RAJKOT

INDIA

Land area (km²/2015)	Population size (2018)	GHG Greenhouse gas emissions (CO_2 equivalent)
129.2	1.8 million	1,887,684 tonnes

Rajkot, the fourth largest city in the western Indian state of Gujarat, has committed to reducing its greenhouse gas emissions 14% by 2022-23 (from 2015-16 levels). Energy consumption in residential buildings totalled 606 million kWh in 2015-16, accounting for around half of all electricity consumption and contributing 35% of greenhouse gas emissions from economy-wide activities in the city. Recent efforts have focused on reducing energy consumption and enhancing energy efficiency in residential buildings. The Capacity Building for Low Carbon and Climate Resilient City Development project (CapaCITIES) has helped maximise the use of renewables in the city, reducing the need to tap into the predominantly coal-based national grid.

The Krantiveer Khudiram Bose social housing complex (known as 11A) consists of five buildings with a total of 140 dwelling units. At full occupancy, common amenities (lifts, lights, pumps, etc.) consume 3,000 kWh of electricity per month. To encourage the adoption of solar PV, a 31.5 kW-peak grid-connected solar PV system is being installed on-site and will be operated and maintained by the contractor/developer for a period of 10 years. The system consists of 100 polycrystalline solar PV panels of 315 watt-peak capacity each, mounted on a frame at a 21-degree panel tilt. It will generate around 3,780 units of electricity per month (45,360 kWh per year) and has the potential to reduce 37 tonnes of CO_2-equivalent greenhouse gas emissions annually. Overall responsibility for the safety, security and periodic cleaning of the panels will lie with the township's Residential Welfare Association, which has been trained on panel maintenance.

Because of its efforts in low-carbon action and community engagement, Rajkot Smart City was selected as the national winner of WWF's Global One Planet City Challenge in 2020. Other noteworthy initiatives in Rajkot that support this award include: the installation of 9,629 kWh of grid-connected solar PV systems on residential buildings (with a further proposed 500 kWh on municipal buildings); retrofitting of 63,178 public street lights with light-emitting diodes (LEDs), resulting in annual energy savings of 11.5 million kWh; the implementation of Smart Ghar III, an affordable green home concept aimed at maintaining indoor thermal comfort with minimal climate impact; and plans to replace diesel buses with electric ones, along with the provision of solar PV charging.

Source: See endnote 124 for this chapter.

India

Some municipal governments have developed building energy codes with performance standards that aim to achieve higher energy efficiency levels and support the adoption of renewable technologies. As of mid-2020, at least 35 cities in California (US) had adopted building codes specifically to reduce their reliance on natural gas in new construction (→ *see Overall enabling environment section*).[127] In some cases, the code is coupled with a renewable energy requirement: for example, Richmond (California) requires new residential buildings under three storeys to be all-electric, and new residential buildings of any size must install a minimum amount of on-site solar (thermal or PV)[i] (→ *see Sidebar 4*).[128] By October 2020, roughly 10% of California's population was living in a city that had building codes requiring solar readiness and/or EV charging readiness (the wiring required to enable the rapid addition of solar PV or EV charging) or the addition of solar PV or solar thermal (→ *see also City-level Transport section*).[129]

Fiscal and financial incentives

Globally, municipal governments were providing fiscal and/or financial incentives such as rebates and grants, low-interest loans, and tax credits and deductions to increase renewable power.[130] Generally, these support mechanisms do not differentiate between new and existing buildings.

Municipal governments offer **investment subsidies** such as **rebates and grants** to encourage the installation of renewable power capacity. For example, the municipal utility serving San Antonio (Texas, US) offers residential rebates of USD 2,500 per solar installation, as well as commercial rebates of 60 US cents per watt (for systems up to 25 kW) and 40 US cents per watt (for systems above 25 kW).[131] Philadelphia (Pennsylvania, US) provides rebates totalling up to USD 500,000 per fiscal year to commercial and residential solar PV installations completed after 1 July 2019.[132]

In 2020, Beijing, Guangzhou, Shanghai and Xian (all China) announced financial support policies for distributed solar PV through 2025, providing a subsidy per kWh produced.[133] In Gdynia (Poland), the municipal government provides one-off subsidies for renewable electricity production that uses solar PV and micro power plants, offering PLN 2,500 (around USD 674) for single-family buildings and PLN 5,000 (over USD 1,348) for multi-family buildings.[134] In Freiburg (Germany), where a subsidy to fund new energy storage systems went into force in 2019, the city provides EUR 150 (USD 184) per kWh of storage capacity (provided the solar PV system has at least 1.25 kW of output per kWh of storage capacity).[135] Similar municipal support for customer-sited solar PV exists in Berlin, Braunschweig, Jena, Stuttgart and Wallenhorst (all Germany), Los Angeles and San Francisco (both US), Tokyo (Japan) and Vienna (Austria).[136]

Some municipal governments provide direct investments in the community for the installation of renewables (→ *see City Snapshot: Seoul*).[137] As part of Australia's efforts to help communities recover from the devastating wildfires of 2019, several local municipalities in Victoria state dedicated recovery and reconstruction funds specifically for renewable energy and storage projects.[138] The initiative will fund the installation of roughly 50 solar PV systems (of 6.5 kW each) at not-for-profit community organisations in several cities and towns, including at schools, emergency service buildings, sporting clubs and community centres that need to be rebuilt.[139]

Municipal governments

are providing fiscal and/or financial incentives to increase renewable power.

i The minimum required share of energy provided by solar PV or solar thermal systems is calculated based on the total square footing of the building.

SEOUL

REPUBLIC OF KOREA

Land area (km²): **605**

Population size (2020): **9.9 million**

Greenhouse gas emissions (CO_2 equivalent): **46,685,000 tonnes**

In July 2020, Seoul, the capital of the Republic of Korea, responded to the country's commitment to achieve climate neutrality by 2050 by developing an integrated policy approach focused on five key areas: buildings, mobility, forestry, clean energy and waste management. Seoul's vision is to be a sustainable city where "human, nature and future co-exist".

The Republic of Korea's policy approach towards climate neutrality mirrors the EU's Green Deal to achieve net-zero emissions and respond to climate change. By 2025, the Korean government will invest around USD 37 billion in Green New Deal policies and a further USD 7 billion in carbon-cutting measures. Seoul has put forward two intermediate goals ahead of the 2050 climate-neutrality goal: to achieve 40% emission reduction by 2030 and 70% emission reduction by 2040 (compared to 2005 levels).

Since 2012, Seoul has adopted policies to reduce its dependency on nuclear energy through two phases of the One Less Nuclear Power Plant Project. In 2017, Solar City Seoul was launched with the goal of adding 1 GW-peak of solar power capacity by supplying PV panels to 1 million households by 2022. The programme, which has a budget of around USD 1.46 billion (funded mostly by public investment), aims to reduce CO_2 emissions by 544,000 tonnes annually and to add 4,500 new jobs by 2022. The programme exceeded its intermediate goal by installing a total of 357.1 MW of solar panels for 285,000 households by 2019.

One of the challenges facing the Solar City Seoul programme is securing enough space at buildings and public facilities to install solar panels. As part of the green energy initiative of the Seoul 2050 climate neutrality plan, Seoul is identifying new installation sites (including urban infrastructure); increasing the standards for solar generation in zero-energy buildings; providing subsidies for building-integrated PV; extending the feed-in tariff system to on-site solar power generators and supporting new solar PV technology.

Source: See endnote 137 for this chapter.

Some municipal governments offer **tax credits and deductions** for producing on-site renewable electricity.

