Towards the Zero-Carbon City

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Foreword

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Transitioning to a low-carbon economy is crucial for limiting further temperature rises. The solutions are clear – halt rising greenhouse gases by enabling widespread energy efficiency and decarbonising the primary energy supply.

There are plenty of opportunities for cities to play their part in solving climate change. Enabling clean transportation and building standards that promote energy efficiency improvements and renewable energy scale up will be critical. Cities are becoming more vocal in their pledges on climate action. Over 9000 cities have pledged to reduce emissions, and around 100 have gone one step further by committing to carbon neutrality.

This report provides signposting for the types of activities that can be put in place by local authorities and business to deliver an emission reduction pathway. It showcases success stories that have already been implemented by cities across the world and demonstrates how the different stakeholders of city infrastructure can participate.

Taken in isolation, the individual activities set out in this report will only make a dent in the emissions challenge. Taken together, these initiatives provide a zero carbon environment that promotes prosperity and preserves our natural environment.

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Introduction

The future belongs to the city.

Just over 50% of the world's population currently live in one. By 2050, this figure will have grown to almost 70%, and by 2080 almost 80% of the world's then 9 billion people will be urbanised. In raw terms, that's roughly 7.5 billion people. Over 80% of global GDP is already generated in cities.

This success is understandable. Cities create positive network effects across vast areas of human endeavour. They are centres of job creation, education, finance and cultural exploration. They can also be dirty, noisy and dangerous. But millions of people flock to urban living every year, willing to make these sacrifices in exchange for a shot at better prospects, amenities and human services.

However, this magnetic appeal could hasten global disaster. As things stand, cities contribute 70% of the world's greenhouse gas output[1]. Without a rethink of the city's growth model, and its relationship with carbon emissions, it will be challenging to stay under the 1.5°C of global warming target put forward by the 2015 Paris Agreement.

This report attempts to set out a new, zero-carbon model for urban growth. What are the biggest sources of city-related carbon emissions? What will governments, city authorities and the private sector need to change? What kinds of financing can be made available to make this change happen?

Creating zero-carbon cities will not be simple. Urban centres across the world will have to radically re-think their approach to housing and other physical infrastructures, transport links, energy use, food and waste.

They will have to re-examine the ways in which their citizens live their lives, and seek greener, more efficient ways of achieving economic growth.

This will require deep cooperation between the public and private spheres. It will require significant sums of investment to be unlocked via a variety of innovative financial instruments. Perhaps most of all, it will require ambition and energy from every level of society.

Fortunately, there are a number of cities and corporations already leading the way. In this report we examine numerous actions developed by individual cities to reduce their carbon footprint, and projects to reduce emissions in specific sectors of the city economy.

[1] C40 Cities - https://www.c40.org/why_cities

The Growth Challenge

Humanity's past, present and future on this planet can perhaps be summed up by two curves on one graph.

One curve maps the growth of carbon dioxide in the atmosphere since the late 19th century, when our species went all in on fossil fuel energy. The other registers the rise of global temperature across the same period. They map each other closely, both rising sharply the closer they get to the present day. The world has already warmed by 1.0°C above pre-industrial levels due to human activities.

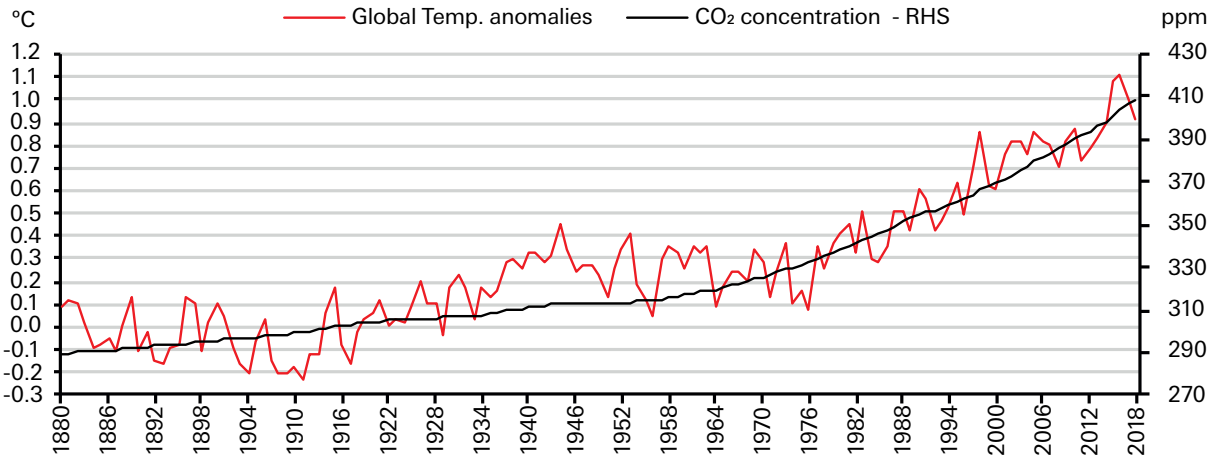
Urbanisation and global warming have enjoyed a symbiotic relationship over the past two centuries. As their populations increased, cities began to devour the electricity produced by traditional fossil-fuel power plants. This led to further urbanisation, and greater demand for power. In 1800, cities with populations of over 1 million were the exception. Now, dozens across the world have populations running into the tens of millions[2].

Many urban environments have been built around the car, pushing transport into one of the top carbon-emitting spots. New infrastructure, commercial buildings and housing require huge amounts of concrete, the creation of which is extremely carbon intensive. Expanding urban areas destroy natural environments.

The growth of the city will continue, but the rise in carbon emissions and the consequent temperature increase must not. At the current rate of warming of 0.2°C per decade, global warming will reach 1.5°C at some point between 2030 and 2052[3]. If carbon emissions are left to grow unchecked, the world could experience warming of between 3°C and 6°C by 2100. This would be a political, economic and environmental disaster for our planet.

In 2015, 174 countries signed the Paris Agreement that aims to limit the global temperature increase to 1.5°C. This objective also falls under the UN Sustainable Development Goals for 2030.

Cities can influence how quickly temperatures rise or fall. More than 100 cities have pledged to take actions in reducing emissions, aiming for at least a 70% reduction in greenhouse gas by 2050. By 2030, cities and local governments could eliminate 1.4 billion tonnes of new carbon dioxide emissions[4].



[2] 'Re-energising the world, the economics of energy: past, present and future' www.sustainablefinance.hsbc.com/reports/re-energising-the-world
[3] The Intergovernmental Panel on Climate Change - https://www.ipcc.ch/sr15/
[4] Global Covenant of Mayors 2018 Global Aggregation Report

Over 100 cities with climate targets

Aarhus (2030)
Abidjan
Accra
Addis Ababa
Adelaide (2025)
Amman
Austin
Barcelona
Berlin
Beverly
Boston
Boulder
Brisbane
Bristol (2030)
Buenos Aires
Cape Town
Caracas
Chengdu
Chicago
Christchurch (2030)
Copenhagen (2025)
Curitiba
Dakar
Dar es Salaam
Des Moines (2040)
Dhaka
Dubai
Durban
Espoo (2030)
Frome
Guadalajara
Halifax
Hanoi
Ho Chi Minh City
Heidelberg
Helsinki (2035)
Honolulu
Houston
Jakarta
Johannesburg
Kampala
Karachi
Kuala Lumpur
Lagos
Lima
Liverpool (2040)
London
Los Angeles
Manchester (2038)
MedelinMelbourne
Mexico City
Milan
Minneapolis
Montreal
Musier
Nairobi
New York City
Niestal (2034)
Nottingham (2028)
Oslo
Paris
Park City (2032)
Philadelphia
Pittsburgh
Portland
Qingdao
Quezon City
Quito
Reykjavik (2040)
Rio de Janeiro
Rome
Salt Lake City
Salvador
San Francisco
San Luis Obispo (2035)
Santa Fe (2040)
Sanat Monica
Santiago
Sao Paulo
Seattle
Seoul
Sheffield, UK
Sonderborg (2029)
St Louis Park
St Paul
Stockholm (2040)
Sydney
Tampere (2035)
The Hague
Tokyo
Toronto
Tshwane
Turku (2029)
Vaasa (2035)
Vancouver
Venice
Warsaw
Washington D.C.
West Hollywood
Yokohama

Cities in bold have even more ambitious carbon neutrality plans

The Scope for De-Carbonisation

Possible carbon reduction isn't just concentrated in the world's megacities. In fact, the greatest potential lies with the roughly 5000 small and medium-sized urban centres dotted all across the globe. The 100 cities already pledged to carbon reduction must act as the spearhead of a broader movement.

Existing climate change policy is signposted by the Paris Agreement, but the work of translating this into reality will largely be done by a panoply of national government, local authority and city mayor plans. As these plans take shape, cities also have to confront other challenges beyond global warming. Some of these sit comfortably with carbon reduction goals, but others don't.

Challenges for cities

- **Managing energy demand**
  Global electricity consumption is set to grow by almost 60% by 2050[5]. Much of this demand will come from cities, meaning significant investment in new sources of power, and improvements to power distribution via 'smart' electricity grids. Renewable power sources must take on much of the load.
- **Controlling the construction boom**
  Cities must deal with population rise by building new housing, increasing the density of existing neighbourhoods and retrofitting buildings to improve the overall quality of the housing stock.
- **Responding to infrastructure pressure**
  More people means more demand placed on public transport, health care systems, schools, logistics, water and waste infrastructure. How can cities maintain or improve the quality of these services while meeting the needs of new consumers and tackling carbon emissions?
- **Optimising the use of new technologies**
  Cities must take advantage of the changes brought on by the Fourth Industrial Revolution to shift to new sources of energy, promote new construction materials, and harness the potential of digital technologies to improve carbon efficiency.
- **Fostering a behavioural change for corporate investors and citizens**
  Cities must encourage movement towards impacting investing models that better account for the external returns on investment as well as the internal returns to balance sheets, and include longer time frames for investment returns.
- **Optimising new economic models**
  Cities must exploit the power of the circular economy, where recycling plays a major role and goods can be loaned out multiple times, rather than bought by one user then thrown away. Serious attention must also be paid to the power of impact investing, and other financial tools.

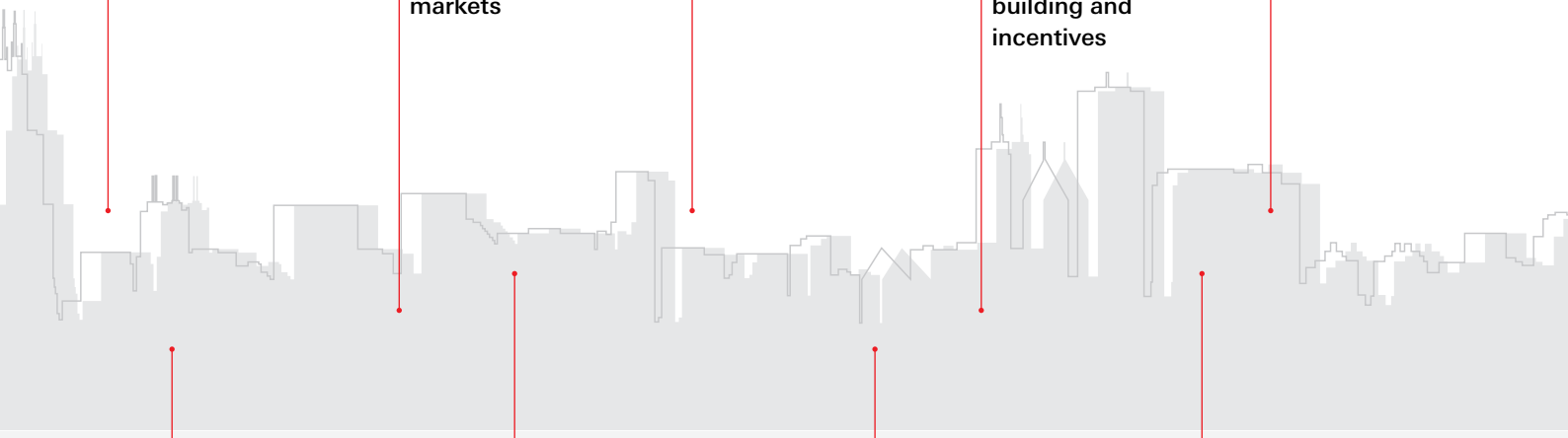
Managing these challenges while also pushing for a zero-carbon growth model will define the activities of hundreds of cities across the world for the next several decades.

