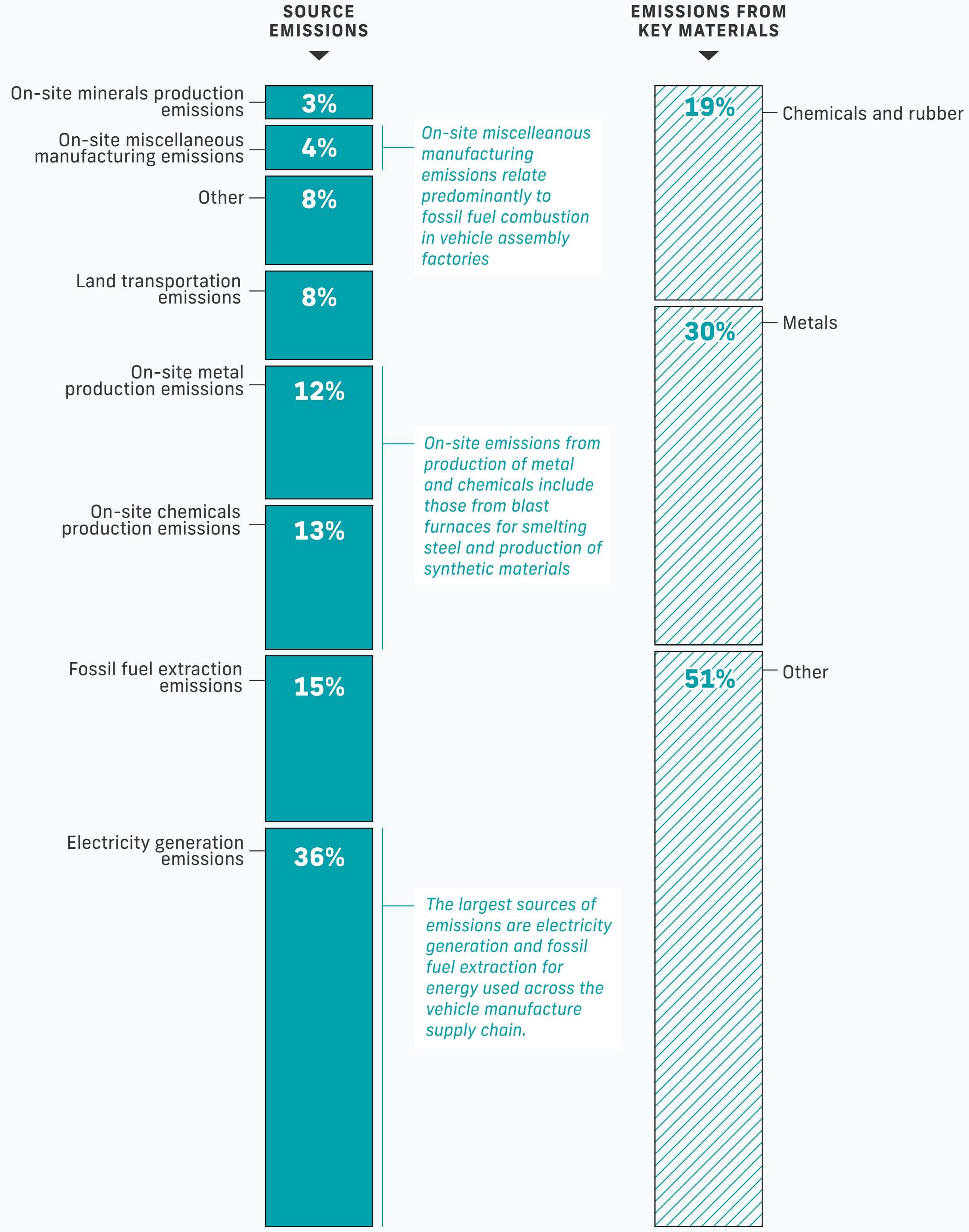
6.6
Private transport

In 2017, the total consumption-based emissions associated with the use and manufacturing of private vehicles in C40 cities represented 8% of total emissions.

A third of the emissions from private transport are related to the materials and processes used to make vehicles and motorbikes, as shown in Figure 22. For this consumption category, there is a clear overlap with Deadline 2020 commitments given that reductions in the use of private transport could catalyse a reduction in ownership and vice versa.

8%
of total emissions of C40 cities in 2017

fig.22
Source emissions from private vehicle manufacturing from 2017-2050 under an NDC scenario.



6.6.1
Private transport: consumption interventions

Three consumption interventions have been modelled to reduce consumption-based emissions from private transport across C40 cities, as seen in Table 5.

[34] The target is 20% lower than C40 cities average of 240 vehicles per 1,000 people, a mid-point between extremes of 940 to 40 vehicles per 1,000 people
[35] On average, the lifetime in C40 cities is 21.5 years, surpassing the target by 8%

Table 5
Consumption interventions for private transport and associated targets.

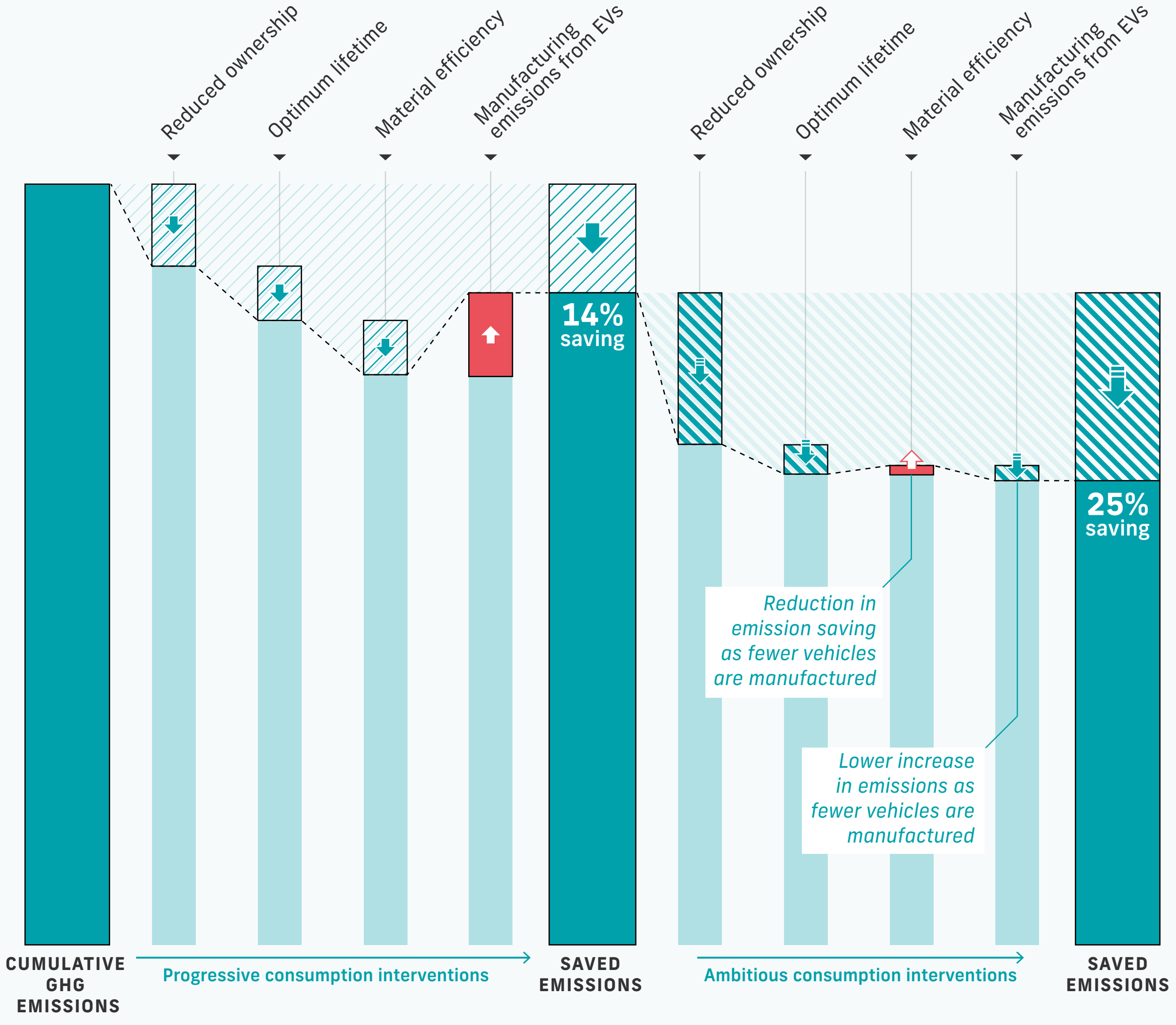
CONSUMPTION INTERVENTION	PROGRESSIVE TARGET IN 2030	AMBITIOUS TARGET IN 2030
Reduce ownership	**190** vehicles per 1,000 people[34]	**0** private vehicles
Optimum lifetime	**20-year** lifetime for body of vehicle (shell & interior)[35]	**50-year** lifetime for body of vehicle (shell & interior)
Material efficiency	**50%** reduction in use of metal and plastic materials	

6.6.2
Private transport: Effect of consumption interventions

If all C40 cities make the changes set out in table 5, emissions from the private transport category could be cut by 23% between 2017 and 2050. The adoption of ambitious targets would enable a further 32% reduction. These reductions are partly offset by the Deadline 2020 commitments which in and of themselves deliver net-zero carbon private transportation operation emissions within the city by 2050. As such, the savings shown below relate to embodied emissions in vehicle manufacture or those associated with a marginal acceleration in operational emissions reductions against the Deadline 2020 impact.

The red column on the far right of Figure 23 shows the additional emissions associated with the production of EVs compared with conventional internal combustion engine vehicles. We have applied this in line with the assumption that there is an early and high penetration of electric vehicles into the market, with most new vehicles being purchased by 2030 being electric.

fig.23
Private transport emission reductions broken down by consumption intervention and target ambition.



6.7
Aviation

Emissions associated with flights in C40 cities make up 2% of total consumption-based emissions in 2017.

This may seem relatively marginal compared to other sectors examined in this report, but air travel is one of the most carbon-intensive activities that individuals can personally undertake and the aviation industry is experiencing rapid growth.