In an innovative policy that focuses on adjusting the electricity rates that customers *pay*, rather than the payment levels they *receive* when exporting their net surplus generation, Newstead (Australia) has set out, in partnership with the local utility, to introduce "solar sponge" tariffs that offer much lower rates to customers during the daytime hours when solar power is abundant.[140] The reduced tariffs are available to all customers that have suitable metering infrastructure, in particular meters that support time-of-use tariff structures.[141] The regional distributor, South Australia Power Networks, started offering the solar sponge tariffs in July 2020, in part to help stabilise the grid during the daytime surge in solar power and to mitigate challenges associated with the "duck curve"[i].[142]

Low-interest loans have remained an important tool for municipal governments. In Milwaukee (Wisconsin, US), the city partnered with a local credit union to offer low-interest loans of up to USD 20,000 for homeowners to finance rooftop solar PV; similar incentives exist for households in Boulder (Colorado, US) and Honolulu (Hawaii, US) and for commercial and non-profit entities in Baltimore (Maryland, US).[143] Since 2018, the municipal bank of Godoy Cruz (Argentina) has provided citizens low-interest loans to finance solar PV systems, and the municipality facilitates approvals and installation.[144]

An increasingly popular financial tool is Property Assessed Clean Energy (PACE) financing, which enables citizens and businesses to repay their solar loans to the municipality through an annual surcharge on the yearly property tax assessment. As of 2020, PACE programmes were available in at least 62 US cities and were starting to be deployed across Europe, including in Olot (Spain) and with plans under way in cities in Austria, Belgium, Italy, Poland and Romania.[145] Frisco (Texas, US), a local PACE administrator, partnered with national banks and the municipality in 2019 to provide long-term, low-interest loans to finance renewable energy projects in the community.[146]

Some municipal governments offer **tax credits and deductions** for producing on-site renewable electricity. Rio de Janeiro (Brazil) passed a tax exemption in 2020 for renewable power produced by distributed generation projects.[147] In Salvador (Brazil), the municipal government offers property tax discounts for installing solar PV; the system must correspond to a minimum percentage consumed by the property.[148] A solar rebate programme in Boulder (Colorado, US), launched in 2019, offers a sales and use tax rebate of around 15% on qualifying solar PV and solar thermal installations.[149] Municipal tax exemptions also are available in US cities such as Chicago, New York and Washington, D.C.[150]

Overall enabling environment

In addition to enacting direct policy measures for renewables, municipal governments are putting in place indirect support policies and improving their permitting and administrative procedures for renewable power projects developed within city limits.[151]

Even residents with sufficient disposable income to invest in on-site renewable power projects may be held back by a lack of suitable roof space, as many live in multi-unit buildings, are tenants rather than owners or face heritage-related restrictions that make installing their own solar system difficult.[152] To overcome this, cities and local governments have embraced a variety of approaches, including developing solar gardens (community solar projects). Many such projects rely on **virtual net metering**, an important enabling policy that allows users to offset their on-site electricity consumption by using electricity generated elsewhere on the grid. Under such models, consumers that participate in community solar projects receive credits on their electricity bills on a pro-rata basis according to their individual share of investment in the project as a whole. When Delhi (India) revised its solar policy in 2019, it introduced virtual net metering to allow residents and businesses without suitable roof space to invest in solar energy systems, overcoming a key barrier to solar uptake in the densely populated city.[153]

Another barrier for some is the inability to conduct maintenance on their solar PV system, whether because of age or mobility, lack of training in the community, the time and cost for maintenance, or other factors. Several approaches have gained momentum to overcome such barriers. In Haystacks (New South Wales, Australia), construction began in 2020 on a community-owned solar garden project that offers members the opportunity to buy one or more of the 300 "plots" of roughly 3 kW each.[154] The approach removes the need for individuals or businesses to engage in operations and maintenance, while the power generated by each member's share of the garden is then credited on their electricity bill.[155]

Another policy option that has rapidly gained ground in the United States and is starting to emerge in Australia and the United Kingdom is **community choice aggregation** (CCA).[156] Under a CCA, municipalities (independently or in partnership with an agency running the CCA) aggregate the electricity demand of residents and businesses and set out to procure electricity for all participating customers city-wide, either through direct contracts with energy producers or via third-party agreements.[157] By enabling local communities to procure their own electricity, CCAs can be an attractive option for cities that want more local control over their electricity mix. The aggregation of demand also helps cities and local governments negotiate better rates with suppliers and lock in contracts for higher shares of renewables, including 100%.[158]

i The "duck curve" refers to the duck-shaped curve of electricity demand in a given jurisdiction that arises as the share of daytime solar PV increases in the system. See J. St. John, "The California duck curve is real, and bigger than expected", Greentech Media, 3 November 2016, https://www.greentechmedia.com/articles/read/the-california-duck-curve-is-real-and-bigger-than-expected.

In the United States, the number of CCAs has grown from just three in 2000 – in Lowell (Massachusetts) and in Cincinnati and Cleveland (both Ohio) – to several hundred nationwide.[159] In California alone, CCAs were present in 182 cities and counties as of 2020, meeting the needs of more than 12 million electricity customers.[160] In 2020, 14 cities and counties across the state were supplying their customers with 100% renewable electricity.[161] Elsewhere in the country, voters in Columbus (Ohio) approved a ballot measure in November 2020 to enable the city to establish its own CCA to help meet its goal of supplying 100% renewable electricity by 2023.[162]

In California, CCAs are present in

182 cities and counties.

An approach similar to a CCA has been adopted in Newstead (Australia), where the local government is developing a 5 MW community solar project on a public plot and offering residents the option to sign up for 100% renewable electricity via a local retailer that will own and operate the project.[163] By tapping into both economies of scale and increasingly low-cost solar, the project promises customers lower electricity bills than those from the region's current retailers.[164] Similar to a CCA, customers will be able to opt in, and the project is designed to be large enough to cover the needs of the entire community.

In addition, some municipal governments have started to benchmark local renewable energy potential, which helps raise awareness and encourages higher uptake among urban actors (→ *see Box 3*).[165]

2

BOX 3. Benchmarking to Harness Renewable Energy Potential in Cities

For many cities, untapped renewable energy potential exists within city limits at locations such as airports, along major rail and road ways, near or on water reservoirs, and on rooftops and vacant land. Cities also often have local sources of bioenergy – including wood chips, local agricultural wastes, and waste fats from restaurants, hotels and food producers that can be used for biodiesel – that can be considered part of the local renewable energy potential (→ *see Sidebar 5 in Markets and Infrastructure chapter*).

The potential for solar PV in cities is significant. For example, one analysis found that two-thirds of commercial buildings in New York City (US) had roof space suitable for solar PV, with the potential to supply around 14% of the city's total electricity consumption, including residential, commercial and municipal demand. An analysis of the solar potential in Berlin (Germany) found that using the city's available rooftop space could power up to 25% of city-wide electricity needs. Cities can better harness this potential by creating solar maps and introducing supportive policies that create the right enabling environments for investment.

Solar maps are tools (often interactive) that allow users to assess the potential and costs of installing solar PV or solar thermal systems on buildings and open land. Although these maps can be customised to produce tailored outputs for projects of all sizes, their main purpose generally is to facilitate greater solar use among property owners. Solar maps have been made available by municipal governments around the world, including in Calgary (Canada), Durban (South Africa), London (UK), Rome (Italy) and several US cities including New York.

One way to tabulate a city's success in harnessing its solar energy potential in new construction is to evaluate what share of the total new rooftop space built in a given year was equipped with solar PV or solar thermal systems. For example, among Germany's 14 most-populated cities, Hannover and Nuremberg managed to harness nearly half of their available rooftop potential[i], whereas Hamburg and Munich tapped into less than 10%. Such benchmarking can highlight which cities are most successful in encouraging the adoption of solar (whether building-integrated, rooftop PV or solar thermal) in new construction city-wide.

Source: See endnote 165 for this chapter.


Nuremberg, Germany

i To calculate this solar potential, the study compared the total newly built rooftop solar PV potential in a given year to the total annual installed solar PV capacity that year.

CITY-WIDE HEATING AND COOLING

Regulatory policies

Municipal regulatory policies to shift to renewables-based heating and cooling in buildings are less widespread than policies in the power sector.[166] Where these policies exist, they often focus on the installation of solar thermal systems for water and space heating (→ *see Sidebar 4*), particularly in new construction.[167]

In Carlsbad (California, US), a water heating ordinance that built on the city's 2015 Climate Action Plan came into effect in January 2020, requiring all new single-family and low-rise multi-family residential buildings to install either a solar water heating system or an electric heat pump coupled with a 0.3 kW solar PV system.[168] In China, Luanzhou's Special Plan for Green Buildings covering the period 2020-2025 requires new residential buildings with fewer than 12 floors to install a solar water heating system for each household (if suitable); for higher buildings the systems must be installed up until the 12th floor.[169] Similar regulatory policies exist in Abu Dhabi (United Arab Emirates), Los Altos Hills (California, US), Loures (Portugal), Montevideo (Uruguay) and São Paulo (Brazil).[170]

Regulatory policies mandating renewables-based heating and cooling in **existing buildings** remain rare. One exception is Basel (Switzerland), where a mandate to replace oil and gas heaters with renewable energy technologies at the time of equipment replacement went into force in 2017; a revision introducing a fine for non-compliance came into force in 2020.[171]

Fiscal and financial incentives

Municipal fiscal and financial support policies for heating and cooling have emerged in cities, particularly in the form of **grants and rebates**.[172] In 2019, as part of its Solar City initiative, the municipal government of Mexico City (Mexico) allocated funding to provide grants to businesses and residential buildings to install solar thermal heating.[173] During the programme period (until 2024), the grants will provide businesses with up to MXP 80 million (USD 4 million; with the target of supporting 400 businesses annually) and will provide residential buildings with MXP 170 million (USD 8.5 million; with the target of supporting around 135,000 systems).[174]

