IRENA
International Renewable Energy Agency

# RENEWABLE ENERGY POLICIES FOR CITIES

## EXPERIENCES IN CHINA, UGANDA AND COSTA RICA

CHONGLI DISTRICT

KASESE

CARTAGO AND GRECIA

TONGLI TOWN

LUGAZI

GUANACASTE

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag

International Renewable Energy Agency




ISBN: 978-92-9260-312-0

Citation: IRENA (2021), *Renewable Energy Policies for Cities: Experiences in China, Uganda and Costa Rica*, International Renewable Energy Agency, Abu Dhabi.


## About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

**www.irena.org**


## IKI support

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.

## Acknowledgements

This report was developed under the guidance of Rabia Ferroukhi (IRENA) and authored by the urban policies team of IRENA's Knowledge, Policy and Finance Centre (Michael Renner, Jinlei Feng, Celia García-Baños (IRENA) and Laura El-Katiri (consultant)), with input from Verena Ommer (Policy Officer - International Climate Initiative (IKI) of the Federal Ministry for the Environment (BMU) and formerly IRENA) and valuable country-based expertise provided by consultants Monica Araya, Runqing Hu and Paul Mukwaya.

Valuable external review was provided by Aijun Qiu (China Centre for Urban Development), Yifan Xu (Energy Foundation China) and Ji Chen (Rocky Mountain Institute) for the Chinese city cases; Michael Ahimbisibwe (Ministry of Energy and Mineral Development, Uganda) and Nelson Tashobya (consultant) for the Ugandan cities; and María José Vasquez (IFAM), Roberto Quirós Balma (ICE) and Esteban Bermudez (UNEP/MOVE) for the case of Costa Rica.

Valuable review and feedback were also provided by IRENA colleagues Diala Hawila, Benson Zeyi, Nopenyo Dabla, Elizabeth Njoki Wanjiru, Binu Parthan, Fabian Barrera, José Torón, Yong Chen, Paul Komor and Neil MacDonald.

For further information or to provide feedback: publications@irena.org

Available for download: **www.irena.org/publications**





**IRENA Headquarters**

Masdar City

P.O. Box 236, Abu Dhabi, United Arab Emirates

**www.irena.org**

# ABOUT THIS STUDY

With their great energy demands and their central role in national economies, cities are critical to the world's overall energy transition. City planners and administrators would therefore do well to acquire the knowledge and skills needed to integrate renewable energy technologies (in addition to efficiency and electrification of buildings and transport) into urban planning and regulations.

To date, most efforts towards energy transitions are taking place in large cities, and they are as a result garnering most of the attention when urban trends are studied. With their larger revenue base, big cities tend to have the regulatory frameworks and infrastructure necessary to scale up renewables and meet emission reduction targets.

Small and medium-sized cities (holding fewer than 1 million inhabitants) frequently lack the requisite access to financing and policy support to advance in this direction. They have far less visibility than megacities, even though they are home to some 2.4 billion people, or 59% of the world's urban population (UN-Habitat, 2018) and are growing faster than any other urban category (UN-Habitat, 2020).

This study fills a knowledge gap regarding the deployment of renewable energy in medium-sized cities, focusing on the challenges and successes to date. The first chapter provides some general background on urban renewable energy initiatives around the world. Each city has its own set of opportunities and obstacles. Regardless of setting, however, openness to best practices is vital. Chapters 2–4 present case studies of six medium-sized cities from three very different countries: **Chongli District** and **Tongli Town (China)**; **Kasese** and **Lugazi (Uganda)**; and, **Cartago and Grecia, and Guanacaste (Costa Rica).** These cities were chosen for study either because they have effective policies in place or they have untapped renewable energy resources that could contribute to their sustainable development. They also illustrate deployment strategies for renewable energy across vastly different socio-economic and institutional contexts.

The findings of this study[1] should, it is hoped, support other countries as they implement their Nationally Determined Contributions, empowering cities to deploy sustainable energy approaches and solutions that can contribute to reductions in greenhouse gas emissions.

Each case study outlines the national-level policies that frame renewable energy deployment at the local level and offers a summary of key lessons learnt and considerations for taking solutions to scale. They also synthesise key takeaway messages for policy makers – both at the local and national levels – to help empower cities in their endeavour to contribute to a more sustainable energy future.

Where the case studies make reference to monetary values, these are expressed in the national currency of the country in question and, with the help of applicable exchange rates, are also stated in US dollars (USD).

1 The study is based on desk research and interviews in the case study countries conducted during 2018 and 2019.

# CONTENTS

# 3



# 4

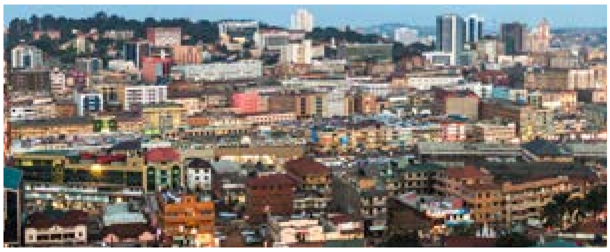


# 5

## FIGURES

## BOXES





## TABLES

## ABBREVIATIONS

| | |
|---|---|
| **ABPP** | Africa Biogas Partnership Programme |
| **ACESOLAR** | Costa Rican Solar Energy Association (Asociación Costarricense de Energía Solar) |
| **ACOPE** | Costa Rican Association of Energy Producers (Asociación Costarricense de Productores de Energía) |
| **ARESEP** | Public Authority for the Regulation of Public Services (Autoridad Reguladora de Servicios Públicos) [Costa Rica] |
| **ASOMOVE** | Costa Rican Association of Electric Mobility (Asociación Costarricense de Movilidad Eléctrica) |
| **BCIE** | Central American Economic Integration Bank (Banco Centroamericano de Integración Económica) |
| **BEETA** | Uganda National Renewable Energy and Energy Efficiency Alliance |
| **BSU** | Biogas Solutions Uganda |
| **CBOs** | community-based organisations |
| **CDI** | Champion District Initiative [Uganda] |
| **CENCE** | National Centre for Energy Control (Centro Nacional de Control de la Energía) [Costa Rica] |
| **CIRCODU** | Centre for Integrated Research and Community Development Uganda |
| **CNFL** | National Company of Power and Electricity (Compañía Nacional de Fuerza y Luz) [Costa Rica] |
| **CNREC** | China National Renewable Energy Centre |
| **CNY** | Chinese yuan [currency] |
| **$CO_2$** | carbon dioxide |
| **CONARE** | National Council of Rectors (Consejo Nacional de Rectores) [Costa Rica] |
| **CORCLIMA** | Commission for Resilience to Climate Change (Comisión para la Resistencia al Cambio Climático) [Costa Rica] |
| **CREEC** | Centre for Research in Energy and Energy Conservation [Uganda] |
| **CREIA** | Chinese Renewable Energy Industries Association |
| **CRUSA** | Costa Rica–United States Foundation for Cooperation |
| **DDP** | District Development Plan [Uganda] |
| **DECC** | Department of Energy and Climate Change [UK] |
| **DFID** | Department for International Development [UK] |
| **DWD** | Directorate of Water Development [Uganda] |
| **EFA** | Eco-Fuel Africa [Uganda] |
| **e-mobility** | electric-mobility |
| **EPSRC** | Engineering and Physical Sciences Research Council [UK] |
| **ERA** | Electricity Regulatory Authority [Uganda] |
| **ERI** | Energy Research Institute [China] |
| **ERT** | Energy for Rural Transformation [Uganda] |
| **ESPH** | Heredia Public Services Company (Empresa de Servicios Públicos de Heredia) [Costa Rica] |
| **EV** | electric vehicle |
| **FIPs** | feed-in premiums |
| **FITs** | feed-in tariffs |
| **FYPs** | five-year plans [China] |
| **GAM** | Grand Metropolitan Area [Costa Rica] |
| **GDP** | gross domestic product |
| **GHG** | greenhouse gas |
| **GIZ** | Deutsche Gesellschaft für Internationale Zusammenarbeit [Germany] |
| **GW** | gigawatt |
| **$GW_{th}$** | gigawatt thermal |
| **GWh** | gigawatt-hours |
| **ICE** | Costa Rican Electricity Institute (Instituto Costarricense de Electricidad) |
| **IFAM** | Municipal Advisory Institute (Instituto de Fomento y Asesoría Municipal) [Costa Rica] |
| **IEA** | International Energy Agency |
| **IMF** | International Monetary Fund |
| **INCOFER** | National Railroads Institute (Instituto Costarricense de Ferrocarriles) [Costa Rica] |
| **INS** | National Insurance Institute (Instituto Nacional de Seguros) [Costa Rica] |
| **JASEC** | Cartago Electric Service Administrative Board (Junta Administrativa del Servicio Eléctrico de Cartago) [Costa Rica] |
| **KAIST** | Korea Advanced Institute Science and Technology |
| **KDRES** | Kasese District Renewable Energy Strategy [Uganda] |
| **KfW** | Kreditanstalt für Wiederaufbau |
| **kg** | kilogramme |
| **km** | kilometre |

| | |
|---|---|
| **km²** | square kilometre |
| **KRW** | Republic of Korea won [currency] |
| **kW** | kilowatt |
| **kWh** | kilowatt-hours |
| **LCOE** | levelised cost of electricity |
| **m²** | square metre |
| **MEE** | Ministry of Ecology and Environment [China] |
| **MEMD** | Ministry of Energy and Mineral Development [Uganda] |
| **MIDEPLAN** | Ministry of National Planning and Economic Policy (Ministerio de Planificación Nacional y Política Económica) [Costa Rica] |
| **MIIT** | Ministry of Industry and Information Technology [China] |
| **MINAE** | Ministry of Environment, and Energy (Ministerio de Ambiente y Energía) [Costa Rica] |
| **MIRENEM** | Ministry of Natural Resources, Energy and Mining (Ministerio de Recursos Naturales, Energía y Minas) [Costa Rica] |
| **MoHURD** | Ministry of Housing and Urban-Rural Development [China] |
| **MOU** | Memorandum of Understanding |
| **MW** | megawatt |
| **NDC** | Nationally Determined Contribution |
| **NDP** | National Development Plan [Uganda] |
| **NDRC** | National Development and Reform Commission [China] |
| **NEA** | National Energy Administration [China] |
| **NEMA** | National Environment Management Authority [Uganda] |
| **NGO** | non-governmental organisation |
| **PEN** | State of the Nation Programme (Programa Estado de la Nación) [Costa Rica] |
| **PSFU** | Private Sector Foundation Uganda |
| **PM** | particulate matter |
| **PV** | photovoltaic |
| **R&D** | research and development |
| **RE** | renewable energy |
| **REA** | Rural Electrification Agency [Uganda] |
| **REFiT** | Renewable Energy Feed-in Tariff [Uganda] |
| **RETs** | renewable energy technologies |
| **SACCOs** | Savings and Credit-Cooperative Organisations [Uganda] |
| **SAMSET** | Supporting African Municipalities in Sustainable Energy Transitions |
| **SE4All** | Sustainable Energy for All |
| **SEN** | National Electricty System (Sistema Eléctrico Nacional) [Costa Rica] |
| **SEPSE** | Energy Planning Secretariat (Secretaría de Planificación del Subsector Energía) [Costa Rica] |
| **SIEPAC** | Central American Electrical Interconnection System (Sistema de Interconexión Eléctrica de América Central) [Costa Rica] |
| **SGCC** | State Grid Corporation of China |
| **SHS** | solar home system |
| **SOPEC** | Southeast Ohio Public Energy Council [United States] |
| **SWH** | solar water heating |
| **tce** | tonnes of coal equivalent |
| **toe** | tonnes of oil equivalent |
| **ToU** | Time of Use |
| **TWh** | terawatt-hours |
| **UECCC** | Uganda Energy Credit Capitalisation Company |
| **UGX** | Uganda shilling [currency] |
| **UIA** | Uganda Investment Authority |
| **UN** | United Nations |
| **UNBS** | Uganda National Bureau of Standards |
| **UNESCO** | United Nations Educational Scientific and Cultural Organisation |
| **UNGL** | National Union of Local Governments (Unión Nacional de Gobiernos Locales) [Costa Rica] |
| **UNREEEA** | Uganda National Renewable Energy and Energy Efficiency Alliance |
| **USD** | US dollar [currency] |
| **USEA** | Uganda Solar Energy Association |
| **USMID** | Uganda Support to Municipal Infrastructure Development Programme |
| **VATs** | value added taxes |
| **WHO** | World Health Organization |
| **WWF** | World Wide Fund for Nature |
| **WWF-UCO** | World Wide Fund for Nature Uganda Country Office |

# EXECUTIVE SUMMARY

Urban areas across the world are home to an ever-increasing share of the global population. As of 2018, cities were home to 55% of the total population, up from 30% in 1950. By 2050, the United Nations (UN) expects that 68% of the world's population will reside in cities (UNDESA, 2018). The UN projects that the fastest growth will occur in low- and lower middle income countries in Asia and Africa.

Cities are engines of the economy, accounting for more than 80% of global gross domestic product (GDP). Energy is the lifeblood of cities, powering transport, industrial production, commerce, building construction, public works, lighting, air conditioning and countless other human activities. Because cities use about 75% of global primary energy, they play a major role in advancing and shaping the global energy transition.

Yet much of current urban energy supply remains fossil fuel–based. As a result, cities are responsible for around 70% of global energy related greenhouse gas (GHG) emissions (UN-Habitat, 2019). At the same time, urban areas have high rates of air pollution; according to the World Health Organization (WHO), 98% of cities with more than 100 000 inhabitants in low- and middle income countries do not meet the agency's air quality guidelines (WHO, 2016).

Renewable energy technologies (RETs), along with greater energy efficiency, play a central role in mitigating climate change and providing cleaner air. While renewable energy deployment measures in the power sector are often developed in the context of national-level policies, many measures relevant to end uses, such as in the building and transport sectors, are taken at the city level (IRENA, 2016; IRENA, 2017a; IRENA, IEA and REN21, 2018). Even so, national policies shape action at the local level. It is important to build the capacity of cities to identify renewable energy solutions that suit their particular circumstances and needs, and to integrate these solutions in urban planning processes.

Most research on urban trends focuses on a particular set of global megacities. Far less attention is devoted to cities with fewer than 1 million inhabitants, which are the fastest growing category (UN-Habitat, 2020) and currently home to some 2.4 billion people, or 59% of the world's total urban population (UN-Habitat, 2018).

Kampala

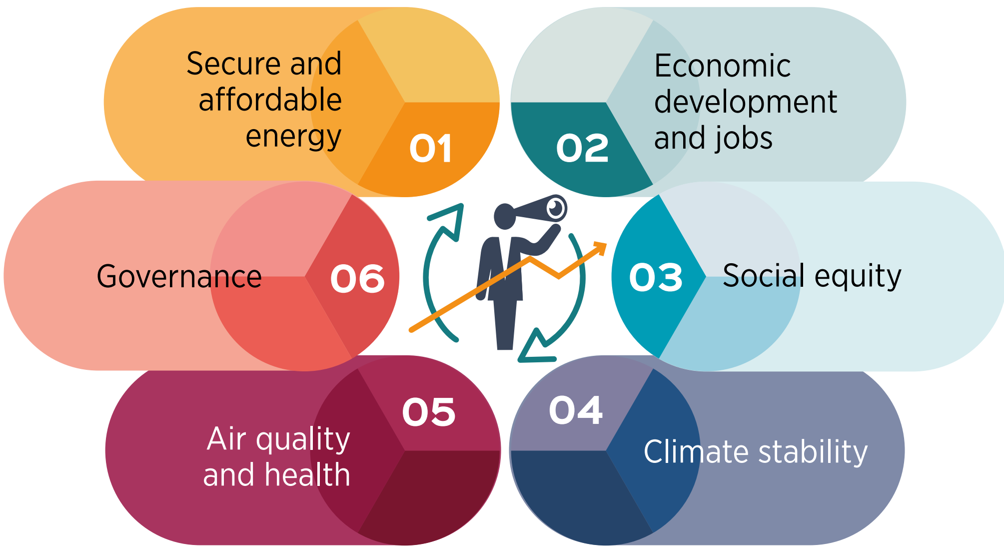
This study focuses on the challenges and successes seen in the deployment of renewable energy in medium-sized cities, which are defined as ranging in population from 30 000 to 1 million inhabitants. City case studies in this report provide specific evidence from three widely divergent countries: China, Uganda, and Costa Rica. The findings of this study aim to support countries in the implementation of their Nationally Determined Contributions by empowering cities to deploy sustainable energy solutions and contribute to reductions in GHG emissions.

The report situates the case studies in an analytical framework that describes the motivations and drivers of urban action and considers cities' needs and capacities to act.

## MOTIVATIONS AND DRIVERS OF MUNICIPAL ACTION ON ENERGY

Cities are motivated to promote renewables by a number of factors (see Figure ES 1). Critical considerations concern the cost and affordability of energy (including energy access); economic development objectives (including the ability to build local supply chains and to attract and retain a diverse array of businesses) and employment generation. Social equity considerations – reducing poverty and ensuring that poorer urban communities have access to clean energy solutions – are also central. Concerns about climate impacts are rising in importance, joining long-standing worries over the health impacts of air pollution from fossil fuel use, as well as the desire to ensure a high quality of life for all urban residents.

**Figure ES 1 Motivations and drivers of municipal action on energy**




Source: IRENA urban policy analysis.

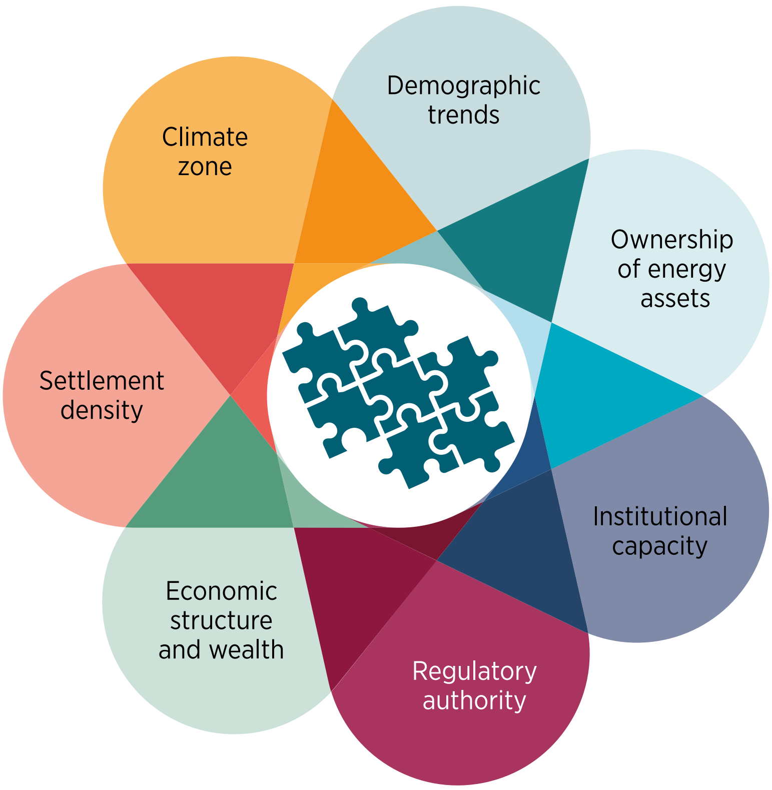
Energy-related policy making is a complex process involving not only governance structures and processes but also the diverse motivations of many stakeholders. Progress requires not only the formulation of comprehensive plans but also the resources and institutional capacity for successful implementation. Implementation requires vision, policy coherence and pragmatic co-ordination across various levels and layers of municipal governance.

Local energy transition strategies are driven by multiple actors whose significance varies from city to city (and country to country), reflecting different administrative and policy-making structures, as well as civic cultures. They may have great power to advance the policy agenda or to hold it back. Mayors, city councils and municipal agencies are key actors in planning, issuing regulations and implementing policies and projects. Utilities and energy companies are important actors too; their roles and influence can vary considerably. They could be strictly local entities or they could operate on a larger scale (provincial, national or international) and be under public or private ownership. Regulatory authority and financing needs can give regional and national governments a strong say in urban affairs. Private sector companies often have considerable influence. Last but not least, local community groups may in some cases be key drivers of change.

## MUNICIPAL NEEDS AND CAPABILITIES

Although cities across the world face many similar challenges, their particular circumstances, needs and capacities to act can vary enormously, typically a product of their historically grown structures and reflecting their various political cultures. Cities' plans thus need to be tailored to their own circumstances. Figure ES 2 provides an overview of the key factors – many of them interconnected – shaping cities' energy profiles.

**Figure ES 2 Factors shaping city energy profiles**




Source: IRENA urban policy analysis.

Individual cities' energy options are conditioned by an array of variables. Some, such as a city's particular climate zone (dictating heating and cooling demand profiles), are immutable – although advancing climate change triggers new challenges. Cities with growing populations confront greater challenges than those with more stable demographics. This is especially the case in urban areas with large and rapidly expanding informal settlements, where energy access is limited or where residents are energy poor. Compact cities are able to build attractive public transportation networks, while sprawling megalopolises struggle to make them work and often remain reliant on energy-intensive passenger cars.

The energy-use profiles of cities are shaped in fundamental ways by their economic structures. "Producer cities" with extensive materials processing and manufacturing industries, or those that function as significant trans shipment nodes for global trade, tend to have a large energy footprint. "Consumer cities", on the other hand, may have effectively outsourced polluting industrial activities and feature an extensive service sector.

In general, wealthy, economically dynamic cities (*i.e.*, those where a diversified economy supports a significant flow of tax revenues) are able to act in ways that poorer cities cannot. But decision-making power over matters that affect urban areas does not always fully rest with municipal authorities. The ability of cities to act is further shaped and constrained by the degree to which they either already have, or are able to acquire, adequate institutional capacity (planning and implementation, budgetary resources and staffing), as well as access to required technical and professional expertise.

Finally, the role of private-sector energy providers varies from city to city, influencing the degree to which cities are able to exert control over energy generation in terms of ownership structures, investor preferences, operational authority or regulatory enforcement power. Cities typically have substantial influence over factors that shape energy consumption, such as spatial planning, building efficiency, urban transport modes, settlement patterns and household consumption practices.

## THE SIGNIFICANCE OF CITIES IN DEPLOYING RENEWABLE ENERGY

IRENA's previous report on renewable energy in the urban context (IRENA, 2016) identified several dimensions of the role cities play in shaping adaptation and mitigation and, as such, in accelerating the deployment of renewable energy solutions as a pillar of national sustainable energy targets (see Figure ES 3). Cities can be target setters, planners and regulators. They are often owners and thus operators of municipal infrastructure such as buildings and vehicle fleets. Cities are always direct consumers of energy and therefore aggregators of demand and can be conveners and facilitators. They can also function as financiers of renewable energy projects, either through municipal action or incentives to businesses and households. Finally, cities through their local governments can build awareness through their existing roles as target setters and planners and through local media.

**Figure ES 3 Roles of municipal governments in the energy transition**


Source: IRENA urban policy analysis (based on IRENA 2016).

---

**Core policies**
**that can fall into municipalities' and local governments' sphere of action include**

- **District energy systems**
- **Solar street lighting**
- Regulations regarding increased deployment of **rooftop solar photovoltaic (PV)**
- **Net metering**
- **Solar thermal ordinances**
- **Electrification** of public transport systems
- **Measures to reduce reliance on individual motorised transport** (such as congestion pricing, vehicle quotas through auctions or lottery systems, license plate restrictions, low-emission zones, parking restrictions and car-free streets)
- **Biofuel blending mandates** and **biomethane use**
- Local **championship** and **awareness raising**.

## **CHINESE CITIES:** CHONGLI DISTRICT AND TONGLI TOWN

China is the world's most populous country, with about 1.4 billion people. Rapid economic growth and large-scale industrialisation have turned it into the world's largest energy consumer. In 2018 China accounted for around one quarter of global primary energy demand. Rising dependence on fossil fuel import and growing concerns about carbon emissions and heavy air pollution are driving the government to adopt increasingly ambitious renewable energy targets. China now has 29% of the world's installed renewable energy capacity, leading in hydropower, wind and solar PV, as well as the second-largest bioenergy capacity worldwide (IRENA, 2020b). China also accounts for 70% of the world's deployment of solar water heaters, 99% of electric buses and 45% of all electric vehicle (EV) stock (IEA, 2019c, 2019d; BNEF, 2018).

**Chongli District** is one of the six districts encompassed by Zhangjiakou City in Hebei Province. Fifty kilometres from downtown Zhangjiakou, Chongli has a population of 105 000 (2016 data) (Zhangjiakou Municipality, 2017b). Local renewable energy deployment is being driven by the decision to have Zhangjiakou cohost (with Beijing) the 2022 Winter Olympics and its designation as a National Renewable Energy pilot city in 2015. Zhangjiakou City aimed to deploy 20 gigawatts (GW) of renewable capacity and generate 40 terawatt-hours (TWh) electricity by 2020; it had reached 15 GW of capacity by December 2019 (Zhangjiakou Municipality, 2020). The Winter Olympics and its national pilot city status bring new economic opportunities to Chongli District, with tourism (skiing and related activities) featuring prominently (Chongli District Government, 2018).

**Tongli Town,** part of the Wujiang District of Suzhou City, Jiangsu Province, has a recorded history going back more than a thousand years. Certified a World Heritage site by the United Nations Educational Scientific and Cultural Organisation (UNESCO), Tongli Town is a protected historical heritage site by the Jiangsu provincial government and ranks among China's top ten tourist destinations, receiving more than 5 million visitors annually since 2011. Local government has recognised the major challenge of reconciling the growth of tourism with the parallel goal of increasing the use of clean energy in Tongli. The Suzhou City and Jiangsu provincial governments have thus adopted a series of policies to encourage the deployment of renewable energy, including targets, development plans, subsidies and a planned phaseout of fossil fuels.

Suzhou

## Lessons emerging from Chongli and Tongli

The two Chinese case studies suggest a number of issues and lessons learnt, as summarised in Figure ES 4 and discussed below.

***Lesson 1: Electrification strategies can support the scaling up of renewable energy and improve the urban environment***

Chongli, and Zhangjiakou as a whole, benefits from the availability of large-scale renewable energy projects, in particular, wind and solar PV. This level of existing deployment provides a solid base for ambitious targets, more than would otherwise be possible in cities where renewable energy has not yet begun to feed into the local energy system.

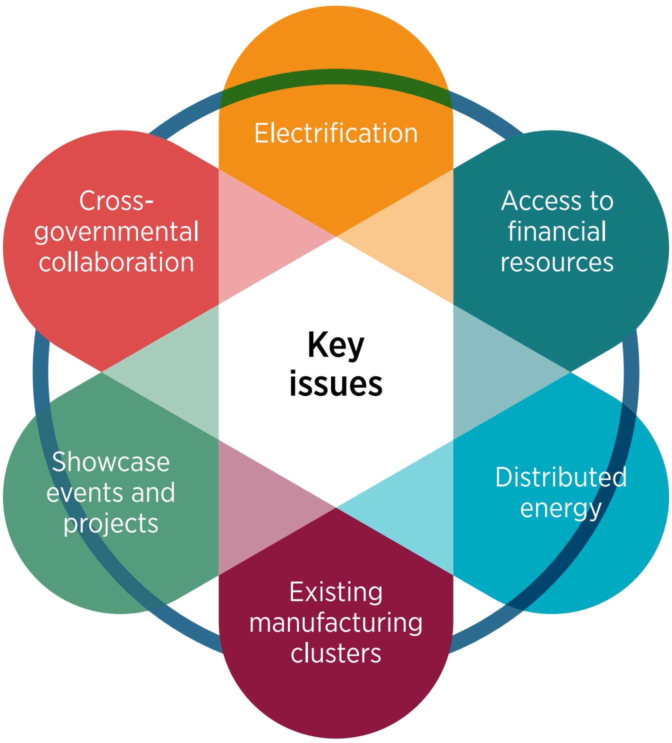
Electrification strategies can support the scaleup of renewable energy. Cities, towns and districts can be important laboratories demonstrating the feasibility of policies supporting electrification nationwide. The utilisation of redundant wind power capacity for heating purposes offers a way to address both the problems of wind curtailment and coal burning for heating. Critical challenges include unclear trading rules and power plant operators not keen on local electricity trading. A more flexible electricity pricing system could help here.