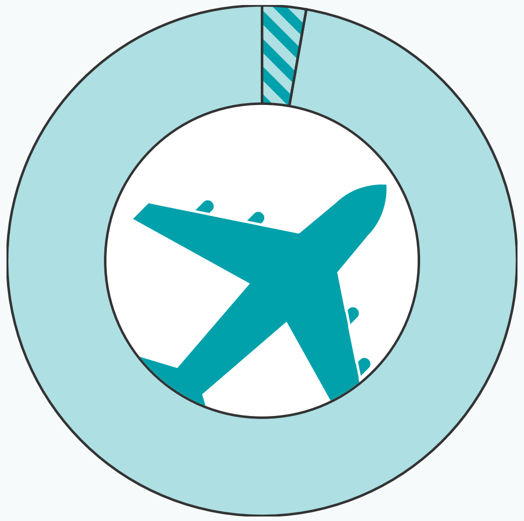
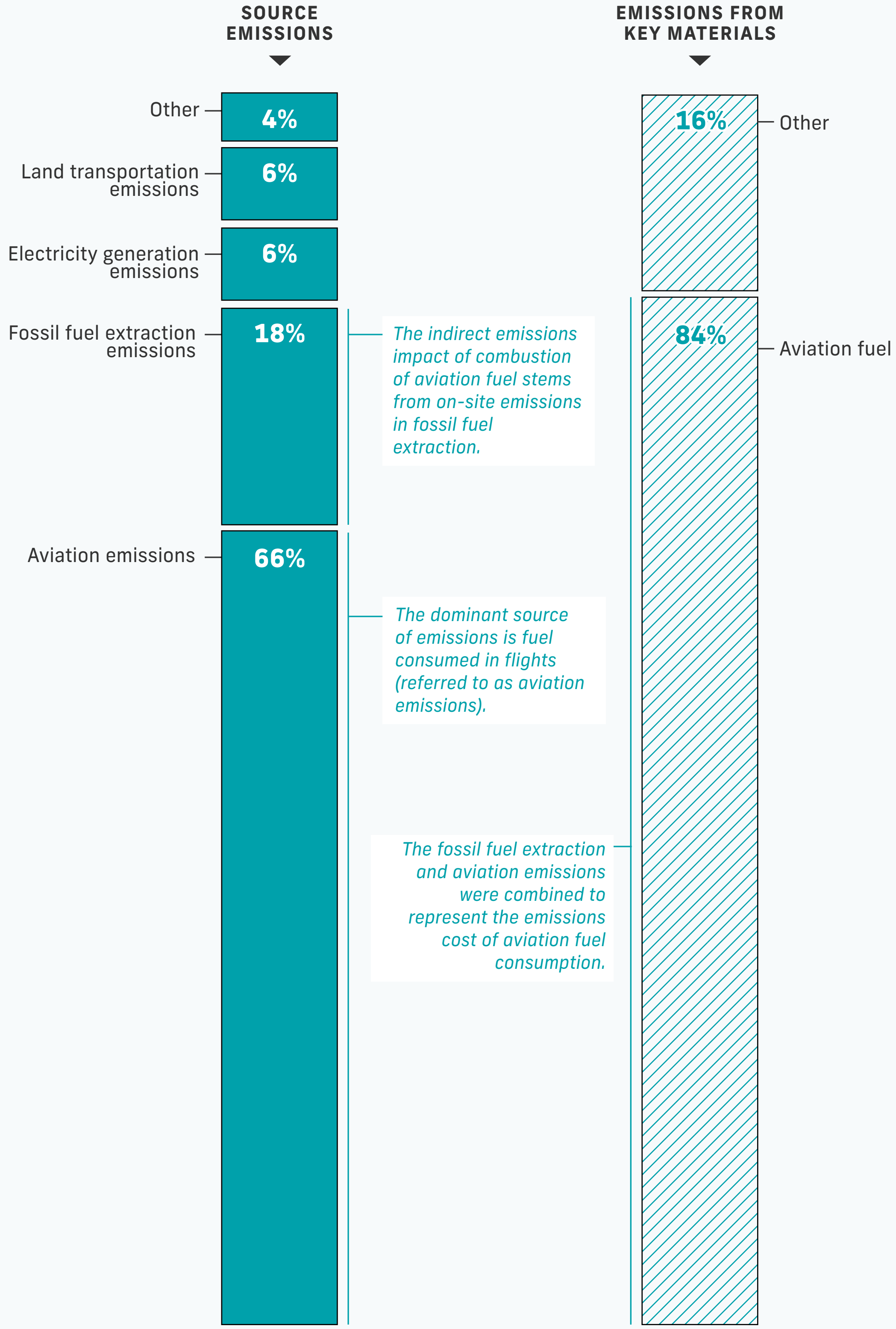


fig.24
Source emissions from flights from 2017-2050 under an NDC scenario.



6.7.1
Aviation: consumption intervention

This study modelled two interventions for reducing consumption emissions from aviation across C40 cities, as seen in Table 6.

Table 6
Consumption interventions for aviation and associated targets.

CONSUMPTION INTERVENTION	PROGRESSIVE TARGET IN 2030	AMBITIOUS TARGET IN 2030
Reduce number of flights	**1** short-haul return flight (less than 1500 km) every 2 years per person[36]	**1** short-haul return flight (less than 1500 km) every 3 years per person
Sustainable aviation fuel	**53%** sustainable aviation fuel adopted (or other equivalent low carbon technology or fuel)[37]	**100%** sustainable aviation fuel adopted (or other equivalent low carbon technology or fuel)

[36] *A short-haul flight is given as an illustrative example and is not meant to promote short-haul flights over long-haul flights. On the contrary, alternatives are more readily available and feasible for short-haul flights and need to be promoted*
[37] *For the purposes of this study, sustainable aviation fuel was used to represent the move towards low and zero carbon fuels. This does not preclude alternatives such as hydrogen or electric planes which are being developed by the aviation industry*

6.7.2
Aviation: effect of consumption interventions

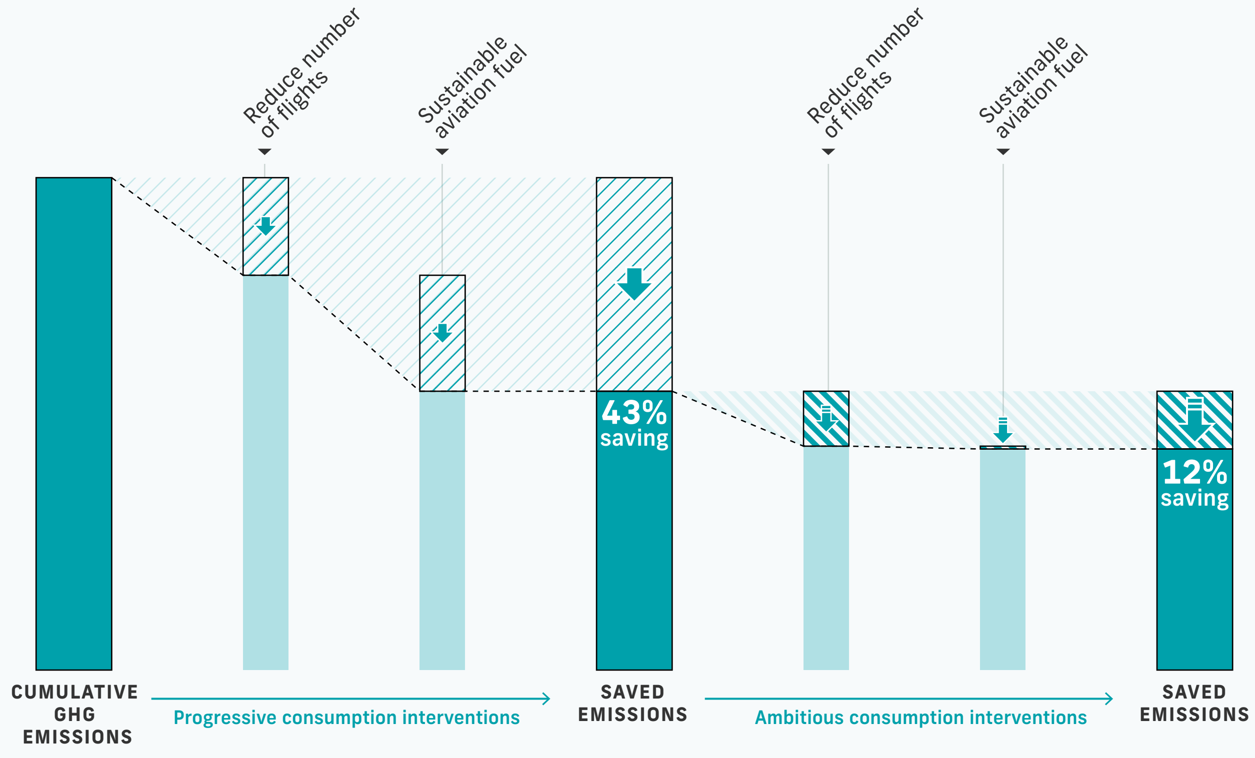
If all residents of C40 cities fly less[38] and airlines increase the proportion of sustainable aviation fuel they use as outlined in the progressive target, a cumulative 43% emissions saving can be achieved (Figure 25). Given the current global disparity in flying, it is important to note that C40 cities can, on average, actually increase flight trips by 43% compared to 2017 levels, if the target is one short-haul flight every two years per person. However, 46% of C40 cities' residents would need to reduce the number of trips, compared to their 2017 levels.

The relative contributions of the two consumption interventions are similar, though it should be noted that the adoption of sustainable biofuel is dependent on also limiting the number of flights to avoid potentially negative consequences on other systems (such as land and water required for producing feedstocks, and potential competition with other land uses such as food production).[39]

In the ambitious scenario, reducing flights is more effective at cutting emissions than further increasing the use of sustainable aviation fuels; the former reduces emissions by 11% and the latter by just 1%. The impact of fuel switching is dampened because the improvement in fuel efficiency[40] remains constant between the two scenarios and there is a knock-on impact of reduced flights under the ambitious target.

[38] *On average residents of C40 cities should reduce flight trips by 28% against 2017 levels.*
[39] *Popp et al (2014) The effect of bioenergy expansion: Food, energy, and environment. Renewable and Sustainable Energy Reviews. Available at: https://www.sciencedirect.com/science/article/pii/S1364032114000677*
[40] *Assumed fuel efficiency of 2.75% per annum between 2017 and 2050*

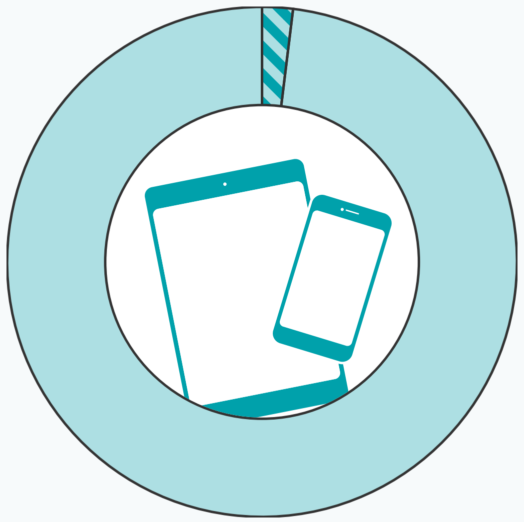
fig. 25
Aviation emissions reductions broken down by consumption intervention and target ambition.



6.8

Electronics and household appliances

The use of electronics and household appliances has grown substantially over the last few decades. Emissions from electronics and household appliances in C40 cities made up 3% of total consumption-based emissions in 2017.

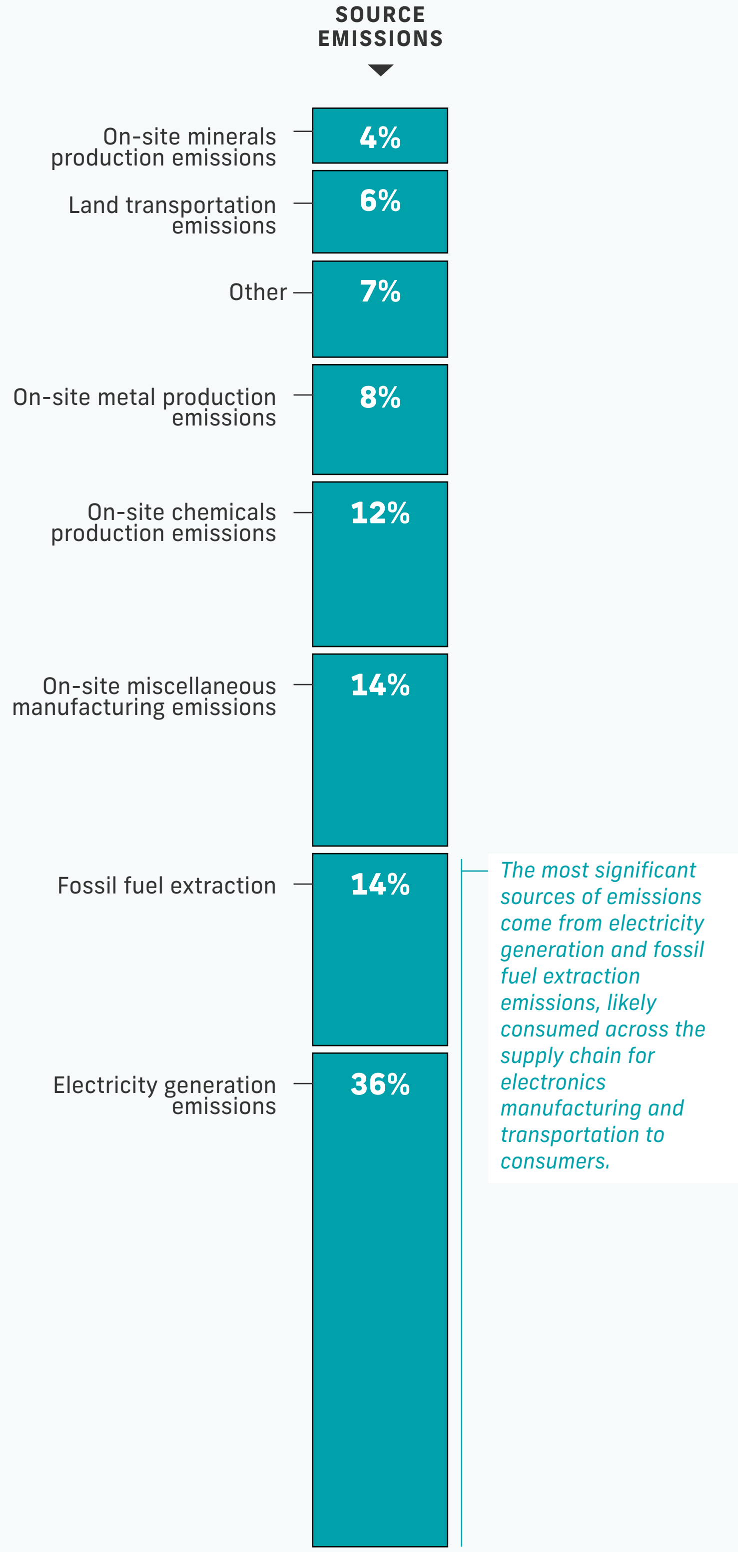


3%

of total emissions of C40 cities in 2017

fig. 26

Source emissions from electronics and household applicances from 2017-2050 under an NDC scenario.