As part of a regional action plan to combat air pollution, between 2018 and 2020 the municipal government of Jiaozuo (China) provided a one-time equipment rebate of CNY 40 (USD 6.1) per square metre of heating area to residents who shifted from using coal to using biomass combined heat and power (CHP), ground-source heat pumps and/or sewage-source heat pumps.[175] In a similar effort to improve air quality, the municipal government of Olsztyn (Poland) allocated a special budget to help co-finance investments in more environmentally friendly heating sources in residential buildings, such as covering a portion of the costs of connecting to the local district heating network.[176]

In Berlin (Germany), the city government initiated a heating exchange programme to replace oil heating systems with wood pellet boilers, solar thermal systems and heat pumps. Owners of residential buildings can apply for grants distributed from a total budget of up to EUR 6 million (USD 7.4 million) for 2020 and 2021.[177] In a similar initiative in Leicester (UK), the municipal government provides grants of GBP 1,000 to GBP 7,000 (USD 1,357 to USD 9,504) for small businesses to implement renewable heating systems and energy efficiency measures.[178] In Barcelona (Spain), the municipal government renewed its housing renovation subsidy in 2020 to offer subsidies of up to 55% of the total costs of renovations to residential households that install solar thermal or solar PV.[179]

Fiscal and financial policies for heating and cooling have emerged in cities particularly in the form of **grants and rebates.**

SIDEBAR 4. Frontrunners in Solar Thermal Mandates in Cities

Building codes are widely used as a way to improve the energy performance of new and refurbished buildings. In around 20 countries worldwide, codes also include requirements that a certain amount or share of hot water and/or space heating demand is met using renewable sources or specifically solar heat. These additional regulations are respectively called renewable and solar thermal mandates.

Over the last two decades, cities have taken the lead in implementing solar thermal mandates, using their regulatory authority to stipulate the use of solar thermal systems on buildings for heating and cooling to reduce local air pollution and achieve climate targets. Mandates force the construction sector to consider renewable energy technologies early in the planning process. Given the labour-intensive nature of the building sector, which is dominated largely by local businesses, this approach also creates local jobs.

As early as 2000, Barcelona (Spain) – Europe's pioneer in solar mandates – adapted its building code to require that solar thermal energy cover at least 60% of the hot water demand in new buildings and in buildings undergoing major renovation. This solar mandate has been the main driver behind Barcelona's emergence as a mature solar thermal market, with more than 96,000 m^2 of collector area installed by small local companies in the last two decades. The policy also spurred broader action as some 50 Spanish towns and cities followed Barcelona's example, culminating in the implementation of national technical building regulations in 2007.

In some countries[i] (such as Germany and South Africa), building codes or mandates are set at the national level, making new solar or other mandates binding at lower levels of governance as well. In such cases, the key role for municipal administrations is to effectively implement the national regulation. In South Africa, a new building standard came into force in September 2011 (followed by a six-month transition period) stipulating that a minimum 50% of annual hot water demand must be provided by means other than electric resistance heating and fossil fuels. The city of Cape Town was able to fully apply the standard from April 2012 onwards, whereas other municipalities delayed the implementation by several years (→ *see Feature chapter*).

The experience of Bengaluru, the capital of Karnataka state (India), illustrates how strict implementation rules increase the effectiveness of solar mandates. To combat chronic power shortage, Karnataka enacted a solar mandate in 2007 requiring developers to install solar water heaters in all dwellings with at least 600 square feet (56 m^2) of floor space. Two years later, the municipal utility Bangalore Electricity Supply Company (BESCOM) started denying grid access to households that were not equipped with a solar water heater. This strict compliance rule led to 1,234 million m^2 of collector area installed across the city by 2017. BESCOM's policy was copied by other utilities across Karnataka, making it the leading Indian state for solar water heater capacity.

In countries where building codes can be set at the local level, several cities have emerged as frontrunners in solar thermal ambition, despite facing challenges. In 2007, São Paulo was among Brazil's first cities to enforce a solar mandate (applicable to all new residential and non-residential buildings), and by 2015 more than 110,000 m^2 of collector area had been installed across the city. Rosario (Argentina) is one of the few towns/cities in that country to have established a solar mandate (adopted in 2012), requiring 50% of hot water consumption in public buildings to be covered by solar thermal systems.


Honolulu, Hawaii

Some cities have pioneered stricter standards or requirements than those set at higher levels of government. In 2019, Honolulu (Hawaii, US) issued a stricter solar mandate, applying also to town halls and condominiums, than the overall state mandate for residential buildings that has been in force since 2010. The Hawaii mandate was the first on the continent and resulted in a high solar thermal penetration in buildings, with one in every two single-family houses using solar-heated water.

Source: See endnote 167 for this chapter.

i Solar mandates at the national level have proven to be able to boost solar thermal markets. Famously, in response to the oil crisis of the 1970s, Israel mandated the installation of solar water heaters in new residential buildings. Today, residential solar thermal systems are standard in the country, with 85% of households showering with solar energy. In Australia, a solar mandate issued in Victoria in 2005 requires residential home owners to install either a solar water heater or a rainwater tank for toilet flushing; 15 years later, 70% of new houses in the province have solar hot water systems.

Overall enabling environment

Municipalities increasingly have introduced enabling policies for renewable heating and cooling in buildings, such as **bans and/or restrictions** on the use of fossil fuel technologies (for example, new natural gas or oil-based boilers) as a way to improve local air quality and encourage the uptake of renewables. By the end of 2020, a total of 53 cities spanning 10 countries had either passed or proposed a ban or restriction on the use of natural gas, oil or coal in buildings for space and water heating purposes (→ *see Figure 11*).[180] While most of these policies target new buildings, some apply to existing buildings.

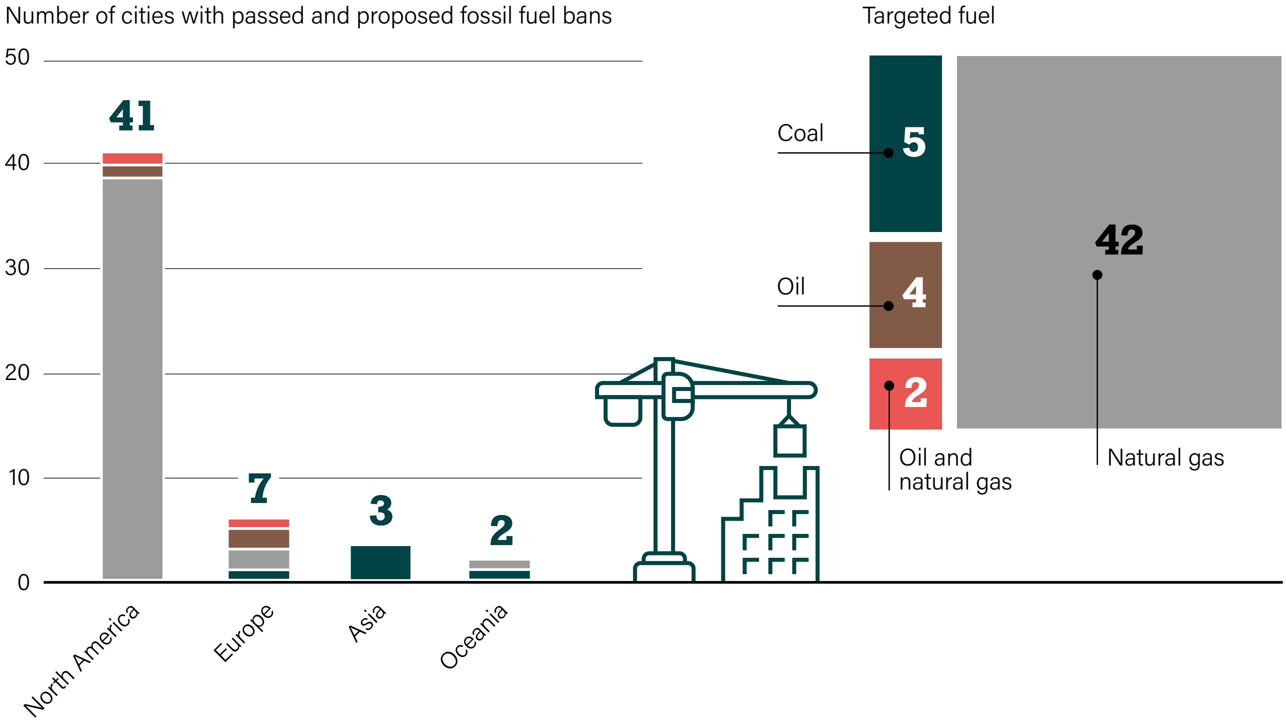
In the United States, several cities (mainly in California) have issued bans on natural gas infrastructure in new construction; although some of these have been contested in court. Berkeley was the first to ban the construction and use of natural gas lines for new residential buildings (in 2019), and more cities in the state have followed suit, including Milpitas and Palo Alto. Other California cities – including Carlsbad, Morgan Hill, Mountain View, Oakland and San Jose – have adopted regulations phasing out natural gas connections for new construction over time.[181] San Francisco banned the use of natural gas in newly built public buildings starting in 2020 and in new residential and commercial buildings and major building renovations starting in mid-2021.[182] Brookline (Massachusetts) bans both heating oil and natural gas for new residential and non-residential buildings.[183] In Canada, the Vancouver city council approved a bylaw requiring zero-emission space and water heating for all residential buildings of three storeys or less starting in January 2022 (→ *see City Snapshot: Vancouver*)[i],[184]

