Urban Climate Governance

Towards 1.5° Celsius Alignment

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2023

Urban Climate Governance

- Towards 1.5° Celsius Alignment

A course compendium from WWF in collaboration
with the IIIEE at Lund University

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Preface

This is a course compendium to learners inside or outside of our online classroom in the course Urban Climate Governance. By reading this compendium, you too will explore how cities can and are addressing the climate crisis, and their crucial role to support efforts to limit anthropogenic global temperature rise to 1.5°C and so avoid the worst impacts of the climate crisis.

In this document, we explore the science behind the 1.5°C goal, as well as useful local governance and technical tools to help cities align to it. The messages highlight the importance of renewable energy together with energy efficiency considerations – as both are essential for cities to address the climate crisis. We also look at the importance of cities' physical layout and its relationship to energy systems, in particular, the role of integrated urban planning and transport planning to support more sustainable energy solutions.

The content in this course is produced by WWF in partnership with Lund University, and builds on our experience of working with cities to support stronger urban climate action. The good news is, we have witnessed many strong city examples from across the globe – showing us that it is possible and often beneficial for cities to take action to address the climate crisis.

Most of these cases come directly from WWF's One Planet City Challenge, where we support cities to report their climate data and action plans on a unified data reporting system, then assess cities' plans in how closely they align to the 1.5°C goal, and importantly how we, together with city networks and other partners, can support cities to move closer to meeting their goals.

This course is intended to help learners understand the role that cities play in addressing the climate crisis. In this course, learners are provided with the tools that are seen as crucial to envision and apply solutions within cities to support the 1.5°C goal. Throughout this course, city climate solutions are illustrated, matched by cases of successful city examples.

In this course, we welcome learners wanting to envision and work towards a better and more sustainable future that begins in our cities. As the WWF motto states: Together Possible! We are eager to explore with you how to move our cities towards 1.5°C alignment. We recognize that this is challenging; but doing so comes with numerous co-benefits, that we are eager to share with you in this course.

The course is free of charge and you can join it on the learning platform here: https://www.coursera.org/learn/urban-climate-governance.

Very welcome, and we are happy to have you onboard this critical mission.

A PUBLICATION BY
The International Institute for Industrial Environmental Economics (IIIEE) at Lund University in collaboration with World Wide Fund for Nature (WWF).

FUNDING
The course and compendium was completed with much gratitude to the Swedish Government in 2022 for supporting the production and dissemination of online courses targeting climate mitigation and adaption.

Published in 2023 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
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Publication design and layout: Charlotte Leire, IIIEE, Lund University.

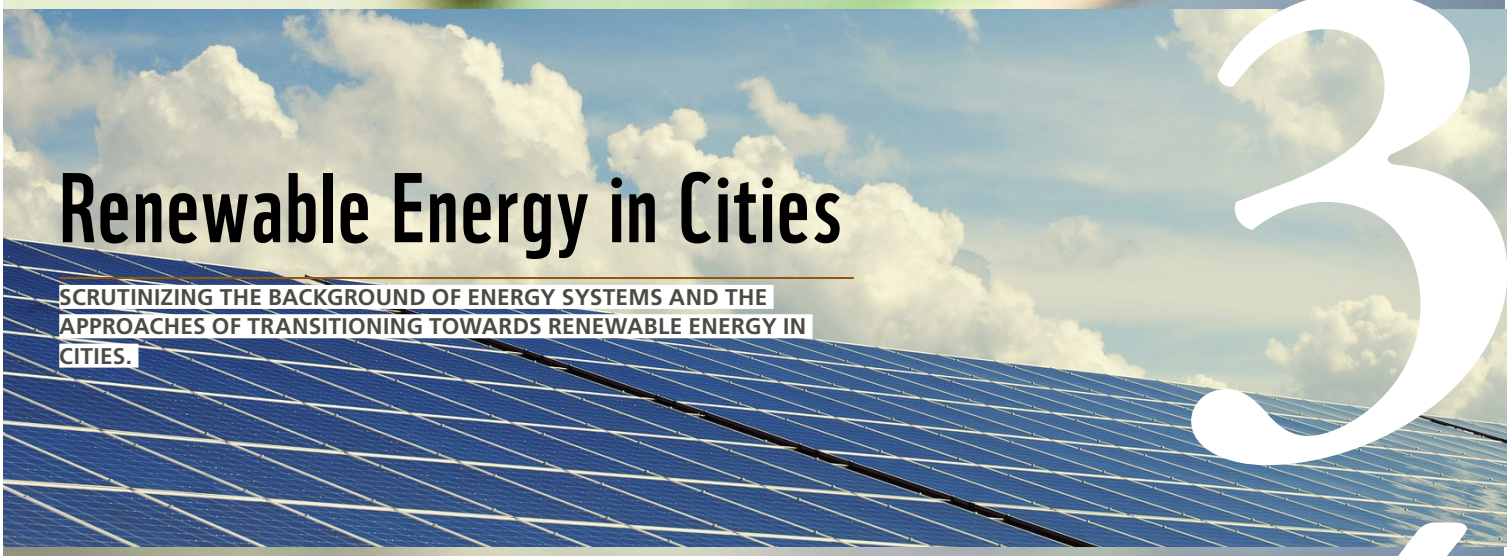
Photographs and images from Shutterstock, Pixabay, WWF Cities, IStock Photos, as well as private photos offered by Charlotte Leire and Håkan Rodhe.

1 Cities & Climate Change

UNDERSTANDING THE CLIMATE CRISIS FACING CITIES AND THE KEY CONCEPTS IN URBAN CLIMATE GOVERANCE.

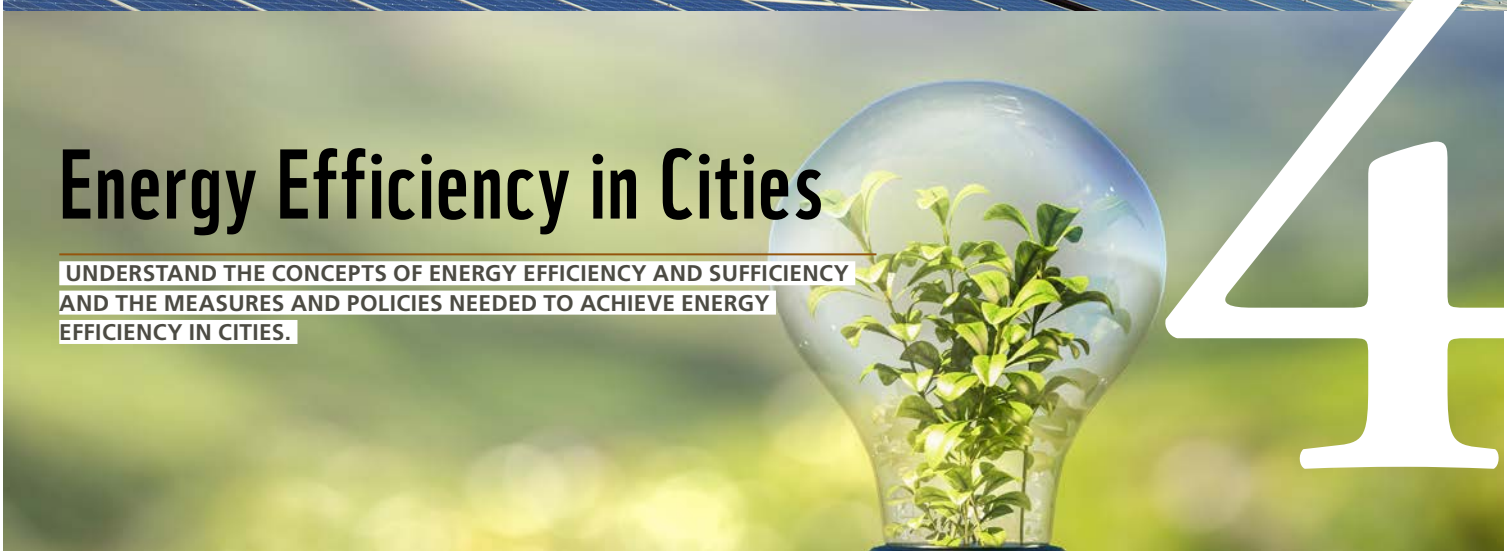
2 Urban Planning & Policy

LEARNING ABOUT THE MODES OF GOVERNANCE AND THE INTERACTIONS BETWEEN PLANNING AND KEY SERVICES.



3 Renewable Energy in Cities

SCRUTINIZING THE BACKGROUND OF ENERGY SYSTEMS AND THE APPROACHES OF TRANSITIONING TOWARDS RENEWABLE ENERGY IN CITIES.



4 Energy Efficiency in Cities

UNDERSTAND THE CONCEPTS OF ENERGY EFFICIENCY AND SUFFICIENCY AND THE MEASURES AND POLICIES NEEDED TO ACHIEVE ENERGY EFFICIENCY IN CITIES.

The case for urban climate governance

Welcome to a journey on urban climate governance! This compendium document provides you with an understanding of the key concepts in supporting integrated sustainable urban development. Each city is unique and will have their own journey. Nevertheless, there are elements and approaches that have proven useful and are worth spreading.

Why this course compendium?

This course compendium was developed to support the learning in the open online course 'Urban Climate Governance - Towards 1.5° Celsius Alignment'. It is a course that is available to anyone and free of charge. It is accessible on the Coursera platform here. This content for this course was produced by WWF and the course platform was established by the International Institute for Industrial Enviornmental Economics (IIIEE) at Lund University. The knowledge shared in the course is built on the experience at WWF of working with cities to support stronger urban climate action. The WWF has witnessed many strong city examples from across the globe – proof that it is possible and often beneficial for cities to take action to address the climate crisis.

Why urban climate governance?

The course highlights the importance of renewable energy together with energy efficiency considerations – as both are essential for cities to address the climate crisis. It also discusses the importance of cities' physical layout and its relationship to energy systems, in particular, the role of integrated urban planning and transport planning to support more sustainable energy solutions.

What is the One Planet City Challenge

In the course we make several references to examples of how cities have been tackling the challenges. Most of these cases come directly from WWF's One Planet City Challenge that aims to support cities to report their climate data and action plans on a unified data reporting system, to assess cities' plans in how closely they align to the 1.5°C goal, and importantly to support cities to move closer to meeting their goals.

What is in it for you?

This compendium, with or without the online course counterpart, will help you understand the role cities play in addressing the climate crisis, and allow you to familiarize yourself with the tools that are useful to envision and apply solutions within cities to support the 1.5°C goal. Throughout this compendium, you will be introduced to city climate solutions, matched by successful city case studies. We welcome you, who want to envision and work towards a better and more sustainable future that begins in our cities. This compendium focuses on four important areas of urban climate governance:

- **Chapter 1** explores the the science of IPCC, the benefits of cities taking action towards 1.5 °C alignment, and the key concepts in current practices in urban climate governance.
- **Chapter 2** explains the levels and modes of urban climate governance and the interactions between urban planning related to urban sprawls and liveability.
- **Chapter 3** focuses on energy systems and starts off with an introductory description of the different energy systems and energy sectors. It then describes the available types of renewable energies.
- **Chapter 4** highlights the concepts of energy efficiency and energy sufficiency and their role in urban climate governance.

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About the WWF

For 60 years, the World Wide Fund for Nature (WWF) has worked to help people and nature thrive. As the world's leading conservation organization, WWF works in nearly 100 countries. At every level, we collaborate with people around the world to develop and deliver innovative solutions that protect communities, wildlife, and the places in which they live.

WWF works to help local communities conserve the natural resources they depend upon; transform markets and policies toward sustainability; and protect and restore species and their habitats. Our efforts ensure that the value of nature is reflected in decision-making from a local to a global scale.

WWF connects cutting-edge conservation science with the collective power of our partners in the field, more than 1.3 million supporters in the United States and 5 million globally, and our partnerships with communities, companies, and governments.

Today, human activities put more pressure on nature than ever before, but it's also humans who have the power to change this trajectory. Together, we can address the greatest threats to life on this planet and protect the natural resources that sustain and inspire us. WWF's vision is to build a future in which people live in harmony with nature. To deliver this mission, we work to conserve and restore biodiversity, the web that supports all life on Earth; to reduce humanity's environmental footprint; and to ensure the sustainable use of natural resources to support current and future generations.

About the IIIEE at Lund University

The International Institute for Industrial Environmental Economics (IIIEE) at Lund University is a centre and node for interdisciplinary research and education focusing on advancing sustainable solutions. There is a call globally for an increased emphasis on research impact as well as more sophisticated approaches to planning, achieving, and measuring impact from research. Broadly speaking, we consider research impact to refer to the contribution that research and education makes to the economy, society, environment, or culture, beyond the contribution to academia. Our impact story series are narratives that present our pathways for creating and amplifying impact. Taking a storytelling format combined with visualisations and personal interviews, the impact story series provides several ways to explore the impact of IIIEE research and education activities. We invite reflections and inputs to our work, initiatives, and future directions.

There is a genuine interdisciplinary approach to all IIIEE research. We synthesize insights not only from economic theory and practice but also from natural sciences, engineering, political science, organisational, legal and behavioural studies. We conduct research in close collaboration with business, public authorities and other societal partners.

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ONE PLANET CITY CHALLENGE

WWF's One Planet City Challenge

WWF developed the One Planet City Challenge (OPCC) to mobilize support from cities in the transition towards a climate resilient future where we all can live in harmony with nature on our one and only planet. WWF runs this challenge as a friendly, biennial competition designed to encourage and support increased climate action in cities as well as transparent reporting of commitments and action plans. Because of the increasing urgency to meet the gap between commitment by nations and the actual emission reduction needed, WWF has launched an updated assessment and feedback framework for the OPCC with the purpose to assess and guide cities towards the 1.5° Celsius goal. This framework is designed to help any type of city in the world to align with the 1.5°C target and to develop best practice climate mitigation and adaptation action plans.

Building on the models presented in the Intergovernmental Panel on Climate Change (IPCC) Special Report, and the principle of the Carbon Law, the OPCC calls on cities to have a mid-term and a long-term target for emission reduction: first, a mid-term target to reduce per capita emissions in line with a global reduction of 50% by 2030. And second, a long-term target to reduce total emissions to net zero by 2050.

The OPCC program spans two years and is broken up into 5 stages. In Stage 1 the registration and reporting stage, participating cities receive training via webinars to report their climate data and ambitions through a global standardized reporting platform. In Stage 2, the pre-screening assessment and feedback stage, data submitted by the cities is assessed against a pre-screening scoring matrix. This assessment focuses on carbon reduction targets, GHG inventories and climate action plans.

The pre-screening matrix is a way for WWF to provide feedback to each participating city, suggesting how they can develop their climate ambition and climate action in line with the 1.5°C goal. Based on the feedback from WWF, all participating cities receive guidance on how they can improve their plans to reduce GHG emissions and adapt to climate change. This allows cities to improve and resubmit their plans for additional review.

Based on data reported before a final deadline, WWF selects up to 3 finalist cities in each country for Stage 3. This stage is a deep dive assessment that reviews in more depth the quality of a city's action plan. In addition to providing qualitative feedback to the cities, this assessment is used to help the external expert jury make final evaluations in Stage 4, OPCC Expert Jury Evaluations.

The jury represents key players in the sustainable urban development and climate arena, and based on criteria developed by WWF, the jury independently selects national and global winners. In last stage, Stage 5, promotion and global awards, national and global OPCC winners are profiled in awards ceremonies, conferences, press releases, media posts, videos and more.

In parallel with Stage 3 and 4, WWF also runs a global public engagement campaign called WeLoveCities. This campaign raises public awareness of what is possible, based on inspiration from shortlisted cities. It also invites citizens to express support and post improvement suggestions for more bold climate action by their mayor. By 2022, more than 700 cities from nearly 70 countries on 6 continents had participated in the OPCC at least once, and the WeLoveCities campaign had reached more than 100 million citizens.

(C) HECTOR ARGUELLO / UNSPLASH

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Cities & Climate Change

At the 2015 UN Climate Change Conference in Paris, nations around the world reached a landmark agreement to unify in an effort to combat climate change. The main goal of the Paris agreement is to strengthen the global response to the threat of climate change by keeping global temperature rise well below 2°C above pre-industrial levels and preferably to limit the temperature rise even further to 1.5°C. In 2018, the Intergovernmental Panel on Climate Change, the IPCC, released a Special Report on the impacts of global warming if it exceeds 1.5°C. This report highlighted the need to act on climate change with urgency in order to reach the 1.5°C goal.

1.1 CITIES, THE PARIS AGREEMENT & THE IPCC: HOW AND WHY TO STRIVE FOR 1.5°C ALIGNMENT?

Urgency to act – global science and policy processes

The impacts of climate change are already occurring, and are quickly accelerating and intensifying. Sea levels are rising, droughts are becoming longer, floods are becoming more devastating, and extreme temperatures- both low and high- are occurring in regions all around the world. If things continue business as usual, according to the most moderate estimates, global temperature is expected to increase by at least 2.9°C by the end of the century. To prevent the most devastating, irreversible impacts that are extremely likely to occur as a result of climate change, the IPCC suggests that fossil-fuel emissions should peak by 2020 at the latest and fall to net zero emissions by 2050. Moreover, global greenhouse gas (GHG) emissions must halve by 2030 if we are to meet the important objective of 1.5°C maximum global temp increase. An international team of researchers led by Johan Rockström have therefore proposed the Carbon Law as a general principle for the needed global emission reduction. According to this principle the world must halve emissions every decade from now on. The clock is ticking, and there is no more time to lose.

Cities play an important role in curbing global GHG emissions, the main cause of climate change. Cities are also very vulnerable to climate change. And this is why researchers representing all 5 chapters of the IPCC Special Report have produced a Summary for Urban Policymakers. In this summary they translate the report's key scientific findings and policy observations for officials and policymakers of the world's cities and urban areas. Among other things the summary states that all 1.5°C consistent pathways require action in and by cities, often in partnership with regional and national governments. Commitment and coordination from cities is crucial in order to overcome socio-cultural, environmental, market, and economic barriers to far-reaching behavior change. With high populations and high emissions, but also readily-available, feasible, and cost-effective options for halting climate change while delivering also on other sustainable development goals, cities are instrumental to deliver on the Paris Agreement.