Tongli Town's tourism industry benefits from the electrification of end-use sectors. With more tourists visiting every year, Tongli demonstrates that the pursuit of innovative energy solutions not only saves money but also increases the safety and security of its residents and visitors, while significantly improving the quality of tourists' experience through better air quality and lessened environmental pollution.

***Lesson 2: Access to financial resources is critical for rapid, proactive measures***

Chinese cities clearly benefit from the availability of financial resources targeting renewable energy deployment. Tongli Town receives financial support from its upper-level administration, the Suzhou municipal government, which has one of the largest revenue streams among Chinese city governments. Given the high upfront investment and long payback for grid networks

**Figure ES 4 Key issues in the promotion of renewable energy in Chinese cities**




Source: IRENA urban policy analysis.

and related infrastructure, Tongli's example is the one most replicable in developed cities that resemble Suzhou. Cities and towns with limited financial capacity or low shares of renewables in the grid may find it difficult to emulate Tongli Town. Zhangjiakou City is not as rich as Suzhou, but its Chongli District received financial support from the national government in the context of the Winter Olympics.

### ***Lesson 3: Distributed renewable energy technologies are becoming more important***

Tongli Town's example also reveals that distributed renewables could play a much more significant role in cities. Distributed renewables such as solar PV generation systems could be deployed outside highly populated urban centres; heat-pump solutions combined with urban sewage systems and district heating and cooling networks could reduce the need for urban-centric deployment. Tongli's case, by way of contrast, is replicable in small towns where the relatively low-rise buildings could be supplied with solar PV through their limited rooftop space.

### ***Lesson 4: Existing manufacturing industries benefit renewables deployment***

Tongli exemplifies the mutually beneficial relationship between local governments and local manufacturing industries in the deployment of RETs. Many Chinese cities and towns have local manufacturing industries for solar PV panels and other parts of the RET value chain. This clustering of industrial production and innovation together with cities willing to support innovative industries through deployment policies benefit both local industries and cities themselves through shortened supply chains and lower costs.

### ***Lesson 5: Showcase events can help increase visibility***

Showcase events like the Winter Olympics can rally policy making. Chongli District and Zhangjiakou Municipality have linked local renewables development targets with the hosting arrangements of the Winter Olympics, focusing political attention and financial support on renewable energy projects.

### ***Lesson 6: Cross-governmental collaboration counts***

One of the replicable success factors in Chongli's ability to raise the share of renewables in end-use sectors is its collaboration with upper government levels, including the municipal government of Zhangjiakou and the Hebei provincial government. The provincial government has played a pivotal role by releasing most of the policies for renewables deployment as well as providing subsidies and facilitating an electricity-trading platform. These will all be vital for Chongli if it is to fulfil its 100% renewable energy heating target by 2022.

Direct policies issued by Suzhou Municipality have set renewable energy targets, banned heavy polluting fuels, created subsidies for EVs and showcased buildings with integrated distributed solar panels. These are replicable policy instruments at the city and town levels, supporting the deployment of renewable energy across various sectors. The collaboration with Jiangsu provincial government and the National Energy Administration (NEA) also supports the scaleup of distributed renewables generation and the electrification of the heating and cooling and transport sectors at the regional and national level.

## UGANDAN CITIES:
## KASESE AND LUGAZI

Socio-economic conditions, demographic trends and rising urbanisation are shaping energy demand and placing Ugandan cities under growing strains. Although Uganda is endowed with a variety of energy resources including hydropower, biomass, solar, geothermal, peat and fossil fuels, only around 20% of the population has access to electricity; access to clean cooking fuels and technologies is estimated by the World Bank to be as low as 2% (World Bank, 2017). Vision 2040, Uganda's 30-year development master plan (2010–2040), envisions increasing access to the national grid to 80% (GOU, 2013). Renewable energy, for which Uganda has plenty of potential, plays a key role in this context, both in the on- and off-grid segments.

**Kasese** is a largely urban municipality in southwest Uganda close to the border with the Democratic Republic of the Congo. It forms the biggest urban centre within Kasese District and has an estimated population of about 130 000. A 2017 report estimated that over half of all households have no electricity, compared with estimated nationwide urban access rates of around 60% (SE4ALL, n.d.). Firewood and charcoal provide a large share of Kasese's non-transport energy use among households and commercial establishments (McCall, Stone and Tait, 2017). The heavy use of charcoal in particular entails hefty environmental impacts, in addition to deforestation caused by heavy fuelwood use (Ndibwami and Drazu, 2018). Kasese's district government and municipality have been active proponents of local renewable energy deployment (*e.g.*, Baluku, 2015). They regard renewables as an important enabler for progress in health, education and poverty reduction (KDLG, 2013). International initiatives combined with local stakeholder engagement have carried renewable energy into policymaking in Kasese.

Located approximately 50 km east of Kampala, **Lugazi** is the second-largest urban area in Buikwe District, with an estimated population of 126 100 people (UBoS, 2018). As in Kasese, Lugazi's energy mix is dominated by traditional sources of energy; Only around 37% of households have access to electricity (BDLG, 2016a). Like the rest of Uganda, Lugazi is located in a region rich in renewable energy sources, including hydropower, solar energy and bioenergy. Buikwe District hosts a 180 MW hydroelectric power station on the Nile at Nalubaale. Some 1 100 households (4% of Lugazi's total) use solar home systems (SHSs). A few solar panels have been fitted on roofs of local hospitals, but all in all solar energy remains largely underexploited. A decisive role in promoting local renewable energy deployment in Lugazi has been played by district-level planning and external development funding tied to nationwide infrastructure development, with support from a willing, but in many ways constrained, local government.

## Lessons emerging from Kasese and Lugazi

As with the city case studies from China, Ugandan cities offer some lessons, as discussed below. Figures ES 5 and ES 6 summarise the benefits and challenges, respectively, in the Ugandan context.

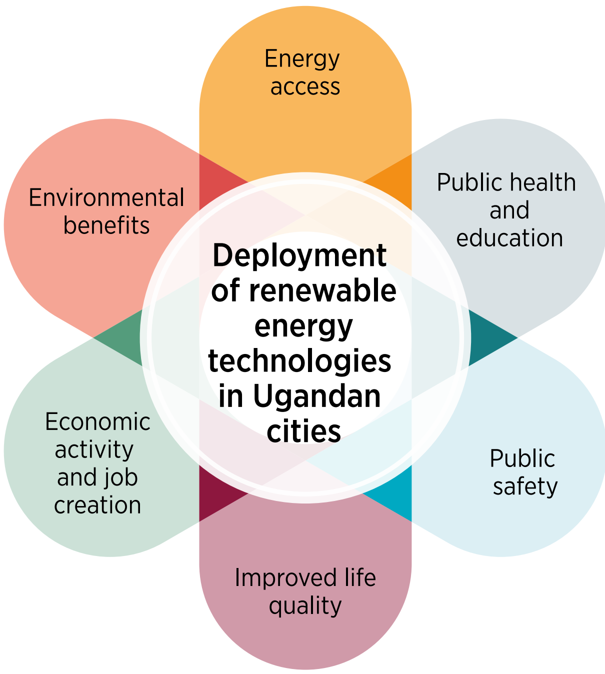
### *Lesson 1: Renewable energy deployment benefits energy access and many other development goals*

One of the overarching conclusions to be drawn from the city case studies from Uganda is that renewable energy deployment benefits local communities in a number of ways and boosts a range of socio-economic development goals (see Figure ES 5). Electricity generated from renewable energy has tremendous benefits for public health. Solar PV panels installed on Lugazi's public hospital provide backup power for lighting, medical equipment and the refrigeration of medicines and vaccines. Residential solar provides light for children to study after sunset and reduces the time women and children spend collecting fuelwood at the expense of education or pursuing paid work. SHSs also power radios, TVs and mobile phones, improving quality of life significantly for residents. In both Lugazi and Kasese, solar street lighting and SHSs have generated massive cost savings for municipalities and households (Mugalu, 2013) while extending the business hours for street sellers and improving public safety. Improved telecommunication also creates job opportunities.

### *Lesson 2: Limited capacity and expertise set hurdles for the deployment of renewables*

Notwithstanding the obvious benefits of renewable energy, Ugandan cities face significant obstacles to greater local deployment. Institutional constraints –

**Figure ES 5 Renewable energy benefits in Ugandan cities**




Source: IRENA urban policy analysis.

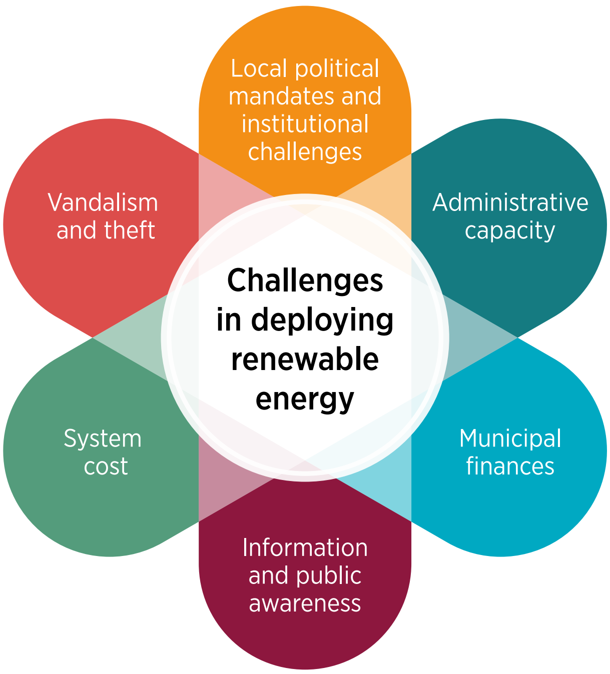
including narrow political mandates, limited administrative capacity and local expertise, and tight municipal finances – all present major obstacles to effective policy action. There are also hurdles of inadequate information, operation and maintenance woes, and vandalism (see Figure ES 6). In the absence of central government action and international finance and capacity-building assistance, Ugandan cities struggle to reach their potential. Experience suggests that national policies and means alone will not suffice.

***Lesson 3:* *Scaling up projects will require greater funding and capacity building***

A national enabling framework that supports and encourages local governments – both at district and at municipal levels – is essential in order to ramp up modern renewable energy use in Uganda, inside and outside cities. Both Kasese and Lugazi have fundamentally benefited from initiatives targeting sustainable energy at the district level, illustrating the importance of strengthening this level of governance through mandates and finances. Local stakeholder engagement and capacity building are critical for moving beyond demonstration projects and internationally funded initiatives.

Adequate financial resources for district and municipal governments are a prerequisite for effective action. Even though renewables offer cost savings in the medium and long run, the substantial upfront costs often surpass the funds available to the country's municipalities and districts. Currently, initiatives such as solar street lighting projects are almost without exception tied to third-party financing support, such as the World Bank's Uganda Support to Municipal Infrastructure Development Programme (USMID). Empowering Ugandan cities beyond development finance to engage in critical public procurement of clean energy will require structural improvements to municipal and district funding, as well as local capacity building and training in project delivery and financial management. Foreign partnerships can in turn drive progress not only through financing, but also by helping build local capacity, as has been demonstrated in Kasese.

**Figure ES 6 Challenges in deploying renewable energy in Ugandan cities**





Source: IRENA urban policy analysis.

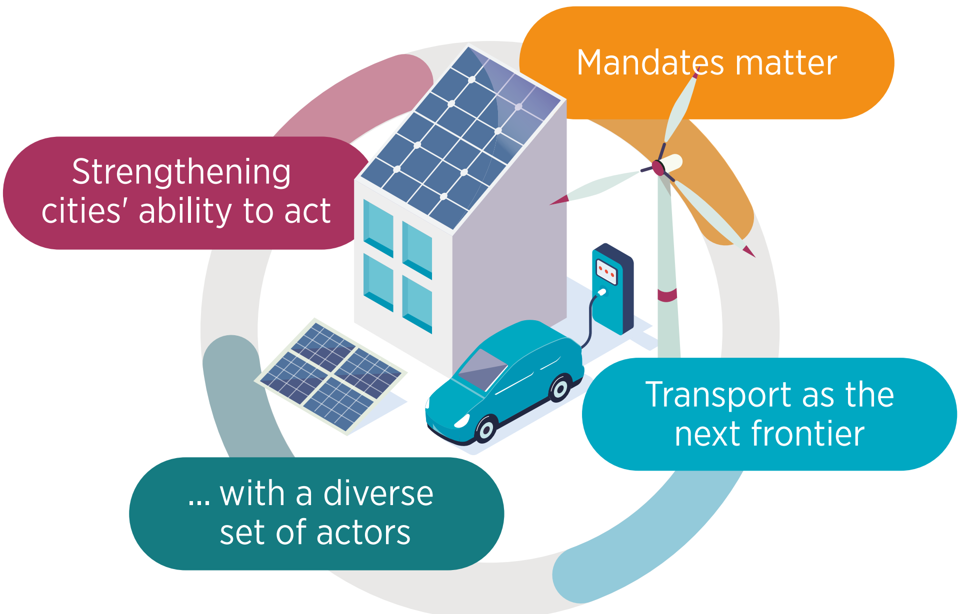
## COSTA RICAN CITIES: CENTRALISATION AND PROMOTION OF E-MOBILITY

With a population of about 5 million and territory of about 51 000 km$^2$, Costa Rica is the smallest of the three countries examined in this report. A highly urbanised country with some 77% of the population living in cities (Presidencia de La República, 2019a), Costa Rica has one of the highest electrification rates in Latin America. Grid coverage expanded from 47% in 1970 to virtually universal access today. Costa Rica is well known for its unusually large share of power generation sourced from renewable sources – 98.5% as of 2019 – based on hydro, wind and geothermal projects. In 2019 the government passed a national plan to make Costa Rica one of the world's first fully decarbonised economies to reach net-zero carbon neutrality by 2050 as established in the Paris Agreement on climate change.


Key questions discussed in the country include the role to be played by the public and private sectors and the degree to which electricity generation should be based on centralised and decentralised sources. Electrification of the transport sector, pursued in order to meet GHG emission reduction goals, will inject a new dynamic into the power sector.

Figure ES 7 summarises the key issues and challenges that characterise Costa Rica's efforts to further promote the use of renewable energy. These are presented in terms of emerging lessons below.

**Figure ES 7 Key issues in the promotion of renewable energy in Costa Rican cities**




Source: IRENA urban policy analysis.

## Lessons emerging from Costa Rica

### ***Lesson 1:*** ***Where cities don't have the mandate, their scope of action remains limited***

Costa Rica's small size allows highly centralised decision-making structures that restrict the ability of cities to make autonomous policy decisions. The municipal landscape, by contrast, is deeply fragmented, which is increasingly being seen as one of the main obstacles to a sustainable urban future (Presidencia de La República, 2019a). Within these limitations, the municipalities of Cartago and Grecia have taken active measures, promoting green policies in the transport and tourism sectors, while the city of Guanacaste – considered Costa Rica's "capital of renewable energy" – has hosted several trailblazing projects in the fields of wind, solar and geothermal energy.

As cities worldwide become central protagonists in sustainability efforts, municipalities in Costa Rica, too, may become more proactive about their country's ongoing energy transformation. In many ways, sustainability is also about better urban governance and local choice. It is unlikely that Costa Rican cities will be running energy projects themselves. But capacity building as part of the GHG inventories established under Costa Rica's Carbon Neutrality Programme could be a first step towards empowering cities to develop their own mitigation strategies and play a more active role in the decarbonisation process.

### ***Lesson 2:*** ***Where the share of renewables in the electricity mix is already high, transport becomes the next frontier***

Governance adjustments are more likely in the realm of public transport. As other Latin American cities (such as Medellín and Cali in Colombia, Panama City in Panama and Santiago in Chile) advance with electric buses and other electric-mobility (e-mobility) projects, the contrast with Costa Rica (*i.e.*, with its lack of municipal transport authorities) becomes clearer.

Solving the energy-transport conundrum in Costa Rica will require rethinking the role of urban planning and the greening of cities. The current level of centralisation may present a barrier to the successful implementation of the National Decarbonisation Plan. The transformation of public transportation holds great promise because of the high cost of the current model.

The integration of e-mobility – given the country's large share of renewable electricity – interfaces with the importance of eco-tourism to the economy. There is a need to offer new experiences and value propositions, and zero-emissions tourist experiences open a new space for decentralised, in situ projects where municipalities can engage in and perhaps even propose their own projects.

### ***Lesson 3:*** ***Collaboration is a key to success***

Having a formal economy-wide decarbonisation plan sends a powerful signal to companies and municipalities. Today the question is how to engage non-state actors and local governments. The country's current administration has prioritised decarbonisation as one of the top pillars of the development strategy, realising that the involvement of the private sector, municipalities and citizens is essential. In parallel, a new ecosystem of stakeholders is emerging around sustainable mobility, cities and climate action.

Costa Rica demonstrates that collaboration with a diverse set of actors is key to success. The Guanacaste renewable energy hub – featuring renewables, e-mobility and a hydrogen ecosystem – confirms the critical importance of multi-stakeholder engagement in pioneering initiatives. In a country where energy and transport decisions are centralised in San José, the Guanacaste developments might pave the way for new modes of achieving goals in renewable energy and clean transportation in Costa Rica and beyond.

### ***Lesson 4:*** ***Strengthening municipalities offers much potential for future action***

Promoting international best practices among municipalities will be essential. Local governments are weak, but they learn from the experience of cities elsewhere, allowing them to avoid mistakes and benefit from lessons learnt. New initiatives, such as promoting e-mobility at the municipal level or measuring GHG emissions, provide critical insights for municipalities.

For now, encounters with representatives of cities elsewhere in the region are informal. Indeed, Costa Rican local governments could benefit from developing "sister city" approaches, or co-operation agreements with cities pursuing similar objectives. The Decarbonisation Plan to 2050 offers a concrete opportunity to rethink the role of cities and to make proposals for engaging cities in the implementation of actions over the short, medium and long terms.

# 1. RENEWABLE ENERGY AND CITIES

Given that cities are dynamic agglomerations of people and their many activities, they are not easily defined (see Box 1.1). But it is beyond doubt that urban areas across the world are home to an ever-increasing share of the global population. As of 2018, cities were home to 55% of the total population, up from just 30% in 1950. By 2050, the United Nations (UN) expects that 68% of the world's population will reside in cities (UNDESA, 2018). This rapid growth is driven both by an increase in the number of people already residing in cities and by the continued movement of people from rural areas into cities, spurred by economic opportunities and higher living standards in urban areas. The UN projects that the fastest growth will occur in low- and lower middle income countries in Asia and Africa.

Cities are where much of the world's economic activity is concentrated, accounting for more than 80% of global gross domestic product (GDP). Energy is the lifeblood of cities, powering transport, industrial production, commerce, building construction, public works, lighting, air conditioning and countless other human activities. Cities are engines of the economy, using about 75% of global primary energy. They have a major role to play in advancing and shaping the global energy transition away from polluting fuels and technologies.

Because much of current urban energy supply is fossil fuel-based, cities are major contributors of air pollutants and greenhouse gas (GHG) emissions. Cities are responsible for around 70% of global energy related GHG emissions and are therefore the main driver of climate change (UN-Habitat, 2019). At the same time, cities suffer from high rates of air pollution; according to the World Health Organization (WHO), 98% of cities with more than 100 000 inhabitants in low- and middle income countries do not meet WHO air quality guidelines (WHO, 2016).

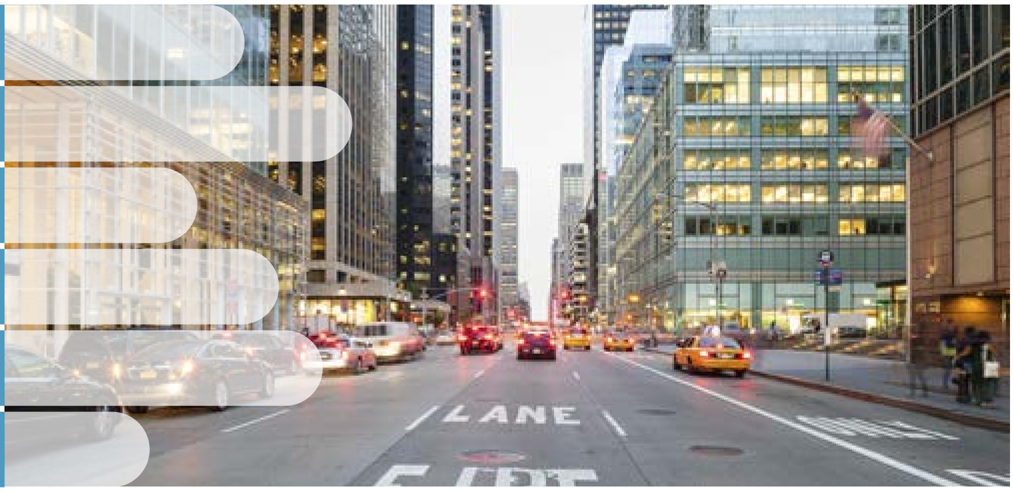
**55%** of the total population are in cities

**70%** of global energy related GHG emissions come from cities

**75%** of global primary energy is consumed in urban areas.

Much of the challenge of sustainable development, in its economic, social and environmental dimensions, relates to how cities are governed and how urban growth is managed. Climate change poses tremendous challenges to cities' economic vitality and even habitability, due to sea-level rise and the increased intensity and frequency of weather events such as storms, flooding, droughts and heat waves. Hundreds of millions of urban residents will be increasingly vulnerable to sustained extreme heat, which will in turn drive increased use of air conditioning. Their lives will be deeply affected by less freshwater availability, lower major crop yields and more coastal flooding as sea levels rise (C40 Cities *et al.*, 2018). Interruptions in power supply because of these climatic changes are likely to be further escalated by greater demand for air conditioning, particularly in emerging economies where grids are still weak. Mitigation and adaptation efforts will require growing material and financial resources.

As urban populations continue to grow, cities will need to increase the integration of renewable energy technologies (RETs) into power grids and other energy distribution systems to mitigate the effects of climate change and achieve their Nationally Determined Contribution (NDC) targets. Analysis conducted by the International Renewable Energy Agency (IRENA) highlights that while renewable energy deployment measures in the power sector are often developed in the context of national policies, many measures relevant to the end uses of renewable energy, such as in the building and transport sectors, are made at the city level (IRENA, 2016; IRENA, 2017b; IRENA, IEA and REN21, 2018). National policies, meanwhile, shape local action. It is important to build the capacity of cities to identify renewable energy solutions that suit their particular circumstances and needs and to integrate these solutions in planning processes. The next step is to secure the requisite financing.



## **BOX 1.1** WHAT IS A CITY?

There are multiple definitions of what constitutes a city, owing to the dynamic realities of urban settlements and reflecting a variety of functional and administrative arrangements. Broadly speaking, a city or urban area is a densely settled place with administratively defined boundaries where inhabitants live on a permanent basis and the bulk of economic activity takes place outside primary sectors like agriculture or resource extraction.

With this generic definition, the term "city" can be applied to a very broad array of urban settlements that share some characteristics but may also be marked by tremendous differences. One of them concerns size of a city's population and its density, and its effective territory, including surrounding rural areas that fall under a city's municipal authority. Jurisdictions and administrative units in this context differ between countries, leading to significant discrepancies between what is being talked about with regards to a "city" – an urban conglomerate, a "city proper", a geographic or administrative unit that extends beyond purely urban areas for example. The vast demographic differences between countries such as China, Costa Rica, or Uganda, as seen in this report, exemplify this.

Conversely, a large contiguous urban area may be sub-divided into multiple towns or districts, a situation that may render effective urban governance difficult. Thus, the city as a governance unit can be dramatically different from the larger metropolitan area that exists. This special circumstance, which can translate into vastly different administrative setups for urban governance, is illustrated by the cases of China and Costa Rica in this report. The particular context of cities may help explain why a large portion of existing literature focuses on large and "mega" cities, rather than secondary and medium-size cities, a gap that this report aims to help bridge.

Urban areas can be broadly grouped into small, medium, large, and megacities. But there are no agreed thresholds. In part this reflects the fact that many cities are continuously growing and thus defy static definitional boundaries. But there is also the reality that each country has its own approach to how it classifies cities. The first, analytical section of this report draws on initiatives and experiences of cities small and large around the world, but the case study cities were selected from the ranks of "medium-size" populations (defined for the purpose of this study as anywhere from 30 000 to 1 million inhabitants).

As this report notes in the context of the case studies it presents, urban governance systems vary significantly. Political mandates, regulatory and revenue-generating authority of a given municipality diverge among cities of comparable size, and strongly affect the degree to which medium-size, or secondary cities can become agents of change within a country's energy transition. Cities can be renewable energy pioneers, but urban decision-making in support of the energy transition often depends strongly on the overall governance hierarchies in each country and thus on effective collaboration with national-level authorities.

Source: López Moreno (2017).

## MOTIVATIONS AND DRIVERS OF MUNICIPAL ACTION ON ENERGY

Cities, can be important agents driving local renewable energy deployment through measures and initiatives that complement policy at the national level. Municipal energy policy is most directly concerned with securing adequate energy supply, which includes considerations of affordability and choices regarding suitable types of energy sources and carriers. How much energy is needed is influenced by decisions in sectors other than energy:

- Urban planning shapes cities in fundamental ways, strongly influencing the amount of energy (and to some extent even the type of energy) required for all types of urban activities.
- Cities with strong zoning laws and land-use controls can more readily affect settlement density and promote mixed-use development (limiting the segregation of residential, commercial and industrial activities). Such structural factors have decisive influence on energy needs. Individual motorised transportation is difficult to avoid in cities spread out over a large area. Similarly, cities with a preponderance of single-family houses require more energy – both for heating and cooling and for transport – than those where apartment buildings make up a large share of available housing.

Far-sighted urban policy will avoid structural path dependencies that lock in high energy demand, or, where they already exist, will seek to minimise and gradually overcome them.

Cities are often motivated to promote renewables by a number of factors beyond energy supply (see Figure 1.1). Critical considerations concern the cost and affordability of energy (including energy access and energy poverty issues); economic development objectives (including the ability to build local supply chains and to attract and retain a diversity of businesses) and employment generation.

Social equity considerations – reducing poverty and ensuring that poorer urban communities have access to clean energy solutions – are also central. Concerns about climate impacts are rising in importance, joining long-standing worries over the health impacts of air pollution from fossil fuel use, as well as the desire to ensure liveability and a high quality of life. Climate and air quality objectives add to the urgency of the energy transition. Yet even greater ambition – higher targets for renewables and shorter implementation timelines – may be needed to confront funding barriers.