In Europe, Hamburg (Germany) introduced a ban in 2019 on oil-based heating and air conditioning, which will come into force in late 2021.[185] Amsterdam (Netherlands), in its wide-ranging climate-neutral roadmap published in 2020, pledged to phase out natural gas use in the city entirely by 2040.[186] Bans also are planned or in place in Krakow (Poland) and London (UK), among other European cities.[187]

In an example of the interplay that often occurs among various levels of government to drive meaningful change at the local level, the district of Ginninderry (Canberra, Australia) succeeded in overturning state-level laws that would have made natural gas supply mandatory for new construction.[188] The change to the state legislation now makes gas connections for new construction voluntary, and has enabled Ginninderry to establish one of Australia's first "gas-free" suburbs.[189]

i See City Snapshot: Vancouver online at www.ren21.net/cities

Figure 11. Fossil Fuel Bans and Restrictions in Buildings in Cities, 2020



Source: REN21 Policy Database and Reference Table R5. See endnote 180 for this chapter.

DISTRICTS AND NEIGHBOURHOODS

Municipal governments have a direct influence over district- and neighbourhood-level planning. They can engage in integrated urban and energy planning processes that take into account the specific spatial, environmental and economic perspectives of these areas. Scaling up renewables in key districts or neighbourhoods can contribute greatly to wider city-level renewable energy strategies and climate targets. Policy activities that local governments have undertaken in their role as planners and regulators include setting targets and plans at the district and neighbourhood levels for the share of district heating, cooling or electricity; the share of district energy in public or other buildings; and the number of buildings connected.[190]

Several cities have sought to scale up renewables at the neighbourhood level. Through the innovative "Barrio 31" Infrastructure Plan, which ended in 2019, Buenos Aires (Argentina) built 120 new homes with access to public services as a way to integrate this marginal neighbourhood into the city.[191] The plan included energy efficiency measures as well as solar panels and solar water heating systems.

In the "smart" city of Eliat (Israel), a municipal bylaw requires every new neighbourhood to include infrastructure for solar panels on the rooftops of homes.[192] The city's Mitzpe Yamthat neighbourhood aims to reduce energy consumption through energy efficiency in public buildings and private homes, and to upgrade existing infrastructure by installing LED lights on utility poles and public buildings, outfitting homes with energy-saving equipment and offering professional guidance on its use.[193] The neighbourhood is seen as a holistic unit, creating a model for other neighbourhoods in the city and elsewhere to replicate.

In Vienna (Austria), a ban on natural gas in new buildings led city authorities to estimate that by autumn 2020, "climate protection areas" would become possible in 8 of the city's 23 districts, with the rest following in 2021.[194] Within these areas, Vienna will be able to produce renewable heat for 80% of new buildings.[195] The city also has an ambitious heat zoning plan, with four districts already banning fossil fuel heating in new buildings and a targeted ban on fossil fuel heating in all buildings city-wide by 2040.[196]

The Haarrjin neighbourhood in Utrecht (Netherlands) aims to power as many as 1,400 households with clean energy from a new floating solar PV plant, which will contribute to the energy-neutral neighbourhood that already has many solar panels on its roofs.[197] In the new residential neighbourhood of Tamarinden in Örebro (Sweden), 600 housing units are being developed with plans to reduce, produce and share renewable energy.[198]

Momentum also has grown (particularly in Europe) for **positive energy districts**: energy-efficient and energy-flexible urban areas that produce net-zero greenhouse gas emissions and have surplus renewable energy generation.[199] These districts focus on energy production, efficiency and flexibility as a means to achieve local environmental, social and economic sustainability.

As of 2020, 61 European cities were developing plans for positive energy districts.[200] Most were in the implementation stage, and only a few had been realised or were in operation, including (since 2018) the Carquefou district in Nantes (France). Carquefou's La Fleuriaye "eco-neighbourhood", which consists of 620 housing units with 6,000 m^2 of solar PV panels, provides 80% of the district's energy needs through solar electricity and is expected to be one of Europe's largest positive energy districts when completed in 2022.[201] Another programme in Europe supports the planning, deployment and operation of "100 Positive Energy Districts and Neighbourhoods" region-wide by 2025.[202]

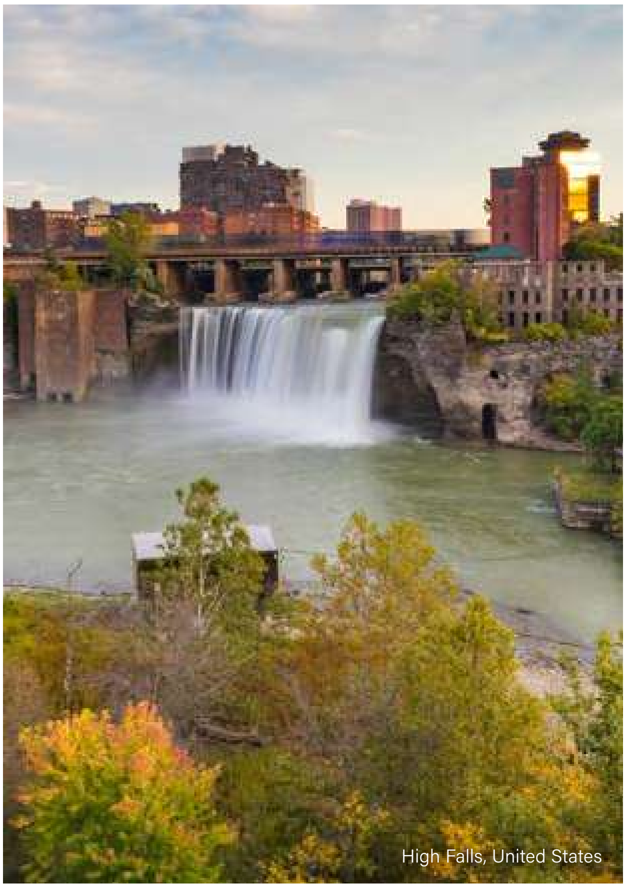
53 cities
have either introduced or planned a ban on the use of natural gas, oil or coal in buildings.

Amsterdam, Netherlands

2

Some US cities have **ecodistricts**[i] that involve urban planning to integrate the twin objectives of social equity and sustainable development, including reducing the ecological footprints of neighbourhoods. For example, the High Falls Ecodistrict, established in 2017 in Rochester (New York), aims to advocate and educate for reduced energy use through energy efficiency upgrades, to catalyse greater use of renewables, and to provide clean, energy-efficient transport options.[203] In Boston (Massachusetts), the Talbot-Norfolk Triangle eco-innovation district (also established in 2017) is implementing projects focused on equitable transit-oriented development, local renewable energy generation, open space, walkability, bikeability, urban agriculture, green infrastructure, public health and safety, and local job creation, addressing both sustainability and economic prosperity within a holistic urban regeneration process.[204]

Ecodistricts being built elsewhere include Yennenga, a sustainable city located 15 kilometres from Ouagadougou (Burkina Faso). The city, which runs on renewable electricity generated in part by a 270 MW solar PV plant, welcomed its first inhabitants in 2020 and is expected to house some 100,000 people by 2030.[205]


High Falls, United States

CITY-WIDE TRANSPORT

Until recently, efforts to increase the use of renewables in transport focused primarily on biofuels, whether ethanol, biodiesel or related fuels.[206] However, in recent years the opportunity to accelerate the uptake of renewables in the transport sector via electrification – using renewable electricity to charge vehicles – has attracted growing attention among urban policy makers worldwide.[207]

Regulatory policies

By the end of 2020, at least 33 cities had issued mandates or obligations to advance or enable the use of renewables in transport.[208] While **biofuel blending**[ii] **mandates** generally are set at higher levels of government, some cities have adopted plans and procurement requirements to promote the local use of biofuels (as well as the use of local biofuels). In 2020, Bogotá (Colombia) adopted a new development plan that encompasses a package of measures to increase the city-wide use of renewable energy, including advanced biofuels[iii].[209]

As momentum behind e-mobility continues to grow, **EV charger mandates** for new buildings have become more commonplace at the city level.[210] In 2019, several cities, including San Mateo (California, US) and Vancouver (Canada), adopted new or revised building energy codes requiring that certain new buildings be both "EV ready" and "solar ready", equipped with the electrical infrastructure required to enable EV charging stations to rely on renewable electricity.[211] Also in 2019, the government of Delhi (India) approved its Electric Vehicle Policy, which among other measures requires all new residential and workplace parking to have EV charging spaces.[212] In 2020, Chicago (Illinois, US) adopted an ordinance requiring new buildings to be equipped with EV charging infrastructure; this new policy – in combination with the city's target to power all buildings with renewable electricity by 2035 – will make it possible to meet the transport needs of building residents or users fully with renewable electricity.[213]

EV charger mandates
for new buildings have become more commonplace.

i Ecodistricts are home to positive energy buildings, or buildings that produce more energy than they consume.

ii Biofuel blending mandates require that transport fuels are blended with a minimum percentage of biofuel such as ethanol or biodiesel.

iii Advanced biofuels are fuels that can be manufactured from various types of non-food biomass, including waste and agricultural residues. See Glossary for definitions.

