the energy efficiency of municipal operations, saving a cumulative ZAR 225 million (USD 16 million) through 2019.[38] The City began supporting small-scale "embedded generation" in 2011, making it South Africa's first city to develop tariffs and rules for distributed renewables and serving as a blueprint for the rest of the country.[39]

In 2013, when South Africa had no national standards in place for solar PV on buildings, Cape Town published guidelines[i] promoting the safe and legal installation of distributed renewables in commercial and residential settings.[40] By 2019, the City had the highest concentration of registered rooftop solar PV systems nationwide.[41] In total, between 2011 and 2020, Cape Town approved the installation of nearly 42 MW of rooftop solar PV and installed 0.6 MW on City buildings through its rooftop PV programme.[42] These systems feed into the local electricity distribution network, helping to reduce reliance on coal-fired power from the national grid. Similar processes, guidelines and tariffs have since been adopted in more than 40 other South African municipalities.[43]

Building on earlier roll-outs of solar water heaters in low-income communities, in 2013 Cape Town implemented a programme to promote this technology more widely, helping to reduce energy from one of the highest electricity-consuming end-uses for city households, water heating.[44] By 2015, some 46,000 solar water heaters had been installed city-wide, saving 128,000 MWh per year, creating employment equivalent to 1,300 job-years[ii], contributing more than ZAR 380 million (USD 27 million) to the local economy and reducing more than 132,000 tonnes of carbon emissions per year.[45]

In 2015, the Cape Town Energy 2040 Vision, developed through an extensive process of energy modelling and stakeholder engagement, set ambitious city-wide targets for increasing energy access, improving energy efficiency and reducing carbon emissions.[46] It also set a target to achieve at least 500 MW of renewable and clean energy capacity by 2040.[47] To help achieve this ambition, the City of Cape Town elevated the role of energy institutionally, combining its two energy-related divisions (one focused on energy and climate change and the other on electricity generation and distribution) into a single new Energy and Climate Change Directorate.[48]

This change also signaled Cape Town's intention to expand its role in local electricity supply. In 2017, the City entered into a court challenge with the national government to enable it to purchase electricity from independent power producers (IPPs) and not be confined to procuring coal-fired power from Eskom, the centrally controlled national energy utility.[49] In a landmark step in October 2020, South Africa's Department of Mineral Resources and Energy amended the country's electricity regulations to enable municipalities in good financial standing to develop their own power generation projects, as a way to ensure security of energy supply in a co-ordinated manner aligned to the national IRP and the municipal Integrated Development Plans (which guide overall planning and development for municipalities in South Africa).[50]

The City of Cape Town has taken an **active leadership role** in renewable energy deployment.

The City of Cape Town has begun laying the foundations for supplying renewable energy at scale. Based on a legislative change in late 2020, the municipal government is exploring the commercial, legal and technical aspects of a municipal-level Renewable Energy Independent Power Procurement Programme (REIPPP) and is developing a guide on how to engage with industries in procuring energy from IPPs.[51] As of 2020, the City was working on a Zero Carbon 2050 action plan (and related policies) as well as developing low-income energy services, a framework for electric vehicles and innovative financing opportunities for engaging households in small-scale rooftop solar PV.[52]

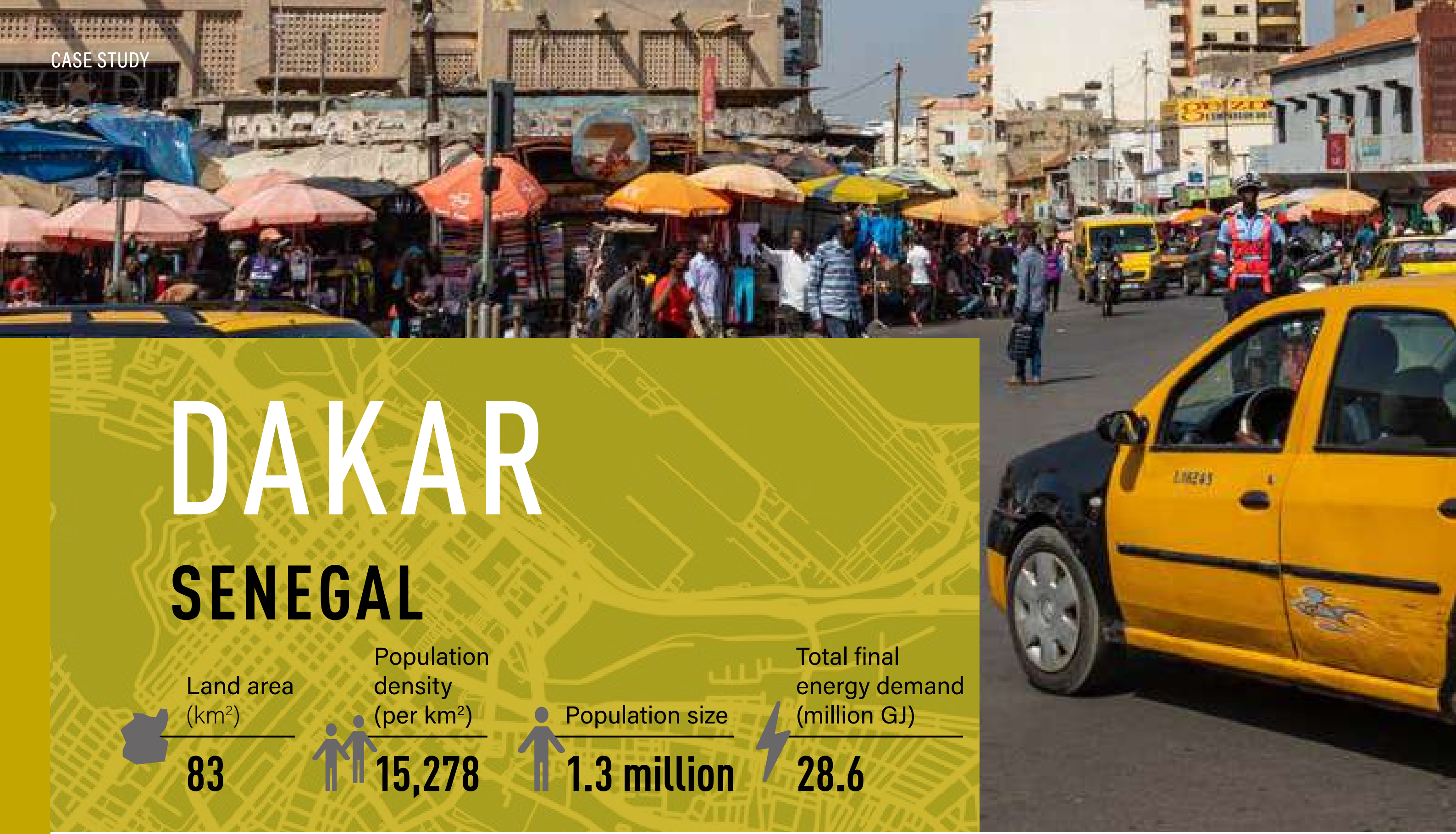
Cape Town is also honouring its international commitments to climate action. It is a signatory to various initiatives including the Mexico City Pact, CDP, the carbon*n* Climate Registry, the Covenant of Mayors in Sub-Saharan Africa and the C40 Cities Leadership Programme.[53] The City also has committed to achieving carbon neutrality by 2050, recognising that this will require ambitious actions across all sectors.[54] To translate these commitments into action, Cape Town has woven them into its Integrated Development Plan for the period 2017-2022.[55]

The City's transport plan includes exploring the potential production and use of biofuels in transport, using renewables for infrastructural facilities such as depots and transport interchanges, and replacing the municipal diesel bus fleet with electric buses (which eventually would be powered with renewables).[56] In a pilot project in early 2018, the City's "MyCITI" bus rapid transport service added 11 locally manufactured electric buses to its fleet.[57]

Cape Town is working to prepare its power grid for high EV penetration in the near future. The Electric Vehicle Framework includes leveraging EV roll-out and charging to increase the share of renewables in final energy consumption, and is considering requiring public EV charging stations that exceed a specific demand threshold to operate on renewable energy.[58] This energy is expected to be either generated from local solar PV capacity or purchased through a contractual arrangement.[59]

i The guidelines, which are non-binding, outline a comprehensive list of City-approved suppliers of inverters, the steps for installing solar systems and the application process for registering and selling electricity to the City.

ii A job-year refers to one of year of work for one person.



DAKAR

SENEGAL

Land area (km²)	Population density (per km²)	Population size	Total final energy demand (million GJ)
83	15,278	1.3 million	28.6

Dakar is the capital of Senegal in West Africa and is located at the western tip of the country. It is an Atlantic port city covering an area of 83 square kilometres with an estimated population of more than 1.3 million inhabitants.[60] As of 2016, the greater Dakar region was home to 50% of Senegal's urban population, 95% of its industrial and commercial companies, 80% of its infrastructure and services and 87% of its formal employment; as a consequence, Dakar contributed an estimated 68% of the country's gross domestic product (GDP).[61]

As of 2019, Senegal had around 864 MW of total installed electricity capacity, 13% of which was renewable (7% from hydropower and 6% from solar PV).[62] The National Energy Development Plan (Lettre de Politique de Développement du Secteur de l'Energie, or LPDSE), signed in 2012, targets increasing the renewable share in power generation from 10% in 2016 to 15% in 2020[i].[63] The country's national economic and social development plan (Plan Senegal Emergent, PSE 2025) aims for a 23% share of on-grid renewables in power generation by 2030.[64]