6.8.1
Electronics and household appliances: consumption intervention

This study modelled one intervention aimed at reducing consumption-based emissions from electronics and household appliances across C40 cities, as seen in Table 7.

Table 7
Consumption intervention for electronics and household applicances and associated target.

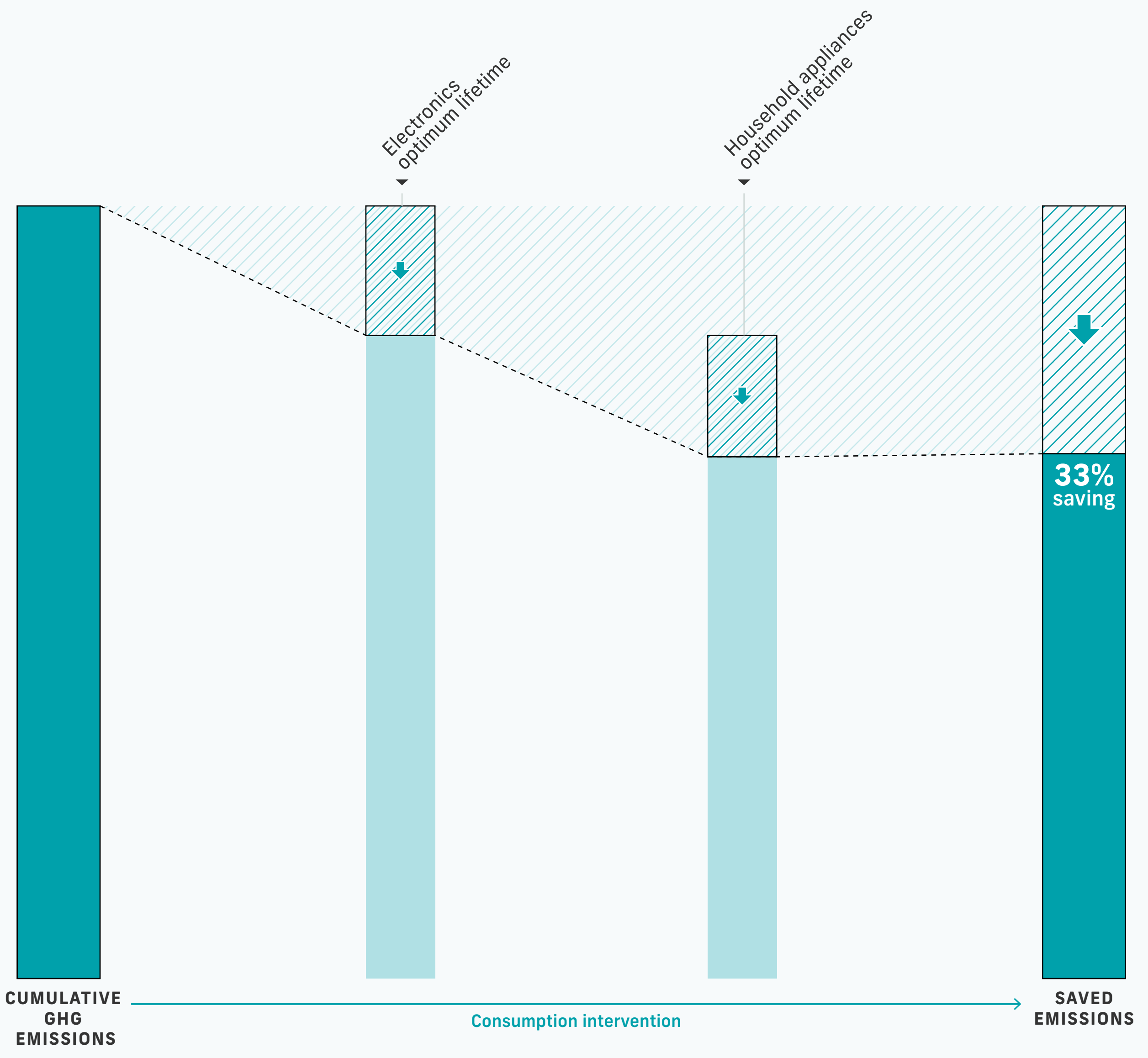
CONSUMPTION INTERVENTION	PROGRESSIVE TARGET	AMBITIOUS TARGET
Optimum lifetime	**7-year** optimum lifetime of laptops and similar electronic devices[41]	**7-year** optimum lifetime of laptops and similar electronic devices

[41] The lifetime of laptops in C40 cities is on average five years and it should aim to be 50% higher. Note that the optimum lifetime has not been established for all household appliances, therefore the same ratio of change in lifetime for electronic devices was assumed

6.8.2
Electronics and household appliances: effect of consumption intervention

By keeping electronic goods and household appliances for longer and optimising their lifespan, a total emissions reduction of 33% can be achieved by 2050 (Figure 27).

fig.27
Electronics and household appliances intervention result broken down by intervention and target ambition.



Main takeaways

→ *Urban climate action can have a significant impact on consumption-based emissions. If cities act on Deadline 2020 commitments and implement the consumption interventions outlined by this report, alongside a global low-carbon transition of production in line with NDC commitments, consumption-based emissions would be cut by 113 $GtCO_2e$. If achieved, this will reduce the emissions gap by 70% between a scenario of no further climate action and the 1.5° target trajectory.*

→ *All these changes are interdependent and need to happen simultaneously. By putting in place consumption interventions, C40 cities can speed up the global transition to low-carbon production as well as the delivery of Deadline 2020 commitments.*

→ *The delivery of NDC and Deadline 2020 commitments, as well as the implementation of consumption interventions, will require hugely ambitious action on a scale the world has not yet seen. But to fully reduce consumption-based emissions in line with a 1.5°C trajectory, further technical, social and economic interventions will be needed. These additional measures are outlined in chapter 9 of this report.*

Consumption-based emissions could be cut by 113 $GtCO_2e$, reducing the emissions gap by 70%.

Implementation of consumption interventions and delivery of NDC and Deadline 2020 commitments need to happen simultaneously.

Additional measures will be needed to fully reduce consumption-based emissions in line with a 1.5°C trajectory.

7 Delivering consumption interventions will provide wider benefits in cities

7.1 Wider benefits of consumption interventions

The changes that need to be made to current consumption patterns can seem dramatic, but residents, businesses and government stand to gain if they are achieved in the right way. The consumption interventions analysed in this report could also deliver wider benefits for urban residents.

Climate change is often seen as competing with a range of other pressing issues, such as lack of affordable housing, poverty, unemployment, and poor health. Without a holistic and persuasive case for climate action that articulates how addressing climate change can simultaneously address other priorities, it will be challenging for city governments to attract the required support for ambitious climate policies. By looking at the wider benefits associated with delivering the proposed consumption interventions, this report supports cities in building the case for taking action. The fact that these changes will benefit many people within cities also strengthens the case for collaboration between city governments, urban residents, businesses, civil society and national governments.

Some of the benefits associated with the delivery of the progressive consumption intervention targets in C40 cities are presented in the next section, both qualitatively and quantitively. If C40 cities delivered consumption interventions in line with ambitious targets, the benefits would be greater still.

As the analysis in this chapter shows, a city that consumes sustainably can also be a city where residents are healthier, where it is safer to walk and cycle, where there is more public space, where there is cleaner air and water, where land is used effectively, and where housing is more affordable.

Urban action on consumption will also bring about wider benefits beyond city boundaries. For example, changing diets has a significant impact on land-use, forests and freshwater use throughout the world.

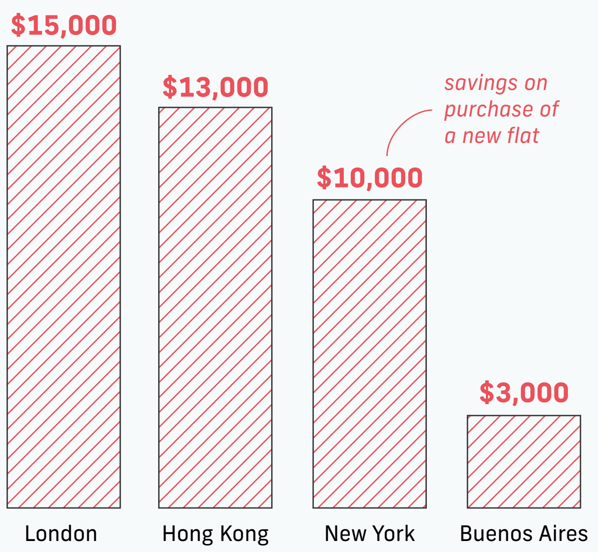
The wider benefits of the most impactful interventions are described in more detail within the six focus reports. The methodology and data sources used to estimate these benefits are detailed within the method report.