Several countries have adopted **hydrogen** strategies that have potentially far-reaching implications for cities. In 2019, the Republic of Korea announced plans to set up three hydrogen-powered cities by 2022, which entails a significant scale-up of hydrogen vehicles as well as hydrogen refuelling infrastructure (although it remains unclear whether the hydrogen will be renewables-based).[214] In China, both Guangzhou (Guangdong province) and Kunshan (Jiangsu province) adopted local development plans in 2020 for the production and use of renewable hydrogen in urban fleets.[215] China also was developing an ambitious roadmap to support the deployment of hydrogen vehicles in more than 20 cities, backed with several policy measures including financial subsidies.[216]

Fiscal and financial incentives

By the end of 2020, at least 17 cities were providing fiscal and financial incentives – including grants, subsidies, tax rebates and tax exemptions – for the purchase and operation of zero-emission vehicles, mainly **electric vehicles**, as well as for associated infrastructure.[217] In a small number of cases, the incentives link EVs directly with new renewable power capacity. For example, in 2020 the municipality of Baden (Austria) and the car dealership Czaker promoted the combination of solar electricity and e-mobility, giving EV buyers a bonus if they already had a solar PV system at their house, and offering a subsidy of up to 30% more for installing a solar PV system if an EV is registered at the same address.[218]

Some financial incentive programmes are directed at expanding electric taxi fleets in cities, although without an explicit link to renewable electricity. Cities that have supported the shift to electric taxis include Edinburgh (Scotland, UK), Medellín (Colombia), Montevideo (Uruguay) and Vitoria-Gasteiz (Spain).[219] Since the end of 2019, Amsterdam (Netherlands) has provided financial incentives for zero-emission vehicles, offering rebates of up to EUR 3,000 (USD 3,684) for a taxi and EUR 40,000 (USD 49,129) for a delivery van, truck or bus.[220]

In China, the national New Energy Vehicles (NEV) policy has been the biggest driver for the uptake of electric passenger vehicles.[221] However, some cities also have provided municipal subsidies to NEV consumers in recent years.[222] In 2020, the local government of Shanghai started offering subsidies of CNY 5,000 (USD 766) to NEV buyers, while the city of Shenzhen offered CNY 20,000 (USD 3,064) for the purchase of a new battery electric vehicle and CNY 10,000 (USD 1,532) for a plug-in hybrid.[223]

In the United States, the District of Columbia's Clean Energy Omnibus Amendment Act, passed in 2019, aims to electrify all public buses and other fleet vehicles in Washington, D.C. and to incentivise owners of private, non-commercial vehicles to purchase fuel-efficient vehicles, in an effort to curb greenhouse gas emissions in the city.[224] The Act establishes a vehicle tax based on fuel efficiency, offers tax rebates for vehicles that are more efficient than the established benchmark and exempts EVs from the tax.[225] In 2019, São Paulo (Brazil) granted an exemption from the Vehicle Property Tax (IPVA) to electric, hybrid and hydrogen vehicles registered in the city.[226]

While financial incentives for **hydrogen** vehicles are still limited, some examples exist (although not linked to renewable electricity). Between late 2018 and mid-2020, Arnhem (Netherlands), in partnership with Gelderland province, supported the H2-Drive initiative, under which citizens could request financial support for leasing or buying a hydrogen fuel cell car.[227] The programme initially aimed to finance 90 hydrogen cars but stopped at 70 due to the COVID-19 pandemic.[228]

Financial tools remain popular among different levels of government supporting the transition to renewable fuels and alternative propulsion vehicles. Many cities rely on financial incentives and support policies set by national and/or state governments to complement the limited resources they themselves have to spend on such programmes. For example, in 2020 the North Central Texas Council of Governments (US) set up a grant funding programme for local governments and private companies working with local governments to replace heavy-duty diesel vehicles with alternative fuel[i] vehicles.[229]

Arnhem, Netherlands

2

i In the context of the programme, "alternative fuel" vehicles encompass vehicles that can rely on renewable fuels (such as biodiesel and ethanol) as well as electric vehicles and vehicles fuelled by hydrogen, natural gas and propane.

Overall enabling environment

As of the end of 2020, at least 14 cities had proposed or passed **bans and/or restrictions** on the circulation of certain types of vehicles in their jurisdictions.[230] Most of these measures focus on banning either just diesel vehicles (as many cities in Germany and Spain have announced plans to do) or banning/phasing out all internal combustion engine vehicles, regardless of whether they burn diesel, petrol or liquefied natural gas. Bans on sales of internal combustion engine vehicles have been more common at the national level, and can affect the uptake of biofuels, drop-in fuels and some renewable synthetic fuels that can be used in conventional engines; meanwhile, cities mostly have adopted bans or restrictions on the use of fossil fuel vehicles, which incentivise all renewable fuels and electricity use in urban transport.[231]

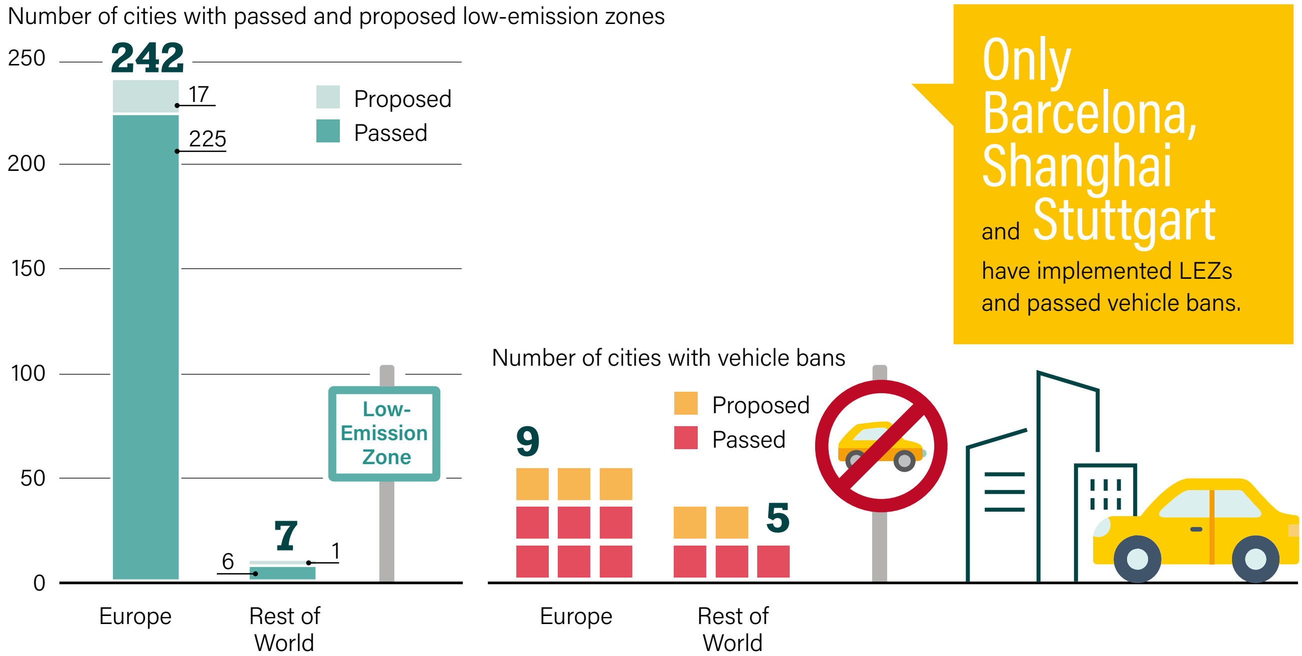
Beginning in 2020, diesel cars up to the Euro 5 emission standard[i] are banned on certain roads in Stuttgart (Germany), with similar restrictions in place in Barcelona (Spain), Berlin (Germany) and Bucharest (Romania).[232] Amsterdam (Netherlands) announced in 2019 that any cars and motorbikes running on petrol or diesel would be banned from driving in the city starting in 2030, and non-electric buses will no longer be able to enter the city centre from 2022.[233] Oslo (Norway) has outlined a plan to make its city centre fossil-free by 2024 and to be the first city to have a fully emissions-free transport sector by 2030.[234] Reykjavik (Iceland) took a different approach, pledging in 2019 to halve the number of petrol stations in the city by 2025 in an effort to phase out internal combustion engine vehicles.[235]