Summary from IPCC

The 2015 Paris Agreement marked a historic step in the global coordination on climate adaptation and mitigation. However, the current global commitments are not sufficient to prevent temperature rise above 1.5°C. Regarding both mitigation and adaptation, there are actions to be taken immediately by cities and governments at all levels, as well as by urban residents and stakeholders, such as civil society, the academic community, and those in business and finance. In order for 1.5°C-consistent pathways to be feasible, enabling conditions must be created that allow for transformational systemic change to energy, land and ecosystems, urban infrastructure, and industrial systems. These conditions are not determined by any single organization or government, but the actions by and between international organizations, countries, regions, cities, and a wide array of stakeholders (Summary for Urban Policymakers, 2018).

Climate change risks to cities, settlements and key infrastructure will rise rapidly in the mid- and long-term with further global warming, especially in places already exposed to high temperatures, along coastlines, or with high vulnerabilities. Costs for maintenance and reconstruction of urban infrastructure, including buildings, transportation, and energy will increase with global warming level, and the associated functional disruptions are projected to be substantial particularly for cities, settlements and infrastructure located on permafrost in cold regions and on coasts. Adverse impacts from climate hazards and resulting risks are cascading across sectors and regions, propagating impacts along coasts and urban centres and in mountain regions. Wildfires, in many regions, have affected ecosystems and species, people and their built assets, economic activity, and health.

In urban settings, climate change has caused impacts on human health, livelihoods and key infrastructure. Hot extremes including heatwaves have intensified in cities, aggravating air pollutions and limiting functioning of key infrastructure. The transportation, water, sanitation and energy systems have been compromised by extreme and slow-onset events, resulting in economic losses, disruptions of services and impacts to wellbeing. Unavoidable sea level rise will bring cascading impacts, causing losses of coastal ecosystems and damages to coastal infrastructure. These impacts will further increase risks to livelihoods, health, well-being, food and water security, and cultural values in the near to long-term.

Growing public and political awareness of climate impacts and risks has resulted in that adaptation measures are included in the climate policies of at least 170 countries. Decision support tools and climate services are increasingly being used and pilot projects and local experiments are being implemented in different sectors. Adaptation can generate multiple additional benefits such as improving agricultural productivity, innovation, health and well-being, food security, livelihood, and biodiversity conservation as well as reduction of risks and damages.

Urban areas can create opportunities to increase resource efficiency and significantly reduce GHG emissions through the systemic transition of infrastructure and urban form. This includes the adoption of low-emission development pathways towards net-zero emissions. Cities can achieve net-zero emissions, but to realize the full potential of reducing urban GHG emission to net-zero requires inclusion of considerations of consumption-based emissions, ie, emissions created by consumption independent of where they occur such as the emissions caused by food production outside of the city or national boundaries. The implementation of multiple city-scale mitigation strategies will have beneficial cascading effects across other sectors (IPCC_AG6_WGIII).

Sources: WGII 2022, WGIII 2014, Summary for Urban Policy Makers

Climate, Nature and our 1.5°C Future: A Synthesis of IPCC and IPBES Reports

The world we occupy today is very different to that of our ancestors. Once wild and untouched, the natural world now bears the fingerprints of humanity. For millennia, nature has fed and protected us and, as it bends beneath our weight, we are losing these contributions nature provides to people.

The IPCC has released three 'special reports' in 2018. These have emphasised some stark scientific findings about how human-caused GHG emissions have affected the oceans, frozen places and land across the globe – and that these negative climate risks will get worse as our planet heats. The IPCC reports contain information on the key role that nature itself can play in addressing climate change.

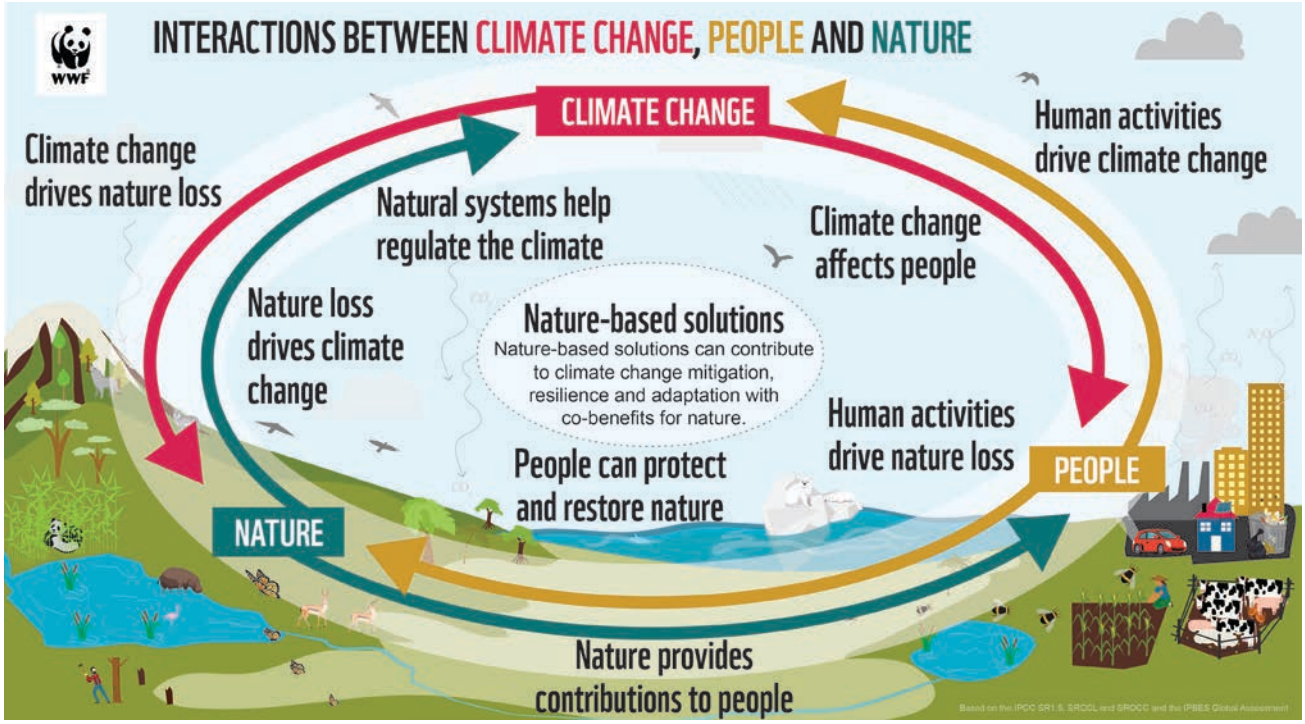
This work was complemented by some findings of the 'global assessment' from the IPBES, which synthesised the scientific literature on the decline of nature and wildlife due to human interference and highlighted the many additional benefits that conserving nature has for sustaining human livelihoods and wellbeing in general. Together, these four authoritative documents from IPCC and IPBES provide an extensive – and alarming – insight into the transformation that our planet and its ecosystems have undergone in the last century as well as the moral and economic imperative of halting nature decline.

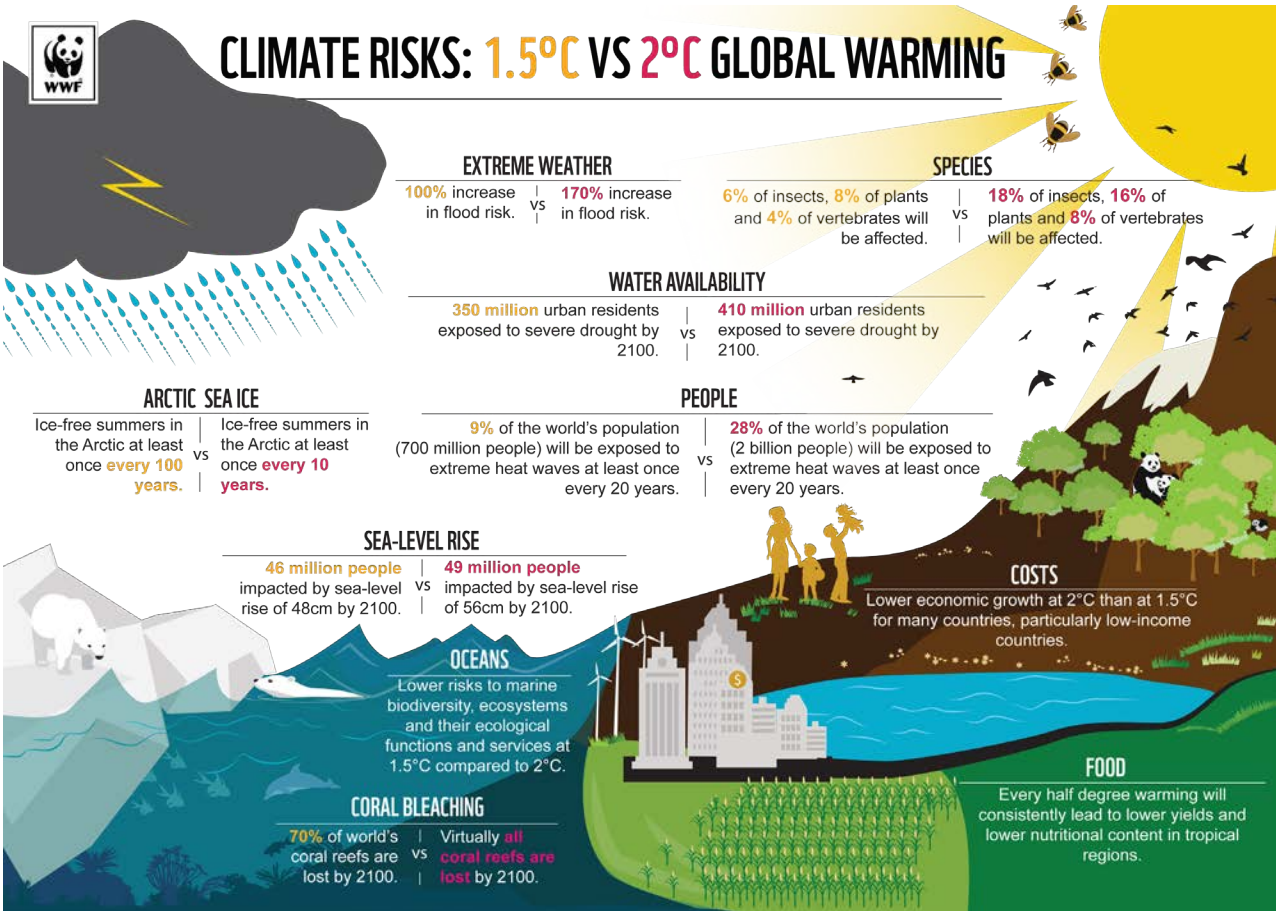
WWF's 2019 report, Climate, Nature and our 1.5°C Future, pulls together the findings from the four UN reports with a focus on climate change as a key driver of nature loss and also the ways that nature can help humanity to mitigate, build resilience and adapt to climate change.Essentially the IPBES global assessment and the three IPCC special reports are about the interactions between climate change, nature and people as outlined in the figure below.

Nature and its contributions are essential for humanity to survive and thrive on this planet. Yet ecosystems and biodiversity are in rapid decline due to human activity. According to the IPBES global assessment, these declines have been driven by five factors, which are, in order of impact: changes in land and sea use, the direct exploitation of organisms, climate change, pollution, and invasive species. But many of these drivers are entwined with and aggravated by climate change: agriculture, for instance, is transforming ecosystems while also, in many cases, contributing to climate change, and many species have shifted or expanded their ranges in response to changing temperatures.

The approximately 1.0°C increase in global average temperatures that has occurred since pre-industrial times is already damaging the planet's ecosystems in ways that are harmful to biodiversity and dangerous to people. In the Arctic, which is warming by more than double the global average, sea ice is declining with impacts on ecosystem structure and the abundance and composition of marine life. On land, changes to Arctic hydrology and wildfires are impacting vegetation, water and food security, and communities are struggling to adapt. The ocean is warming and sea-level rise is accelerating, which is putting low-lying coastal communities at risk. Ocean acidification has affected over 95% of the near-surface open ocean and is a major threat to some marine species including corals. Freshwater ecosystems are also feeling the impacts of climate change, which is exacerbating the other numerous pressures that they face: today, they are showing among the highest rates of decline in nature.

The world's forests – from the cold boreal ecosystems in the north to the tropical ones in the south, and the temperate forests in between – are facing a number of climate-exacerbated threats, such as pests, diseases and wildfires. Meanwhile, the destruction of these forests, as well as the conversion of grasslands and savannahs into cropland and pasture, is contributing to climate change. More than 30% of global forest area has been destroyed since the pre-industrial era. While unsustainable agricultural systems are driving much of this destruction, food production is also vulnerable to the impacts of climate change, such as higher temperatures and changing precipitation patterns, which is undermining global food security.





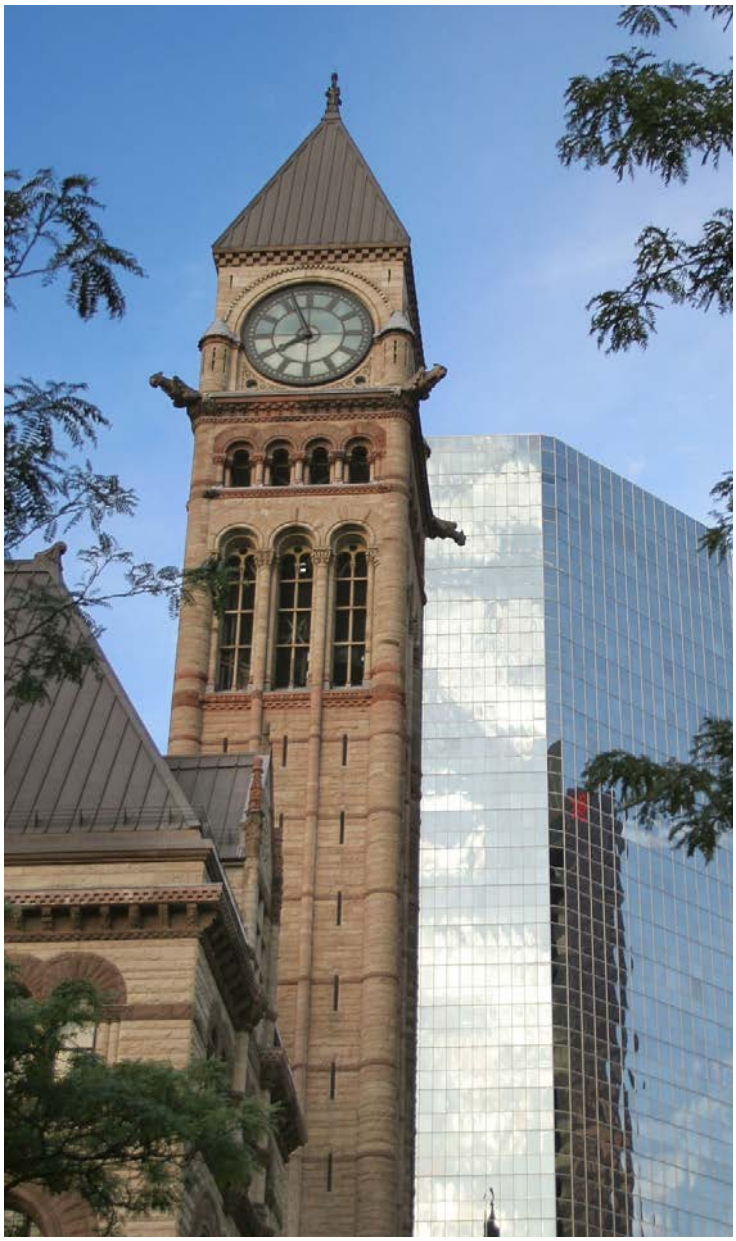
Biodiversity is suffering as a direct response to climate change and due to the degradation and a transformation of habitats in which species have lived for thousands of years. There are an estimated eight million plant and animal species on this planet, and around one million of them are now threatened with extinction, many within decades. Indeed, humans have already driven at least 680 vertebrate species to extinction since 1500, including the Pinta Giant Tortoise in the Galapagos in 2012. The rate of introduction of invasive species is higher than ever before, thanks to climate change and other human interferences like the rise in travel by air and sea. These introductions can have a damaging effect on native biodiversity, which is outcompeted by the incomers, particularly on islands and in other places with high proportions of endemic species. Overall, this has contributed to the erosion of the differences between different ecological communities, a phenomenon known as the "anthropogenic blender".

Furthermore, the damage to nature is expected to become more severe as climate change gets worse. The IPCC's 1.5°C report spells out the intensifying risks if global temperature rise reaches 2°C compared to 1.5°C – the target that countries adopted in the Paris Agreement. Temporarily exceeding the 1.5°C limit (i.e. a so-called "temperature overshoot" pathway) increases the risk of losing some ecosystems, an impact that would be long-lasting and in some cases irreversible. There are greater risks to biodiversity at 2°C compared to 1.5°C, including local losses and extinctions, forest fires, extreme weather events, and the spread of invasive species, pests and diseases. Equally, the greater the temperature rise, the harder it becomes for both nature and humanity to adapt. Limiting global warming to 1.5°C is essential – this means urgent action through raising Nationally Determined Contributions (NDCs) under the Paris Agreement to put the world on a low-emissions pathway.

But protecting and restoring nature can also help to mitigate climate change, while also protecting humans against its impacts. Agriculture, forestry and other land use accounts for almost a quarter of global GHG emissions. Reducing these emissions while simultaneously managing the land sector to draw down carbon dioxide from the atmosphere is critical to limiting global warming to below 1.5°C. In addition, integrating nature into cities and along coastlines, such as the creation or restoration of wetlands, tidal marshes or mangroves, can protect residents from climate-related hazards like storm surges and erosion. Protecting and managing our ecosystems and biodiversity can be an inexpensive and sustainable way to improve resilience against climate change impacts, and ensure that the land can continue to provide food, water, security and other vital contributions to people for years to come.