Buildings and infrastructure

KEY BENEFITS

- Making housing more affordable
- Reducing congestion
- Re-investing in other city priorities such as energy efficiency retrofits of existing buildings
- Improving air quality

Material efficiency *could mean savings on the purchase of a new flat:*



+$11 billion

could be saved in a city such as London over the next 5 years by using materials efficiently and avoiding new construction

Choosing timber over cement and steel *could allow for a near*

60%

reduction in deliveries to building construction sites

750,000

London homes could be retrofitted by using those savings

Food

KEY BENEFITS

- Making city residents healthier and live longer
- Avoiding deforestation and wasteful freshwater use
- Personal financial savings
- Global economic savings

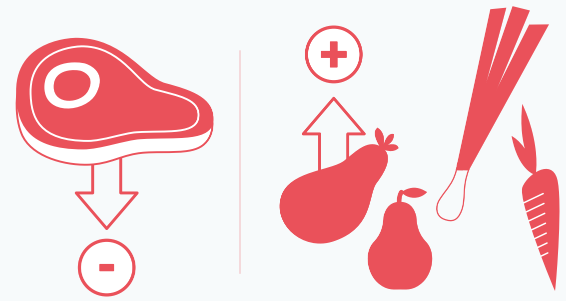
By avoiding ***household food waste****, over a 20 year period, city residents in C40 cities* ***could save*** *on average*

$5,500

Avoided food waste in the supply chain would save

$25 billion

globally per year



Eating less red meat and more vegetables and fruit *could reduce the risk of death associated with diseases such as cancer, heart disease, diabetes and stroke. In C40 cities* ***this could save***

170,000

deaths per year

Reducing dairy *intake could save*

19

billion m³ of freshwater per year

460

billion m² of land per year

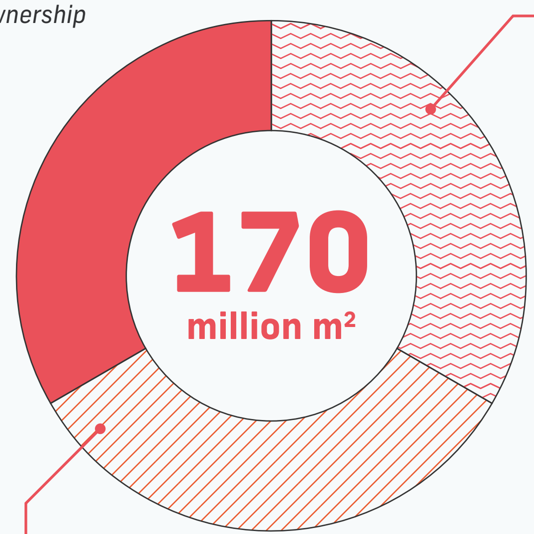
(equivalent to the **size of Spain** or **32 billion trees**)

Private vehicles

KEY BENEFITS

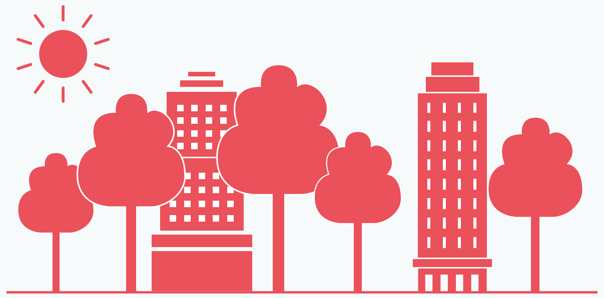
- Reducing congestion
- Improving air quality
- Promoting active and low carbon transport
- Releasing land for urban greening and public space
- Reducing energy consumption

Space *from on-street parking that could be released back to the public realm by reducing private vehicle ownership*



1/3 of this land could be used for planting

2.5 million trees

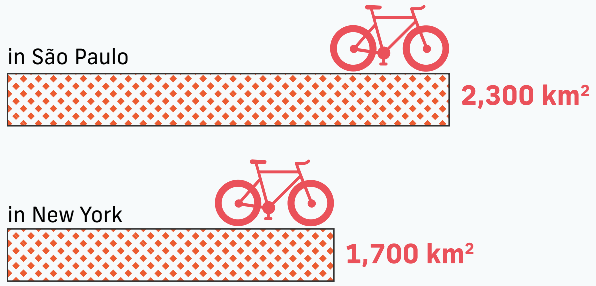


Trees reduce energy demand in sunny cities by an average

5-10%

for each household they provide shade and reduce demand for cooling (air conditioning)

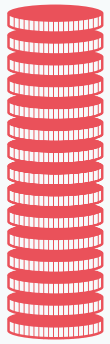
1/3 of this land could be used for **25,000 km** of cycle lanes



Clothing and textiles

KEY BENEFITS

- Personal financial savings

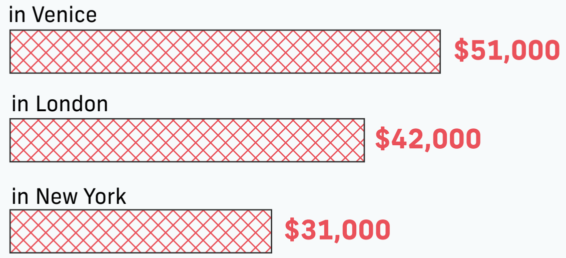


Overall C40 cities' residents could save **$93 billion** on clothing and textiles

By buying fewer clothes, residents in C40 cities could save an average of

$15,500

per person over 20 years



Aviation

KEY BENEFITS

- Improving air quality
- Local economic savings
- Improving health and extending lives

Aviation interventions could avoid **$70 million** in damages to human health, buildings and infrastructure as well as agricultural production

The combination of reducing flights and adopting sustainable aviation fuels could avoid

22 million kg of NO_x and

3 million kg of SO_2 per year

The SO_2 pollution is equivalent to **9 million cars** driving continuously for a year
The NO_x pollution is equivalent to **120,000 cars** driving continuously for a year

7.2

A just transition to a low-carbon economy

The previous sections of this report outline some of the transformative changes needed across the economy to reduce consumption-based emissions in line with a 1.5°C target.

To avoid climate breakdown across the world, including in C40 cities, major industries such as energy generation, transportation, agriculture, construction, electronics, and clothing and textiles, will have to undergo significant structural changes. Evolving consumer demands will both require new, sustainable products and services, and that existing consumer goods are made in a more resource-efficient and sustainable way. These changes in consumer demands and production will affect businesses and workers throughout supply chains across the world.

A global transition to clean production will make the world safer and greener, and research suggests that it will generate more jobs than it will replace over time.[42-43] Furthermore, the green economy is growing in many places, and is performing well. In the United States, for example, more people work in the solar energy field than in the oil, coal and gas industries combined.[44]

However, even though net job creation will benefit the global economy as a whole, all cities, regions and nations will not benefit equally. While some industries will experience rapid growth, others may undergo a period of decline, depending on their ability to respond to changing demand. If a city's economy is dominated by industries that need to undergo significant structural change to adopt new sustainable business models and modes of production, such as textiles or vehicle manufacturing, a transition to a greener economy will be more difficult than in a city that already is a centre of sustainable industries, such as renewable energy and low-carbon construction. However, certain technologies, such as CCS, adopted to capture process emissions associated with steel, cement and chemicals production, can facilitate decarbonisation without disrupting the job structure and supply chains of currently carbon-intensive industries.[45]

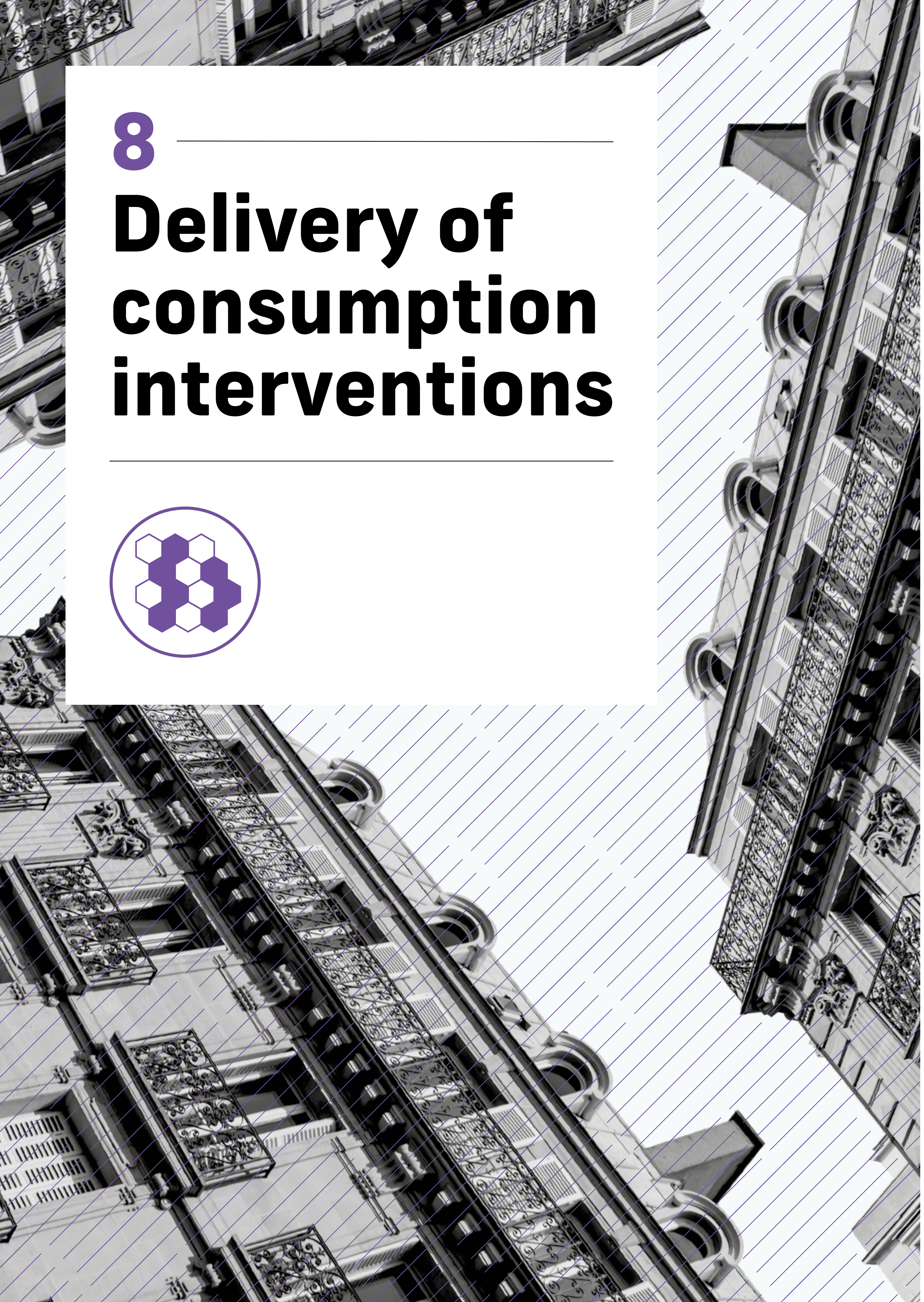
The challenges associated with this economic transition should be seen as an integral part of the climate fight itself. A successful transition to a low-carbon economy has to be managed in a just way – socially and geographically – to address increasing inequality, economic stagnation and growing political rifts. While it is important to highlight the wider benefits of taking ambitious climate action to reduce consumption-based emissions, the possible inequitable consequences of an economic transition must be addressed.

Climate change is linked to inequality, poverty and economic development in multiple ways. On the one hand, a city's consumption-based emissions are correlated with its income level, with high-income cities contributing a disproportionate share of global emissions, as seen in Chapter 4. On the other hand, the people who are most vulnerable to negative climate impacts such as extreme heat, drought and flooding tend to live in low-income areas of the world that have contributed the least to climate change.[46-47] These low-income areas are in need of rapid economic development but cannot follow the same carbon-intensive development models or adopt the same consumption patterns as Europe, North America, Oceania or East Asia, since that would further accelerate climate change and magnify its impacts in developing cities and countries. In this context, it is clearly impossible to tackle climate change and economic transitions without also addressing local and global inequality.

[42] *World Bank: Green Growth, Green Jobs and Labor Markets*
[43] *Grantham Research Institute on Climate Change and the Environment: Climate change, innovation and jobs*
[44] *Grantham Research Institute on Climate Change and the Environment: Investing in a just transition*
[45] *The Bellona Foundation: An Industry's Guide to Climate Action*
[46] *C40 Cities: The Future We Don't Want*
[47] *Carbon Brief: Historical emissions around the world*
[48] *Grantham Research Institute on Climate Change and the Environment: Investing in a just transition*
[49] *OECD: Investing in Climate, Investing in Growth*

Cities cannot deliver ambitious climate policies without broad support from individuals, civil society and businesses. Concerns from businesses and workers should be managed in an inclusive way by formulating and implementing policies with input from the affected stakeholders. By implementing a just transition, society can acknowledge that some assets will be stranded, such as coal mines, but that an economic transition does not have to mean stranded workers and communities. A just urban transition to a low-emission economy should therefore ensure that all members of a community have an opportunity to benefit.

A just transition will vary from city to city, but recommendations from the International Trade Union Confederation emphasise the importance of researching the full socio-economic impacts early on, as well as engaging industrial actors and labour groups in a broad social dialogue. Climate policies should be paired with labour market initiatives that support a transitional period of training and skills development, as well as economic policies that provide support for industries and communities that need to readjust to a new economic landscape.[48] The Organisation for Economic Co-operation and Development (OECD) also highlights the need for early engagement of workers and communities who depend on carbon-intensive industries, coupled with a clear and stable policy framework that supports investment in a low-carbon economy.[49]



8 Delivery of consumption interventions

To deliver the consumption interventions identified in Chapter 6 it will be necessary for multiple city actors, including residents, governments and business, to collaborate. In many cases, actions are interdependent.