Low-emission vehicle zones (LEZs) continued to spread during 2019 and 2020, predominantly in Europe. By mid-2020, of the 249 passed or proposed LEZs worldwide, more than 97% of them were in European cities (→ *see Figure 12*).[236] Poland's first LEZ was established in Krakow in 2019, and additional LEZs were approved in Stockholm (Sweden) and in UK cities including Aberdeen, Bath, Birmingham, Dundee, Edinburgh, Leeds, Leicester and Southampton.[237] Due to measures enacted in response to COVID-19, some planned UK-based LEZs (including in Oxford) were postponed, and some existing LEZs and associated financial penalties and congestion charges were suspended and then later reinstated – including in Barcelona (Spain), London (UK) and Milan (Italy).[238]

Although the main goal of LEZs is to improve local air quality, they also can result indirectly in greater use of renewable fuels and electricity in transport by allowing concessions to alternative powertrains. In Madrid (Spain), for example, only certain vehicle types – including battery electric, fuel cell electric and plug-in

i Since 1992, new car models in the EU have had to meet increasingly stringent emissions limits, known as the Euro emissions standards, before they can be sold. The Euro 5 emissions standard, which relates to the EU standard for pollutants put in place in 2009, covers carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter, and introduces particulate filters for diesel vehicles.

Figure 12. Number of Cities with Low-Emission Zones and Vehicle Bans on Certain Technologies, 2020



Source: SLOCAT, REN21 Policy Database and Reference Table R5. See endnote 236 for this chapter.

Note: The figure includes cities with LEZs and vehicle bans which have been passed or proposed. Of the total of 231 cities with passed LEZs, 195 were passed before 2020 (between 2006 and 2019), 23 were passed in 2020 and 13 are scheduled to be enforced between 2021 and 2028. Of the 9 cities that have passed vehicle bans, three were enforced in 2019 and 2020 and the remaining six were scheduled to come into force during 2021-2025.

hybrid vehicles with a minimum electric range of 40 kilometres, and range-extended EVs – are allowed to circulate and park in the LEZ without restrictions.[239] In 2020, Paris (France) stipulated that only battery electric and fuel cell vehicles will be permitted in its LEZ by 2030.[240]

Outside of Europe, LEZs have emerged in Chinese cities such as Foshan, Guilin, Huia'an, Shanghai, Suzhou and Zhengzhou.[241] Israel's first LEZ was established in 2018 in Haifa, and in 2020 a new LEZ was implemented in Jerusalem.[242]

The use of **fees and levies** to encourage or discourage certain behaviours and investment choices also can stimulate the transition to zero-emission transport alternatives – and, indirectly, greater use of renewables.[243] Several Dutch cities – including Amsterdam, Eindhoven, The Hague, Rotterdam and Utrecht – offer **free public EV charging**, as does Lisbon (Portugal).[244] Lisbon also offers free EV parking, while at least 12 Chinese cities, including Hefei and Shenzhen, offer reduced parking fees for EVs.[245]

During 2019 and 2020, many city governments – including Delhi (India) and Hong Kong and Shenzhen (both China) – continued to promote the use of EVs by subsidising the installation of charging infrastructure within city boundaries.[246] Community choice aggregation programmes also have started to explore scaling up investments in EV charging infrastructure and increasing the share of renewables used in charging, especially in cities across California (US).[247] By contrast, Amman (Jordan) was forced to cancel its EV financial incentive scheme due to the lack of charging stations to accommodate the growing number of EVs in circulation.[248]

More joint transport-related commitments involving cities and other jurisdictions were announced in 2019 and 2020. Under the Climate Mayors Electric Vehicle Purchasing Collaborative, some 182 US cities and counties have committed to purchasing a total of more than 3,500 EVs before the end of 2021.[249] Additionally, through the C40 Fossil Fuel Free Streets Declaration, 35 cities (including 7 non-C40 cities) pledged to establish major zero emission areas within their cities by 2030.[250] However, there is a high risk that these efforts will not be implemented or successfully linked to renewable energy without complementary policies, such as those highlighted throughout this chapter.

At least
14 cities
have proposed or implemented bans on the circulation of fossil fuel vehicles.

Chongqing, China


Bradley, United States

2

Toronto
Bristol
Klemetsrud
Duiven
Tampa
Cotonou
Lagos
Lalitpur
Hong Kong
Salt Lake City

3 MARKETS AND INFRASTRUCTURE

Cocody
Malmö
Oxford

MARKETS AND INFRASTRUCTURE

Cities are both consumers and producers of energy. They account for around 75% of global energy use[i] and are the leading growth markets for utilities.[1] Because cities (including their governments, inhabitants, and commercial and industrial entities) use so much energy, they have the potential to drive large amounts of renewable energy deployment. However, cities worldwide vary greatly in their energy use – depending on factors such as the level of economic development and the presence of industry, among others – and in their overall ability to deploy renewables, which may reflect local resource and other constraints. In 2020, the COVID-19 pandemic sharply reduced energy use in many cities, particularly in the transport sector (→ *see Sidebar 1 in Global Overview chapter*).[2]

City governments often are constrained by policies and regulations at higher levels of government, as well as by the availability and condition of energy distribution infrastructure. When provided sufficient autonomy, however, a city can exercise greater flexibility over its energy mix and define, to a large extent, the trajectory of its energy future. Overall, cities have significant opportunity and potential to steer the energy system towards renewable energy – not just locally, but well beyond.

Globally, a relatively small but growing share of the energy consumed in cities comes from modern renewable sources[ii]. To some extent, this renewable share is expanding in direct proportion to developments outside of the urban purview, thanks to the greater deployment of renewables elsewhere. For example, state/provincial or national mandates, as well as the changing economics of energy technologies, have led to rising shares of renewable electricity or fuels in regional grids – which has led to higher city shares as well. At the same time, more and more cities worldwide are directly increasing their production and consumption of energy from renewable sources.[3]

Urban demand for renewables is rising in response to growing recognition of the diverse economic, environmental, social and other benefits associated with renewable energy[iii]. So far, the greatest focus has been on meeting municipal government demand (via city procurement authority) followed by efforts to reshape the wider urban energy supply and demand structure. Private procurement also plays a growing role, as individuals and businesses determine their own renewable energy needs. Although most of the renewables used in cities are still sourced from outside the urban area (through regional grids, pipelines and other infrastructure), local production of renewable energy – in the forms of electricity, direct thermal energy and transport fuels – is significant and growing.[4]

i Not including energy embedded in imported agricultural, electronic and other products or materials. See endnote 1 for this chapter.

ii In many cities (especially in sub-Saharan Africa), the traditional use of biomass for heating and cooking is still widespread. See Glossary for definitions of modern renewable energy and traditional biomass.

iii See Drivers chapter in REN21, *Renewables in Cities 2019 Global Status Report* (Paris: 2019), https://www.ren21.net/wpcontent/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf.

Around the world, city governments as well as urban households and commercial and industrial actors are shaping their energy infrastructure and use to better accommodate rising shares of renewables. They are expanding district heating and cooling networks, implementing efficient end-use technologies, increasing electrification of the transport and heating sectors, installing energy storage capacity and facilitating greater flexibility on the demand side – all of which can provide benefits such as greater system efficiency, improved reliability of service and lower overall system costs.[5] To address multiple urban challenges in a cost-effective manner, city governments also are linking energy supply with other municipal activities – for example, using rapidly growing urban waste and wastewater streams as feedstocks to produce solid, liquid and gaseous biofuels (→ *see Sidebar 5*).[6]

The availability and reliability of energy data vary greatly across countries and cities. In general, data on renewable energy capacity and generation are tracked at the national (and often state/provincial) level, but not always at the local level. As a result, comprehensive global statistics on urban renewable markets (for both energy and technologies) and generation are incomplete or lacking.[7] Further, although energy consumption is reasonably well documented at the national level, the urban/rural breakdown of this use is generally unavailable.