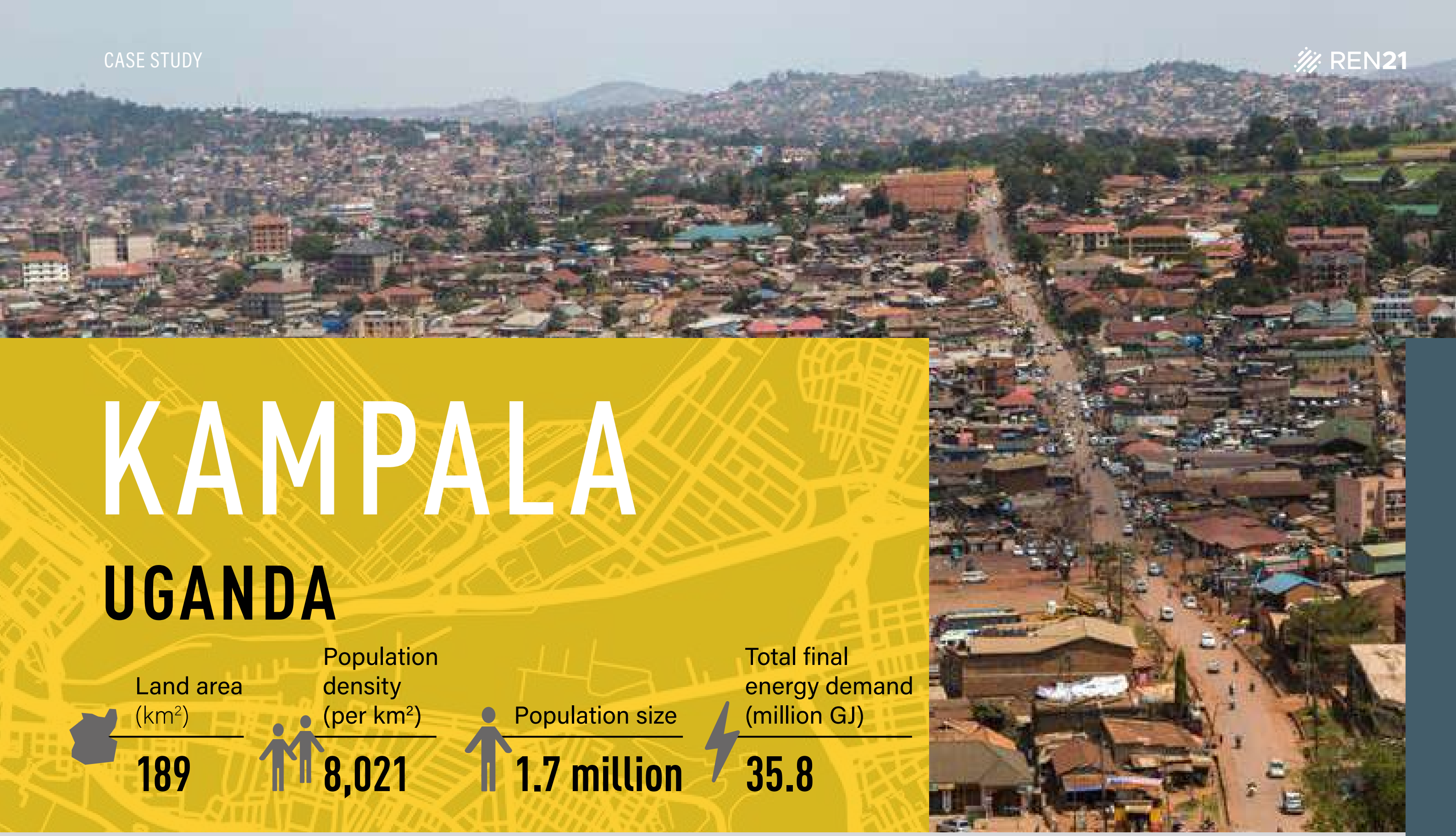
The City of Dakar reinforces these objectives through municipal policies and strategies such as the Environmental Action Plan (P.ACT.E.) and the Master Plan for Urban Development of Dakar and Its Surroundings (PDU 2035). The PDU aims to achieve 15% local electricity production from renewables by 2035 and to reduce reliance on diesel power generation from 90% in 2013 to 5% in 2035.[65] The City intends to finalise (by March 2021) its Plan Climate Energie Territorial (PCET), which will be the integrated energy and climate change development plan informing Dakar's short- and long-term renewable energy roadmap.[66] The PCET is being developed as a result of Dakar's commitment under the C40 Cities Leadership Programme to be net-zero carbon by 2050.[67]

The transport sector dominates the city's energy demand – accounting for 55% of total energy consumption – followed by the industrial (34%) and residential (8%) sectors (→ *see Figure 18*).[68] Despite Dakar's high electrification rate of more than 95%, household electricity use remains low at around 153 kWh per capita annually (compared to 10,649 kWh per capita in the United States), with lighting as the main end-use application.[69] Liquefied petroleum gas (LPG) is the primary energy source for cooking (averaging 12 kilograms per month per household), followed by charcoal (0.2 kilograms per person per day) and some use of firewood.[70]

The high energy demand for transport reflects Dakar's deteriorating road infrastructure, inefficient public transport networks and ageing vehicle fleet, with 80% of on-road vehicles estimated to be more than five years old.[71] This has led to urban mobility challenges, including permanent traffic jams at peak hours that contribute to high air pollution and negatively affect residents' economic competitiveness, health and well-being, and quality of life.[72] In response, the national transport entity, Conseil Exécutif des Transports Urbains de Dakar (CETUD), piloted the city's mobility and urban planning strategy, the PDUD 2008-2025. The plan articulates three ambitious infrastructure projects – the Express Transit Train (TER), bus rapid transit and renewal of the on-road transport fleet – with a common goal of increasing the share of electrification and reducing fossil fuel dependence across these three transport modes while also reducing air pollution from on-road transport emissions by 2030.[73]

Although the local authority has control over municipal buildings only, the City recently completed a pilot energy audit of all municipal and public buildings, as the first phase of an ambitious target to equip more than half of municipal buildings with grid-connected distributed rooftop solar PV by 2030, as envisaged in the PCET.[74]

i As of late 2020, no reporting had been identified to verify that this renewable energy target had been met.



KAMPALA

UGANDA

Land area (km²)	Population density (per km²)	Population size	Total final energy demand (million GJ)
189	8,021	1.7 million	35.8

Kampala is the capital city and largest urban centre of Uganda, with more than 1.7 million inhabitants in 2020.[75] As the country's economic hub, it accounted for 80% of Uganda's industrial and commercial activities in 2016 and generated around 65% of national GDP that year.[76] City operations fall under the responsibility of the Kampala Capital City Authority (KCCA).

KCCA is a pioneer signatory to the Covenant of Mayors in Sub-Saharan Africa (joining in 2015), through which the city developed its first energy and climate action plan – the Kampala Climate Change Action Strategy – in 2016.[77] This strategy frames KCCA's approach to furthering the deployment of renewables through assessing the local renewable energy potential, supporting the city's green economy, promoting the implementation of a feed-in tariff system and reducing the use of individual motorised transport in favour of non-motorised mobility and green and public transport.[78] KCCA's strategy is consistent with the Draft National Energy Policy of 2019, which promotes the deployment of non-hydropower renewable generation sources to diversify the energy mix and thereby mitigate Uganda's over-reliance on hydropower, which accounted for 90.5% of the national electricity supply in 2018.[79]

The transport sector dominates Kampala's energy demand, accounting for 45% of the total in 2016, followed by the residential (23%), industrial (21%) and services (11%) sectors (→ *see Figure 18*).[80] The majority of this energy demand is fuelled by fossil fuels used in transport (55%) and by (mainly traditional) biomass used for cooking and water heating (36%).[81] After biomass, electricity (90% of which comes from hydropower) is the second largest non-transport energy carrier, accounting for 17% of total final energy consumption; it is used across the industrial, services and residential sectors, mainly for lighting, cooling and the powering of heavy machines.[82]

The transport sector's large share of energy consumption is seemingly in contrast with Kampala's service-based economy. However, the service sector has low energy intensity, in part because 57% of businesses in the city were informal as of 2017, focused mainly on non-tradeable services such as retail, transport and restaurants.[83] Informal roadside vending has added to city congestion, and significant passenger travel also occurs through inefficient transport modes such as motorcycles (boda boda) and private cars, which together accounted for 70% of total passenger transport energy demand in 2016.[84]

These transport and mobility challenges helped shape KCCA's Climate Change Action Strategy 2016 and the Kampala City Strategic Plan 2025, which hinges on the principle of SMART mobility[i] to improve the efficient movement of people and goods within and through Kampala City.[85] The City established an air quality monitoring and assessment system and is promoting electric mobility to gradually replace conventional commercial motorcycles as a way to reduce noise and air pollution, petrol demand and traffic jams.[86]

KCCA's leadership has enabled successful public-private partnerships, and by 2020 start-ups such as Bodawerk and Zembo had resulted in the use of more than 200 new and retrofitted electric motorcycles for public transport in the city (charged mostly from the hydropower-dominant grid).[87] Electric mobility through e-motorcycles provides a framework for KCCA to contribute to national and international climate change mitigation efforts by deploying renewables in the transport sector. Because electric motorcycles require little infrastructure, are silent and produce virtually no emissions (thereby improving air quality levels), they hold promise for successful uptake among boda boda riders.

i The SMART mobility strategy, detailed in the Transport Master Plan for the Kampala Metropolitan Area, supports the construction and operation of a Mass Rapid Transit System based on buses, rail and cable cars by 2040.

