REN21 - Renewables in Cities 2019 Global Status Report - Preliminary Findings

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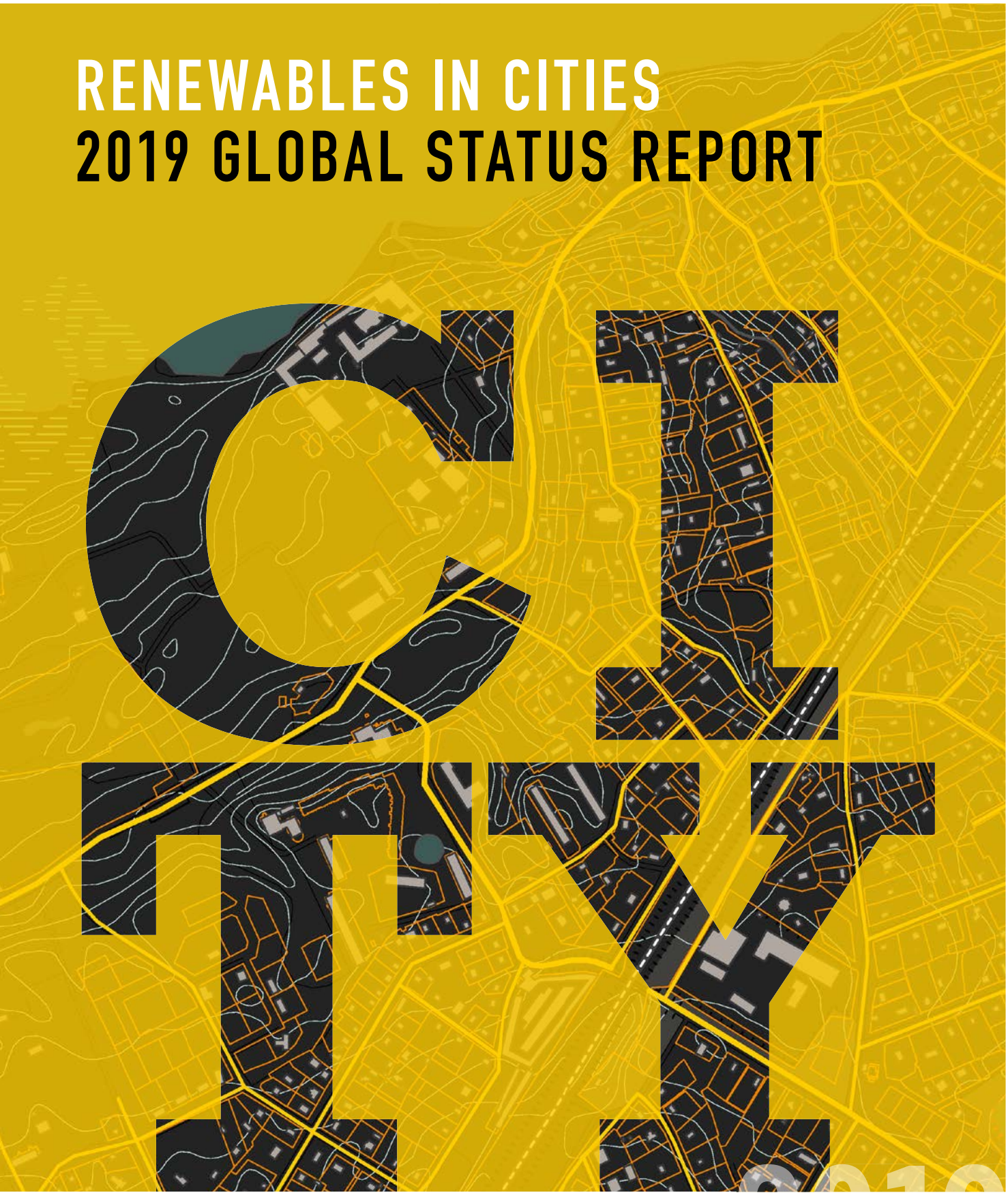
2019

REN21 Renewable Energy Policy Network for the 21st Century

RENEWABLES IN CITIES
2019 GLOBAL STATUS REPORT



PRELIMINARY FINDINGS

2019

REN21 MEMBERS

INDUSTRY ASSOCIATIONS

Alliance for Rural Electrification (ARE)
American Council on Renewable Energy (ACORE)
Associação Portuguesa de Energias Renováveis (APREN)
Association for Renewable Energy of Lusophone Countries (ALER)
Chinese Renewable Energy Industries Association (CREIA)
Clean Energy Council (CEC)
European Renewable Energies Federation (EREF)
Global Off-Grid Lighting Association (GOGLA)
Global Solar Council (GSC)
Global Wind Energy Council (GWEC)
Indian Renewable Energy Federation (IREF)
International Geothermal Association (IGA)
International Hydropower Association (IHA)
Renewable Energy Solutions for the Mediterranean (RES4MED)
World Bioenergy Association (WBA)
World Wind Energy Association (WWEA)

INTERGOVERNMENTAL ORGANISATIONS

Asian Development Bank (ADB)
Asia Pacific Energy Research Centre (APERC)
ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
European Commission (EC)
Global Environment Facility (GEF)
International Electrotechnical Commission (IEC)
International Energy Agency (IEA)
International Renewable Energy Agency (IRENA)
Islamic Development Bank (IDB)
Regional Center for Renewable Energy and Energy Efficiency (RCREEE)
Renewable Energy and Energy Efficiency Partnership (REEEP)
United Nations Development Programme (UNDP)
United Nations Environment Programme (UN Environment)
United Nations Industrial Development Organization (UNIDO)
World Bank (WB)

NGOS

Association Africaine pour l'Electrification Rurale (Club-ER)
Climate Action Network International (CAN-I)
Council on Energy, Environment and Water (CEEW)
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Fundación Energías Renovables (FER)
Global 100% Renewable Energy
Clean Cooking Alliance (CCA)
Global Forum on Sustainable Energy (GFSE)
Global Women's Network for the Energy Transition (GWNET)
Greenpeace International
ICLEI – Local Governments for Sustainability, South Asia
Institute for Sustainable Energy Policies (ISEP)
Jeunes Volontaires pour l'Environnement (JVE)
Mali Folkecenter (MFC)
Partnership for Sustainable Low Carbon Transport (SLoCaT)
Power for All
Renewable Energy Institute (REI)
World Council for Renewable Energy (WCRE)
World Future Council (WFC)
World Resources Institute (WRI)
World Wildlife Fund (WWF)

MEMBERS AT LARGE

Michael Eckhart
Mohamed El-Ashry
David Hales
Kirsty Hamilton
Peter Rae

GOVERNMENTS

Afghanistan
Brazil
Denmark
Germany
India
Mexico
Norway
South Africa
Spain
United Arab Emirates
United States of America

SCIENCE AND ACADEMIA

AEE - Institute for Sustainable Technologies (AEE INTEC)
Fundación Bariloche (FB)
International Institute for Applied Systems Analysis (IIASA)
International Solar Energy Society (ISES)
National Renewable Energy Laboratory (NREL)
South African National Energy Development Institute (SANEDI)
The Energy and Resources Institute (TERI)

CHAIR

Arthouros Zervos
National Technical University of Athens (NTUA)

EXECUTIVE SECRETARY

Rana Adib
REN21

ABOUT REN21

REN21
Renewable Energy Policy Network for the 21st Century

REN21 is an international policy network of passionate experts committed to building a sustainable energy future.

Building a sustainable energy future means...

... **having a vision:** REN21 stands for a renewables-based energy system.

... **making good decisions:** REN21 provides high-quality, up-to-date information to shape the energy debate.

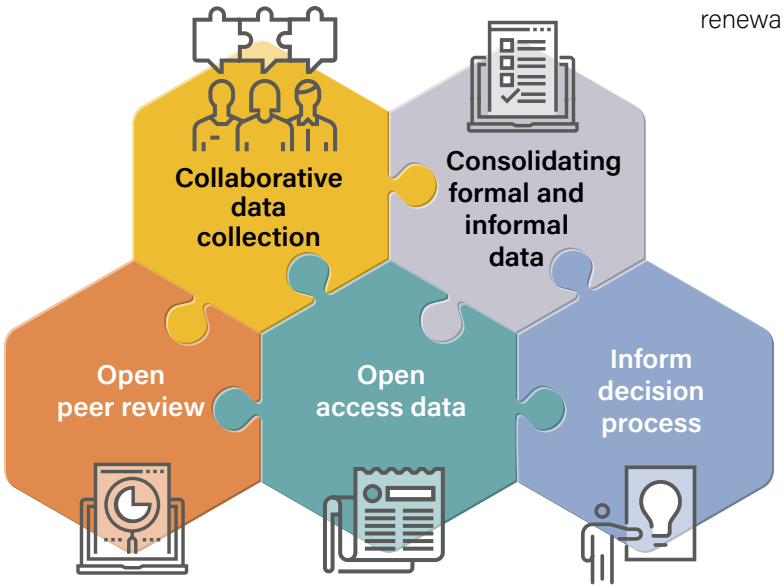
... **telling a compelling story:** REN21 consolidates information about what is happening across the energy sector to prove that the global transition to renewable energy can happen.

... **inspiring and mobilising people:** REN21 builds on an international community of players from governments, inter-governmental organisations, industry, NGOs, and science and academia.

REN21 data and reporting culture:

REN21 has developed a unique renewable energy reporting culture. REN21 is recognised as a neutral data and knowledge broker that provides credible and widely accepted information. The REN21 reporting culture comprises the following elements:

- Developing data collection processes that build on an international community of experts, allowing access to dispersed data and information that frequently are not consolidated and are difficult to collect;
- Consolidating formal (official) and informal (unofficial/unconventional) data gathered from a wide range of sources in a collaborative and transparent way (e.g., by using extensive referencing);
- Complementing and validating data and information in an open peer-review process;
- Using validated data and information to provide factbased evidence and to develop a supportive narrative to shape the global debate on the energy transition, monitor advancements and inform decision processes;
- Making data and information openly available so they can be used by people in their work to advocate for renewable energy.



Building on this process, REN21 has contributed significantly to making renewable energy visible in the global debate, drawing decision makers' attention to it and changing the norm in reporting and tracking. REN21 has been successful in "making the invisible visible" – beginning with its first status report on renewable energy in 2005 – and aims to continue in this mission by highlighting the critical role of cities in the renewable energy transition.

ABOUT THIS REPORT

Why cities?

Cities play an important role in developing and promoting the use of renewable energy. Data on local- and city-level renewable energy policies and achievements, however, are generally vast and decentralised; consolidated data are limited, and available data often are outdated. Compiling a comprehensive overview of city developments needs a dedicated process to accurately capture trends and progress.