For example, individuals will only be able to buy more sustainable products if they are available at affordable prices, and businesses may rely on government policy to make changes.

Cities can play an important role in influencing consumption across the six consumption categories that are the focus of this report. As well as leading by example, city governments are experienced in convening stakeholder groups to tackle difficult policy issues and are therefore well-placed to enable participatory action on climate change. City governments manage dense, complex, built-up areas on a daily basis, where multiple actors have an economic and social stake in common urban spaces and resources such as infrastructure and public services. Any change in urban policy, and especially any significant change, such as large-scale urban development efforts, will affect a great number of actors; some positively, some negatively. It is therefore part of any city government's core function to consult, coordinate and attempt to create a consensus between multiple actors through day-to-day interactions with urban residents, businesses, civil society groups and other levels of government. Hence, city governments are well-positioned positioned to bring together a broad range of stakeholders to initiate action on consumption emissions.

A stakeholder mapping framework has been developed alongside this report to identify how climate actions are distributed across the different supply chain actors, and to identify the key opportunities for combined action. This framework can be used by city governments to devise a strategy for collaboration. The framework is structured around five stakeholder groups:

- City government
- Urban residents
- Business
- Civil society groups
- National government

A more detailed perspective on consumption changes is presented in two 'change stories' on the following pages. These provide a narrative describing the stakeholder relationships, responsibilities and interdependencies in two example categories: food, and buildings and infrastructure. Both of these categories have markedly different sets of stakeholders who are best-placed to influence the delivery of consumption interventions. A more detailed presentation of change stories is provided for all five sectors in the supporting In Focus report.

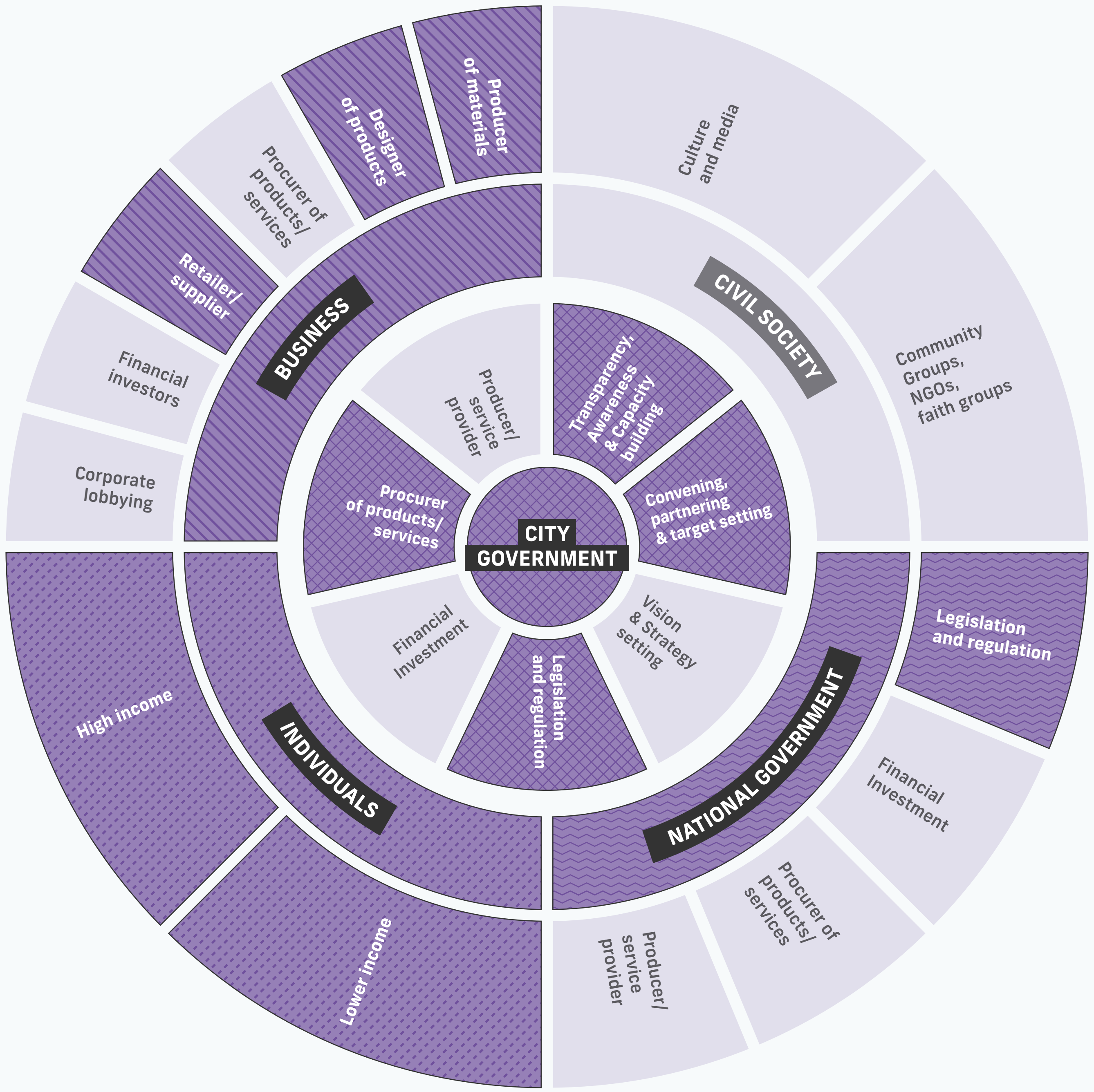
Change Story: achieving dietary change

Cities can work together with individuals, business and other levels of government to achieve dietary change.

City governments can use both their influencing and direct powers to drive dietary change for residents. For example, they can convene key actors through food boards or other taskforces for healthy eating, where relevant stakeholders can agree on and trial mutually-supporting actions. Use of their powers, although arguably making a small direct impact, can be an effective influencing tool. For instance, city governments can change the menus in school and public buildings, encouraging large city employers to follow suit in their canteens. Other potential direct actions include using their powers to remove or reduce the stimuli that make poor choices too easy, such as fast food near schools or junk food advertising on public transport, as well as creating city certification schemes that give public recognition to sustainable food businesses which help support consumer choices while benefiting the local economy.

The role of business is multi-faceted. Pioneering manufacturers can lead a shift in demand by providing consumers with new options. Retailers are also key in supporting consumers to make better decisions by stocking more healthy, plant-based options and fewer meat and dairy products. Aisle design and advertising in supermarkets is another effective strategy. The same principles apply to restaurants and food outlets by making the healthy option the default option and ensuring plant-based options are displayed more prominently. Consumers are influenced by the choices that businesses make, but they also have a prominent role in catalysing change. Cities and businesses alike should consider how to leverage the influencing role of early adopters of low animal-based diets so that a virtuous circle can be created.

Cities can work together with individuals, business and other levels of government to achieve dietary change.



Stakeholder with high impact potential[50]

Stakeholder with lower impact potential

[50] Stakeholder scoring is from 0 to 3. High impact is defined by ability to directly impact change or show high influence (typically scores 2 or above however other stakeholder are included where they are recognised as important to the change story).

Change Story: adopting of building techniques for material efficiency

Both city and national governments have an important role to play in facilitating the adoption of building techniques for material efficiency and switching to lower embodied emissions, establishing a framework for the industry players to step up and implement change.

Taxes, building codes, planning and specification requirements should be reviewed to ensure that important opportunities to proactively drive this shift are taken and that the existing regulatory environment does not act as an unnecessary barrier to new low- or zero-carbon buildings. Public procurement can set maximum requirements for carbon intensity and put a higher emphasis on material carbon footprints in the weighting of procurement criteria when awarding contracts. Most importantly, city and national governments should clearly define long-term regulatory outcomes, enabling the market and supply chain to adapt, build capacity and develop new ways of delivering buildings and infrastructure to meet these outcomes.

Architecture, engineering and construction firms can highlight opportunities for low-carbon design. Solutions currently available in the market are capable of delivering low or zero-carbon buildings across many typologies. Architects and engineers need to propose them, surveyors need to price them and clients need to procure them.

Materials producers for the construction sector can set ambitious targets for reducing the carbon intensity of production. This can be supported by trade bodies and industry certification schemes, as well as governments, NGOs and client-sector reporting.

Third sector organisations can play an important role in catalysing change, raising awareness within business and consumer groups and supporting transformation by providing research, tools and guidance for decision-makers.

Both city and national governments have an important role to play in facilitating the adoption of building techniques for material efficiency and switching to lower embodied emissions, establishing a framework for the industry players to step up and implement change.

Stakeholder with high impact potential[51]

Stakeholder with lower impact potential

[51] Stakeholder scoring is from 0 to 3. High impact is defined by ability to directly impact change or show high influence (typically scores 2 or above however other stakeholder are included where they are recognised as important to the change story).

9 Closing the emissions gap

9.1 An accelerated global transition of production is needed

Chapters 5 and 6 of this report demonstrate the combined emissions reduction impact of current NDCs, C40's Deadline 2020 programme and a range of consumption interventions. If these actions are implemented, consumption emissions in C40 cities could be reduced by 70% by 2050, compared to a future scenario with no further climate action.

A combination of climate action on city, national and global levels would mean a dramatic reduction in consumption-based emissions.

However, it would still leave an emissions gap of 48 $GtCO_2e$ in C40 cities, beyond what is compatible with a 1.5°C warming scenario. This means that even if national governments follow through on their commitments and C40 cities undertake highly challenging climate action to minimise emissions within and beyond their jurisdictions it would still not limit global warming to 1.5°C. Something else needs to happen as well.

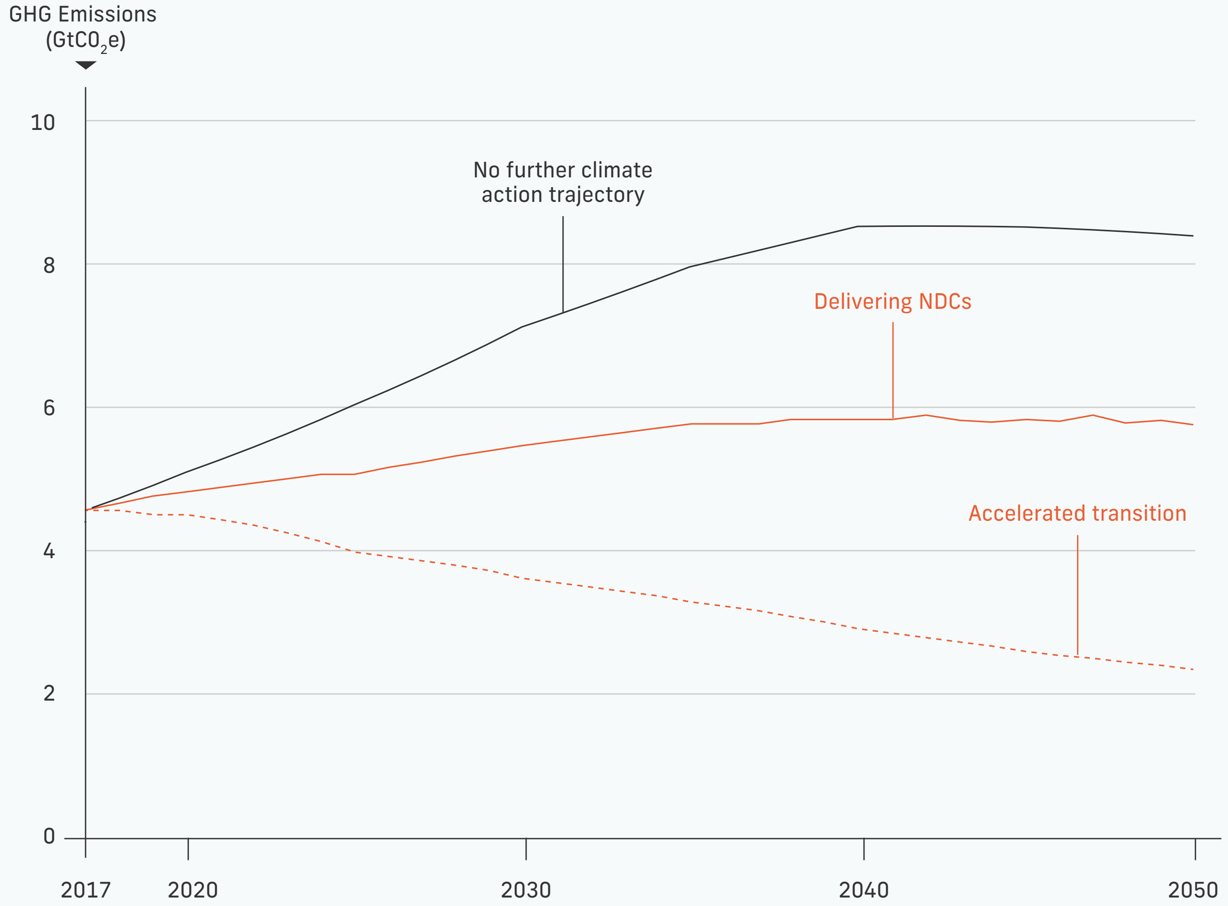
This final section of this report outlines a number of additional developments that can reduce C40 cities' consumption-based emissions in line with a 1.5°C trajectory.