TSÉVIÉ

TOGO

Population density (per km²)	Population size	Total final energy demand (million GJ)
596	103,000	0.4

Tsévié, a small town 35 kilometres north of Togo's capital Lomé, had a population of around 103,000 in 2017, growing at a rate of 2.8% annually.[88] The town has minimal industrial activity, and its economy is built largely on agricultural activities centred on crop production and livestock farming, generating a low annual economic output of USD 519 per capita.[89]

Togo's electricity infrastructure development plan, as outlined in the national Electricity Sub-Sector Strategic Plan of 2010, is based on a least-cost electricity supply and demand balance, taking into account security of supply and the environment.[90] This led to the development of the Togo National Action Plan for Energy Efficiency (PANEE) and the Togo National Renewable Energy Action Plan (PANER), which respectively define the country's objectives for energy efficiency and renewable energy deployment by 2030.[91] The national objective for renewables is to increase the share of solar PV in total final energy consumption to 10% in 2030, including both on- and off-grid PV.[92]

Due to Tsévié's low levels of industrialisation and electricity access (estimated at 24% in 2017), traditional biomass in the form of wood and charcoal is the single most important fuel in the peri-urban settlement.[93] Traditional biomass accounts for 64% of total final energy consumption and is used to meet household cooking and water heating needs.[94] The residential sector is responsible for 73% of total final energy consumption, followed by the transport sector (25%) and the town's few commercial facilities (2%).[95] Because of the low levels of electrification, the town's street network is largely unilluminated, limiting potential economic activity in the evenings.[96]

To boost local energy access and development, Tsévié implemented a three-year municipal energy programme (2017-2020) under the Covenant of Mayors in Sub-Saharan Africa, with the goal of developing a community-wide energy and climate action plan (the Plan d'Action en faveur d'un Accès à l'Energie Durable et du Climat (PAAEDC) de la commune de Tsévié). Under this flagship programme, the municipality aims to achieve its sustainability ambitions in four strategic areas: 1) sustainable biomass use, 2) deployment of distributed rooftop solar PV, 3) increased adoption of electric motorcycles and 4) a modal shift to public transport.[97]

Under the PAAEDC framework and with funding from the European Union, Tsévié led a series of pilot projects in 2018-2020 to boost energy access and development and increase the share of renewables in energy consumption.[98] To improve access to clean cooking facilities, the municipality distributed 8,200 improved and efficient cook stoves in the town and its environs as a means to limit the prolific household use of traditional biomass for cooking and water heating (and thus improve indoor air quality and human well-being).[99] The city also sought to bridge the electricity access gap and to improve lighting solutions by installing 75 solar street lamps for public lighting, distributing 95 solar home systems to the most vulnerable households and installing five community solar kits in schools.[100]

To boost local energy access and development, Tsévié implemented a **three-year municipal energy programme.**

YAOUNDÉ IV

CAMEROON

Land area (km²)	Population density (per km²)	Population size	Total final energy demand (million GJ)
59	13,445	793,000	7.6

Yaoundé IV is one of the seven communes of Yaoundé (Cameroon), with an estimated 793,000 inhabitants in 2018 spread over an area of around 59 square kilometres.[101] Yaoundé IV is primarily a service-oriented city, with a major informal economy that includes unlicensed street vendors (locally referred to as "sauveteurs") and small neighbourhood boutiques.[102] This translates to a low annual economic output (GDP) of around USD 1,632 per capita, comparable to the Sub-Saharan African average of USD 1,585 per capita.[103]

Renewable energy (exclusively from hydropower) makes up 73% of the power generation mix in both Cameroon and Yaoundé IV, with oil and gas constituting the remaining 27%.[104] Based on the national Economic Emergence Plan 2035, the country has ambitions to deploy increasing amounts of renewable energy, particularly hydropower and solar PV, to reduce its greenhouse gas emissions by 32% by 2035.[105]

Although the national government does not allow municipalities to undertake electricity generation and distribution projects, a number of decrees provide local authorities with the ability to receive technical and financial support towards climate action.[106]

Yaoundé IV's residential sector is the second most energy-intensive sector (accounting for 30% of total final energy consumption) after transport (35%).[107] An estimated 86% of households cook and heat their water with LPG, which represents 51% of the total residential final energy use.[108] Household electricity consumption averages 507 kWh per capita per year, above the national average of 280 kWh, and is used mostly for lighting and water heating services.[109]

As a signatory city of the Covenant of Mayors in Sub-Saharan Africa, Yaoundé IV in 2020 adopted its short-term energy and climate action plan (Plan d'Action Communal en faveur d'un Accès à une Energie Durable et du Climat, or PACAEDC), which sets out the municipality's ambitions to reduce greenhouse gas emissions and increase energy access by 2030.[110] As part of the plan, the city aims to increase the renewable energy share through multiple cross-sectoral actions, such as installing 3,000 solar streetlights in the 65 neighbourhoods, installing distributed rooftop solar PV on 30 municipal buildings, distributing 3,600 solar kits to poor households and incentivising increased adoption of electric motorcycles (to 5% by 2030, running mostly on electricity from the hydropower-dominant grid).[111]

> The city aims to increase renewable energy, installing 3,000 solar street-lights and distributing
> **3,600 solar kits**
> to poor households.

Motivated by studies suggesting that switching to biogas to offset just 20% of household LPG use could reduce residential greenhouse gas emissions by more than 12%, the municipality (through the PACAEDC) rolled out a demonstration project in 2019 to build nine micro biogas plants, each with a capacity of 20 cubic metres.[112] As of 2020, six of the systems were operational, meeting the cooking energy demand of 135 low-income households with biogas.[113] The success of the project has paved the way for similar programmes, notably ENERGIE PLUS, a municipal energy programme which in collaboration with relevant national entities and international donors seeks to build an industrial-scale biogas plant to supply electricity to Yaoundé IV and its environs.[114]

BARRIERS AND OPPORTUNITIES FOR ADVANCING RENEWABLES

The competitive advantage of renewable energy can be a key lever to power the economic growth of Sub-Saharan African cities, providing greater access to modern energy services.[115] Renewables also offer important co-benefits such as reducing air pollution (and thus improving public health), mitigating climate change, creating more liveable urban areas and enabling a better quality of life through increased access to basic services.[116] However, municipal governments in the region face numerous barriers to the deployment of renewables. Key areas of both challenge and opportunity include policy and regulation, underdeveloped grids and infrastructure, unstable off-taker arrangements, access to financial markets, data needs and internal capacity.

POLICY AND REGULATION

The control of energy supply in Sub-Saharan African cities remains largely the domain of national governments or utilities, with an emphasis on centralised, large-scale generation. As highlighted in the five city case studies, national energy strategies that chart country-wide renewable energy roadmaps rarely make provisions for local governments, whose roles are still considered secondary. Even when regulations and policies are in place to support renewable energy deployment and use, the requirements are often expensive, complex and difficult to navigate.[117]

However, municipal governments in most Sub-Saharan African countries have mandates to issue building permits, which could serve as incentives or mandates to advance the deployment of renewable energy systems. Local governments could fast-track permits for buildings that embed distributed renewables, or they could include renewable energy deployment as a requirement for obtaining a permit (or receiving one at a reduced fee, as in Accra).

In addition, the case studies illustrate how cities might leverage their facilitative roles to develop enabling policies or regulatory frameworks – such as local net metering and feed-in tariffs – to support the deployment and use of renewable electricity.[118] Focused local plans and policies can enable energy efficiency improvements and the uptake of renewables, even if national policy is inhibitive.

Although city authorities in Sub-Saharan Africa may have limited influence over infrastructure and services, they can all take action to encourage local renewable energy deployment. Developing low-carbon pathways requires multiple collaborations across a broad range of stakeholders, including national policy makers. City authorities are well placed to facilitate and co-ordinate such efforts.[119]

ACCESS TO FINANCIAL MARKETS

Although numerous fiscal programmes and instruments exist at the national level across Africa, fiscal decentralisation – whether through transfers from the central government or by granting local governments revenue-raising powers – remains a serious challenge for empowering local governments.[120] Most local governments in Africa depend on national government grants as their main revenue source; they borrow little money (even if they are formally able to) and spend most of their revenue on operations instead of capital investments.[121] This means that they have few funds to invest in new infrastructure projects such as distributed renewable generation.[122]

As a result, nearly all renewable energy projects in Sub-Saharan Africa rely on some form of non-commercial grant or equity investment, with funding coming largely from development finance institutions, donor agencies, foundations and governments.[123] Although this helps to reduce debt risk, it is not always adequate to enable renewables to achieve true scale into the future.[124] Moreover, factors such as the lack of available income to allocate to energy consumption – as well as the prevalence of a strong informal sector that experiences poor housing quality, irregular income flows and low demand for electricity – constrain the business case for electrification for utilities.[125]

Nonetheless, cities across the region have demonstrated progressive leadership through piloting various demonstration projects. For example, Yaoundé IV was able to leverage on the visibility and proof-of-concept of its pilot biogas micro-project and to draw sufficient interest from investors to take the pilot project to scale.

In most cases, national policies also allow local governments to enter into public-private partnerships. Although such partnerships are few and generally have occurred outside the scope of electricity generation and distribution projects, the rise of electric mobility in Kampala is a strong example of how such relationships could be leveraged to advance the renewable energy agenda at the city level.

Notably, local governments are constrained in how they can spend public funds (for example, to ensure public finance management best practice, as articulated in South Africa's Municipal Finance Management Act).[126] However, this can pose a barrier when trying to demonstrate and pilot pioneering and innovative work.

DATA NEEDS

> **Renewable energy deployment** benefits from collaboration between municipalities and like-minded stakeholders.

Primary data are notoriously difficult to access in the African context, particularly at the city level given the often limited capacity, funding and political ambitions to undertake such exercises. This is a major barrier for private investors who often do not have access to statistical data on key parameters needed for investment and for project-level decisions, such as grid expansion plans, consumer baseload, customer willingness to pay, etc.[127]

This places local governments, which generally are closer to the population (potential customers), in a unique position to provide investors with such information or to engage with relevant entities (including electric utilities) to facilitate data collection. Such leverage helped the City of Dakar to complete the energy audit of its own buildings in a bid to generate sufficient data for future renewable energy deployment strategies.[128] Building data resources is crucial to support decision making and resource allocation, as evidenced by the City of Cape Town.

INTERNAL CAPACITY

Due to capacity constraints (in skills, experience and knowledge as well as human and financial resources), local governments in Sub-Saharan Africa generally are limited in their ability to play a more pro-active role in renewable energy deployment. The ability to influence local uptake of renewables often requires new areas of work and new skillsets to deal with the complexities of this development.