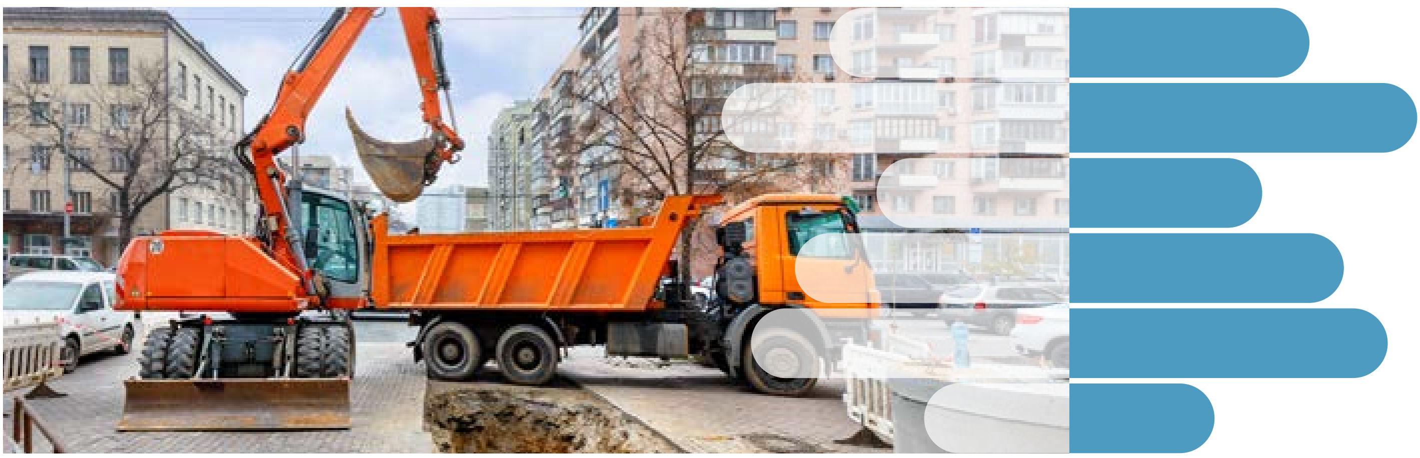
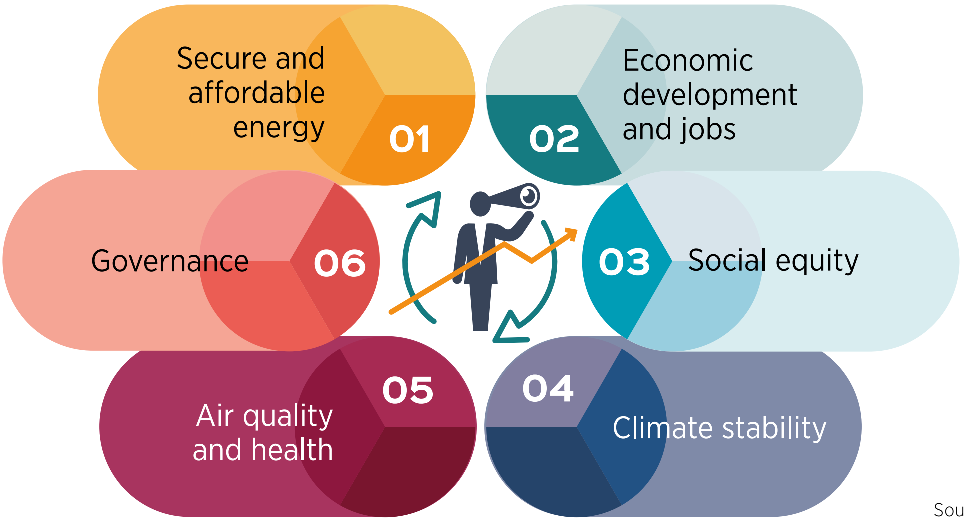


**Figure 1.1 Motivations and drivers of municipal decision making on energy**




Source: IRENA urban policy analysis.

Energy-related policy making is a complex process involving the diverse motivations of many stakeholders, from local community groups to the private sector. Progress not only requires the formulation of comprehensive plans, but also the resources and institutional capacity for successful implementation. Implementation requires vision, policy coherence and pragmatic co-ordination across various levels and layers of municipal governance.

In advancing the use of renewable energy, cities have multiple roles and responsibilities. IRENA's report on *Renewable Energy in Cities* (IRENA, 2016) characterised cities as important actors in several dimensions: they can and must act as planners, regulators, owners of municipal infrastructure, procurers and distributors of energy services, direct consumers of energy, aggregators of demand, advocates and facilitators, and financiers of renewable energy projects.

These are highly diverse roles and responsibilities that entail a broad array of policy tools. In some cases, cities have the authority to take policy and regulatory action directly and on their own, whereas others may be able to act only in conjunction with authorities at the national and state/provincial levels or may only have indirect influence through persuasion and awareness-raising. These various roles and activities will be discussed in the following chapters with the help of specific examples and experiences in energy supply, the building sector and transportation.

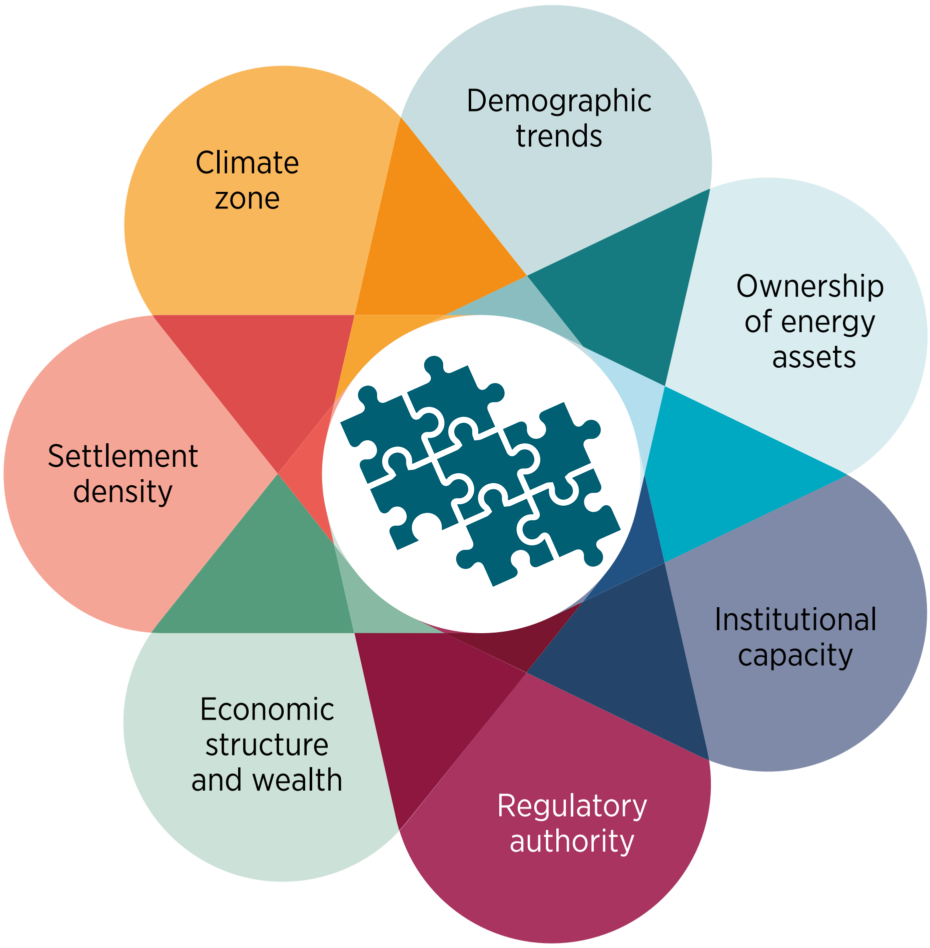
Local energy transition strategies are driven by multiple actors whose significance varies from city to city (and country to country), reflecting different administrative and policy making structures, as well as civic cultures. Mayors, city councils and municipal agencies are key actors in planning, issuing regulations and implementing policies and projects. Utilities and energy companies are other important actors; their roles and influence can vary considerably, depending on whether they are strictly local entities or operate on a larger (provincial, national or international) scale and whether they are under public or private ownership. Regulatory authority and financing needs can give regional and national governments a strong say in urban affairs.

The energy needs of the private sector – manufacturers, commercial businesses and service providers – shape a city's energy demand profile, along with household consumption. Community groups and other grassroots organisations may launch initiatives to urge faster or more ambitious action on the energy transition, but citizens may also express opposition to planned policies and projects. The presence of so many different stakeholders in the urban landscape makes for a dynamic situation.

## MUNICIPAL NEEDS AND CAPABILITIES

Although cities across the world face many similar challenges, their particular circumstances, needs and capacities to act – which are typically a product of their historically grown structures and reflect their various political cultures – can vary enormously. Cities' plans thus need to be tailored to their specific circumstances. Figure 1.2 provides an overview of the key factors – many of them interconnected – that shape cities' energy profiles.

**Figure 1.2 Factors shaping city energy profiles**




Source: IRENA urban policy analysis

- **Climate zone:** Individual cities' energy options are conditioned by an array of variables. Some, such as the particular climate zone in which a city is located (dictating heating and cooling demand profiles), are immutable – although advancing climate change triggers new challenges.
- **Demographic trends:** Cities with growing populations confront greater challenges than cities with more stable populations. This is especially the case in urban areas with large and rapidly expanding informal settlements, where energy access is limited or where residents suffer from energy poverty.
- **Settlement density:** Compact cities are able to build attractive public transportation networks, while sprawling megalopolises struggle to make them work and often remain reliant on energy-intensive passenger cars. The extent of mixed-use, transit oriented development influences the amount of energy required for routine human activities. In the building sector, the age, characteristics and condition of the building stock are of great importance to energy use.
- **Economic structure and wealth:** Cities' energy use profiles are shaped in fundamental ways by their economic structures. "Producer cities" with extensive materials processing and manufacturing industries, or those that function as significant trans shipment nodes for global trade, tend to have a large energy footprint. "Consumer cities", on the other hand, may have effectively outsourced polluting industrial activities and feature an extensive service sector. In general, wealthy, economically dynamic cities (*i.e.*, those where a diversified economy supports a major flow of tax revenues) are able to act in ways that poorer cities cannot.
- **Legal and budgetary authority:** Decision-making power over matters that affect urban areas does not always fully rest with municipal authorities. Statutory authority often lies with national energy utilities and national or state/provincial regulatory authorities.
- **Institutional capacity and expertise:** The ability of cities to act is shaped and constrained by the degree to which they either already have, or are able to build, adequate capacity (in terms of planning, implementation, budgetary resources and staffing) and access to required technical and professional expertise.
- **Regulatory power and asset ownership:** The role of private-sector energy providers varies from city to city, influencing the degree to which cities are able to exert control over energy generation in terms of ownership structures, investor preferences, operational authority or regulatory enforcement power. Cities typically do have substantial influence over factors that influence energy consumption, such as spatial planning, building efficiency, urban transport modes, settlement patterns and household consumption practices.

## THE SIGNIFICANCE OF CITIES IN DEPLOYING RENEWABLE ENERGY

IRENA's report on *Renewable Energy in Cities* (IRENA, 2016) identified several dimensions of cities' role in shaping adaptation and mitigation efforts, and as such in accelerating the deployment of renewable energy solutions as a key pillar of national sustainable energy targets.

Cities can be target setters, planners and regulators. They are often owners, and thus operators of municipal infrastructure. Cities are always direct consumers of energy and therefore aggregators of demand, and can be conveners and facilitators, and financiers of renewable energy projects. Finally, cities through their local governments can be important awareness builders, both through existing roles such as target setters and planners, and through their own voice through local media.

The following subsections explore several ways in which cities can promote the use of renewable energy (see Figure 1.3). They focus on three key sectors of the urban economy, namely, the energy sector itself (production and procurement of energy) and two key end-use sectors, buildings and transport. The discussion draws on selected examples of policy initiatives and experiences from cities around the world which are presented in short text boxes.

**Figure 1.3 Roles of municipal governments in the energy transition**


Source: IRENA urban policy analysis (based on IRENA 2016).

## CITIES' ROLES IN ENERGY GENERATION AND PROCUREMENT

Municipal energy generation and procurement are fundamental functions. In many countries, the statutory authority for urban electricity supply lies with national energy utilities and regulatory authorities. Public ownership can be an effective lever for driving local energy transitions and for channelling funding to renewables. But the degree to which cities own their municipal generating facilities varies substantially among countries; privatisation moves in previous decades have limited the extent of public control in many places.

Germany is one country where local public utilities, as well as citizens' energy co-operatives, play a significant role in electricity generation and distribution, in some cases after successful grassroots campaigns to "remunicipalise" energy assets. In the United States, as of 2013, more than 2 000 communities, with about 14% of the country's population, got their electricity from city-owned utilities (IRENA, 2016). In a number of countries, municipalities are setting up new entities to generate renewable power from local resources, such as in the United Kingdom, where public companies and community-owned enterprises have been set up in Aberdeen, Bristol, Nottingham and Woking (Cumbers, 2016). Cape Town, South Africa, offers another example (see Box 1.2).

### **BOX 1.2** MUNICIPAL EFFORTS TO PROMOTE RENEWABLE ENERGY IN CAPE TOWN

Cape Town, South Africa, has undertaken a number of initiatives and infrastructure projects aimed at reducing city-wide electricity consumption (through greater efficiency in buildings, transport and street lighting as well as metering and monitoring measures) and at increasing renewable energy capacity, to reduce heavy dependence on coal-generated power. As is the case for other cities in this country, concerns about the reliability of supply (load shedding), rising electricity prices and increasing awareness of the promise of renewable energy technologies have been key drivers of action.

Cape Town has installed rooftop solar photovoltaic systems on several municipal buildings and facilities and maintains four microhydro generation turbines at water treatment plants that meet 5% of the total electricity used for municipal operations. Cape Town is also one of 18 municipalities in the country that have begun to facilitate small-scale distributed energy projects in the residential, commercial and industrial sectors. Some 274 projects, with a peak generation capacity of 247 kilowatts (kW), had been approved as of early 2018, and more than 2 megawatts (MW) of additional capacity were in the planning pipeline (ICLEI and IRENA, 2018).

Cape Town, South Africa

Even where they do not own energy-generating assets, municipalities can promote the adoption of renewable energy by exercising the purchasing power inherent in their roles as aggregators and regulators of energy demand. Green public procurement has become a widely used term, and the European Union has developed criteria and guidelines for it (European Commission, 2020). Municipal authorities may, for example, adopt clean energy guidelines governing their purchases of electricity, energy for heating and cooling, or transport fuels. By setting targets, adopting labelling schemes or requiring green certificates, cities can influence what kinds of energy sources private providers develop and offer to local households and businesses. In this manner, they may also shape companies' own purchasing decisions, as seen in the growing move towards corporate sourcing of renewable power (see Box 1.3).

## **BOX 1.3** CORPORATE SOURCING OF RENEWABLE ENERGY

Companies in the commercial and industrial sector account for roughly two-thirds of the world's end-use of electricity. An increasing number of these companies are committing to ambitious renewable electricity targets to power their own operations, driven amongst other by the steady decline in renewables costs as well as a growing demand for corporate sustainability among investors and consumers. Already in 2017, over 465 terawatt-hours (TWh) of renewable electricity were actively sourced by companies – comparable to the electricity consumption of France. Policies to support corporate sourcing have been introduced in over 70 countries, however, barriers in many markets are preventing companies from sourcing renewables and exercising their full purchasing power.

Cities can play an important role in ensuring that the growing corporate demand for renewables can be met and leveraged to accelerate investments in renewables. Cities can, for example, ensure that enabling frameworks are available to support corporate production of electricity for self-consumption; "green procurement" options should also be available. Cities with utility ownership can directly shape their energy offerings and may consider, *e.g.*, green premium products or tailored renewable energy contracts, such as green tariff programmes. These programmes enable companies to purchase renewable electricity from a specific asset through a longer-term utility contract similar to a corporate Power Purchase Agreement. In the United States, utilities in 13 states and the District of Columbia were offering green tariff programmes as of late 2017. Deals totalling more than 950 MW were contracted over the 2013-17 period through these programmes.

While there is a growing interest from the corporate sector to source renewables, there is still room for companies to strengthen their ambitions and accelerate decarbonisation of their operations. Through long-term renewable energy targets and energy transition plans, cities can encourage companies to further participate in the energy transition while fostering a greener and more resilient business environment, even attracting new economic development.

Source: IRENA, 2018d.

## Expanding the use of district energy systems

District energy is a technology option particularly suited to municipal procurement. Many cities have considerable authority over the generation and distribution of heating and cooling (IRENA, 2016). District energy systems could play a role as enabling infrastructure to achieve better efficiency for dense urban areas and offer opportunities to integrate low temperature renewables such as geothermal heat (IRENA, IEA and REN21, 2020).

Renewable energy at present supplies only 8% of district heat worldwide, a share that would need to rise to 77% in 2050 under an ambitious energy transition scenario (IRENA, 2020d). A few European countries have achieved shares of 50% or more (see Box 1.4). Globally, 417 solar district heating systems (with a combined capacity of 1.73 $GW_{th}$) were in place in 2019, up from 345 in 2018 (REN21, 2020).

Business and policy models vary, depending on local conditions and priorities, ranging from full public ownership to public private partnerships to private ownership, including models where the owners are also the consumers (IRENA, 2017b; IRENA, IEA and REN21, 2018). The public model allows cities to control tariffs and thus to guard against energy poverty among residents.

### **BOX 1.4** DISTRICT HEATING AND COOLING PIONEERS

Several cities are building or expanding district energy systems. **Växjö**, Sweden, is a pioneer in using biomass and co-generation for district heating purposes (Agar and Renner, 2016). Another leader is Iceland's capital, **Reykjavik**, where some 95% of residences are connected to a geothermal-based district heating network (IRENA, 2016). Industrial waste heat is being recycled in various European cities (IRENA, 2016). European cities lead the move towards solar district heating systems (which numbered about 340 worldwide as of 2018), but such systems are beginning to spread to other regions, such as **Bishkek**, Kyrgyzstan, which inaugurated a solar system in 2017 (REN21, 2018). The development of modern district heating systems and efficient buildings running at low temperatures has paved the way for a greater utilisation of low-enthalpy resources, including from abandoned mines and through heat pumps.

### Installing solar street lighting

Solar PV technology is another key technology suitable for municipal deployment and energy generation. Cities and municipalities can support the deployment of solar photovoltaic (PV) technology, for instance by modernising street lighting. Streetlights account for a significant share of urban energy use. Worldwide, lighting accounts for around 20% of all electricity used (Rondolat, n.d.), with public lighting consuming as much as 40% of a city's energy budget (IRENA, 2016). Solar-powered LED bulbs offer energy and cost savings of 50% or more and, with life spans of up to 20 years, are far more durable than conventional lights. They offer additional benefits if they are networked (rather than standalone installations) and combined with smart grid development, net metering and demand response policies. The potential is huge: only about 10% of the approximately 300 million streetlights globally are LEDs, and only 1% are networked (Rondolat, n.d.).

## CITIES' ROLES IN REGULATION AND URBAN PLANNING

Cities can play a key role in promoting rooftop solar PV in urban spaces. Rooftop solar PV is a dynamic and increasingly cost-effective technology (IRENA, 2017b) whose adoption can be boosted significantly through regulatory requirements, in particular building codes, or through incentives to building owners. The impact of systematic deployment can be significant, as buildings are among the biggest users of energy and contribute substantially to greenhouse gas emissions (UNEP, 2018). For cities, encouraging the deployment of rooftop solar applications through regulatory measures can be a win-win policy that integrates well with parallel local and national efforts to increase energy efficiency. Urban policies in particular promise greater success if they address common barriers to the deployment of solar rooftop solutions (such as a large portion of tenants rather than owners in a building). Box 1.5 offers some examples of such policies.

### **BOX 1.5** EXAMPLES OF ROOFTOP SOLAR IN CITIES

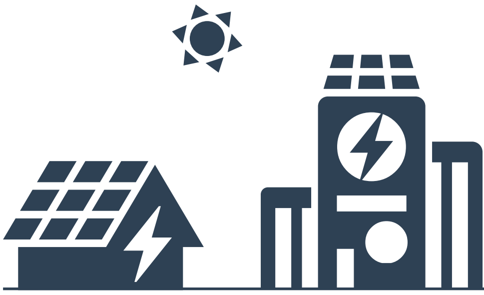
Chinese cities have been at the forefront of solar rooftop efforts. The city of **Dezhou**, in Shandong Province (northwest China), launched its "Million Roof Project" in 2008, requiring that all new residential buildings be equipped with solar water heaters. Solar thermal or solar PV technology is integrated in 95% of new buildings in the city (ICLEI and IRENA, 2013a).

Elsewhere in Asia, **Tokyo**, Japan, plans to install 1 gigawatt (GW) of rooftop systems by 2024, including 22 MW on publicly owned buildings and facilities. The city has created Japan's first solar map, the "Tokyo Solar Register", which calculates suitable solar photovoltaic (PV) system size (kW) and potential electricity generation (kilowatt-hour, kWh) by assessing solar insolation, rooftop space, roof tilt and shading for each specific home or building (Movellan, 2015). **Seoul** in the Republic of Korea also has a PV capacity goal of 1 GW by 2022. The "Solar City Seoul" plan is set to invest KRW 1.7 trillion (USD 1.56 billion). In addition to increasing the number of miniature solar generators on household rooftops and verandas to as many as 1 million, Seoul will also install PV panels at major buildings and parks, designating a number of areas around the city as solar energy landmarks or solar energy special districts (Renewables Now, 2017; Lennon, 2017).

**San Francisco**, California, became the first major US city in April 2016 to require all new buildings to install rooftop solar PV (IRENA, 2016). The city administration also has a goal of installing 100 MW of solar power on public buildings and spurring the installation of 250 MW on private buildings by 2025 (Patel, 2016). To deal with the variability of solar power, **New York City** is the first city in the United States to adopt a citywide target of 100 megawatt-hours (MWh) by 2020 for energy storage, though stringent safety and permitting rules have slowed progress (Maloney, 2018).

## Adopting net metering

Net metering is a billing mechanism that allows consumers who generate their own electricity (*e.g.*, through solar rooftop assemblies) to store that energy in the grid. Production in excess of the generator's own needs can be sent to the grid in exchange for credits, which can be used to pull power from the grid when demand exceeds generation (at night, for example).



Through net metering, local or national authorities can encourage solar PV deployment, allowing households or businesses that generate their own electricity to feed any surplus back to the grid, thus turning them from consumers into "prosumers". They can either receive a credit against future consumption or remuneration at a specified rate (IRENA, 2016). In some countries, national-level authorities are responsible for net metering; however, where national regulators have not set up such regulations, municipal authorities may do so under their function as local electricity regulators. See Box 1.6 for examples.

### **BOX 1.6** NET METERING ACROSS THE WORLD

Net metering has been introduced in a number of cities across the world. In the United Arab Emirates, the Shams **Dubai** programme adopted by the Dubai Electricity and Water Authority led to an installation of 30–40 MW of solar capacity on the premises of the Dubai Ports Authority (IRENA, 2019).

In India's capital, **New Delhi**, net metering was introduced in 2014. Homeowners can either own a solar power system or lease it on a monthly basis from project developers (Times of India, 2017).

In India's state of Karnataka, **Bangalore** is struggling to meet its energy needs as demand rises while droughts diminish hydropower generation. After the city introduced its net-metering programme in 2014, deployment of rooftop solar panels by residents, business owners, schools and other public institutions expanded rapidly. Solar capacity connected to the grid of the city utility BESCOM expanded from 5.6 MW in 2016 (Martin and Ryor, 2016) to 98 MW in the fall of 2018 (New Indian Express, 2018).

Bangalore, India

## Promulgating solar thermal ordinances

Municipal ordinances may establish minimum requirements for the use of renewable energy, including solar energy, biomass, and air- or ground-sourced heat pumps. Such measures are typically required in new buildings and buildings that undergo major refurbishment. In several cases, municipal requirements are more ambitious than national ones; in this way, cities function as pioneers, helping to elevate national standards over time. Solar thermal ordinances are a key example of such measures; they are municipal regulations that stipulate that solar energy provide a specified minimum share of heating demand. Over the past decade or so, solar ordinances have become an increasingly common tool to promote the deployment of solar thermal technology across many countries worldwide (ESTIF, 2018) (see Box 1.7). Integrating solar water heaters into social housing programmes can also be an important way to ensure that low-income households can benefit from renewables as well.

### **BOX 1.7** SOLAR THERMAL ORDINANCES IN PRACTICE

China is home to about 70% of global installed solar water heating (SWH) capacity. More than 80 cities in China having adopted favourable policies for installing such systems, often including mandatory installation in new buildings. The city of **Rizhao**, in Shandong Province, has promoted SWH in residential buildings for the past 20 years through regulations, subsidies and information campaigns for residents. Today, virtually all households in the city centre use it. The Shandong provincial government helped finance solar research and development, resulting in competitive pricing of SWH systems compared to electric heaters (IRENA, 2016; REN21, ISEP and ICLEI, 2011).

In 2000, **Barcelona**, Spain, became the first European city to pass a solar thermal ordinance. It requires that 60% of running hot water needs in all new, renovated or repurposed buildings – both private and publicly owned – be covered through solar thermal energy. To ensure public awareness and acceptance, a "Solar Reflection Days" initiative showcased state-of-the-art systems. "Taula Solar" was set up to promote stakeholder discussion. More than 70 other Spanish cities have replicated Barcelona's ordinance; in 2006, a requirement to install solar thermal systems became part of Spain's national Technical Building Code (ICLEI, 2014).

In Brazil, **São Paulo's** 2007 solar ordinance mandates that solar technology cover at least 40% of the energy used for water heating in all new buildings. Public consultations were a key element in drafting the ordinance. Product certification efforts were critical to avoid the use of low-quality equipment that could have damaged public acceptance (ICLEI and IRENA, 2013b; ABRAVA, 2015). The ordinance inspired similar measures in cities across Brazil; the country is a global leader in deploying solar water heaters (Weiss and Spörk-Dür, 2018).


Barcelona, Spain

## Adopting measures to decarbonise transport

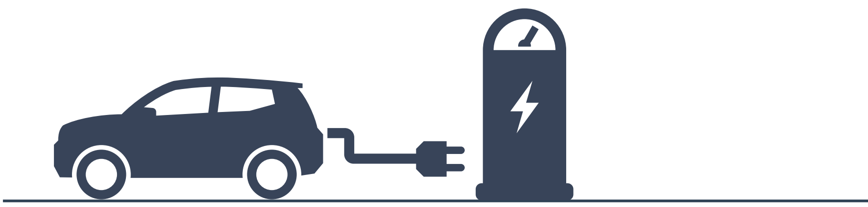
Accounting for one-third of total final energy consumption worldwide, the transport sector is one of the largest energy users in the urban environment, making it an important, yet often neglected target of renewables-focused policy. Energy demand in the transport sector is growing fast, and a significant share of urban transport energy use remains in the form of gasoline and diesel fuels, as well as power generated from coal.

Urban policy making that seeks to decarbonise the transport sector can tap into a broad array of measures aimed at supporting cleaner fuels, electrification, a better modal mix and reduced need for motorised transport. Often driven by air pollution concerns, cities around the world are increasingly trying to reduce the number of cars on urban streets, by encouraging passengers to shift to the most efficient or environmentally friendly mode(s) to improve trip efficiency. Such modes include, for example, non-motorised transport, public transport or carpools. Policies to support such shifts include the promotion of car sharing, closing certain roads entirely or for high-emission vehicles, and the creation of pedestrian walkways and bike-sharing systems (IRENA, IEA and REN21, 2018).

Although such policies do not directly concern renewable energy use, they create the context within which cleaner fuels and electricity assume growing significance. Relevant policies undertaken at the city level include congestion pricing, vehicle quotas through auctions or lottery systems, license plate restrictions, low-emission zones, parking restrictions and car-free streets (McKerracher, 2018; SLOCAT, 2018; Hidalgo, 2014; Renner, 2016; Reuters, 2015).

The use of renewable energy in transport offers numerous additional benefits, such as enhanced energy security, reduced transport-related carbon emissions and increased opportunities for sustainable economic growth and jobs (*e.g.*, there are more than 1.7 million jobs in the biofuels industry worldwide) (IRENA, 2017c). Depending on the renewable fuel, it may also improve local air quality.

A growing number of cities are pushing for reducing and eventually ending the use of vehicles with internal combustion engines in favour of electric vehicles (EVs) – an important though not exclusive avenue towards renewable energy's greater role in transport. For example, **Athens** in Greece, **Madrid** in Spain and **Mexico City** in Mexico have decided to ban petrol- and diesel powered cars by 2025, and **Paris** will do so by 2030 (UNFCC, 2016). More than 30 cities[1] around the world have signed the C40 Fossil Fuel Free Streets Declaration (see Box 1.8), which includes a commitment to transition away from vehicles running on fossil fuels (C40 Cities, n.d.). These policies create the context within which cleaner transportation energy, whether in the form of biofuels or renewable-energy-based electricity, will play an increasing role.