[5] Bloomberg NEF New Energy Outlook 2018

Towards The Zero-Carbon City

Nine principles can guide work in cities around the world

Aiming for zero-carbon cities means little without a clear idea of what the end result looks like in practice. Zero-carbon, alongside other terms like 'carbon neutrality' and 'climate neutrality' are often used interchangeably when they are in fact distinct from one another. This hampers clear communication and policy-making.



1: Treat building energy codes as part of a larger transformation

2: Develop ambitious and appropriate building energy codes in all markets

3: Implement robust enforcement and tracking mechanisms

4: Ease compliance challenges through knowledge building and incentives

5: Foster leadership buildings and platforms in every market

6: Link codes to larger decarbonization efforts in energy supply, compact city development, and transformation

7: Account for energy use throughout a building's life span

8: Drive energy impact outside of codes through incentives, appliances, and bulk procurement.

9: Support research and innovation

Source: The Chicago Council on Global Affairs (2018), Building Urban Futures: City Carbon Actions Anchored in Building Codes and Standards

Once you cut through the jargon, however, things become fairly clear at a conceptual level.

In their current guise, cities are carbon-positive – they produce more greenhouses gases than they sequester or offset.

The immediate target for policymakers is carbon-neutrality. This means net-zero carbon emissions are achieved first by reducing the amount of carbon dioxide released in the air to a minimum and also balancing the remaining emissions with an equivalent amount sequestered or offset, or buying enough carbon credits to make up the difference.

'Climate neutrality' is a more recent phrase that casts the emissions net a little wider, recognising that carbon dioxide is not the only greenhouse gas that needs to be eliminated.

At first glance, a zero-carbon city means exactly what it says on the tin – a city where no carbon emissions are produced at all. But even here the definitions get a little slippery. Where does a city end? Does it mean no carbon emissions within the strict boundaries of city limits, where the remit of the mayor or other governing structure ends? What about nearby airports, which contribute to the city's economic growth? What about nearby ports that bring in goods for the city on oil-powered container ships? What about the natural gas power station 30 miles down the road that provides the electricity to keep the city's lights on? How far should a city's zero-carbon policy cast its net?

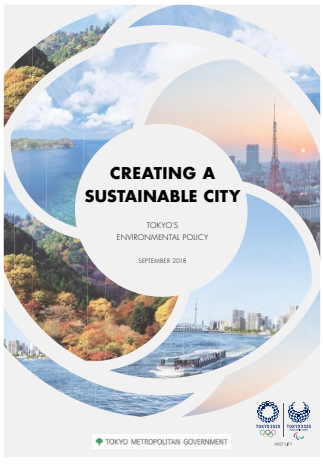
Despite these questions, over 100 cities have pledged to reach the carbon-neutral or net zero-carbon stage by 2050[6] by addressing emissions in power generation, buildings, the transport system, and elsewhere.

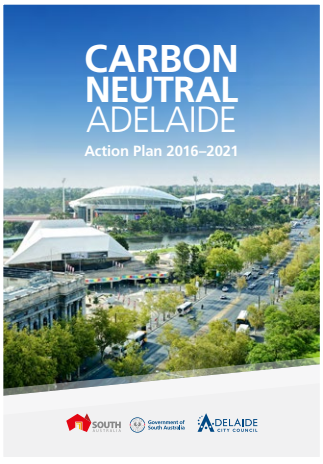
These cities hail from every continent in the world, from Aarhus to Yokohama. Within their number are a further 20 or cities aim to be zero-carbon some time before then – Adelaide and Copenhagen being the earliest, each having set a target date of 2025. All of these cities have published specific emissions-reduction plans (see appendices).

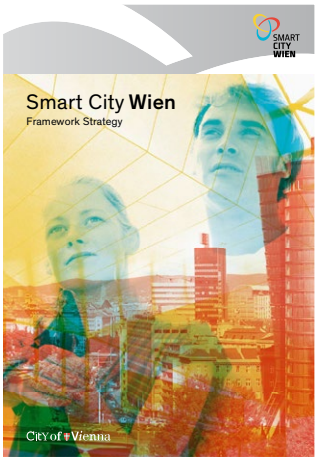
Within these cities, a whole host of different groups will be contributing to climate policies – city governments, airports and other transport hubs, universities, businesses, start-ups and ordinary citizens.

Individual city efforts are bolstered by a high degree of inter-city collaboration, with a number of networks promoting the climate agenda. These include:

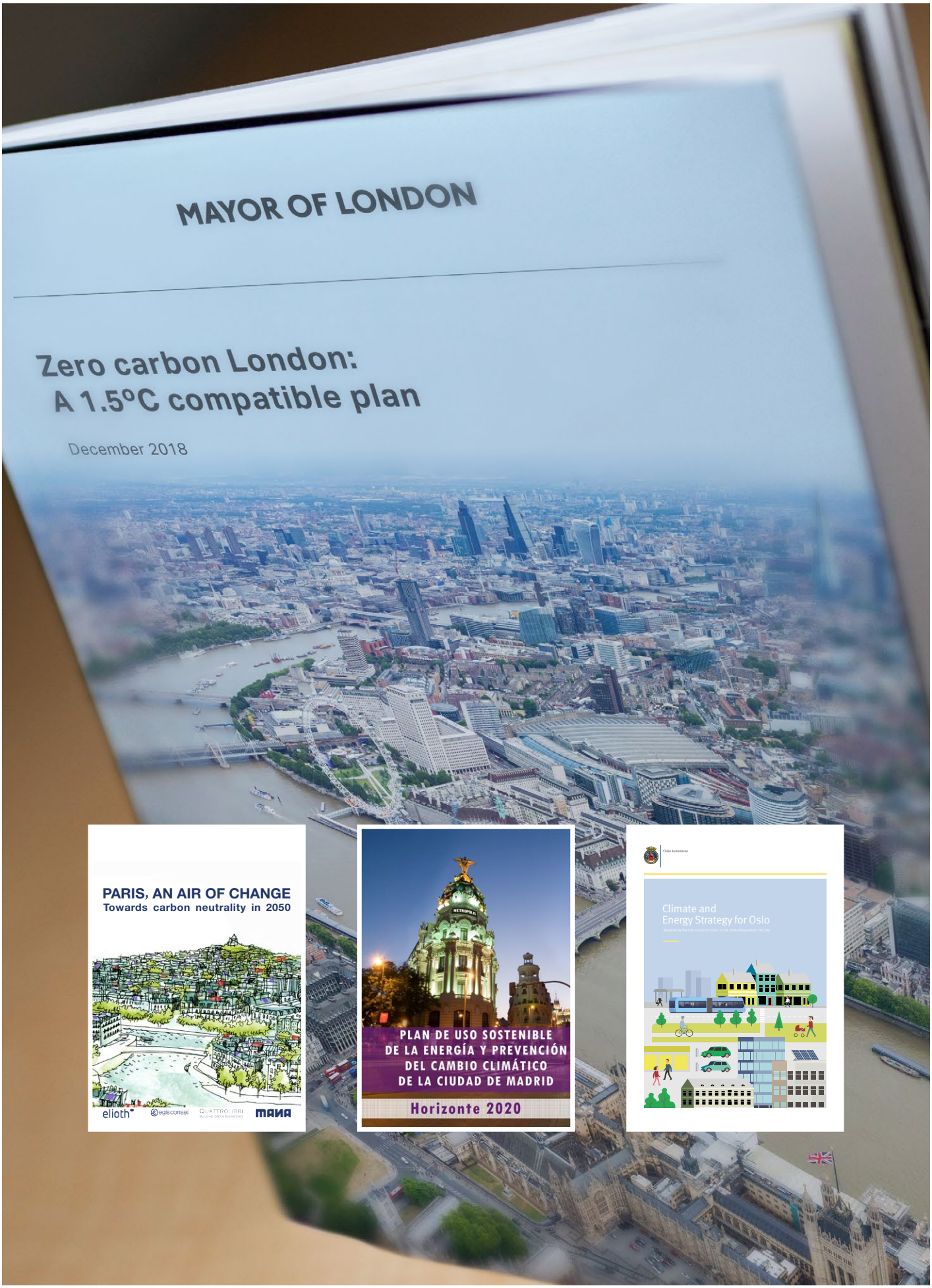
- Global Covenant of Mayors for Climate Change
- Carbon Neutral Cities Alliance
- C40 Cities
- Ellen McArthur Foundation Circular Cities Network
- Rocky Mountain Institute Zero Carbon Cities Network
- Under2 Coalition
- ICLEI – Local Governments for Sustainability
- FC4S