To help build internal capacity and knowledge, municipalities can form partnerships with external organisations (for example, universities and environmental organisations / intermediary organisations[i]) that could bring much-needed skills and capacity, and can establish or join other local city networks (such as the Urban Energy Network in South Africa[ii]) or international urban-related networks (such as the C40 Cities Leadership Programme and the Covenant of Mayors SSA Programme, which helps to share implementation experience (technology, regulatory frameworks, funding, etc.).[129]

Municipalities also could develop public-private partnership platforms to facilitate private sector engagement with local government to aid the implementation of renewable energy.[130]

To leverage these opportunities, it is important for municipalities to build a support base of like-minded stakeholders, such as renewable energy industry players and specialists in energy and urban development from academia, non-governmental organisations, development institutions and other cities. This would enable cities to further their renewable energy deployment aims, participate in networks and develop their own networks – signalling a more dynamic system involving many more players.

As demonstrated in the five case studies, the effective implementation of city energy action plans necessitates developing a unit within the lead department that can drive the process over the short, medium and long terms. This unit must steer the critical stakeholder collaboration and establish fora for information exchange and action plan collaboration, including guidance and feedback.[131] A particular challenge in many cities is interdepartmental collaboration.[132] Because energy projects are often cross-cutting in nature, the lead department or unit must overcome the lack of communication and co-ordination that often prevents departments from working together.

i A local intermediary organisation such as a non-governmental organisation, academic institution or civil society organisation with experience in energy research, implementation and capacity building is important, as it gives rise to capacity building beyond municipal staff and ensures that the approaches and solutions are locally appropriate, rather than being generated solely from foreign expertise that may lack the deeper local context.

ii The Urban Energy Network is a 20-year-old learning partnership for cities in South Africa run by Sustainable Energy Africa, the South African Local Government Association and the South African Cities Network. The network aims to build municipal staff capacity on current sustainable energy issues, to enable lesson sharing and co-ordination among municipalities and to develop relationships and facilitate information flow between different levels of government.

REFERENCE TABLES

Tables R1-R5: see data online at: **www.ren21.net/cities/datapack**

TABLE R6. Selected Cities with High Shares of Electricity Generation from Solar PV and Wind, 2019

City	Population	Wind and solar share of electricity mix (2019)	Renewable* share of electricity mix (2019)	Renewable energy and emission reduction targets
Örebro, Sweden	156,000	100%	100%	Carbon neutral by 2050
Georgetown, Texas, United States	50,000	100%	100%	100% local renewable energy generation (achieved in 2018)
Diu, India	52,000	100% (during day)	100% (during day)	N/A
Denton, Texas, United States	139,000	83%	83.8%	100% renewable electricity by 2020
Gladsaxe, Denmark	70,000	52%	77%	100% renewable energy by 2035
Adelaide, Australia	1,300,000	51%	51%	100% renewable electricity in municipal operations (achieved in mid-2020)
San Diego, California, United States	1,400,000	33%	35%	100% renewable electricity by 2035
Madrid, Spain	3,260,000	24%	41%	N/A
London, United Kingdom	8,980,000	21%	23%	1 GW solar by 2030 and 2 GW solar by 2050; carbon neutral by 2050
Birmingham, United Kingdom	1,100,000	21%	33%	60% emission reduction by 2027 (from 1990 baseline); national carbon neutral target by 2050
Los Angeles, California, United States	3,990,000	21%	34%	100% renewable energy by 2045; carbon neutral by 2050
Jaipur, India	3,070,000	20%	45%	N/A
Hamburg, Germany	1,850,000	15%	30%	100% renewable electricity by 2035; 55% emission reduction by 2030 (from 1990 baseline); carbon neutral by 2050
Toronto, Canada	2,930,000	13%	37%	75% renewable energy by 2050
Bangalore, India	11,440,000	10%	25%	N/A
Nelson Mandela Bay, South Africa	1,150,000	10%	10%	N/A
Santiago, Chile	7,300,000	9%	51%	100% renewable electricity by 2040
Zaragoza, Spain	7,000,000	8%	14%	N/A
Paris, France	2,300,000	7%	21%	Carbon neutral and 100% renewable energy by 2050
Seoul, Republic of Korea	10,300,000	7%	8%	Carbon neutral by 2050
Barcelona, Spain	1,600,000	7%	18%	45% emission reduction by 2030 (from 2005 baseline); carbon neutral by 2050
Manchester, United Kingdom	2,800,000	6%	13%	Carbon neutral by 2038

TABLE R6. Selected Cities with High Shares of Electricity Generation from Solar PV and Wind, 2019 (continued)

City	Population	Wind and solar share of electricity mix (2019)	Renewable* share of electricity mix (2019)	Renewable energy and emission reduction targets
Calgary, Canada	1,300,000	5%	10%	80% emission reduction by 2050 (from 2005 baseline)
eThekwini, South Africa	3,900,000	5%	5%	40% renewable electricity by 2030 and 100% by 2050; 40% emission reduction by 2030 and 80% by 2050 (from 2015 baseline)
Tainan, Chinese Taipei	1,900,000	5%	7%	20% renewable electricity and 20 GW cumulative installed solar PV capacity by 2025
Buenos Aires, Argentina	15,100,000	4%	32%	20% renewable electricity for the city's largest public sector users by 2025
Singapore	5,600,000	4%	4%	50% reduction in the city's 2030 peak greenhouse gas emissions by 2050
Istanbul, Turkey	15,500,000	4%	32%	33% emission reduction by 2030 (from 2015 baseline)
Taoyuan, Chinese Taipei	2,200,000	3%	5%	850 MW cumulative installed renewable power capacity by 2021
Chicago, Illinois, United States	2,700,000	3%	5%	100% renewable energy for municipal buildings by 2025
Berlin, Germany	3,600,000	1%	3%	Carbon neutral and 25% solar electricity by 2050
Tokyo, Japan	14,000,000	1%	9%	30% renewable energy by 2030
Hyllie, Sweden	700,000	N/A	N/A	100% renewable or recycled** energy by 2030

Notes:

* Includes solar, wind, biomass, geothermal and hydropower. City-level targets for renewables are listed unless otherwise noted.

** Energy recycling from waste and wastewater to generate district heating, electricity and biogas.

N/A = data not available.

Source: Deloitte analysis and REN21 Policy Database (2020), available at www.ren21.net/cities/datapack and Reference Table R1. Data are compiled by REN21 and based on CDP-ICLEI Unified Reporting System, CDP Open Data, The Global 100% Renewable Energy Platform, Climate Action Network, ICLEI, C40, IRENA, Sierra Club, UK100 and REN21 data collection. Some research is based on voluntary reporting and therefore may not be exhaustive. For a list of cities with over 1 million people, see United Nations, *The World's Cities in 2018* (New York: 2018), https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf; for shares of wind and solar power, see CDP, "CDP Open Data Portal", https://data.cdp.net, updated November 2020. City-level targets for renewables are listed unless otherwise noted. Deloitte, "Smart Renewable Cities", from https://www2.deloitte.com/content/dam/insights/us/articles/4971_Smart-renewable-cities/DI_Smart-renewable-cities.pdf. It identifies and classifies cities globally that are deploying solar and/or wind power in connection with their smart city plans. This requires that cities have a publicly available city plan that presents a vision integrating renewables and smart city initiatives. In addition, the city must have already deployed solar and/or wind power (at least 1% of its energy mix) and plan to deploy more.

DATA COLLECTION AND VALIDATION

REN21 has developed a unique renewable energy reporting culture, allowing it to become recognised as a neutral data and knowledge broker that provides credible and widely accepted information. **Transparency is at the heart** of the REN21 data and reporting culture, and the following text explains some of REN21's key processes for data collection and validation in the context of the *Renewables in Cities Global Status Report* (REC).

DATA COLLECTION

Production of REN21's REC begins with an Expression of Interest form to mobilise contributors. The data collection process then involves the following elements:

1. **Global tracking database.** The REC team compiles data on city-specific indicators, especially targets and policies, building mostly on existing consolidated datasets at the global or regional level.
2. **Open city questionnaire.** In the city questionnaire, contributors from around the world submit data on renewable energy in their respective cities or cities of interest. This covers information about technology and market trends, targets and policy developments, investment, citizen participation and other local developments. Each data point is provided with a source and verified independently by the REC team.
3. **Regional contributors.** For each world region, REN21 appoints one principal data contributor to provide city-specific data regarding renewable energy across different sectors and to share an overview of general trends and developments in cities in the respective region. The contributions of other organisations and individuals in each region also are collected, mostly through the questionnaire and peer review feedback.
4. **Open peer review.** To further collect data and project examples and to ensure that significant developments have not been overlooked, REC-GSR contributors and reviewers participate in an open peer review process that typically occurs halfway through the report's production cycle. Peer review is open to all interested experts.
5. **Expert interviews.** REN21's global community consists of a wide range of professionals who provide their expert input on renewable energy trends ad hoc in specific topics, including through interviews and personal communication with the REN21 REC team and chapter authors. The vast majority of the information is backed up by primary sources.
6. **Desk research.** To fill in remaining gaps in the report and to pursue new topics, the REN21 REC team and chapter authors conduct extensive desk research. Topics of research can vary among REC editions and depend on emerging topics, important trends and annual availability of relatively recent formal or informal data in cities.
7. **Data sharing agreements.** REN21 holds several data sharing agreements with some of the largest and most reliable data providers/aggregators in the energy sector. These formal data are used exclusively in some cases or, in others, form the foundation of calculations and estimations presented in the REC.

DATA VALIDATION

REN21 ensures the accuracy and reliability of its reports by conducting data validation and fact-checking as a continuous process. Beginning during the first submission of the country questionnaires, data are continually verified up through the design period and until the final report is published. **All data provided by contributors, whether written or verbal, are validated by primary sources, which are published alongside the full report.**

METHODOLOGICAL NOTES

This 2021 report is the second edition of the *Renewables in Cities Global Status Report*. Readers can see the previous REC edition for additional details.