1 Among the signatories are a number of cities with fewer than 1 million inhabitants: Copenhagen, Cape Town, Heidelberg (Germany), Oslo, Rotterdam, Vancouver, Honolulu, Oxford, Manchester, Santa Monica and West Hollywood.

## **BOX 1.8** C40 FOSSIL FUEL–FREE STREETS DECLARATION

Participating cities pledge to procure only zero-emission buses from 2025 and to ensure that a major area of the city is a zero-emission zone by 2030. To meet this commitment, a range of measures will be taken (and progress will be reported on a bi-annual basis):

- Increasing the rates of walking, cycling and the use of public and shared transport that is accessible to all citizens.
- Reducing the number of polluting vehicles on the streets and transitioning away from vehicles powered by fossil fuels.
- Procuring zero-emission vehicles for city fleets as quickly as possible.
- Collaborating with suppliers, fleet operators and businesses to accelerate the shift to zero emission vehicles and reduce vehicle miles.

Source: C40 Cities, n.d.

## Promoting renewable-energy-based e-mobility

The electrification of transport creates opportunities for greater integration of renewable electricity for trains, light rail, trams and two-, three- and four-wheeled EVs. Urban efforts to reduce reliance on internal combustion engines are often paired with targets, mandates and incentives to support the electrification of municipal bus fleets, taxis and private vehicles. Measures including changes in subsidies, fleet procurement and conversion, and the provision of charging infrastructure are among the efforts being undertaken in a growing number of cities. The life-cycle emissions of EVs compare favourably with those of internal combustion vehicles (ICCT, 2018), even in countries like China, where power generation is still dominated by coal (Energy Foundation China, 2018).

Moscow, Russia

Policies that support the uptake of e-mobility need to be paired with renewable energy deployment to decarbonise the electricity sector. If efforts are made to raise the share of renewable energy in the electricity mix in parallel to electrification policies, the electrification of transport can become a stepping-stone to the more comprehensive use of renewable energy (as seen in the case study of Costa Rica featured in Chapter 4).

Policies in favour of passenger car electrification are being formulated at national and local levels in growing numbers of countries (IRENA, IEA and REN21, 2018). Support measures include public procurement and investment plans which help to create and stimulate an EV market. Various financial incentives to reduce EV costs include vehicle purchase subsidies, exemptions from applicable taxes and differentiated taxes that penalise polluting or inefficient vehicles and favour better-performing ones. Additionally, regulations such as fuel economy and fuel quality standards and zero emission vehicle mandates can play an important role. Creating a sufficiently dense network of charging stations is an essential part of an EV strategy. Cities can directly invest in building such infrastructure, issue deployment targets and regulations that standardise hardware and software and introduce measures to encourage privately owned charging stations through building codes and zoning regulations (IRENA, 2016). Integrated planning for e-mobility and renewable electricity production, transmission and distribution is crucial to link electrification to renewable energy deployment.

Electrification efforts also extend to municipal bus fleets, which typically run on highly polluting diesel fuel. According to ICCT (2012), the world's total bus fleet is projected to grow from 16 million vehicles in 2010 to 20 million by 2030. Among the barriers to widespread adoption of electric buses are higher upfront costs (although total life-cycle costs may be not much higher than those for diesel models); battery replacement costs (which can represent almost half the vehicle price) and the need for an adequate charging infrastructure (Lu, Xue and Zhou, 2018). Altogether, more than 300 cities worldwide now have at least some battery-powered electric or hybrid buses (SLOCAT, 2018), with China accounting for the vast majority of the global fleet (Bloomberg, 2019).

This development has been supported at the national government level by generous subsidies for vehicle purchases and charging infrastructure, in parallel with reduced subsidies for diesel fuel. Shenzhen has been a leader in switching its bus fleet to EVs (see Box 1.9).

Oslo, Norway

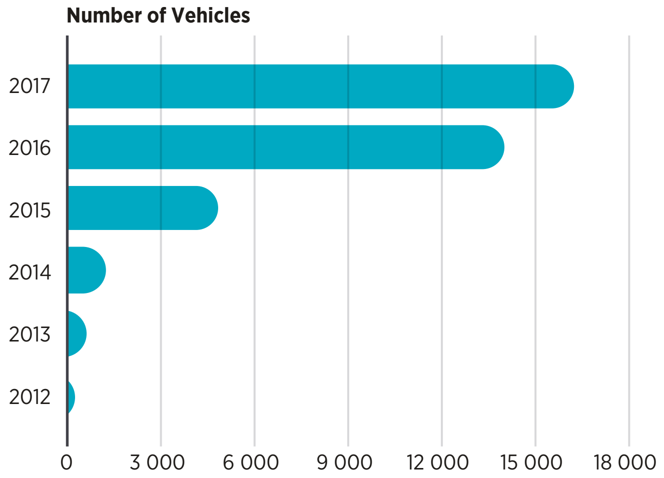
## BOX 1.9 PIONEERING ELECTRIC BUS USE IN SHENZHEN

In 2009, China launched the piloting programme for "new energy vehicles (新能源汽车), starting from 25 cities and expanded to hundreds of cities and the whole country. Chosen to be the first "new vehicle" pilot city, Shenzhen had by the end of 2017 completely switched its bus fleet to electric (see Figure 1.4). This makes Shenzhen the world's first city whose entire bus fleet is electrified. With financial support from the central government, Shenzhen has provided substantial subsidies for buses and charging facilities, totalling RMB 3.3 billion (USD 490 million) in 2017 alone (Dixon, 2017).

E-buses deployed in Shenzhen consume 73% less energy than diesel buses and emit 48% less carbon (67 kilogrammes of carbon dioxide per 100 kilometres, compared to 130 kg for diesel vehicles). During 2017, the fleet's carbon dioxide emissions were cut by 1.35 million tonnes. Pollutants such as nitrogen oxides, hydrocarbons and particulate matter are also down (ITDP, 2018). According to the Shenzhen Municipal Transportation Commission, the resulting energy savings amount to 366 000 tons of coal saved annually, substituted by 345 000 tons of alternative fuel (Dixon, 2017). As China reduces its heavy reliance on coal power plants, the advantages of e-buses will further widen.

Leasing rather than buying buses from manufacturers[2] has allowed bus operators in Shenzhen to lower upfront costs and thus the need for debt financing. Manufacturers are providing lifetime warranties for vehicles and batteries, limiting risks to operators. Because e-buses tend to have shorter driving ranges per charge,[3] more of them are needed than is the case for a diesel powered fleet, translating into greater procurement costs. Shenzhen managed to avoid most of these extra costs by co-ordinating charging and operation schedules; e-buses are charged overnight and recharged at terminals during off-peak hours (Lu, Xue and Zhou, 2018). Shenzhen has 510 bus charging stations with a total of 8 000 charging points, so that half the fleet can be charged at once (Dixon, 2017).

**Figure 1.4 Electric bus adoption in Shenzhen, China**





Source: Lu, Xue and Zhou, 2018. © OpenStreetMap contributors

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

2 Shenzhen is home to the car and bus manufacturer BYD, the world leader in e-bus production. Promoting local industry, Shenzhen has awarded nominally competitive tenders for e-buses to BYD. However, in February 2018 the central government reformed EV subsidies, prohibiting local authorities to discriminate against non-local vehicle manufacturers (OECD/IEA, 2018).

3 But performance is improving; the average daily mileage of e-buses in Shenzhen increased 41% between 2012 and 2016 (ITDP, 2018).

## Adopting biofuel blending mandates and biomethane use

Switching from internal combustion engines to electric models will take time. A number of governments around the world are pursuing renewable energy deployment policies – often through biofuel blending mandates, but also through fiscal incentives and public financing – in an effort to decrease the carbon footprint of internal combustion engines (REN21, 2018; IRENA, IEA and REN21, 2018).

National or subnational governments in at least 50 countries have enacted biofuel blending mandates, though only seven aim for shares higher than 10% (SLOCAT, 2018). In most cases, biofuel blending mandates are adopted at the national level, though some cities have their own initiatives. For example, **Curitiba** in Brazil is implementing a 100% biodiesel mandate for its municipal bus fleet, as part of its Biocidade programme (IRENA, 2015). **Vancouver**, British Columbia (Canada), hopes by the end of 2030 to convert its fleet of 577 diesel powered vehicles (buses, fire engines, garbage trucks, etc.) to biodiesel made from organic wastes like fats and used vegetable oils, and to cut emissions in half compared with 2007 (Danigelis, 2018).

## THE ROLE OF CITIES IN TARGET SETTING, ENGAGEMENT AND CAPACITY BUILDING

Cities can drive local renewable energy deployment by championing it through municipal policy and awareness-raising programmes (as outlined in several case studies in Chapters 2 to 4). Progress will likely be greatest if local citizens play an active role in formulating and implementing municipal policies, and if policy makers ensure that all urban residents benefit from the move to renewable energy. The social equity dimension is thus crucial.

Around the world, community energy approaches are an increasingly popular solution to local energy supply challenges. Amongst other, community energy can be defined as a combination of at least two of the following elements (IRENA Coalition for Action, 2018):

- Local stakeholders own the majority or all of a renewable energy project.
- Voting control rests with a community-based organisation.
- The majority of social and economic benefits are distributed locally.

Such projects may be initiated and directed by municipalities, even as co-operative structures allow urban residents to participate in decision-making processes directly and actively. Citizens must thus acquire the knowledge and capacity needed to act as informed participants in energy decision making (Roberts, Bodman and Rybski, 2014). National and local governments can also contribute to the development of alternative business models to encourage financial institutions to dispense loans (IRENA Coalition for Action, 2018). One recent example of community energy is in **Athens, Ohio** (United States) (see Box 1.10).

## **BOX 1.10** COMMUNITY CHOICE IN ATHENS, OHIO (UNITED STATES)

Residents of Athens, Ohio, have access to a community choice programme, the Southeast Ohio Public Energy Council (SOPEC). The city's 2017 Sustainability Action Plan includes a goal of reducing municipal energy use by 20% by 2020. UpGrade Ohio (which used to be a part of SOPEC) launched the Solar ACCESS programme to help bring solar electricity to low- and moderate-income households. The programme was entered into the US Department of Energy's "Solar in Your Community Challenge".

Further, in May 2018, Athens residents approved a ballot initiative in favour of a small carbon fee per kilowatt-hour (kWh). The fee will be routed through the community choice programme (and translate into a USD 1.60 to USD 1.80 monthly cost per household, though residents are allowed to opt out). The revenues will be used to purchase solar panels for public buildings in the city. Community choice aggregation is seen in Athens as a way to help local utility dollars stay local (Farrell, 2018).

In 2019, close to 2 000 solar panels were installed at a nearby middle school, supplying 70% of its power needs and lowering its power costs (Beard, 2019).

Many bottom-up grassroots efforts feature the active involvement of local residents and community groups, including co-operatives, non-profit associations, community trusts and others that support renewable deployment in urban spaces. For instance, in the favela of Morro de Santa Marta, **Rio de Janeiro**, Brazil, solar panels were installed at day-care centres, schools and along alleys and courtyards by Insolar, a local social enterprise. The panels reduce energy costs of the 4 000 residents and provide relief from frequent power outages.

Santa Marta, Rio de Janeiro, Brazil

## MOVING FORWARD

This lead chapter has laid out the key circumstances, drivers and motivations that shape the ways cities can act to promote the use of renewable energy in areas under their jurisdiction. It has also offered a brief overview of some of the initiatives and measures taken in pursuit of energy transition objectives, drawing on examples of cities small and large around the world.

However, to understand both the possibilities and the constraints (and the real-world ability to scale up efforts and replicate them elsewhere), it is important to examine specific circumstances. The bulk of this report is focused on city case studies in three diverse countries, China, Uganda, and Costa Rica. The cities chosen for the case studies vary somewhat in size. But they are all medium-sized cities, defined as ranging in population from 30 000 to 1 million inhabitants. As such, the focus of this report varies from that of other assessments, which often concentrate on large and internationally known cities.

Geographically and culturally diverse, China (Asia), Uganda (Africa), and Costa Rica (Latin America) are divergent not only in their territorial expanse and population size, but also in their economies and governance systems. The point of this report is not to find commonalities amid such diversity, but to discern the manifold real-world contexts that influence challenges that divergent cities face and to examine what they can (or cannot) do about them.

Chinese cities can increase their reliance on renewables in order to address pervasive air pollution caused by the country's heavy use of coal. By way of contrast, cities in Uganda are mainly concerned with deploying renewables to improve energy access. Because Costa Rica's power sector is already largely based on renewables (hydropower), the policy discourse there has identified the electrification of the transport sector as the area with the highest potential, nationally and locally, to reduce the use of fossil fuels and associated GHG emissions.

With a population of 1.4 billion, China's size is such that many of its more than 600 prefecture- and county-level cities each have a million residents or more. To remain within the range of population size chosen for this report, the case studies focus on specific districts within larger cities: Chongli District of Zhangjiakou and Tongli Town of Suzhou (see Chapter 2).

With a rapidly growing population of about 46 million and a territory of roughly 241 000 square kilometres ($km^2$), demographically and spatially Uganda sits between Costa Rica and China. Despite an ongoing national political dialogue on decentralising and devolving government authority in certain policy areas, local capacities and competencies in energy matters are still limited. They depend on the relevance of a given region to the national energy supply, *e.g.*, regions with large power plants have slightly more authority and influence in national energy politics. The Uganda case studies focus on the cities of Kasese and Lugazi (see Chapter 3).

With a population of just 5 million and territory of about 51 000 $km^2$, Costa Rica is the smallest of the three countries covered in this report. Highly urbanised, Costa Rica has some 77% of its population living in cities. Its small size allows it to have a surprisingly high degree of centralisation in political decision-making structures. At the same time, administrative units at the city level are deeply fragmented, circumstances that severely restrict the ability of cities to make autonomous decisions and limit the incentive local policy makers have to take independent action to promote renewable energy projects. Reflecting these circumstances, the Costa Rica case study discusses municipal engagement in carbon-neutrality efforts in the context of the ambitious national decarbonisation plan, with initiatives taken by Cartago, Grecia or Guanacaste as examples (see Chapter 4).

Each of the chapters presenting the country case studies begins with a sketch of the national context and is followed by a discussion of the initiatives and experiences of select cities. They each conclude with a set of lessons learnt. The report wraps up with some broader conclusions.

### Country Case

- National Context
- Initiatives and Experiences
- Lessons learnt

# 2. CHINESE CITIES: CHONGLI DISTRICT AND TONGLI TOWN

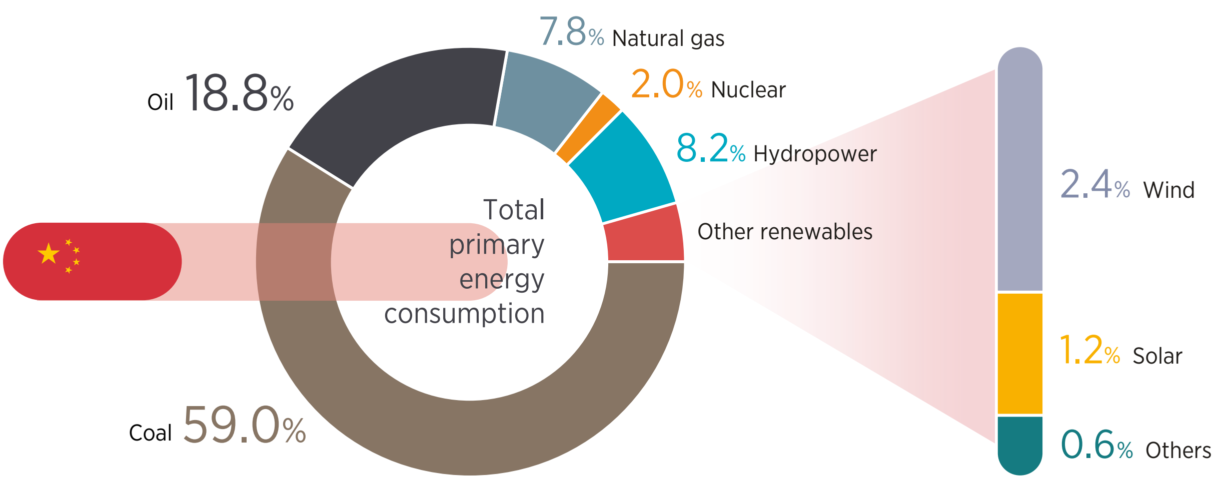
# NATIONAL CONTEXT

## BACKGROUND

China is the world's most populous country, with about 1.4 billion people. Rapid economic growth and large-scale industrialisation has made China the world's largest energy consumer, accounting for around one-quarter of global primary energy demand in 2018. China is the largest producer and consumer of coal and the largest emitter of carbon dioxide (IEA, 2019e).

Although the share of renewable energy in the primary energy mix is still at around 12% (Figure 2.1), China is a major market for and producer of renewable energy technologies (RETs). In the power sector, clean energy has been accorded priority in an effort to reduce heavy reliance on coal and other fossil fuels.

**Figure 2.1 Share of total primary energy consumption in China, by fuel, 2018**




Source: CEPPEI, 2019.

China relies heavily on energy imports, which accounted for more than 70% of oil use and 43% of natural gas in 2018 (CREEI, 2019). Natural gas consumption rose 34% over just two years, from 2016 to 2018 (IEA, 2019a; NDRC, 2019, 2017).

While industries account for more than half of China's final energy use, their share fell by 10% between 2010 and 2017, whereas demand in the building (22%) and transport (17%) sectors has risen rapidly (Wang Qingyi, 2019) (see Figure 2.2). Increasing urbanisation along with higher living standards and the growth of megacities translate into ever-increasing urban energy demand.

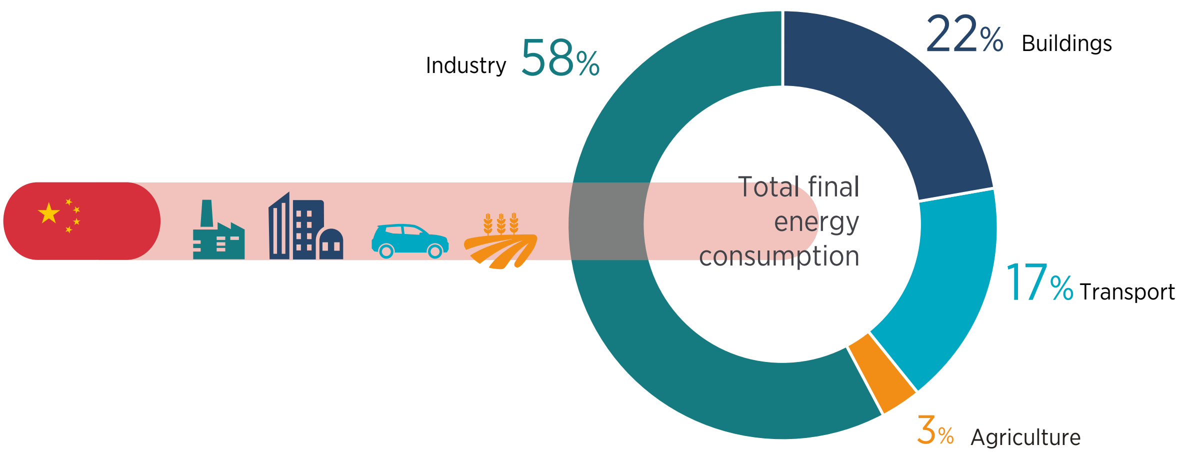
Including urban-based industries, cities are estimated to account for more than 60% of China's total energy consumption and this share is expected to rise further (SGCERI, 2018). In 2018 alone, urban growth added more than 17 million new urban residents, around 2 billion square metres ($m^2$) of building space and more than 22 million vehicles (National Bureau of Statistics, 2020; Jiang *et al.*, 2018).

Urban residents also bear much of the ill effects of high levels of air pollution. Nearly half of the locations in the WHO's list of the 100 most polluted cities (measuring particulate matter pollution) in 2019 were in China (IQ Air, 2020). Coal burning used to be a major source of China's air pollution, but its contribution has receded since 2012. The share of vehicle emissions ranges from as low as 10% in smaller urban areas to much greater shares in some large Chinese cities like Shenzhen (52%), Beijing (45%) and Shanghai (29%) (MEE, 2018). Ongoing efforts to replace coal fired heating in northern China have lowered the nation's average pollution levels, and Beijing's annual PM2.5[1], over the past several years. But 98% of Chinese cities still exceeded WHO's PM2.5 target (IQAir, 2020).

Given China's massive population, many of its cities are gigantic by global comparison. This report focuses on replicable, scalable experiences at smaller urban scales, exploring the cases of Chongli District (which is part of Zhangjiakou City in Hebei Province) and Tongli Town (part of Suzhou City in Jiangsu Province). Box 2.1 explains China's city level designations and governance structures as background to the analysis that follows.

1 Particulate matter.

**Figure 2.2 Share of total final energy consumption in China, by sector, 2017**




Source: Wang Qingyi, 2019

## BOX 2.1 ADMINISTRATIVE UNITS IN CHINA: PROVINCE, CITY, DISTRICT AND COUNTY

Subnational jurisdictions in China differ from typical structures in other parts of the world; a city or district, for instance, may include both urban and rural areas, including villages, that are administratively part of a city and fall under municipal governance. Clearly classifying medium-sized cities based on only the size of their urban population is thus intrinsically difficult.

The population of a Chinese city can range from several thousand to more than 30 million. More than 91 cities have urban populations of more than 1 million, and 15 are home to more than 5 million. A medium-sized city in China would normally have between 500 000 and 1 million urban inhabitants (State Council, 2014). The administrative level most comparable with a medium-sized European city is in many cases a town or district of a prefecture city (Li Tie, 2019).

China divides subnational governance into four levels of administration: provincial, prefectural, county and township. As Figure 2.3 indicates, there are 34 provincial level administrations. These include provinces, autonomous regions, directly administered municipalities and special administrative regions. Many of them are subdivided. Prefectural level cities are in turn divided into districts, county-level cities or counties. Most cities are either prefecture level or county level. A large share of county-level cities' GDP comes from secondary and tertiary sectors and urban residents, while counties focus more on rural development and agriculture.

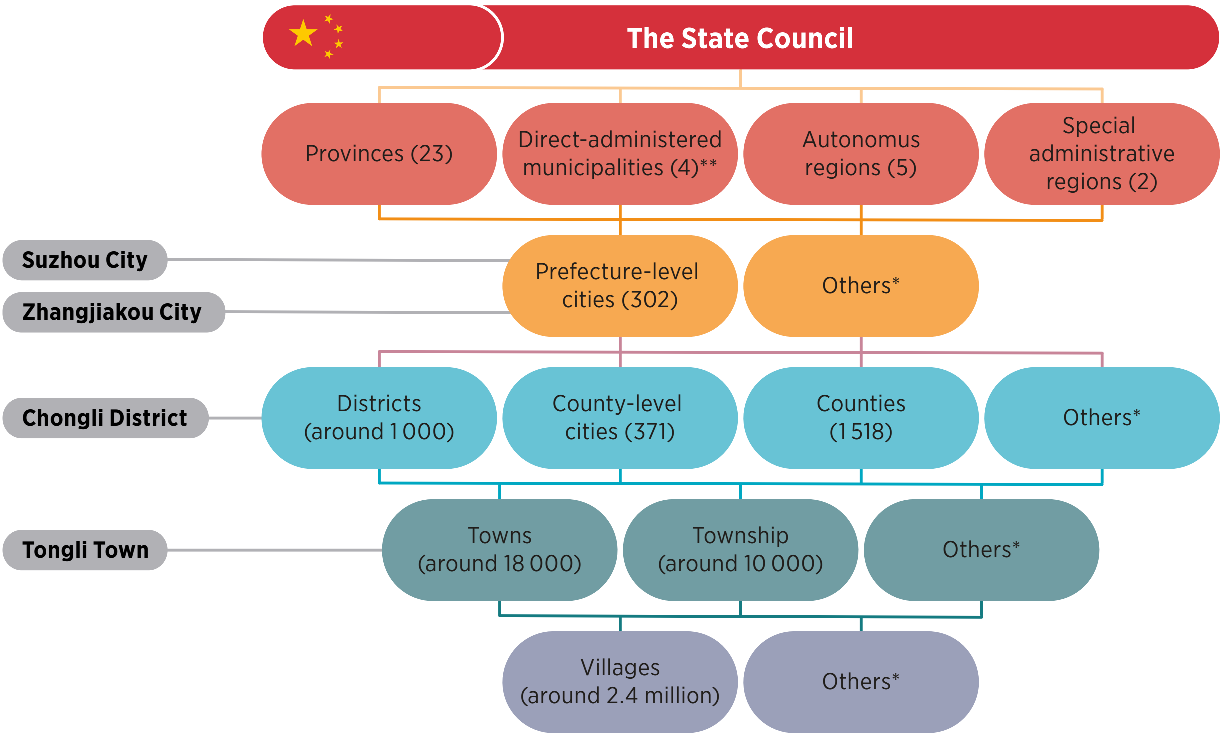
The various levels of administration are not necessarily hierarchical in terms of their decision making power.

Currently, China has 673 cities, excluding four provincial-level municipalities under the direct administration of the central government – namely Beijing, Shanghai, Tianjin and Chongqing City – 302 prefecture-level cities and 371 county-level cities (see Figure 2.3) (MoHURD, 2020). Provinces are usually the administrative layer above municipalities.

For instance, Suzhou City is a prefecture-level city under the administration of Jiangsu Province and is divided into six districts, the administrative level under prefecture-level cities, and four county-level cities. Tongli Town is in one of Suzhou's districts.

Suzhou City, Industrial Park

**Figure 2.3 Administrative layers of the Chinese government**




Source: MoHURD, 2018, 2020; National Bureau of Statistics, 2020.

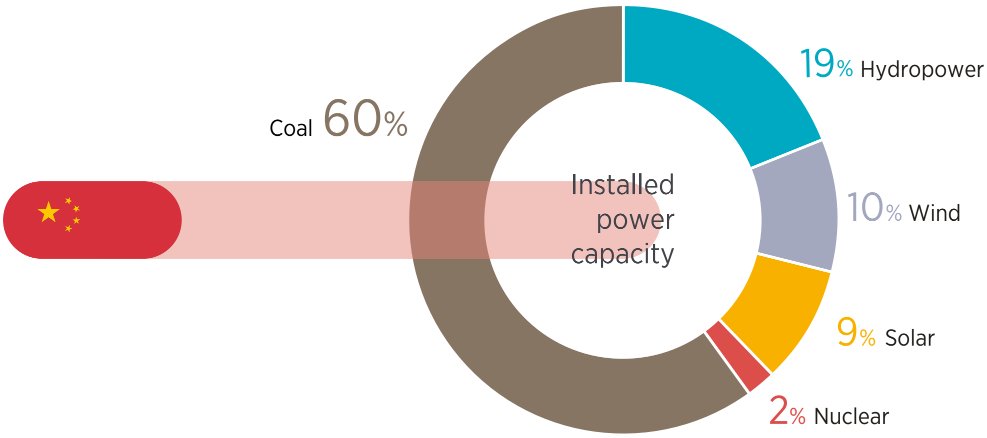
Notes: *Including some administrations at the same level.
** The four cities directly under the central government are Beijing, Shanghai, Tianjin and Chongqing.
Figures on prefecture-level cities, county-level cities, counties and districts are as of 2018. Other figures are as of 2016.

## RENEWABLE ENERGY DEVELOPMENT IN CHINA

Rising dependence on fossil fuel imports and growing concerns about carbon emissions and heavy air pollution are driving the government to adopt more ambitious renewable energy targets. Renewable energy represented 40% of China's installed power generation capacity in 2019 and 28% of its power generation (NEA, 2020). Figure 2.4 shows power capacity from different energy sources in 2018. China now has 29% of the world's installed renewable energy capacity, leading in hydropower, wind and solar PV, as well as the second-largest bioenergy capacity worldwide (IRENA, 2020b). China also accounts for 70% of the world's deployment of solar water heaters, 99% of electric buses and 45% of all EV stock (IEA, 2019c, 2019d; BNEF, 2018).