The current NDCs are not sufficient to meet the Paris Agreement's ambition to limit the global average temperature increase to 1.5°C. More climate action is needed to initiate a global transition to low-carbon production that goes beyond NDCs in terms of decarbonising electricity generation and adopting wider energy efficiency measures as well as shifting to zero-carbon fuels within buildings, transport and industrial processes.

fig.28
Emissions reduction potential of a low-carbon production transition in line with NDCs compared with an accelerated transition.

In a future scenario where an accelerated global transition takes place, through a maximum deployment of current low-carbon technologies (i.e. technologies that are in use or innovations that are at an advanced stage), the carbon footprint of goods and services in C40 cities would shrink and consumption-based emissions would fall.[52] While a low-carbon transition of production in line with current NDC commitments would reduce C40 cities' consumption-based emissions by 56 $GtCO_2e$, an accelerated transition to clean production, as defined by the International Energy Agency (IEA), would reduce C40 cities' consumption-based emissions by an additional 50 $GtCO_2e$ (Figure 29).

[52] *This accelerated transition scenario correspond to a global average temperature increase of 1.75°C.*



The difference in carbon intensity between an NDC and an accelerated transition scenario

The NDC and accelerated transition scenarios were developed using third party analysis by the International Energy Agency (IEA). In 2017, they published a report, Energy Technology Perspectives, which included projections of the scale and speed of energy decarbonisation according to a number of scenarios of which two were considered for this analysis; an NDC scenario and an accelerated transition that is commensurate with a 1.75°C climate scenario. Table 8 highlights the International Energy Agency's key indicators of the low carbon production developments that underpin these scenarios.

The IEA is a globally recognised source of energy analysis however integration of different modelling analysis is not without limitations. These are described fully within the method report.

Note that the adoption of CCS and BECCS proposed within the IEA analysis was excluded from the accelerated transition scenario for the purposes of this study.

Table 8
Summary of global indicators for an NDC scenario versus a scenario with an accelerated transition to clean production.

SOURCE OF EMISSIONS	SELECTION OF GLOBAL INDICATORS OF LOW-CARBON TRANSITION BY 2050	
	Current NDC commitments (2.9-3.4°C)	Accelerated transition (1.75°C)
Electricity generation	**52%** is from lower carbon generation sources; grid carbon factor is 308 g CO_2/kWh	**90%** is from lower carbon generation sources; grid carbon factor is 78 g CO_2/kWh
Land freight	Carbon intensity of heavy duty vehicles is **50gCO_2/km**	Carbon intensity of heavy duty vehicles is **13gCO_2/km**
Rail	Carbon intensity of rail is **11gCO_2/km**	Carbon intensity of rail is **0gCO_2/km**
Shipping	Carbon intensity of shipping is **90gCO_2/kJ**	Carbon intensity of shipping is **61gCO_2/kJ**
Cement production	**16%** of energy used in cement production from biomass and waste and 14% from natural gas	**28%** of energy used in cement production from biomass and waste and 22% from natural gas
Steel production	Energy intensity of crude steel production **22 GJ/t**	Energy intensity of crude steel production **12 GJ/t**
Pulp and paper production	Proportion final energy consumption from fossil fuels and coal is respectively **18% and 9%**	Proportion final energy consumption from fossil fuels and coal is respectively **13% and 3%**
Petrochemicals	Energy intensity of primary petrochemicals reaches **72 GJ/t** including feedstocks	Energy intensity of primary petrochemicals reaches **57 GJ/t** including feedstocks

9.1.1
The impact of Deadline 2020 commitments and consumption interventions under an accelerated low-carbon transition

This accelerated transition to low-carbon production would affect C40 cities' consumption-based emissions in two key ways. Firstly, as seen in figure 29, the impact of city climate action would be less significant under this more ambitious global climate scenario. This is because a high degree of grid decarbonisation and deployment of technological innovation would take place before Deadline 2020 commitments and city consumption interventions are fully deployed. If C40 cities implement ambitious consumption interventions under this accelerated transition scenario, they would cut carbon emissions by 22 $GtCO_2e$ (Figure 29).

Secondly, if an accelerated transition to cleaner production takes place, alongside a delivery of Deadline 2020 commitments and the implementation of consumption interventions, C40 cities' consumption emissions would be reduced by 153 $GtCO_2e$. Altogether, this reduces the emissions gap in C40 cities by 95%, compared to a scenario with no further climate action. The remaining emissions gap in this case would be 8 $GtCO_2e$.

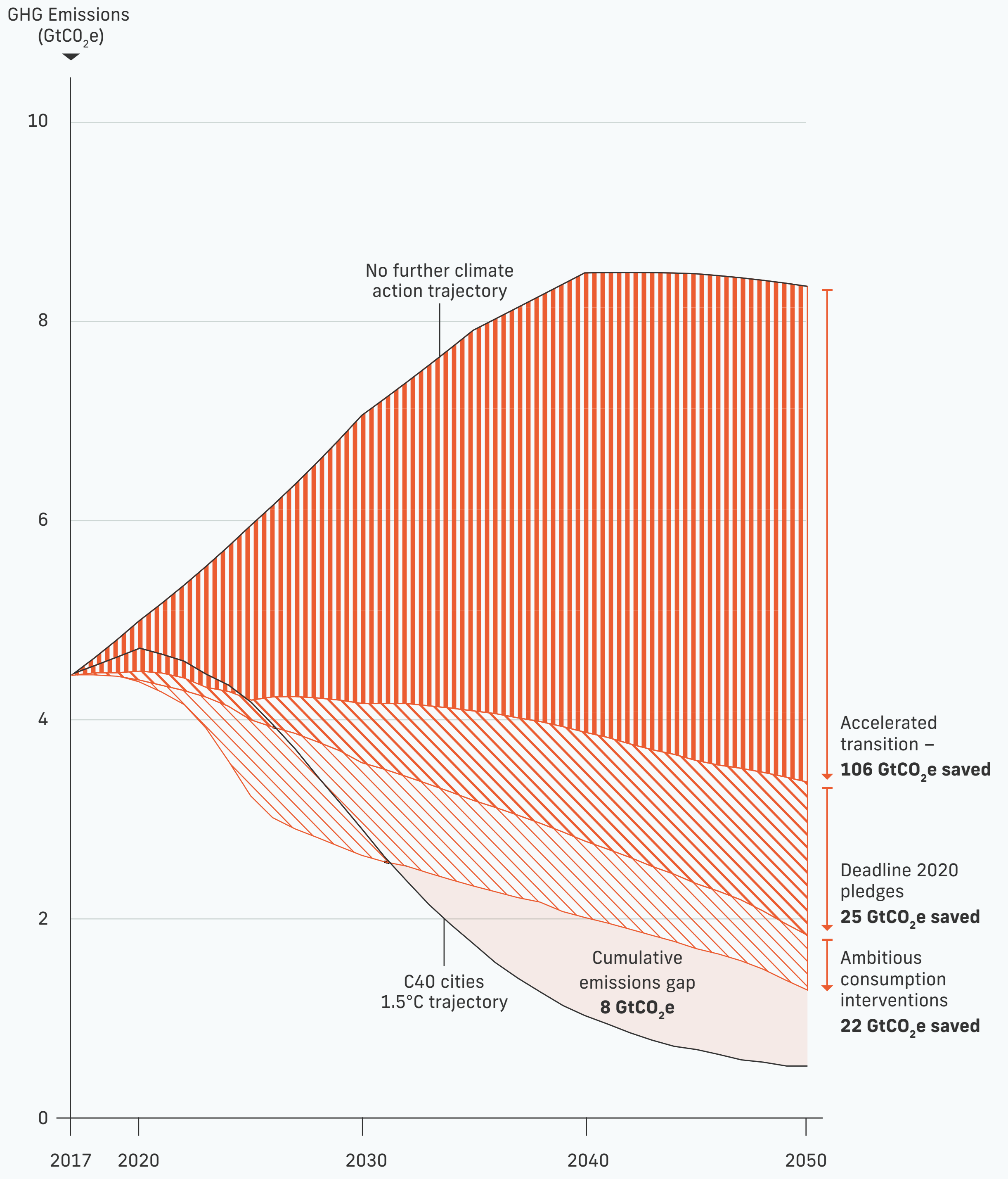
An accelerated transition to low-carbon production is therefore a necessity for C40 cities to reduce their consumption-based emissions in line with a 1.5°C trajectory. Without the additional level of climate action in the surrounding world that an accelerated transition entails, goods and services consumed by city residents would still have a level of carbon intensity that makes it near impossible for C40 cities to fully close their emissions gap. Furthermore, if C40 cities cannot close their consumption emissions gap, due to the continued carbon intensity of imported goods and services, it also means that the world's emissions gap cannot be closed without an accelerated transition to clean production.

This global-local interplay is complex, but also shows why it is useful to look at urban emissions from a consumption-based perspective. Given that C40's overall goal is to reduce global emissions in line with a 1.5°C scenario, to avoid catastrophic climate change, C40 cities need to understand how they are affected by, and how they affect, global emission levels. A city may undertake highly ambitious climate action to decarbonise the local electricity supply and phase out all fossil fuel vehicles, for example, while urban stakeholders continue to encourage carbon-intensive production of goods and services elsewhere through their consumption. In practice, urban stakeholders need to continuously evaluate both their local and global climate impact and use all of the levers at their disposal – as producers and consumers – to speed up an accelerated transition to low-carbon production everywhere.

The remaining emissions gap in an ideal scenario would be

8 $GtCO_2e$

fig.29
Emissions reduction potential of Deadline 2020 commitments and consumption interventions under a future scenario with an accelerated transition of production.



9.2

Uncertainty requires a wide range of climate actions

Reducing C40 cities' consumption-based emissions in line with a 1.5°C trajectory requires a wide range of climate action at city, national and global levels, from both public and private actors.

Although an accelerated transition of production, alongside Deadline 2020 commitments and the full deployment of consumption intervention, nearly bridges the consumption-based emissions gap in C40 cities, this outcome is far from certain.

In fact, the delivery of Deadline 2020 commitments and consumption interventions, alongside the pace of change set out within the accelerated transition scenario, needs an unprecedented deployment of technology as well as ambitious shifts in social norms to take place within the next decade.