REN21 is building on lessons learned from the GSR process to fill in some of these gaps and to showcase the many developments related to renewables at the city level. This information will appear in a new report series: *Renewables in Cities 2019 Global Status Report (REC-GSR)*. The REC-GSR will be the first comprehensive resource to map out the current trends and developments of renewable energy in cities. The result of a collaborative effort, the report series will be a powerful tool for accelerating transformations to renewables in cities, supporting city-level commitments and inspiring innovation in policy, financing and technology development. The preliminary findings presented here will serve as the basis for the first full report, to be released in September 2019.

Cities are key players in the energy transition:

55% of the global population lives in cities

Cities account

for 65% of global energy demand and

for 75% of global carbon dioxide emissions

Municipal governments have played increasingly key roles in advancing the transition to renewable energy, complementing national and state/provincial frameworks. **This includes their roles as:**

- **Owners and operators** of municipal infrastructure (such as utilities, transport networks and district heating networks), developing renewable energy plants to run this infrastructure;
- **Energy consumers** in public buildings (such as government buildings and schools), using their buying power to purchase renewables;
- **Target setters**, committing to ambitious renewable energy goals;
- **Regulators and policy makers**, using their regulatory authority to expand urban renewable energy generation, such as through building codes and land-use planning;
- **Investors**, allocating public resources;
- **Facilitators**, enablers and conveners, bringing together diverse stakeholders to co-create solutions for the energy transition; and
- **Visionaries and champions**, setting a direction for change, establishing a vision for the future and pushing other stakeholders, including national and state/provincial governments.

Data gaps exist on:

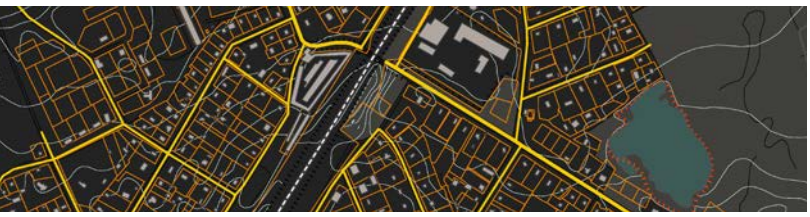
- Municipal policies / incentives to promote renewable energy deployment in power, heating and cooling, transport
- Generation capacities: Renewable energy, renewable electricity, renewable heating and cooling
  - Publicly owned (municipal, public utilities)
  - Within city boundaries
  - Community energy projects
- Renewable energy share in public transport, municipal fleets and shared transport economy
- Renewable energy share in urban district heating
- Degree of energy independence (Share of self-consumption)
- City-level policies to advance renewable energy
- Renewable energy investment in
  - Public municipal
  - Within city boundaries
  - Community energy projects
  - Public spending on renewable energy
  - Energy storage capacities
- City innovation to foster renewable energy uptake
- Penetration of digital technologies

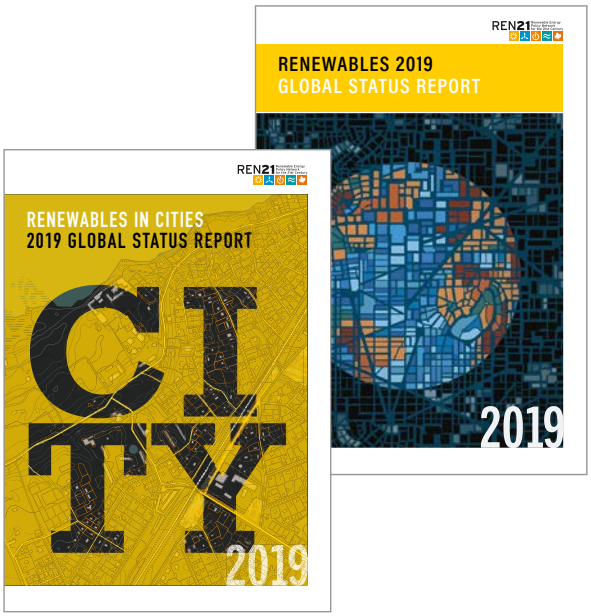
MAKING THE CONNECTIONS

Good decisions require good information. REN21's *Renewables Global Status Report (GSR)* tracks the annual development of renewables using the most up-to-date information and data available. Its neutral, fact-based approach documents in detail the annual developments in market, industry and policy. The report is a collaborative effort, drawing on an international network of more than 900 authors, contributors and reviewers from over 155 countries. Now in its 14th year, the GSR is the most frequently referenced report on renewable energy market, industry and policy trends.

Since the first edition of the GSR in 2005, REN21 has continuously expanded its reporting. To highlight regional trends, REN21 has developed Regional Renewable Energy and Energy Efficiency Status Reports and is now including reporting on renewable energy development in cities, considering the crucial involvement of cities in the energy transition and the existing data gap.

The Renewables in Cities 2019 Global Status Report builds on the success of the Renewables Global Status Report and focuses specifically on the state of renewables in cities around the world and on the role of local action in the renewable energy transition. It looks at trends and developments of renewable energy in cities and its associated benefits, including impacts on air pollution, energy security and access, and socio-economic issues. This publication will help improve understanding of cities' role in the energy transition, increase visibility for local action and showcase effective policies, finance and business models to inform decisions. The full publication will be available in September 2019.





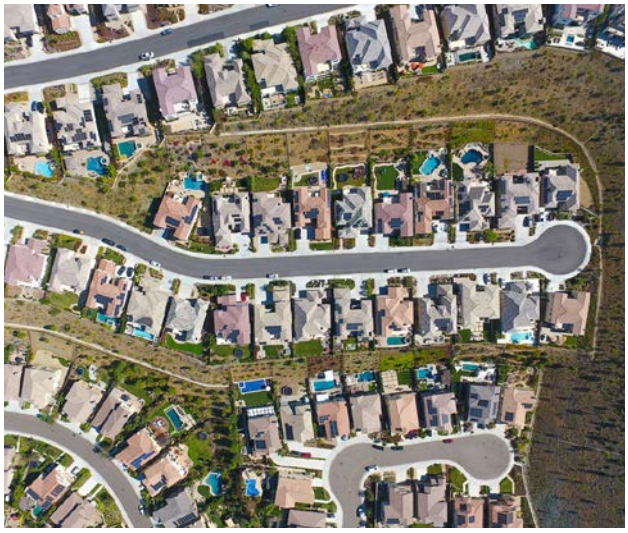
Access the reports:

www.ren21.net/GSR

www.ren21.net/cities

Bridging and building the energy future.

www.ren21.net



San Diego, United States of America

HOW TO GET INVOLVED

The production of the *Renewables in Cities 2019 Global Status Report* is a collaborative effort of many. More than 200 experts from around the world have contributed data so far, and data collection is still ongoing. We invite experts to share their expertise and to showcase renewable energy action in cities. To get involved, visit ren21.net/cities. You can also see who has contributed so far to this process.

Who is getting involved?

More than **200** experts have participated so far; many major city networks support REN21's reporting effort on cities

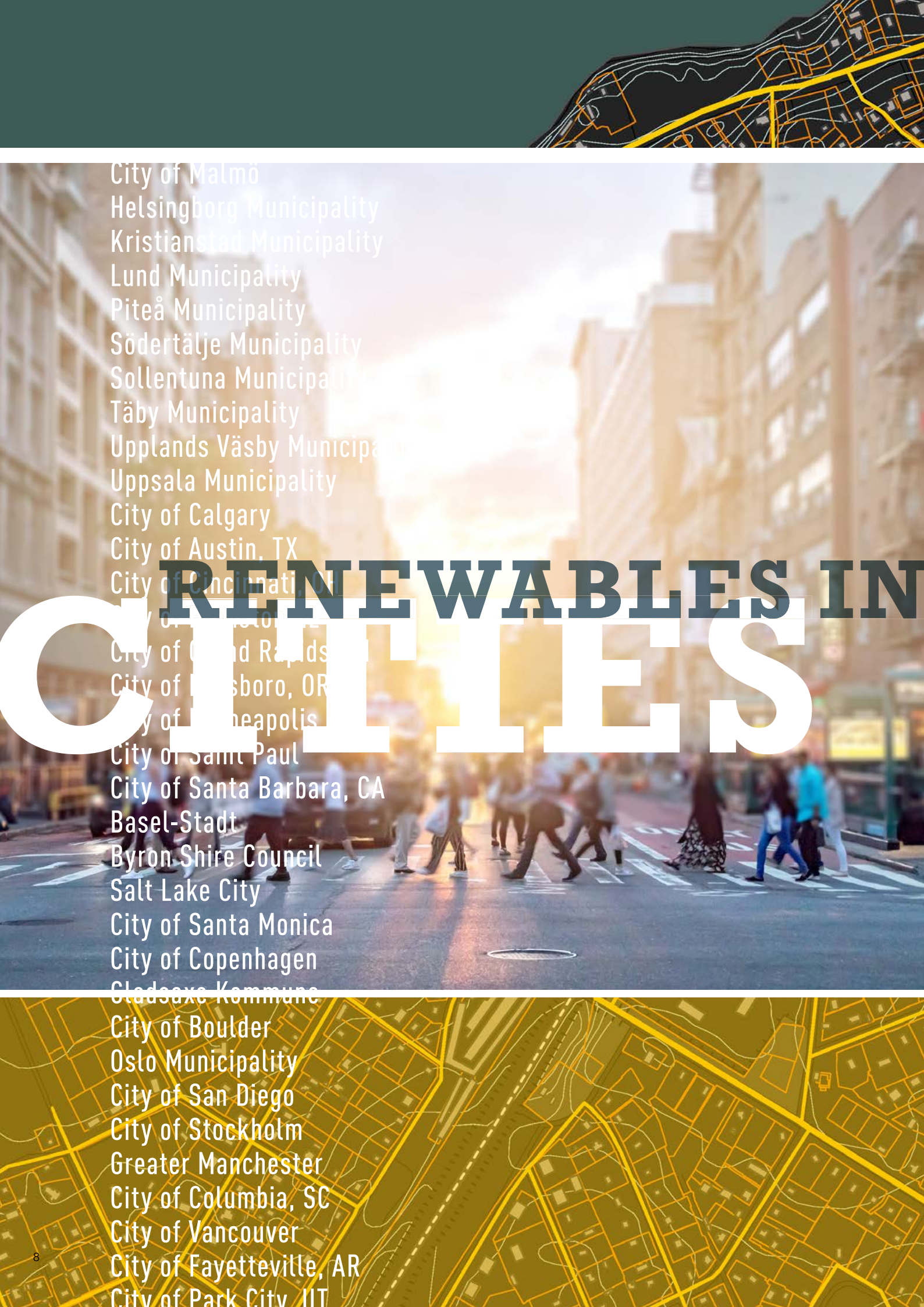
Nearly **50%** of contributors are new members of the REN21 Community, indicating the attractiveness of this focus on cities in the energy transition

More than **40** interviews with city or sector-specific experts from around the world.