Hydropower continues to account for the largest share of all renewables in power generation capacity (46%), followed by onshore wind (26%) and solar PV (25%) (CEPPEI, 2019). Mounting environmental concerns regarding China's large-scale

**Figure 2.4 Installed power capacity in China, by source, 2018**

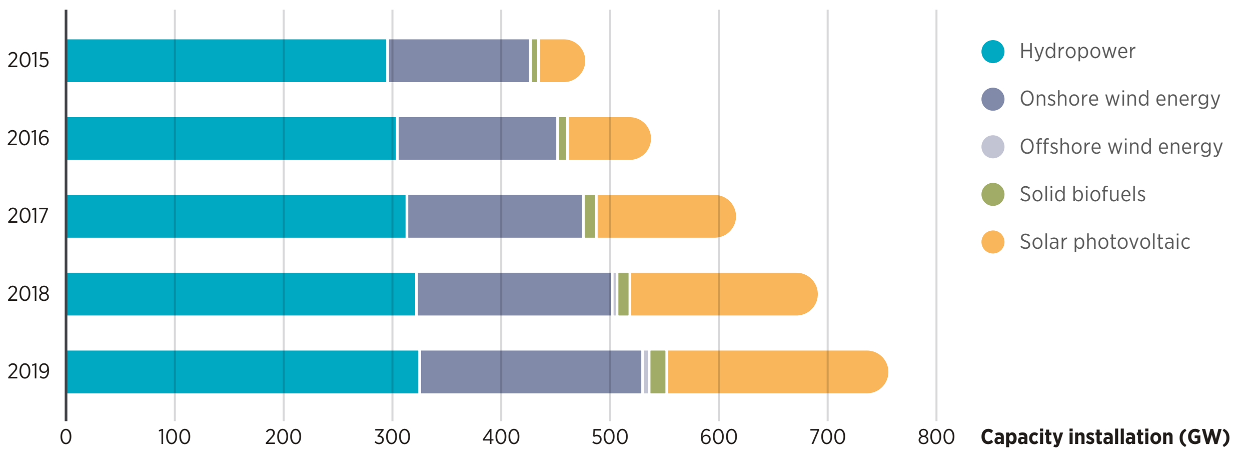



Source: CEPPEI, 2019.

hydropower have further boosted other RETs such as solar, wind and bioenergy as technologies of choice for new renewable energy projects (see Figure 2.5).

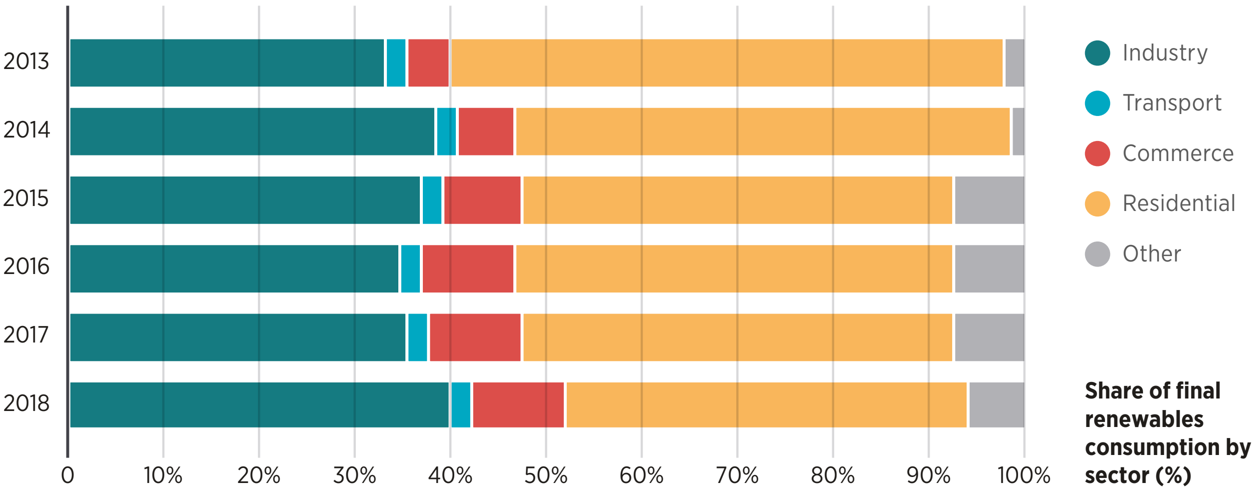
As for the consumption of renewables by sectors, China's residential and commercial buildings and industries consumed 91% of renewables in 2018 (including for power and for heating), while transport consumed only 2% of total renewables. The residential sector has taken on a bigger role due to the higher share of renewable energy used in electricity and in solar water heaters (see Figure 2.6).

**Figure 2.5 Cumulative renewable energy installations in China, 2015–2019**




Source: IRENA, 2020b.

**Figure 2.6 Share of renewable energy consumption in China, by sector, 2013–2018**




Source: IRENA, 2020c.

---

The expansion of renewable energy in China has been driven by strategic planning and various supportive policies, some of which are summarised below.

## China's Five-Year Plans

China's five-year plans (FYPs) constitute the government's fundamental policy instrument for target setting and strategy development and implementation. The FYPs set national targets for all renewable technologies as well as influence investment and research and development (R&D). The most recent 13th FYP for 2016–2020 entails a target of 27% renewable energy in total electricity generation by 2020 and aims for 675 GW cumulative renewable electricity generation capacity by 2020, of which 50% is hydropower (excluding pumped storage), 31% wind power, 16% solar PV, 0.7% CSP and 2% from bioenergy (NDRC, 2016).

## Renewable Energy Development Fund

The Renewable Energy Development Fund plays a hefty role in renewables' development. The 2006 Renewable Energy Law set a fixed rate of CNY 0.001 (USD 0.00015) and gradually doubled it to CNY 0.019 (USD 0.0029) per kWh of electricity to finance the Renewable Energy Development Fund, which is the financial source of feed-in tariffs (FiTs), feed-in premiums (FiPs) and various subsidies to renewables (NPC, 2006). In 2018, close to half, or 44%, of funds went to wind projects, 37% to solar and 20% to bioenergy. Those are made available for R&D, industrial development, construction of renewable power plants, procurement and operation of renewable heating equipment and appliances.

But China's Renewable Energy Development Fund faced a cumulative shortfall of USD 32 billion (around CNY 230 billion) as of 2018 (Yuan Si, 2019). The finalisation of a renewable energy portfolio standard and green certificate policies announced by the National Energy Administration (NEA) are expected to mobilise alternative financial resources for renewables and prioritise auctions for onshore wind projects after 2020 (Hove and Watzel, 2018; NEA, 2019b). To support this change, more progress is needed in integrating policies and the power market.

## Feed-in tariffs (FiTs)

Since 2006, the National Energy Administration (NEA) has promulgated FiT policies applicable to onshore and offshore wind, solar PV, concentrating solar power (CSP) as well as biomass for electricity generation. As shown in Table 2.1, FiTs for onshore wind are determined according to natural resource classification standards that classify all regions in China into four types (Types 1 through 4), based on their renewable energy potential combined with the comparative plant construction costs. Type 1 has the greatest potential and lowest costs. Regions with greater renewable potential (and thus presumed lower cost) receive lower tariffs than regions with less potential. A similar classification applies to solar PV, which has three types of regions. Within this context, local governments are responsible for approving renewable generation. Over time, FiT rates have declined, in recognition of lower costs (NEA, 2019b).

## Feed-in premiums (FiPs)

FiPs are available for distributed solar PV renewable generation, including household-scale solar rooftop and self-consumed industrial and commercial projects. A number of cities with higher ambitions for renewables deployment as well as sufficient local financial capacity offer their own local FiPs for distributed solar PV generations. For instance, in 2015, Beijing Municipality announced an extra premium of CNY 0.3/kWh (USD 0.043/kWh) to distributed solar PV projects for a five-year period from 2015 to 2019. A few cities in the Yangtze Delta region released similar local FiP policies, which played an important role in making this the region with the most installations of distributed solar PV projects in China (WRI, 2018).

**Table 2.1 Feed-in tariffs and feed-in premiums, by type, 2020**

| Policies | Renewable energy technologies | Rates, in CNY | | | |
|---|---|---|---|---|---|
| | | Type 1 | Type 2 | Type 3 | Type 4 |
| *FiTs* | Onshore wind[2] | 0.29 | 0.34 | 0.38 | 0.47 |
| | Offshore wind (coastal) | n/a | n/a | n/a | 0.75[3] |
| | Offshore wind (intertidal) | n/a | n/a | n/a | 0.47 |
| | Solar photovoltaic (PV) (utility scale, commercial and industrial projects that 100% feed-in grid) | 0.4 | 0.45 | 0.55 | n/a |
| | Solar PV (poverty alleviation purpose) | 0.65 | 0.75 | 0.85 | n/a |
| | Concentrated solar power | 1.15 | | | |
| | Biomass (agro-forestry) | 0.75 | | | |
| | Municipal solid waste (waste incineration) | 0.65 | | | |
| *FiPs* | Distributed solar PV (self-consumption by industrial and commercial projects) | 0.1 | | | |
| | Distributed solar PV (residential) | 0.18 | | | |

Source: CNREC, 2019; NDRC, MoF and NEA, 2018.

Note: Rates highlighted in green are applicable to Chongli District. All rates are for the projects approved in 2020 according to the related policies released in 2019. The exchange rate is USD 1 = CNY 6.910, according to the yearly average rate in 2019.

2 The rate for distributed onshore wind to participate in market trading pilots is based on negotiation between sellers and consumers. FiTs are not applicable.

3 All offshore wind generation is in Type 4 areas.

## Subsidies to electric vehicles

Chinese national and local governments also provide subsidies for the procurement of EVs and related charging infrastructures. Different from the FiTs and FiPs, these subsidies draw not from the Renewable Energy Development Fund but from other, dedicated government budgets. A newly adjusted policy on subsidies for new energy vehicles was released by the Ministry of Finance, Ministry of Industry and Information Technology (MIIT), Ministry of Science and Technology and National Development and Reform Commission (NDRC). MIIT has a more proactive role to play in EV related policies, due to its relevance in cultivating the manufacturing industry.

During the 13th FYP from 2016 to 2020, some USD 62 billion was planned to be allocated for the procurement of new energy vehicles, including plug-in hybrid and EVs (MEE, 2018). Subsidies from national and subnational governments have also been used for infrastructure development related to EVs.

## Other policies

Given the curtailment of renewables, enabling and integrating policies were introduced to help build a smart grid system and begin a restructuring of the power market. In 2017, the curtailed renewable energy generation (100 TWh) was nearly equal to the total residential electricity consumption of the United Kingdom (NEA, 2018a, 2018b). In 2018, NDRC released a national action plan for accommodating clean energy and resolving the curtailment problem (NDRC, 2018). The main policy instruments focus not only on the targets and flexible operation of power plants but also encourage the deployment of electric heating technologies using renewable electricity to replace coal-fired heating in northern China (see Chongli case).

The implementation of these national and subnational policies leaves considerable space for local actions and complementing policies. Cities can and need to be more ambitious than national targets in their mandate to foster sustainable urban growth and address local environmental and social challenges, including air pollution and poverty, as well as reap benefits such as local employment generation and economic income. The Chongli District of Zhangjiakou City and Tongli Town of Suzhou City are among these pioneers.

Shenzhen, Electric Taxi

## CHINA'S ENERGY SECTORAL ORGANISATION AND THE ROLE OF CITIES

The governance of China's energy sector remains relatively state-centric, though oversees and co-ordinates energy sector and related industrial planning, including target setting (through its five-year plans), industrial strategy, standards, regulation and project approval. The NEA allocates targets to all provincial administrative divisions for the approval of utility-scale (*i.e.*, 6 MW and above) wind and solar installations, while distributed generation and household solar rooftops are managed by municipal governments. Beginning in 2015, provincial energy administrative departments were authorised to approve utility-scale projects. Distributed solar PV generation (up to 6 MW) for industrial and commercial self-consumption requires registration with the local government. Residential rooftop projects are easier to connect to the grid.

The NEA is also responsible for co-ordinating and managing the roles of various ministries in support of deploying renewables in power generation, heating and other end-use sectors. The relevant ministries are responsible for different technologies and strategic and cross-cutting issues, such as setting targets and regulating the respective market. For example, the NDRC, the NEA and the Ministry of Finance usually have a greater role in renewables planning and policies, while the project permitting for new capacity installation involves many other ministries, including the Ministry of Natural Resources and Ministry of Ecology and Environment (MEE), among others. The national 2017–2021 winter clean-heating plan in China was released by the NDRC, the NEA, MEE and the Ministry of Housing and Urban-Rural Development (MoHURD). MEE also has primary responsibility for climate change, which is related to renewables to some extent.

The NEA has been providing guidance to the renewable energy piloting projects and cities, including Zhangjiakou City. Further, in the context of the National Clean Heating Demonstration Cities, the NEA, in collaboration with the Ministry of Finance, MoHURD and MEE, facilitates CNY 500 million (USD 71 million) annually over a three year period to support the deployment of clean heating solutions and related infrastructure.

### Sectoral organisation in the electricity sector

Two publicly owned companies operate China's six regional electricity grids. They have important roles for renewables in terms of grid connection, smart grid and power market reform (NPC, 2006). NEA regulations require that transmission and connection lines for all new plants are approved by provincial (6 MW and above) or lower level municipal or county level authorities (less than 6 MW), with involvement from the two state grid giants (NEA, 2013). The branch grid companies in cities are also responsible for building all the infrastructure needed to enable plants' connections. Wind plants follow a similar procedure.

The State Grid Corporation of China (SGCC) is the only grid company for 26 out of the 34 provincial-level administrative divisions. The sub-branch company of SGCC in cities is the main stakeholder to provide grid connections for all utility-scale and distributed solar and wind power plants in both Chongli District and Tongli Town. It owns and operates the grid networks for both transmission and distribution of electricity to all consumers. In Chongli District, the SGCC branch company is indispensable for meeting the expected six-fold increase in local electricity consumption and for the transactions at the four-party co-ordination platform (see case study 1: Chongli District). It has been in the process of improving the grid and distribution networks in urban Chongli for the electrification of space heating (which would substitute coal burning) and also building more grid infrastructure in Chongli District, especially for the Winter Olympics sports venues. For Tongli Town, the SGCC, including the sub-branch company in Suzhou, has been actively engaged in promoting renewable energy, not only by making adjustments to grids to allow for more variable electricity to be fed into them, but also by using their own buildings in Tongli to exhibit innovative renewables technologies as well as raise to local residents' awareness of the potential of renewables (see Box 2.6 in one of the following subsections).

## Roles of different layers of government and non-governmental institutions

China's regulatory authority related to renewable energy spreads across different layers of the administrative system. The roles of provinces, cities and other actors such as research institutes and industry associations are briefly discussed below.

**Provinces.** The five-year plans and sectoral plans released by provincial governments include targets and plans in cities. The provincial governments follow the maximum yearly new capacity installation of both utility- and distributed-scale projects that are allocated by the NEA and eligible to receive FiT and premiums. Under the allocation, provincial governments decide the list of projects that can move forward. Meanwhile, the provincial governments decide the electricity tariffs, including the peak-valley tariffs which play a significant role in the electrification of heating activities. Provincial-level policies and development directives provide the framework for cities' work on renewables deployment.

**Cities.** National ministries and provinces have more roles in setting policy and mobilising fiscal revenues than cities, which usually follow upper-level authorities. But cities can be more ambitious and proactive when it comes to local target setting and policy making, providing additional subsidies and other financial support and adopting renewables-friendly land-use and zoning policies. Such measures, however, depend on local development strategies, renewables resources, financial revenues as well as support from national or provincial governments. For instance, Zhangjiakou City, with support from national governments and abundant wind capacity installation, announced China's first 100% renewable energy city target. Job creation and the cultivation of the renewables industry have been the incentives for local governments, who could benefit from GDP growth in the long term and tax revenues in the near term.

While the NEA regulates feed-in tariff (FiT) and fiscal policies, cities can offer extra financial support for innovative renewable projects covering not only power generation but also clean heating and EVs. In the past, this has resulted in many pioneering local policies including reductions or exemptions to land-use or property-related taxes for a specific period for solar PV producers, clean heating operators or EV manufacturers. Land-use policy is an important tool for local governments and could influence the cost of renewables generation.

**Research institutes and industrial associations.** These are widely involved in cities' actions for renewable energy, providing expertise and knowledge support. The Energy Research Institute (ERI) and the China National Renewable Energy Centre (CNREC) are the leading national energy research institutes under NDRC, conducting research and providing policy recommendations to ministries, provincial governments and cities on energy-related matters. Renewable energy industrial associations also fulfil a number of roles, including facilitating companies' engagement in renewables-related policy consultation, supporting local renewables demonstration projects as well as providing capacity building and information sharing for industrial development. For instance, the Chinese Renewable Energy Industries Association (CREIA) has been providing consultation work and reporting of policy development for China's renewable energy industry.

# CASE STUDY 1: CHONGLI DISTRICT

## BACKGROUND

Chongli District is one of the six districts of Zhangjiakou City in Hebei Province (see Figure 2.7). This district is 50 km from downtown Zhangjiakou and has a population of 105 000 (2016 data) (Zhangjiakou Municipality, 2017b). Reflecting the reduced role of agriculture (typical for designation as a county in China; see Box 2.1 for an explanation of administrative units and hierarchies) and the rising importance of industries and the tertiary sector (typical markers for a district), Chongli's status was changed to a district in 2016 but still directly reports to the Zhangjiakou Municipality. Owing to its geographic location in mountainous territory, Chongli has a cold climate, with average temperatures of –12°C and five months of snow cover during the year (Qingzhe *et al.*, 2017). This makes space heating an important component of the district's energy demand.

With a per capita GDP of around USD 4 500 in 2018, Chongli is less affluent than Zhangjiakou City on average (around USD 5 200) or China as a whole (around USD 9 700) (Zhangjiakou Municipality, 2019a, 2018). The main reason is that Zhangjiakou City was defined as an ecological conservation area and therefore restricted from hosting heavily polluting industries. At the same time, Chongli has been transitioning from primary and secondary industries to services, mainly tourism. Some iron and gold mining companies have been shut down, and between 2014 and 2017 their output reduced by more than half, with local GDP dropping (Zhangjiakou Municipality, 2017a).

There are two drivers of the renewable energy strategy in the Zhangjiakou and Chongli districts. One is the decision to have Zhangjiakou co-host (with Beijing) the 2022 Winter Olympics (see Box 2.2). The other is the designation in 2015 of Zhangjiakou as a National Renewable Energy Pilot City. Zhangjiakou City aimed to deploy 20 GW of renewable capacity and generate 40 TWh electricity by 2020.It had achieved a total 15 GW of cumulative installed capacity as of December 2019 (Zhangjiakou Municipality, 2020). The Winter Olympics and the National Pilot City status bring new economic opportunities to the district, among which tourism (skiing and related activities) feature prominently (Chongli District Government, 2018). The local GDP has risen since 2017, and the improvement of the local economy allowed Chongli District to be removed from the National Poverty Counties list in May 2019 (Hebei Provincial Government, 2019b).

**Figure 2.7 Chongli District in China**


Source: © OpenStreetMap contributors | For visual purposes, maps are on different scales.

Disclaimer: Boundaries and names shown on this map do not imply any formal endorsement or acceptance by IRENA.

### BOX 2.2 CHONGLI DISTRICT AND THE 2022 WINTER OLYMPICS

By co-hosting the XXIV Winter Olympics in 2022, Zhangjiakou aims to achieve a low-carbon Olympic Games tied to the upscaling of renewable energy sources.

This objective offers Chongli District, which will host most of the Olympic skiing events, the opportunity to accelerate renewables in its own right. Plans are to use low-carbon energy sources to supply electricity to all the venues, residential buildings and transport systems in a special, 21.9 hectare zone (the Tai-zi-cheng village), to an Olympic square (1.2 hectares) as well as to local neighbourhoods (13.6 hectares), and to an area set aside for offices and operational facilities (7.1 hectares) (NDRC and NEA, 2015).

Chongli District also plans to expand this model to the entire district, in order to achieve 100% renewably generated electricity supply by 2022. All these targets and commitments were presented in Zhangjiakou City's National Renewable Energy Pilot City Programme, released in 2015.

Integrating renewables into development plans in preparation for the 2022 Winter Olympics is in process. Zhangjiakou Municipality and the Chongli District government have been collaborating with the special office for Winter Olympic preparation and co-ordination, with the aim of renewable energy providing 100% of the electricity and heating needed for the Winter Olympic venues and buildings.


## Energy supply and consumption

As is true throughout China, coal remains the dominant energy source. The total final energy consumption of Chongli was 163 195 tonnes of oil equivalent in 2016.[4] Primarily used for district heating and residential heating systems but also for industrial processes in the mining sector, coal burning accounted for 80% of total final energy consumption. Chongli's electricity mix (which accounts for about 19% of total energy demand), on the other hand, is already largely renewable energy based. The 1.1 GW of installed renewable capacity consists mainly of wind power with a small solar PV share. Chongli generates more electricity than it consumes itself and supplies other parts of Zhangjiakou City. Petroleum and diesel are mainly consumed by the transport sector, and at a much smaller scale than coal and electricity use. As of 2016, most vehicles on the roads had internal combustion engines; the number of electric buses remains small.

Installed renewable power capacity in Chongli District has reached 1.1 GW, including 1 116.75 MW wind power and 4.5 MW solar PV. Some more capacity for hydrogen production is to be built by 2020 (see Table 2.2). The 2020 targets foresee more than a doubling of capacity to 2.39 GW (including 1 GW wind and 1.39 GW solar). It is expected that electricity production by 2022 will reach 2.13 TWh, based on 2 300 hours of annual grid-connection hours for wind power and 1 500 hours for solar PV, which is much higher than Chongli's estimated total electricity consumption (IRENA, 2018a). It should be noted that the district, like the surrounding areas, taps into a regional grid that is fed by a mix of sources. Renewable capacity accounted for 60% of the regional grid as of 2019, the highest share of all of China's regional grids and more than the national average of 40% (NEA, 2020; SGCC, 2019).

Chongli District plans for a substantial increase in the share of renewable energy as part of its electricity mix. If it reaches planned renewable capacity additions in 2022 fossil fuel use could be reduced by 770 000 tonnes of coal equivalent per year, thus avoiding 2 million tonnes of $CO_2$ emissions, 20 000 tonnes of sulphur dioxide emissions and 3 300 tonnes of nitrogen oxide emissions (IRENA, 2018a). Without doubt, this would contribute significantly to the improvement of the region's air quality.

4 Given limitations on available data from the national government, some data on energy demand in Chongli District are derived from local government reporting as well as estimates made for this case study.

**Table 2.2 Installed and planned solar and onshore wind power generation in Chongli District, 2018**

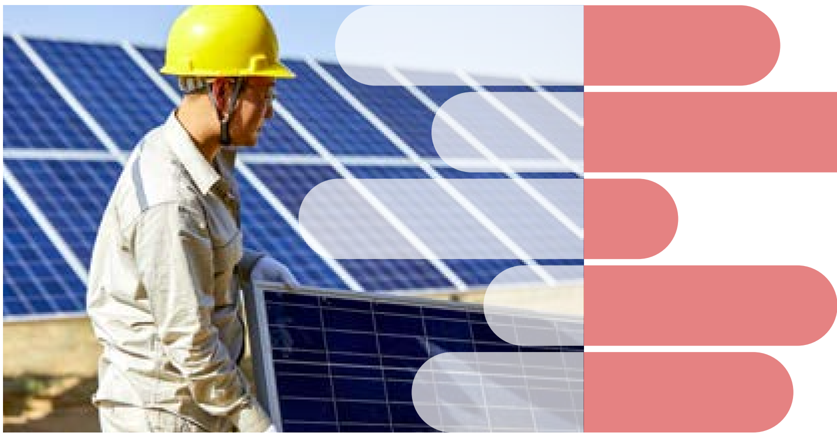
| | Projects | Capacity (MW) | |
|---|---|---|---|
| **On-grid plants** | Qing-San-Ying wind power plant | 949.4 | Wind 1 116.8 |
| | Xi-Qiao-Liang wind power plant | 147.9 | |
| | Hong-Hua-Liang wind power plant | 9.8 | Solar 4.5 |
| | Wang-Shan-Ba wind power plant | 9.7 | |
| | Village-scale poverty alleviation solar power plants (15 * 300 kW) | 4.5 | |
| **Planned capacity** | Solar rooftop in Olympic special zone | 4.3 | Wind 149.5 |
| | Ma-Ni-Ba wind power plant | 49.5 | |
| | Wind power plants for hydrogen | 100 | Solar 504.3 |
| | Olympic corridor solar power plant | 500 | |

Source: Zhangjiakou Municipality, 2019b.

## Renewable energy potential in Chongli

Chongli has good solar PV and wind power potential. Chongli District is classified as a Type 2 Solar Resource Area as per national classification (see Table 2.3 further above), with average solar radiation hours of around 2 756 to 3 062 hours every year in Zhangjiakou. Solar radiation is around 1 500–1 700 kilowatt hours per square metre (kWh/m²) per year, which is above China's average level (1 486.5 kWh/m² in 2018). Chongli also classifies as a Type 2 Wind Resource Area, with wind resources of about 200–500 kWh/m² at a height of 70 m. The wind speed in some areas can reach more than 6 meters/second (m/s) at 70 m height, and 7.2–9 m/s at 80 m height; this is above the national average, which was 5.5 m/s at 70 m height in 2018 (IRENA, 2018b).

Chongli has a relatively high rate of forest coverage, mainly on mountains, giving it potential to utilise substantial amounts of local forestry residue for biomass energy. The rate of forest coverage rose from 52% in 2015 to 67% in 2019 (Chongli District Government, 2020, 2016). However, published plans by Zhangjiakou Municipality do not include an assessment of this local biomass potential.



# DEPLOYING RENEWABLE ENERGY IN CHONGLI

Zhangjiakou Municipality has adopted a number of enabling policies in support of renewables, and these are discussed below together with renewable energy targets for Chongli. This section also outlines the significance of national-level policies in the context of Chongli. The roles of a number of actors and stakeholders are essential to understanding policy making in Chongli District. Below, we discuss the importance of the Chongli district government, Hebei provincial government, Zhangjiakou Municipality, the local grid company and renewable energy companies operating locally.

## The role of Hebei provincial government

The Hebei provincial government is the upper level administration of Zhangjiakou City and plays proactive roles in provincial level targets, strategies and planning. These in turn enable city-level renewable policies and actions. The Hebei provincial government also plays a key role in engaging the national government, regional-level authorities and grid companies, as well as pricing electricity and providing financial support for pilot projects in its jurisdiction.

Hebei Province

## Roles of Zhangjiakou Municipality

***Target setter and regulator***

Zhangjiakou Municipality is the main body developing city-level plans (which include Chongli District), implementing all related local policies, as well as facilitating communication between all related stakeholders and co-ordinating platforms (for more on these platforms, see Box 2.3).

Under its 2015 pilot plan, Zhangjiakou City committed to raising the share of renewables in terms of both capacity and percentage of final energy consumption. Renewables are to supply 55% of electricity by 2020 and 80% by 2030; 40% of all residential building energy needs, 50% of public buildings and 100% of public transport energy needs by 2020; and 100% of residential public building energy needs by 2030 (NDRC and NEA, 2015). Renewables based electricity generation capacity is to reach 20 GW by 2020 and 50 GW by 2030 (NDRC and NEA, 2015). As for consumption, Zhangjiakou City aimed for a 35% renewable share in total final energy consumption by 2020, and 50% by 2030. It also aims to achieve 100% renewables in total energy consumption of public buildings and urban households by 2030, across all districts. These are very ambitious renewable targets for China, where the national target for renewables' share of electricity was 28% by 2020.

This affects all end uses. In heating, Zhangjiakou's target to phase out all coal burning boilers, except co-generation projects, by the end of 2020 has increased pressure on the company providing heating energy as well as industries consuming energy for heating. In transport, the city further established a target of 100% renewable energy based urban public transport, supported by a newly released strategy and policies to promote local renewable energy based hydrogen industries and the manufacturing and deployment of hydrogen fuel cell vehicles in 2019.