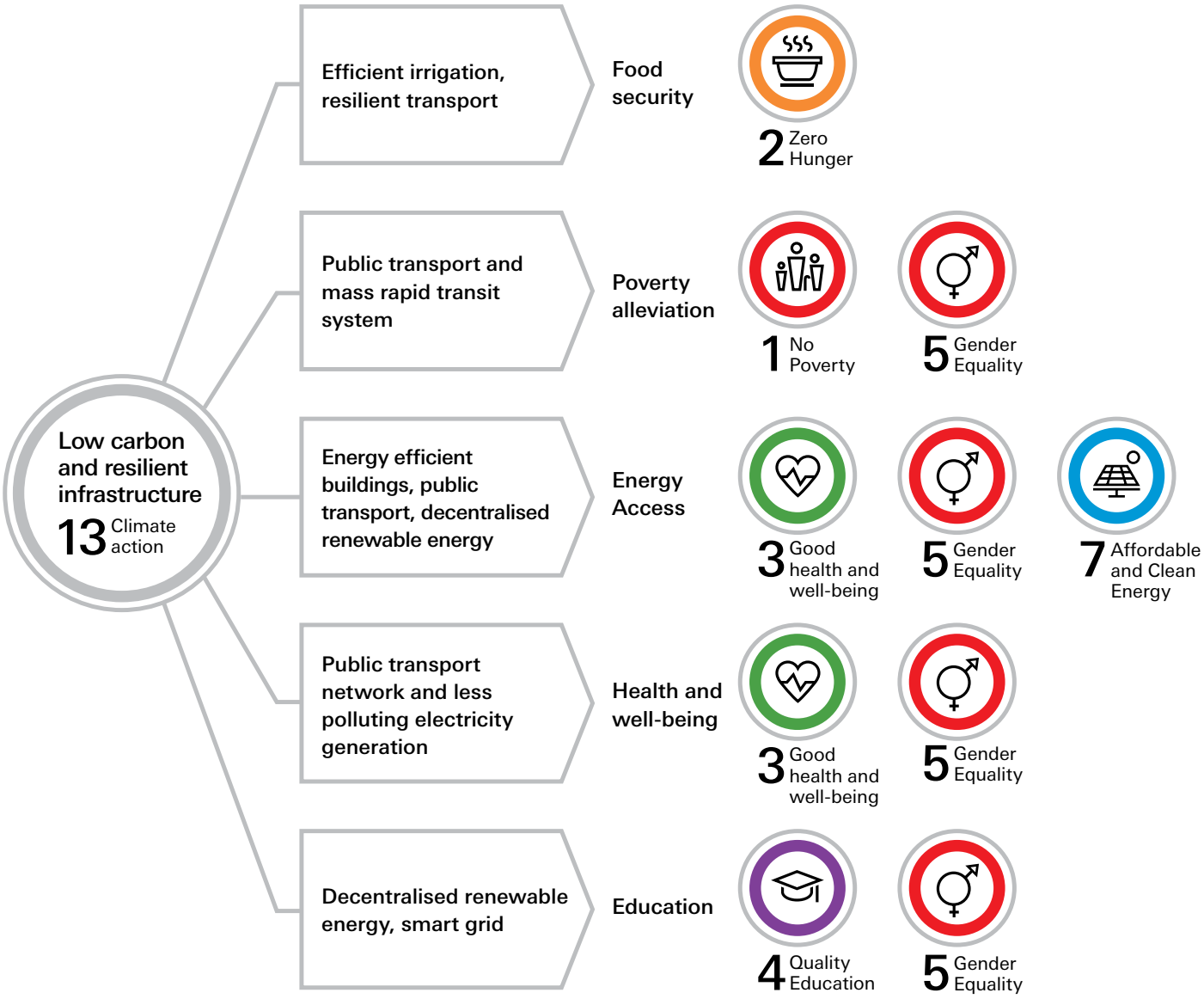


[6] C40 Cities - https://www.c40.org


MAYOR OF LONDON
Zero carbon London:
A 1.5ºC compatible plan
December 2018
PARIS, AN AIR OF CHANGE
Towards carbon neutrality in 2050
elioth
egis conseil
QUATTROLIBRI
MANA
PLAN DE USO SOSTENIBLE
DE LA ENERGÍA Y PREVENCIÓN
DEL CAMBIO CLIMÁTICO
DE LA CIUDAD DE MADRID
Horizonte 2020
Oslo kommune
Climate and
Energy Strategy for Oslo

Zero-Carbon Benefits

The links between low-carbon, climate-resilient infrastructure and the SDGs



Source: OECD (2017), Investing in Climate, Investing in Growth.

Getting to the zero-carbon stage will not be a swift or clear transition – it will involve incremental, overlapping changes from a wide range of economic and governance sectors.

However, there will also be clear benefits along the way, both in terms of addressing climate change and in other areas.

- **Environmental preservation**
  Most of the world's major cities are sited on the coast, or near the mouth of major rivers. As such, they are exposed to the rising sea levels that will be a result of climate change. Even if global temperature increase is kept to 1.5°C degrees, sea levels will still rise by half a metre. This will make damage to cities and their surrounding environs from tidal and storm flooding more likely, and more extensive.

- **Improved health and quality of life**
  According to the World Health Organisation, ambient air pollution is estimated to cause 4.2 million premature deaths per year globally via heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children[7]. Millions more people are also negatively affected to a less serious degree. Particulate matter, nitrogen dioxide and sulphur dioxide from transport, factories and coal-fired power stations are the primary causes of such pollution. Reducing or eliminating emissions from these sources could significantly ease this health crisis. Reducing traffic noise and numbers can also bring benefit through reduced stress levels and safer streets for pedestrians. Tackling climate change as a whole will also reduce the chances of major heat waves, which can prove lethal to many vulnerable people living in cities.

- **Job creation and greater productivity**
  Fears of job losses in carbon-intensive industries have long been used to forestall serious action on climate change. However, any transition to the zero-carbon city will involve significant job creation, through the manufacture of new renewable power technologies and electric vehicles, new transport and energy infrastructure, and building construction. According to an International Labour Organisation Report, by 2030 most economies will experience net job creation and reallocation across industries as a result of zero-carbon efforts, with as many as 24 million new jobs created globally[8].

- **Better quality services**
  Zero-carbon transition will require cities to make significant investment in new services, particularly public transportation, energy supply, and water use. In transport, residents should see a rise in the availability of suburban rail, allowing commuters and other passengers to ditch their car in favour of the train. The development of autonomous electric vehicles could also increase mobility more generally, and especially for those unable to easily access private cars or public transport. The rise of the innovation economy, and the use of data to make cities more efficient, should see improved access to Wi-Fi and 5G services for the population as whole. This will allow for more localised, more productive economies where people do not have to travel to the office every day in order to do their job.

- **Cost savings**
  According to the World Bank, extreme natural disasters produce USD520 billion of consumption loss globally every year[9]. Mitigating or repairing the damage of floods, droughts and wildfires sucks of city resources, and places a drag on economic growth. Each drop of cash spent in these areas is one drop less spent on other vital sectors, such as social care, healthcare or education. The private sector will also have to funnel resources into dealing with a changing climate – the increased cost of cooling buildings, and moving offices and factories away from vulnerable areas, for instance. As temperatures continue to rise, these costs are set to go up, placing greater strain on national and city budgets.

[7] World Health Organisation - https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
[8] International Labour Organisation - https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_628654.pdf
[9] Word Bank - http://www.worldbank.org/en/news/feature/2016/11/14/breaking-the-link-between-extreme-weather-and-extreme-poverty

Implementing Transition

Energy

Energy generation is an obvious place to start phasing out emissions. Natural gas-fired power stations are in many ways the public face of harmful climate change.

Decarbonising power sets a strong foundation for many of the steps that cities need to take, just as electrification in other sectors is a key decarbonisation strategy e.g. for transport, logistics, real estate, and energy intensive digital industries and applications.

Huge inroads have been made into making renewable power sources such as wind and solar energy more reliable and more affordable. Solar power has grabbed the most headlines here. Thanks to private innovation and government subsidy, the cost of photovoltaic modules has dropped by 99% in the past 40 years[10]. The development of large scale, more efficient wind turbines means that in many places they can compete with coal and nuclear power on a price-per-kilowatt hour basis.

The historical weakness of renewables has been reliability. There is always more coal or natural gas to burn, but the wind doesn't always blow and the sun doesn't always shine. Producing and storing renewable energy so that it is available when consumers most need it remains a challenge. Significant investment is being made into large-scale battery technology. Bloomberg New Energy Finance expect around 50 gigawatts (GW) of battery power to be installed globally by 2020. By 2040, this will have shot up to 1000GW[11].

As electricity grids are switched over to renewables, grids themselves will need to be upgraded. At present, most grids worldwide are designed to distribute large, predictable chunks of power from a small number of centralised sources – a few dozen coal, gas and nuclear power stations across a given area.

With renewable energy, grids will need to be smarter, and more flexible. They need to be able to absorb and distribute intermittent power loads from a larger number of dispersed, localised sources – offshore and onshore wind arrays scattered along entire coastlines and landmasses, solar panels on individual houses and building, for example.

These upgrades will come at a cost. In London, the mayor's zero-carbon action plan predicts a required investment of just under GBP4 billion by 2050 to make the necessary changes to grid infrastructure, including reinforcement of up to 180 primary substations[12]. However, much of this investment would have been required anyway in the normal upgrade cycle.

[10] Bloomberg NEF New Energy Outlook 2018
[11] Bloomberg: https://www.bloomberg.com/news/articles/2018-11-06/the-battery-boom-will-draw-1-2-trillion-in-investment-by-2040
[12] Mayor of London: https://www.london.gov.uk/sites/default/files/1.5c_compatible_plan.pdf

What can cities do?

- **As customers**
  Cities can facilitate direct investment in, or purchase of, renewable energy. They can use policymaking power to require utility providers to move to cleaner energy sources.
- **As regulators**
  Cities can set clear decarbonisation goals, and promote energy efficiency standards in new infrastructure and building projects to help lower energy use where possible. Cities can also promote the use of locally-sourced clean energy through solar panels or small-scale wind turbines on the roofs of commercial buildings and houses.
- **As service procurers**
  Cities can shift more urban energy consumption to electricity. For example, building codes could mandate the use of air source heat pumps, rather than gas boilers, for central heating and electric rather than gas ovens for cooking in new homes and commercial buildings.
- **As partners**
  Throughout this process, cities will need to work in partnership with regional and national energy regulators, utilities providers and other stakeholders in the private sector.

New York Solar Power

In 2016 ConEdison, a US renewable energy firm, started work on a large rooftop solar installation at New York's Brooklyn Navy Yard. The installation, comprising over 3,000 panels, is one of the largest such arrays in the city, and will mean a reduction of around 630,000 tonnes of carbon dioxide emissions per year.

The project forms part of New York mayor Bill de Blasio's plan to generate 100 megawatts (MW) of renewable energy on public buildings by 2025, and reduce greenhouse gas emissions by 80% by 2050[13].

Solar has become a major industry in the United States, but is still a small part of its overall power mix. By the end of 2018, the USA had installed 64.2GW of solar energy production, most of which is located in the south-western and south-eastern states[14]. Solar contributed 1.9% of the country's power needs in 2018[15].

However, the rate of growth is startling. In 2016, solar made up 39% of new electricity generation capacity, more than any other source. More people are employed in the solar industry than in coal, oil or gas – 260,000 in total in 2016.

[13] City of New York: https://www1.nyc.gov/office-of-the-mayor/news/769-16/mayor-de-blasio-completion-3-000-solar-panels-the-brooklyn-navy-yard
[14] Solar Energy Industry Association - https://www.seia.org/us-solar-market-insight
[15] PV Magazine: https://pv-magazine-usa.com/2018/02/28/solar-rises-to-nearly-2-of-u-s-generation-in-2017/

Copenhagen Wind Power[16]

Denmark is not a particularly wind-rich country, especially when compared to other European countries such as the UK. However, over 20% of the country's electricity is generated by wind turbines, the highest rate in the world. n unusually windy days, it can even export excess power to neighbouring countries.

The Municipality of Copenhagen plans to build over 100 large wind turbines by 2025, bringing its total investment into the technology close to DKK 5.5 billion (USD830 million) and moving the city entirely to clean energy consumption.

These will be sited both onshore and offshore, and both within and outside the municipal boundaries. Total power generation from these turbines is expected to be 360MW. Construction will be carried out by Copenhagen Energy, a company owned by the Municipality itself.

Berlin – Working with businesses and the community

Commanded by the Energy Transition Law, the city has phased out lignite for the production of district heating since 2017 and is now working towards the end of energy production from hard coal by 2030[17]. Working with players from the energy and solar industry as well as the housing industry, the city is currently designing a 'Solar Capital Berlin' master plan to promote the use of solar energy in buildings[18].

The city is also encouraging its utilities companies to restructure their networks and maximise circularity in order to reduce energy consumption and optimise electricity production[19]. A solar centre has also opened in the city to advise local authorities, homeowners, energy consultants and housing companies on photovoltaics[20]. The Berlin Senate is also involving other actors to help the city achieve its target. The institution financed a project to send experts to nightclubs to advise them on eco-friendly measures[21].