- **Support data collection:** Do you know of city targets, policies or innovative business models that are integrating renewable energy in buildings, industry, transport or power grids? How are cities mobilising finance and involving citizens in renewable energy projects? Your contribution will help increase visibility for local action and showcase examples so that we can jointly shape the debate on cities in the energy transformation.
- **Peer review** the first draft of the full *Renewables in Cities Global Status Report* publication.
- **Use open-access data** to advance your work, inform decision makers and advocate for renewable energy in cities.

GET INVOLVED TODAY!

Pingtung, Chinese Taipei



RENEWABLES IN CITIES

City of Malmö
Helsingborg Municipality
Kristianstad Municipality
Lund Municipality
Piteå Municipality
Södertälje Municipality
Sollentuna Municipality
Täby Municipality
Upplands Väsby Municipality
Uppsala Municipality
City of Calgary
City of Austin, TX
City of Cincinnati, OH
City of [illegible]
City of Grand Rapids
City of [illegible]sboro, OR
City of [illegible]neapolis
City of Saint Paul
City of Santa Barbara, CA
Basel-Stadt
Byron Shire Council
Salt Lake City
City of Santa Monica
City of Copenhagen
Gladsaxe Kommune
City of Boulder
Oslo Municipality
City of San Diego
City of Stockholm
Greater Manchester
City of Columbia, SC
City of Vancouver
City of Fayetteville, AR
City of Park City, UT

RENEWABLES IN CITIES: PRELIMINARY FINDINGS

Cities[i] are at the forefront of the global energy transition.[1] By 2018, more than half the world's population – 4.2 billion people – lived in cities, up from 46.7% (2.9 billion people) in 2000.[2] Rapid urbanisation, coupled with population growth, has led to rising energy demand at the municipal level: in 2013, cities accounted for two-thirds of global energy demand, compared with less than half (45%) in 1990.[3] Cities also are important drivers of the global economy, with a growing number of cities – including London, Tokyo and New York – boasting economies larger than some G20 countries.[4] Meanwhile, cities account for around 75% of global carbon dioxide (CO_2) emissions and play a key role in addressing climate change, including limiting the rise in global average temperature to 1.5 degrees Celsius above pre-industrial levels, in line with the Paris Agreement.[5]

Cities have taken a leading role in renewable energy deployment and are adopting some of the world's most ambitious targets for renewables, putting them at the forefront of the energy transition. This renewable energy action typically does not happen in isolation, but instead is part of wider urban planning efforts and broader initiatives to transition to livable, sustainable and low-carbon cities.[6]

City actions and policies driving renewables both supplement and complement frameworks that exist at the national and state/provincial levels. Many cities have used their direct regulatory and purchasing authority to shape renewable energy pathways within their jurisdictions. Some cities are able to accomplish more ambitious renewables goals than national and state/provincial bodies, as cities can tap into strengths such as their direct responsibility for providing services to residents and ensuring day-today quality of life, their contractual relationships with energy providers and large-scale users, and their authority to create incentives that drive lifestyle and development choices at the local level.

DRIVERS FOR RENEWABLES IN CITIES

In their efforts to advance renewable energy, cities are driven by a wide range of objectives, including environmental (such as reducing air pollution and carbon emissions), socio-economic (such as reducing energy costs, providing energy access and creating local jobs) and energy security and governance goals.[7] (→ *See Figure 1.*) Renewables have the potential to achieve all of these objectives, and most cities pursue renewable energy for more than one of these reasons.

i No standardised international criteria exist to determine the boundaries of a city. In this report, "city" generally refers to the larger metropolitan area, although in some cases actions taken by particular town councils or boroughs within cities are highlighted. Beyond municipal government authorities, key city-level stakeholders include individual citizens, groups of citizens and private enterprises that are active within the realm of the city. "Urban areas" generally refers to districts within metropolitan areas that are more densely populated than suburban or peri-urban communities within the same metropolitan area. "Municipal government" refers specifically to the public administration or governing body of a city. See endnote 1.

FIGURE 1. Drivers and Opportunities for Urban Renewable Energy

Source: see endnote 7.

ENVIRONMENTAL DRIVERS

Cities are vulnerable to the impacts of **climate change**. Sea-level rise and the increased frequency of extreme weather events such as floods, droughts and storms can affect city infrastructure, livelihoods and health.[8] The more than 1 billion people worldwide who live in urban slums and informal settlements are particularly vulnerable to climate impacts, as they often live close to waterfronts and along river banks.[9] In 2017, 70% of the 96 cities that belonged to the C40 network (which represents a total of 700 million people worldwide) reported that they had experienced negative effects linked to climate change.[10]

Cities are using distributed renewable energy technologies to make their energy systems more resilient to the weather-related impacts of climate change. For example, after hurricanes Irene and Sandy hit the US east coast in 2012, locations within the New York metropolitan area began investing in renewables and microgrids to help prevent power shortages during future storms.[11] To boost resilience and meet rising energy demand, Marcus Garvey Village, a low-income housing complex in the city of New York, installed a microgrid comprising a 400 kilowatt (kW) solar photovoltaic (PV) system, a 400 kW fuel cell system and a 300 kW battery storage system.[12]

Elsewhere in the United States, the city of Boulder (Colorado) implemented a solar-plus-storage system in 2018 that enables municipal operations to continue during power emergencies, and in early 2019 Chicago (Illinois) presented its roadmap for urban resilience, including a transition to 100% renewable energy.[13] In the African city of Kamenge (Burundi) – where 95% of the population does not have access to electricity and the national power supply cannot keep up with growing demand – the city has installed a 260 kW PV system at the Hospital University Center to provide more reliable energy.[14]

At the same time, cities are significant contributors to climate change, accounting for two-thirds of total energy demand and for around 75% of global CO_2 emissions.[15] Globally, the electricity and heating sectors (combined) and the transport sector account for a majority of CO_2 emissions from fuel combustion – contributing 42% and 24%, respectively – or 66% together – in 2016.[16] A large share of these emissions occur in cities: in 2018, one-fifth of global CO_2 emissions came from only 100 cities, including Guangzhou (China), London (United Kingdom), New Delhi (India) and Seoul (Republic of Korea).[17] Thus, cities must play a key role in reducing emissions, including by integrating renewable energy in their decarbonisation strategies.[18]

In addition, worldwide increases in road transport, industrial activity and power generation, as well as the open burning of waste in many cities contribute to elevated levels of **urban air pollution**. In many developing countries, the use of charcoal and fuelwood for heating and cooking in urban areas also contributes to poor indoor air quality. In 2016, an estimated 91% of the global urban population was exposed to fine particulate matter (PM 2.5) levels exceeding World Health Organization guidelines, and more than half of the urban population was exposed to air pollution levels at least 2.5 times above the safety standard.[19] High levels of ambient air pollution contributed to the deaths of some 4.2 million people worldwide in 2016.[20]

Reducing CO_2 and other harmful emissions and addressing **public health concerns** is a priority for local governments, and the deployment of renewables has become integral to city efforts in this context. Beijing (China) has been replacing coal-fired power generation with renewable energy since 2013, and in 2018, in a push to improve urban air quality, the city announced a target to achieve an 8% renewable energy share in its total final energy consumption by 2020.[21] Overall, the deployment of renewable energy in Chinese cities, along with energy efficiency measures, contributed to an estimated 12% reduction in average PM 2.5 concentrations in surveyed cities between 2017 and 2018.[22]

London, United Kingdom

SOCIO-ECONOMIC DRIVERS

Cities are attracted to renewable energy solutions because of the many socio-economic benefits renewables offer. These include the potential to create new local industries and businesses as well as associated jobs. In developing and emerging economies in particular, cities are deploying renewables as a means to meet rising energy demand and to provide energy access to populations that previously were without electricity and/or lacked clean energy for cooking.

Significant reductions in renewable energy costs in recent years (particularly for wind power and solar PV, where module prices have fallen 80% since 2009) have only increased interest in renewables, providing cities with opportunities to reduce and more easily control **municipal energy expenses**.[23] In 2015, the city of Washington, D.C. (United States) installed solar panels on the roofs and parking lots of 34 government-owned facilities, driven by expected savings of USD 25 million over the 20-year duration of the power purchase agreement.[24] In 2018 the city announced a broader goal of achieving 100% renewable electricity by 2032.[25] In South Tarawa (Kiribati), the city government installed grid-connected solar systems totalling 548 kW on four buildings in 2016, a move that was expected to save the national government USD 290,000 in reduced diesel fuel consumption.[26]

In light of drastic cost reductions in renewables, municipal governments have been replacing imported fuels with local renewable energy as an opportunity to retain and attract local industries and businesses, thereby keeping revenue local and spurring **urban development**.[27] East Hampton (New York, United States) has set ambitious targets for 100% renewable electricity by 2020 and for 100% renewables use in heating and transport by 2030, with the aim of boosting the local economy and creating jobs.[28] In Europe, Stockholm (Sweden) has attracted companies to the city's data parks, which offer a combination of renewable power and waste heat recovery that is fed into the local district heating system.[29] Meanwhile, Freiburg (Germany) and Samsø (Denmark) are among a growing number of cities that have used their renewable energy strategies as branding tools to attract tourists, thereby stimulating the local economy.[30]

Worldwide, the number of **jobs** in renewable energy – for example, in research and development, project development, engineering, installation, and operation and maintenance – is increasing (to a total of 10.3 million in 2017).[31] In cities, the creation of employment opportunities is an important driver of policy implementation for renewables.[32] China is the leading country for renewable energy jobs, and many cities nationwide have experienced rapid growth in the sector: in Dezhou, in Shandong province, local policy support for solar power resulted in the presence of 120 solar companies by 2010.[33] In 2018, the United States was home to more than 320,000 renewable energy jobs across 50 cities, led by Los Angeles, California (41,000 jobs) and New York City (21,000 jobs).[34] In the Netherlands, a district heating project launched in 2008 in the former coal mining town of Heerlen – which uses an abandoned coal mine for geothermal energy production – has a specific focus on training former coal industry workers.[35]

Increasingly, cities in the developing world are adopting renewable energy policies and targets to advance **energy access**, particularly in suburban and peri-urban areas as well as in urban slums and informal settlements. Overall, energy access in cities is expanding, despite rapidly rising energy demand. In sub-Saharan Africa, nearly 76% of the urban population had access to electricity by 2016, up from only 60% in 2000.[36] However, worldwide, more than 110 million people in cities (and over 1.1 billion people in total) still lacked electricity in 2018, as the overall growth in the urban population offset gains in electricity access.[37] In many cities in the developing world (and in some industrialised countries), part of the population relies on the direct burning of inexpensive fuels such as charcoal and scrap wood for cooking and heating, affecting both ambient and indoor air quality.