## BOX 2.3 THE FOUR-PARTY CO-ORDINATION PLATFORM OF ZHANGJIAKOU CITY

Renewable energy developers in Chongli District are mainly involved in the construction and operations of wind and solar power plants, and thus form the on the ground backbone of efforts to promote local economic development and achieve ambitious renewable energy goals. The companies are a mix of large national renewable energy firms and developers controlled by the provincial government, for example, joint ventures between leading developers and local investors. Following project approval by the provincial government, the developers sign a power purchase agreement with the national grid company and establish eligibility for FiTs, to ensure grid connection.

Given the curtailment of wind and solar generation in this region due to excess capacity, project operators have been involved in a four-party co-ordination platform to sell more electricity generation (out of the national guaranteed generation hours) at a lower price. The platform was initiated in 2018, with the aim of promoting wind electricity for heating in Zhangjiakou City, as well as reducing curtailment and utilising more renewables potential. The platform involves Zhangjiakou Municipality, the grid company, wind and solar power plant operators and heating companies as the electricity consumers. The platform facilitates the trading of wind and solar electricity between heating companies and power plants via the regional grid. The four parties facilitate monthly electricity trading.

The regional branch company of the state-owned grid company is responsible for establishing the trading rules, electricity connection, and operation and recording of the trading. Each month, Zhangjiakou Municipality aggregates demand from heating companies and other consuming companies and industries. Wind and solar power plants subscribe to the aggregated electricity needs with offered prices. Heating companies and other electricity consuming companies and industries will pay the subscribed power plants through the grid company in trading prices. Trading electricity on this platform, with a tariff lower than one-third of the normal electricity tariff, could also reduce the operation cost of heating companies. Solar and wind power plants could sell more electricity, at a lower tariff, outside of guaranteed hours.

Although trading on this platform is voluntary, pressure from the national policy (especially, the planned phase-out of coal-fired boilers) and the prospect of lower heat energy costs are incentives for the producers and consumer companies to participate.

In 2017, 52 solar and wind power plants participated in the platform. During the winter of 2018, around 425 heating companies and 4 226 distributed heating consumers traded more than 235 gigawatt-hours (GWh) of renewables electricity on the platform. As of 2019, the platform organised 12 trades with a total of 700 GWh of trading electricity (Zhangjiakou Municipality, 2020; Hebei Provincial Government, 2019a).

Zhangjiakou City

***Financier and operator***

Renewable energy electricity projects, including onshore wind, solar PV and municipal waste generation, are already economical for generators receiving national FiTs, as well as for the distributed generation and household generators under provincial and city-level FiP policies. The business case for renewable-energy-sourced electricity used for space heating, on the other hand, still needs to be demonstrated. In Zhangjiakou City, the municipality and grid companies have planned significant investment of hundreds of millions of dollars for the improvement of local energy infrastructure, including district heating stations and a distributed system, as well as electricity transmission and distribution networks. Zhangjiakou provides subsidies to cover 85% of electric heating equipment of a heating company using wind power, as well as caps the electricity price at CNY 0.15/kilowatt-hour (kWh), or USD 0.0218/kWh for heating companies on the four-party co-ordination platform. Zhangjiakou had deployed 194 hydrogen fuel cell buses for public transport by the end of 2019, with funding from both the central and its own municipal government budget (Zhangjiakou Municipality, 2020).

## Roles of Chongli District

***Target setter and planner***

The district government defines its own renewable energy strategy and targets. However, it has little in the way of independent policy making authority, especially when it comes to fiscal and financial aspects. Therefore, collaboration with upper-level governmental authorities, including Zhangjiakou Municipality and the Hebei provincial government, with the aim to support comprehensive planning in Zhangjiakou City is key. The district government does have roles in district planning as well as managing and facilitating the implementation of projects locally, in collaboration with Zhangjiakou Municipality, the grid company and other key stakeholders.

Renewable energy targets for electricity, heating and transport in Chongli are included in the Renewable Energy Demonstration Plan of Zhangjiakou City, which was announced by the State Council of China and released by Zhangjikou Municipality with support from the provincial government. The plan establishes targets for reaching a very high share of renewables for Chongli District, in the context of planning to host the Winter Olympics (as discussed in Box 2.3). According to the Low-Carbon Olympics Plan, electricity will be supplied mainly from renewables within Chongli District and some wind and solar electricity will be sourced from nearby counties in the Zhangjiakou City area. Solar thermal energy will provide heating for all buildings in the Special Zone for the Winter Olympics. The plan is to build four to six solar district heating stations, each providing heat energy for 10 000 m$^2$ of floor space (NDRC and NEA, 2015).

Targets also include 100% electric heating in urban areas of Chongli District by 2021, 70% for suburbs and 40% for rural areas (NDRC and NEA, 2015; see Box 2.4 below). Renewably sourced electricity was to cover the heating needs of 3 million m$^2$ of existing buildings and 0.6 million m$^2$ of new buildings in 2020. Altogether, this was expected to add 360 million kWh of new electricity consumption in Chongli District.

The targets are supported by differentiated technology solutions. Renewable energy combined with district heating networks will provide heat for urban areas and the Olympic village. Distributed heating solutions will be applied mainly in rural households. However, given the available assessment, the use of bioenergy and geothermal as heating sources in this district is limited.

## BOX 2.4 DEPLOYMENT OF RENEWABLE ENERGY HEATING SOLUTIONS IN CHONGLI

The electrification of heating is a core element of transitioning from coal towards clean energy in China and Chongli. At the national level, NDRC and nine other ministries in 2017 joined hands to create policies aimed at substituting coal-fired boilers with electric boilers. Heat pumps as well as gas fired boilers and other renewables-based options including biomass and geothermal. Chongli has set a target of replacing all coal-fired heating with the help of electric solutions and wind power. The electricity used for this purpose reflects the mix of energy sources of the regional grid; meanwhile, the provincial government, in collaboration with the grid operator, seeks to raise the share of wind power.[5]

The share of heating in total energy consumption is expected to increase significantly. Local power generation capacity requirements are estimated to rise nine-fold from 2019 to 2022 due to the rising needs for electric heating. Chongli will need to source additional supplies of renewable energy as existing local capacity will eventually fall short of electricity needs for heating. As of 2018, Chongli District had planned an additional 608 MW of renewable electricity generation capacity for heating purposes (Zhangjiakou Municipality, 2018). The most likely option would be to utilise clean electricity from nearby areas within Zhangjiakou City.

Zhangjiakou City

5 Chongli District's existing district heating system was built and operated by a privately owned company on the basis of a 2010 franchise agreement. The district system provides space heating for 4.5 million m2 of building floor area, supported by seven 46 MW boilers, and 39 km of district heating network through 38 heating exchange stations.

Renewables based electric heating could address the curtailment of renewable power as well as provide cleaner heating.

### *Financier and operator*

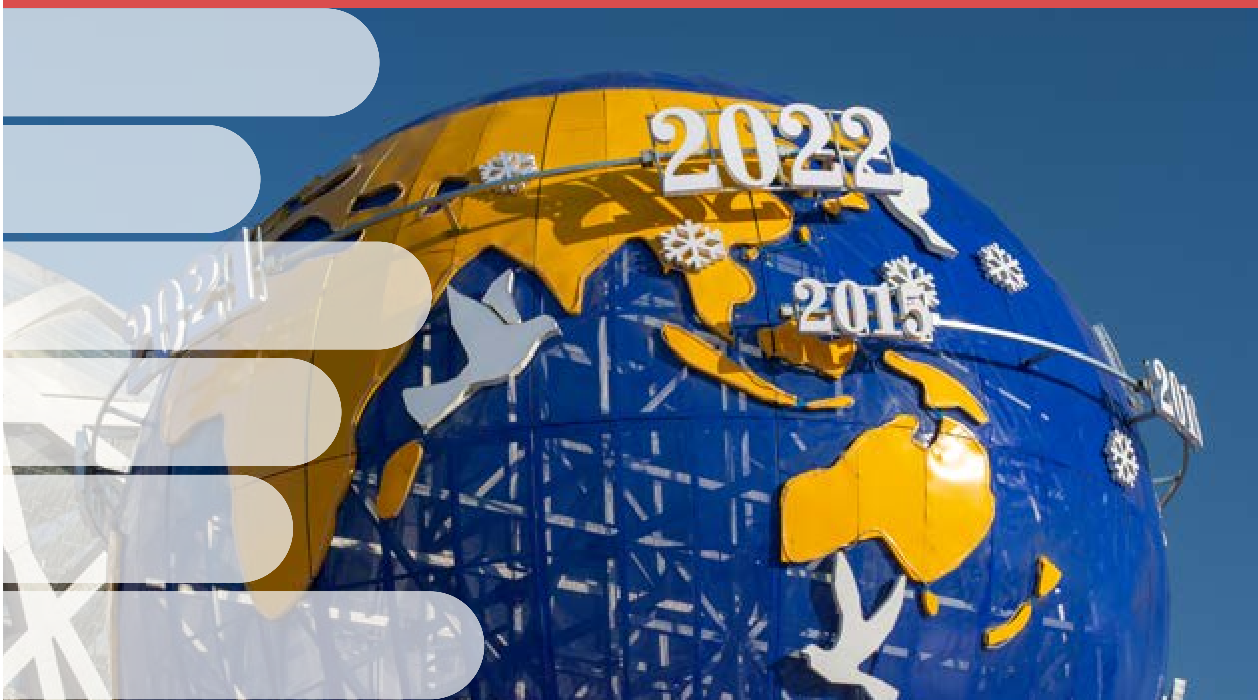
Meanwhile, Chongli District committed to all energy consumption of municipal owned buildings being sourced from renewables. This target includes government office buildings, hospitals, schools, parks, squares and public spaces (NDRC and NEA, 2015). Renewables will provide both heating and power for the buildings' operation. It is expected that the electricity will be from the procurement of wind electricity from power plants located in Zhangjiakou City through a regional piloting electricity market platform initiated by the NEA, the grid company and the provincial government.

## **BOX 2.5** INVESTMENT IN RENEWABLES-BASED PROJECTS RELATED TO THE WINTER OLYMPICS

Fulfilling Chongli's goal of 100% renewable energy for the Winter Olympics entails large-scale investment – in construction and operations of new power generation plants, grid networks and infrastructure upgrading, improvement of heating networks and appliances, and power supply and charging stations for EVs and hydrogen cell vehicles. It will also require investments and financial support for operations and maintenance of renewable generation, heating and transportation.

Estimation of project costs is mainly associated with the comprehensive energy supply planning for the Green Olympic Zone and Low-carbon Chongli District planned by Zhangjiakou Municipality. Of the total required investment for renewables generation, transmission and distribution as well as consumption, 11% will be used for the Olympic zone, 9% for electric heating projects, 2% for electric vehicles charging stations, 1% for an energy transaction data service platform and 45% for grid upgrading and improvement. The remaining 32% of the investment will be supporting energy efficiency in the building, industry and transport sectors (IRENA, 2018a).

Financial support from the central government of China is estimated to cover most of the investment for public facilities and public buildings, as well as most of the construction and infrastructure required for the Winter Olympics. The private sector and other stakeholders are also involved in renewable projects in heating and transportation sectors. Given data constraints, it is difficult to estimate private investment. However, the privately owned heating company and some renewable power plants with private investors have invested in the procurement of boilers and the construction of plants.



# CASE STUDY 2: TONGLI TOWN

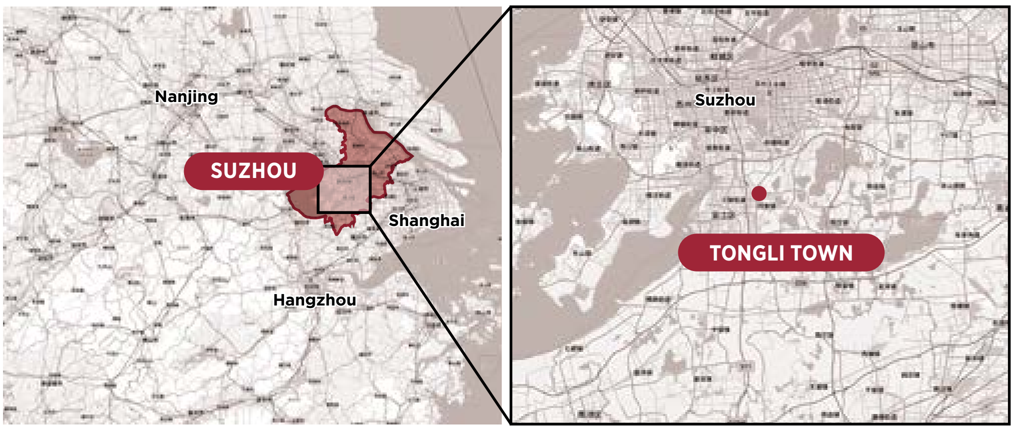
## BACKGROUND

Tongli Town, part of the Wujiang District of Suzhou City, Jiangsu Province, has a recorded history going back more than 1000 years. Situated among farmland, forests, rivers and lakes, the city was built during the Song dynasty. Located on the eastern shore of Taihu Lake, 18 km from the city centre of Suzhou and 80 km from Shanghai, Tongli covers a 98.03 km$^2$ area and has a population of 67 900 spread across 5 neighbourhoods and 11 villages (see Figure 2.9). The historic centre of Tongli Town stretches over 2.4 km$^2$ – and the city core is just a tiny portion (Suzhou Municipality, 2018a).

Tongli Town is certified as a World Heritage site by the United Nation Educational Scientific and Cultural Organisation (UNESCO) as well as a protected historical heritage site by the Jiangsu provincial government. Tourism is therefore a mainstay of the local economy. Tongli Town ranks among the top-ten tourist destinations in China, receiving more than 5 million visitors annually since 2011. Its status as a historical site has translated into restrictive policies on changes to buildings, decorations or reconstruction. The mounting number of visitors, meanwhile, has boosted energy consumption[6] and created more risks to buildings in the ancient town.

6 Since 2014, the flow of tourists to Tongli Town has increased by more than 30% every year, driving growth in energy consumption to the tune of 7.4% annually, according to local authorities.

**Figure 2.8 Tongli Town**




Source: © OpenStreetMap contributors | For visual purposes, maps are on different scales.

Disclaimer: Boundaries and names shown on this map do not imply any formal endorsement or acceptance by IRENA.


Suzhou city

## Energy supply and consumption

Suzhou, of which Tongli Town is part, has the third-largest energy consumption out of the more than 300 prefecture-level cities in China. Suzhou's total final energy consumption was more than 85 million tce[7] or around 59 million tonnes of oil equivalent (toe) in 2017 (Lei *et al.*, 2019; Suzhou Municipality, 2018b). This is 20% higher than Beijing's energy demand (due to the great concentration of industries), even though the capital's population is more than double that of Suzhou (National Bureau of Statistics, 2020). Tongli itself, however, has a small population and no energy-intensive manufacturing industries, implying the town's energy demand is comparatively small, accounting for less than 1% of Suzhou's total electricity consumption. Power demand has been rising rapidly in recent years, however, and is projected to continue to boom (IRENA, 2018a). Renewable energy could help protect Tongli's integrity as a historical town while ensuring support for more tourism. So supporting sustainable and clean energy sources is a core challenge.

Tongli is supplied by Suzhou's municipal grid company covering all districts, counties and towns in Suzhou City. This implies Tongli's electricity mix is to some degree determined by Suzhou. The energy mix of Tongli Town is not clear due to limited available data. However, in 2019, a national energy newspaper reported that the renewable energy share in total final energy consumption reached 15%, mainly due to hydroelectricity, distributed solar PV and wind generation (Zhang Rongxin, 2019). Most of these renewable energy solutions, including groundwater-sourced heat pumps deployed in the district cooling system, are installed in the office buildings of the local grid company. So far, the installed distributed solar panel generation is about 477 kW and includes several 1–2 kW installations on household rooftops. The capacity of distributed wind generation reached 20 kW from four deployed 5 kW wind turbines (Feng, 2019).

Tongli Town has no local resources providing fossil fuel energy. All local energy supply is derived from other regions of China, including electricity, coal, oil and natural gas. Electricity is from hydropower plants in Sichuan Province transported to Suzhou. Natural gas comes from Sichuan Province and western China (natural gas is provided by one state-owned company in Jiangsu Province, its supply allocated by a higher-level administration). In 2015, Tongli's natural gas supply accounted for a small share of Suzhou's total supply. It is projected that the natural gas consumption of Tongli Town will keep increasing, which will require the expansion of existing natural gas networks and pipelines and other infrastructure.

The Suzhou City and Jiangsu provincial governments have adopted a series of policies to encourage the deployment of renewable energy, including targets, development plans, and subsidies, while planning the phaseout of fossil fuels. More than 1 GW of renewables capacity has been deployed, of which 300 MW is distributed solar rooftop and wind power. In Tongli, installed capacity amounts to around 500 kW. The fleet of electric vehicles (EVs) now surpasses 11 000 in Suzhou City; Tongli Town has built 60 EV charging stops and 6 charging stations for electric buses.

7 Tonne coal equivalent (tce) is the main unit in China's energy reporting system; 1 tce = 29 307.6 megajoule = 0.7 tonne oil equivalent (toe).

Tongli Town

## Local challenges

Local government has recognised the major challenge of reconciling the growth of tourism with the parallel goal of increasing the use of clean energy in Tongli. The major energy consumers in Tongli Town are households and the tourism industry, including restaurants, hotels and transportation for tourists. Around 70% of all buildings in the ancient town were built in the Ming and Qing dynasties, one thousand years ago. Most old buildings have brick and wood foundations vulnerable to fire hazards. Open fires continue to be used for cooking and heating in the densely populated town, while increasing electricity consumption also raises the risk of overloaded old wires. The widespread use of gas tanks, coal and oil products for cooking and water heating significantly adds to the local hazard of fire,[8] as does the amateur wiring connecting private homes and small businesses to the local grid.

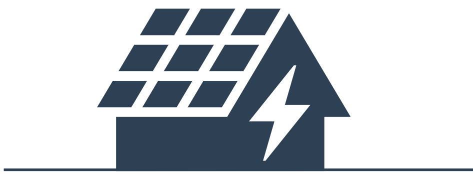
The local tourism industry has added to the strain on local infrastructure. Numerous new, small-scale merchants and shops have been opening in the tiny centre of the ancient town, increasing demand for electricity and other energy resources for lighting, transport and heating and cooling, burdening the electric transmission and distribution network. Existing distribution networks thus struggle to meet the growing energy needs of businesses. Safety concerns related to fuel use, old wires and an overloaded distribution network have been voiced by an increasing number of town managers, merchants and residents. Local government, in collaboration with the grid company, has noted that electrification could help to reduce the fire hazard from open fires.

## Renewable energy potential in Tongli

Tongli Town is classified as a solar energy Type 3 zone (see Box 2.1 and Table 2.1). Suzhou City and its environs register average solar radiation of about 1279 kWh/$m^2$ per year and 3.5 kWh/$m^2$ per day. The utilisable irradiation of Suzhou is about 1280 hours per year, below the average as a whole. Based on the assumption of an average living area in Tongli of around 50 $m^2$ per capita, and 25% of total rooftop area utilisation, the estimated available rooftop area for solar PV could reach 300 000 $m^2$.[9] This would translate into around 30 MW of potential capacity for rooftop solar PV installations, more than 60 times the installed solar panels in Tongli Town (Jiao, 2017).

Nonetheless, lack of space and restrictive building protection policies limit the exploitation of renewable resources in Tongli Town's historic centre. The estimated area available for integrated solar PV solutions is 90 $km^2$, mainly on farmlands and fishponds outside of the ancient town. With an assumed 1% deployment of solar PV, solar generation capacity could reach 90 MW, enough to meet all current local electricity needs. It is estimated that the payback period for distributed solar PV generation in this region is about five to ten years, depending on the technology, which becomes more efficient and affordable every year.

Outlying areas also have the potential to deploy various other technologies, including solar thermal, heat pumps (groundwater- and sewage-sourced) as well as biogas from sewage. According to the master development plan of Tongli 2011–2030, the city and surrounding areas will build three sewage-treatment plants. Heat pumps utilising heat from sewage in Tongli Town could be deployed at up to 21 MW of total capacity. This technology could meet heating and cooling needs for an area of around 2 $km^2$, roughly the size of the historic town centre (IRENA, 2018a).

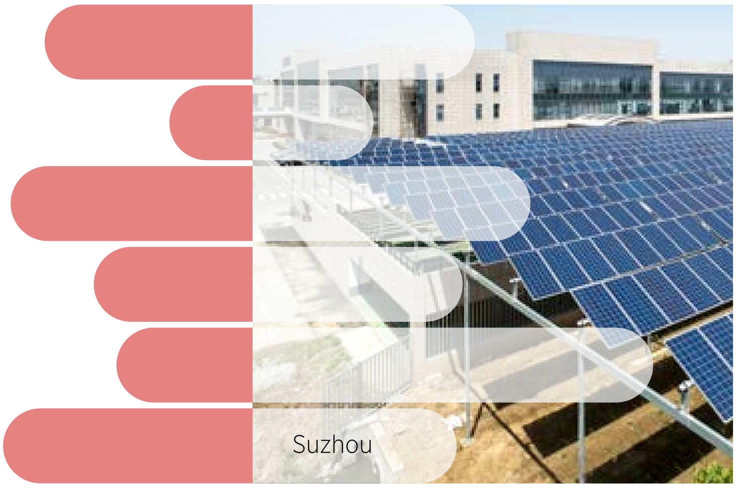


8 In the historic centre of Tongli Town there are 4 500 households, 255 of which use coal and oil products for cooking and heating and cooling; the remaining 4 200 households use gas canisters for the same purpose (IRENA, 2018a).

9 Assumption is based on regional average and local experts' research (Jiao, 2017).

## DEPLOYING RENEWABLE ENERGY IN TONGLI

In accordance with China's policy framework for renewables, Tongli Town releases no policies on its own but implements those released by higher-level government departments, including the NEA, the Jiangsu provincial and Suzhou Municipality government (see Figure 2.9). Tongli's renewable energy deployment is hence the result of interwoven policies that include higher-level governments, as well as local initiatives.


Suzhou

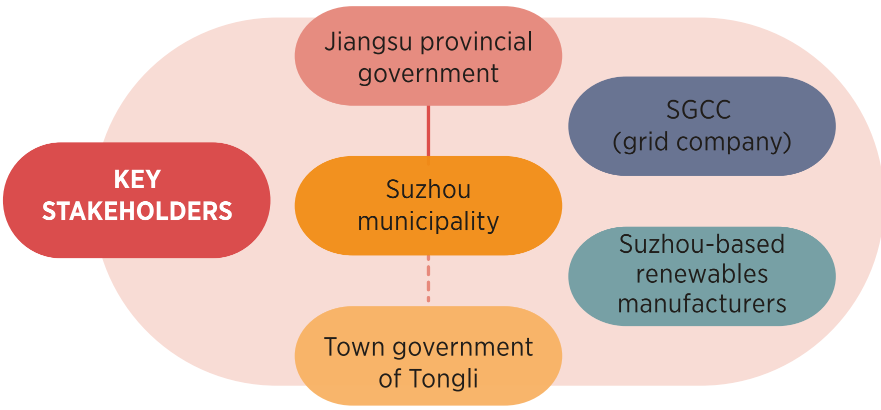
### The role of Jiangsu provincial government

The Energy Division of the Jiangsu provincial government is responsible for all energy-related policy making, implementation and strategies in the province, and guides all energy-related work of municipalities in this province. In collaboration with the NEA, the Energy Division provides support for Tongli's ambitious renewable energy targets as well as expertise and knowledge. It also facilitates necessary support in strategies, power market co-ordination and other necessary guidance to ease the involvement of the NEA and other national institutions.

### Roles of Suzhou City

Suzhou City, acting through Suzhou Municipality, is responsible for setting, facilitating and financing energy policy, including renewables deployment, throughout its jurisdiction. This includes Tongli, which is under the administration of Suzhou City. All targets, strategies, action plans and local financial supports for renewables in Tongli are released by Suzhou City in collaboration with the Jiangsu provincial government.

**Figure 2.9 Key stakeholders in Tongli Town's renewables policy**





Tongli

Source: IRENA urban policy analysis

***Target setter and planner***

Suzhou is the main planning body for renewables deployment, as Tongli Town cannot issue such plans itself and all actions taken locally require the city's approval. Suzhou adopted a 2020 target of 55% of total electricity consumption coming from clean energy sources, which in practical terms means mostly hydro plants in southwest China. Hydroelectricity is equivalent to a 30% renewable share in total final energy consumption by 2020 (see Tables 2.3 and 2.4) (Suzhou Municipality, 2018b). Further, Suzhou plans to deploy some 310 MW of local renewable electricity capacity, of which 250 MW would be solar PV, 10 MW onshore wind and 50 MW biomass power. For heating and cooling, the city established a target of 85 000 m$^2$ of solar water heater collector area, and 150 000 m$^2$ of building floor area using geothermal, groundwater and sewage-sourced heat pumps. For transport, the target is to build enough charging stations to serve a fleet of 50 000 EVs.

**Table 2.3 Targets for renewables' share of energy consumption in Suzhou City, Tongli Town and town centre, by 2020**

| | RE in total energy consumption | Electricity in TFEC | RE in electricity consumption | RE in the building sector | Deployed electric vehicles |
|---|---|---|---|---|---|
| **Suzhou City** | – | 30% | 55% derived from hydro | – | 5 000 |
| **Tongli Town** | around 20% | – | – | – | – |
| **Historic centre of Tongli Town** | near 100% | near 100% | near 100% | near 100% | – |

**Table 2.4 Targets for renewable deployment, by technology, in Suzhou City, and Tongli Town, by 2020**

| | Solar PV generation | Onshore wind generation | Biomass generation | Solar water heaters * | Biogas output | Geothermal** |
|---|---|---|---|---|---|---|
| **Suzhou City** | 250 MW | 10 MW | 50 MW | 85 000 m$^2$ | 250 000 m$^3$ | 15 000 m$^2$ |
| **Tongli Town** | 121.6 MW | – | – | – | – | 1.9 MW |

Source: NEA, 2016; IRENA, 2018a.

Note: * By area of collectors; ** Includes groundwater- and sewage-sourced heat pumps, by heated building floor areas.


Other targets include reducing per capita energy consumption by 11% and building energy intensity by 10%, limiting government-owned institutions' energy consumption to 210 000 tons of coal equivalent (tce) (Suzhou Municipality, 2017a). Achieving these targets in Suzhou would not only drive the sustainable transition of this city but also provide a model for other industry-intensive cities to follow. Renewable energy policies, along with energy efficiency measures, support Suzhou's climate pledges and renewable energy targets.

***Regulator***

Like dozens of other Chinese cities, Suzhou decided to ban coal burning due to air quality concerns in all its districts and towns in early 2017. Suzhou even went one step further to ban all heavy polluting fuels, including oil products. The construction of new boilers using such fuels is prohibited, while most existing boilers were to be phased out and replaced by cleaner fuel-burning technologies by the end of 2019 (Suzhou Municipality, 2017b). Selling these fuels is also outlawed. Cleaner fuels are defined as natural gas, liquid natural gas (LNG), electricity and renewables.

Several renewables-based solutions and energy efficiency measures have been identified for deployment in Tongli Town. These include:

- Securing the town's energy supply through the utilisation of derived hydropower, local megawatt-scale solar PV plants and natural-gas-sourced trigeneration;
- Deploying more local distributed renewables, including groundwater-sourced heat pumps (for heating and cooling) and distributed solar PV generation in collaboration with mini-grids;
- Improving power infrastructure in the historic town centre, including the grid network, electricity distribution and local energy storage capacity;
- Setting up energy efficiency measures in the building sector and green transportation;
- Supporting renewables-related technology innovation and companies that provide relevant solutions.