Among the thousands of pages and dozens of narratives that make up the story of climate change, the IPBES and IPCC paint a detailed picture of how nature – ecosystems and biodiversity – will suffer at the hands of climate change, and also how strong and healthy ecosystems endow resilience and can help us adapt to climate impacts. WWF's Climate, Nature and our 1.5°C Future shines a spotlight on this picture. We look at the impacts and risks of climate change across six biomes and systems: the polar regions, freshwater, oceans, grasslands and savannahs, forests, and food and provide a top three recommendations from WWF to each. We also examine some of the nature- based solutions (see box) in the IPCC and IPBES reports, and how WWF is already implementing some of these interventions on the ground. Finally, we outline WWF's summary and recommendations to governments and non-state actors.

1.2 BACKGROUND ON CITIES & CLIMATE CHANGE



Framing the opportunity

About 55% of the world's population lives in urban areas, and the United Nations predicts that this percentage will grow to roughly 70% by 2050. With a large percentage of the world's population working and living within cities, they are massive hubs for economic growth, accounting for 80% of global GDP. At the same time, this makes cities key contributors to climate change, as urban activities are major sources of GHG emissions. Estimates suggest that cities are responsible for about 70% of global carbon emissions, with transport and buildings among the largest contributors.

While cities are the biggest contributors to the climate crisis, they also suffer from the consequences. An estimated 70% of cities already experience the impacts, and as sea levels continue to rise and extreme weather events become more intense, this percentage swells. But the good news is that even if cities are big emitters, they have a huge potential to curb global carbon emissions in line with the 1.5°C goal by taking action.

At the municipal level cities can implement policies and improve planning to minimize their emissions. Cities also play an important role in global climate governance. With more than half of the global population, cities are starting to carry weight within global climate negotiations: with discussions expanding related to city climate finance, sustainable urban transportation and energy systems, to name just a few. Still many of these discussions are only starting, since much of the negotiation space remains focused on national governments. Because of this, it is both a challenge and an opportunity for cities to commit to cutting carbon emissions in order to align with the 1.5°C goal and become more sustainable, while creating livable spaces that meet the needs of their citizens.

Case study Copenhagen - First carbon neutral capital by 2025

Copenhagen aims to be the first carbon neutral capital by 2025, and plans to get there by switching to biomass in the district heating system; extending cycling 'superhighways' in its continued modal shift; and making heavy investments in wind power and other renewables. Copenhagen's remaining transport emissions will be offset by exports of green electricity. The city has been rewarded for its efforts, being named 2014 National Earth Hour Capital and 2014 European Green Capital, and receiving the 2013 Climate Leadership Award for Carbon Measurement and Planning.

Copenhagen is one of a handful of cities that stand out for their long-term work with urban sustainability – in Copenhagen's case going all the way back to 1962 when it pedestrianised its famous main thoroughfare Strøget. The city is especially renowned for its efforts to create a walkable and livable environment, competing with Amsterdam for the title of the most bicycle-friendly city in the world. Investments in energy efficiency, district heating, and offshore wind farms have also helped Copenhagen reduce its direct carbon dioxide (CO2) emissions by more than 40% since 1990, despite a real economic growth of 50% (see also Copenhagen).

Climate change plans

Since the 2009 UN Climate Change Conference in Copenhagen, the city has concentrated its efforts on climate-change mitigation. In the Copenhagen Climate Plan from that year, the city set the goal of a 20% reduction of emissions by 2015 from a 2005 baseline. That goal was reached already in 2011, and in 2012 Copenhagen launched a new Climate Plan which aims for carbon neutrality by 2025.

In 2012 Copenhagen's starting point was annual emissions of 1.9 million tons of CO2. Earlier plans and legislation on energy and transport were already on target to reduce this figure to 1.16 million tons by 2025. The city plans to accomplish this steep decline mainly through a switch from coal to biomass at Amager and Avedøre, the two major combined heat and power (CHP) plants that feed the district heating system covering 98% of heating demands in Copenhagen.

To get from 1.16 million tons to zero, Copenhagen is carrying out a range of measures to reduce energy consumption and divert energy production to renewables. A surplus of green energy must be produced to offset the emissions that will continue to be generated by city activities. Transport alone will generate an estimated 400,000 tons of CO2 by 2025, and more time will probably be needed to make private cars fossil free.

Energy efficiency

In its own operations, the city administration will set an example by: reducing energy consumption in buildings by 40%; introducing high energy-efficiency requirements for new buildings; running all vehicles on electricity, hydrogen or biofuels; retrofitting all street lightning; and installing 60,000 square meters of solar PV panels on municipal buildings. This is estimated to reduce CO2 emissions by 20,000 tons. Heat and electricity consumption account for around 75% of CO2 emissions in Copenhagen, and the city plans significant energy efficiency improvements in all sectors, reducing CO2 emissions by 80,000 tons. The major goals are: a 20% reduction of heat consumption, a 20% reduction of electricity consumption in commercial and service companies, a 10% reduction of electricity consumption in households, and installation of solar PVs corresponding to 1% of electricity consumption by 2025. Copenhagen plans to regulate and increase investments in energy-efficient retrofits and new construction, to develop a digital smart city infrastructure, and to invest $74 million in solar PVs up to 2025.

The city also plans to introduce energy finance schemes for retrofitting. The so-called landlord/tenant dilemma makes retrofits of older apartment buildings difficult, as most people in Copenhagen rent their apartments. Thus the city plans to incentivize an energy service market, where private firms take on the risk of guaranteeing energy savings, and in return are paid a fee by landlords or tenants.

Cycling superhighways

Copenhagen aims to reduce emissions from transport by 135,000 tons by 2025. The sector accounts for around 22% of CO2 emissions – a low figure for a big city and the result of Copenhagen's earlier efforts in this area. More than half of Copenhageners claim bicycles are their main means of transport and the ratio of bicycle-to-car ownership is 5:1.

The city has 359 kilometers of cycle tracks and 36% of all trips to work and school are by bike (which is more than by car). The Climate Plan aims to increase this figure to 50% by 2025, and ensure that 75% of all trips in Copenhagen are on foot, by bike, or via public transport. The city also aims to increase the use of public transport by 20%, and make it carbon neutral. Further, it set goals that by 2025 20-30% of all light vehicles, and 30-40% of all heavy vehicles run on new fuels such as electricity, hydrogen, biogas.

To achieve these goals, Copenhagen is expanding and improving its cycling and public transport infrastructure in a number of ways, including 'green wave' traffic signals prioritizing bicycles and buses, and resting bars for cyclists at intersections. In cooperation with neighboring communities, Copenhagen has started construction of 'bicycle superhighways' – wider, smoother and better-lit cycle tracks, in some places with three lanes – to encourage more suburban commuters to abandon cars for bikes. A total of 26 bicycle superhighways are planned, covering 300 kilometers.

Green electricity exports

The bulk of reductions, 855,000 tons of CO2, will come from investments in renewable energy production. By 2025, Copenhagen's production of electricity and heating will be mainly based on wind, biomass, geothermal energy, and waste. The district heating will be carbon neutral and the city will produce green electricity exceeding its consumption, in order to offset remaining CO2 emissions. The excess of green electricity will be exported to other parts of Denmark.

To achieve this, Copenhagen is investing in wind power, in new biomass-fired combined heat and power plants (CPHs), and in a new, high-tech waste treatment center that will incinerate rest waste for district heating, and feature biogasification of organic waste. Before 2025, Copenhagen plans to install 100 new wind turbines with a total capacity of 360 MW, both inside and outside the municipal boundary, and both onshore and offshore. The city also plans to build a wood-fired CHP of 115-350 MW, a geothermal plant of 65 MW, and a heat storage tank with 200 MW of capacity, all of which will help the city with flexibility in heat and electricity supply.

The Climate Plan entails investments of around $ 4 billion up to 2025, yet Copenhagen expects the plan to save money through energy efficiency and reduction of fossil fuel imports while it generates income in the green sector, including around 3,500 new jobs over the 10-year period.

Co-benefits for city climate action and the need for urgency

The Climate Crisis is one of the greatest crises that humanity has ever faced. And due to its complexity and global scale, it also interacts with multiple other global challenges, like air pollution and biodiversity loss. WWF's 2022 Living Planet Report revealed unprecedented global wildlife loss, up to a 69% decline in the population size of most mammals, birds, fish, reptiles and amphibians in just over 40 years, through habitat loss and other challenges, including climate change. Therefore, the challenges are complex and interconnected.

The climate numbers speak for themselves. Between 2006 and 2016, observed global mean surface temperature was 0.87°C higher than between 1850 and 1900. And due to current and past emissions, it is estimated that global mean surface temperature is increasing at 0.2°C per decade. As GHG emission rates increase, this trend marches on.

Global temperature has already led to the melting of glaciers and polar ice, sea level rise, more extreme weather including: increased intensity and frequency of flooding and droughts, extreme heat, as well as other impacts. These impacts are escalating. Unchecked, climate change could undo much of the economic and social progress since the end of World War II. While the climate crisis will impact everyone and all habitats, natural and manmade, cities are especially vulnerable, since they are home to dense populations and are economic hubs.

However, there are also signs of hope. The IPCC does not shut the door on meeting the 1.5°C goal; but it calls for unprecedented efforts to address the climate crisis, including in our cities. Other reports, like the Exponential Climate Action Roadmap offer guidance as to how. Both stress the need for far-reaching transitions in urban policy, planning and infrastructure, including energy, buildings and transport.

Although a challenge, addressing the climate crisis in our cities has and can provide many co-benefits: for our cities, for our citizens and for nature. Many of these co-benefits will be discussed in the following lectures, together with key policy, planning tools and technical strategies to help cities transition towards 1.5°C alignment. In the next chapter we move from "the why" cities need to address the climate crisis to "the how" they can do so.

Exponential Roadmap

The Exponential Roadmap focuses on moving from incremental to exponential climate action in the next decade. It presents 36 economically viable solutions to cut global GHG emissions 50% by 2030 and the strategies to scale this transformation including key strategies for cities to address urban challenges . The roadmap is consistent with the Paris Agreement's goal to keep global average temperature "well below 2°C" and aiming for 1.5°C above preindustrial levels. The roadmap recognizes the need for sectoral transformation in areas such as energy supply, industry, digital industry, building, transport, food consumption, and nature-based solutions The roadmap identifies four pillars required to scale the transformation as well as necessary actions for each: policy, climate leadership and movements, finance and exponential technology.

Read more here.

Puebla energy efficiency - Climate change mitigation´s low hanging fruits

In 2013, at the city´s request, Puebla became a pilot city for the World Bank Tool for the Rapid Assessment of City Energy (TRACE), which has since been deployed in dozens of cities worldwide. The study jumpstarted measures focused on street lighting, municipal buildings and solid waste in Puebla and contributed to the development a national urban energy efficiency strategy. In 2015 the city was chosen as Mexico´s National Earth Hour Capital, in particular for its ambitious commitments and high level of investments.

With 1,540,000 inhabitants, the industrial city of Puebla is Mexico´s fourth largest urban area. It is located at the foot of the Popocatepetl volcano in central Mexico, 2,100 meters above sea level, which gives it a pleasant climate that minimizes the need for heating or air conditioning. In 2013 Puebla asked to be chosen together with Léon, Mexico and Bogotá, Colombia to participate in the World Bank's Latin America and the Caribbean Energy Unit's research project on energy use, through the testing of the new TRACE tool.

Rapid assessment of city energy

TRACE is a simple and practical tool for picking the low-hanging fruits of urban climate change mitigation. It helps decision makers identify under-performing sectors, evaluate improvement potential and prioritize actions for energy efficiency measures tailored to the city´s context. Since TRACE is a rapid assessment tool, it doesn´t provide a deep or comprehensive analysis but focuses on six sectors that in many cities around the world are under municipal control: transport, municipal buildings, water and wastewater, street lighting, solid waste, and power and heat. TRACE contains a benchmarking module with data from dozens of cities and a set of energy efficiency interventions supported by a database of hundreds of case studies. Since its creation in 2010, TRACE has been deployed in 27 cities in Africa, Asia, Europe and Central Asia, and Latin America.

Puebla, city of light

The three sectors that the Puebla TRACE study recommended for prioritized action were street lighting, municipal buildings, and solid waste:

Puebla had already started a program for modernizing its public lighting with magnetic induction lamps and local dimming. The TRACE study identified several additional measures, including a procurement guide for new street lights with strict rules, a city-wide street lighting retrofit with LEDs, and involvement of an energy service company (ESCO) that could help finance the investments from a share of the energy savings. Puebla is now continuing with the "Puebla, City of Light" program, which is converting 20,000 out if its approximately 100,000 street lights to LEDs, and is expanding the coverage to previously poor lit neighborhoods.

Buildings and waste management

Following the advice of the TRACE study, Puebla has started an energy efficiency program for its municipal buildings, including a switch to LED lighting and construction of solar PVs on the City Hall. Most of the energy use in Puebla´s buildings is for lighting and IT because of the pleasant climate, but the TRACE study identified other energy saving measures, including building audits, database programs and mandatory energy efficiency codes for new buildings. Puebla has started a program to measure, regulate and promote the efficient use of energy also in the community building stock.

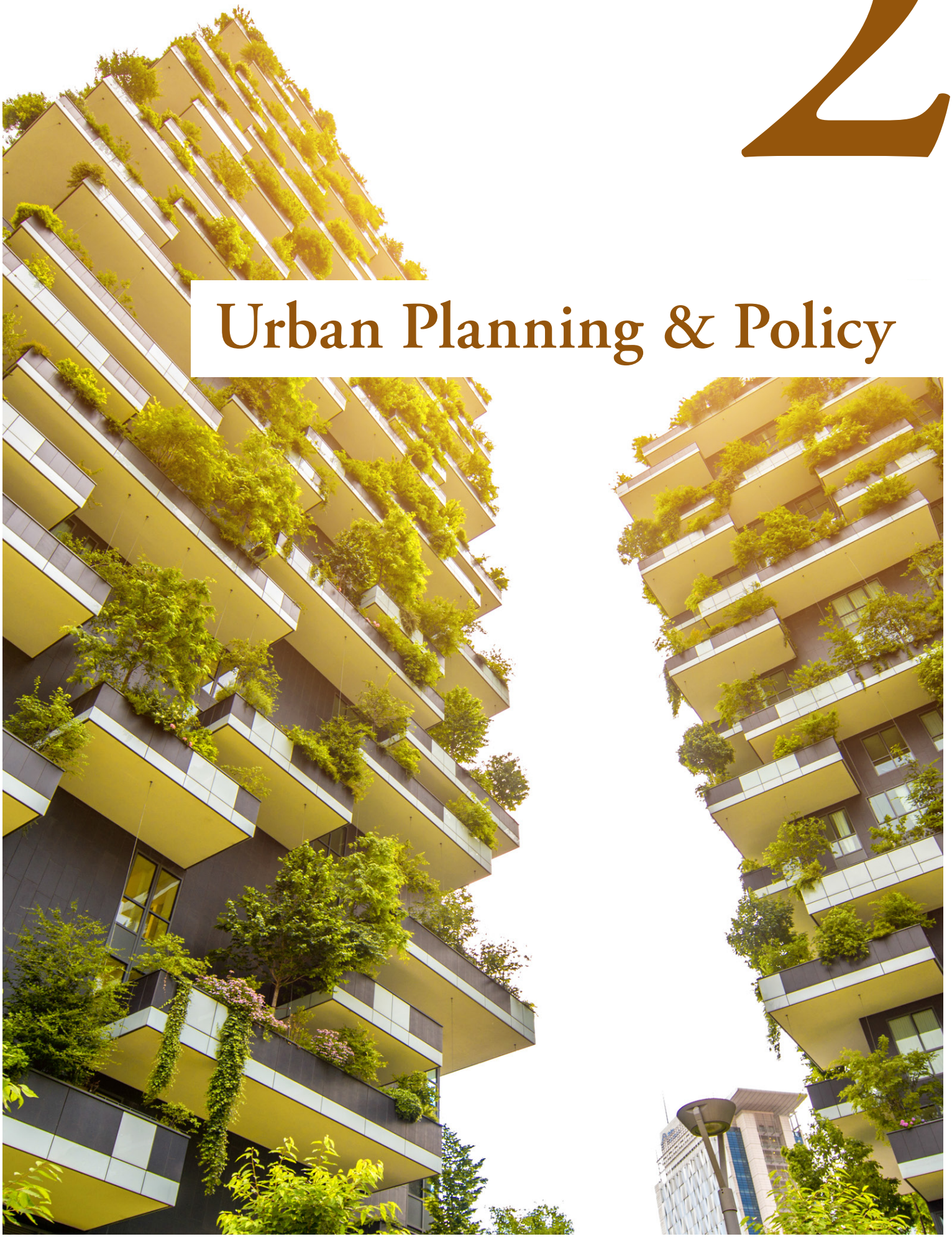
The TRACE study identified a low level of recycling in Puebla, although recent measures had started to improve the situation, including a new program that allows companies to buy recyclable solid waste from private informal collectors, with the money collected going into a fund to improve safety in the city. Puebla has started to implement some of the proposals in the TRACE study, which included transfer stations to reduce the number of waste truck trips, solid waste auditing and planning, and public awareness campaigns. In addition, Puebla is investing heavily in waste to energy, including a plant for production of biogas at the Chiltepeque landfill.