Many cities have embraced distributed renewable energy systems as cost-effective options for providing access to modern energy services – including for electricity, space and water heating, and cooking fuel.[38] In 2012, the district of Kasese in western Uganda set a target for 100% electricity access by 2020 (as of 2015, only 7.6% of the district's 134,000 households had grid access) based on a transition to 100% renewables using micro-hydropower, solar PV, biomass and geothermal.[39] By 2015, tens of thousands more Kasese residents had acquired energy access – including many off-grid – and renewables were supplying energy to an estimated 26.8% of the district.[40] Numerous other efforts in Africa and worldwide support the deployment of distributed renewables for energy access in urban areas. In South Africa, the University of Witwatersrand in Johannesburg developed a 420 kW solar district heating system in 2018 to service 14 student residence buildings.[41]

Washington, United States of America

ENERGY SECURITY AND GOVERNANCE

Cities have advanced the local production and use of renewable energy to address **energy security** challenges and to improve urban governance. The lack of energy security, referring to the absence of reliable access to affordable energy resources, can take a number of forms and results from wide-ranging factors including geopolitical instability, climate change impacts, fuel shortages and price fluctuations.[42] Many cities see a transition to renewables as a way to insulate their residents and economies from the risks associated with dependence on imported fossil fuels.[43] For example, energy security was a key factor behind the Ukrainian city of Zhytomyr's decision to adopt a target for 100% renewable energy by 2050.[44]

Cities also are advancing renewables in an effort to improve the **governance** of their energy systems. In Germany, Japan and the United States, the desire for more direct citizen or municipal ownership of key energy infrastructure (also referred to as energy democracy[i]) is playing an increasing role in city action.[45] A growing number of municipalities in these countries have taken ownership of infrastructure such as district heating systems, local power grids and generation assets – often as part of efforts to increase the share of renewables in the mix – and this trend is expanding elsewhere.[46] For example, the municipal government of Hamburg (Germany) used the results of a 2013 local referendum to purchase the city's electricity and gas distribution grids in 2014, and the city's district heating system in 2018.[47]

At the same time, cities are using renewable energy to provide civil society with the opportunity to participate in municipal initiatives, particularly in light of growing public demand for more ambitious climate action. (→ *See Civil Society section.*) The participation of local residents, organisations and others in renewable energy can take a variety of forms, including supporting the development of community energy projects.[48] For example, as part of its plan to generate 20% of electricity demand locally by 2050, Paris (France) is making public spaces and rooftops available to a local co-operative for the installation of solar PV plants, which also allows residents to invest in the co-op.[49]

OPPORTUNITIES FOR URBAN RENEWABLE ENERGY

Cities are advancing renewable energy in the electricity, heating and cooling, and transport sectors. They also are developing cross-sectoral approaches, for example using urban waste and wastewater streams as feedstocks to produce biogas, biomethane and other renewable energy sources.[50] In many cities, there is growing recognition of the opportunities that exist in increasing the use of local, renewable energy sources, driving policy makers to adopt renewable energy targets and support policies.

In the **power sector**, the number of cities powered by at least 70% renewable electricity more than doubled between 2015 and early 2018 (from 42 to 101[ii]), including Auckland (New Zealand), Dar es Salaam (Tanzania), Nairobi (Kenya) and Seattle (United States) (→ *See Figure 2.*).[51] Of the cities reporting, more than 275 cities use hydropower, 189 electricity and 184 solar PV.[52] More than 40 cities were already entirely powered by renewables, with the majority in Latin America (30), the US cities of Burlington (Vermont), Georgetown (Texas) and Rock Port (Missouri), as well as Reykjavik (Iceland) and Shenzhen (China).[53] Many cities boasted higher shares of renewable electricity than their national counterparts, showcasing their leadership in advancing renewables.

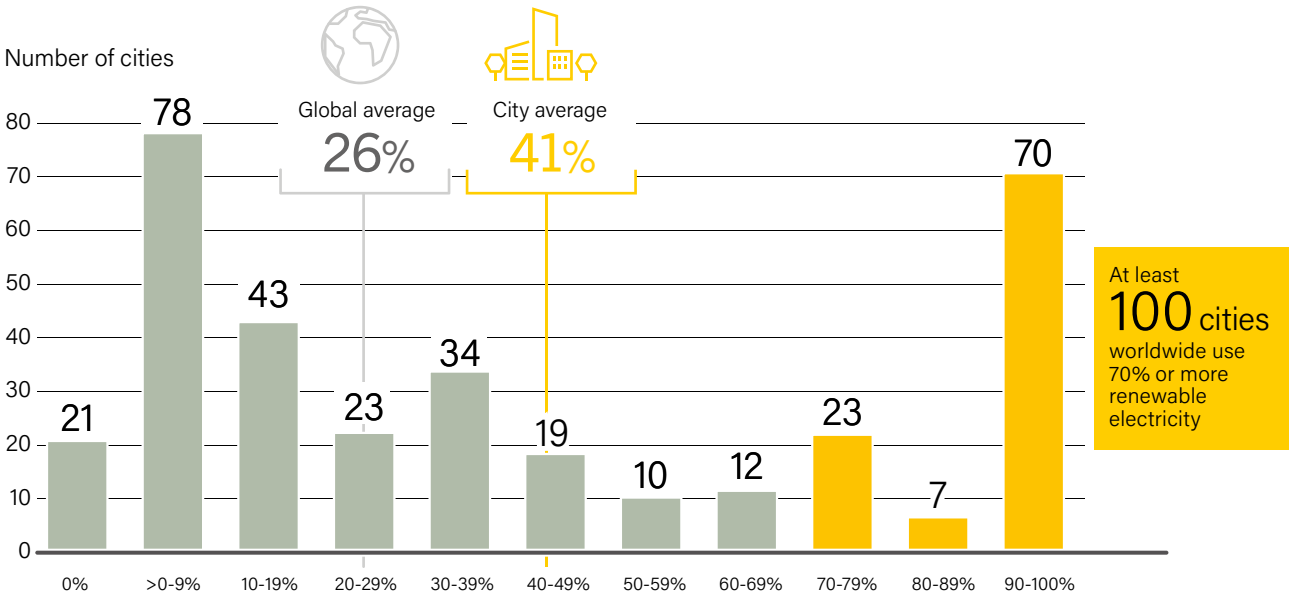
Cities are increasingly integrating renewables – such as bioenergy, geothermal and solar thermal – into their **heating and cooling sectors**. A growing number of cities are starting to promote the use of electric heating for both space and water heating, as these loads represent significant sources of flexible demand that can be used to ease the integration of variable renewable energy into the grid.[54] In cities across China, building codes requiring the installation of solar water heaters on residences, public buildings and other structures have helped increase the country's total solar thermal capacity to more than 375 GW – or 78% of global installed capacity – making China the world's largest market for solar thermal technologies.[55]

District Heating, Russia

i Energy democracy goes beyond national security of the energy supply to bringing energy resources and infrastructure under public or community ownership or control. See endnote 45.

ii Of the more than 570 cities that self-reported via CDP, more than 100 reported that they were sourcing at least 70% of their electricity from renewables. See endnote 51

FIGURE 2. Renewable Power Shares in Selected Cities, 2017



The figure shows shares of renewables in the electricity consumption of 340 cities that self-reported to CDP.

Note: City average is calculated based on the 340 cities shown.
Categories include all values below the lower limit of adjacent category.

Source: see endnote 51.

Urban **district heating and cooling networks** provide an opportunity for cities to integrate renewables into the heating and cooling sector. Globally, bioenergy provides 95% of the renewable energy used in district heating, and has been growing rapidly at more than 5% annually during the period 2006-2017.[56] In Austria, more than 2,100 municipal district heating systems use local biomass purchased from local farmers as a primary fuel source.[57] Similarly, Saint Paul (Minnesota, United States), converted its district heating and cooling system to municipal wood waste, with 65 megawatts (MW) of heating capacity and 25 MW of power capacity and in early 2019 phased out coal completely.[58] In Tartu (Estonia), the district heating system is based primarily on biomass derived from local wood chips, combined with solar and geothermal; natural gas is used only when renewable energy sources are insufficient.[59]

Cities also are supporting the use of renewables in the **transport** sector, both through their own investments as well as through supportive regulation. Many cities are in the process of transitioning their public transit and/or municipal fleets to run on biofuels or hydrogen, or are increasing the number of electric vehicles (EVs) that they use. As the operating costs of EVs continue to fall, operators of fleet vehicles (such as city buses and trams, taxis and municipal vehicles) as well as car sharing companies are finding it increasingly attractive to go electric.[60]

In 2017, some 385,000 electric buses were operating in over 300 cities worldwide.[61] More than 98% of these buses were deployed in China, but the vehicles also were present in Berlin (Germany), Moscow (Russian Federation) and Tshwane (South Africa).[62] The European EV bus market has expanded in recent years, and in 2017 some 1,250 EV buses were ordered in the region, representing 10% of the city bus market.[63] In 2018, an estimated 5% of city buses registered in Western Europe and Poland were electric.[64]

While EVs and other forms of electrified transport by themselves do not increase the renewable share of energy consumption, they enable the use of renewable electricity in the transport sector. For example, in 2018 Santiago (Chile) commissioned a 100 MW solar PV park to supply more than half the electricity demand of its underground rapid transit system.[65] In Melbourne (Australia), the city's entire tram system of 410 cars is transitioning to solar power, supplied by electricity from a 35 MW solar PV plant slated for completion in 2019.[66] In New Delhi (India), trains of the Delhi Metro Rail Corporation are being powered in part by off-site solar PV, while auxiliary services such as lighting and air conditioning are being powered by on-site rooftop solar PV.[67]

Commonly, municipalities are responsible for managing the large volumes of **waste and wastewater** produced at the city level – and increasingly, they must face the social, economic, environmental and health impacts of this mounting waste. In 2017, more than 80% of urban wastewater was still being discharged directly into the world's waterways: the city of Lagos (Nigeria) alone generated 1.5 million cubic metres of wastewater every day, most of which flowed untreated into the Lagos Lagoon.[68] The world's cities also generated some

2 billion metric tonnes of solid waste In 2016, an amount that is projected to increase 70% by 2050, to 3.4 billion tonnes.[69] When landfilled, the organic portion of municipal solid waste can release large amounts of methane, which, if not captured to be flared or used, can contribute significantly to global warming[i].[70]

By developing waste-to-energy – particularly waste-to-biogas – cities have the opportunity to minimise the environmental and other impacts of their urban waste while producing a local, renewable energy source. Because biogas is created through the anaerobic digestion of any organic material, in cities it can be produced from the organic portion of municipal solid waste, from restaurant waste, from wastewater sludge and from waste from surrounding agri-businesses. Biogas can provide heat and electricity and also can be upgraded to biomethane, a renewable substitute for natural gas that can be injected into the natural gas grid or used to fuel natural gas vehicles.[71]

As of 2018, more than 10,000 digesters in Europe and more than 2,200 sites in all 50 US states were producing biogas, often in or close to cities.[72] Although the technology has been deployed mainly in Europe and North America, it is expanding elsewhere: in Yabu City (Japan), a new waste-to-biogas production facility that will convert farm and food waste into renewable energy is scheduled to begin operation in 2019.[73] The plant will convert biogas produced from the digestion process into some 1.4 megawatt-hours (MWh) of electricity per year, and the waste heat will be used by a nearby greenhouse.[74]