***Financier and awareness-raiser***

Apart from the FiT defined by the NEA, Suzhou Municipality subsidises distributed solar PV generation. In all districts and towns of Suzhou, households, businesses and industries investing in distributed solar PV projects are eligible for a FiP, set at CNY 0.05/kWh (around USD 0.007/kWh), on top of the NEA's FiT. Moreover, the distributed solar PV projects not eligible for FiTs have the chance of receiving financial support from Suzhou Municipality at CNY 0.37/kWh (around USD 0.053/kWh), a rate nearly two-thirds that of the national FiT level. These rates are initially guaranteed for a three year period.

Suzhou Municipality also provides financial incentives for renewable energy plant developers and technology innovation companies. Both state-owned and private companies are allowed to develop, own and operate power plants and sell electricity to the sub-branch of the state-owned grid company. According to a recently released policy in Suzhou, companies that have developed and are operating more than 10 MW of new renewables-based power plants in 2018 are eligible to receive financial support from Suzhou Municipality in addition to FiTs. The support is based on installed capacity, about CNY 0.1/watt (around USD 0.015/watt) and up to around USD 300 000 per company (Suzhou Municipality, 2018d).

## Roles of Tongli Town

In collaboration with Suzhou Municipality, the town government of Tongli is responsible for defining strategy, setting targets and implementing development plans and related policies.

***Target setter and planner***

With higher-level political support, Tongli Town's government released its *Development Plan for a New Energy Tongli Town* in 2016. It aims to deploy renewable energy, mainly from hydro electricity derived from western China, as well as some distributed solar PV and wind demonstration projects and electric buses (Suzhou Municipality, 2018c).

The plan set 2020 targets for both the historic town centre (100% share of new energy in total final energy consumption) and for Tongli Town as a whole (a 20% share) (NEA, 2016). Approaches to the two targets are slightly different. For the historic town centre, the focus is on the electrification of buildings; replacing all primary energy (coal, petroleum, diesel, biomass and other) used in cooking, heating and cooling with electric appliances powered by derived hydroelectricity; and the deployment of a fast-charging EV station, 4 electric bus-charging stations and 60 regular EV charging stops.

The larger area of Tongli Town, on the other hand, aims to draw half of its renewables from local sources and the other half from hydropower derived from western China. According to the local government, the local renewable energy potential includes 121.6 MW of distributed solar PV, 1.9 MW of water-sourced heat pumps for heating and cooling as well as biomass consumption (around 4 400 tce).

The 2020 renewable energy targets for both the larger Tongli Town and its historic town centre were achieved in 2018. The town's full electrification, and a planned move away from traditional fuel in the transport sector, requires further support. The benefits are both financial and social. For instance, a restaurant in the town centre used about 20 kWh in its kitchen after electrification, indicating a USD 2.50 daily bill, which is much lower than the USD 8[10] paid for the use of natural gas, petroleum and coal before the installation of electric cookstoves. Social benefits include less air pollution and reduced fire hazard for kitchen workers.

Enabling factors include the availability of derived hydro electricity as well as the absence of heavy industries for which the electrification of heating could be much more challenging. Moreover, Tongli's success has benefited from collaboration with others; to achieve the targets for the entire town, Tongli's development plan was combined with that of part of the Wujiang District, another district under Suzhou City. As Wujiang has more industries, the combined plan provides opportunities to utilise local renewable industries to provide tailored plans and solutions for Tongli's deployment of renewables.


Suzhou

10 Based on the estimation of its previous monthly consumption: USD 150 for petrol, USD 70 for LNG and USD 30 for coal.

***Financier and awareness builder***

The development plan also outlines actions and demonstration projects to support the targets. These include the electrification of heat uses in households and restaurants, an energy service centre hosted by the utility running the grid, and a demonstration project in the buildings sector.

Tongli Town's pilot electrification project has expanded from a focus on dozens of restaurants and hotels in the historic town centre to more districts of Suzhou City, which has replaced the traditional gas-fired oil or coal-fired cookstoves with electric cookstoves in more than 150 restaurants and hotels by 2019 (SGCC, 2020; Zhang Cong, 2020). The local branch company of SGCC has taken actions to improve the grid network and capacity, thus enhancing service access and quality. Since 2016, all low-voltage grid networks in the historic town centre have been upgraded to meet the energy needs of restaurants and hotels without fire hazards from inadequate grid networks and distribution lines. While Tongli's electricity mix is still not 100% renewables based, renewables' share in the grid is planned to increase.

In addition, the town's several demonstration projects include an international energy transition forum co-hosted by the NEA, Jiangsu provincial government and IRENA (see Box 2.6).

## BOX 2.6 DEMONSTRATION PROJECTS IN TONGLI TOWN: SGCC'S ENERGY SERVICE CENTRE AND A PERMANENT VENUE FOR AN INTERNATIONAL ENERGY TRANSITION FORUM

SGCC, the largest state-owned grid company in China, has collaborated with Suzhou Municipality to build a comprehensive energy service centre in Tongli Town. Located on the north side of the historic part of town, the service centre is the office building of the SGCC branch company in Suzhou and features a demonstration of renewable technologies deployed here.

Utilised renewables include small-scale solar PV, low-speed wind generation and a groundwater-sourced heat pump, among others (SGCC, 2018a). New technologies like solar thermal power generation and liquefied air storage have been deployed for heating and cooling (Feng, 2019). SGCC also set up a self-use EV charging station, a wireless charging road and a passive building construction.

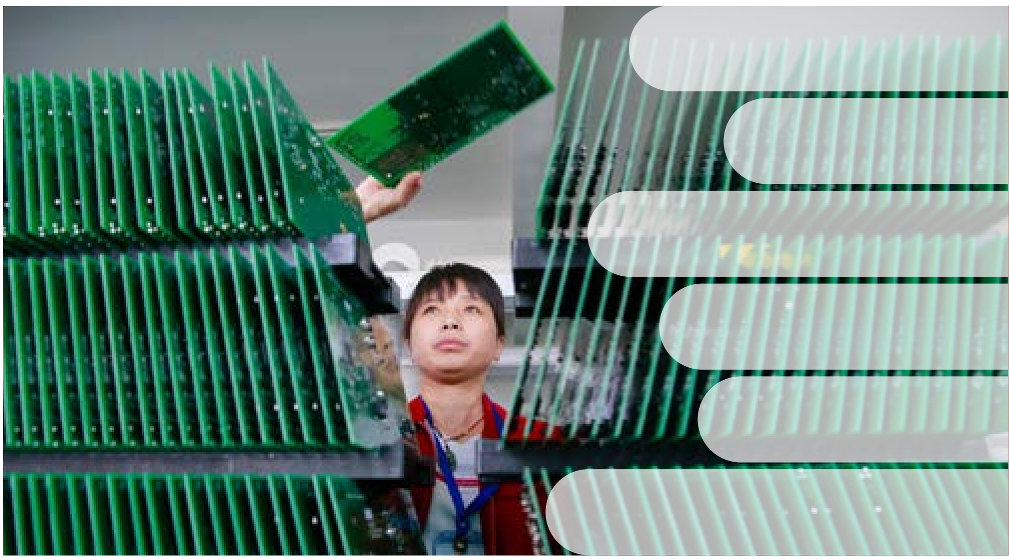
In collaboration with Suzhou Municipality, Tongli is also building a permanent venue for the International Forum on Energy Transition, which was cohosted by the NEA, Jiangsu provincial government and IRENA in 2016 and 2018 (Suzhou Municipality, 2016).

It is difficult to estimate the total investment thus far. Suzhou Municipality and Tongli Town invested in most of the demonstration and pilot projects, in collaboration with SGCC and the Jiangsu provincial government, while the FiTs and additional incentives for technology development come from the NEA and other related ministries. The procurement and operational costs of electric cookstoves and water heaters were borne by households and businesses.

## The role of Suzhou-based renewables manufacturers

Renewable energy-based manufacturers play a role in the deployment of renewables locally. Suzhou City is one of the most industrialised cities and seeks to transition from conventional manufacturing industries to renewables and other strategic emerging industries. Solar PV manufacturing is a key industry asset. The city is home to more than 70 manufacturers covering the entire supply chain, especially battery storage and PV panels and modules. Their numbers include two of the world's leading solar PV manufacturers in module products and supply. Related industry branches manufacture EVs and batteries.

This industrial cluster implies that local political awareness of available RETs is high, as is the motivation of local government to promote renewable energy products. Under China's taxation system, tax receipts from local companies account for a sizable portion of municipal government revenues, providing municipalities with incentives to promote local industries. Many municipalities promote renewables projects, such as in solar and wind generation, heat pumps and electric vehicles. This includes support of local industries to procure solutions and products from local manufacturers that contribute to the local economy and jobs. The availability of renewable energy products manufactured locally also adds to their cost advantage, which in turn supports the local government's interest in promoting these technologies. This is a win-win situation for both sides, and renewable energy deployment in Tongli clearly benefits from this.



# LESSONS LEARNT

Advancing towards ambitious renewable targets in Chinese cities requires collaboration across all levels of government to enable a change in energy policies that were originally designed for fossil fuels. It also requires the upgrade of grid infrastructure. More important, the transition of end-use sectors from fossil fuels to renewables not only offers financial and social benefits but also addresses key environmental challenges.

## Electrification strategies can support the scaling up of renewable energy and improve the urban environment

Chongli and Zhangjiakou as a whole benefit from the availability of renewable energy projects on a large scale, in particular wind and solar PV. This level of already existing deployment provides a solid base for more ambitious targets than would be possible in cities where renewable energy has yet to begin to feed into the local energy system.

Electrification strategies can support the scaling up of renewable energy. Cities, towns and districts can be important laboratories demonstrating the feasibility of policies supporting electrification nationwide. The utilisation of redundant wind power capacity for heating purposes offers a way to address both the problems of wind curtailment and coal burning for heating. Overcoming challenges such as unclear trading rules and limited motivation for power plants to participate in local electricity trading will be critical. Greater flexibility in the electricity pricing system can support this objective.

Tongli Town's tourism industry also benefits from the electrification of end-use sectors. With more tourists visiting every year, Tongli demonstrates that the pursuit of innovative energy solutions not only saves money but also increases the safety and security of its residents and visitors, and significantly improves the quality of tourists' experience through better air quality and lessened environmental pollution.

## Access to financial resources is critical for rapid, proactive action

Chinese cities clearly benefit from the availability of financial resources targeting renewable energy deployment. Tongli Town receives financial support from its upper-level administration, the Suzhou municipal government that has one of the largest government revenue streams among Chinese cities. Given the high upfront investment and long payback for grid networks and related infrastructure, Tongli's example is most replicable in developed cities similar to Suzhou. Cities and towns with limited financial capacity or low shares of renewables in the grid may find it difficult to emulate this example. Zhangjiakou City is less wealthy than Suzhou, but its Chongli District received financial support from the national government in the context of the Winter Olympic Games.

## Distributed renewable energy technologies are becoming more important

Tongli Town's example also reveals that distributed renewables could play a much more significant role in cities. Distributed renewables such as solar PV generation systems could be deployed outside highly populated urban centres, and heat pump solutions combined with urban sewage systems and district heating and cooling networks could reduce the need for urban-centric deployment. Tongli's case, on the other hand, could suit many small towns with relatively low-storey buildings that could realistically be supplied through their limited rooftop space.

## Existing manufacturing industries benefit renewables deployment

Tongli exemplifies the mutually beneficial relationship between local governments and local manufacturing industries in the deployment of RETs. Many Chinese cities and towns have local manufacturing industries for solar PV panels and other parts of the RET value chain. This clustering of industrial production and innovation together with cities willing to support innovative industries through deployment policies benefit both local industries and cities themselves through shortened supply chains and lower costs.

## Showcase events can help increase visibility

Showcase events can rally policy making, as in the case of the Winter Olympics in China. Chongli District and Zhangjiakou Municipality have linked local renewables development targets with the hosting of the Winter Olympics in Chongli, thus focusing political attention and financial support on renewable energy projects.

## Cross-governmental collaboration counts

One of the replicable success factors in Chongli's ability to raise the share of renewables in end use sectors is its collaboration with upper government levels, including the municipal government of Zhangjiakou and the Hebei provincial government. The provincial government has played a pivotal role in this context by releasing most of the policies for renewables deployment as well as providing subsidies and facilitating an electricity trading platform that is key for Chongli to fulfil its 100% renewable energy heating target by 2022.

Direct policies released by Suzhou Municipality include setting renewable energy targets, banning highly polluting fuels, subsidising EVs and integrating distributed solar panels in buildings. These are replicable policy instruments at the city and town levels, supporting the deployment of renewable energy across various sectors. The collaboration with Jiangsu provincial government and the NEA also supports the scaleup of distributed renewables generation and the electrification of the heating and cooling and transport sectors at the regional and national levels.

# 3. UGANDAN CITIES: KASESE AND LUGAZI

## NATIONAL CONTEXT

Uganda is a young, rapidly growing country on the East African plateau in the Nile River Basin; to the south it borders on Lake Victoria. The country's socio-economic conditions and pressures arising from demographic trends and rising urbanisation are shaping the demands placed on the country's energy sector. These are unfolding against the backdrop of limited access to modern energy services such as electricity and clean cooking fuels.

The country surpassed the Millennium Development Goal of halving poverty by 2015, with notable progress in reducing hunger and child and maternal mortality and promoting gender equality (World Bank, 2019). Still, estimates from the Uganda National Household Survey 2016/2017 put the proportion of the population living below the national poverty line at about 21% in 2017, with major challenges in universalising access to clean water and sanitation, health services, education and modern energy services (UBoS, 2016).

Close to half (48%) of Uganda's population[1] is younger than 15, well above sub-Saharan Africa's average of 43% and the world average of 26% (PRB, 2019). Uganda's population growth rate is 3% per year, among the highest in the world. The World Bank expects Uganda's population to surge to more than 100 million people by 2050, with International Monetary Fund (IMF) estimates suggesting the country will need to create 600 000 new jobs each year in order to accommodate its rapidly growing labour force (World Bank, 2019; IMF, 2019).

But sustained population growth exerts considerable pressure on cities. Towns and cities provide better access to services such as health, education and jobs, thus attracting people. Uganda's urban population share of 24% is low in comparison with Africa's 43% and the world average of 55%. But rural–urban migration, partly as a result of climate-induced rural problems like drought, has raised the rate of urbanisation in Uganda. Kampala, the capital city, and other urban areas have witnessed rapid growth in recent decades. The overall urban population of Uganda is expected to rise from 6.4 million in 2014[2] to 22 million by 2040 (World Bank, 2019).

Uganda's expected demographic changes and rapid urban growth will require co-ordinated government intervention in order to create urban habitats that are safe, healthy and productive (UN-Habitat, 2010). This includes a focus on affordable housing, basic services such as water and electricity and jobs and economic opportunities (UN-Habitat, 2010). Local municipalities and secondary cities will play an increasingly important role in driving this agenda beyond Kampala.

1 The Uganda Bureau of Statistics (UBOS, 2018) put the total population at 37.7 million in 2017 and 38.8 million in 2018.

2 UBOS (2018) estimates the urban population at 9.4 million in 2017.

## THE CONTEXT FOR RENEWABLE ENERGY IN UGANDA

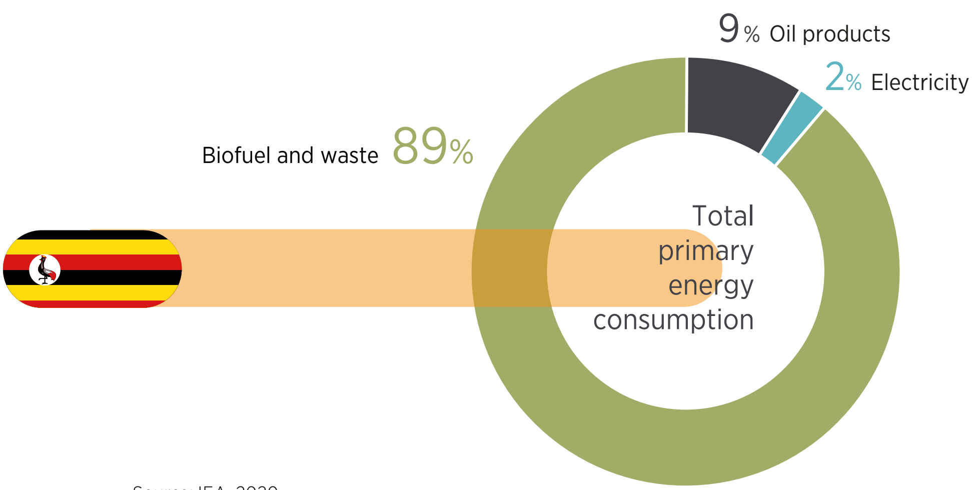
Although Uganda is endowed with a variety of energy resources – including hydropower, biomass, solar, geothermal, peat and fossil fuels – only around 20% of the population has access to electricity; access to clean cooking fuels and technologies is estimated by the World Bank to be as low as 2% (World Bank, 2017). Vision 2040, Uganda's 30-year development master plan (2010–2040), envisions increasing access to the national grid to 80% (GOU, 2013). Renewable energy, both in the on- and off-grid segments, plays a key role in this context. Uganda's Second National Development Plan (NDP) for 2015–2019 reflects this, focusing on hydropower and geothermal energy, including the construction of several large dams in the country (Republic of Uganda, 2015). The NDP also sets a target of 30% access to electricity by 2020, and 80% by 2040 (Republic of Uganda, 2015).

Traditional renewable energy is already a key energy source. Biofuels (mostly solid biomass) and waste accounted for almost 90% of primary energy supply in 2015 (see Figure 3.1).[3] Fuelwood and charcoal are primary sources of household energy across Uganda and are associated with serious environmental and health problems, including deforestation, the destruction of wetlands and indoor air pollution (Hepworth, 2010; KDLG, 2013). Fossil fuels are used primarily in the transport sector, to a lesser extent in manufacturing industries and in small quantities in the agricultural sector.

As Figure 3.1 indicates, electricity accounts for a marginal share of overall energy supply in Uganda at present. Lack of access to electricity is thus not only a rural problem

3 The International Energy Agency (IEA) defines biofuels and waste as solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Nonenergy use is not taken into consideration (IEA, 2019e). Current analysis necessarily relies on imperfect data sets.

**Figure 3.1 Total primary energy supply in Uganda (TJ), 2015**




Source: IEA, 2020.

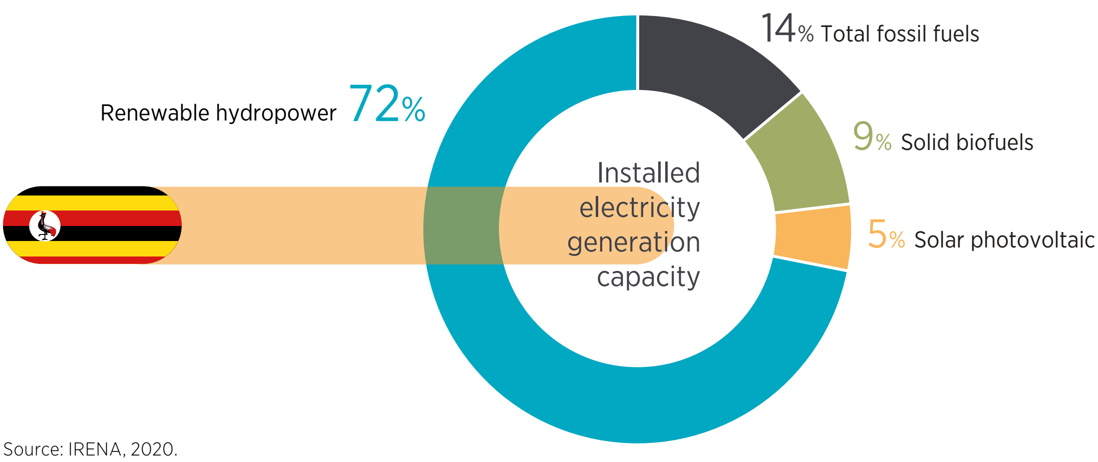
in Uganda but also an urban challenge that residents, businesses, schools and medical centres all face. There are insufficient sources of energy to power modern technologies such as lighting, refrigerators and technical equipment for use in medical facilities, for instance. Around 80% of Uganda's electricity generation is based on renewable energy, in particular hydropower (see Figure 3.2).

Modern renewable energy has a potentially important role to play in supporting Uganda's parallel aims to facilitate long-term growth and sustainable urban development. Developing renewable energy as part of local urban planning can help support a young, innovative industry with the potential to create jobs and contribute towards wider sustainable development goals, providing safe, clean energy to urban as well as rural households and businesses, while building productive and sustainable urban habitats through a more efficient use of energy and natural resources (GOU/NCEP, 2016). Renewable energy also contributes towards Uganda's climate mitigation measures, an important additional consideration given the country's extreme vulnerability to the adverse consequences of climate change (Hepworth, 2010; Henderson, Storeygard and Deichmann, 2014; Jones *et al.*, 2013).

## UGANDA'S RENEWABLE ENERGY POTENTIAL

Uganda has a rich but underexploited renewable energy endowment, including hydropower, modern biomass, geothermal, wind and solar energy. The Ugandan Electricity Regulatory Authority (ERA) estimates the electricity generation potential of modern renewable energy at about 5 300 MW (ERA, 2012), more than double the country's installed capacity

**Figure 3.2 Installed electricity generation capacity (MW) in Uganda, 2018**




Source: IRENA, 2020.

of 2 200 MW in 2018. Already today, hydropower is the dominant source for electricity generation, and the government plans to further raise its share in the power mix from around 78% in 2018 to 90% by 2030 (IHA, 2018). Working with private-sector firms and with support from development agencies, Uganda has built several new large hydropower plants in recent years, with more to be completed in the coming years (IHA, 2018; UEGCL, n.d.). Utility sector reform has triggered private investment in small and medium-sized hydropower plants. Many private small-scale generation projects have been encouraged by the national Renewable Energy Feed-in Tariff (REFiT) programme. REFiT was launched by the ERA in 2007, and the subsequent GET FiT programme was initiated by Germany's Kreditanstalt für Wiederaufbau (KfW) with support from development partners in Norway and the United Kingdom, as well as the European Union (World Bank, 2019; Du Can *et al.*, 2017; ERA, 2012).

Uganda also has considerable potential for solar and wind energy. Solar global horizontal irradiation potential is around 4.37–6.29 kWh/m$^2$/day (IRENA, n.d.) with up to eight hours of sunshine per day (Fashina *et al.*, 2018). This could translate into PV output of between 3.58 and 4.92 kWh/kWp, a potential that remains largely underexploited. Fashina *et al.* (2018) highlight that the majority of solar PV systems in the country were installed through projects supported with government or development partners, many of them driven by Energy for Rural Transformation (ERT), a rural electrification programme supported by the World Bank. The authors estimate the number of institutional and residential solar PV systems at over 30 000, with a cumulative installed capacity of 1.25 MW, mostly in rural areas. More recently, some private public partnerships have been announced for medium-scale solar and wind farms in different regions of Uganda (Takouleu, 2020).

In recent years, the Ugandan government has promoted solar energy through tax breaks and consumer subsidies as well as rural electrification projects. More than 200 companies, including foreign investors, are active in the Ugandan PV and solar thermal field (Environmental Alert, 2018), and this represents an opportunity to utilise more solar technology in cities as well. At present, IRENA data suggest that at least 3% of Uganda's population benefits from Tier 1 energy access[4] either through solar home systems or connecting to a solar mini-grid (IRENA, 2018c); more than 6% of the population uses small scale solar systems for basic energy services such as lighting (IRENA, 2018c). Translating potential into actual applications can be facilitated by various tools, such as IRENA's online solar city simulator that helps to address purchase and lease financing options (see Box 3.1).

In addition to hydropower and solar energy, initiatives such as the Uganda Domestic Biogas Programme and the Africa Biogas Partnership Programme (ABPP)[5] aim to facilitate the emergence of a large-scale biogas sector across the country. Data are scarce, and progress appears to have stalled, although some initiatives have allowed several institutions such as schools to derive energy services from biogas (Christensen, 2014).

By 2016, more than 7 600 households had constructed biogas digesters through the support of the Uganda Biogas Programme as the national implementing agency, giving more than 45 600 people in rural Uganda clean energy for cooking and lighting (EnDev, 2018).

4 The Multi-Tier Framework for measuring household access to electricity classifies access to electricity according to the six attributes of electricity supply. As electricity supply improves, more electricity services become possible. Tier 1 applies where a household has access to task lighting and phone charging (or radio) (see IRENA, 2013).

5 This is a four-year initiative being implemented by Biogas Solutions Uganda (BSU) with technical assistance from SNV Uganda to promote biogas as an alternative source of clean, high-quality energy for cooking and lighting. The waste products from a biodigester also produce organic fertilizer (bioslurry) that can be used to improve household agricultural production. Since its launch in 2010 in Uganda, over 7 600 households have constructed biogas digesters, giving 45 600 people in rural Uganda clean energy for cooking and lighting. Details can be found at Kansiime (2017).

## BOX 3.1 IRENA'S SOLAR CITY SIMULATOR FOR KASESE CITY

IRENA is in the process of demonstrating a pilot solar city simulator for Kasese City. This intends to address purchase and lease financing options for rooftop solar photovoltaic (PV) installations in the city, with three business cases:

- An individual homeowner seeking to compare rooftop PV to alternatives
- An estate promoter investigating the prospects of a small community (group of buildings) being equipped with rooftop solar
- A municipality investigating the cost of different policy options on a broad scale across the entire city

For individual homes and small communities, this simulator allows for the dynamic optimisation of rooftop PV systems in the city and generates several key decision factors, such as total available surface area, installable capacity, generation potential, total investment cost, levelised cost of electricity (LCOE), net present value and savings, among others. The same tool also helps to investigate the long-term benefits of rooftop PV installations in load-shedding situations compared to alternatives (*e.g.*, small gas-fuel generator sets). For municipal authorities, the system optimises installations for the entire city, assuming the best areas are equipped to meet target capacity. It allows for highly simplified simulations of the impact of a limited list of policy options on the viability and affordability of rooftop systems in the community.

Source: IRENA, 2020a.

## RENEWABLE ENERGY AND OPPORTUNITIES FOR UGANDAN CITIES

Cities are increasingly important players in the deployment of renewable energy in Uganda, functioning as centres of demand growth but also as focal points of modern industries and research. As is true for urban areas in other countries, Ugandan cities are regulators, planners, service delivery vehicles and facilitators of development (Ndibwami and Drazu, 2018). These roles were, in principle, strengthened by the devolution of political powers during the 1990s, though their day-to-day capacity to act varies significantly (see Box 3.2).

In the following sections, this report examines the challenges, opportunities and policy experiences of two case studies, the municipalities of Kasese and Lugazi. Kampala, the capital, is by far the largest urban agglomeration, followed by close to ten cities with a few hundred thousand residents each. Lugazi and Kasese are somewhat smaller, each being home to more than 100 000 people. Drawing on the two city cases, the final section offers some thoughts on lessons learnt and possibilities for replicability.

## **BOX 3.2** DEVOLUTION OF POWERS AND CITY-LEVEL GOVERNANCE IN UGANDA

The ability of Ugandan cities to shape local energy policies has expanded since the country took steps to decentralise its political system – first through a presidential policy statement in 1992, and later in the 1995 constitution and operationalised in the Local Government Act of 1997. The objective was to devolve functions, powers and services to local levels. These changes were driven by the recognition that long-term development challenges such as poverty reduction and greater socio-economic opportunities require more dynamic political processes, including more empowered local communities.

A wide range of powers, responsibilities and functions were subsequently transferred to local governments at the district level and lower, including cities, municipalities and town councils. The devolved responsibilities include planning, management, legislation, local administration of justice, allocation of resources and the promotion of local economic development (MoLG, 2014).

Municipalities and town councils are the principal decision-making bodies at the city level. As of September 2019, Uganda had 134 districts, 41 municipalities and 422 town councils (Kahungu, 2018; MoLG, 2019). Municipal councils are administrative units within the local government structure, composed of executive committees drawn from all divisions in the area, a mayor and a deputy mayor (CLFG, 2018).