Most 2019 and 2020 data[i] for national and global capacity, output, growth and investment provided in this report are preliminary. Where necessary, information and data that are conflicting, partial or older are reconciled by using reasoned expert judgment. Endnotes provide additional details, including references, supporting information and assumptions where relevant.

Each REC edition draws from thousands of published and unpublished references, including: official government sources; reports from international organisations and industry associations; input from the REN21 community, including questionnaires submitted by regional and technology contributors as well as feedback from several rounds of formal and informal reviews; additional personal communications with scores of international experts and special advisors, including an international advisory committee created specifically to support the production of each report; and a variety of electronic newsletters, news media and other sources.

Much of the data found in the REC is built from the ground up by the authors with the aid of these resources. Other data, often very specific and narrow in scope, come more-or-less prepared from third parties. The REC attempts to synthesise these data points into a collective whole for the focus years.

The REC endeavours to provide the best data available in each edition; as such, data should not be compared with the previous version of this report to ascertain year-by-year changes.

i For information on city-level renewable energy data and related challenges, see Box 1 on Page 30.

NOTE ON ESTABLISHING RENEWABLE ENERGY SHARES OF TOTAL FINAL ENERGY CONSUMPTION (TFEC)

For methodology related to calculating renewable energy shares of TFEC see methodological notes in REN21's *Renewables 2020 Global Status Report*.

DEFINITION OF HEATING AND COOLING AND THERMAL APPLICATIONS

In the REC, the term "heating and cooling" refers to applications of thermal energy including space and water heating, space cooling, refrigeration, drying and industrial process heat, as well as any use of energy other than electricity that is used for motive power in any application other than transport. In other words, thermal demand refers to all end-uses of energy that cannot be classified as electricity demand or transport.

OTHER NOTES

This report includes data on projects, policies and other information prior to 31 December 2020. Editorial content of this report closed by 31 January 2021. Data provided for 2020 in the figures, tables and reference tables are as of the end of 2020, unless indicated otherwise. Growth rates in the REC are calculated as compound annual growth rates (CAGR) rather than as an average of annual growth rates. All exchange rates in this report are as of 31 December 2020 and are calculated using the OANDA currency converter (http://www.oanda.com/currency/converter). Corporate domicile, where noted, is determined by the location of headquarters.

GLOSSARY

Absorption chillers. Chillers that use heat energy from any source (solar, biomass, waste heat, etc.) to drive air conditioning or refrigeration systems. The heat source replaces the electric power consumption of a mechanical compressor. Absorption chillers differ from conventional (vapour compression) cooling systems in two ways: 1) the absorption process is thermochemical in nature rather than mechanical, and 2) the substance that is circulated as a refrigerant is water rather than chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs), also called Freon. The chillers generally are supplied with district heat, waste heat or heat from co-generation, and they can operate with heat from geothermal, solar or biomass resources.

Auction. See Tendering.

Bagasse. The fibrous matter that remains after extraction of sugar from sugar cane.

Behind-the-meter system. Any power generation capacity, storage or demand management on the customer side of the interface with the distribution grid (i.e., the meter).

Biodiesel. A fuel produced from oilseed crops such as soy, rapeseed (canola) and palm oil, and from other oil sources such as waste cooking oil and animal fats. Biodiesel is used in diesel engines installed in cars, trucks, buses and other vehicles, as well as in stationary heat and power applications. Most biodiesel is made by chemically treating vegetable oils and fats (such as palm, soy and canola oils, and some animal fats) to produce fatty acid methyl esters (FAME). (Also see Hydrotreated vegetable oil (HVO) and hydrotreated esters and fatty acids (HEFA).)

Bioenergy. Energy derived from any form of biomass (solid, liquid or gaseous) for heat, power and transport. (Also see Biofuel.)

Biofuel. A liquid or gaseous fuel derived from biomass, primarily ethanol, biodiesel and biogas. Biofuels can be combusted in vehicle engines as transport fuels and in stationary engines for heat and electricity generation. They also can be used for domestic heating and cooking (for example, as ethanol gels). Conventional biofuels are principally ethanol produced by fermentation of sugar or starch crops (such as wheat and corn), and FAME biodiesel produced from oil crops such as palm oil and canola and from waste oils and fats. Advanced biofuels are made from feedstocks derived from the lignocellulosic fractions of biomass sources or from algae. They are made using biochemical and thermochemical conversion processes, some of which are still under development.

Biogas/Biomethane. Biogas is a gaseous mixture consisting mainly of methane and carbon dioxide produced by the anaerobic digestion of organic matter (broken down by microorganisms in the absence of oxygen). Organic material and/or waste is converted into biogas in a digester. Suitable feedstocks include agricultural residues, animal wastes, food industry wastes, sewage sludge, purpose-grown green crops and the organic components of municipal solid wastes. Raw biogas can be combusted to produce heat and/or power; it also can be transformed into biomethane through a process known as scrubbing that removes impurities including carbon dioxide, siloxanes and hydrogen sulphides, followed by compression. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without risk of corrosion.

Biomass. Any material of biological origin, excluding fossil fuels or peat, that contains a chemical store of energy (originally received from the sun) and that is available for conversion to a wide range of convenient energy carriers.

Biomass, traditional (use of). Solid biomass (including fuel wood, charcoal, agricultural and forest residues, and animal dung), that is used in rural areas of developing countries with traditional technologies such as open fires and ovens for cooking and residential heating. Often the traditional use of biomass leads to high pollution levels, forest degradation and deforestation.

Biomass energy, modern. Energy derived from combustion of solid, liquid and gaseous biomass fuels in high-efficiency conversion systems, which range from small domestic appliances to large-scale industrial conversion plants. Modern applications include heat and electricity generation, combined heat and power (CHP) and transport.

Biomass gasification. In a biomass gasification process, biomass is heated with a constrained amount of air or oxygen, leading to partial combustion of the fuels and to production of a mix of combustion gases that, depending on the conditions, can include carbon monoxide and carbon dioxide, methane, hydrogen and more complex materials such as tars. The resulting gas can be either used for power generation (for example, in an engine or turbine) or further purified and treated to form a "synthesis gas". This then can be used to produce fuels including methane, alcohols, and higher hydrocarbon fuels, including bio-gasoline and jet fuel. While gasification for power or heat production is relatively common, there are few examples of operating plants producing gas of high-enough quality for subsequent synthesis to more complex fuels.

Biomass pellets. Solid biomass fuel produced by compressing pulverised dry biomass, such as waste wood and agricultural residues. Pellets typically are cylindrical in shape with a diameter of around 10 millimetres and a length of 30-50 millimetres. Pellets are easy to handle, store and transport and are used as fuel for heating and cooking applications, as well as for electricity generation and CHP.

Biomethane. Biogas can be turned into biomethane by removing impurities including carbon dioxide, siloxanes and hydrogen sulphides, followed by compression. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without risk of corrosion. Biomethane is often known as renewable natural gas (RNG), especially in North America.

Blockchain. A decentralised ledger in which digital transactions (such as the generation and sale of a unit of solar electricity) are anonymously recorded and verified. Each transaction is securely collected and linked, via cryptography, into a time-stamped "block". This block is then stored on distributed computers as a "chain". Blockchain may be used in energy markets, including for micro-trading among solar photovoltaic (PV) prosumers.

Building energy codes and standards. Rules specifying the minimum energy standards for buildings. These can include standards for renewable energy and energy efficiency that are applicable to new and/or renovated and refurbished buildings. See Renewable building codes.

Capacity. The rated power of a heat or electricity generating plant, which refers to the potential instantaneous heat or electricity output, or the aggregate potential output of a collection of such units (such as a wind farm or set of solar panels). Installed capacity describes equipment that has been constructed, although it may or may not be operational (for example, delivering electricity to the grid, providing useful heat or producing biofuels).

Capital subsidy. A subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater). These include, for example, consumer grants, rebates or one-time payments by a utility, government agency or government-owned bank.

Carbon neutrality. The achievement of a state in which every tonne of carbon dioxide emitted to the atmosphere is compensated for by an equivalent tonne removed (e.g., sequestered). Emissions can be compensated for by carbon offsets. Carbon neutrality refers to net zero emissions of only carbon dioxide, whereas **climate neutrality** indicates a broader focus on net-zero emissions of all greenhouse gases.

Circular economy. A closed-loop system in which the waste from one process is a resource that can be used as input for another. By having a flow of resources that is circular rather than linear, the production of waste is minimised.

City. No international criteria or standards exist to determine what a city is. Most definitions of "cities" rely on settlement density and/or population numbers, although the criteria vary widely across countries. Generally, the term "urban area" refers to settlement areas that are more densely populated than suburban or peri-urban communities within the same metropolitan area. The term "city", meanwhile, has broader meanings: according to the United Nations, it can connote a political or civic entity, a geographic unit, a formalised economy or an infrastructure bundle. In some instances, local communities, neighbourhood associations, urban businesses and industries may be subsumed under the term "city". Throughout the report, municipal and city government refers to the local decision-making bodies and government authorities (the mayor's office, city council, etc.), unless noted otherwise. "Local government" is a more generic term that can refer to different sub-national levels of public administration, including also counties, villages and other intermediate levels of government. In addition to municipal governments, key city-level stakeholders include individual citizens, groups of citizens and private enterprises, as well as various civil society groups that are active within the city.

City-wide. Extending or happening in all parts of a city.

Combined heat and power (CHP) (also called co-generation). CHP facilities produce both heat and power from the combustion of fossil and/or biomass fuels, as well as from geothermal and solar thermal resources. The term also is applied to plants that recover "waste heat" from thermal power generation processes.

Community choice aggregation (CCA). Under a CCA, municipalities themselves (independently or in partnership with an agency running the CCA) aggregate their residents' and businesses' electricity demand and set out to procure electricity for all participating customers city-wide through direct contracts with energy producers or through third-party energy providers. 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, for instance to increase the share of renewable electricity.