In Europe, more than 500 biomethane installations were in operation as of the end of 2018, many of them in cities.[75] Across Sweden, more than 60% of municipalities collect food waste for energy purposes, producing an estimated 5.2 PJ of biomethane annually that can be injected into the local gas grid for use as a transport fuel.[76] In Kalundborg (Denmark), a biogas plant will use 300,000 tonnes of factory waste to produce 8 million cubic metres of biomethane per year.[77] In Beerse (Belgium), a digester facility that uses garden and vegetable waste from local households to produce heat and electricity in an existing combined heat and power (CHP) plant was upgraded in 2018 to transform 25% of the biogas into biomethane.[78]

Elsewhere, an organic waste-to-energy plant in Rialto (California) processes 700 tonnes of food and 300 tonnes of biosolids daily to produce biomethane and electricity.[79] Biomethane plants also are being developed rapidly in China, where some 140 plants were in operation country-wide by the end of 2018, including sludge-to-energy systems in Beijing, Changsha, Chengdu, Hefei and Jinmen.[80] In Karachi (Pakistan), a new bus rapid transit system with more than 200 public buses, due to start operating in 2020, will be powered by biomethane produced from 3,200 tonnes of cow manure.[81]

CITY LEADERSHIP IN THE GLOBAL ENERGY TRANSITION

In many parts of the world, cities have developed ambitious targets for renewable energy deployment and are implementing innovative projects as a result. In numerous cases, these commitments and actions at the municipal level have exceeded the ambition at the national and state/provincial levels, making cities leaders in accelerating the worldwide transition to renewables.[82]

City policies can supplement and complement renewable energy policies designed at other levels of government. Many city-level strategies are informed to some extent by national strategies and policies; however, the intensity of co-operation between municipal governments and national and state/provincial governments (referred to as vertical integration or multi-level governance[ii]) varies widely.[83] In some cases, cities have been held back in their renewable energy ambitions because of policies at a national or state/provincial level, or because of a lack of local ownership.[84] This may occur, for example, when actors other than the city government have full or partial control of urban infrastructure systems (electricity, waste, water), whether by regulation, through the presence of public-private partnerships, or in the case of direct ownership and funding from the national or state/provincial level.[85]

In cases of shared jurisdiction, transforming the energy systems at the city level may require support from the national and state/provincial governments.[86] In some instances, national governments may develop incentives that encourage renewable energy action at the city level, in addition to providing cities with access to financial and other resources. In 2018, the Indian government allocated INR 1 billion (around USD 15.8 million) to 60 cities across the country to develop a combined 8.1 MW of solar PV projects and to install solar water heating systems covering 7,894 square metres of collector area.[87] The government of Canada has committed CAD 21.9 billion (USD 16.2 billion) in green infrastructure funding, some of which is directly available to cities to invest in local priorities.[88]

Rio de Janeiro, Brazil

i Methane gas created in landfills has 21 times the near-term global warming potential of CO_2 and accounts for 14% of global greenhouse gas emissions. For example, the EU tackles landfill gas under its Climate and Energy Package, and in the United States regulations require that landfill gas containing high concentrations of methane be prevented from going beyond the landfill boundary. See endnote 70

ii Vertical integration refers to close co-operation and collaborative decision making between different levels of government. In this type of governance arrangement, national and state/provincial governments are able to work with cities to provide incentives, funding and larger policy mandates than cities could provide on their own.

Climate action at the city level has contributed to national-level commitments to reduce greenhouse gas emissions and to take steps towards climate mitigation and adaptation. For example, as part of their Nationally Determined Contributions (NDCs) submitted under the Paris Agreement, 113 national governments out of 164 made commitments as of 2016 to support the transition to low-carbon cities.[89]

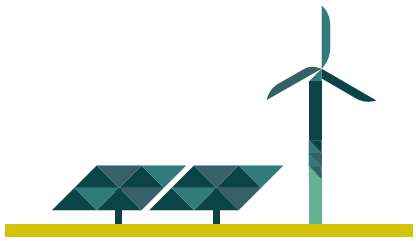
By contributing to wider global efforts, municipal governments ensure that city voices are represented at the national and international levels, while national and state/provincial governments are able to connect more directly with communities to understand local priorities and create more effective policies.[90]

At the Climate Summit for Local Leaders, held in parallel to the 2015 United Nations climate negotiations in Paris, 440 mayors from five continents demonstrated their willingness to partner globally by committing to reduce 3.7 gigatonnes of urban greenhouse gas emissions annually by 2030.[91] Since then, cities worldwide have accelerated their efforts to address climate change, including through energy efficiency improvements and renewable energy deployment.

City-level climate commitments often have exceeded the ambitions of the country-level NDCs, highlighting the importance of vertical co-operation.[92] For example, in response to the withdrawal of the United States from the Paris Agreement in 2017, the US Conference of Mayors – representing more than 1,400 cities nationwide – adopted a resolution in support of 100% renewables; similarly, the We Are Still In coalition, which includes more than 280 US cities and counties, pledged to honour the Paris Agreement.[93] In Japan, 158 local governments, businesses, non-governmental organisations and research institutions signed the Nagano Declaration in 2017, committing to increase co-operation and accelerate the transition to 100% renewable energy cities.[94]

At both the national and international levels, networks of municipal governments have expanded their scope and membership to increase their capacity, share learning on climate and energy solutions, and inspire other cities to act. In 2018, another 1,800 signatories joined the Global Covenant of Mayors – committing to actions to address climate change, including scaling up renewable energy – bringing the total number of signatories to 9,400 municipalities, representing some 770 million people or nearly 10% of the global population[i].[95] Similarly, by the end of 2018, the international network C40 connected 96 cities (representing more than 700 million people and 25% of gross world product) to take climate action, and ICLEI – Local Governments for Sustainability united more than 1,750 local and regional governments committed to sustainable urban development, representing more than a quarter of the global urban population.[96] In early 2019, ICLEI began collaborating with CDP to streamline the process of city climate reporting, including on renewable energy, by engaging in joint reporting.[97]

Hills of east San Francisco bay, California, United States of America

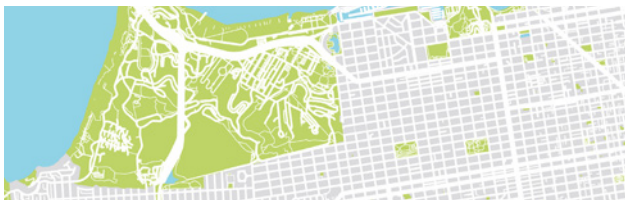


i Since 2017, the group has formally brought together the EU's Covenant of Mayors and the Compact of Mayors to advance the city-level transition to a low-emission, climate-resilient economy and to demonstrate the global impact of local action. See endnote 95.

AMBITIONS, TARGETS AND POLICIES

To advance the energy transition within their jurisdictions, many cities have committed to ambitious renewable energy targets. Cities are using a diverse toolbox of policy mechanisms to help achieve these targets, including regulatory policies, such as obligations, building codes and outright bans of certain technologies and fuels; fiscal and financial incentives, including tax incentives and low-interest loans; and public financing mechanisms, such as public procurement and direct public investment.[98] (→ *See Table 1.*)

As at the national level, most of the support for renewables at the city level has been directed towards the electricity sector. However, policies supporting the use of renewables in the heating, cooling and transport sectors, as well as measures linking renewables and energy efficiency, are gaining momentum.



TARGETS

By the end of 2018, more than 200 cities worldwide had committed to 100% renewable electricity in the **power** sector, with target years ranging between 2020 and 2050.[99] (→ *See Figure 3.*) In the United States alone, more than 100 cities and towns had established targets for 100% renewables by year's end, including most recently Cincinnati (Ohio), Minneapolis (Minnesota) and Washington, D.C.[100] Many other cities, such as Adelaide (Australia), have adopted targets for renewable energy use in municipal operations, with the intention of setting an example for businesses and civil society to follow.[101] Some cities – including Malmö (Sweden) and Breckenridge (Colorado) – first set targets for renewables in government operations, then later extended them to municipality-wide targets.[102]

Cities also have made commitments for renewable-based **heating and cooling**. In 2018, 19 cities across five continents, representing 130 million people, pledged through C40 to ensure that all new buildings are net-zero carbon[i] by 2030, including through the use of renewables in heating and cooling.[103] These signatory cities also set a target to expand their net-zero carbon goal to cover all buildings by 2050.[104] By the end of 2018, more than 110 cities and municipalities had adopted targets for 100% renewable heating and cooling.[105] (→ *See Figure 3.*)

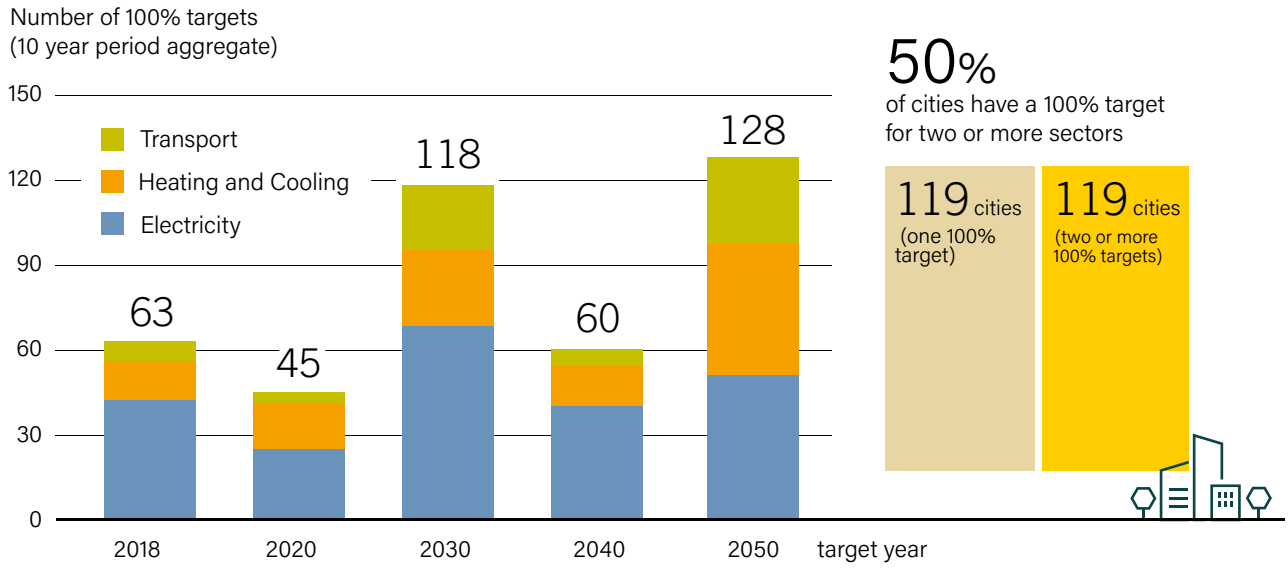
TABLE 1. Overview of Selected Renewable Energy Policies in Cities