[16] State of Green - https://stateofgreen.com/en/partners/city-of-copenhagen/solutions/wind-turbines-in-copenhagen/
[17] Berlin.de https://www.berlin.de/rbmskzl/aktuelles/pressemitteilungen/2018/pressemitteilung.715783.php
[18] https://www.berlin.de/sen/energie/energie/erneuerbare-energien/masterplan-solarcity/
[19] https://www.berlin.de/senuvk/klimaschutz/bek_berlin/download/BEK_Monitoringbericht_2018.pdf
[20] https://www.photovoltaik.eu/Archiv/Meldungsarchiv/article-873483-110949/dgs-eroeffnet-solarzentrum-berlin-.html
[21] https://www.dw.com/en/making-berlin-clubbing-greener/a-47412968

Transport

After power generation, transportation is perhaps the next big greenhouse gas target. Internal combustion vehicles – everything from mopeds up to commercial airliners and container ships – contribute roughly 20% of man-made carbon emissions globally[22].

In cities, the problem is particularly acute. Many urban centres are clogged with traffic jams, and are heavily reliant on busy airports and ports for movement of people, goods and raw materials. Internet shopping and the increase in home delivery has intensified the use of vans and other large vehicles for logistics. The pollution problem gives cities an extra reason to transition to clean modes of private and public transport.

Private

Much focus has been placed on electric cars and trucks in recent years. Most of the major motor vehicle manufacturers are developing electric models, and in some cases plan to ditch combustion engine models entirely in the coming years.

Significant investment is required in new infrastructure to support this change. If electric battery cars are to fully replace their fossil-fuel predecessors, a vast network of new charging stations will need to be built, not just at current petrol/diesel station sites, but dispersed all across the road network. A large electric vehicle roll-out will also require a far greater capacity of electric power generation, placing further emphasis on the transition to renewables.

If hydrogen-cell cars start to proliferate, existing fuel stations will have to install methods of storing liquid hydrogen, which must be kept at extremely low temperatures. Significant amounts of energy will have to be expended to get it into a pure, liquid form in the first place, and then transport it in that state, so this only works with a high degree of renewable electricity generation.

In the meantime, many cities are pressing ahead with plans to limit the use of internal combustion vehicles within their centres. This can be achieved through emissions zone charging, or outright bans during specific times of the day or days of the week (see London case study).

Cities must also be conscious of the impact of air and marine transport. Airports and ports may often lie outside a city's boundaries, but the magnetic pull of urban living is bolstered by having these transport links close at hand.

Air travel already accounts for 2% of man-made carbon dioxide emissions[23], and the marine diesel used by container ships is, tonne for tonne, one of the worst sources of pollutants used in the transport sector. Pathways to decarbonise both these industries, via electrification, synthetic fuels and radical new ship design, are underway, but are still in their infancy[24].

[22] https://ourworldindata.org/grapher/carbon-dioxide-co2-emissions-by-sector-or-source
[23] European Commission - https://ec.europa.eu/clima/policies/transport/aviation_en
[24] Shipping: Mission Possible – Reaching net-zero carbon emissions from harder to abate sectors by mid century

Public

Private transport is only part of the story. For many policymakers, the real goal is to encourage city residents to give up cars altogether in favour of walking, cycling, buses and trains.

A number of cities have focused on public bus services as an appropriate place to begin the transition to electric vehicles. This makes a lot of sense – buses operate on fixed routes, and return to the same place at the end of their shift, making it easy to predict battery use and cheaper to install re-charging or re-fuelling facilities (see Shenzhen case study).

In promoting public transport, cities will also have think about the way they use physical space. Suburban sprawl makes it hard to build efficient rail services, as potential passengers are too dispersed to easily access stations. Indeed, some cities have been designed with mass car use in mind and do not have extensive public transport networks. Building such networks are among the most expensive infrastructure projects that a city can embark upon. But, they can be made easier with a more holistic view on planning and development.

When planning new housing or commercial hubs, cities must focus on compact, mixed-use developments that maximise the potential of rail, tram and bus services, and that allow residents to safely make journeys by bike or on foot.

What can cities do?

- **As planning authorities**
  Cities can promote compact, mixed-use, transit-orientated development. They can also enable the uptake of next-generation electric vehicles through investments in infrastructure, and ensure major areas of cities are zero-emission.
- **As procurers of services**
  Cities can electrify modes of public transport, particularly rail and bus services.
- **As regulators**
  Cities can implement measures to ban or discourage the use of high-emissions vehicles, including logistics vans and trucks, and promote shared mobility through public transport or private hire vehicles. Freight traffic can be shifted from the road to ships and rail. Centralised distribution centres and shared delivery zones can be established to reduce the logistics presence on the road.
- **As partners**
  Cities will need to work closely with public transport providers, infrastructure companies and car manufacturers. They can facilitate logistics providers to switch to zero-emission vehicles, and help develop improved delivery models.

London – Ultra-Low Emission Zone

In the transportation sector, an ultra-low emission zone (ULEZ) was implemented in central London in 2019 and is to be expanded by 2021.

Vehicles driving in the ULEZ must meet tight emission standards or pay a daily charge to travel within the area.

The ULEZ is expected to reduce nitrogen oxide emissions by up to 45 per cent and improve the air quality in central London[25]. Some boroughs are following, as shown by the launch of ultra-low emission streets in Hackney and Islington[26]. In addition transport companies such as Transport for London and black cabs are committing to electrifying their fleets.

[25] The Mayor of London's Office - www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/mayors-ultra-low-emission-zone-london
[26] The Guardian - https://www.theguardian.com/environment/2018/aug/28/london-boroughs-islington-hackney-ultra-low-emission-zones

Shenzhen – Electric fleet

Named China's most sustainable city[27], Shenzhen is taking strong steps towards reducing its greenhouse gas emissions. In 2017, it became the first major city to deploy an all-electric public bus fleet and in 2019, 99% of the city's taxis were electric[28].

The city is implementing regulations and incentives targeting all types of vehicles, including logistics, trains and private cars, to enable the rapid shift to low carbon, zero-emissions transport. The city has also allocated more than USD500 million in subsidies and incentives for the construction of charging facilities[29].

Tokyo – The hydrogen society

Hosting the 2020 Olympic and Paralympic Games has boosted Tokyo's efforts to reinvigorate the city and its image through sustainable urban development[30].

In addition to expanding the use of renewable energy, the metropolitan government is hoping to create a hydrogen-based society.

JPY40 billion (USD370 million) has been set up to support efforts to be made through to the Tokyo 2020 Olympic and Paralympic Games[31]. The government has deployed fuel-cell buses and hydrogen stations in downtown Tokyo and along transportation routes for athletes and officials.

[27] The Guardian - https://www.theguardian.com/environment/2018/aug/28/london-boroughs-islington-hackney-ultra-low-emission-zones
[28] https://www.jamaicaobserver.com/environment-watch/giving-up-gas-china-s-shenzhen-switches-to-electric-taxis_154184?profile=1123
[29] https://asiancorrespondent.com/2018/06/how-shenzhen-became-chinas-most-sustainable-city/
[30] http://www.climateaction.org/climate-leader-interviews/the_green_games_tokyo_2020
[31] http://www.kankyo.metro.tokyo.jp/en/about_us/videos_documents/documents_1.files/creating_a_sustainable_city_2018_e.pdf

Real estate

One asset that is common to all cities is physical infrastructure – houses, roads, schools, shops, offices, hospitals. Our built environment consumes power and heat in vast quantities, making it a significant contributor to urban greenhouse gas emissions.

In many cities, much of the built environment is decades or even centuries old, constructed long before the age of environmental regulations or efficiency standards. That means a lot of wasted heat and electricity, putting further demands on resource consumption. Any route to the zero-carbon city will involve extensive retrofitting of existing structures, and strict efficiency standards on new developments.

In London, for example, only 35% of homes reach an adequate level of energy efficiency (as set by new building regulation guidelines). To hit the city's zero carbon target, at least 70% of London's buildings will need to get to this level by 2030.

Retrofitting comes in many forms. Gas boilers used for central heating can be exchanged for electric air heat pumps, which take advantage of the temperature differential between indoor and outdoor air to warm or cool a building. Gas ovens and hobs can be replaced with electric induction models. Smart meters can be installed to more efficiently manage and record water, power and heat use. Solar panels or small wind turbines can be installed on building roofs to provide local sources of power. Any excess power generated can be sold back to the grid for the owner's benefit.

There are more prosaic options, too. Better insulation. Double-glazed windows. Better fitted doors. More efficient light bulbs and electrical appliances. Buildings waste heat and power in a variety of ways, and preventing some of this waste would be an important step forward. Alternative heat sources such as air heat pumps generally work best in more energy-efficient homes – they provide warmth at a slower pace over longer periods, and so are less effective in leaky homes that lose heat quickly.

Retrofitting is a huge task. Cities contain tens of thousands of buildings, and many of the changes involved are expensive. London's zero-carbon plan estimates an investment of GBP10 billion on its buildings is needed by 2050[32]. In wall insulation alone, the target rate will peak at just under 160,000 buildings per year in the late 2020s. That dwarfs the previous city's previous governance-driven peak of around 40,000 buildings in 2009-10. Cities and national governments need to find innovative subsidy and financing solutions to make these sorts of project work.

Much of the technology involved in retrofitting can be applied to new buildings. In 2018, 26 cities and regions from across the world signed the Net Zero Carbon Buildings Declaration. Following the pathways set out by the 2015 Paris Agreement, this pledges to introduce regulations and planning policy to ensure all new buildings within those cities are net zero carbon by 2030. By 2050, this pledge will cover all buildings, both new and existing.

What can cities do?

- **As owners and users of buildings**
  Cities can commit to owning, occupying and developing only net zero-carbon assets. They can also embed 'circular economy' principles into procurement.
- **As planning authorities**
  Cities can raise standards for new and existing buildings, both for commercial and housing use. Increasing intensification and density targets for redevelopment and new development must also be a priority.
- **As convenors**
  Cities can encourage and facilitate the retrofit of existing buildings, and build the market for replacement technologies through incubators and pilot programs.
- **As partners**
  Working with real estate owners, construction companies, financial institutions, investors and individual home-owners will be crucial throughout this process.

[32] https://www.london.gov.uk/sites/default/files/1.5c_compatible_plan.pdf

Adelaide – Financing building retrofits

The City of Adelaide aims to become one of the world's first carbon neutral cities. To stimulate citizens and businesses engagement, the city has rolled out a wide range of sustainability incentives for individuals and businesses. Between July 2015 and February 2019, the South Australia government and the city of Adelaide have granted over AUS900,000 (USD625,000) in rebates[33]. The city also launched a Solar Savers Programme, providing upfront funding for the purchase and installation of solar photovoltaic energy systems on eligible low-income and rental residential properties[34].

Adelaide has also entered into Building Upgrade Agreements with building owners and financiers. This financial model enables commercial building owners to improve energy, water and waste performance in existing buildings without having to advance upfront capital. The building owner pays a quarterly Building Upgrade Charge to the council, which is then passed on to the financier[35].

Tokyo – Cap-and-Trade programme

Since 2000, the Tokyo Metropolitan Government has been developing effective policies to improve buildings' energy efficiency and develop an environment-friendly real estate market. In 2010, it started the Tokyo Cap-and-Trade Programme for large building facilities, as measured by energy use. In the first five-year compliance period more than 9 companies out of 10 met their reduction obligations through their own energy efficiency measures, such as the introduction of LED lighting[36]. The government has expanded its programme to small and medium facilities. Its Green Building Programme, started in 2002, requires owners of newly built buildings over 5,000 square metres to submit a building environmental plan[37].