Community energy. An approach to renewable energy development that involves a community initiating, developing, operating, owning, investing and/or benefiting from a project. Communities vary in size and shape (for example, schools, neighbourhoods, partnering city governments, etc.); similarly, projects vary in technology, size, structure, governance, funding and motivation.

Competitive bidding. See Tendering.

Concentrating solar collector technologies. Technologies that use mirrors to focus sunlight on a receiver (see Concentrating solar thermal power). These are usually smaller-sized modules that are used for the production of heat and steam below 400°C for industrial applications, laundries and commercial cooking.

Concentrating solar thermal power (CSP) (also called solar thermal electricity, STE). Technology that uses mirrors to focus sunlight into an intense solar beam that heats a working fluid in a solar receiver, which then drives a turbine or heat engine/generator to produce electricity. The mirrors can be arranged in a variety of ways, but they all deliver the solar beam to the receiver. There are four types of commercial CSP systems: parabolic troughs, linear Fresnel, power towers and dish/engines. The first two technologies are line-focus systems, capable of concentrating the sun's energy to produce temperatures of 400°C, while the latter two are point-focus systems that can produce temperatures of 800°C or higher.

Crowdfunding. The practice of funding a project or venture by raising money – often relatively small individual amounts – from a relatively large number of people ("crowd"), generally using the Internet and social media. The money raised through crowdfunding does not necessarily buy the lender a share in the venture, and there is no guarantee that money will be repaid if the venture is successful. However, some types of crowdfunding reward backers with an equity stake, structured payments and/or other products.

Demand-side management. The application of economic incentives and technology in the pursuit of cost-effective energy efficiency measures and load-shifting on the customer side, to achieve least-cost overall energy system optimisation.

Demand response. The use of market signals such as time-of-use pricing, incentive payments or penalties to influence end-user electricity consumption behaviours. Demand response is usually used to balance electrical supply and demand within a power system.

Digitisation. The conversion of something (for example, data or an image) from analogue to digital.

Distributed generation. The generation of electricity from dispersed, generally small-scale systems that are close to the point of consumption.

Distributed renewable energy. Energy systems are considered to be distributed if 1) the systems are connected to the distribution network rather than the transmission network, which implies that they are relatively small and dispersed (such as small-scale solar PV on rooftops) rather than relatively large and centralised; or 2) generation and distribution occur independently from a centralised network. Specifically for the purpose of this report, "distributed renewable energy" meets both conditions. It includes energy services for electrification, cooking, heating and cooling that are generated and distributed independent of any centralised system, in urban areas.

Distribution grid. The portion of the electrical network that takes power off the high-voltage transmission network via sub-stations (at varying stepped-down voltages) and distributes electricity to customers.

Ecodistrict. A district relying on integrated urban planning that encompasses the objectives of sustainable development and social equity and is aimed at reducing the ecological footprint of a neighbourhood, urban area or region.

Electric vehicle (EV) (also called electric drive vehicle). A vehicle that uses one or more electric motors for propulsion. A battery electric vehicle is a type of EV that uses chemical energy stored in rechargeable battery packs. A plug-in hybrid EV can be recharged by an external source of electric power. Fuel cell vehicles are EVs that use pure hydrogen (or gaseous hydrocarbons before reformation) as the energy storage medium. Also see Plug-in hybrid electric vehicle.

Energy. The ability to do work, which comes in a number of forms including thermal, radiant, kinetic, chemical, potential and electrical. Primary energy is the energy embodied in (energy potential of) natural resources, such as coal, natural gas and renewable sources. Final energy is the energy delivered for end-use (such as electricity at an electrical outlet). Conversion losses occur whenever primary energy needs to be transformed for final energy use, such as combustion of fossil fuels for electricity generation.

Energy audit. Analysis of energy flows in a building, process or system, conducted with the goal of reducing energy inputs into the system without negatively affecting outputs.

Energy efficiency. The measure that accounts for delivering more services for the same energy input, or the same amount of services for less energy input. Conceptually, this is the reduction of losses from the conversion of primary source fuels through final energy use, as well as other active or passive measures to reduce energy demand without diminishing the quality of energy services delivered. Energy efficiency is technology-specific and distinct from energy conservation, which pertains to behavioural change. Both energy efficiency and energy conservation can contribute to energy demand reduction.

Energy intensity. Primary energy consumption per unit of economic output. Energy intensity is a broader concept than energy efficiency in that it is also determined by non-efficiency variables, such as the composition of economic activity. Energy intensity typically is used as a proxy for energy efficiency in macro-level analyses due to the lack of an internationally agreed-upon high-level indicator for measuring energy efficiency.

Energy poverty. In poor countries, the term refers to the lack of access to modern energy services (for example, electricity and clean cooking). In wealthier countries, fuel poverty is associated with having energy costs above typical levels and mostly affects low-income households.

Energy service company (ESCO). A company that provides a range of energy solutions including selling the energy services from a (renewable) energy system on a long-term basis while retaining ownership of the system, collecting regular payments from customers and providing necessary maintenance service. An ESCO can be an electric utility, co-operative, non-governmental organisation or private company, and typically installs energy systems on or near customer sites. An ESCO also can advise on improving the energy efficiency of systems (such as a building or an industry) as well as on methods for energy conservation and energy management.

Energy subsidy. A government measure that artificially reduces the price that consumers pay for energy or that reduces the energy production cost.

Ethanol (fuel). A liquid fuel made from biomass (typically corn, sugar cane or small cereals/grains) that can replace petrol in modest percentages for use in ordinary spark-ignition engines (stationary or in vehicles), or that can be used at higher blend levels (usually up to 85% ethanol, or 100% in Brazil) in slightly modified engines, such as those provided in "flex-fuel" vehicles. Ethanol also is used in the chemical and beverage industries.

Fatty acid methyl esters (FAME). See Biodiesel.

Feed-in policy (feed-in tariff or feed-in premium). A policy that typically guarantees renewable generators specified payments per unit (e.g., USD per kWh) over a fixed period. Feed-in tariff (FIT) policies also may establish regulations by which generators can interconnect and sell power to the grid. Numerous options exist for defining the level of incentive, such as whether the payment is structured as a guaranteed minimum price (e.g., a FIT), or whether the payment floats on top of the wholesale electricity price (e.g., a feed-in premium).

Final energy. The part of primary energy, after deduction of losses from conversion, transmission and distribution, that reaches the consumer and is available to provide heating, hot water, lighting and other services. Final energy forms include, among others, electricity, district heating, mechanical energy, liquid hydrocarbons such as kerosene or fuel oil, and various gaseous fuels such as natural gas, biogas and hydrogen.

(Total) Final energy consumption (TFEC). Energy that is supplied to the consumer for all final energy services such as transport, cooling and lighting, building or industrial heating or mechanical work. Differs from total final consumption (TFC), which includes all energy use in end-use sectors (TFEC) as well as for non-energy applications, mainly various industrial uses, such as feedstocks for petrochemical manufacturing.

Fiscal incentive. An incentive that provides individuals, households or companies with a reduction in their contribution to the public treasury via income or other taxes.

Generation. The process of converting energy into electricity and/or useful heat from a primary energy source such as wind, solar radiation, natural gas, biomass, etc.

Geothermal energy. Heat energy emitted from within the earth's crust, usually in the form of hot water and steam. It can be used to generate electricity in a thermal power plant or to provide heat directly at various temperatures.

Green bond. A bond issued by a bank or company, the proceeds of which will go entirely into renewable energy and other environmentally friendly projects. The issuer will normally label it as a green bond. There is no internationally recognised standard for what constitutes a green bond.

Green building. A building that (in its construction or operation) reduces or eliminates negative impacts and can create positive impacts on the climate and natural environment. Countries and regions have a variety of characteristics that may change their strategies for green buildings, such as building stock, climate, cultural traditions, or wide-ranging environmental, economic and social priorities – all of which shape their approach to green building.

Green energy purchasing (also called green tariffs). Voluntary purchase of renewable energy – usually electricity, but also heat and transport fuels – by residential, commercial, government or industrial consumers, either directly from an energy trader or utility company, from a third-party renewable energy generator or indirectly via trading of renewable energy certificates (such as renewable energy credits, green tags and guarantees of origin). It can create additional demand for renewable capacity and/or generation, often going beyond that resulting from government support policies or obligations.

Heat pump. A device that transfers heat from a heat source to a heat sink using a refrigeration cycle that is driven by external electric or thermal energy. It can use the ground (geothermal/ ground-source), the surrounding air (aerothermal/air-source) or a body of water (hydrothermal/water-source) as a heat source in heating mode, and as a heat sink in cooling mode. A heat pump's final energy output can be several multiples of the energy input, depending on its inherent efficiency and operating condition. The output of a heat pump is at least partially renewable on a final energy basis. However, the renewable component can be much lower on a primary energy basis, depending on the composition and derivation of the input energy; in the case of electricity, this includes the efficiency of the power generation process. The output of a heat pump can be fully renewable energy if the input energy is also fully renewable.

Hydropower. Electricity derived from the potential energy of water captured when moving from higher to lower elevations. Categories of hydropower projects include run-of-river, reservoir-based capacity and low-head in-stream technology (the least developed). Hydropower covers a continuum in project scale from large (usually defined as more than 10 MW of installed capacity, but the definition varies by country) to small, mini, micro and pico.

Hydrotreated vegetable oil (HVO) and hydrotreated esters and fatty acids (HEFA). Biofuels produced by using hydrogen to remove oxygen from waste cooking oils, fats and vegetable oils. The result is a hydrocarbon that can be refined to produce fuels with specifications that are closer to those of diesel and jet fuel than is biodiesel produced from triglycerides such as fatty acid methyl esters (FAME).