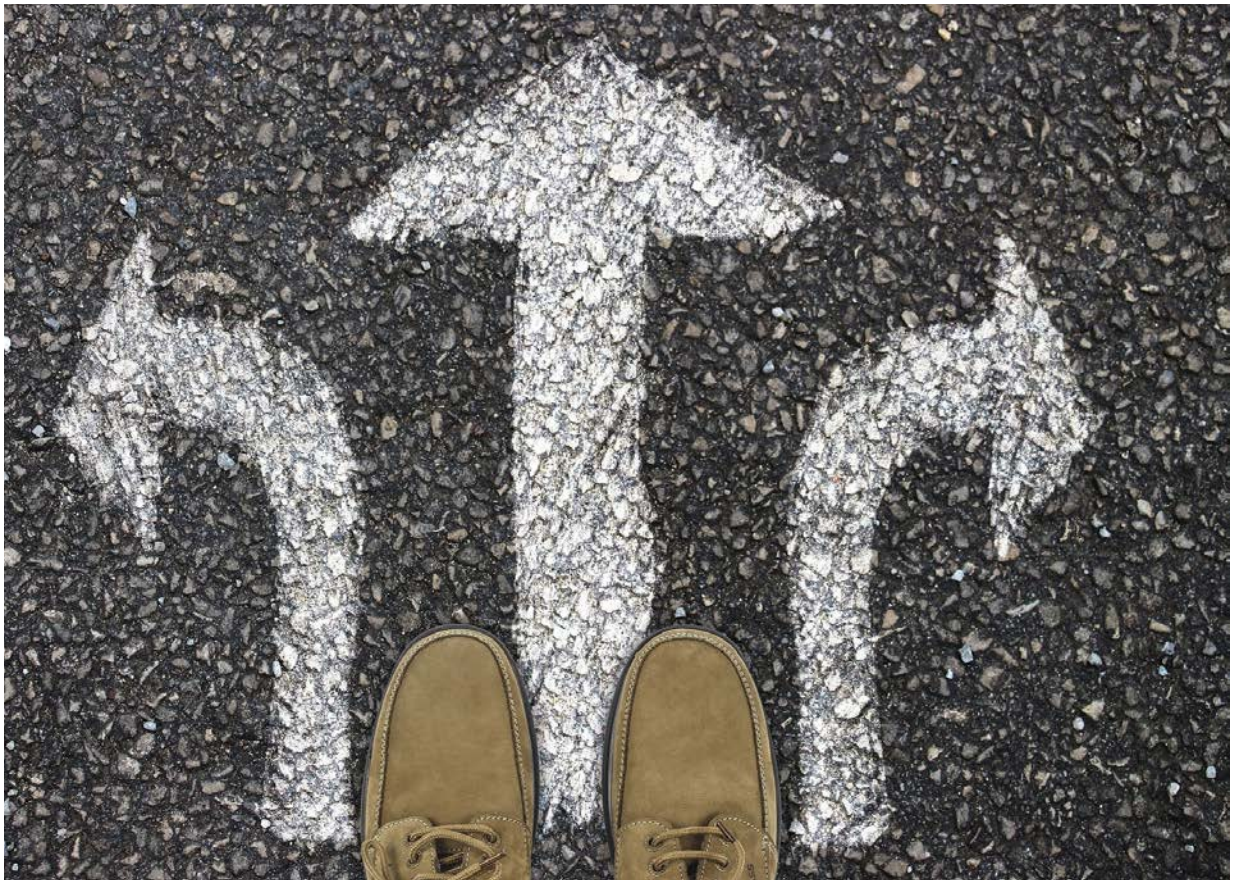
Transport biggest emitter

The transport sector accounts for over 54% of energy use in Puebla, but the city already has a good mobility program in place to improve on that number. Almost half of the residents use public transport, while more than a third bike or walk, especially in the historic district, where there is a good pedestrian network. Puebla is now expanding its Bus Rapid Transit system RUTA from one corridor to three, and is making the city more bicycle friendly with more lanes. It has partnered with the Institute for Transportation and Development Policy (ITDP) Mexico to develop a comprehensive mobility plan, which includes the recovery of public spaces and implementation of a parking policy.

2

Urban Planning & Policy





In this chapter, we explain the levels and modes of urban climate governance and the interactions between urban planning and some key services. We also explore the co-benefits of strategic urban planning and the role of sustainable transportation and mobility, as well as the co-benefits of nature-based solutions and ecosystem services.

2.1 URBAN CLIMATE GOVERNANCE TOWARDS 1.5°C : METHODS, MODES & KEY STAKEHOLDERS

Multi-level Governance

It is critical to consider the difference between government and governance. Government refers to a ruling body of a nation or other political scale. In contrast, governance refers to the process of a group of people organizing themselves to make decisions – this often includes government actors, but it is not limited to them.

The actions that a city or a local government takes to address the climate crisis locally must therefore be placed into a larger and multi-level governance system. This includes the influences and interdependencies of both vertical and horizontal levels of governance, as well as the interactions with key stakeholders and other cities and regions.

Vertical governance refers to how local governments interact with higher governing bodies at regional, national, and international scales. Often, decisions taken at higher governing levels - for example the national government level that may control access to finance or be responsible for regulations or laws, will influence a local government's ability and resources to adopt or implement climate strategies, or even how ambitious such local climate strategies can be. To address this, it is crucial that cities work together to lobby for additional resources, capacity or autonomy to develop and implement ambitious strategies to move towards 1.5°C alignment. Occasionally, ambitious or innovative city policies may be adopted by higher levels of government, putting cities in a strategic place as testbeds for new ideas on the frontlines of climate action.

Horizontal governance on the other hand refers to how local governments collaborate with stakeholders, such as companies or citizen groups, within their own cities or outside their borders. It also refers to how they work with other local governments – often via city networks, for learning and lobbying or to bring in external resources, such as finance or technical support to a city. Some of the main international city networks include C40 Cities Climate Leadership Group, ICLEI – Local Governments for Sustainability, as well as the Global Covenant of Mayors for Climate & Energy.

The role of stakeholder engagement can be another

influential horizontal governance factor to develop and drive ambition. This could include collaborations between businesses and the local government, or even private individuals. And one example of this is the "Greta Thunberg" effect: a Stockholm teenager who sat outside the Swedish parliament in August 2018 in a "school strike for the climate". A few months later, Greta inadvertently launched a global student movement in multiple cities around the world, while simultaneously challenging – and inspiring – UN climate delegates, world leaders in business and government, and EU parliamentarians. She called on them to replace hope with panic and critically: ambitious action to renew that hope, in accordance with climate science recommendations to support 1.5°C alignment.

Spurred on by students marching through their streets, a growing set of local governments have declared a "climate emergency," slowly recognizing and reacting to the grave threat of the climate crisis. But here, these cities need to be granted autonomy and the resources, often coming from higher governing levels, in order to effectively address the climate crisis at the local level. That is to react to the demands that their citizens are calling for – demonstrating the interactions between vertical governance and horizontal governance in cities.

Horizontal and vertical governance

Urban climate change governance must "consider how, why and with what implications other actors are seeking to govern the climate through the city," according to Bulkeley (2010, p. 233) Continuing she describes multilevel governance as "the stage upon which the drama of urban responses to climate change are played out" (2010, p. 240).

Vertical governance includes how local authorities interact with higher governing bodies at regional, national and international scales this is important to govern and build climate change strategies, since many higher-level decisions influence a local authority's ability and resources to implement urban climate actions on the ground. Higher government may support local authorities (via financial subsidies, legal support, or guidance) or constrain local authorities' ability to address climate change (by reducing a local authority's regulatory powers). Vertical governance can even include local or regional authorities' actions to influence and shape national or international governing bodies to adapt strategies on climate change or other policy issues.

Horizontal governance includes how local authorities collaborate with other local authorities (in other cities) for learning and lobbying (e.g. within the Local Governments and Municipal Authorities constituency at UN climate conferences). It includes interactions within a particular city (for example between local authorities and stakeholders, including local businesses or neighborhood associations) as well as in city networks (such as ICLEI, C40 or even WWF's community of cities). Such networks support learning and sharing between cities, while collectively lobbying on behalf of cities' interests.

Case study on Uppsala

Uppsala, Sweden, a bustling city just north of Stockholm, has taken a horizontal governance approach, working within a network of businesses and organizations from all sectors in the city, to reduce GHG emissions. Notably, Uppsala was the winner of the WWF One Planet City Challenge in 2018 for its ambitious actions to meet its emission reduction targets. Uppsala set targets to cut the total GHG emission by more than 100% no later than 2050.

Thereafter, the city aims to become climate positive, which means implementing initiatives to remove additional CO2 from the atmosphere. Since 2010, city officials and local stakeholders have worked together within a network, referred to as a "local Paris Agreement" to work toward this goal. The network initiative is called the Uppsala Climate Protocol, and more than 40 organizations are active members, consisting of companies, public agencies, universities and associations.

The Climate Protocol's organisation and structure have been developed over the years to support effective action and sharing of experience. The practical work of the Climate Protocol is concretised in different focus groups that are formed on the basis of the interests and needs of the members. Currently, there are five focus groups in different areas: selection of building materials, energy, reduction of plastics, sustainable freight transport, and sustainable urban development. The network's focus groups play an important role in collaboration, inspiration and the exchange of knowledge and experience.

Environmental and management representatives from each member meet twice a year for discussions and decision making at Round Table meetings. Climate managers from each member meet four times a year for coordination, development and practical work. The City of Uppsala provides process management to guide and support cooperation in the Climate Protocol. There is also a Coordination Group, consisting of eight members, who support the process management.

Today, the Uppsala Climate Protocol has grown to become an effective instrument in the work of achieving Uppsala's long-term climate goals; a fossil free Uppsala in 2030 and a climate positive Uppsala in 2050. WWF has calculated that if municipalities around the world replicated this Climate Protocol by engaging 20% of their local companies and organizations, it would lead to yearly emissions cuts of at least 58,000,000 tons of CO2 per year. That number is higher than Sweden's total annual emissions.

Modes of urban governance

There are many different ways, or modes of governing that local governments can use to address challenges, like the climate criss. Five of these include: regulatory governance, self governance, governing by provision, governing by enabling, and governing by collaboration.

Regulatory governance is where local governments use regulatory tools like laws, taxes, bans and policies to govern the establishment and operation of sustainability initiatives within cities. Cities may use such tools to limit one behavior or to support the implementation, management or even acceleration of a sustainability initiative or positive behavior.

Take carbon tax, where emitters must pay for the social and environmental costs of their carbon emissions. In November 2006, voters in Boulder, Colorado (USA) passed the first municipal carbon tax on electricity consumption, with deductions for using electricity from renewable sources. Tax revenues are directed to the city's Office of Environmental Affairs to fund programs to reduce community-wide GHG emissions.

Self-governance is where local governments focus on governing their own activities and infrastructure. Examples include improving energy efficiency in municipal buildings, adding solar panels to local schools, or investing in electric vehicles for public use – that is, buildings or infrastructure managed by the local government.

Governing by provision is where governments provide practical, material and infrastructural means to support climate actions. For example, where local governments provide the infrastructural means for citizens to safely bike – such as safe and separated bike lanes, enough bike parking or efforts to link public transport to cycling.

Governing by enabling is where intangible means like persuasion, argumentation and incentives are used to bring stakeholders on board and improve ownership. For example, providing tax exemptions to incentivize residents to purchase solar panels, making the panels more affordable for the consumer. Other examples include eco or energy labelling on food and other products to help citizens or stakeholder groups make informed and sustainable decisions.

And closely linked to this is **governing by collaboration**, where collaborative mechanisms are used and where both parties play active roles in the governing process, such as through partnerships, or education and awareness building efforts.

In Malmö (Sweden) a collaborative partnership called "Solar Region Skåne" connects local and regional governments, as well as solar energy providers and experts together with interested stakeholders, providing technical and market knowledge on solar energy, so interested consumers can make informed decisions.

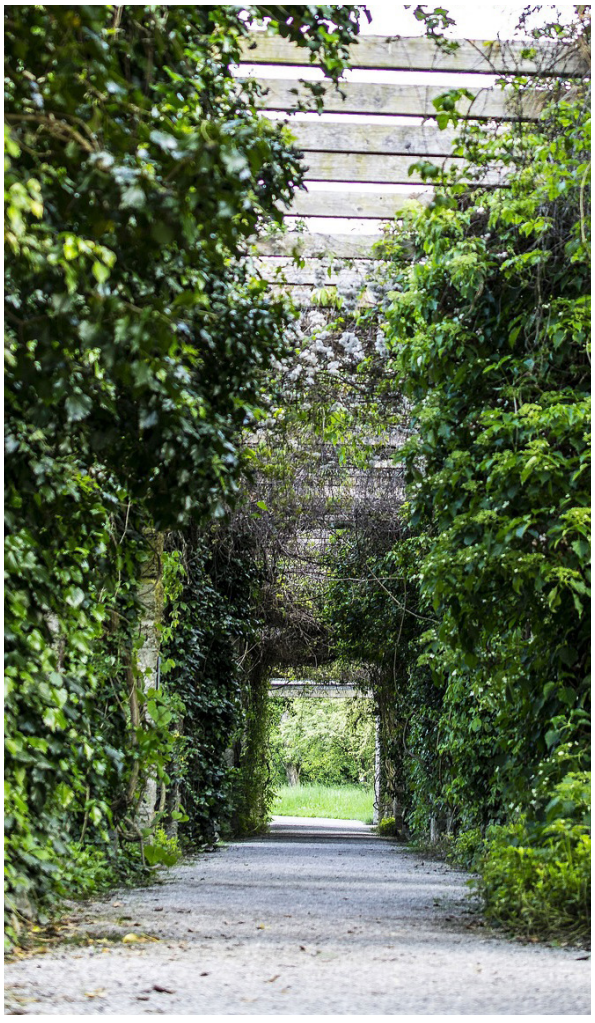
2.2 INTERACTIONS BETWEEN URBAN PLANNING AND KEY SERVICES FOR 1.5°C ALIGNMENT

Urban Ecological footprint

Cities are like complex puzzles. They include different services and functions that help maintain resource flows, including that of energy, water and waste. Unfortunately, most often these resource flows are linear, with raw materials coming in from outside a city, and waste products later leaving the city. Cities are also built within a variety of natural habitats that support urban services, like clean water and food provision, and they are home to diverse and dynamic urban populations, with their own needs and desires.

All of this comes together as one cohesive whole, interacting with and unfortunately often negatively impacting the natural environment. This happens both within a city's periphery, as well as far beyond the city borders – impacting anything from local pollution to climate change and global sea-level rise.

Urban areas now account for more than 70% of global carbon emissions. And two of the biggest contributors are buildings and transportation, where buildings and construction account for about 40% of energy-related carbon emissions; and the transport sector accounts for about 25% of total energy-related carbon emissions.



Auckland Case study - Low Impact Urban Design and Development

Low Impact Urban Design and Development (LIUDD) is an approach developed primarily in New Zealand for creating sustainable urban spaces. LIUDD advocates alternative, cost-effective urban design and development by working with nature and creating community environments that respect, conserve and enhance natural processes. Auckland's green corridors provide flood protection and increases the city's resilience in the face of climate change.

LIUDD sounds fancy yet at its heart are common sense, eco-responsive solutions such as rain-gardens, green roofs, green corridors, open swales, detention ponds and ecologically friendly pervious surfaces. LIUDD is a New Zealand sustainable cities concept that combines the US or North America's Low Impact Development (LID), Conservation Sub-Divisions (CSD), Integrated Catchment Management (ICM) and Sustainable Building/Green Architecture (SB).

Successful implementation

Auckland's use of green corridors is aimed at protecting sensitive marginal areas from unsuitable development. On the practical side, infiltration zones and overland flow paths facilitate flood protection by containing up to a 100-year flood event. Green corridors are much more – home to birds and bees, these reserves provide walkways and cycle paths for inhabitants, enhancing the cityscape.

In Auckland, preliminary results show that ecological conditions in the LIUDD transitional sub-catchments are better than normal for both urban and rural sub-catchments. Exceptional stream quality is also present in LIUDD stream sections that now get little or no storm water. The corridors help reverse 150 years of landscape modification and temper the result of thousands of exotic species introductions in New Zealand by providing space for new introductions of area-appropriate species.

Studies in both the Northern and Southern hemispheres have shown LID and LIUDD have the potential to moderate environmental changes that are the result of urbanization. Research in Washington DC and Gothenburg, Sweden indicate that urban parks reduced temperatures by up to 6 °C for up to 1,000 m from the boundary for a park of 156 ha. This can reduce the problem of urban heat islands.

Adaptation to climate change

Urban development and growth are inevitable, particularly in rapidly urbanizing and emerging economies of the Global South. LIUDD uses essentially adaptive practices based on the objectives and constraints of particular locations, communities and developers. In the light of possible impacts of climate change on water availability in areas such as Sub-Saharan Africa, LIUDD may prove crucial in averting water shortages and ameliorating impacts of drought. It must be acknowledged, however, that for LIUDD to be successful anywhere in the world it must cut across spatial scales and be implementable at household as well as catchment level.

Role of city planning

Due to the large ecological footprint and land footprint of cities, cities need to learn how to think in a more integrated manner when it comes to urban planning, combining or crossing services and urban functions, like energy and

wastewater. This, to make more efficient use of resources already being used within a city. If we envision cities as symbiotic ecosystems, where different functions can connect or even benefit from each other, the possibilities are numerous. We call this integrated urban planning and local governments often have the power to facilitate integrated urban planning and policy.

One example of combining urban functions is greening transport corridors. Doing so can improve park planning and access to urban green spaces by combining this with urban transport, in the form of green tramways or tree-lined bike lanes. Many cities increasingly design such green streets, but more cities need to do so. Such green spaces can have a powerful effect on combating the climate crisis. During heat waves, green corridors are significantly cooler and more comfortable than asphalted streets that suffer from overheating. Surrounding buildings are more comfortable and require less cooling; and trees sequester carbon naturally. In short, green streets for people and nature can help a city with its efforts toward 1.5°C alignment.

Integrated urban planning can also combine spatial and energy planning. Rotterdam (Netherlands) has developed an integrated planning method called the Rotterdam Energy Approach and Planning, or REAP,which links urban functions that are in close proximity to each other and whose waste streams can be used by each other, like swimming pools and ice hockey rinks, one needs heating, the other, cooling, and their waste products are useful resources for the other. Doing so, REAP aims to find the optimum solution for site-level development and design.

District energy systems, like district heating or sometimes district cooling, are another great way for cities to make energy captured from unused byproducts useful, like heat from electricity generation or from industrial processes. Cities can also collect organic waste like food waste or sewage sludge to create biogas. This biogas can then be used to fuel city buses, with remaining product used for nutrient-rich compost to enhance soil quality. Most often, this gas is emitted straight into the atmosphere; then additional energy is used to fuel buses. Biogas uses gases naturally emitted by biodegradation, providing an affordable transport fuel for local buses.

Taking a "circular city", as opposed to a linear city, approach enables us to see how waste products can become resources. Doing so effectively requires thinking a bit more strategically about city planning: combining services and urban functions, like waste management and transport; tracking energy or water flows in how they interact with city design; or exploring how to creatively expand urban green spaces. With a bit of creative thinking, and a willingness to take risk and support innovation, the benefits of such strategic city planning are multiple: reusing energy and resources, reducing waste, saving a city's economic resources.