[33] https://www.cityofadelaide.com.au/your-council/funding/sustainable-city-incentives-scheme
[34] https://www.cityofadelaide.com.au/your-council/funding/solar-savers-adelaide
[35] https://www.cityofadelaide.com.au/your-council/funding/building-upgrade-finance
[36] http://www.kankyo.metro.tokyo.jp/en/about_us/videos_documents/documents_1.files/creating_a_sustainable_city_2018_e.pdf
[37] https://www.c40.org/case_studies/tokyo-tokyo-metropolitan-government-green-building-program

Construction

Construction is perhaps one of the more unseen contributors to climate change. Until recently, it has not grabbed the headlines like gas-guzzling cars, or air travel, or fossil-fuel power-stations.

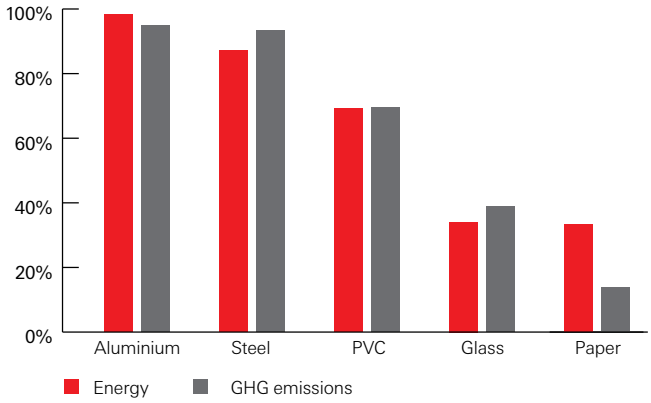
However, 15% of global carbon dioxide emissions come from the construction industry. The industry itself is expected to expand by 85% in just the next decade or so[38].

Building materials generate significant amounts of greenhouse gases during their production and transportation – a term known as 'embodied' carbon, which counts to their carbon output before construction even begins.

Concrete production is a major part of this problem, producing over half of the construction sector's emissions, about 8% of the world's total[39]. If concrete were a country, it would be third behind China and the US in the list of greenhouse gas sources[40].

Embodied carbon can be reduced through greater recirculation of materials, more efficient use of materials in buildings and by optimising the efficiency robustness of materials during the course of their lifespan. This can include:

- Recycled concrete aggregates, blended cements and concrete;
- New materials with lower embodied carbon can also substitute conventional carbon intensive materials. These can include natural 'carbon sinks' – materials that absorb carbon throughout their lifespan, like wood and bamboo; and,
- Low-carbon alternatives to traditional cement and concrete, such as recycled metals or green tiles made up of recycled glass and other minerals.



Potential energy and greenhouse gas emissions savings achieved through recycling compared to primary material production[41]

What can cities do?

- **As owners and occupiers**
  Cities can ensure that procurement of new buildings and associated fittings and furnishings is done on a zero-carbon basis. Cities can also promote the sourcing of local materials to reduce the carbon footprint of construction supply chains.
- **As standard setters**
  Cities can raise standards for new and existing constructions, and can set retrofit, reuse and recycling targets for the construction sector.
- **As convenors**
  Cities can help build the market for new, low-carbon materials by including such materials in their procurement processes.
- **As partners**
  Cities must work closely with construction and deconstruction firms, engineers, designers, architects, and financial institutions.

[38] Global Construction Perspectives and Oxford Economics (2015) Global Construction 2030
[39] Carbon Brief - https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change
[40] https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change
[41] https://hoffmanncentre.chathamhouse.org/article/circular-economy-and-decarbonisation-lessons-from-industry/

Oslo – Green procurement

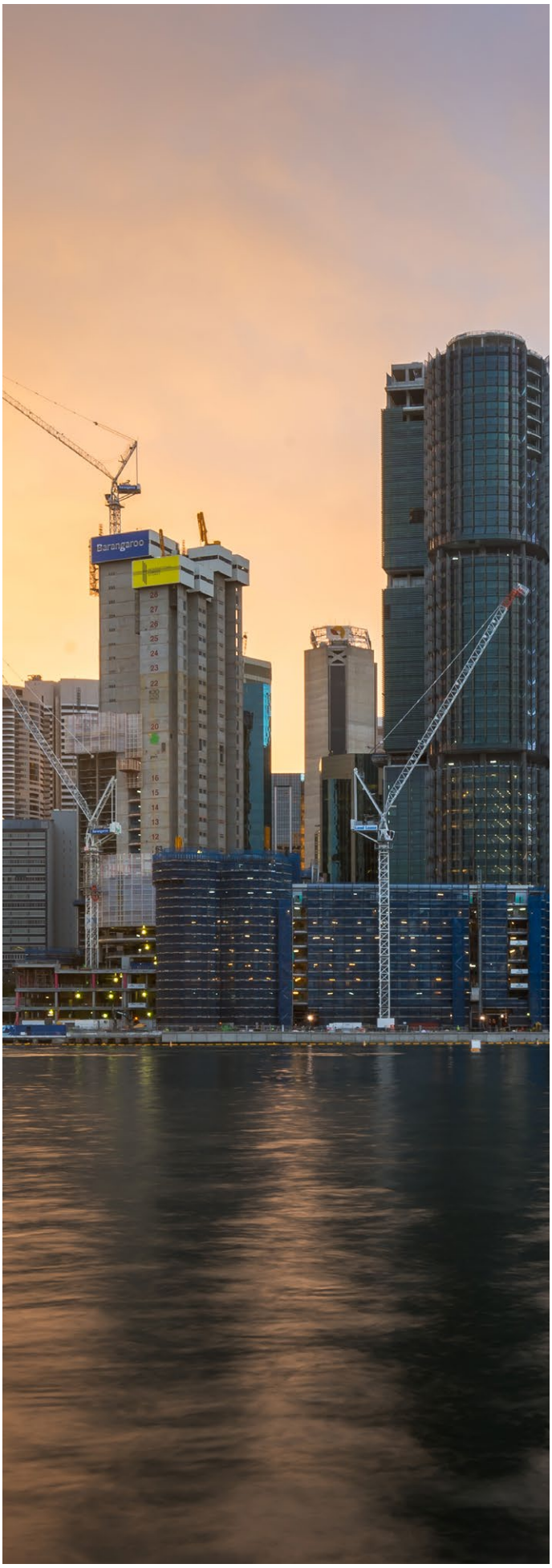
The city of Oslo has been using green procurement policies to incentivise the business community to be more sustainable. With the aim to reduce greenhouse gas emissions on construction sites, the city requires fossil free construction sites in all of its public procurement procedures since 2017[42]. It has also launched four pilot projects to support innovation in zero-emission construction vehicles and machinery, including the design and produce of battery- and hydrogen-powered diggers in collaboration with SINTEF, NASTA, Siemens and Skanska[43]. Given that the municipality is to invest NOK30 billion (USD3.47 billion) in buildings, roads, and water and wastewater infrastructure, the city has the power to hasten the adoption of eco-friendly practices through green procurement[44].

Sydney – Partnering with the property sector

Through the Better Buildings Partnership, the City of Sydney has spurred leadership from leading commercial property owners and managers to reduce greenhouse gas emissions. Representing over half the office floor space across Sydney's city centre, the partnership aims to increase resource recovery during all office refurbishments from 21% to 80%[45]. In order to achieve their target, the members have been trialling new materials that can be recycled locally[46].

Vancouver – Reuse of demolition materials

The City of Vancouver's Green Demolition by-law aims to reduce the amount of construction and demolition waste disposed to landfill. Since its adoption in June 2014, around 10,000 tonnes of demolition waste was diverted. Its scope was expanded in 2018 to cover 70% of residential demolitions in Vancouver, up from 40%[47].In addition, the by-law requires deconstruction instead of demolition of heritage-listed homes to increase the volume of materials that can be reused rather than recycled. The City is also allocating up to USD250,000 from its Innovation Fund to support the creation of an independently operated Deconstruction Hub, to stimulate the local market for restoring, upcycling and selling salvage materials[48].



[42]http://www.procuraplus.org/fileadmin/user_upload/Activities_files/Events/Oslo_2018/Procura__Seminar_Oslo_2018_-_Oslo_procurement_strategy.pdf
[43]https://www.klimaoslo.no/2019/04/10/moving-on-from-fossil-free-construction/
[44]https://www.klimaoslo.no/2019/04/10/moving-on-from-fossil-free-construction/
[45]http://www.betterbuildingspartnership.com.au/projects/stripout-waste/
[46]https://www.betterbuildingspartnership.com.au/reinventing-office-fitout-waste/
[47]https://vancouver.ca/files/cov/greenest-city-action-plan-implementation-update-2017-2018.pdf
[48] https://council.vancouver.ca/20180516/documents/pspc2c.pdf

Water

Angkor, in modern-day Cambodia, was seat of the Khmer Empire from the beginning of the 9th century AD, and home to Angkor Wat, a vast network of stunning temples.

Able to support hundreds of thousands of inhabitants, it stood as one of the world's major cities until the 1400s, when it was slowly abandoned.

Why?

One modern theory points to problems with a single, vital resource: water. Water was supported by a highly sophisticated system of canals and reservoirs, designed to irrigate crops and handle an unpredictable monsoon season. The changing climate of the 1400s is believed to have produced a series of droughts and floods, overwhelming the water storage system and contributing to the decline of the city[49].

A similar fate could befall modern cities. Climate change increases the likelihood of both prolonged droughts and sudden floods. Melting glaciers threaten the supply of fresh water to many millions of people[50]. By 2040, the demand for fresh water could exceed supply by 50%.

In recent years, Cape Town has provided a vivid foretaste of a city with a water crisis. A lengthy period of low rainfall and poor water management led to the critically low levels in the dams supplying the city by mid-2017. The city was at risk of becoming the first in the modern era to run out of water. Authorities introduced a wide-ranging series of restrictions, reducing daily water demand by more than half. This, combined with well-timed rainfall, ended the most acute phase of the crisis, but water restrictions are still in place.

At the same time as protecting freshwater resources, cities must maintain defences against unwanted water from floods or sea level increase. Many of the world's major cities lie on the coast, putting huge chunks of national economies at risk from further climate change.

The way we use water is also a contributor to the emissions problem. Current wastewater practices produce small amounts of methane, which is an extremely potent greenhouse gas. All told, these small amounts add up to a lot - 10% of global methane emissions are produced in this way[51].

What can cities do?

- **As procurers of services**
  Cities can use powerful data analytics to assess water consumption to improve operations and better understand supply/demand dynamics. They can also optimise water treatment processes and improve infrastructure to minimise leaks.
- **As convenors**
  Cities can create better connections between the energy and water sectors. They can also establish circuits to facilitate the reuse of wastewater in agriculture.
- **As regulators**
  Cities can raise awareness of water preservation among the private sector and residents. They can also enact legislation to protect water resources, such as lakes, rivers and aquifers.
- **As partners**
  Cities can work with water companies, individual citizens, energy companies, developers and the agricultural sector to bring more efficiency to their water use and reduce the greenhouse gas emissions in wastewater treatment.

Aarhus – Producing energy from wastewater

To achieve its goal of an energy-neutral water cycle by 2020, the city of Aarhus and its water company have invested in new equipment for its largest wastewater treatment plant. In doing so, they hope to minimise the plant's energy consumption while maximising its energy production through the implementation of a new energy-efficient biogas engine. As a result, the self-sufficient Marselisborg plant produces 40% more energy than it consumes, and the excess electricity can be used to pump drinking water around the city[52].