Inverter (and micro-inverter), solar. Inverters convert the direct current (DC) generated by solar PV modules into alternating current (AC), which can be fed into the electric grid or used by a local, off-grid network. Conventional string and central solar inverters are connected to multiple modules to create an array that effectively is a single large panel. By contrast, micro-inverters convert generation from individual solar PV modules; the output of several micro-inverters is combined and often fed into the electric grid. A primary advantage of micro-inverters is that they isolate and tune the output of individual panels, reducing the effects that shading or failure of any one (or more) module(s) has on the output of an entire array. They eliminate some design issues inherent to larger systems, and allow for new modules to be added as needed.

Investment. Purchase of an item of value with an expectation of favourable future returns. In this report, new investment in renewable energy refers to investment in: technology research and development, commercialisation, construction of manufacturing facilities and project development (including the construction of wind farms and the purchase and installation of solar PV systems). Total investment refers to new investment plus merger and acquisition (M&A) activity (the refinancing and sale of companies and projects).

Investment tax credit. A fiscal incentive that allows investments in renewable energy to be fully or partially credited against the tax obligations or income of a project developer, industry, building owner, etc.

Joule. A joule (J) is a unit of work or energy equal to the work done by a force equal to one newton acting over a distance of one metre. One joule is equal to one watt-second (the power of one watt exerted over the period of one second). The potential chemical energy stored in one barrel of oil and released when combusted is approximately 6 gigajoules (GJ); a tonne of oven-dry wood contains around 20 GJ of energy.

Light commercial vehicle. Vehicle used for commercial purposes that has a gross vehicle weight of less than 3,500 kilograms.

Low-emission vehicle zone. A type of vehicle restriction that limits or prohibits the access of certain types of fossil fuel vehicles in defined city areas.

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 a percentage of total supply, a stated amount of capacity, or the required use of a specified renewable technology. Costs generally are borne by consumers. Mandates can include renewable portfolio standards (RPS); building codes or obligations that require the installation of renewable heat or power technologies (often in combination with energy efficiency investments); renewable heat purchase requirements; and requirements for blending specified shares of biofuels (biodiesel or ethanol) into transport fuel.

Market concession model. A model in which a private company or non-governmental organisation is selected through a competitive process and given the exclusive obligation to provide energy services to customers in its service territory, upon customer request. The concession approach allows concessionaires to select the most appropriate and cost-effective technology for a given situation.

Micromobility. A range of small, lightweight vehicles such as bicycles and scooters often used by individuals to travel short distances in cities.

Mini-grid/Micro-grid. For distributed renewable energy systems for energy access, a mini-grid/micro-grid typically refers to an independent grid network operating on a scale of less than 10 MW (with most at very small scale) that distributes electricity to a limited number of customers. Mini-/micro-grids also can refer to much larger networks (e.g., for corporate or university campuses) that can operate independently of, or in conjunction with, the main power grid. However, there is no universal definition differentiating mini- and micro-grids.

Monitoring. Energy use is monitored to establish a basis for energy management and to provide information on deviations from established patterns.

Municipal operations. Services or infrastructure that are owned and/or operated by municipal governments. This may include municipal buildings and transport fleets (such as buses, police vehicles and refuse collection trucks).

Municipal solid waste. Waste materials generated by households and similar waste produced by commercial, industrial or institutional entities. The wastes are a mixture of renewable plant and fossil-based materials, with the proportions varying depending on local circumstances. A default value that assumes that at least 50% of the material is "renewable" is often applied.

(Re-)Municipalisation. Legal process by which municipalities assume control of their electricity procurement and distribution assets, generally through purchase from private entities.

Net metering / Net billing. A regulated arrangement in which utility customers with on-site electricity generators can receive credits for excess generation, which can be applied to offset consumption in other billing periods. Under net metering, customers typically receive credit at the level of the retail electricity price. Under net billing, customers typically receive credit for excess power at a rate that is lower than the retail electricity price. Different jurisdictions may apply these terms in different ways, however.

Net-zero carbon building / Net-zero energy building / Nearly zero energy building. Various definitions have emerged of buildings that achieve high levels of energy efficiency and meet remaining energy demand with either on-site or off-site renewable energy. For example, the World Green Building Council's Net Zero Carbon Buildings Commitment considers use of renewable energy as one of five key components that characterise a net-zero building. Definitions of net-zero carbon, net-zero energy and nearly zero energy buildings can vary in scope and geographic relevance.

Net-zero strategy. Policy or plan to achieve carbon neutrality by a certain date. In most cases, this involves reducing community-wide emissions as much as possible, for instance through improvements in energy efficiency and a transition to renewable energy, while investing in carbon mitigation options or offsets elsewhere in the world.

Ocean power. Refers to technologies used to generate electricity by harnessing from the ocean the energy potential of ocean waves, tidal range (rise and fall), tidal streams, ocean (permanent) currents, temperature gradients (ocean thermal energy conversion) and salinity gradients. The definition of ocean power used in this report does not include offshore wind power or marine biomass energy.

Off-take agreement. An agreement between a producer of energy and a buyer of energy to purchase/sell portions of the producer's future production. An off-take agreement normally is negotiated prior to the construction of a renewable energy project or installation of renewable energy equipment in order to secure a market for the future output (e.g., electricity, heat). Examples of this type of agreement include power purchase agreements and feed-in tariffs.

Off-taker. The purchaser of the energy from a renewable energy project or installation (e.g., a utility company) following an off-take agreement.

Pay-as-you-go (PAYGo). A business model that gives customers (mainly in areas without access to the electricity grid) the possibility to purchase small-scale energy-producing products, such as solar home systems, by paying in small instalments over time.

Plug-in hybrid electric vehicle. This differs from a simple hybrid vehicle, as the latter uses electric energy produced only by braking or through the vehicle's internal combustion engine. Therefore, only a plug-in hybrid electric vehicle allows for the use of electricity from renewable sources. Although not an avenue for increased penetration of renewable electricity, hybrid vehicles contribute to reduced fuel demand and remain far more numerous than EVs.

Positive energy district (PED). An area within a city that is capable of generating more renewable energy than it consumes.

Power. The rate at which energy is converted into work, expressed in watts (joules/second).

Power purchase agreement (PPA). A contract between two parties, one that generates electricity (the seller) and one that is looking to purchase electricity (the buyer).

Primary energy. The theoretically available energy content of a naturally occurring energy source (such as coal, oil, natural gas, uranium ore, geothermal and biomass energy, etc.) before it undergoes conversion to useful final energy delivered to the end-user. Conversion of primary energy into other forms of useful final energy (such as electricity and fuels) entails losses. Some primary energy is consumed at the end-user level as final energy without any prior conversion.

Primary energy consumption. The direct use of energy at the source, or supplying users with unprocessed fuel.

Product and sectoral standards. Rules specifying the minimum standards for certain products (e.g., appliances) or sectors (industry, transport, etc.) for increasing energy efficiency.

Production tax credit. A tax incentive that provides the investor or owner of a qualifying property or facility with a tax credit based on the amount of renewable energy (electricity, heat or biofuel) generated by that facility.

Property Assessed Clean Energy (PACE) financing. Provides access to low-interest loans for renewable energy that can be repaid through increases on property taxes.

Prosumer. An individual, household or small business that not only consumes energy but also produces it. Prosumers may play an active role in energy storage and demand-side management.

Public financing. A type of financial support mechanism whereby governments provide assistance, often in the form of grants or loans, to support the development or deployment of renewable energy technologies.

Pumped storage. Plants that pump water from a lower reservoir to a higher storage basin using surplus electricity, and that reverse the flow to generate electricity when needed. They are not energy sources but means of energy storage and can have overall system efficiencies of around 80-90%.

Regulatory policy. A rule to guide or control the conduct of those to whom it applies. In the renewable energy context, examples include mandates or quotas such as renewable portfolio standards, feed-in tariffs and technology-/fuel-specific obligations.

Renewable building codes. Building energy codes that mandate that a certain amount of energy demand be met by renewable energy (e.g., solar obligations). They differ from green building codes, which tend to focus on improving the performance of buildings by using materials, equipment and components that enhance energy efficiency. See Green building.

Renewable energy. This includes all forms of energy produced from renewable sources, including solar, wind, ocean, hydropower, biomass, geothermal resources and biofuels.

Renewable energy certificate (REC). A certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). In systems based on RECs, certificates can be accumulated to meet renewable energy obligations and also provide a tool for trading among consumers and/or producers. They also are a means of enabling purchases of voluntary green energy.

Renewable hydrogen (also referred to as green hydrogen). Hydrogen produced from renewable energy, most commonly through the use of renewable electricity to split water into hydrogen and oxygen in an electrolyser. The vast majority of hydrogen is still produced from fossil fuels, and the majority of policies and programmes focused on hydrogen do not include a focus on renewables-based production.

Renewable portfolio standard (RPS). An obligation placed by a government on a utility company, group of companies or consumers to provide or use a predetermined minimum targeted renewable share of installed capacity, or of electricity or heat generated or sold. A penalty may or may not exist for non-compliance. These policies also are known as "renewable electricity standards", "renewable obligations" and "mandated market shares", depending on the jurisdiction.

Sector integration (also called sector coupling). The integration of energy supply and demand across electricity, thermal and transport applications, which may occur via co-production, combined use, conversion and substitution.

Shore power (also called cold ironing). This entails connecting a maritime vessel to the power grid while at berth in a port so that the electricity demand from the vessel while hotelling is supplied directly by the grid rather than by the generator on the vessel, which typically is diesel powered.

Smart charging. Optimisation of the charging process of an electric vehicle according to external inputs (e.g., user requirements, power system characteristics, grid constraints and renewable energy availability). Smart charging includes unidirectional controlled charging (V1G), bi-directional vehicle-to-grid (V2G) and vehicle-to-home/building (V2H/B). Developing smart charging brings several advantages for balancing the grid, also helping to integrate renewables into the system and possibly improving operating expenses for consumers. Also see Vehicle-to-grid.