Take the electricity sector, for example. While the global average carbon intensity of electricity decreased by less than 1% annually in 2008-2017[53] that rate of change has to increase to 5% per year between 2017-2050, under a scenario with an accelerated transition to cleaner production. A 5% annual drop in carbon intensity will be very challenging, but not impossible. The United Kingdom, for example, reduced its carbon intensity of electricity by 17% per year in 2012-2016, mainly by swiftly and drastically decreasing coal-fired power generation by 80% during that period.[54]

On the other hand, the quantitative analysis undertaken in this report is based on current technologies, informed by expert opinion and evidenced research. This factual basis makes the emission reduction targets realistic, in the sense that no technological constraints prevent suggested consumption interventions from being implemented. But it may also contribute to an overly pessimistic outlook, because the targets are limited by what is currently deemed possible. It does take time to deploy and scale up new technology and its associated infrastructure, but unforeseen technical developments could increase the likelihood of reducing C40 cities' consumption-based emissions in line with a 1.5°C trajectory. Similarly, social norms and consumer choices may also shift more rapidly than expected.

However, given that ground-breaking technological developments are uncertain, cities may want to consider a range of supporting measures that go beyond the IEA elements of the low-carbon transition as well as Deadline 2020 commitments and consumption interventions. Adopting these additional measures increases the likelihood that C40 cities stay within their consumption-related 1.5°C GHG budgets.

[53] *Drax (2018) Energy Revolution: A Global Outlook. Available at: https://www.drax.com/wp-content/uploads/2018/12/Energy-Revolution-Global-Outlook-Report-Final-Dec-2018-COP24.pdf*
[54] *Imperial College London (2017) Available at: https://eandt.theiet.org/content/articles/2017/11/carbon-emissions-associated-with-uk-s-electricity-generation-have-halved-since-2012*

9.2.1 Tackling emissions through a wider range of city consumption interventions

This study concentrates on six categories where cities could have a significant impact on consumption-based emissions. However, to align with a 1.5°C trajectory, additional bespoke and tailored interventions may be needed across other consumption categories. These other categories of consumption, which were not analysed in detail in this report, as outlined in 4.1.1, are listed below:

- Utilities e.g. electricity consumption
- Services e.g. financial and hospitality services
- Government activities
- Public transport outside city e.g. by rail and coach
- Fixed assets e.g. industrial equipment
- Household chemical products e.g. toiletries, household cleaning products and medicine
- Ports and shipping including activities related to trade that is not imported into a city[55]
- Miscellaneous (this covers a broad range of remaining categories such as DIY equipment etc.)

Figure 30 presents the remaining consumption-based emissions by consumption category, between 2017 and 2050, following the delivery of an accelerated transition of production, Deadline 2020 commitments and the consumption interventions.

The consumption interventions for food, buildings and infrastructure, private transportation, aviation, clothing and textiles, and electronics and household appliances have the potential to reduce emissions from these categories by 85% between 2017 and 2050. Out of 1.3 $GtCO_2e$ total consumption-based emissions, just over 0.3 $GtCO_2e$ remain out of the six focus consumption categories by 2050. This would be equivalent to average consumption emissions, across all C40 cities, of 0.4 tCO_2e per capita.

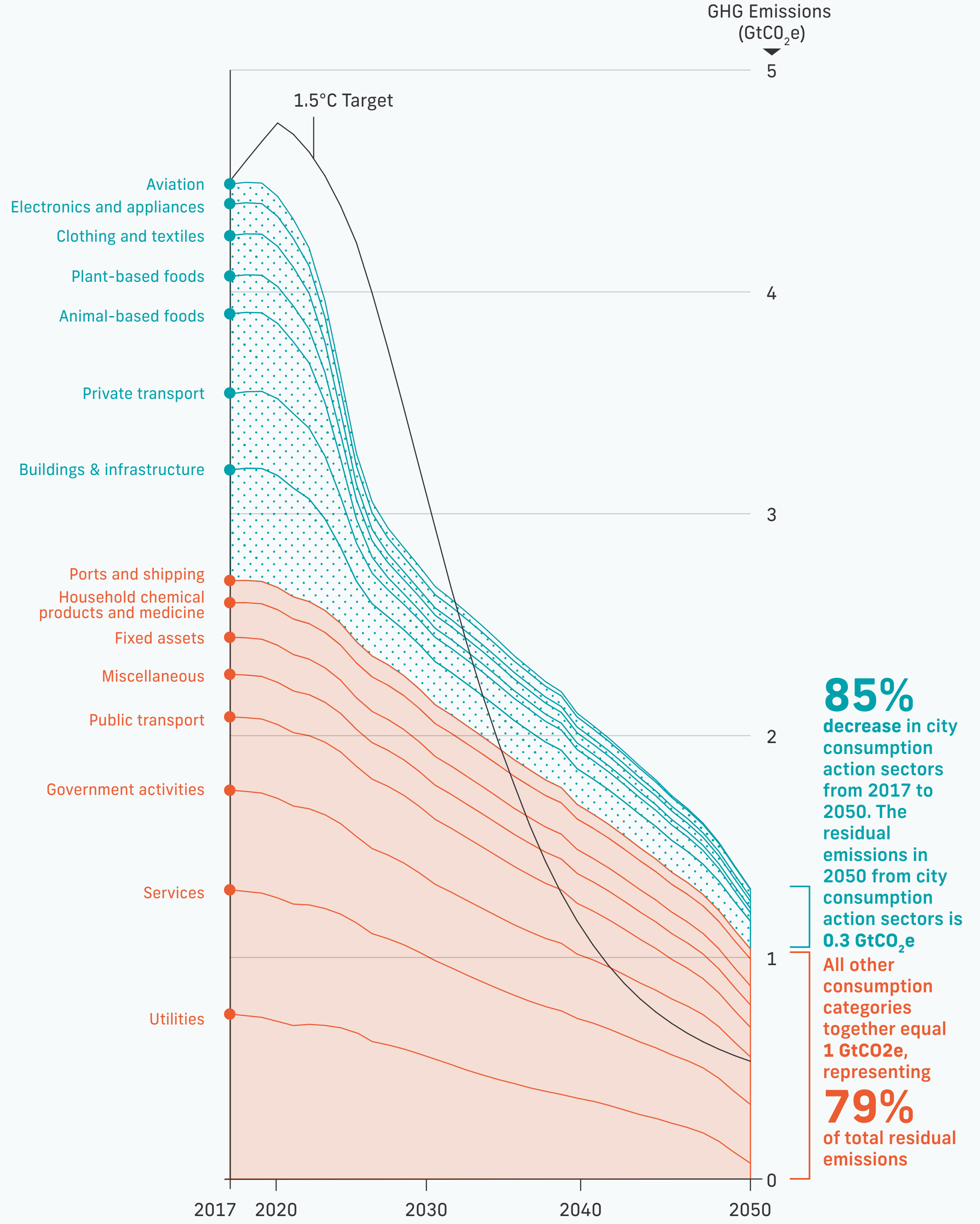
Assuming that consumption interventions with a similar emissions reduction impact as those analysed in this report could be applied across these additional categories, it would be possible to fully close the cumulative emissions gap and reduce total emissions to just 0.4 $GtCO_2e$ in 2050.

The consumption interventions for the six categories have the potential to reduce emissions from these categories by 85% between 2017 and 2050.

[55] *For instance, Singapore has a very active port even though only part of the shipping contents are imported into the city*

fig.30

Reduction in consumption-based emissions across consumption categories between 2017-2050. The largest consumption-based emission categories, which have not been fully decarbonised by 2050, are services (23%), government activities (18%) and public transportation outside of city boundaries (11%).



9.2.2
Behavioural change: driving a social and economic transition

Reducing consumption-based emissions will require significant behavioural changes. Individual consumers cannot change the way the global economy operates on their own, but many of the consumption interventions proposed in this report rely on individual action. It is ultimately up to individuals to decide what type of food to eat and how to manage their shopping to avoid household food waste. It is also largely up to individuals to decide how many new items of clothing to buy, whether they should own and drive a private car, or how many personal flights to catch every year. As this report shows, these are some of the most impactful consumption interventions that can be taken to reduce consumption-based emissions in C40 cities. Furthermore, businesses and elected leaders respond to consumer demands and voter priorities. Signs of broad behavioural change will therefore support low-carbon corporate and political action. If C40 cities are to cut their consumption-based emissions in half by 2030 and reduce them by 80% over the period up to 2050, it is critical that large-scale behavioural changes occur as soon as possible, and that governments and businesses support a swift transition to more sustainable consumption through policy incentives and new business models.

9.2.3
Technology deployment: carbon capture and storage (CCS)

When considering ways to reduce the carbon intensity of the economy, CCS features as an important technological tool. CCS can both limit emissions from unavoidable chemical processes that produce direct emissions as well as sequester emissions from industries that struggle to transition to their full decarbonisation potential. CCS is central to many emissions scenarios that can achieve official climate mitigation targets, but the pace of CCS implementation is far behind established aggregate decarbonisation pathways.[56]

It is recognised that the electric power sector and electrified road transport can leverage emissions-free renewable solutions that do not require CCS. By contrast, industries that produce essential materials, including cement, steel and chemicals, release CO_2 as a result of the production process. Emissions reductions in industry by energy and process efficiency alone are therefore insufficient for limiting warming to 1.5°C with no or limited overshoot.[57] For example, when making cement CO_2 is released from the fuel used to heat the kiln and from the chemical transformation of limestone to clinker. The latter is a process where emissions can only be abated by using CCS or by avoiding the use of a limestone-based clinker entirely.

The deployment potential of CCS is still uncertain, however, as it remains hampered by high upfront investment costs, lack of transport and storage infrastructure, and a lack of funding schemes that can distribute the costs between producers, consumers and governments. But cities are leading the way in addressing these constraints. Adoption of CCS is currently planned for a waste-to-energy plant for Oslo, for example, and similar projects are currently under construction in the Netherlands. These waste-to-energy installations are either partly or fully owned by local municipalities.[58]

Moreover, while industrial CCS can scale to the level of several gigatons of CO_2 being abated every year, concerns remain as to the scalability of CCS applied to biomass (BECCS), which ultimately competes for limited land area for food production and the goal of preserving biodiversity.[59] The primary alternative, to avoid an overreliance on BECCS, is to reduce the generation of emissions altogether.

[57] Peter et al (2017) Key indicators to track current progress and future ambition of the Paris Agreement. Nature Climate Change, 118-122. Available at: https://www.nature.com/articles/nclimate3202
[57] IPCC (2018) Global warming of 1.5C Summary for Policymakers. Available at: https://www.ipcc.ch/sr15/
[58] Guardian (2019) Empty North Sea gas fields to be used to bury 10m tonnes of CO_2. Guardian. Available at: https://www.theguardian.com/environment/2019/may/09/empty-north-sea-gas-fields-bury-10m-tonnes-C0$_2$-eu-ports
[59] Fayardi et al, M. (2019) BECCS deployment: a reality check. Briefing paper n°28. Grantham Research Institute on Climate Change and the Environment.

9.2.4 Policy example: carbon pricing

Carbon pricing has long been proposed as an effective mechanism to reduce the carbon intensities of products and services in a flexible and cost-effective manner. Carbon pricing sends a price signal to consumers by making high-carbon goods more expensive, thereby triggering a positive behaviour change towards a lower-carbon alternative. This price signal has the dual benefit of spurring innovation on low-carbon alternatives while influencing consumer choices and dampening negative rebound effects (see Chapter 6.3). Carbon pricing mechanisms are scalable at local, national and multinational levels, and allow carbon reductions to occur where they are most cost effective.