Sydney – Using water for district cooling

The property and infrastructure company Lendlease has designed a water-positive precinct in Barangaroo South, Sydney, which combines a district cooling plant with a recycled water plant able to export water to the rest of the neighbourhood. The site also includes a greywater treatment plant which allows wastewater to be recycled and reused onsite in place of drinking water for flushing irrigation and other non-drinking purposes.

[49] National Geographic - https://news.nationalgeographic.com/2017/04/angkor-wat-civilization-collapsed-floods-drought-climate-change/
[50] Nature - https://www.nature.com/articles/549166a
[51] https://www.raconteur.net/sustainability/wastewater-resource-city
[52] https://www.aarhusvand.dk/en/international/solutions/marselisborg-wwtp---turning-wastewater-into-green-energy2/

Human Behaviour

Awareness

Efforts to reduce emissions will be harder to achieve if urban dwellers cannot be convinced to alter carbon-intensive behaviours.

Much of our carbon footprint is created by a societal lay-out that we have little choice in. The individual citizen can't invent practical electric vehicles, or advance the progress of renewable energy or the heat efficiency of buildings, all by themselves. Until recently, society has created a choice structure that all but guarantees a carbon-heavy lifestyle, especially in developed economies.

However, there are actions that the individual can take which, on a collective level, could help reduce carbon emissions significantly.

The most basic of these is to be more considerate of consumption and generate less waste. Developed-world economies are incredibly consumer driven. We buy a thing, use it for a bit, see a new thing we want to buy, and throw the old thing away – everything from cars to clothes to carrier bags.

Altering this – reusing items where possible, reselling or recycling unwanted items, reducing food waste – reduces the burden for a variety of other industries.

It cuts down the number of items that need to be produced or grown in the first place, directly reducing the carbon emissions involved in these processes. It also limits the sheer tonnage that needs to be recycled or sent to landfill.

It means a lower demand on the power grid, less water used in the construction of fabrics and other goods, less land used to grow crops and raise livestock, and fewer vans, trucks and lorries used to cart all this stuff to where it needs to go.

Barcelona – Promoting responsible consumption

The city of Barcelona advocates for more responsible consumption through the introduction of deposit systems, repair workshops and buying local produce. The city has also opened energy advice points to offer information as well as grants for citizens to improve energy efficiency at home. The city is planning to allocate EUR200,000 in subsidies every two years up to 2030 to finance local organisations or projects that promote the reduction of greenhouse gas emissions[54].

Hanoi – Reducing indoor pollution

Hanoi has also committed to replace the 55,000 coal stoves in the city with cleaner stoves burning biomass by 2020 to reduce households and small businesses' emissions[55]. In 2018, it launched a pilot programme in collaboration with Netherlands Development Organisation to raise awareness of the benefits of cleaner stoves, giving discounts to citizens who buy them[56].

Milan – Tackling Food Waste

Through a combination of incentives and penalties, Milan has successfully managed to change consumer behaviours, reaching a recycling rate of 50%, the highest of an European city[57]. In addition to a wide awareness campaign for citizens and students, with information available on leaflets, smartphones and online, the city developed a kerbside scheme for the collection of organics which covers the entire population. To ensure participation, the city implemented high fines for contamination. In case of multi-unit dwellings, fines are payable to the building, which also adds the risk of a social sanction. The municipality also offered 20% tax reduction in favour of food businesses that would donate their food surplus to charities instead of throwing it away[58].

[54] http://lameva.barcelona.cat/barcelona-pel-clima/sites/default/files/documents/eng_climate_plan_def.pdf
[55] https://www.c40.org/case_studies/hanoi-households-emissions-reduction-through-cookstove-conversions
[56] https://vietnamnews.vn/environment/422734/ha-noi-to-end-use-of-deadly-stoves.html#vVuF8ZMHuQ75iFsI.97
[57] Let's Recycle - https://www.letsrecycle.com/news/latest-news/milan-lessons-from-a-large-city/
[58] http://www.milanurbanfoodpolicypact.org/wp-content/uploads/2018/06/CIRCULARITY-1.pdf

Waste

Humanity has a serious waste problem on its hands. Plastics, for instance, have leached into every part of our natural world, from deep sea trenches to mountain plateaus.

They can take hundreds of years to break down, and in the process they are worn down into tinier and tinier segments. These micro-plastics are making their way into the food chain via plants and animals, and in the long run could be a major threat to the health of the natural world.

Over 270 million tonnes of plastic goes to waste every year. Roughly 20% is recycled. A further 20% is incinerated, often an extremely toxic process. The remainder is discarded, finding its way into the ocean, onto landfills, or simply left exposed to the elements .

Plastics are just part of the mess. Vast quantities of food goes to waste every day. Metals, timber and masonry also find their way on to the waste heap when they could be reused in other ways.

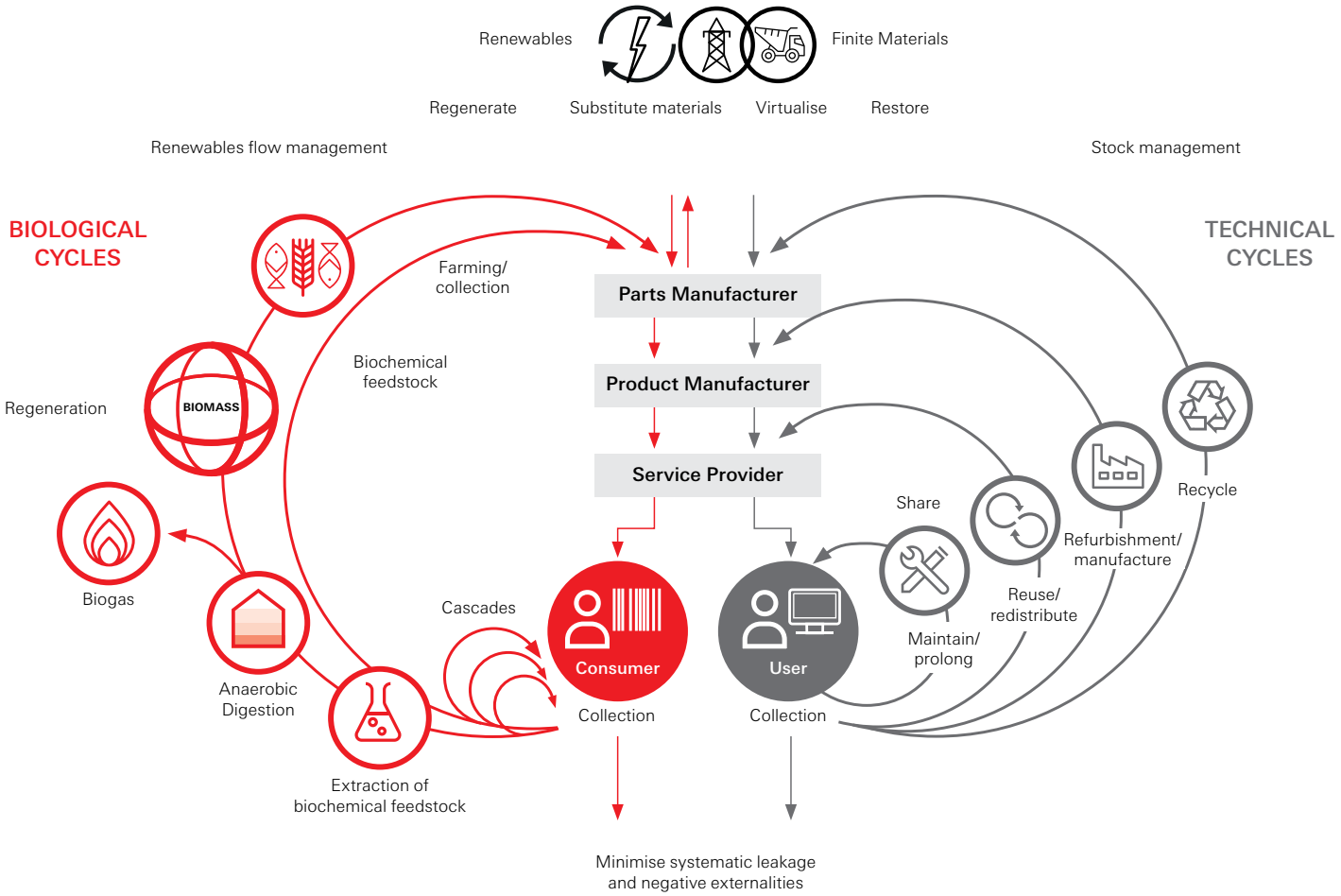
Circular economy

The circular economy closes the loop between consumption and production by reducing, re-using, recycling, and recovering materials where possible.

This relies on three main principles:

- Optimising the way resources are used;
- Preserving the value of input materials in production processes and final produces; and,
- Improving the productivity in production and consumption.

The new business models arising from the circular economy can support cities and companies in achieving their zero-carbon agenda.



Source – Ellen MacArthur Foundation 2018

What can cities do?

As consumers

- Cities can adopt a 'highest and best use' approach for physical materials. They can also repurpose items used on city government properties before they become waste.

As procurers of services

- Cities can introduce circularity criteria (see below) into public procurement. They can also develop new models for waste management, and divert organic waste to composting facilities.

As convenors

- Cities can encourage innovation, developing platforms to reduce waste and knowledge sharing.

As partners

- Cities will have to work with companies, citizens and utility providers to change individual behaviour and promote waste reduction and recycling.

Amsterdam – Pioneering the circular economy

In 2015, Amsterdam became the first city to explicitly explore the opportunities of a circular economy through a roadmap providing guidance on circularity in the city's value chains[60]. The city government launched two programmes to spur research and innovation on circular practices. The city also highlights initiatives undertaken by its partners and citizens to encourage greater circularity in all sectors. As the city aims to increase its waste separation rate to 65% by 2020, from 19% in 2013, it is testing new methods for collecting organic kitchen and garden waste to achieve its target.

Austin – Giving a second life to materials

Recognising the value of waste, the city of Austin has developed an online materials marketplace to keep materials and products out of landfill. Launched in 2014, the marketplace aims to foster exchanges between users from across different sectors. Materials include construction and demolition waste, plastics, organics and packaging. In addition to reducing the city's waste management expenditure, it also enables local businesses to avoid disposal costs and can even generate an additional income. Following the success of its marketplace, which diverted 400 tonnes of material from landfill, the city has also launched a complementary competition to connect businesses seeking to dispose products less in demand with entrepreneurs looking to develop innovative ways of repurposing materials[61].

[60] https://www.c40.org/case_studies/amsterdam-s-circular-economy-roadmap-lessons-learned-and-tools-for-upscaling
[61] https://www.ellenmacarthurfoundation.org/assets/downloads/Austin_-Case-Study_Mar19.pdf

How to Get There

The zero-carbon movement faces the same challenge as any new company or brand or ethos looking to break through into wider society. It needs to build momentum, reach a critical mass or tipping point, then move into the mainstream and become part of the furniture of everyday life.

In many cases, cities find themselves at the very beginning of the first stage. Policymakers, tech innovators and economic participants need to start making noise now to draw focus to and generate energy on decarbonisation.