Policy Type	Policy Definition
Targets	**Target:** An official commitment, plan or goal set by a government (at the local, state, national or regional level) to achieve a certain amount of renewable energy or energy efficiency by a future date. Targets may be backed by specific compliance mechanisms or policy support measures. Some targets are legislated, while others are set by regulatory agencies, ministries or public officials.
Regulatory policies	**Mandate/obligation:** A measure that requires designated parties (consumers, suppliers, generators) to meet a minimum – and often gradually increasing – standard for renewable energy (or energy efficiency), such as percentage of total supply, a stated amount or capacity, or the required use of a specified renewable technology.
	Building codes and standards: Rules specifying the minimum standards for buildings. These can include standards for renewable energy and energy efficiency that are applicable to new and/or renovated and refurbished buildings.
	Congestion charge: Money motorists must pay to drive in some city centres. Congestion charges are intended to reduce traffic within designated areas.
Fiscal/financial incentives	**Fiscal incentive:** An incentive that provides individuals, households or companies with a reduction in their taxes, whether sales taxes, income taxes, or other.
	Subsidy: A financial contribution made by (or on behalf of) a government or a public body to support a particular action or project.
Public investment and procurement policies	**Tendering:** A procurement mechanism by which renewable energy supply or capacity is competitively solicited from sellers, who offer bids at the lowest price that they would be willing to accept. Bids may be evaluated on both price and non-price factors.
	Public procurement: A commitment by a given level of government to purchase only certain products and services that comply with their own procurement policies and standards. Such standards can include environmental and energy performance criteria, such as commitments to purchase only zero-emission vehicles.

Source: see endnote 98
Note: this table summarises renewable energy policies at a city level; the full Renewables in Cities 2019 Global Status Report will provide a more comprehensive overview.

i A net-zero carbon building is defined as a building that is highly energy efficient and fully powered from on-site and/or off-site renewable energy sources. See World Green Building Council, "What is net zero?" https://www.worldgbc.org/advancing-netzero/what-net-zero, viewed 10 May 2019.

FIGURE 3. Overview of Existing 100% Renewable Energy Targets in Cities, 2018



Note: Data included in this figure were compiled by ICLEI and The Global 100% Renewable Energy Platform with material provided by a variety of stakeholders, including CDP, CAN, C40, IRENA, Sierra Club, Renewable cities (2018); and may not be comprehensive.

Source: see endnote 102.

Amsterdam, Netherland

For example, Munich (Germany) adopted a target in 2018 for a 100% renewable district heating network by 2040, joining cities such as Amsterdam (the Netherlands), Helsingborg (Sweden), Osnabruck (Germany) and Vienna (Austria).[106] Gothenburg (Sweden) has committed to phasing out fossil fuels in its district heating system entirely by 2030, replacing them with renewables and waste heat from industry.[107]

In addition, some cities have committed to using biofuels and EVs in the **transport** sector. In general, these measures are part of broader strategies to promote the use of lower-carbon transport technologies and mobility options[i].[108] By the end of 2018, more than 70 cities and municipalities had committed to using 100% renewable energy in the transport sector.[109] (→ *See Figure 3.*) In 2018, San Francisco (United States) announced renewable power targets for its transit rail system of 50% by 2025 and 100% by 2045, joining existing pledges by Oslo (Norway) to power its public bus fleet with renewables by 2020 and by Helsinki (Finland) to fuel all city buses and heavy-duty vehicles with renewables by 2020.[110]

In some cases, cities have adopted comprehensive targets that cover all three sectors of energy end-use (electricity, heating and cooling, and transport). By the end of 2018, around 50 cities and municipalities had committed to 100% renewable energy in all of these sectors.[111] (→ *See Figure 3.*)

i Renewable energy in transport is often part of broader plans to reduce energy demand by expanding infrastructure for cycling, walking and public transit.

REGULATORY POLICIES

Cities often use a mix of regulatory policies to advance renewable energy, helping to guide the decisions of developers, businesses, investors and residents alike. In 2010, Copenhagen (Denmark) developed a plan to transition its district heating system to renewable energy sources (including solar, geothermal, biomass, biogas and waste heat) that relies on a broad variety of policy mechanisms. These include obligations requiring building owners to connect to the network (with a nine-year grace period for existing buildings), tax incentives, zoning rules and a tariff regime designed to ensure cost-recovery for operators of different heating and CHP projects on the network.[112] Supporting policies in the country, such as CO_2 pricing, have helped speed the transition by making carbon-intensive sources of heating comparatively more expensive, and are combined with tax exemptions specifically for biomass, biogas and solar thermal heating sources to make renewable options cheaper.[113]

Through the use of **mandates and obligations**, cities can influence the adoption and penetration of renewable energy technologies within a specific sector. For example, Chandigarh (India) mandates the use of solar hot water in industry, hotels, hospitals, prisons, canteens and housing complexes, as well as in government buildings and new residential construction.[114] Numerous cities in Brazil have adopted solar mandates, including São Paulo, where 40% of the energy for heating water in new residential and commercial buildings must now come from a solar source.[115] Municipal solar water heating mandates also exist in Barcelona (Spain), Bangalore (India), Beirut (Lebanon) and Rosario (Argentina), among others.[116]

As of 2012, Belgrade (Serbia) has required all new buildings and all public buildings to connect to the local district heating system, a move that has helped guarantee demand and that was key to unlocking the needed investments.[117] Belgrade's experience builds on similar district heating obligations in cities across Europe, including in systems with higher shares of renewable energy in the mix, such as Copenhagen (Denmark), Hamburg (Germany) and Tartu (Estonia).[118]

Many cities have adopted **building codes** that require the use of low-emissions energy sources and building-integrated renewables, in particular for new buildings.[119] For example, Vancouver (Canada) developed building codes requiring that all new buildings be zero emissions by 2030, and in 2018 Tübingen (Germany) introduced building codes that require the installation of solar PV on all new buildings.[120] Many Chinese cities have enacted building codes requiring the installation of solar water heaters, a measure that has helped make China the world's largest market for solar thermal technologies – with 375.4 GW of capacity, or 78% of the global total.[121]

In addition, many cities are implementing **restrictions** on certain energy technologies and favouring renewable-based alternatives, most notably in the transport sector. Vehicle-related restrictions are directed mainly at internal combustion engine vehicles (especially diesel), although some apply more broadly to older, heavily polluting models. As of early 2019, 15 major cities around the world had plans to ban or heavily restrict the use of diesel vehicles, and circulation restrictions for petrol and/or dieselpowered vans have been adopted in Athens (Greece), Brussels (Belgium), Lisbon (Portugal), Madrid (Spain), Mexico City (Mexico), Paris (France) and Rome (Italy).[122] Cities also have imposed restrictions on other energy sources, as major Chinese cities have done with the use of coal for residential heating.[123]

Also in the transport sector, cities are using **congestion charges** to discourage drivers (particular drivers of more polluting vehicles) from entering their city centres, often coupled with fee exemptions for alternative fuel or low-emission vehicles. In early 2019, London revamped its congestion charge[i] – originally intended to reduce traffic in the 21-square-kilometre city core – to allow exemptions exclusively for zero-emission vehicles and to eventually cover most of the city by 2021.[124] Congestion charges also are in place in Singapore and Stockholm and are scheduled to take effect in New York in 2021.[125] Other cities, such as Berlin (Germany), have created low-emission zones that restrict the use of more-polluting vehicles, imposing fines for non-compliance.[126]

Chandigarh, Punjab, India

i Since being adopted in 2003, London's congestion charge has reduced the number of cars on the road in the city centre by roughly 30%. See endnote 124

FISCAL AND FINANCIAL INCENTIVES

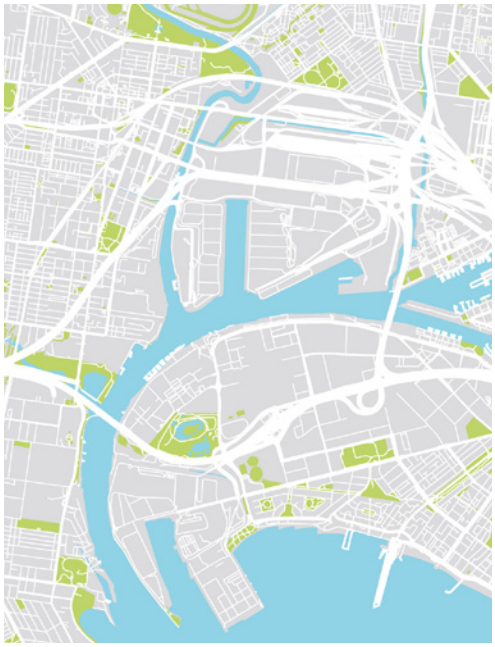
Financial incentives – such as rebates, tax incentives and low-interest loans for renewable energy – have been used not only at the national level (for example, in Canada, China, Mexico, Norway and the United Kingdom), but also at the city level.[127] The City Council of Washington, D.C. offers a personal property tax exemption for investments in various renewable energy technologies, including solar thermal and solar PV.[128] In a suburb of Melbourne (Australia), the Darebin Council's newly launched Solar Saver programme helps residents finance 1 kilowatt (kW) to 5 kW of solar panels interest-free over a 10-year period.[129] The Council is able to buy the solar panels without paying the local sales tax, and the programme enables residents to repay their system gradually from the savings on their electricity bills. By the end of 2018, Darebin had 18 MW of installed solar PV capacity, which it aimed to double in the coming four years.[130]

Cities are using investment grants and other forms of direct **subsidies or rebates** to support the development of renewable heating and cooling. In 2017, Grenoble (France) established a Local Heating Fund to support small-scale renewable heating projects.[131] Low-interest loan funds (i.e., concessional loans) are available at the city level in Brussels (Belgium) and in Amsterdam and Delft (the Netherlands).[132] In the United States, a programme in Boulder (Colorado) uses rebates to help fund the installation of residential electric heat pumps, which can replace natural gas-fuelled heating systems and provide new access to cooling for the city's many homes that lack air conditioning.[133] Coupled with Boulder's target for 100% renewable energy use, the programme will help ensure that city residents have access to renewable heating and cooling resources at an affordable price.[134]

PUBLIC INVESTMENT AND PROCUREMENT POLICIES

Many cities have used their purchasing power to directly invest in renewable energy technologies, for example by adding environmental or performance standards to their **public procurement** policies. For example, the metropolitan areas of Malmö and Lund (both in Sweden) have used environmental criteria in the procurement of their public transport fleets: as of 2015, renewable fuels (mainly biogas and biodiesel) accounted for more than 53% of the fuel mix used in the cities' 1,000-plus public buses.[135] City governments throughout Latin America are stepping up their purchases of electric buses, and In 2017 San Francisco (United States) procured a total of 61.7 MW of wind energy and 45 MW of solar PV to provide renewable electricity to its rapid transit system.[136]

Auckland, New Zealand



Melbourne, Australia

BUSINESS MODELS DRIVING RENEWABLES IN CITIES

The development of renewable energy markets – both at the national level and in cities – is being driven not only by national, sub-national and municipal policies, but also by rapid reductions in the costs of renewable energy technologies.[137] In cities, renewables provide energy to all three of the end-use sectors (power, heating and cooling, and transport), but large variations in markets reflect urban specificities. (The full *Renewables in Cities 2019 Global Status Report* will provide a more detailed overview of urban renewable energy market developments up to 2018.)