Case study Rotterdam

Rotterdam Energy Approach and Planning (REAP) was initiated by Rotterdam's local authority in 2009 and aims to close resource-waste cycles by re-using energy and water. The initiative has three core steps (reducing energy consumption via architecture, re-using waste energy flows, and using renewable energy) and operates at four geographic scales (building, neighborhood, district, and city).

REAP emphasizes energy efficiency by exchanging waste energy flows between urban functions. In practice, this means using the energy that is already there, the harbor's waste heat for example. At the city scale, REAP feeds waste energy from harbor industries into the district heating grid. At the district/neighborhood scale, the waste heat of offices and shops can be cascaded to homes and energy can be exchanged between swimming pools (which require heat) and ice rinks (which require cooling).

To increase efficiency, REAP operates at these different geographic scales depending on the amount of resource. For larger resource exchanges, it focuses on the city-level while for smaller exchanges, it makes sense to focus on the building or neighborhood level. For the remaining demand, REAP encourages use of renewable energy. REAP also includes water reuse and aims to reconfigure water networks to increase symbiosis between buildings, services and industries. REAP has been applied to several projects in Rotterdam, including a large-scale retrofit of housing, offices and cultural spaces on vacant lots.

Co-benefits and Increased Livability

Strategic urban planning not only has the potential to make a city more sustainable, there are also multiple co-benefits for citizens, local businesses and other urban

stakeholders.

Part of strategic (and smart) city planning is to ensure that basic services are located close to where people live and can be easily accessible, without needing a car to do so. This, combined with regular access to sustainable mobility alternatives, can decrease the need for personal cars. Choosing to live car-free, especially where city planning enables this, can increase a city's livability and the quality of life of urban residents.

Enabling a car-free lifestyle can also reduce the cost of living for many urbanites, as not owning a car can lift a significant financial burden. Moving around on a bicycle, or walking, promotes a more active lifestyle; this can result in improved health or even reduce associated healthcare costs.

When city design is optimized for human use, or designed at the human scale, such cities are generally cleaner, greener and more accessible. And the people living there benefit from better air quality, less time in traffic, less noise pollution, less surface space dedicated to cars, as well as more social interactions with fellow city-dwellers, to name a few benefits.

Investing in district energy systems can also make utility costs lower for customers, as energy is provided at scale, taking advantage of a well-connected and compact city grid. But, district energy is not as effective in a sprawling city as efficiency is lost over distance.

In fact, because of its high social, environmental and economic costs, as well as extensive land footprint, urban sprawl and its necessary car dependency, should be avoided and de-incentivized. This is especially crucial if we are to effectively address the climate crisis and ensure 1.5°C alignment, as well as related environmental challenges. Instead, through better city planning, local governments and urban stakeholders have the potential to cultivate the kind of cities that people want to live in, by optimizing a particularly rare resource in cities – space – and thereby creating cities for people that can coexist with nature.

Cost of urban sprawl

There are many social, environmental, and economic costs associated with urban sprawl.

One such cost is the social disadvantages. Urban sprawl results in more cars on the road and more time spent in traffic. When more time is spent in traffic, less time is spent interacting with other people. If less time was spent in the car, pedestrians would have more opportunities for random contacts with other pedestrians, creating more social interaction.

Additionally, spending time alone in suburban homes combined with spending time alone in the car creates an isolated effect on people. So much car use also takes a toll on air quality, impacting the health of millions of people.

Air pollution is associated with between 4.5 to 9 million deaths per year. Nearly 90% of the global urban population is breathing polluted air, with children and the elderly experiencing the greatest impacts from air pollution. The climate crisis and air pollution both derive from the same source: the burning of fossil fuels, especially from our motor vehicles.

Sprawling low-density development is also responsible for seemingly endless construction of roads and highways, turning natural environments into impervious surfaces - contributing to biodiversity loss, pollution of waterways, and accelerated flooding.

Finally, urban sprawl is also associated with economic costs as well. Cars can be a huge financial burden for many people; costs may include car payments, fuel costs, insurance, and maintenance. Additionally, sprawl increases the distance between homes, businesses, services, and entertainment.

This means that many tax dollars are spent instead on providing suburban infrastructure and services. Theres are financial resources that could be spent on education, public spaces, and civic buildings.

Moreover, more time spent communing or sitting in traffic wastes can result in lower productivity, thus limiting the economy.

2.3 - MOVING CITIES TOWARDS 1.5°C: TRANSPORTATION & MOBILITY

The Current Issue with Transportation

Transportation accounts for roughly 25% of energy-related carbon emissions. This means that the role of transport planning, especially in cities, is crucial to meet the

goal of 1.5°C maximum global warming. The good news is that there are many things a city can do to improve its transport system. An important step is to provide safe and connected infrastructure for cycling and walking. This can include, bike lanes separated from the road, or closing central streets to cars, either temporarily or permanently. Or even turning car streets into "shared streets" where space is more equally distributed among different transportation modes, instead of only motor vehicles. Santiago (Chile) has made efforts to support shared streets, as well as closing central streets to cars, and in this way expanded the city's public spaces. And Stockholm (Sweden) has adopted "summer streets" that are closed to vehicles to expand public spaces in summer months.

Another effective way of cutting transport-related emissions is through the implementation of public transport, so the provision of energy-efficient, affordable, safe and regular public transport needs to be expanded to make public transport as convenient, or even more convenient than private cars. As a fun example, cities, including Medellin (Colombia), La Paz (Bolivia) and Tbilisi (Georgia) have incorporated cable cars into their public transportation grid – providing a unique birds-eye view of the surrounding city and distant mountains, while floating above their cities' traffic congestion.

Incentivizing the rollout of electric vehicles is another important step in moving towards zero carbon transportation. This can include recharging stations or privileged parking for electric vehicles. Amsterdam (Netherlands) and Oslo (Norway) are world leaders in e-vehicle rollout, where Amsterdam provides special incentives and subsidies for businesses and startups that want to develop and improve e-vehicle technology and Oslo has a goal to create an all-electric zero emissions cab system by 2023.

Cities also need to create disincentives for personal car use, for example, by implementing congestion charging in city centers, removing parking or making parking more expensive, or limiting the use of private cars in city centers. The finances generated from these methods can then be reinvested in more sustainable public transport alternatives. While often initially controversial, cities like London (UK) have had positive experiences with congestion charging in their efforts to address air quality, the climate crisis as well as traffic congestion. Cities should also make use of IT alternatives to support more sustainable mobility, like the emergence of bike or scooter sharing-services in many cities, or even car-sharing systems, which provide information via smartphone apps, indicating where the closest possibility may be. Or smart data systems that track public transportation, to provide real-time information about when they will arrive.

Also, it is important to connect the local transport networks to regional networks. In Copenhagen or Amsterdam, it is possible to take your bike on the train or tram for distances that may be a little too far to bike. Doing so reduces the need for a personal car, especially if more sustainable alternatives are readily provided in a more systematic fashion, thinking of the whole journey. Likewise, many cities have transport tickets for regional trains that also allow you to jump on local public transport with no additional cost to the journey. Taking all or several of these steps is a good way to support 1.5°C alignment with respect to urban transport. But taking these steps also addresses another critical, but often under-recognized health crisis: that of air pollution.

As mentioned before, nearly 90% of the global urban population is in fact breathing polluted air – with children experiencing the greatest impacts from air pollution. The climate crisis and the air pollution crisis both derive from the same source: the burning of fossil fuels, especially from our motor vehicles. It is time we shift our transport systems towards more sustainable alternatives which will be better for us, and better for the. At WWF, we are working to address the climate crisis and air pollution jointly, focusing on how we move around our cities, highlighting the role of personal choice to opt for more sustainable mobility, as well as calling on our political leaders to provide the right conditions to move around cities in a more sustainable fashion.

Malmö, Sweden

Launching in 2006 and for several years after in Malmö, the month of May meant bright orange billboards reading messages like: "More than half of car trips in Malmö are ridiculously short" across the city. One central billboard even hosted an actual cyclist pedaling in place with a live band underneath to gather attention. Citizens witnessed civil servants and volunteers – dressed in bright orange jumpsuits, with shiny silver helmets – sporting bike bags that read, "I used to be a car driver" as they rode on baby blue bikes. They flooded city squares handing out bike water bottles and bicycle seat covers, as the live music played. Children sang songs on bikes and buses about the benefits of public transit, and companies with the most employees that biked to work were promoted. Citizens could enter themselves or a friend into a raffle for "the most ridiculous car journey" (less than 5 km) and the winner won a free bike. This campaign was updated every May to reflect changes to transport patterns, going from "over half of all car rides in Malmö are ridiculously short," to "38%" as the numbers fell from the campaign's visibility, while highlighting citizen engagement in the improving numbers.

Optional readings: Malmö: No Ridiculous Car Journeys

Santiago, Chile

In Santiago, the urban innovation lab, Ciudad Emergente, piloted the Shared Streets for Low Carbon Districts programme (Calles Compartidas in Spanish). Initiated in 2016 in partnership with Santiago municipality, the UK Embassy, Arup, the Eden Project and the Ministries of Transportation and Environment, Shared Streets was enacted in Santiago's Barrio Lastarria to test how streets could be transformed from car-centric to multi-use spaces for cars and people.

This process began with six months of data collection, including environmental data, bike counters and citizens' perceptions. Data was collected and then the street was painted with giant turquoise circles, cones were placed to guide cars so that bikes and pedestrians could safely pass, and street furniture made from recycled pallets invited people to stay a little longer. Formal and leisure activities were organized, including an opening ceremony with the city mayor and project dignitaries, as well as music concerts and street potlucks, where neighbors gathered to share food and build community.

What was once an area dedicated for cars, became a public space painted to look like an extended living room. Cars could pass, but people were prioritized. Picnic tables gathered neighbors; musicians performed; politicians and neighbors voiced support; and cyclists and pedestrians traveled safely. Citizen surveys were taken from pedestrians, cyclists, lunch goers and car drivers. Car and bike numbers were counted, and air quality and carbon measured through smart data sensors. According to the sensors, the Shared Streets action saw a nine-fold reduction in C02 emissions over the course of the week, a drop in air and noise pollution and an improvement in public safety and interaction.

Following the pilot testing, the process pushed for a permanent change to the street design. In 2018, a permanent bike lane was built on the site, after neighbors and the local government learned to perceive new ways of using the space. Cycling grew 560% and CO2 emissions reduced ninefold, with a significant decrease in noise and air pollution and an improvement in public safety.

Sustainable Transport

In much of the world, the car sits at the top of the transport pyramid and dominates perception regarding human transportation and planning. Since its market debut some 100 years ago, owning a car has been a sign of individual economic wealth, status and freedom. This individualistic thinking has had far-reaching societal as well as environmental consequences. And infrastructure supporting road vehicles, such as highways, streets, parking lots and garages dominate often between 50-60% of urban public space.

What if some of these car spaces were repurposed into shared public spaces, turning parking lots into tree-lined city parks, or expanding walking and biking – shared streets for multiple mobility modes, instead of just personal cars.

A transition to more sustainable mobility for 1.5°C alignment requires reducing the number of personal cars on the road significantly. But critically it is also about improving access. In many places, public transportation and cycling or walking are simply not possible – well, not yet! Where these options are limited, those without personal cars are essentially stranded. As such, this is not just about the climate crisis; it is also a fairness issue and an economic one.

A recent study by World Resource Institute found that 56% of residents in Mexico City and 42% of residents in Johannesburg (South Africa) cannot easily get to work because of their location, limited transport options, traffic congestion or a combination of these.

And people with cars often spend multiple hours in traffic, limiting work productivity from exhaustion or frustration, as well as burning fossil fuels and their personal economic resources – while spending time in a car that could be spent with family or for leisure.

Mobility

Often, we think of transportation and mobility as the same thing. It can be, but that is not always the case. Transportation is simple: moving people and stuff. But mobility is much more: it provides people with access to places necessary for living a healthy life, like work, school, healthcare, parks, and even entertainment.

To achieve better mobility, transportation within cities should be planned around human-scaled mobility. So what is that? Well in an ideal scenario, people can access everything they need for day-to-day living within a 30-minute bike ride, or public transport journey – what has become known as the 15-minute city. And the environmental, economic, social, psychological and physical benefits of increasing sustainable mobility within cities are numerous.

When people commute to work on a bike, they spend that time enjoying the outdoors and getting exercise – instead of sitting and stressing in traffic. Those who use public transportation can be productive during their commute by catching up on emails, reading or resting. And doing so will also result in significant air quality improvements, another added health benefit in addition to more exercise and less stress.

So how do we move forward on sustainable mobility to support 1.5°C alignment? Well, we need the right policy and guidance to implement mobility solutions in cities. But once they are in place, people must want to use them. For people to want to use sustainable mobility alternatives, public transport must be safe, affordable and convenient. There must also be an improvement in the availability of alternatives and physical infrastructure like safe bike parking and separate bike lanes so cyclists are not competing with speeding vehicles. These alternatives must heighten individual experience as well – people will see that cycling next to parks, community gardens, or on bike lanes safe from car traffic, can be enjoyable.

Nature-based Solutions and Ecosystem Services

Getting city planning "right" to address the climate crisis is not just about bike lanes or the energy grid. It is also about ensuring a strong connection between cities and natural systems, and incorporating nature-based solutions in our cities, for multiple reasons, including to support 1.5°C alignment. The International Union for Conservation of Nature (the IUCN) defines nature-based solutions as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

Cities should be designed as part of the wider ecosystem, instead of separate from it. Whether people realize it or not, everyone is dependent on ecosystem services from nature for everyday needs like water, oxygen, food, resources and recreation, to name only a few. Not only is nature important to provide for our everyday needs, but when we design with nature in mind, nature-based solutions can improve building efficiency, enhance livability and make cities more resilient to the climate crisis.

One example of a nature-based solution is green roofs or green walls that provide habitat for insects and migratory birds, as well as to regulate building temperature and reduce electricity use. Green roofs and green walls can even help manage extreme rain events, or "cloud bursts".

Another example is a nature-based stormwater management system, like stormwater collection channels or ponds that provide habitat for aquatic species as well as places for city-dwellers to interact with urban nature. Doing so can divert stormwater away from the energy-intensive process of wastewater treatment, and instead use stormwater collection that is integrated into a city's biodiversity points –

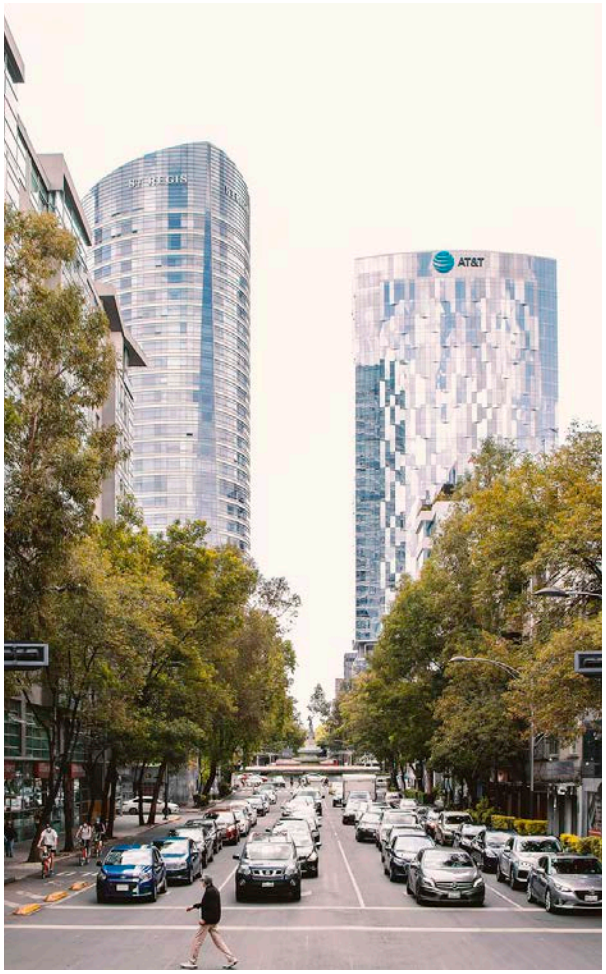
thus providing an asset to a city.

Co-benefits of NBS

Urban temperatures are already warmer than their surrounding periphery areas, due to the Urban Heat Island effect. This is caused when buildings and other dark surfaces (like roads or rooftops) absorb heat from the sun, or reflected heat from glass buildings. Additionally, energy systems and infrastructure add concentrated heat sources. When the temperature in cities increases, cooling demand also rises. Often this comes from air conditioning, adding an extra monetary cost as well as increased carbon cost.

Nature-based solutions are important to address the Urban Heat Island effect. What if we planted more trees or installed additional green roofs or gardens, instead of AC installations in order to help cool cities? Not only will an abundance of trees in urban landscapes help mitigate the urban heat island effect, but they also help capture stormwater, filter pollutants from runoff and capture CO2 to support 1.5°C alignment – as well as being far more pleasing to look at in a city landscape.

The importance of nature-based solutions for cities to address the climate crisis and related sustainability challenges – as well as for cities to live in better synergy with natural systems – is a critical new area for research and policy making and an important area for cities to follow the latest developments.



Case study Mexico City

Mexico City has worked hard to make transportation more active – one of the reasons that Mexico City was selected as WWF's OPCC Global Winner in 2020.. Mexico City is notorious for unpredictable traffic - a normal 30 minute commute sometimes taking hours. To help citizens avoid traffic and have better access to work, school, services, and entertainment, the city is putting more focus on pedestrians and bicycles. From 2008 to 2016, the city introduced new policies around active transport including: a bike share, segregated bike lanes, and mass bicycle parking at public transportation terminals. Within those eight years, bicycle trips taken within the city increased by 500%. Like many other cities, Mexico City has also implemented more shared streets, or "open street programs." Madero Street, a main street that runs through the city center, has been closed to cars since 2010. This has put more emphasis on cycling and walking, showing citizens that they may not need a car for daily transport.