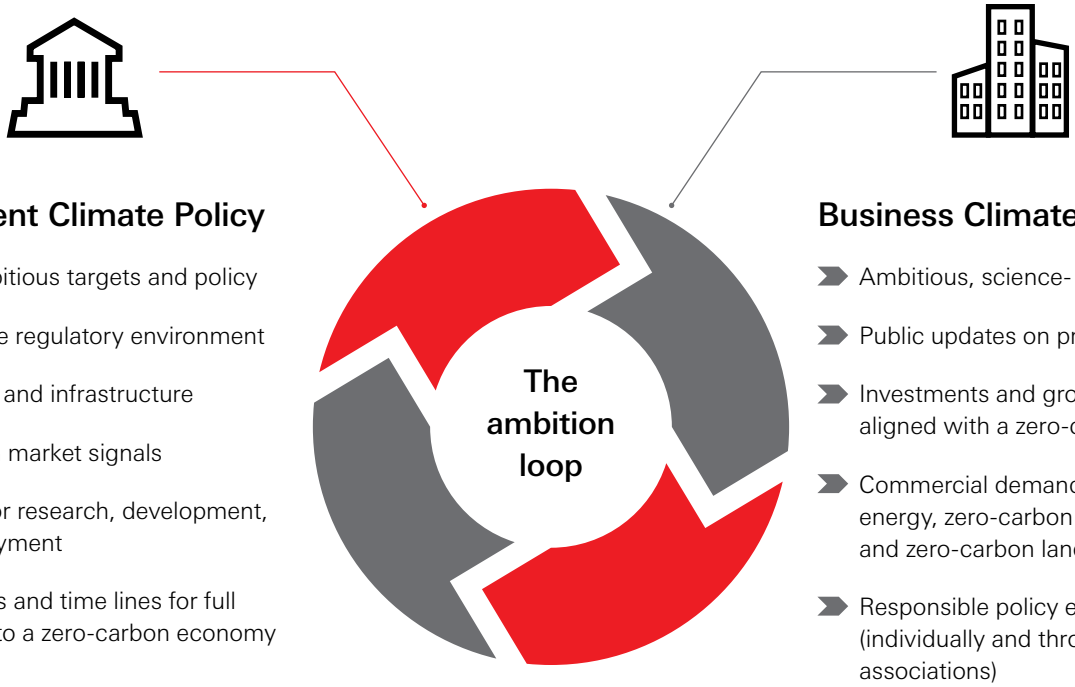
City authorities can help by clearly marking out milestones that they wish to reach in the future. Such milestones in London's zero-carbon plan, for instance, aims to install a smart meter in every home and small-to-medium-sized enterprise by 2020, and to send zero waste to landfill by 2026.

Accompanying these goals are more general emissions aims – London is targeting a 60% reduction in carbon dioxide emissions by 2028-32. These link back to a series of carbon budgets set by the city, each covering a period of four years up to 2032. Transport, workplaces and homes are each given their own targets within these budgets. This ensures that policymakers can track progress against stated objectives, and spread the effects of transition over a longer time period rather than being forced to implement drastic measures at the last minute.

The ambition loop

Once momentum builds, there is an opportunity for the 'ambition loop'. This is a positive feedback mechanism where bold policy and business leadership are mutually supportive, in turn accelerating further action.

This can unlock progress on the zero carbon agenda, transmit the urgency of the matter to a wider audience, and create more market opportunities.



Source: United Nations, We Mean Business, and World Resources Institute (2018) The Ambition Loop

Financing Solutions

Cities cannot finance the zero-carbon transition alone. In some cases they lack the economic heft to raise the large sums of required. In others, they lack the legal means to do so.

A re-think of global and local financial frameworks is required. City access to diverse sources of finance that are efficient, transparent and affordable must be supported.

The Climate Action in Financial Institutions Initiative is a global movement consisting of 42 public and private financial institutions that are collaborating to address to the urgent challenge of climate change. A core goal of the movement is to make climate change and sustainability a core consideration in the way institutions deploy capital.

City governments have significant power in their own hands which is sometimes overlooked. Trillions of dollars go into public procurement every year. This is a powerful tool for city governments to stimulate zero carbon action.

Cities can lean on collaboration with each other in terms of best practice, and with a diverse list of actors from the investment community. In some economies, cities are partnering-up with sovereign wealth funds or development banks to access sources of finance (see below).

The difference between funding and finance must also be recognised. Investors will often shy away from providing cash for the bare bones of new infrastructure projects such as roads, railways and other public sector goods. These typically require direct funding from city budgets, but increasingly blended finance approaches are emerging.

However, investors are often more willing to look at financing the services that run on the new infrastructures – the buses and trains. With the infrastructure already built, these are less risky investments, and come with a guaranteed income stream as citizens use the transport.

Green bonds

Green bonds – that is, debt financing where the proceeds are explicitly used for green projects – are so far not a universal resource for cities. Of the 500 largest cities in developing economies, only 4% have access to international capital markets[62].

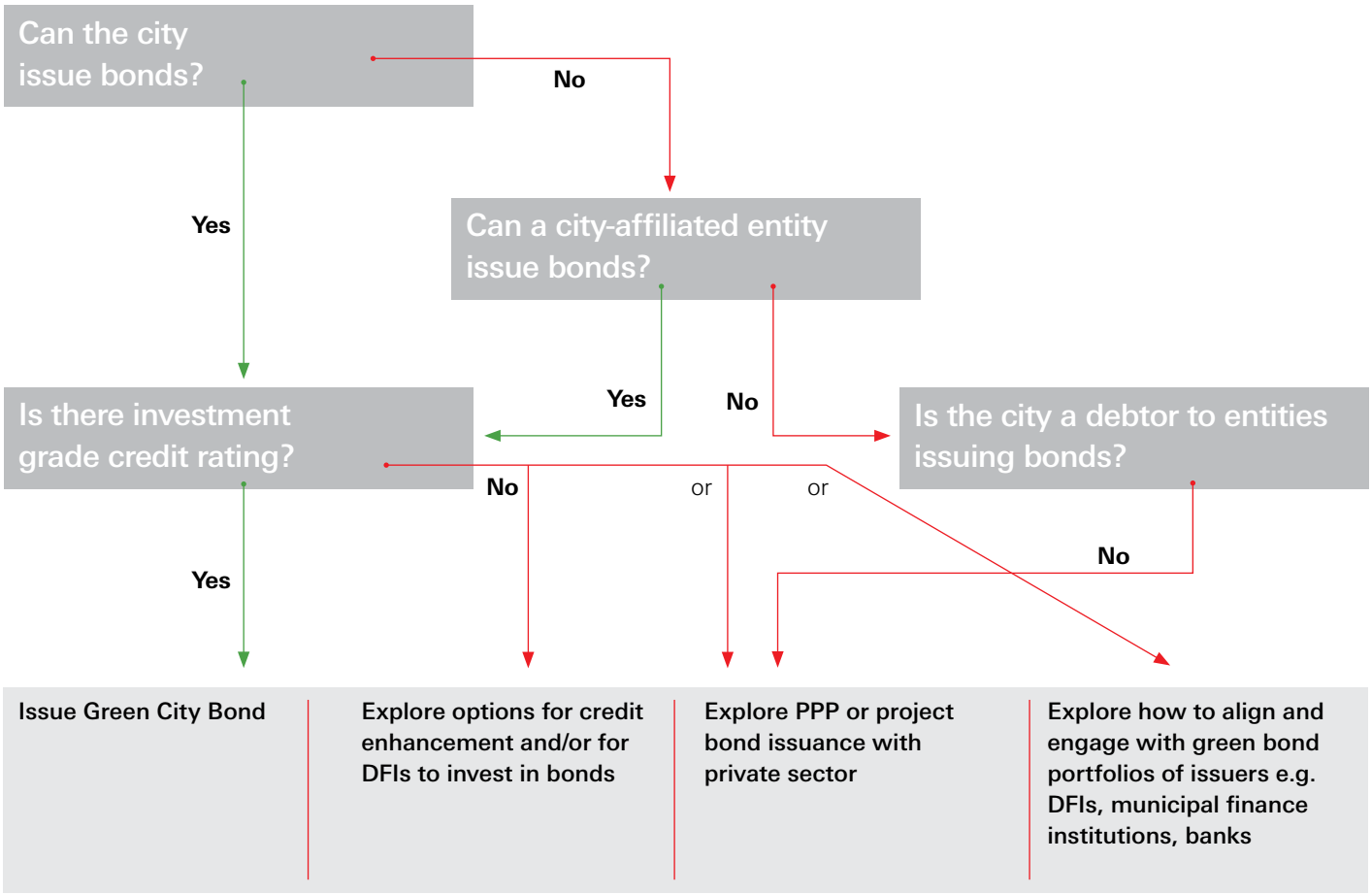
However, the market is growing. Over 180 labelled green city bonds from 13 different countries have been issued since 2013[63]. By 2016, USD10.5 billion-worth of this type of instrument was out in the market.

Green bonds can be used by any bond issuing entity – municipalities, utilities, public-private partnerships and private companies undertaking green urban projects.

For instance, Johannesburg has issued $136m of green bonds to finance hybrid buses, biogas energy, rooftop solar water heaters and other green developments. Paris has issued USD336m of green bonds to cover the retrofitting of schools, a new electric bus line and 300 charging points for electric vehicles[64].

Nairobi – Green Bonds Programme

The launch of the Green Bonds Programme in Nairobi is promising a stronger focus on environmental projects such as climate change mitigation and natural resources depletion[65]. The programme, led by the Kenya Bankers Association, signed a memorandum of understanding with international investors in 2018 to stimulate green lending for low-carbon climate resilient buildings in the region.



[62] https://climatepolicyinitiative.org/wp-content/uploads/2016/12/Green-Bonds-for-Cities-A-Strategic-Guide-for-City-level-Policymakers-in-Developing-Countries.pdf
[63] Li https://www.climatebonds.net/files/files/CBI-SotM_2017-Bonds%26ClimateChange.pdf
[64] https://www.c40.org/case_studies/cities100-paris-dedicated-climate-bonds-for-cities
[65] https://www.greenbondskenya.co.ke/single-post/2019/04/09/Green-Bond-Market-Launched-in-Kenya