A variety of business models exist that enable city governments, local businesses, citizens and large corporations to use or develop renewable energy – some of which consider the specific city context. These diverse business models have emerged in response to a mix of factors, including price reductions in renewable energy, supportive tax policies, new digital technologies, and changes in consumer awareness and behaviour. While innovation in renewable energy business models previously was limited mainly to the electricity sector, new opportunities are increasingly available in the heating, cooling and transport sectors as well.

City governments and local businesses have used **renewable energy certificates**, or RECs, to purchase specific amounts of renewable electricity in bulk. RECs typically represent 1 MWh of certified renewable electricity production, enabling city governments and businesses to purchase the certificates to meet part or all of their annual electricity needs, rather than investing directly in renewable energy technologies (e.g., on their rooftop or on adjacent land). In Burlington (Vermont, United States), the municipal utility uses a mixed approach to supplying electricity, meeting a portion of the demand with a local biomass plant (in which it has a 50% ownership share) combined with the purchase of RECs from renewable energy projects in the region, including wind, solar and small hydropower.[138]

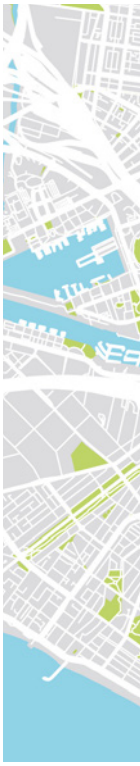
In many cities, municipal governments and companies use third-party **power purchase agreements** (PPAs) with renewable electricity suppliers to buy renewable electricity directly. In some cases, as in the US cities of Cincinnati (Ohio) and Garland (Texas), the power is purchased directly from project developers.[139] In a different approach, the City of Melbourne (Australia) joined with cultural institutions, universities, local companies and other municipalities in the area to collectively purchase renewable electricity from a newly built 80 MW wind farm.[140] This combined purchasing power enabled the construction of the wind farm, while at the same time allowing the Melbourne City Council to be powered by 100% renewable electricity.[141] In another form of agreement, the "virtual PPA", no physical exchange of electricity takes place, but the individual, municipal government or company agrees to purchase a specific amount of renewable energy every year to help the project obtain financing; the renewable generation then becomes part of the region's overall electricity supply mix.

Cities typically do not act alone in their efforts to advance renewables; they often work in parallel with a growing number of businesses and private sector partners that are seeking to promote renewable energy. For example, solar leasing companies such as Sunrun, Sungevity, SolarCity, Vivint (all active in North America) are enabling customers to install solar power directly on their rooftops or on adjacent land at little-to-no upfront cost, using a range of leasing options. These contracts often help customers save money by providing a discount on the electricity price offered by local utilities. In addition to parts of Canada, Europe and the United States, **solar leasing** is active in cities such as Cape Town (South Africa) and Manila (the Philippines).[142] Sunrun, the largest solar leasing company in the United States, has helped unlock more than USD 5 billion worth of new residential investment in renewable energy projects nationwide.[143] By the end of 2018, the company had provided solar systems to more than 233,000 customers, representing a cumulative installed capacity of 1.6 GW.[144]

Solar leasing also has triggered a wave of innovation in parts of Africa and Asia through the rise of socalled pay-as-you-go (PAYG) companies that offer customers the ability to access a solar home system equipped with a battery bank and a range of appliances to meet household needs.[145] While much of the PAYG market traditionally has concentrated on providing electricity access in rural and remote regions, a growing number of companies are starting to focus on customers in urban and peri-urban areas where income levels are higher but the grid supply is often unreliable.[146] In this way, PAYG companies are helping to address the lack of energy access in and around major urban areas, particularly in sub-Saharan Africa.

In some cities, customers that generate their own renewable power supply are using **peer-to-peer energy trading platforms** to trade with their neighbours, making it possible to monitor and exchange energy in real time. Participants often receive better financial return for smaller amounts of power than what is available through traditional net metering or feed-in tariff policies that compensate producers for feeding their excess energy to the grid. Energy trading systems are active in cities around the world including in the London boroughs of Hackney and Brixton (United Kingdom), Wyomissing (Pennsylvania, United States), Fremantle (Australia) and more than 11 cities in Germany.[147]

In the transport sector, a growing number of companies that provide **mobility-as-a-service (MaaS)**[i] expanded their offerings in 2018 to include electric-powered cars, bicycles and scooters, among others.[148] Companies such as Coup, Ecooltra, Emmy, Felyx, Sacoora, ShareNow, Tier and Voi Technology were active in cities across Europe, while in North America companies like Bird, Lime, Lyft, Uber and a range of traditional car rental companies began to offer electric mobility options.[149] As of 2018, more than 40 different MaaS providers were operating in China, mainly in the larger urban regions.[150] In New Zealand, Yoogo Share offered only EVs from its locations in Auckland and Christchurch.[151] Some companies are pairing the MaaS infrastructure directly with renewable energy: for example, US-based EVgo committed in early 2019 to powering its entire network of EV charging stations with 100% renewables.[152]



i Mobility as a Service (MaaS) describes a shift away from personally-owned modes of transportation towards mobility solutions that are consumed as a service. MaaS provides users a range of different transportation options on-demand, including car- and bike sharing as well as taxis and buses, while integrating both travel planning and payments.

MOBILISING FINANCE

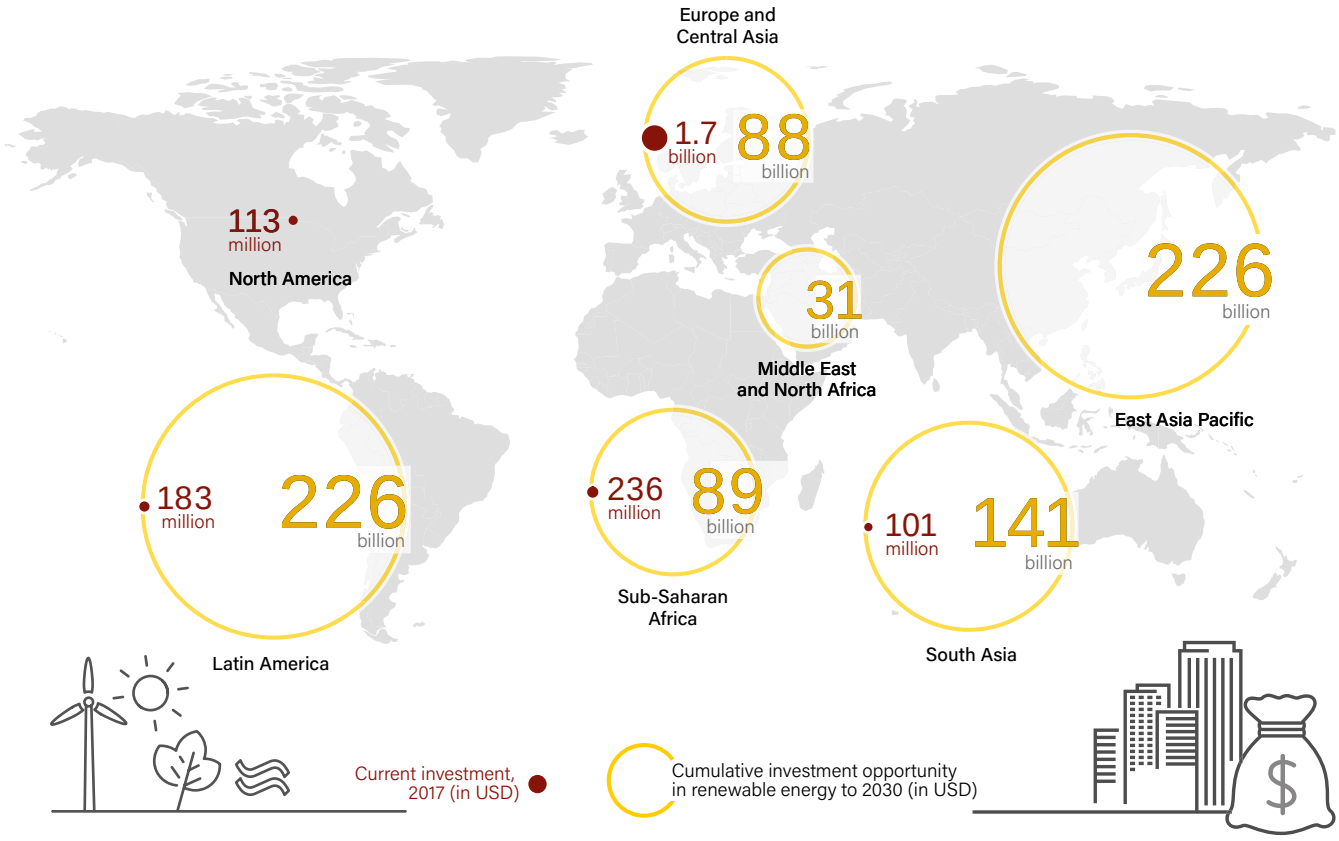
Cities are investing rising sums in local renewable energy and climate-related projects. As of March 2019, more than 30 cities worldwide had signed on to the 10% Resilience Pledge, which commits mayors to earmarking 10% of their cities' annual budgets for resilience-related projects.[153] This represents a total commitment of more than USD 5 billion for a wide range of public investments in renewable energy and other climate-oriented projects, ensuring that resilience and related concerns are reflected in local budget and planning processes.[154]

In 2017, the cities reporting to CDP initiated some 150 renewable energy projects, representing a total investment of USD 2.3 billion (including USD 1.7 billion in Europe, USD 236 million in Africa and USD 113 million in North America).[155] These projects are part of a wider portfolio of 1,000 clean infrastructure projects (which also comprise electric transport and energy efficiency), for a total investment value of more than USD 52 billion.[156] Investment in renewable energy and clean infrastructure in the world's urban areas is expected to only grow: the International Finance Corporation estimated in 2018 that opportunities for global climate investment in cities will reach USD 29.4 trillion by 2030, mainly in green buildings (USD 24.7 trillion), EVs (USD 1.6 trillion) and public transport (USD 1 trillion).[157] Direct investment opportunities in renewable energy in cities are expected to total USD 842 billion that year.[158] (→ *See Figure 4.*)

City governments are responsible for only a small share of the total financing that occurs within their boundaries. Many of the investments that occur – whether in the energy, buildings, commercial or industrial sectors – are made by private individuals and companies, which have their own priorities, funding constraints and planning horizons. This underscores the importance of understanding the various roles that cities can play not simply in levying taxes and spending the proceeds, but also in taking critical action as conveners, rule makers, trendsetters and promoters of low-carbon investment.