The city has built one of the world's largest bus rapid transit (BRT) systems – Metrobus – and one of the world's leading bike sharing systems – Ecobici – in a major overhaul of the city's transport system. The transport sector contributed 62% of the total carbon dioxide cut during Mexico City's successful Climate Action Program 2008-2012. That program reduced emissions by 13% in just four years, beating the 12% target. As of 2014, the Metrobus corridor system consisted of five lines totaling 105 kilometers. As reported by the city, already. Metrobus typically transports 900,000 passengers a day. Until July 2021, the program has carried out extensions of the five bus lines. 173 buses were added to the Metrobus, with the Line 1 carrying 144,000 passengers per day and the Line 2 carrying 108,000.

Metrobus is designed in cooperation with ITDP, and has a silver BRT rating by ITDP's standards, which specify: segregated busways or bus-only corridors; signal priority at intersections; enhanced stations; pre-board automated fare collection and verification; at-level boarding; integration with bike sharing systems; and improvements to nearby public spaces. Line 5 and the projected Line 6 follow best practice in BRT design by including center-aligned stations, wheelchair accessibility and integrated intermodal connections such as segregated bike lanes, bicycle parking and walkable greenways in the middle of the corridors. The system has a flat fare regardless of how far passengers travel, including bus transfers. The system's operational costs are completely covered by fare collection.

The Ecobici bike sharing system was launched in 2010 in downtown Mexico City, and has since expanded twice. It is now recognized as one of the world's leading bike-share systems. As of 2014, it had 275 stations and around 4,000 bicycles, and the third ongoing expansion will add 171 stations and 2,600 bikes. The system has attracted more than one hundred thousand members, who take nearly 30,000 trips daily, accumulating more than 18 million trips to date. Ecobici was launched as a part of the city's Bicycle Mobility Strategy, which included planning for infrastructure, protected bike lanes, signposting, traffic lighting, installation of bike parking stations, road safety upgrades, an urban cyclists' manual, and modifications to transit regulations. A survey in 2012 concluded that 64% of users did not ride bicycles before signing up for the system. Eighty-six percent of respondents noted improvements in their quality of life.

Sources:

https://wwf.panda.org/?229199/Mexico-City-transport

https://wwwwwfse.cdn.triggerfish.cloud/uploads/2019/01/urban-solutions-handbook-2017_lowres_spreads.pdf

3

Renewable Energy in Cities

This chapter focuses on energy systems and starts off with an introductory description of the different energy systems and energy sectors. It then describes the available types of renewable energies. It examines the needs and approaches of transitioning towards renewable energy in cities.

3.1 BACKGROUND ON ENERGY

Energy systems

People in our societies use energy for many different reasons. Individuals and families use energy to keep warm and cool, to cook their meals and to light up the dark night. Factories use energy to turn raw materials into finished products. And we use energy to power vehicles that transport people and goods on land, air and sea. Almost all of our energy comes from the sun originally.

The sun's energy heats us directly and is stored above ground in living things and below ground in fossil fuels. The sun's energy powers our weather and our wind and has given rise to rivers and lakes. And through the years we found many ways to harness this energy for our use. We burn plants and fossil fuels to make heat. We use steam, wind and water to turn turbines and generate electricity. And in fact, the story of the Industrial Revolution and economic growth around the world has been in large part, the story of humans finding ways to put energy to use.

So until the 20th century, most of our energy use was based on heat. We burned fuels and used the heat directly to cook or stay warm. We use the energy from combustion to power a machine. Like a furnace or an engine, but over the last 100 years more and more of our energy has been harnessed in the form of electricity. And we increasingly use electricity to do things that used to be done by burning fuels directly. These days we can power our vehicles, heat our homes and even make steel using electricity. Often, energy is harnessed centrally at large plants and then distributed to the places where it's used. We use wires to deliver electricity and pipelines and trucks to deliver fuels, but energy can also be harnessed in a house or office building.

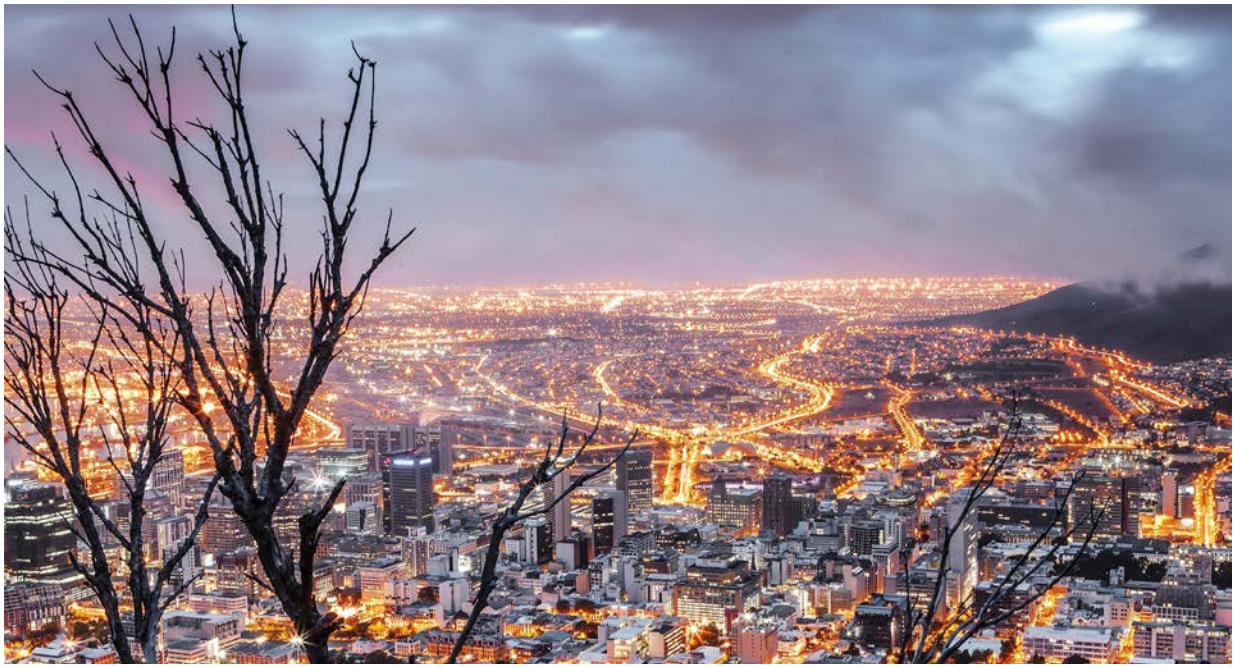
In fact, wherever you can install a generator, a boiler, a solar panel, or any other energy converting technology you can harness energy. And the interconnected web of places where energy is made and where it's used is what we call "the energy system". Cities are a part of the energy system. Much of the electricity and fuel used in cities is produced elsewhere and delivered to us, but cities are also home to factories and power plants. And the way cities plan their streets and buildings plays a crucial role in what kind of energy they need and how much. And cities are increasingly looking to take a more active role in determining how they produce, distribute and use energy. Since cities are home to more than half the world population and because so much happens in cities, their activities account for around 2/3 of global energy consumption and 70% of planet warming GHG emissions.

Energy usage and need for transition

Regardless of the source, energy is a major factor for development. It is needed for transport, industrial and commercial activities, buildings and infrastructure, water distribution, and food production. Since cities are home to more than half the world population and most of these activities take place in or around cities, it accounts for around 2/3 of global energy consumption and 70% of emissions. Buildings also consume vast amounts of energy at all stages of their existence. Energy is needed for the raw materials, construction processes, and maintenance and daily operational needs such as lighting, air conditioning, and cleaning. In addition, urban sprawl, increasing distances between destinations, and inefficient public transport systems prompt overall reliance on private motorized transport, such as cars, which have a high energy consumption, mostly of petroleum products. As the way cities plan their streets and buildings plays a crucial role in what kind of energy they need and how much, they are increasingly looking to take a more active role in determining how they produce, distribute and use energy.

Urban areas require uninterrupted energy supply. Cities, being part of the urban energy system, will need low-carbon technologies and efficient distribution infrastructures, as well as reduced overall energy consumption. The shift from fossil fuel energy reliance towards renewable energy sources will be crucial to meet the needs of cities. Major changes in demand, coming from the end-users - residents, business, and industries - will be critical to reduce the urban energy consumption. Houses, offices, and factories need to integrate efficient energy systems to promote energy saving. Cities also play an active role in developing infrastructure for a sustainable public transport system that supports non-motorized transport. Cities also need to establish policy ambitions and standards for sustainable urban energy system. Legislation and regulation of energy use and consumptions will be essential to promote the energy transition and support for research and innovation and efficient technologies to increase collaboration and mutual understanding between different sectors.

Sources: UN-Habitat, UN Energy



From fossil fuels to renewables: the energy transition

Most of the rise in energy used since the Industrial revolution has come from fossil fuels.

Fossil fuels pack a lot of energy and they can be easily shipped around the world. But fossil fuels have two big problems - They're finite and more urgently, burning them releases carbon that had been buried underground, contributing to dangerously accelerating climate change. So limiting the impacts of climate change means stopping fossil fuels and transitioning to renewable energy.

Until recently, renewable energy has been more expensive to harness than fossil energy, but that's changing. Today, generating new electricity from the sun and wind is usually cheaper than building a fossil fuel power plant. While energy from the sun and wind varies throughout the day, new solutions for optimized distribution and energy storage are making it possible to get more and more of our electricity from renewable sources. And at the same time, more activities that once required combustion of fuels like driving or heating a home can now be powered by electricity.

With time it will be possible to run the entire energy system only using renewable energy at a cost that will be similar or lower than today. But if we're going to stop climate change, the transition will need to accelerate today. Another challenge is that many people still lack access to energy and this is a major obstacle to economic development and human well-being.

The 2030 Agenda for Sustainable Development provides a shared blueprint for peace and prosperity for people on the planet now and into the future. It identifies 17 sustainable development goals or SDG's, which are an urgent call for action by all countries in a global partnership. SDG7 is to ensure access to affordable, reliable, sustainable and modern energy for all people. It directly impacts almost all of the other goals, so expanding renewable energy can help meet these goals as well.

Renewable energy, particularly wind and solar, is low emission and can significantly reduce GHGs and air pollution. It is also cost-competitive with non-renewable alternatives and an affordable way to expand energy access for the poor. The transition away from fossil fuels will be a challenge, but urban policy and planning can help make it possible. Many cities around the globe are already taking action, and the number of cities powered by at least 70% renewable electricity more than doubled between 2015 and 2017, from 42 to 101. And an increasing number of communities, cities and regions have introduced 100% renewable energy targets.

Types of renewable energies

Renewable energy sources, such as bioenergy, geothermal resources, hydropower, ocean, solar, and wind energies are natural resources that can be converted into these types of clean, usable energy.

Bioenergy is derived from recently living organic matters known as biomass, which is used for producing fuels for transportation, heat, electricity and product. It has two main categories – traditional and modern. The traditional use of bioenergy refers to the combustion of biomass such as wood, animal waste and charcoal while the modern technologies refer to liquid biofuels, bio-refineries, and biogas and other technologies. Biomass is increasingly used in populous nations with rising demand, such as Brazil, India and China. It can be directly burned for heating or power generation, or it can be converted into oil or gas substitutes. Liquid biofuels, a convenient renewable substitute for gasoline, are mostly used in the transport sector. However, using biomass for energy may put further strain on land resources, and in certain cases may indeed increase CO2 emissions. In general, using waste feedstock (e.g. agricultural residues) is better than using crops grown uniquely for bioenergy.

Geothermal energy is heat derived within the earth which

water and steam carry to the Earth's surface. The heat is accumulated from groundwater or surface water, or from the ground, e.g. by means of heat exchangers or collectors. The use of heat pumps then allows the geothermal heat to be utilized directly for heating buildings or water. The generation of electricity need high or medium temperature resources, which are usually located close to tectonically active regions. This key renewable source supplies a significant share of electricity in countries like Iceland, El Salvador, New Zealand, Kenya, and Philippines. The advantage of this renewable energy is its independence from weather conditions and its high-capacity factors. This makes geothermal power plants capable of supplying baseload electricity and providing supplementary services with flexibility.

Hydropower is energy derived from flowing water. Its basic principle is using water to drive turbines and generate energy. Hydropower plants usually consist of dams and reservoirs, in which the dams with a large reservoir rely on stored water to generate electricity on demand. Large reservoirs can retain water for months or longer, and provide flood protection and irrigation services. Hydropower without dams and reservoirs produce electricity at a smaller scale. However, in many cases hydropower can damage ecosystems, particularly large-scale projects.

Ocean energy Tides, waves and currents can be used to produce electricity. Although still at the research and development stage and not yet commercially available, ocean energy has the potential to scale up if with large and well-distributed resources. It includes four type of energy sources: wave energy, whereby converters capture the energy of ocean waves to generate electricity; tidal energy, produced by tidal-range technologies using a barrage to harvest power between high and low tide; salinity gradient energy, harnessed through differing salt concentrations, as occurs where a river empties into an ocean; and ocean thermal energy conversion, arising from the temperature difference between warm surface seawater and cold seawater at 800–1,000 metres depth.

Solar energy can be harnessed directly from the sun. It is generated in two main ways - Photovoltaics (PV) and Concentrated solar power (CSP). PV, also called solar cells, are electronic devices that convert sunlight directly into electricity. Its advantages include that the solar PV can be installed to provide electricity on a commercial scale or arranged for mini-grid or personal use. CSP uses mirrors to concentrate solar rays. It heats fluid that generates steam for driving turbine to produce electricity. CSP is applied in large-scale power plants. Solar power is one of the cleanest forms of electricity, and has great potential to meet rising energy demand. Solar may need to be combined with batteries in the future to provide power when the sun is not shining, though battery prices are expensive for now.

Wind power is harnessed through capturing the kinetic energy created by air in motion. This is transformed into electrical energy using wind turbines or wind energy conversion systems. The amount of power harvested by wind depends on the size of turbines and the length of its blades, and the output changes proportionally according to the diameters of the rotor and the cube of wind speed. The location of wind power differs in two categories – onshore and offshore. Onshore technology can unlock the potential more sites with lower wind speed while offshore technology takes advantage of the wind sources at the sea and can achieve more full-load hours depending on availability. Wind power has great potential to provide much of the world's power, but should be installed in respecting the nature and communities around it (e.g. taking into account bird flight paths and sites of natural beauty, as well as the rights of indigenous communities).

3.2 RENEWABLE ENERGY IN CITIES

How can cities promote renewable energy?

Most of the cities' energy use takes place in its residential, commercial and public buildings through heating, cooling, and the powering of appliances. Buildings can increase their use of renewable energy indirectly by buying electricity and heat from renewable producers or directly by installing solar heating, solar panels, biomass boilers, and modern cook stoves that use bioenergy. Many urban buildings also receive energy from local systems for district heating and cooling.

District energy systems consist of a network of underground insulated pipes that supply hot or cold water to multiple buildings in a district, neighborhood or city. Some systems just connect a few buildings, while others connect thousands of buildings and homes across a whole city. In many cities, this heat is generated in waste to energy plants. In this way a city can simultaneously reduce landfilled waste and minimize emissions from energy production using household or industry waste as fuel. One typical example of this is biogas, which is a byproduct of food waste. Biogas can be burned for power or heat, or it can be used as a replacement for natural gas or as a vehicle fuel.

And transportation is another area where cities can introduce renewable energy. For rail transport, the main options are electric powered trains, light rail and metro systems. For roads, the main options are electric vehicles or vehicles running on biofuels or hydrogen produced from renewable electricity. Many of the policies that drive renewable energy uptake, like carbon taxes, requirements on electricity providers, and subsidies for electric vehicles are determined at the national or international level.

But cities can still do a lot to promote renewables. Urban policymakers can promote the production of renewable energy and buildings through a range of policies and regulations like building codes, permits, zoning regulations, and building performance ratings. More specific examples include incentivizing rooftop solar panels and solar water heating. Cities also play an important role as owners and operators of their own buildings and fleets of vehicles. By using their procurement processes to purchase energy and mobility based on renewables, cities can help create a bigger market for these solutions.

Case study Barcelona, Spain Solar Power

Trailblazer for mandatory solar water heaters

Barcelona was the first European city to require solar water heaters be installed in all new buildings and renovations. This ordinance helped Barcelona reduce the carbon intensity of its electricity by about 30%.

Barcelona portrays itself as a sun city, and that's especially true when looking at the rooftops – in 2000 the city began requiring that 60% of hot water heating in all new and renovated big buildings be derived from solar panels. The ordinance applies to both public and private buildings, and in 2006 was extended to smaller buildings. In addition, Barcelona in 2002 adopted an energy plan to install solar PV panels on public buildings.

Carbon intensity reduced

As a result of these policies, the number of solar water heaters has multiplied forty-fold, to a figure of 63,000 sq m in 2008, an equivalent of 5.75 MW. If solar PV panels are added in, Barcelona's solar installations in 2008 were equivalent to a 7.4 MW power plant. With the help of these investments, energy efficiency measures and other renewable energy sources, Barcelona has reduced its carbon intensity in electricity by about 30% since 2000.

Barcelona has solar panels on bus stops and on top of the City Hall. In 2004 the city built Europe's largest urban solar array (10,500 sq m), at the Forum Esplanade as a monument to its solar orientation. In 2007 the city won the EU ManagEnergy Local Energy Action Award.

Education and maintenance have been key to the success. The Barcelona Energy Agency, established to administer the project, believes that solar panels ought to be managed like elevators – inspected on a regular basis. An information centre, run by the agency, has provided assistance in installation and maintenance.

Success spreads

Barcelona's successful model has been replicated by over 70 Spanish municipalities introducing similar regulations. In 2006 the Spanish government was the first in the world to enact a national building code requiring the installation of solar panels for both electricity and hot water in new construction and renovation for larger buildings. Many other countries have followed suit with similar programs: Italy, Portugal, India and Brazil, for example.

The regulation helped Spain move closer to Germany, Austria and Greece, Europe's leaders for solar water heating. This is a sector that has expanded hugely in the 2000s. In 2010, total world capacity reached 185 GW, of which China accounted for 64% and the EU for 14%. When it comes to solar PVs, however, Spain is one of the world's leading nations, thanks to its generous and early feed-in tariff (see also Gainesville). By 2010, Spain had an installed capacity of 3.8 GW, amounting to 10% of the world's total capacity, second only to Germany, which boasts a 44% share.