Carbon Pricing

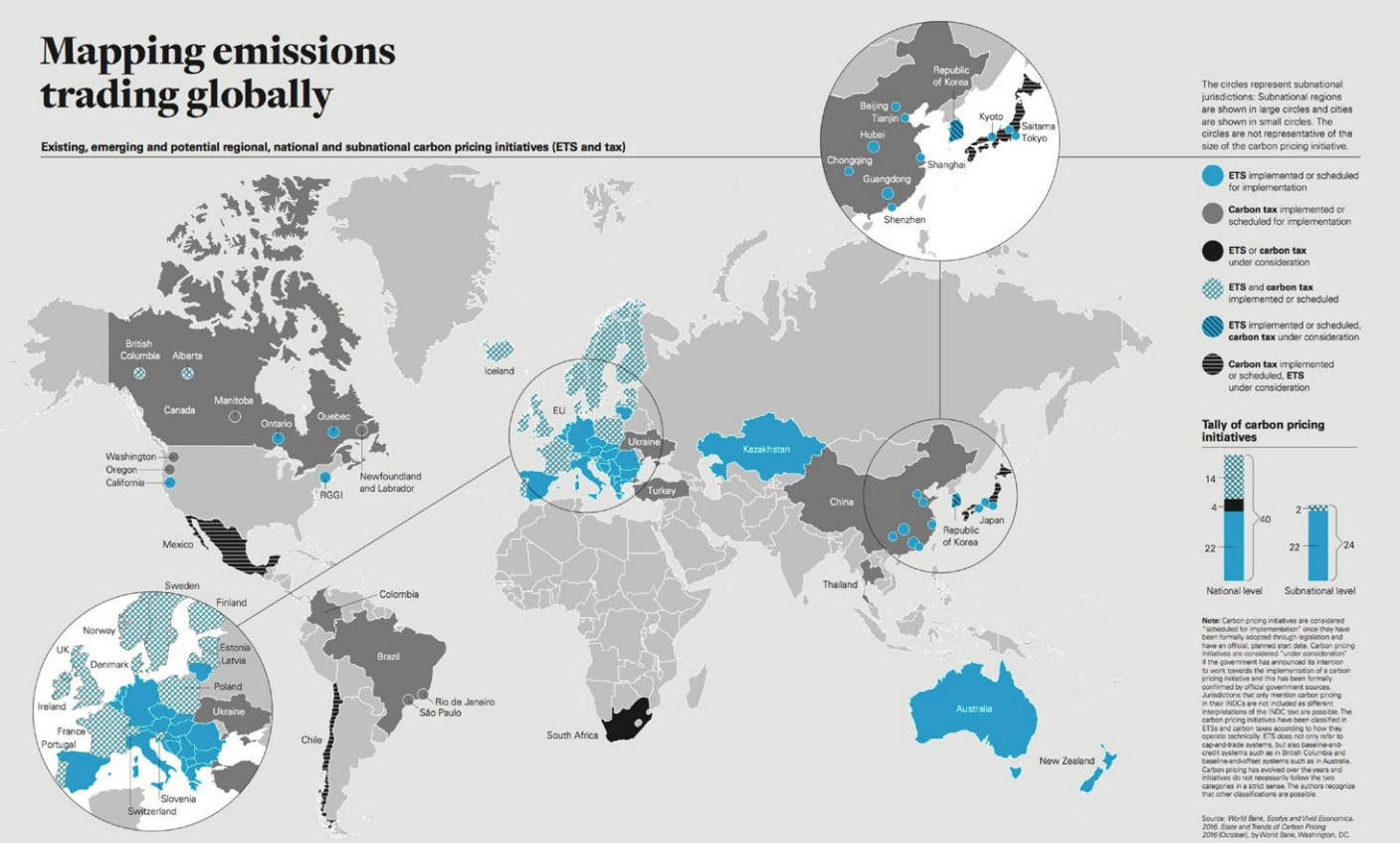
One of the fundamental problems relating to climate change is that large-scale private sector greenhouse gas emitters face no direct cost for doing so. There is no automatic market mechanism to charge for carbon use and curb company behaviour.

Carbon pricing is an attempt by policymakers to redress this by generating a price for CO_2 release on a per-tonne basis. The more you release, the more you pay, prompting carbon-intensive industries to find greener, more sustainable operating methods.

This pricing falls into two broad categories – a direct carbon tax, or a 'cap-and-trade' system. In the latter, companies are given permits to release a specific quantity of carbon. If they want to increase this quantity, they can buy additional credits from other companies that operate below their limit.

More than 20 cities, states and provinces already use carbon pricing mechanisms. The Carbon Pricing Leadership Coalition, organised by the World Bank, aims to advance the implementation of carbon pricing worldwide and is comprised of national, regional and city governments, businesses, and civil society organizations.

The highest-profile international carbon pricing agreement is the European Union's Emissions Trading Scheme, first launched in 2005 and covering more than 10,000 power stations, factories and other infrastructures.



Source: WhiteCase (2017) Greenhouse gas emissions trading schemes: A global perspective

Shenzhen – Emissions Trading Scheme

In 2013, China launched ETS pilot programmes in Shenzhen, Guangdong, Shanghai, Beijing, Tianjin, Hubei and Chongqing. After 2 years of operation, CO_2 emissions were reduced by around 9% on average. Shenzhen municipal government also introduced a pilot cap-and-trade emissions trading system for manufacturers in 2013. 5 years later, the system was the first pilot in China to reach CNY 1 billion (approx. USD 145 million) and it covers more than 800 entities in various sectors such as manufacturing, energy, building and logistics.

British Columbia – Carbon Tax

In 2008, British Columbia province implemented North America's first carbon tax. From USD10 per tonne of carbon dioxide emissions, the province has gradually increased the tax rate with the aim to reach USD50 a tonne in 2021. Since its inception, per capita emissions in the province have decreased by 14% . The carbon tax has also achieved more, spurring the growth of clean innovation in the province as companies look for more energy-efficient and cleaner ways to operate. The province is also using some of the proceeds to fund green infrastructure.

[66] https://icapcarbonaction.com
[67] https://www.theglobeandmail.com/opinion/article-dont-believe-a-carbon-tax-can-effect-huge-change-just-ask-british/

Performance-based contracts

Performance-based contracts are long-term arrangements between the user of an asset – say, a building – and a third party, where the third party agrees to maintain the asset over the course of its lifespan. Specific metrics are used to measure the quality of this maintenance, and the third party is paid as it continues to meet those metrics.

This type of contract has long existed outside the sustainability space, but can be used to make physical assets more efficient and reduce carbon emissions. For instance, the third party can manage the installation of low-carbon solutions and then continually optimise a building's systems to ensure full benefits are realised in return for a share of the energy savings. Give the scope of the construction and real estate challenge facing cities on the path to zero carbon, this could be a common arrangement in the years ahead.

Land value capture

Land value capture is another common financing method that can be repurposed to meet green ends.

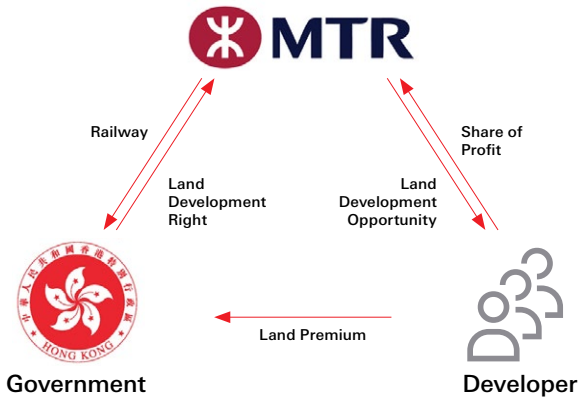
Typically used as a way to fund large urban infrastructure and development projects, land value capture uses the natural increase in the value of land around new developments – a subway station for instance – to provide additional returns to the developer, investors, or public purse.

The simplest way of doing this is a land value or property tax. As the land value increases, so do tax returns, without the need to raise the actual tax rate. Other examples include user charges, licensing, and tax incremental financing, among others.

These sorts of arrangements could also be used to incentivise the construction of green developments within cities, such as public transport networks and new housing or commercial real estate.

Hong Kong – Land Value Capture

Hong Kong's land value capture "Rail plus Property" business model allows MTR Corporation, Hong Kong's railway operator, to make money from the increase in property value that follows the construction of rail line



Impact investing

With the effects of climate change becoming apparent and public awareness of the problem growing, institutional investors are facing some thorny problems.

Climate change is also forcing investors' clients to reassess their long-term objectives, and green assets may offer higher returns in the long run. Impact investing refers to the practice of making investment into companies, organisations or funds with the intention to generate a positive social or environmental impact, alongside a positive financial return. A collaborative approach to addressing these problems has become popular. For instance, more than 400 institutional investors have backed the 2018 Global Investor Statement to Governments on Climate Change[68].

A number of low-carbon equity indices have emerged in response to rising demand from investors, such as the MSCI Low-Carbon Leaders and HSBC Low-Carbon Energy Production Index. As significant investors in, and owners of, many of the world's largest companies, investors are engaging with boards and senior management to take action to reduce emissions.

Sovereign wealth funds

Sovereign wealth funds (SWFs) are a specific class of investor that can be influential for pushing cities forward along the path to zero carbon. SWFs have already acted as reliable, high-credit partners for a number of city investment projects.

However, SWFs collectively own USD8 trillion in assets but currently invest just 0.19% in green energy[69]. The One Planet SWF working group, established in 2017, has committed to only invest in companies that factor climate risks into their strategies.

SWFs are increasingly investing in alternative assets, including through co-financing arrangements – e.g. with pension funds and private equity.

As SWFs tend to make investments at a large scale to reduce transaction costs, new mechanisms such as pooling or co-investment platforms need to be introduced to increase the scale of green projects.

How can SWFs contribute to green investment?

- Make investments in green listed and private companies
- Introduce specific investment policies and regulations to address climate risk
- Support blended finance initiatives between public and private sector

[68] https://www.forbes.com/sites/trevornace/2018/12/11/with-32-trillion-in-assets-investors-demand-immediate-action-on-climate-change/#1032e35f2b48
[69] https://www.forbes.com/sites/trevornace/2018/12/11/with-32-trillion-in-assets-investors-demand-immediate-action-on-climate-change/#1032e35f2b48

Conclusions

Cities are at a crossroads. They can continue with the same carbon-intensive growth model and keep contributing to the climate problem. Or, they can transition to a new, zero-carbon path that secures future health and prosperity.

Taking the zero-carbon path won't be easy. Energy, transport, real estate, construction, water, waste – the way cities handle and plan for all of these will need a major overhaul.

But, global climate benefits aside, transitioning to zero carbon will also bring more jobs and greater productivity, better health prospects and living conditions for urban dwellers, and a higher quality of public services.

Time is running out. Cities must act fast if the global temperature rise is to be kept below 1.5°C. If significant strides in the right direction are not made by 2030, it may be too late to reverse some of the damage. If the worst climate predictions come true, many cities may not have a future at all.

As this report has shown, there are lots of ways to deliver the change. The financial sector can offer a host of different ways for cities to raise capital required for transition, even for authorities with no access to capital markets. Many cities have already made a success of green transition projects, from electric buses to better recycling. There is huge scope for greater cooperation between cities, investors and other bodies to bring more projects online.

The zero-carbon city isn't a pipe dream. It's an achievable goal for cities all around the world if the right action is taken soon.

About the Centre of Sustainable Finance

"For more than a decade, HSBC has been at the forefront of the sustainable finance market. In November 2017, HSBC made five sustainable finance pledges. We committed to provide USD100 billion of sustainable financing and investment by 2025, source 100 per cent of electricity from renewable sources by 2030, reduce our exposure to thermal coal and actively manage the transition path for other high carbon sectors, adopt the recommendations of the task force on climate related financial disclosures to improve transparency, as well as leading and shaping the debate around sustainable finance and investment.

Taken together, these commitments reflect the scale of the challenge of delivering the Paris Agreement and UN Sustainable Development Goals. They also demonstrate the heights of our ambition to be a leading global partner to the public and private sectors in the transition to a low-carbon economy."

Daniel Klier, Global Head of Sustainable Finance

"Each and every one of us has a stake in developing a sustainable economic system. It is the combined responsibility of all players in society to respond to climate change, rapid technological innovation and continuing globalisation to secure a prosperous future. Yet addressing these changing forces is by no means straightforward. More work is needed to provide the financial system with the right toolkit to solve sustainability challenges.

Working with internal and external partners, this central think tank is uniquely positioned to lead and shape the debate. We will promote the sustainable finance agenda using our global network which covers the world's largest and fastest growing trade corridors and economic zones. We can provide the connections needed to foster sustainable growth across borders and geographies. We aim to mobilise the capital flows needed to address the world's major sustainability challenges."

Zoë Knight, Group Head, HSBC Centre of Sustainable Finance

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