To scale up financing in low-carbon infrastructure, and particularly in renewable energy, cities around the world are implementing policies in tandem with specific financing instruments, including climate bonds, land value capture, public-private partnerships, Property Assessed Clean Energy (PACE) financing, cooperative financing models and concessional financing from development finance institutions.[159] This broad range of instruments is complemented by new business models – including solar leasing, community solar and energy service companies (ESCOs) – that are making it easier for individuals, companies and municipal

FIGURE 4. Investment and Investment Opportunities in Renewable Energy in Cities, by Region, 2017 and 2030



Note: Current investment is based on data of the more than 570 cities that self-reported via CDP. No data available on East Asia Pacific and the Middle East and North Africa. Investment opportunity is derived from the International Climate Fund (IFC). No data available on North America.

Source: See endnote 163.

governments themselves to invest in renewable energy (→ *see Business Models section*).

As of March 2019, approximately USD 4 billion in green bonds – a sustainable asset class that includes a wide range of sustainable investments – had been issued at the city-level worldwide.[160] While the bulk of this funding was used to finance city investments in the water, transport and buildings sectors, more than USD 500 million was allocated specifically to finance renewable energy investments.[161] Green bonds (or "climate" bonds) are not only helping to attract major institutional investors, but also providing local residents with an opportunity to invest in local renewable energy developments.[162] In 2018, the City Council of Auckland (New Zealand) became the first in the country to issue green bonds to finance its lowcarbon infrastructure.[163] The initial NZD 200 million (USD 134 million) bond will help fund the city's electric train network as well as its commitment to procure zero-emission buses for municipal transit.[164]

In addition to mobilising private capital, a growing number of **development finance institutions**, often in partnership with local banks, are providing the catalytic finance required to unlock investments in larger assets such as metro lines and district heating networks. For example, in 2018 the city of Banja Luka (Bosnia and Herzegovina) partnered with the European Bank for Reconstruction and Development to create a new district heating company that uses a 49 MW biomass boiler plant to provide heat to surrounding districts, reducing reliance on expensive heavy fuel oil.[165]

Given the volume of funds being managed by asset managers and institutional investors worldwide – estimated at EUR 65.7 trillion (USD 73.8 trillion) in 2018 – there is growing interest in finding ways to involve fund managers in the financing of sustainable infrastructure such as renewable energy and lowcarbon mobility.[166] Such investors traditionally have been risk averse, however, and have avoided taking on direct exposure to individual infrastructure projects because of concerns about political and regulatory risks, the possibility of cost overruns, and a range of other economic and currency-related risks.

University of Johannesburg, South Africa

Sydney, Australia

CIVIL SOCIETY PARTICIPATION

To gain the support of everyday citizens in advancing the energy transition, civil society participation is critical. The design of urban energy systems affects urban residents in direct ways by defining how energy is produced, transmitted and consumed. Citizens can actively shape the energy infrastructure of their cities in a range of ways, including by making direct investments in renewable energy technologies and by opting into renewable energy purchasing programmes offered by local utilities (whether for electricity or heating). Citizens also can have an impact by partnering with others to create community-based energy projects and by voicing their opposition to fossil fuel (or even renewable) energy projects in their region.[167] (These topics will be covered in greater detail in the full *Renewables in Cities Global Status Report*.)

PROSUMER PATHWAY

Advances in renewable energy and in information and communication technologies, combined with supportive policies and regulations, have made it increasingly possible for individual households and businesses to generate renewable energy for their own consumption. This has led to a new player in the energy system: the prosumer.[168] By definition, prosumers are both producers and consumers of energy, using their own energy supply to meet part or all of their energy needs.[169]

Although many categories of prosumer exist, including at the residential, commercial and industrial scales, the most common type is a homeowner who installs solar panels on his or her roof to offset a portion of household electricity needs, while exporting the rest to the grid.[170] Millions of rooftop solar systems exist in countries around the world, including in Bangladesh (more than 4 million), Japan (more than 2.2 million), Australia (more than 2 million) and Germany (1.7 million).[171] In Lagos (Nigeria), approximately 0.2% of households have solar panels.[172] Other viable technologies for urban residents include CHP generators that use biomass-based fuels (e.g., wood chips), air-to-air heat exchangers, ground-source heat pumps and solar hot water systems. Germany alone has 2.4 million solar thermal installations, most of them on single-family homes.[173]

The main policy and regulatory instruments to support the rise of prosumers in cities around the world have been net metering and feed-in tariff policies. For example, the city governments of Cape Town and Durban (both in South Africa), as well as in other parts of the world, have introduced policies to encourage local citizens and businesses to invest in distributed renewable energy projects.[174] In the United States, tax incentives play a significant role as well, as does the emergence of new business models such as solar leasing (→ *see Business Models section*). In a slightly different approach, Newstead (Australia) established a deal with its electricity distributor in 2018 for reduced network charges for power generated from smallscale solar PV.[175]

CONSUMER CHOICE PATHWAY

In a growing number of US states and in some other electricity markets worldwide – including Australia, Germany and the Philippines – industrial, commercial and even residential customers have access to consumer choice in their electricity supply, meaning that they can select their own supplier rather than buying from the incumbent. The presence of consumer choice enables customers to play a more active role in shaping the electricity mix being used to serve their region – for example, by choosing the supplier that is investing the most in scaling up renewable energy projects in the region. For customers without their own roof space, with limited disposable income or who rent rather than own their living space, consumer choice is one of the most readily available tools to actively support renewables in urban areas.

In the United States alone, approximately 850 utilities – ranging from utility-owned to municipal and cooperatively owned utilities – are offering renewable energy options and products to their customers.[176] By the end of 2017, an estimated 5.5 million retail electricity customers procured around 112 terawatthours of electricity from a variety of such programmes, representing about 3% of US retail electricity sales.[177] Notably, the largest and most successful US programmes are led by municipally owned utilities, including in River Falls (Wisconsin), Sacramento (California) and Wellesley (Massachusetts), demonstrating the importance of local leadership from municipal utilities.[178]

Freiburg, Germany

COMMUNITY ENERGY AND CO-OPERATIVES

In recent years, the number of community energy[i] projects using solar PV and other renewable sources has increased steeply in various parts of the world.[179] Although community energy frequently is associated with northern European countries such as Denmark and Germany, such projects are emerging in other parts of the world including Canada, Japan, Thailand and the United States.[180] Historically, community energy has been more prevalent in rural areas, but the number of urban projects is increasing, driven in part by environmental awareness as well as by a desire for greater ownership of local energy infrastructure (→ *see Drivers section*).[181]

In Europe, around 3,000 community energy projects have been registered as Renewable Energy Cooperatives (RESCOOPs).[182] Approximately half of them are organised in REScoop.eu, investing EUR 2 billion (USD 2.3 billion) in renewable energy installations with a combined capacity of around 1,250 MW.[183] Their annual turnover is EUR 750 million (USD 858 million), and the co-ops have created around 1,100 direct jobs.[184]

More than 100 community energy projects are active in Australia, and Japan was home to some 200 community energy projects as of 2016.[185] In the United States, hundreds of communities spanning 43 states had successfully developed community solar and so-called shared solar projects by the end of 2018, totalling 1,387 MW of installed capacity.[186] Community solar projects draw on individual contributions from hundreds or even thousands of households to finance solar power projects larger than households could finance on their own, and are often driven by national, state/provincial or local net metering policies (→ *see Finance section*). Community solar projects in hundreds of communities are now helping customers, local businesses as well as low-income residents save money.[187]

City administrations can support community energy projects in different ways, for example by allocating a certain quota for local ownership of new renewable energy projects. This approach is widespread in Denmark, where local residents as a collective have the preferential right to buy up to 20% of shares in wind farms before shares are sold to external investors.[188]

Shibuya, Tokyo, Japan

i Community energy projects vary in size and shape and can include, for example, schools, neighbourhoods, housing associations and city government partners collectively owning a wind turbine or setting up solar panels. See endnote 179

The REN21 Secretariat has produced this document to highlight preliminary trends and developments of renewable energy in cities, putting these trends and developments in the context of the global energy transition. This work is being expanded on, and the results will be published in September 2019 as the *Renewables in Cities 2019 Status Report*. The report production process is ongoing. REN21 invites experts to showcase renewable energy action in cities with data, examples and case studies. To get involved visit **ren21.net/cities**

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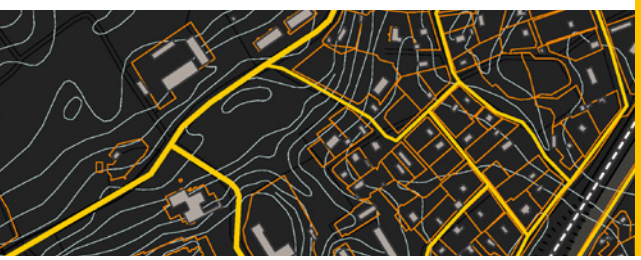

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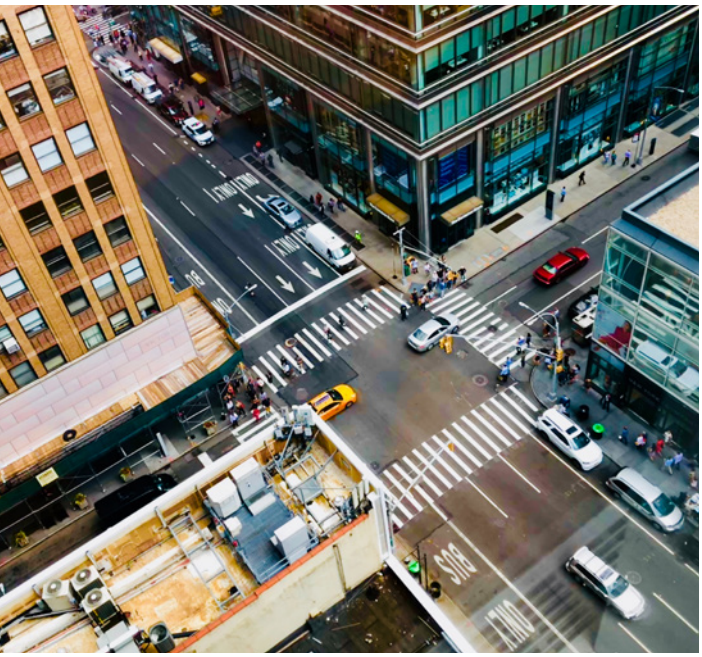

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