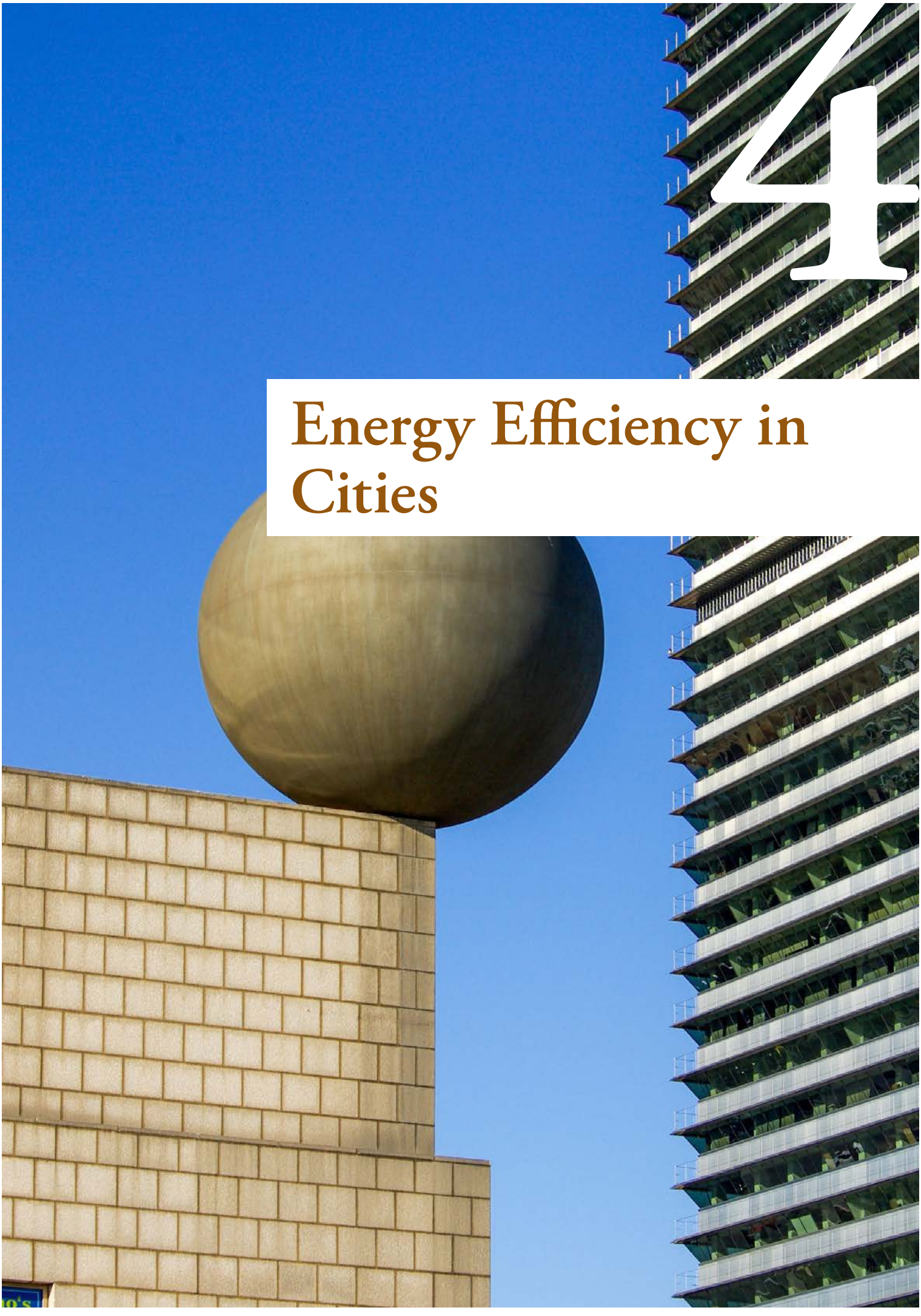
The conventional manufacturing approach, the top-down method, works in the opposition way. This starts with bulk

RECOMMENDED READINGS

Case study Reykjavik **(GEOTHERMAL ENERGY)**

Case Study Malmö **(BIOGAS)**

The transition away from oil and gas**: A WWF NETWORK POLICY POSITION**



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Energy Efficiency in Cities

This Here we explore the fundamental concepts of energy efficiency and energy sufficiency, as well as the role in climate governance. We also describe the different measures of energy efficiency that are applicable for cities as well as the policies needed to reach energy efficiency in cities.

4.1 WHAT IS ENERGY EFFICIENCY AND WHY IS IT IMPORTANT?

Efficiency vs Sufficiency

Put simply, energy efficiency means using less energy to deliver a given service and reducing energy waste as much as possible. An energy efficient air conditioner for example is one that requires less electricity to provide the same amount of cooling than other equivalent models on the market.

Energy sufficiency is a different - but linked - concept. While energy efficiency can be technical in nature, energy sufficiency has close ties to behaviour. It implies making a conscious decision to consume just enough energy to meet our basic needs, and to not go beyond that. In short, making sure that we don't consume more energy than what we reasonably need. For example, for heating, this might mean reducing the room thermostat by one or two degree Celsius and instead putting on warmer clothing.

Combining sufficiency and efficiency can bring about major gains in terms of reducing energy demand - more than only efficiency or sufficiency would bring about on their own. Recent analysis from the International Energy Agency shows that out of the emission reductions needed to achieve our climate targets, 40% can be achieved from energy efficiency alone.

Adding on the gains brought about by energy sufficiency, the potential of energy sufficiency and efficiency to drive down energy demand and limit global temperature rise to 1.5°Celsius is huge. The combination of efficiency and sufficiency is therefore a crucial opportunity to avoid the more devastating impacts of the climate crisis and to ensure that we reach the goals that the world has set itself with the Paris Agreement.

Efficiency and renewables need to complement one another

In order to limit global temperature rise to 1.5°Celsius, renewable energy and energy efficiency need to complement each other. Renewable energy needs to be deployed at a fast enough rate to meet energy needs, which can be significantly driven down through energy efficiency and sufficiency measures.

But energy efficiency improvements are not happening quickly enough to counteract global economic growth, population growth, and rising standards of living. So efforts

need to be ramped up! Since cities consume over two-thirds of the world's energy and account for about 70% of global CO2 emissions, improving energy efficiency within cities is crucial to decrease global energy demand.

The implementation of the Kigali Amendment to the Montreal Protocol offers a concrete opportunity for cities to reduce energy demand and work towards 1.5°C alignment. The Amendment focuses on commonly used refrigerants that also happen to be extremely potent GHGs called Hydrofluorocarbons (HFCs). Under the Kigali Amendment, countries will cut the use of HFCs by 85% by 2045.

As the global standard of living improves, energy demand for cooling equipment is projected to soar - and it is estimated that the demand for cooling in buildings will increase by 60% by 2030. Part of the implementation of the amendment will require deploying alternative refrigerants and cooling technologies; but another key factor to reduce the climate impact of the cooling sector is to work on driving down the energy use of cooling equipment, which represent 80% of the GHG emissions emitted by the sector.

Minimum Energy Performance Standards are an instrument used at national level, but can be advocated for by local governments to drive down energy needs. And removing inefficient appliances from the market through these standards can offset this increase in energy demand for cooling equipment.

Read more about the global energy efficiency trends here: Energy efficiency 2019

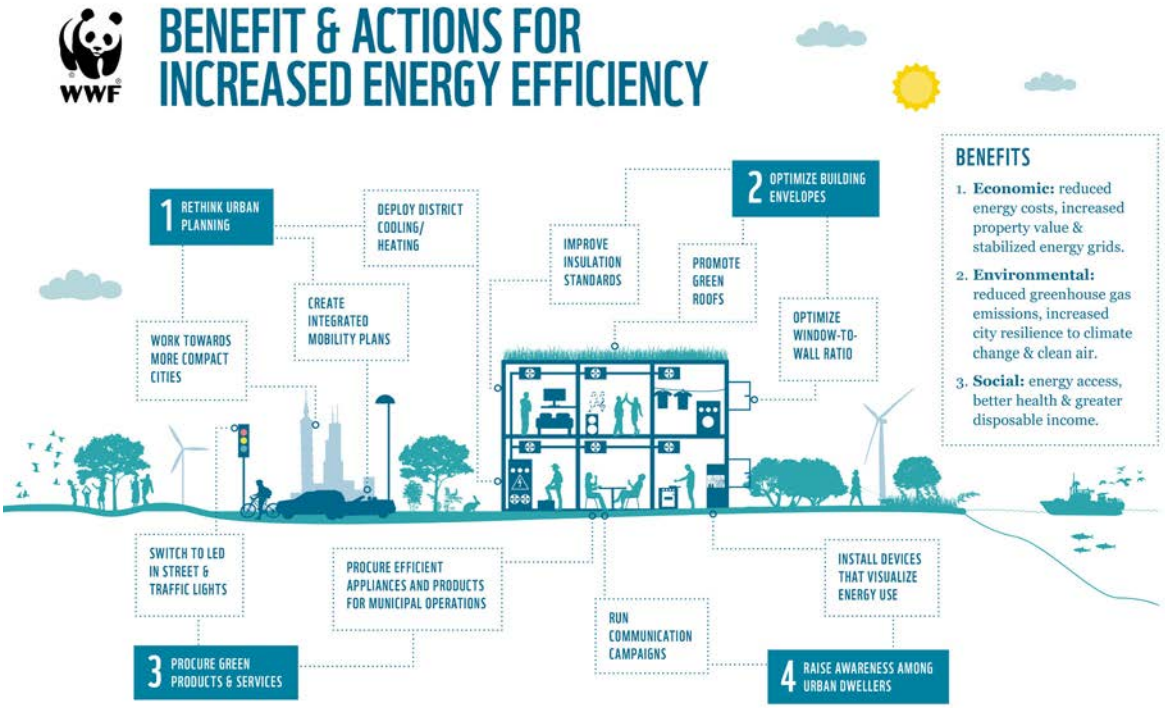
Energy efficiency benefits

Energy efficiency is crucial for cities to help limit global temperature rise within 1.5°C as it is an important component of the sustainable public procurement. There are benefits in three dimensions: social, economic, and environmental.

Economic benefits: Energy efficient products are the cheapest options in the long run as they generate lower energy bills and requires less maintenance. For example, buying desktop PCs and displays with an efficiency performance 60% higher than the Energy Star Standard allowed Italy's Consip, the central purchasing body for the Italian public sector, to save 2.3 million euros on electricity during the length of the equipment's procurement contract. It also prompts technological advancements in sectors that have evolved only marginally over decades. This can help imitative actions from business and individuals to adopt energy efficiency and stimulate innovation in cities.

Environmental benefits: Energy efficient products reduce pollutants and consume less energy and emit less GHGs throughout their life cycle, particularly for vehicles. For example, China can save 1,057 terawatt hours of electricity (equivalent to the annual production of 403 mid-sized coal plants) by 2030 by raising the energy efficiency of 9 appliances to that of the most efficient model currently on the market.

Social benefits: Cities' investment in energy efficient products can reduce the cost, making them more accessible to lower-income families. It also reduces the risks of power black-outs by reducing overall load on the grid. For example, the Lumitsits program's distribution of over 500,000 energy saving lamps in Madagascar saved $5.5 million per year in reduced peak load and fossil fuel imports. This program also generated an annual savings of $33 per household on electricity bills in a country in which 75% of the population lives on less than $1.90 per day. Similarly, improving building energy efficiency can improve building comfort levels, when cities face extreme heat or cooling.



Source: WWF OPCC Energy Efficiency Series

Energy Sufficiency

Sufficiency is an amount of something that is enough for a particular purpose. From the above, we propose this working definition of energy sufficiency: Energy sufficiency is a state in which people's basic needs for energy services are met equitably and ecological limits are respected. We will also be using the term energy sufficiency to refer to an organising principle for achieving that state.

Many of the words and phrases in this definition could be questioned. What are 'basic needs'? Why 'energy services' rather than energy? What do we mean by 'equitably, and what 'ecological limits' do we have in mind? We explore the definition as a whole in more detail below, and set out why the definition refers to energy services, rather than energy. Then there is a brief discussion of how this definition interacts with other sufficiency definitions and the concept of sustainable energy. Following this, there is a longer discussion on the concept of 'basic needs', and the question of whether there can be a distinction between needs and wants (Section 4) – as this is fundamental to the idea of sufficiency."

Source: ECEEE (2018). Energy Sufficiency: An Introduction

Recommended readings

- IEA (2020). Energy Efficiency and economic stimulus.
- IEA (2019). The Multiple Benefits of Energy Efficiency
- ECEEE (2019). Energy Sufficiency in Buildings
- UNEP (2016).OzoneAction Factsheets on the Kigali Amendment
- WWF (2020). OPCC factsheet series on energy efficiency in Cities
- WWF Energy Efficiency Series: Efficient Building Envelopes to Reduce Emissions
- "Chapter 5: Urban planning as a way of reducing energy use" (pg. 40-48) in Energy Cities (2014), 30 Energy Cities' proposals for the energy transition of cities and towns

Recommended readings

- Deep Energy Tretrofit: A Guide for Decision-Makers

4.2 WHAT MEASURES CAN YOU PUT IN PLACE IN YOUR CITY IN RELATION TO ENERGY EFFICIENCY?

Methods at the local government level

There are many ways in which energy needs within a city can be reduced while still maintaining a comfortable living and working environment for city dwellers, and in this video we will cover four of these. Namely, urban planning, optimizing buildings, improving energy efficiency of appliances and changing people's behaviour.

Let's start with efficient urban planning. Efficient urban planning has the strongest potential to drive down a city's energy demand, it should therefore be the first thing considered by policymakers in order to minimize a city's energy needs. This can be done by, for instance, limiting urban sprawl, planning construction around service and transport hubs, as well as implementing district heating and district cooling systems.

Another way to reduce energy demand in a city while still meeting consumer needs is through improving the structure of buildings. For example, many buildings in cities around the world are poorly insulated. This makes them cold in the winter, and hot in the summer. So by improving wall and ceiling insulation we can save a lot of energy. And through other means like installing appropriate windows for sun exposure we can improve on these gains even more! All this is important to think about when designing and constructing new buildings, but it is also important to carry out retrofits of older buildings to comply with higher efficiency standards.

A third way cities can decrease their energy footprint is to promote and procure more efficient appliances. Appliances have two costs - the monetary cost of the purchase and maintenance, and the energy cost required to operate it. So a cheap to buy appliance can end up being a costly affair if it requires a lot of energy to operate. One example of this is refrigerators, where older refrigerators consume several times more than a new one. In this case, getting rid of the old refrigerator in favour of a new energy efficient one can save both energy and money only after a few years! Efficiency standards, labels, rebate programs and technological innovation have made transitioning to more efficient appliances more practical and cost-effective for consumers.

The concept of cooling-as-a-service is also worth exploring, in particular in hot countries. It is a financial instrument designed to overcome market barriers to implementing more efficient cooling systems. It enables customers to base their purchasing decisions on life cycle costs, instead of upfront costs, which are often a barrier to implementing more energy efficient cooling systems. Instead of paying a large upfront cost for purchase and installation of the cooling system, customers instead pay for the cooling they receive.

The fourth way a city can reduce its energy needs is closely linked to energy sufficiency. It involves tackling behavioural aspects. For example, a city can encourage people to wear lighter clothing in the work environment during heat waves in order to reduce the need for air conditioning. Such an initiative has been running since 2005 in Japan when the government launched its Cool Biz campaign in an effort to cut the carbon emissions of its activities. This campaign encouraged government employees during summer months to set their air conditioners to no lower than 28°C and to come to work in a simpler, more casual summer dress code. Since it started in 2005, the initiative has developed outside of government circles and is followed by many businesses.

Cities can also run awareness-raising campaigns on energy sufficiency in order to make their citizens more aware of their consumption habits and their environmental impact.

Iconic building in Lima gets energy efficiency 'makeover'

Lima's famous landmark, the Palacio Municipal, is doing its part to reduce its energy usage.

Lima's bright yellow Palacio Municipal is a beautiful neoclassical building. It proudly covers the entire west side of this capital city's centrally-located Plaza Mayor, and its grand arched balconies and imposing box bay windows recall earlier eras in Peru's colorful past.

A WWF partnership with local building managers in Peru, Chile, Columbia and Vietnam saw iconic structures treated to energy efficiency 'makeovers' thanks to innovative energy management technology.

Energy efficiency: vital to reduce emissions

In essence, energy efficiency is simply making the most of every unit of energy we use. That may seem too basic to be a cornerstone in fighting the climate crisis. But to limit global temperature rise to 1.5°C, it is just as important for us to significantly cut our energy consumption as it is to move to renewable power sources.

The International Energy Agency says 40% of the emissions reductions we want can be achieved with existing energy efficiency technologies, processes, and policies. But we are not implementing these measures fast enough. Energy use is rising (up 2.3% in 2018) rather than shrinking.

There is no proven technology that can take carbon from our atmosphere in huge volumes. That makes energy efficiency our best tool – our hidden superpower, if you want – to help meet our energy needs and control rising temperatures and help avert the risks presented by the climate crisis. Which brings us back to the Palacio Municipal.

Reducing energy use at the Palacio Municipal

Using the energy management tool Smappee, WWF and building managers identify technical fixes and behavioral changes needed to makeover the building's old energy systems and lower its energy usage. Results of the makeover at Palacio Municipal will let people see how today's tools deliver efficiency and fight climate catastrophe.