Within these limitations, this chapter provides an overview of city-level renewable energy market and infrastructure developments during 2019 and 2020. It examines the installation of renewable energy technologies and associated infrastructure in cities, the energy capacity procured for use in cities, as well as relevant consumption trends across the buildings, industry and transport sectors (→ *see Global Overview chapter*).


Santiago, Chile

SIDEBAR 5. Waste-to-Energy in Cities

The rise of urban refuse, including municipal solid waste (MSW) and wastewater, has been a major component of the rapidly growing global waste stream[i]. As the volume of refuse in urban areas skyrockets – driven by population growth, urbanisation and changing patterns of consumption – cities have faced major challenges, leading many to undertake measures to improve their waste management systems.

Key challenges include: the effective and comprehensive collection and transport of refuse to waste processing facilities; separating and capturing recyclable materials and energy content from the waste stream (including methane emissions[ii]); and identifying adequate land for treatment and disposal of remnants (often at high economic cost) – all while minimising the impacts on public health from local air, soil and water contamination. In developing countries and emerging economies, more than two-thirds of MSW is deposited improperly in open landfills that lack advanced environmental protection, let alone adequate energy and material recovery protocols.

At the same time, waste is a resource that, if properly recycled, can be recovered to be used as an input for new products. Cities have numerous opportunities to manage their waste in a more sustainable (and economically beneficial) manner. To minimise the volume of waste going to landfill and to recapture both material and energy resources, many cities divert, capture and recycle usable materials. Any refuse with direct energy potential (meaning usable fuel and direct heat, as opposed to recaptured embedded energy in materials such as processed metals) can be captured for direct and indirect energy applications.

For example, organic waste can be extracted and reformed into solid, liquid or gaseous biofuels to generate electricity, to directly provide heat via combustion (for cooking and heat in buildings, and in industry) and to fuel vehicles. Organic waste also can be processed into organic fertiliser, which displaces demand for fossil fuel-based fertilisers and avoids emissions associated with using fossil fuel as a feedstock.

To extract energy from waste, cities have adopted a variety of technologies, including anaerobic digestion of solid and liquid organic waste to produce biogas, the capture and use of landfill gas, and direct combustion of solid waste[iii]. Biogas, whether from digesters or landfill, is considered to be a renewable fuel. It has high methane content and can be combusted directly to produce electricity and/or heat.

In Santiago (Chile) in 2017, the water utility Aguas Andinas transformed three wastewater treatment plants into the Greater Santiago Biofactory, which converts the city's effluent to biogas to produce heat and electricity; the utility also reuses the additional sewage sludge as fertiliser for agriculture. In 2019, the plant generated 57.2 gigawatt-hours (GWh) of electricity and reused 69% of bio-solid as fertiliser. In Victoria (Australia), the Environmental Protection Authority approved construction in 2020 of a second biogas plant at the Melbourne Regional Landfill, which is expected to generate 68,000 MWh of electricity annually.

Cities also are converting food waste to biogas. In the United States, both legislation and public demand to limit landfill sizes and reduce carbon footprints has motivated city actors to take action. In 2020, Los Angeles (California) expanded the capacity of its food-to-biogas plant from 165 tonnes to 550 tonnes of separated food waste per day, which is used to produce fuel for electricity generation and for transport vehicles. In New York City, the Newtown Creek Wastewater Treatment Plant has processed around 3% of the city's daily liquefied food waste into biogas for electricity generation since 2016, and plans were announced in 2019 to double the plant's capacity.

New Zealand was building its first large-scale food waste-to-biogas plant with anaerobic digester technology in Reporoa on the North Island in 2020. The facility, expected to be operational in 2022, aims to process up to 75,000 tonnes of household and commercial food waste from Auckland annually to provide electricity for the equivalent of around 2,500 households in the region and to provide bio-fertiliser for 2,000 hectares of local farmland, as well as to produce CO_2 and heat for local greenhouses.

Biogas can be upgraded to biomethane and used as a transport fuel or injected into fossil natural gas pipelines. Biomethane plants have become increasingly common, particularly in Europe where the number of facilities rose 51% between 2018 and 2020, from 483 to 729. Lille (France) converts more than 108,000 tonnes of household waste annually into biomethane to fuel half the city's bus fleet. In 2020, Bristol (UK) partly funded the deployment of 77 buses fuelled with biomethane derived from anaerobic digestion of food waste. Toronto (Canada) partnered with the gas company Enbridge Gas to install biogas upgrading equipment for biomethane production at the Dufferin Solid Waste Management Plant. The facility is expected to produce some 3.3 million cubic metres of biomethane per year for injection into the natural gas distribution grid, which supplies fuel to waste collection trucks and other municipal vehicles as well as heat for Toronto's buildings and other facilities.

i Global waste generation increased more than 50% between 2012 and 2016, from around 1.3 billion tonnes to 2.01 billion tonnes, according to the latest data available. See endnote 6 for this chapter.

ii Methane, emitted during the decomposition of organic wastes, is a potent greenhouse gas that contributes to climate change and can potentially cause explosions at waste facilities if ignited.

iii Not all energy produced from the remaining waste is renewable. Energy derived from MSW combustion cannot be considered entirely renewable, as MSW also contains inorganic material. Generally, about 50% of this energy is classified as renewable.

The direct disposal of MSW through incineration is a common practice, and more than 4,800 incinerators are in operation worldwide, a growing number of which use the thermal energy released through combustion to generate usable heat and electricity. However, only the energy produced from the organic portion of MSW can be considered renewable, and emissions from incineration greatly affect air quality in the absence of pollution control systems. Cities have begun to install control systems to reduce air emissions from incinerators. In 2018, the Norwegian government initiated a carbon capture project at the Klemetsrud waste-to-energy facility – which processes more than 400,000 tonnes of waste annually – to generate electricity and heating for the city of Oslo. In 2019, the Dutch waste-to-energy company AVR equipped its waste combustion plant in Duiven (Netherlands) with a flue gas purification system to reduce CO_2 emissions.

Source: See endnote 6 for this chapter.

Auckland, New Zealand

Toronto, Canada

3

BUILDINGS AND INDUSTRY

PRODUCTION AND PROCUREMENT OF ELECTRICITY

In towns and cities around the world, municipal governments and other urban actors – including residents, businesses, universities and places of worship – are producing and procuring renewable electricity to power building systems and run all forms of commercial and industrial activity. Depending on their local resource options, laws and regulations, and other location-specific variables (including institutional and financial capacities), these entities are pursuing activities in at least three general areas to increase their use of renewable electricity:

- installing distributed renewable power systems at or near the point of demand (on-site);
- purchasing renewable electricity through green tariff programmes; and
- signing power purchase agreements (PPAs) with developers for projects in and outside of urban areas.[8]

In cities where these options are not available or are insufficient – often because national and state/provincial laws and regulations govern activities related to energy production, procurement, and electricity transmission and distribution – municipal governments and other urban actors use alternative avenues to achieve their local renewable energy goals.[9] In many instances, city governments have partnered with diverse stakeholders, including utilities and other cities, to engage with legislators and regulators to remove barriers.[10] Many city governments are pursuing community aggregation efforts or the municipalisation[i] of electricity procurement and distribution (→ *see Citizen Participation chapter*).

ON-SITE GENERATION

Thousands of examples exist of recent on-site projects in cities, ranging in capacity from a few kilowatts to hundreds of megawatts. Based on available information, most of these local projects are solar PV systems (combined with battery storage in a small but increasing number of systems), although many cities also tap into local wind, biomass and hydropower resources. These systems are being installed on or near government buildings, schools and universities, single-family homes and high-rise apartment buildings, hospitals, airports, commercial and industrial facilities, places of worship, carports, rail and bus stations, urban waste sites and city streets (→ *see Box 1*).[11]

i See Glossary for definition.

BOX 1. Solar Streetlights

Public street lighting consumes as much as 40% of the electricity budget in some cities. To reduce costs, municipal governments around the world are embracing renewably powered street-lights (as well as energy-efficient lighting programmes) as cost-effective and reliable solutions.

In 2020, Epperson, a master-planned community in Tampa (Florida, US) was deploying more than 10,000 solar streetlights that will run entirely off the grid. In Canada, Prince George (British Columbia) launched a pilot project to test an off-grid solar-powered streetlight, and in Australia the Mareba Shire Council (Queensland) installed 10 solar-powered off-grid public lights, which helped the council save more than 30% on lighting costs in addition to improving road safety.