Carbon pricing would be most effective at a global level, but it can be developed incrementally, region by region and sector by sector. Some of the most effective carbon pricing schemes have been introduced at a sub-national scale. The Regional Greenhouse Gas Initiative, for example, was set up by ten neighbouring U.S. states. Additionally, several cities have introduced forms of carbon pricing on the built environment and private vehicles, such as Tokyo's cap and trade programme[60] and London's Ultra Low Emission Zone.[61] Today, 40 countries and more than 20 cities, states and provinces use carbon pricing mechanisms. According to the World Bank, these schemes cover 13% of annual global GHG emissions.[62]

[60] Tokyo Metropolitan Government (2019) Tokyo Cap-and-Trade Program. Available at: http://www.metro.tokyo.jp/english/topics/2016/161116_01.html
[61] BBC (2019) ULEZ: New pollution charge begins in London. BBC. Available at: https://www.bbc.co.uk/news/uk-england-london-47815117
[62] World Bank (2019) Pricing Carbon. Available at: http://www.worldbank.org/en/programs/pricing-carbon

9.2.5 Policy example: managed growth

If existing technologies cannot be scaled-up quickly enough, or if no unforeseen technological and social shifts occur, it may be necessary to address another macro driver of consumption emissions: increased expenditure due to economic growth. As outlined in Chapter 4, annual GDP growth rates have a significant impact on emission levels in C40 cities over time. For example, by assuming an annual growth rate of 1.3% instead of 2.3% over 2017-2050, C40 cities' consumption emissions would decrease by 49 $GtCO_2e$ during the same period.

Recently, China's efforts to expand renewable energy provided a clear example of the impact that GDP growth can have on the scale of necessary climate action. Despite significant Chinese investments in renewable energy over the past few years, research indicates that clean electricity deployment still needs to double to keep up with a growing demand and simply maintain emissions at their current level.[63]

The inherent challenge in having efficiency improvements keep up with, and outpace, increasing demand due to economic growth has led academics and thinkers to question the viability of the dominant economic paradigm within which the global economy operates. This paradigm uses the proxy of GDP as the primary indicator of development. Being the primary indicator, GDP also becomes the primary goal of governments around the world. As with any individual indicator, GDP is incomplete, and questions have been raised as to how fruitful a single-minded pursuit of GDP growth is. This is because the measure lacks the ability to quantify full human prosperity and because it does not address environmental degradation or climate change.

[63] Greenpeace Unearthed: China's emissions keep on rising

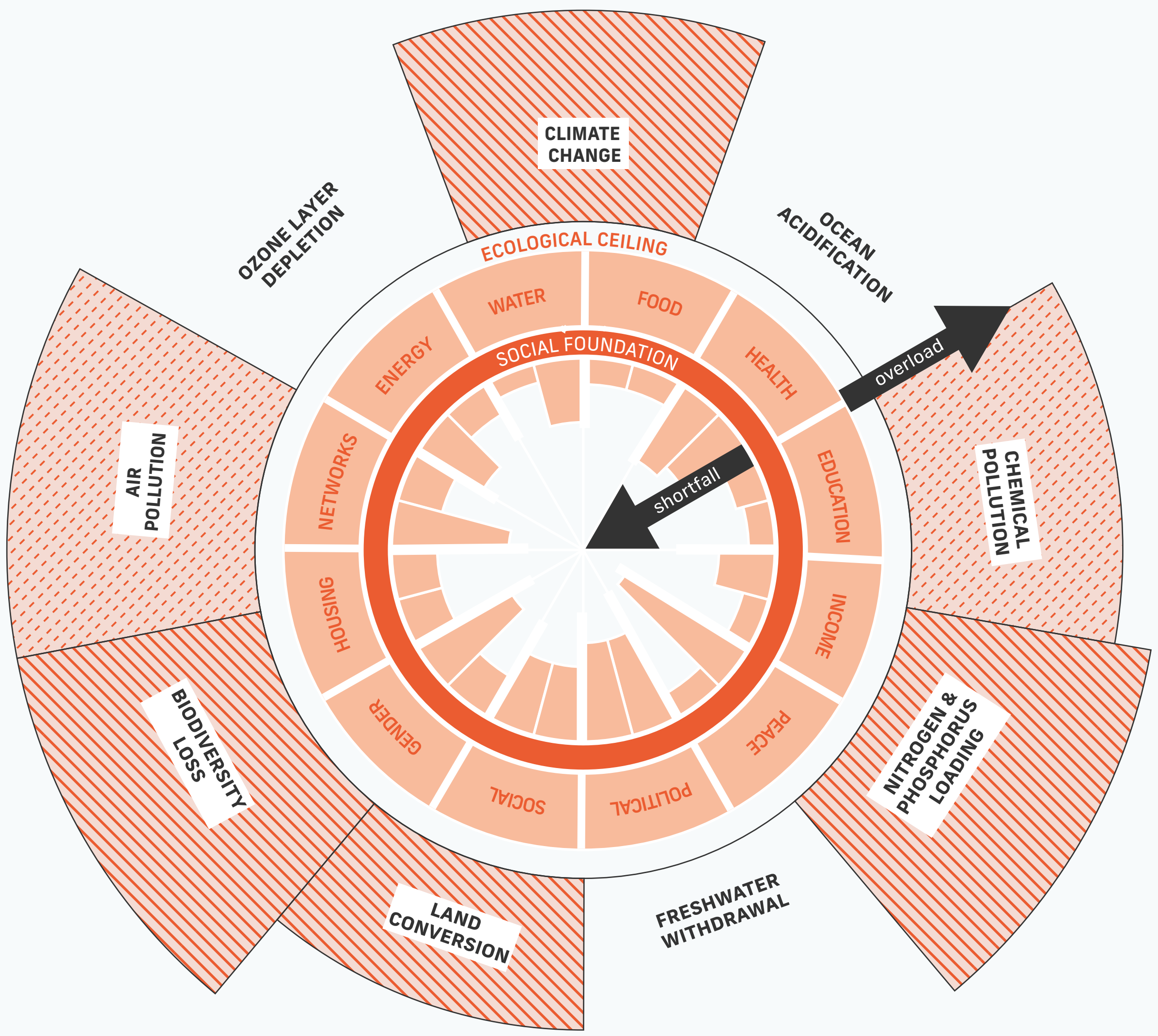
Alternative socio-economic frameworks do exist. Doughnut Economics, for example, which is shown in Figure 31 below, estimates that the world has already exceeded at least four planetary boundaries without meeting any indicators of social wellbeing.

These concepts attempt to encapsulate an economy that allows societies to operate within planetary boundaries while ensuring that human needs are met. In such a scenario, policy makers would be agnostic about economic growth; it would not be an indicator of success or failure but merely one thing to consider alongside a wider range of social, economic and environmental factors.

The inherent challenge in having efficiency improvements keep up with, and outpace, increasing demand due to economic growth has led academics and thinkers to question the viability of the dominant economic paradigm within which the global economy operates.

fig.31
Doughnut economics diagram showing global 'performance' across indicators of social and planetary wellbeing.[64]

beyond the boundary
boundary not quantified



[63] *Raworth, K. (2018) Doughnut Economics.*

9.2.6
Summary: closing the emissions gap

If an accelerated transition to clean production is initiated across the world that drastically reduces the carbon intensity of electricity generation, shipping, land freight and rail, limiting global warming to 1.5°C will be within reach.

If these developments are coupled with a substantially decreased carbon-intensity of industrial processes, the consumption-based emissions gap in C40 cities will have been reduced by approximately two-thirds over the period up to 2050. Under such a scenario, C40 cities are within reach of closing their emissions gap, given that complementary climate action takes place within cities.

On top of the primarily global and national action described above, C40 cities need to meet their Deadline 2020 commitments so that production-based emissions peak by the early 2020s, before collectively halving by 2030, in order to achieve net carbon neutrality by 2050. By also meeting Deadline 2020 commitments, C40 cities will have closed 80% of their consumption-based emissions gap. But the commitment requires that cities also rethink their approach to heating and cooling, building efficiency, mobility, urban planning and waste.

While C40 cities attempt to meet their Deadline 2020 ambitions, they will also have to deliver a series of consumption interventions that further impact how goods and services are produced and consumed. On construction, cities need to change what types of buildings and infrastructure are built as well as what materials are used. On transport, private car ownership needs to end and the shared vehicles that replace it have to use less materials and be longer lasting. Urban residents will also need to adopt a largely plant-based diet, mostly replace flying with less energy-intensive forms of long-distance transport, change how clothes and textiles are consumed and keep electronics and household appliances for longer. Altogether, the listed global, national and city actions will close 95% of C40 cities' consumption-based emissions gap over the period up to 2050.

C40 cities are within reach of closing their emissions gap, given that complementary climate action takes place within cities.

If cities develop additional bespoke consumption interventions, for a diverse set of products that have not been the focus of this report, the modelling suggests that C40 cities are able to close their full consumption-based emissions gap by 2050.

However, most of the above-mentioned climate actions – on global, national and local levels – have to take place within the next ten years. Climate action over the coming decade will therefore decide whether C40 cities, and the world at large, can reduce consumption-based emissions in line with a 1.5°C trajectory. Transforming production and consumption requires a rapid global, national and local alignment of climate policies, new business models and society-wide behavioural change that delivers an unprecedented level of climate action by government, business and individuals.

Since the wide range of action that enables a 1.5°C scenario leaves little room for delay or failure over the coming decade, other broad supporting policies can provide a safety net by bringing about complementary emission reductions.

Examples of such complementary policies are CCS, particularly in industries that emit direct emissions, and carbon pricing mechanisms that underpin climate action across the entire economy. Even deeper paradigmatic shifts may be relevant, such as adopting an agnostic approach to economic growth as a primary indicator for development. This report presents a short list of potential policy examples, but many more will be worth exploring throughout an ongoing process that reconsiders what a sustainable global future will look like. In practice, no one city or nation will follow the exact same emissions reduction pathway, but this report provides urban and non-urban actors with a sense of the nature, scale and pace at which actions need to be taken.

Most of the above-mentioned climate actions – on global, national and local levels – have to take place within the next ten years.

10 Conclusion

C40 cities are at the frontline of climate action, as evidenced by their commitment to Deadline 2020 and the measures they have already taken to reduce their GHG emissions. However, until now, the typical focus has been on production-based emissions and traditional city roles and responsibilities such as urban planning, energy, transport and waste. This study shows that cities can have a much greater impact on global climate action by considering the emissions associated with the full breadth of their consumption.

The potential influence of city climate action extends far beyond municipal limits. Focusing on consumption-based emissions enables a city to consider the positive impact it can have on emission reductions within and beyond its borders to help bring about a global transition to clean production. Individuals, businesses and governments in C40 cities have significant spending power, which means they can affect what and how goods and services are bought, sold, used, shared and re-used.

This study re-imagines the role of cities in influencing consumption within the city as well as production processes beyond their jurisdiction. This does not supplant ongoing efforts, it simply complements the approach of Deadline 2020. If all cities deliver on their Deadline 2020 commitments, it will also help C40 cities to reduce their consumption emissions.

Alongside their Deadline 2020 commitments, this report recommends that C40 cities focus on reducing emissions within six consumption categories: buildings and infrastructure; food; private transport; clothing and textiles; aviation; and electronics and household appliances. In total, the delivery of NDCs, city action on Deadline 2020 and consumption interventions can reduce the emissions gap in C40 cities by 70%, compared to a scenario with no further climate action. To fully close the consumption-based emission gap in C40 cities, in line with a 1.5°C trajectory, an accelerated global transition to clean production is necessary.

The changes to current consumption patterns that need to be delivered in cities are in some cases dramatic, but individuals, businesses and city governments all stand to gain if the changes are delivered in a just way. Some of the wider urban benefits of making these changes are quantified in this report, proving that consumption interventions can reduce emissions and make cities healthier and more equitable places to live in.

Focusing on consumption-based emissions enables a city to consider the positive impact it can have on emission reductions within and beyond its borders.

Reducing consumption-based emissions across the economy involves multiple actors. Urban decision-making is enabled and constrained by behavioural practices, societal priorities, institutions, laws and regulations at regional, national and international levels, as well as by actions taken by non-governmental actors such as corporations, media, NGOs, academia, community groups and individual residents. The consumption interventions analysed for this project can be collectively delivered by different actors and coalitions of actors, but forward-thinking and proactive city governments can facilitate this wider collaboration by providing a platform for action.

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THE FUTURE OF URBAN CONSUMPTION IN A 1.5°C WORLD

This report has been co-created and co-delivered by C40, Arup and University of Leeds with funding from Arup, University of Leeds and Citi Foundation.

Design by Datcha