Smart city. A city that utilises digital technologies to collect data that is then used to manage assets, resources and services more efficiently, improve operations across the city and generally increase the quality of life of citizens.

Smart energy system. An energy system that aims to optimise the overall efficiency and balance of a range of interconnected energy technologies and processes, both electrical and non-electrical (including heat, gas and fuels). This is achieved through dynamic demand- and supply-side management; enhanced monitoring of electrical, thermal and fuel-based system assets; control and optimisation of consumer equipment, appliances and services; better integration of distributed energy (on both the macro and micro scales); as well as cost minimisation for both suppliers and consumers.

Smart grid. Electrical grid that uses information and communications technology to co-ordinate the needs and capabilities of the generators, grid operators, end-users and electricity market stakeholders in a system, with the aim of operating all parts as efficiently as possible, minimising costs and environmental impacts and maximising system reliability, resilience and stability.

Solar collector. A device used for converting solar energy to thermal energy (heat), typically used for domestic water heating but also used for space heating, for industrial process heat and to drive thermal cooling machines. Evacuated tube and flat plate collectors that operate with water or a water/glycol mixture as the heat-transfer medium are the most common solar thermal collectors used worldwide. These are referred to as glazed water collectors because irradiation from the sun first hits a glazing (for thermal insulation) before the energy is converted to heat and transported away by the heat transfer medium. Unglazed water collectors, often referred to as swimming pool absorbers, are simple collectors made of plastics and used for lower-temperature applications. Unglazed and glazed air collectors use air rather than water as the heat-transfer medium to heat indoor spaces or to pre-heat drying air or combustion air for agriculture and industry purposes.

Solar home system. A stand-alone system composed of a relatively low-power photovoltaic module, a battery and sometimes a charge controller that can provide modest amounts of electricity for home lighting, communications and appliances, usually in rural or remote regions that are not connected to the electricity grid. The term solar home system kit also is used to define systems that usually are branded and have components that are easy for users to install and use.

Solar photovoltaics (PV). A technology used for converting light directly into electricity. Solar PV cells are constructed from semiconducting materials that use sunlight to separate electrons from atoms to create an electric current. Modules are formed by interconnecting individual cells. Building-integrated PV (BIPV) generates electricity and replaces conventional materials in parts of a building envelope, such as the roof or façade.

Solar photovoltaic-thermal (PV-T). A solar PV-thermal hybrid system that includes solar thermal collectors mounted beneath PV modules to convert solar radiation into electrical and thermal energy. The solar thermal collector removes waste heat from the PV module, enabling it to operate more efficiently.

Solar-plus-storage. A hybrid technology of solar PV with battery storage. Other types of renewable energy-plus-storage plants also exist.

Solar water heater. An entire system consisting of a solar collector, storage tank, water pipes and other components. There are two types of solar water heaters: pumped solar water heaters use mechanical pumps to circulate a heat transfer fluid through the collector loop (active systems), whereas thermosyphon solar water heaters make use of buoyancy forces caused by natural convection (passive systems).

Storage battery. A type of battery that can be given a new charge by passing an electric current through it. A lithium-ion battery uses a liquid lithium-based material for one of its electrodes. A lead-acid battery uses plates made of pure lead or lead oxide for the electrodes and sulphuric acid for the electrolyte, and remains common for off-grid installations. A flow battery uses two chemical components dissolved in liquids contained within the system and most commonly separated by a membrane. Flow batteries can be recharged almost instantly by replacing the electrolyte liquid, while simultaneously recovering the spent material for re-energisation.

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.

Tender (also called auction/reverse auction or tender). 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.

Thermal energy storage. Technology that allows the transfer and storage of thermal energy.

Transmission grid. The portion of the electrical supply distribution network that carries bulk electricity from power plants to sub-stations, where voltage is stepped down for further distribution. High-voltage transmission lines can carry electricity between regional grids in order to balance supply and demand.

Urban form. Refers to a city's physical characteristics, including size, shape and population density.

Urban freight transport. The movement of goods in to, out from, through or within the urban area made by light or heavy vehicles, including but not limited to service transport, construction material transport and reverse logistics for waste removal.

Variable renewable energy (VRE). A renewable energy source that fluctuates within a relatively short time frame, such as wind and solar energy, which vary within daily, hourly and even sub-hourly time frames. By contrast, resources and technologies that are variable on an annual or seasonal basis due to environmental changes, such as hydropower (due to changes in rainfall) and thermal power plants (due to changes in temperature of ambient air and cooling water), do not fall into this category.

Vehicle-to-grid (V2G). A system in which electric vehicles – whether battery electric or plug-in hybrid – communicate with the grid in order to sell response services by returning electricity from the vehicles to the electric grid or by altering the rate of charging.

Virtual net metering. Virtual (or group) net metering allows electricity utility consumers to share the output of a renewable power project. By receiving "energy credits" based on project output and their ownership share of the project, consumers are able to offset costs on their electricity utility bill.

Virtual power plant (VPP). A network of decentralised, independently owned and operated power generating units combined with flexible demand units and possibly also with storage facilities. A central control station monitors operation, forecasts demand and supply, and dispatches the networked units as if they were a single power plant. The aim is to smoothly integrate a high number of renewable energy units into existing energy systems; VPPs also enable the trading or selling of power into wholesale markets.

Virtual power purchase agreement (PPA). A contract under which the developer sells its electricity in the spot market. The developer and the corporate off-taker then settle the difference between the variable market price and the strike price, and the off-taker receives the electricity certificates that are generated. This is in contrast to more traditional PPAs, under which the developer sells electricity to the off-taker directly.

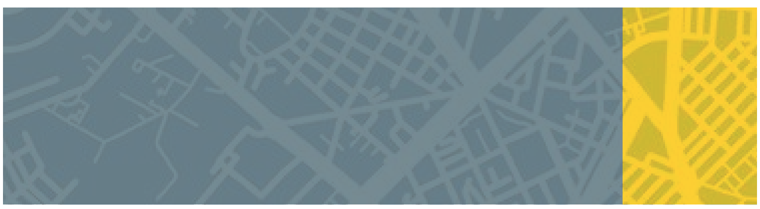
Watt. A unit of power that measures the rate of energy conversion or transfer. A kilowatt is equal to 1 thousand watts; a megawatt to 1 million watts; and so on. A megawatt-electrical (MW) is used to refer to electric power, whereas a megawatt-thermal (MW_{th}) refers to thermal/heat energy produced. Power is the rate at which energy is consumed or generated. A kilowatt-hour is the amount of energy equivalent to steady power of 1 kW operating for one hour.

Wheeling. Refers to the transport of electric energy from within an electrical grid from one party (the seller) to another party (the buyer). Wheeling deals with the use of the network and the cost of delivering the energy.

Zero-emission vehicle. A vehicle that does not produce tailpipe emissions (the air pollutants emitted during the operation of a vehicle). These emissions often include greenhouse gases, particulate matter, volatile organic compounds, nitrogen oxides, carbon monoxide and sulphur dioxide. The term zero-emission vehicle typically refers to an electric vehicle, although the charging of the vehicle is not necessarily linked with renewable energy.

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
AUD	Australian dollar
BRL	Brazilian real
CCA	Community choice aggregation
CDP	Carbon Disclosure Project
CHP	Combined heat and power
CNG	Compressed natural gas
CNY	Chinese yuan
CO_2	Carbon dioxide
COP26	26th Conference of the Parties
COVID	Coronavirus disease
CSP	Concentrating solar thermal power
DHC	District heating and cooling
EBRD	European Bank for Reconstruction and Development
EDGE	Excellence in Design for Greater Efficiencies
EJ	Exajoule
ESCO	Energy service company
ESG	Environmental, social and corporate governance
EU	European Union
EUR	Euro
EV	Electric vehicle
FIT	Feed-in tariff
GBP	Pound sterling
GDP	Gross domestic product
GJ	Gigajoule
GO	Guarantee of origin
GSR	Global Status Report
GW/GWh	Gigawatt/gigawatt-hour
GW_{th}	Gigawatt-thermal
HEFA	Hydrotreated esters and fatty acids
HVO	Hydrotreated vegetable oil
ICCT	International Council on Clean Transportation
ICE	Internal combustion engine
ICLEI	International Council for Local Environmental Initiatives
IDR	Indonesian rupiah
IEA	International Energy Agency
INR	Indian rupee
IPP	Independent power producer
IPVA	Vehicle Property Tax
IRP	Integrated Resource Plan
JPY	Japanese yen
KCCA	Kampala Capital City Authority
km^2	Square kilometre
KPLC	Kenya Power and Lighting Company
kW/kWh	Kilowatt/kilowatt-hour
LED	Light-emitting diode
LEZ	Low-emission zone
LPG	Liquefied petroleum gas
MENA	Middle East and North Africa
MSW	Municipal solid waste
MW/MWh	Megawatt/Megawatt-hour
MW_{th}	Megawatt-thermal
MXN	Mexican peso
NDC	Nationally Determined Contribution
NEV	New Energy Vehicle
NUP	National urban policy
OECD	Organisation for Economic Co-operation and Development
PACE	Property Assessed Clean Energy
PAYGo	Pay as you go
PCET	Plan Climat-Energie Territorial
PHEV	Plug-in hybrid electric vehicle
PLN	Polish zloty
$PM_{2.5}$	Fine particulate matter
PPA	Power purchase agreement
PPI	Private participation in infrastructure
PPP	Public-private partnership
PV	Photovoltaic
REC	Renewable energy certificate
REIPPP	Renewable Energy Independent Power Procurement Programme
SDG	Sustainable Development Goal
SEA	Sustainable Energy Africa
SEED	Sustainable Energy for Environment and Development
SEK	Swedish krona
SPV	Special purpose vehicle
SSA	Sub-Saharan Africa
TW/TWh	Terawatt/Terawatt-hour
UK	United Kingdom
UN	United Nations
URBACT	Urban development network programme
US	United States
USD	United States dollar
WHO	World Health Organization
ZAR	South African rand



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