Solar street lighting also is providing more reliable illumination across Africa. In 2020, Djoum and Yaoundé in Cameroon, which suffer frequent power outages, installed solar streetlights, and 12 towns in Liberia's upper Bong County switched on 60 solar streetlights, serving more than 5,500 residents. In Senegal, a project to install 50,000 solar streetlamps in several cities was delayed by COVID-19 but was 50% complete by mid-2020, providing lighting to more than 20,000 urban dwellers. Cotonou (Benin) and Lagos (Nigeria) were testing solar traffic lights, mainly to reduce road congestion and accidents caused by unstable power supply.

At the same time, some cities with existing solar lights that no longer function due to theft or lack of maintenance are exploring other options. Ekurhuleni (South Africa), Harare (Zimbabwe), Kampala (Uganda) and Kathmandu and Lalitpur (both Nepal) have all opted for "smart" electric streetlamps, which send signals to a central power control module when they experience technical problems so that they can be fixed promptly.

Source: See endnote 11 for this chapter.


Colombo, Sri Lanka

In the **United States**, local government transactions related to renewable energy (for both on-site and off-site systems) increased considerably after the federal government announced in 2017 that it would withdraw from the Paris Agreement.[12] Many US cities – including Cincinnati (Ohio), Honolulu (Hawaii), Los Angeles, San Diego and San Jose (all California), New Orleans (Louisiana) and Phoenix (Arizona) – have built small-scale on-site or community solar projects as a first step towards achieving their renewable electricity goals.[13] By 2019, public authorities, residents and businesses in Los Angeles had installed some 440 MW of grid-connected solar PV capacity, supplying around 11% of the city's electricity mix and making Los Angeles the top US city for grid-connected solar PV.[14] Honolulu leads for solar PV capacity per capita, with more than 646 watts for each city inhabitant as of the end of 2018.[15]

In the US northeast, most renewable energy deals made by local governments are for on-site projects due in part to favourable policies for distributed energy (particularly solar PV).[16] New York City's transit authority launched an initiative in 2019 to lease many of its rooftops and parking lots for solar projects, and city agencies announced plans in 2020 to install solar PV on 46 public schools, a wastewater facility and other buildings as part of a goal to install 100 MW on New York public buildings by 2025.[17]

Elsewhere in the country, Seattle (Washington) generated nearly all of its electricity with renewables in 2019, thanks to an estimated 8,000 solar buildings and a public utility that has been carbon-neutral since 2005 (due mainly to hydropower).[18] Fayetteville (Arkansas) completed a solar project in 2019 to power two wastewater facilities that account for most of the municipal government's electricity use.[19]

Across **Europe**, numerous city governments added renewable power capacity in 2019 and 2020, with local projects including biomass facilities as well as other renewable power systems. In Ukraine, the eastern city of Dnipro began operating a 16 MW biopower plant in 2019.[20] In the United Kingdom, Glasgow (Scotland) opened an anaerobic digestion facility to convert organic landfill waste into methane for electricity generation, with the goal of powering nearly 26,500 households annually.[21] Exeter (England) was developing its first solar-plus-storage project in 2020, consisting of a 1.2 MW ground-mounted solar array co-located with a 1 MW / 2 MWh battery to provide electricity for city council operations.[22]

As of 2020, Athens (Greece) planned to install solar PV systems on 50 schools to cover all school electricity needs in the municipality, and Kaunas (Lithuania) planned to install systems on 77 city buildings, including schools and healthcare facilities – both with support from their respective national governments.[23] Tychy (Poland) announced plans to add hundreds of renewable energy systems, including 647 solar PV systems, by the end of 2021 to improve local air quality and reduce energy costs.[24] In Bordeaux (France), a 59 MW plant under construction on the site of a former landfill was expected to produce the equivalent of 28% of the city's electricity consumption when completed.[25]

In **Asia**, much of the city-focused activity has occurred in India, where several "smart cities"[i] have embraced renewables. In 2018, Diu Smart City became the country's first city to operate on 100% renewable electricity, thanks in part to a 9 MW solar PV park and solar panels installed on 79 government buildings; several other smart cities issued tenders in 2019 and 2020 for local solar PV capacity atop buildings, canals and sewage treatment facilities.[26] In Delhi, solar PV installations on government and educational buildings totalled around 105 MW in 2019, with another 5 MW on residential buildings.[27] By the end of 2019, the industrial city of Pune had more rooftop solar capacity (130 MW) than any other Indian city.[28] Across India, the higher electricity rates, readier access to financing and larger rooftops for industrial versus residential users have encouraged the industrial adoption of solar PV.[29]

Urban consumers in many other Asian countries have opted for solar PV rooftop systems. Hong Kong Disneyland (China) installed a 1.8 MW system that became viable after local utilities introduced a feed-in tariff scheme to help achieve Hong Kong's green goals.[30] In Malaysia, supermarkets, retail chains and one of the world's largest solar glass manufacturers (Xinyi Glass Holdings) launched projects or plans for substantial urban rooftop capacity during 2019 and 2020.[31]

In **Latin America**, falling solar PV system costs have propelled significant investments in several cities. The government of Mexico City (Mexico) installed rooftop solar PV on some municipal buildings in 2020 as part of the city-wide initiative Solar City.[32] Private consumers in the region also have embraced solar PV, with Walmart deploying systems on its Mexican stores in Aguascalientes, León, Puebla and Salamanca.[33] In Colombia in 2020, Bancolombia installed nearly 2,000 solar panels at its headquarters in Medellín, and in Bogotá the Diverplaza mall inaugurated a solar PV system with nearly 700 panels.[34] In Brazil, Uberlândia nearly tripled its solar PV capacity between mid-2019 and mid-2020, to nearly 50 MW, making it the nation's top city for solar PV.[35]

Across **Africa**, municipal governments as well as large commercial and industrial actors have deployed a significant number of distributed renewable energy systems to ensure reliable and affordable electricity supply (→ *see City Snapshot: Cocody*).[36] During 2020, several solar power projects were being developed in Libya to reinforce local grids and ensure security of supply, including in Benghazi, Kufra, Rajban, Sebha, Tripoli, Ubari and Zintan.[37] In the Democratic Republic of the Congo, the city of Goma inaugurated a 1.3 MW hybrid solar power plant (with a storage system) and distributes electricity to the local community via a mini-grid.[38] Egypt's New Administrative Capital east of Cairo planned to install rooftop solar PV systems on 65 municipal buildings starting in 2020.[39]

Private sector solar PV projects in Africa included the 2019 installation of the first system in Tatu City (Kenya) atop the headquarters of Dormans Coffee, and the installation of an off-grid system on the Windhoek (Namibia) production facility of beverage multinational Coca-Cola.[40] The furniture manufacturer Maroc Bureau installed solar panels on its factory rooftops in Casablanca and Rabat (both Morocco) In 2020.[41]

i See Glossary for definition.

COCODY

CÔTE D'IVOIRE

Land area (km²)	Population size (2018)
135	800,000

The City of Cocody, located north of Abidjan on the coast of Côte d'Ivoire, released its Green City Plan in 2017, pledging to reduce carbon emissions 70% by 2030 to combat climate change. The city established the pledge to complement efforts to achieve the national goal of 42% renewable electricity generation by 2030, as put forward in Côte d'Ivoire's 2016 Nationally Determined Contribution towards reducing emissions under the Paris Agreement. Achieving the city's emissions reduction target will be challenging due to Cocody's rising energy demand, which is caused largely by rapid urban development and economic growth.

Cocody Green City is an ambitious plan that aims to minimise local greenhouse gas emissions while also creating 100,000 direct jobs and 400,000 indirect jobs, promoting women's empowerment and increasing citizen participation in adopting sustainable living. This community-based climate action plan aims to reduce CO_2 emissions by up to 90% by 2030, using renewable energy and carbon sequestration efforts. The city has set up a Reforestation and Carbon Sequestration Program that includes the development of green spaces and the restoration and replanting of 2 million mangrove trees to protect local climate health.

The Green City plan takes a holistic approach towards upgrading energy use and generation, transport, habitat restoration and land use, conservation and protection of water resources, community sensitisation and adoption. As of 2017, 23 measures were under development, including using solar energy to power large public buildings, installing 5,000 solar lamp posts, installing 1,600 solar traffic lights at 400 crossroads and supplying 200,000 solar PV power kits to households. Other measures to reduce carbon emissions include distributing to households 300,000 efficient cook stoves that run on ethanol procured locally from sugarcane manufacturers, producing 1,000 solar dryers for community women, distributing solar water heaters and setting up four wind farms on the banks of Ebrie lagoon.

The Cocody Green City plan also emphasises the development of sustainable transport and mobility plans through a Transport Demand Management scheme that aims to remove 1,000 old vehicles annually from city roads to improve local air quality and eliminate some 50 million tonnes of CO_2 emissions per year. In addition, a used vehicle repair centre has been created to provide 100,000 catalytic exhaust systems for polluting vehicles.

Source: See endnote 36 for this chapter.