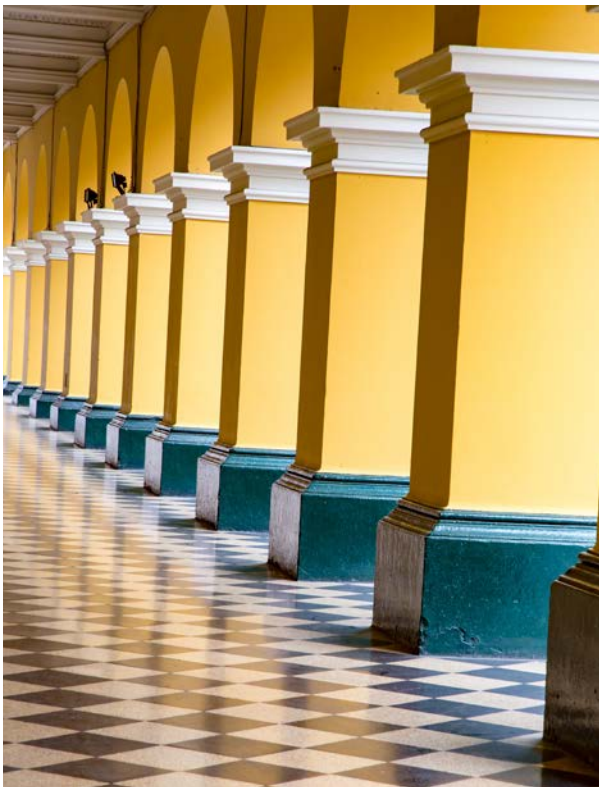
Ximena Giraldo Maca, Lima's City Services and Environmental Management Department Manager said an inventory of GHG emissions conducted in 2015 showed that 41% of the city's emissions come from stationary energy. This included energy consumption in homes, municipal buildings, industries and street lighting.

"We need to be more energy efficient. So we welcome the opportunity to test smart tools that generate data in real time, allowing us to evaluate the way in which we consume energy and to identify actions that can be applied at municipal level and replicated at a city level to improve our energy performance."

Other iconic buildings that will joined the project include the Santiago Stock Exchange in Chile, the Huong Giang Hotel in Vietnam, and La Gobernación de Cundinamarca in Colombia.

By focusing on beautiful buildings that many city dwellers already have a feeling for and a relationship with, provides residents with a vision for how energy efficiency measures can help help reduce GHG emissions.

Source: WWF project on supporting energy efficiency in iconic city buildings.



Recommended readings:

Peru to implement the Iconic Buildings Energy Efficiency Project
Bank of Bhutan is WWF's Next Iconic Building in promoting Energy Efficiency Measures
Efficient Urban Lighting in Chennai
The 'Energy Efficiency and Demand Side Management' Project of the City of Johannesburg
Seoul's Sustainable Energy Action Plan

4.3 POLICIES NEEDED TO GET THERE

Policy instruments

There are many different policy instruments that local governments can implement in order to help their cities become more energy efficient. Here we examine economic incentives, direct regulatory approaches, information programs, energy efficiency targets and public awareness-raising campaigns.

Because upfront costs are often a barrier to implementing efficiency improvements, economic incentives, like taxes or subsidies for efficiency improvements, can be implemented at the municipal level to lower the costs.

Direct regulatory approaches are another form of policy that local governments can use to improve city-wide energy efficiency. For instance, building efficiency codes and standards ensure that energy efficiency is taken into consideration at the design phase. These instruments set a minimum level of energy efficiency in buildings, and this is

best done at the state or local government level, because no single code or standard is suitable for all economies.

Building efficiency codes are commonly designed as either prescriptive, simple trade-off, or performance-based codes.

Prescriptive codes specify performance requirements for things like wall and ceiling insulation, roofs, heating, ventilation, air-conditioning and equipment efficiency.

Simple trade-off codes also prescribe performance for components but allow trade-offs among them, for example less insulation but more equipment efficiency.

And performance-based codes specify a required maximum level of energy consumption or intensity for the whole building. They require energy modeling to be conducted at the design stage.

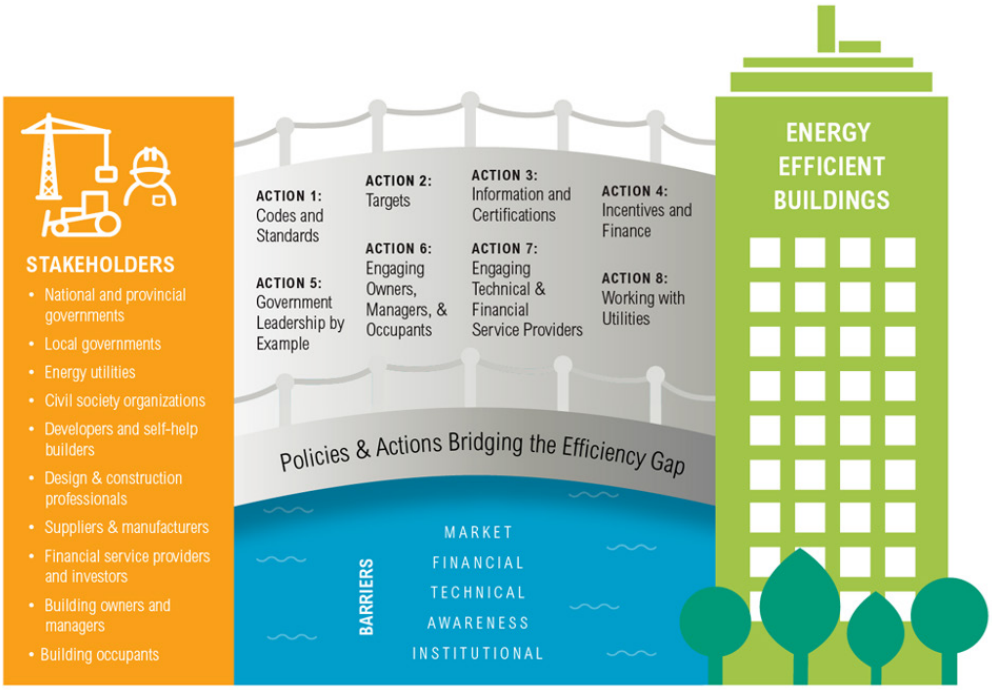
Another form of policy that is implemented at the national level, but can be advocated for at the local government level is information programs, like labelling and energy audits that enable the consumer to make informed purchasing decisions. The so-called "A-G" label, which ranks energy with A being highest, is an example of a government-backed efficiency labeling program in the EU. Products with an A-G label let consumers know that the product they are purchasing will save them money as well as energy.

Another example of information programs include government-led auditing processes. Hong Kong's 2012 Energy Audit Code for instance, requires owners of commercial buildings to carry out an energy audit on four main types of building services once every ten years. These audits present an estimate of the potential for energy savings within the buildings as well as a cost-benefit analysis of implementing the audit's recommendations. This exercise informs commercial building owners of the current efficiency of their building, as well as the cost of efficiency improvements.

Cities can also set efficiency targets. Like emission reduction targets, setting energy efficiency targets can be an effective way for local governments to improve the use of energy in their cities and to align with 1.5°C. Targets can be implemented at the city-level, institutional level, or building level. The city of New York, for instance, set in 2019 new energy efficiency targets requiring buildings that are over 25,000 square feet - such as the Empire State Building - to cut their energy use by 20% by 2030 compared to today's levels. This measure is a central part of the City's Green New Deal and is expected to significantly contribute to the city's goal of cutting its emissions by 80% by 2050.

Another key tool is public awareness-raising campaigns. They can inform city dwellers of their consumption habits, and how improved energy efficiency can lower their environmental impact. This increased awareness of the issue can inspire individuals and businesses to invest in energy efficiency improvements.

Through the "WWF UPFRONT" initiative, we monitor the electricity consumption of many of our offices using a state-of-the-art, user-friendly technology that measures a building's electricity consumption and production in real time. This information is then available through simple, attractive, online visuals that can be used by our staff or shared with partners. Through this project, WWF aims to inspire other organisations, businesses and cities to undertake similar energy efficiency improvements, enabling the scaling up of energy efficiency measures in your city and beyond.



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Policy and program pathways

Cities can develop a policy pathway and a program pathway to improve energy efficiency by combining the policies that are most adapted to their local contexts with other relevant actions.

Every policy plan should include three crucial components: the what, the how and the who.

The "what" will highlight the current efficiency of the city, identify targets, and prioritize policies. The "how" will create an action plan based on performance indicators that will allow policymakers to assess progress over time, develop a workforce, and a plan to finance projects. The "who" will identify institutions, engage with stakeholders, and develop a governance framework.

Local governments can partner with WWF to initiate the energy transition in their city through WWF's Cool and Solar Initiative. This initiative is designed to provide a package of practical and concrete energy solutions for state and non-state actors to significantly reduce the emissions related to energy use in buildings, notably by leveraging the power of electricity data visualisation, rooftop solar power generation and efficient cooling.

Recommended readings

- Chapter 2.2: Optimizing energy efficiency in buildings in C40 & The McKinsey Center for Business and Environment (2017) - Focused acceleration - A strategic approach to climate action in cities to 2030 (Pg. 29 - 38)
- WRI (2016), Accelerating Building Efficiency: 8 actions for urban leaders (Executive Summary)

Optional Readings

- C2E2 (2016), Tools for energy efficiency in buildings: a Guide for policy-makers and experts
- GABC et al. (2018) Global Status Report 2018: Towards zero-emission efficient and resilient buildings

Case Study Toronto

City of Toronto's Eco-Roof Incentive Program and Green Roof Bylaw

Between 2010 and 2017, approximately 420 green roof permits were issued in Toronto, totaling 450,000 square meters of green roof space. The Eco-Roof Incentive Program has received over 500 applications and successfully supported 336 eco-roof projects since 2009. Achievements of projects funded through the Eco-Roof Incentive Program are summarized in the table below.

AREA OF CONCERN	OUTCOMES
STORMWATER MANAGEMENT	APPROXIMATELY 11 MILLION LITERS OF STORM WATER DIVERTED FROM SEWERS ANNUALLY, RESULTING IN A COST SAVING OF AT LEAST $100,000.
ENERGY EFFICIENCY	AVERAGE OF 1000 MEGAWATT HOURS PER YEAR IN ENERGY SAVINGS PRIMARILY FROM REDUCED NEED FOR AIR CONDITIONING.
GREENHOUSE GAS EMISSION REDUCTIONS/AIR QUALITY	AVERAGE OF 220 METRIC TONS OF GHG AVOIDED ANNUALLY.
GREEN SPACE ENHANCEMENT AND BIODIVERSITY	GREEN ROOFS WILL HELP INCREASE GREEN SPACE IN THE URBAN ENVIRONMENT WITH THE POTENTIAL TO ENHANCE BIODIVERSITY.
ECONOMIC DEVELOPMENT URBAN HEAT IS	MINIMUM OF 12 PERSON-YEARS OF NEW EMPLOYMENT GENERATED.
LAND MITIGATION	WIDESPREAD IMPLEMENTATION OF GREEN ROOFS CAN REDUCE LOCAL AMBIENT AIR TEMPERATURE 1.5 TO 2°C, WITH A DIRECT 4-5°C TEMPERATURE ROOF SURFACE COOLING EFFECT.

Note: Data is only available for projects funded through the Eco-Roof Incentive Program at this time.

4.4 COURSE WRAP-UP

Call to Action

The Climate Crisis is increasingly recognized by leading scientists, world leaders, and youth movements as one of, if not the, greatest challenge humanity has ever faced. World leaders have been called on to act now and align with the Paris Agreement and limit global temperature rise to 1.5°C maximum. Our failure to do so would threaten much of the economic and social progress made since the end of World War II, while escalating the loss of natural habitats and biodiversity. Climate change is a big and complex global phenomenon; but it is also personal, impacting our cities, our communities, and ourselves.

How old will you be when the impacts of climate change become unbearable? How grave will the impacts of the climate crisis be when our children should be celebrating their birthday parties, looking forward to graduation or planning their weddings?

The endless challenges from climate change are quickly approaching. Scientists tell us that if we continue business as usual, by the year 2050, sea levels will have risen by nearly 1 meter, our ocean's coral reefs will be nearly, if not completely, gone, and global biodiversity will be a fraction of what it is now. And that world, scarred by the actions of generations that came before, is the only reality that our future children will ever know. That is, unless we act now to stop it.

Let's envision a different future for the year 2050, applying lessons discussed in this course to our cities. Imagine that your morning commute is a bike ride down a tree-lined pathway. Personal cars are no longer a necessity and the massive parking lots to store them are transformed into lush city parks. The roofs of our office buildings and apartment complexes are green sanctuaries, covered by wildflowers and butterflies. That is a future we want our children to live in.

Our cities have the capacity to move us towards a sustainable future, but they need our help to do it; it's time to commit.

"For the future of our planet, I commit to public transportation and advocating for safer and more accessible cycling. I commit to calling on my representatives to implement more nature-based solutions in integrated urban planning. I commit to pushing representatives to expand renewable energy in my city – in transport, buildings, and smart integrated urban energy systems. I commit to making changes in my own home for better energy efficiency and calling on politicians to prioritize efficiency measures, such as economic incentives, efficiency codes and standards, efficiency targets, and public awareness campaigns. I commit to fighting for a brighter future – a future in line with 1.5°C maximum global warming – and I urge you to do it too."

We encourage city representatives to join WWF's One Planet City Challenge, standing with hundreds of other cities around the world who are committed to move towards 1.5°C alignment and learn about their emission trajectories. And we call on cities to join forces to collectively demand the enabling conditions from national governments and financial institutions to support their efforts.

We call on you – as individuals, businesses, organizations, and representatives of our cities – to join our united front and sign WWF Cities' petition to commit to doing your part in your city and in your community to halt the worst impacts of the climate crisis.

WWF Horizontal Study: Policy Lessons from 1.5 C Aligned Cities

With the urgency to curb the global climate crisis, the role of local governments is clear - local governments needs to enable sustainable economies and lifestyles that provide all residents with a high quality of life, and the emissions reduction policies and technologies that are needed in sectors that cause the most emissions to achieve climate neutrality by 2050.

There are enormous benefits and economic opportunities for establishing zero-emission cities and building climate-resilient communities. However, barriers remain as local governments often face systemic financial constraints. They are also subject to democratic processes where popular mandates are obtained and maintained and the required massive transformations are difficult to achieve.

But many cities are taking actions now. In the UNFCCC's Race to Zero campaign more than a thousand cities have signed-up to show that they are committed to achieving net-zero carbon emissions by 2050 at the latest. Also, in the WWF's One Planet City Challenge (OPCC) in 2022, over 280 cities from 53 countries participated by disclosing their emissions and climate plans in the CDP-ICLEI unified reporting system.

Based on analysis of reported data and interviews with local contacts in the best performing cities in the OPCC, WWF Cities have compiled an overview of what these are doing that enables them to successfully meet the climate crisis facing cities around the globe.

Summary and reflections

In 2018, the Intergovernmental Panel on Climate Change, the IPCC, released a Special Report on the impacts of global warming if it exceeds 1.5°C. Together with the lately released reports the sixth annual reports of Working Group II and III adaptation and mitigation, climate science highlighted the need to act on climate change with urgency to reach the 1.5°C goal and the significant roles cities play in addressing the need and urgency for climate action.

Cities play an important role in global climate governance. With more than half of the global population, cities are starting to carry weight within global climate negotiations. The actions that a city or a local government takes to address the

climate crisis locally must be placed into a larger and multi-level governance system. This includes the influences and interdependencies of both vertical and horizontal levels of governance, as well as the interactions with key stakeholders and other cities and regions.

Strategic urban planning not only has the potential to make a city more sustainable, there are also multiple co-benefits for citizens, local businesses and other urban stakeholders. This includes ensuring that basic services are located close to where people live and can be easily accessible. Combined with regular access to sustainable mobility alternatives, it can decrease the need for private cars. Transportation especially in cities, is also crucial to meet the goal of 1.5°C maximum global warming. To achieve better mobility, transportation within cities should be planned around human-scaled mobility. City planning should also ensure a strong connection between cities and natural systems, and incorporating nature-based solutions.

Cities are a part of the energy system. Much of the electricity and fuel used in cities is produced elsewhere and delivered to us, but cities are also home to factories and power plants. The way cities plan streets and buildings plays a crucial role in energy utilization, as cities around the globe are increasingly looking to take a more active role in determining how to produce, distribute and use energy. The activities in cities account for around 2/3 of global energy consumption and 70% of planet warming GHG emissions.

Renewable energy can significantly reduce GHG and air pollution. It is also cost-competitive with non-renewable alternatives and an affordable way to expand energy access for the poor. Uban policy and planning can help make this energy transition possible.

For buildings in cities, renewable solutions can be through buying electricity and heat from renewable energy production or installing renewable technologies. To promote the production of renewable energy, urban policymakers can apply a range of policies and regulations like building codes, permits, and zoning regulations. More specific examples include incentivizing rooftop solar panels and solar water heating. Cities also play an important role as owners and operators of their own buildings and fleets of vehicles. By using their procurement processes to purchase energy and mobility based on renewables, cities can help create a bigger market for these solutions.

Combining energy sufficiency and efficiency can bring about major gains in terms of reducing energy demand. Renewable energy needs to be deployed at a fast enough rate to meet energy needs, which can be significantly driven down through energy efficiency and sufficiency measures. Improving energy efficiency within cities is crucial to decrease global energy demand. There are many ways in which energy needs within a city can be reduced while still maintaining a comfortable living and working environment for city dwellers, namely, efficient urban planning, optimizing the structures of buildings, improving energy efficiency of appliances and changing people's behaviour. Same are with policy instruments that local governments can implement to help their cities become more energy efficient, including economic incentives, direct regulatory approaches, information programs, energy efficiency targets and public awareness-raising campaigns.

To combat the climate crisis, we have the solutions at hand and our cities have the capacity to move towards a sustainable future. This requires commitment from urban policy makers, stakeholders, and citizens to take climate action towards 1.5C alignment. WWF Cities encourages individuals, organizations and representatives from cities to take leadership in driving the transformation towards a sustainable future.

This is a course compendium to learners inside or outside of our online classroom in the course Urban Climate Governance. By reading this compendium, you too will explore how cities can and are addressing the climate crisis, and their crucial role to support efforts to limit anthropogenic global temperature rise to 1.5°C and so avoid the worst impacts of the climate crisis.

The content in this course is produced by WWF in partnership with Lund University, and builds on our experience of working with cities to support stronger urban climate action. The good news is, we have witnessed many strong city examples from across the globe – showing us that it is possible and often beneficial for cities to take action to address the climate crisis.

Join the online course below, it is free of charge and open for all:

https://www.coursera.org/learn/urban-climate-governance

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