A municipality holds powers of self-government and jurisdiction, including planning and legislative powers such as the right and obligation to formulate, approve and execute their budgets and plans, provided the budgets are balanced (Mugerwa, 2016). Consistent with national development priorities, municipalities can also initiate local regulation for renewable energy deployment; levy, charge and collect revenues; and borrow money or accept and use a grant or assistance for energy development.

Typically, municipalities incorporate not only urban areas but also surrounding semi-rural and rural areas. As a consequence, municipal policies are not by definition urban centric, but often involve careful consideration of the needs of both urban and rural populations.

With regard to energy policy making, a municipality or town council has the power to:

- Formulate policies and strategies for renewable energy development.
- Initiate and maintain programme relations with third-party non-governmental organisations.
- Provide incentives for adoption of renewable energy technologies.
- Make by-laws, which if well designed would promote renewable energy.
- Own and procure, by deploying renewable energy projects on municipally owned land, for instance, solar streetlights.


Kampala

# CASE STUDY 3: KASESE

## BACKGROUND

Kasese is a largely urban settlement in southwest Uganda, on the border with the Democratic Republic of the Congo. With a population estimated at about 130 000, including people in the surrounding rural and semirural areas, Kasese is governed by Kasese Municipality. It is the largest city in the district (see Figure 3.3) and Uganda's tenth most-populous town – after Kampala, Nansana, Kira, Makindye Sabagabo, Mbarara, Mukono, Gulu, Lugazi and Masaka (Ndibwami and Drazu, 2018). Kasese Town Council became a municipality in 2010, encompassing the divisions of Bulembia, Nyamwamba and the Central Division, which means the population of Kasese lives in a coherent geographic area – common for administrative structures throughout Uganda and sub-Saharan Africa.

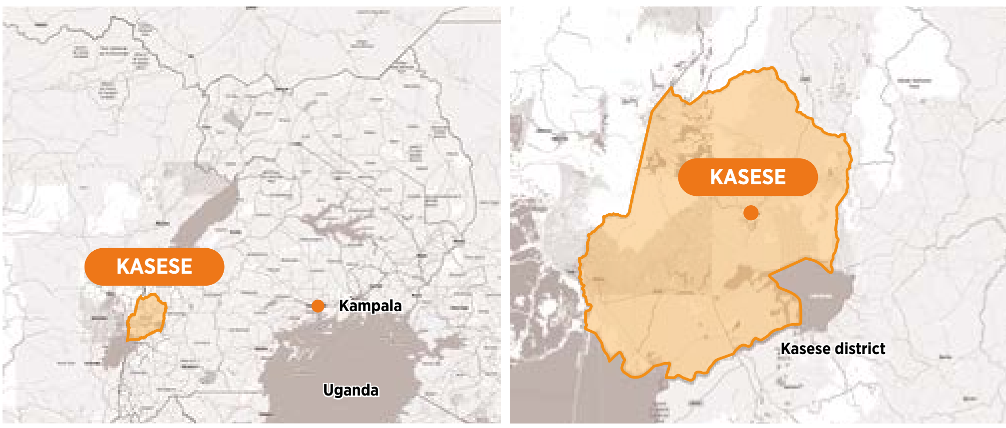
Kasese's population expanded by about 18% between 2002 and 2014 (Binego, 2014; UBoS, 2014), reflecting Uganda's countrywide trend of very fast population growth as well as high rates of rural–urban migration. Much of this urbanisation is a result of increased economic activity tied to trade, mining and agriculture. In addition, conflict and insecurity in the neighbouring Democratic Republic of the Congo have compelled many people to migrate to Kasese and the surrounding areas.

Historically a trade hub close to the eastern districts of the Democratic Republic of the Congo, Kasese is becoming more industrialised; small- and medium-scale agro-processing enterprises and a newly created industrial park all contribute to its status as an economic centre in Kasese District. The city is also a gateway for tourists visiting the popular Queen Elizabeth National Park and Rwenzori National Park (KDLG, 2013).

## Energy consumption in Kasese

Kasese suffers from a continued gap in access to electricity and other types of modern energy. A 2017 report estimates that over half of all households have no electricity, compared with estimated nationwide urban electricity access rates of around 60% (SE4ALL, n.d.). Traditional biomass in the form of firewood and charcoal provides a large share of Kasese's non-transport energy needs among households and commercial establishments (McCall, Stone and Tait, 2017) (see

**Figure 3.3 Kasese City, 2018**




Source: © OpenStreetMap contributors | For visual purposes, maps are on different scales.

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

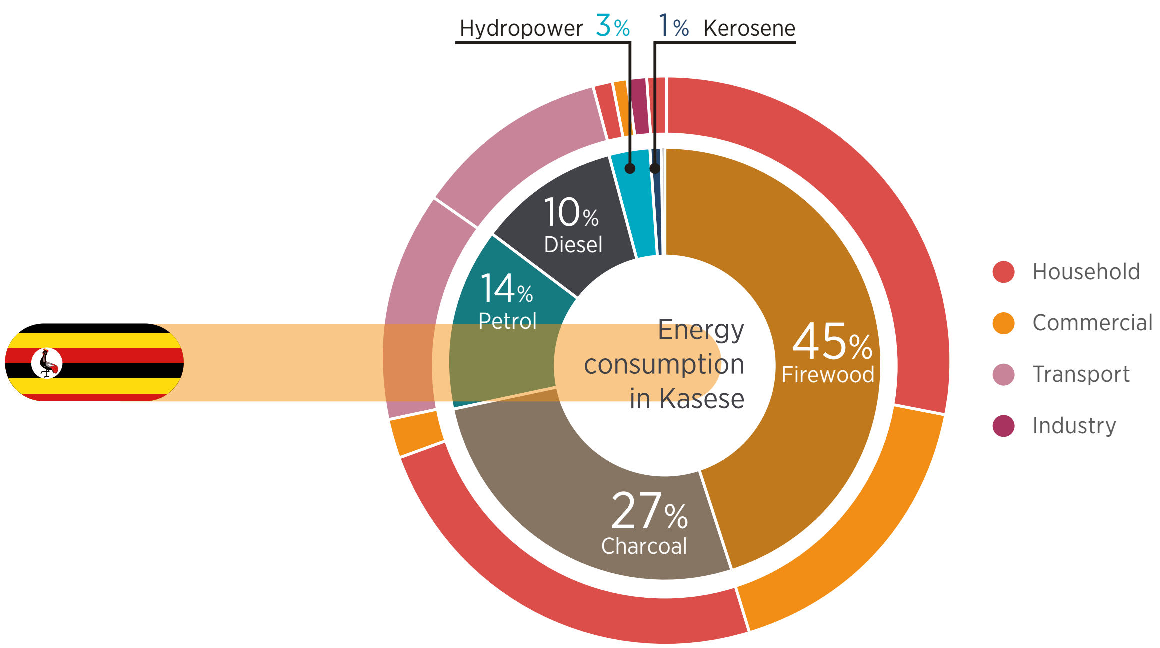
Figure 3.4). The heavy use of charcoal in particular entails considerable environmental challenges, in addition to deforestation caused by heavy fuelwood use (Ndibwami and Drazu, 2018). Transport energy use is dominated by petrol and diesel. Electricity use remains low due to absent or unreliable electricity supplies and the high cost of energy relative to incomes (KDLG, 2013). Over 55% of all energy in Kasese City is consumed by the residential sector, followed by transport and commercial consumers, with limited industrial activity.

The potential for modern renewable energy in Kasese is considerable, in particular for solar energy and small-scale hydropower. Small-scale hydropower has historically been used for power generation, with Kasese District being considered the hydropower capital of the country, given the number of projects developed and commissioned since the 1950s to date. Some 48 MW of dams are operational; another 7.8 MW are under construction and 21 MW are proposed (MEMD, 2015; ERA, 2019). Home to several rivers (the Mubuku, Nyamwamba, Rwimi, Nyamughasani, Kyanyampara and Lhubiriha), Kasese boasts many suitable sites for further development. Like the rest of Uganda, Kasese also offers excellent resource potential for solar power solutions, as demonstrated in past pilot schemes (*e.g.*, WWF-UCO 5th Annual Energy Symposium, 2013).

## Deploying renewable energy in Kasese

Both Kasese district government and Kasese Municipality have been active proponents of local renewable energy deployment in Uganda (Baluku, 2015). Renewable energy forms part of the local governance focus on sustainable development, where access to modern energy is promoted as an important enabler for progress in other development areas such as health, education and the fight against poverty (KDLG, 2013). International initiatives combined with local stakeholder engagement have carried renewable energy into policy making in Kasese. Key initiatives regarding this goal include the Kasese District Renewable Energy Strategy emerging out of the Champion District Initiative, and Kasese's Municipal Sustainable Energy Strategy arising out of the Supporting African Municipalities in Sustainable Energy Transitions (SAMSET) project. Efforts also include a set

**Figure 3.4 Energy consumption in Kasese, by source and sector, 2018**




Source: Ndibwami and Drazu, 2018.

of incentives for residents and businesses, promotion of community-focused financial institutions, support for local champions and greater awareness of renewable energy opportunities among residents. These are explored below in more detail.

Kasese's renewable energy initiative has been driven by a network of stakeholders. Table 3.1 provides an overview, followed by a brief discussion of major local, national and international actors, plus research institutions. As the table shows, the regulatory dimension involves a large number of institutions, indicating a level of complexity that could become an obstacle to effective policy making in the absence of effective co-ordination. A few actors stand out given their multiple roles and thus greater influence over renewable energy development.

**Table 3.1 Roles of stakeholders in Kasese's renewable energy deployment**

| Roles | Stakeholders | Government | Local | Donor | NGOs |
|---|---|---|---|---|---|
| **Policy, co ordination and oversight** | Kasese district local government, Kasese municipality | | X | | |
| **Regulations, standards and quality** | Ministry of Energy and Mineral Development (MEMD), Electricity Regulatory Authority (ERA), National Environment Management Authority (NEMA), Directorate of Water Development (DWD), Kasese district local government, Uganda National Bureau of Standards (UNBS), Centre for Research in Energy and Energy Conservation (CREEC), Centre for Integrated Research and Community Development Uganda (CIRCODU), Uganda National Renewable Energy and Energy Efficiency Alliance (BEETA) and international partners (World Wide Fund for Nature, WWF). | X | X | X | |
| **Policy support, implementation and capacity building** | BEETA, community-based organisations (CBOs), MEMD, Private Sector Foundation (PSFU), Uganda Investment Authority (UIA) and international partners. | | | X | X |
| **Financing** | Development partners including the World Bank, national banks, MEMD, WWF and savings and credit co-operative organisations (SACCOs). | | | X | |
| **Awareness, mobilisation and promotion of renewable energy** | Kasese district local government, Kasese municipality, CBOs, cultural institutions, international stakeholders, local media, universities, think tanks and associations such as CREEC, CIRCODU and BEETA. | | X | | X |
| **End-user technology access** | CBOs, suppliers, SACCOs and telecommunication companies. | | | | X |

Source: Original compilation based on KDLG (2013).

Note: This list of stakeholders is indicative and not exhaustive, providing only a snapshot of institutions that have contributed in different ways to local renewable energy deployment.

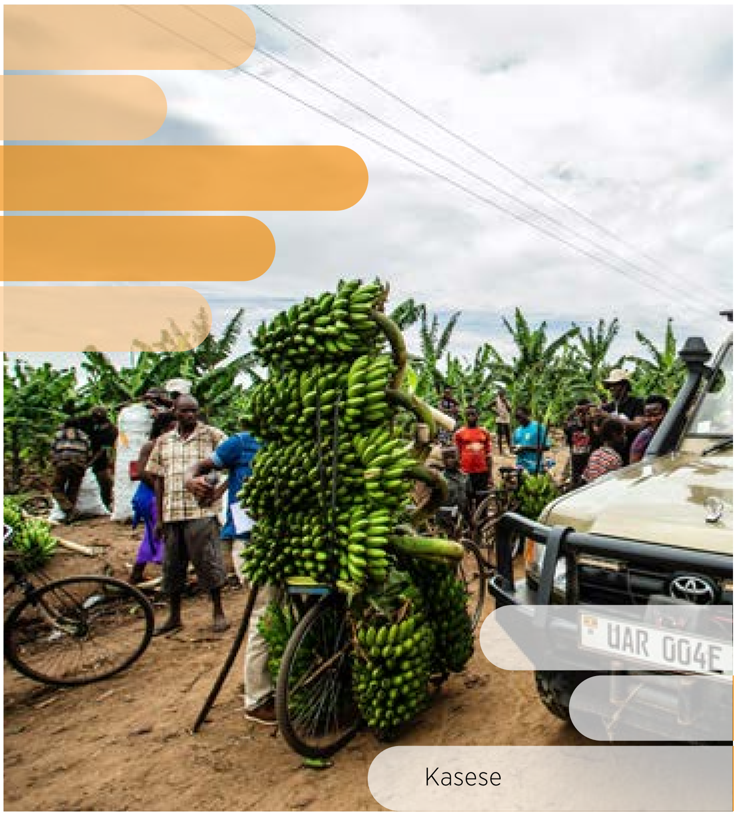
## Roles of Kasese District

Kasese's district-level government has been instrumental in supporting renewable energy deployment throughout its territory, specifically by overseeing funds and co-ordinating the implementation of the Kasese District Renewable Energy Strategy (KDRES); working together with national stakeholders on the implementation of regulatory frameworks and contributing to the promotion of renewable energy districtwide through awareness campaigns and high-level support. The district government has co-ordinated co-operative efforts with international partners such as the WWF.

### *Target setter and planner*

In 2012 the **Kasese District Council launched the Kasese District Renewable Energy Strategy (KDRES 2013–2020)**, a 100% renewables programme with the aim of bringing access to clean energy services to all local households by 2020 (KDLG, 2013). The programme aims to integrate renewable energy access into all government-funded projects and institutions, including schools, health centres, markets and other public infrastructure. The strategy specifically sets the following targets, expressed in terms of annual growth rates:

1. Number of institutions accessing clean renewable energy: +20%
2. Number of renewable energy enterprises in the district: +20%
3. Number of households accessing modern renewable technology: +10%
4. Number of local industries using renewable energy technology: +10%



Kasese

The strategy emerged out of the multipartner clean energy **Champion District Initiative (CDI)** (see Box 3.3), funded by the WWF through the District Energy Access Programme and now implemented by both the Kasese District local government and Kasese City. The strategy highlights wider socio-economic objectives, aiming for "a socio-economically empowered community accessing and utilising renewable energy technologies in place" (KDLG, 2013).

Despite the special focus on the rural poor, all residents of Kasese District are potential beneficiaries of the district renewable energy strategy and the CDI. The city has (1) actively lobbied relevant government agencies to abolish or reduce taxes on renewable energy technologies and equipment so that the uptake of renewable energy can be increased; and (2) adopted the district energy strategy to serve as a guide for its own transition trajectory (Ndibwami and Drazu, 2018).

## BOX 3.3 THE CHAMPION DISTRICT INITIATIVE (CDI), 2012–2016

CDI was a district-led, demand-driven and multi-stakeholder initiative to promote renewable energy access at the district level in Uganda. It was implemented between 2012 and 2016 by the World Wide Fund for Nature's Uganda Country Office (WWF-UCO), with technical support from other WWF country offices (WWF-UCO, 2017).

Kasese was selected in 2013 as the initiative's first Clean Energy Champion District. The CDI's ultimate objective was not only to increase access to renewable energy services for cooking and lighting but also to demonstrate solutions harnessing renewable energy, increasing energy efficiency and enabling access to modern energy services for all (WWF-UCO, 2017).

The project included support from a coalition of international development organisations, including Access2innovation, WWF Nordic, WWF China, WWF Global Climate and Energy Initiative and WWF Uganda.

The CDI has made noteworthy progress in meeting its targets of demonstrating the viability of replicable renewable energy access projects. For instance, a 5 kW mini-grid piloted in 2014 under the CDI was developed in the Kayanzi fishing village (see images) (Nygaard *et al.*, 2018; WWF, 2018), to provide electrical power to households and businesses, mainly for lighting (Pedersen, 2016). WWF-UCO, with funding from the European Union and the Rural Electrification Agency (REA), has also been developing six mini-grids in Kasese and the neighbouring Rubirizi districts to supply electricity to 900 households and 2 000 businesses (WWF, 2018).

**Solar mini-grid installed in the village of Kayanzi**

***Regulator and project financier***

A number of district-level financial and regulatory incentives support the use of renewable energy. Kasese District has implemented tax breaks/waivers on business license costs and abolished taxes and levies on businesses dealing in RETs (Ndibwami and Drazu, 2018; Environmental Alert, 2018). Not all products are included, as the regulatory framework focuses on SHS and tax incentives only apply to companies that have registered with the Uganda Solar Energy Association (Malinga, 2019; Cardoso, Mugimba and Maraka, 2018).

Kasese has been promoting savings and credit co-operative organisations (SACCOs) and community-based organisations (CBOs) as local mechanisms to finance home-based renewable energy systems (see Box 3.4). SACCOs provide access to members and work with financial institutions and their partners to get approval for solar loans including by collecting regular payments. For example, Kasese People's SACCO offers members who are able to save 20% of the cost of RETs to pay for the remaining 80% in instalments (Environmental Alert, 2018). Some funds are also provided by international development aid organisations, for example, WWF-UCO, with the aim of reducing the risk of private-sector players in hard-to-reach areas (Environmental Alert, 2018).

## **BOX 3.4** EXPLAINING SACCOs AND CBOs

Uganda has seen the development of various community-focused organisations that cater to the specific needs of low-income communities.

Uganda's **savings and credit co-operatives (SACCOs)** are financial community-level organisations that provide micro-finance solutions for a variety of local goods and services. SACCOs offer savings opportunities for their members and channel savings into loans that in turn allow micro-level lending. SACCOs are member-driven organisations, where members agree to save their money together and offer loans to one another at reasonable rates of interest. Interest is charged on loans, to cover the interest cost on savings and the cost of administration.

**Community-based organisations (CBOs)** are non-profit associations that work at a local level to improve the life of residents in all spheres, including health care, environmental health, education and energy.

## Roles of Kasese Municipality

***Target setter and planner***

Kasese Municipality has been an active proponent of renewable energy. Using district-level and international initiatives as a vehicle, it has promoted renewable energy through its own strategy and self-funded initiatives. The municipality has also been instrumental in providing training in the installation, maintenance and distribution of renewable energy technologies; and fostering partnerships between international non-govermental organisations (NGOs) such as the WWF and local entrepreneurial businesses (Mukobi, 2015).

Following the Kasese District Renewable Energy Plan, Kasese Municipality launched its own sustainable energy strategy in 2017 (Ndibwami and Drazu, 2017), an outcome of the SAMSET project that ended earlier in the decade (see Box 3.5). Kasese's sustainable energy strategy aims to support the municipality's vision of becoming "a well-planned, clean, green and poverty free municipality by 2025", specifically by promoting renewable energy and energy efficiency through direct policy and communication (KDLG, 2013).

The development of the municipal sustainable energy strategy was premised on the availability of various alternative sources, notably solar and hydro, the strong political will of municipal council leaders and subsequently the support of the mother district, Kasese (Ndibwami and Drazu, 2017). It is hoped that with the strategy's implementation, Kasese City will have not only the tools but also the capacity – the network and a model structure – to position itself as a champion in urban sustainable energy transition in western Uganda (Ndibwami and Drazu, 2017).

### **BOX 3.5** SUPPORTING AFRICAN MUNICIPALITIES IN SUSTAINABLE ENERGY TRANSITIONS (SAMSET)

In operation from October 2013 to September 2017, SAMSET was funded by the United Kingdom through the Engineering and Physical Sciences Research Council (EPSRC), the Department for International Development (DFID) and the former Department of Energy and Climate Change (DECC). Its objective was to develop a knowledge exchange framework for supporting local and national bodies involved in municipal energy planning in the effective transition to sustainable energy use in urban areas. At the core of the SAMSET project was the promotion of responsible use of and access to clean energy, empowering local communities to thrive on their own (Ndibwami and Drazu, 2017).

In addition to Kasese City, SAMSET involved five other cities in three African countries: Ghana, Uganda and South Africa. Through engagement with universities,[6] businesses and non-governmental organisations, the SAMSET project helped Kasese fill various data gaps in the energy sector; conducted capacity building through various continuous professional development courses; encouraged international exchange visits by Kasese City staff and expanded the municipality's network of contacts both locally and internationally (Ndibwami and Drazu, 2018). The project also resulted in the development of several reports, including reports on existing and projected energy uses and sources, policy case studies, technical briefs and guidelines for implementation of renewable energy across the city.

6 University College London (UCL) administered the programme on behalf of Sustainable Energy Africa (SEA) – Scientific Lead, Uganda Martyrs University, University of Ghana, University of Cape Town, University of Sheffield and Gamos Limited. Project details can be found at http://samsetproject.net/.

The Kasese Municipal Council established a one-stop centre that brings together the government, the private sector, and NGOs to showcase opportunities/services they offer to boost renewable energy financing to local communities. This initiative has attracted banking institutions, the Uganda Revenue Authority, the Micro Finance Support Centre and SACCOs. In addition, Kasese Municipality allocated 20 acres of land for investors interested in solar plants (Environmental Alert, 2018), and provided training in the installation, maintenance and distribution of RETs.

Aiming to increase access to solar energy among both residents and small businesses, Kasese Municipality has also participated in the Solar Loan Programme run by the Uganda Energy Credit Capitalisation Company (UECCC). UECCC is a government agency put in place to facilitate investments and provide credit support for renewable energy projects in Uganda (UECCC, 2016). With a particular focus on enabling private-sector participation, the company's main objective is to provide financial, technical and other support for renewable energy development in Uganda.

UECCC also runs a credit support facility that provides financing to energy products and/or programmes. In Kasese City and the surrounding districts of Hoima and Kabarole, UECCC has established linkages with grassroots financial institutions such as SACCOs and other micro-finance institutions, in order to extend solar loans to households and commercial enterprises. UECCC's credit support facility encompasses three components:


Uganda

a) **A solar loan product,** available to micro-finance institutions, institutions that accept micro-finance deposits, commercial banks and credit institutions primarily engaged in micro-lending licensed by the Bank of Uganda (UECCC, 2016). The facility is a short-term loan aimed at facilitating the acquisition and installation of SHSs by households and businesses and seeks to overcome the barrier of high upfront costs (UECCC, 2016). The value of loans ranges from UGX 100 000 (USD 27), roughly equivalent to a small multi-function solar home lighting system, up to a maximum of UGX 20 million (USD 5 440), which could fund one integrated solar street light and a solar water heater. Features of two loan types offered through the financing facility are provided in Table 3.2.

b) **A power connection loan programme.** The Government of Uganda's Free Electricity Connection Policy/Programme has set an annual target of 300 000 grid connections. Because of the progress made in extending and deploying renewable energy in the city, Kasese City was the launching pad for the programme on 14 August 2018. Through its Connection Loan Programme, UECCC has extended financing to households and commercial enterprises in the city, helping to overcome the problem of upfront costs and also subsidising connection costs under the condition that households take charge of their own wiring.[7]

c) **A solar vendors' working capital facility.** This facility targets solar companies selling solar systems on pay-as-you-go, pay plan and cash business models in Kasese. Working capital loans support the purchase and import financing of SHSs, including taxes, import duties, transport costs and clearing (Von Hülsen, Koch and Huth, 2016).

7 The distribution infrastructure alone is not sufficient in promoting electrification. One key factor in the electrification equation is the high cost charged by distribution companies to connect a customer, as well as the cost for house wiring. The minimum wiring costs for a small house are estimated at about USD 90 (about UGX 333 498). These expenditures are well beyond the average monthly income of a household, which is less than USD 50 (about UGX 185 276).

**Table 3.2 Features of solar loans offered by Uganda's credit support facility based on two examples**

| | Cente Solar Loan (Centenary Bank) | POSTBANK Solar Loans (POSTBANK) |
|---|---|---|
| **Features** | • Loan amounts from UGX 100 000 to UGX 20 million for a period of 6–24 months, for up to 70% of the purchase/installation price<br>• Loan application processing within 48 hours<br>• Regular and flexible repayment plans based on borrower's cash flow<br>• Government subsidy for clients located 100 metres or farther from the grid | • No loan amount restriction<br>• Fast loan processing<br>• Flexible repayment period of up to 36 months<br>• No penalty charged on early payments<br>• Individuals will only pay up to 70% of the cost of the solar system; 30% subsidy by the Rural Electrification Agency (REA)<br>• Guarantee on the system (batteries and panels) |
| **Loan requirements** | • Proof of regular income<br>• Secured with a combination of securities: moveable, immoveable and guarantors | • Proof of regular income<br>• Cash deposit of 20% of the cost of the loan |

Source: Authors' compilation based on original bank documents.

Note: Centenary Bank has partnered with Kasese City and several NGOs in the municipality to provide loans for renewable energy, especially solar and cook stoves, by contributing 50% of the loan pool from UECCC towards acquisition of solar systems and working capital for companies. It also provides a specific loan facility, Cente Solar, to finance standalone solar systems. Dedicated bank staff manage the bank's relationship with UECCC and the REA.

Renewable energy deployment has been supported by national-level stakeholders, particularly in regulatory issues, over which in some cases neither Kasese Municipality nor the Kasese district local government has authority. While the national regulatory framework for renewables does not in itself target urban development per se, it is an important element of the policy framework under which municipalities operate. The national level has also been instrumental in facilitating the development of financial channels, the collection and provision of data and the forging of partnerships with international NGOs – all areas where municipalities in Uganda have no mandate or capacity. So effective action at the national level not only complements but also drives local-level action.

In addition to political stakeholders, renewable energy deployment in Kasese has benefited from a range of local, district-level and national stakeholders, including CBOs, national and local banks, SACCOs, local cultural institutions and the media.

## The role of International partners and NGOs

International partners have been critical enablers of renewable energy deployment in Kasese. Usually funded as part of wider sustainable energy and development initiatives, renewable energy has benefited from numerous plans and programmes designed, partly implemented and often financed by international partner organisations. Key examples include the CDI and SAMSET initiatives (see discussion above), but also smaller schemes, for instance, subgrants by NGOs, such as funding by the WWF, to help fund instalment plans for solar systems.

National NGOs have also played an important part in providing training and financing for schemes to support renewable energy deployment. Examples include the provision of affordable payment options through instalment payment schemes for solar PV panels and improved cookstoves, green business creation, training young people and women and providing minimal startup capital support for locally produced briquettes, improved cookstoves and tree nurseries. Both initiatives were funded by Kasese's Conservation and Development Agency, a local NGO (Ndibwami and Drazu, 2018).

## The role of national research institutions

In addition to the above, Kasese's renewable energy plans (most of them at the district level) have benefited from the involvement of national research institutions in the collection of data and provision of analysis. Key institutions include the Centre for Research in Energy and Energy Conservation, Centre for Integrated Research and Community Development Uganda and Uganda National Renewable Energy and Energy Efficiency Alliance (Ndibwami and Drazu, 2018). The output of the SAMSET initiative, including Kasese's first Municipal State of Energy Report in 2017, was produced at the Uganda Martyrs University. These institutions play an important role in filling a gap left by the capacity shortages of local governments across Uganda.

# CASE STUDY 4: LUGAZI

## BACKGROUND

Located approximately 50 km east of Kampala, Lugazi is the second-largest urban area in Buikwe District, Uganda, with an estimated population of 126 100 people (see Figure 3.5) (UBOS, 2018). As is true for all local governments in Uganda, Lugazi Municipality represents a diverse territory that includes three urban centres – Lugazi Town and, since 2015, Kowolo and Najjembe – as well as surrounding villages (BDLG, 2016b). Lugazi Town's core population is around 38 000 people, though rural–urban migration will translate into a growing urban population in coming decades (BDLG, 2016b). The local economy has historically been dominated by the sugar industry. A large sugar factory and associated industries remain the largest employers, providing jobs to over 7 000 people in the municipality and livelihoods to 6 000 growers (personal communication with industry representatives).

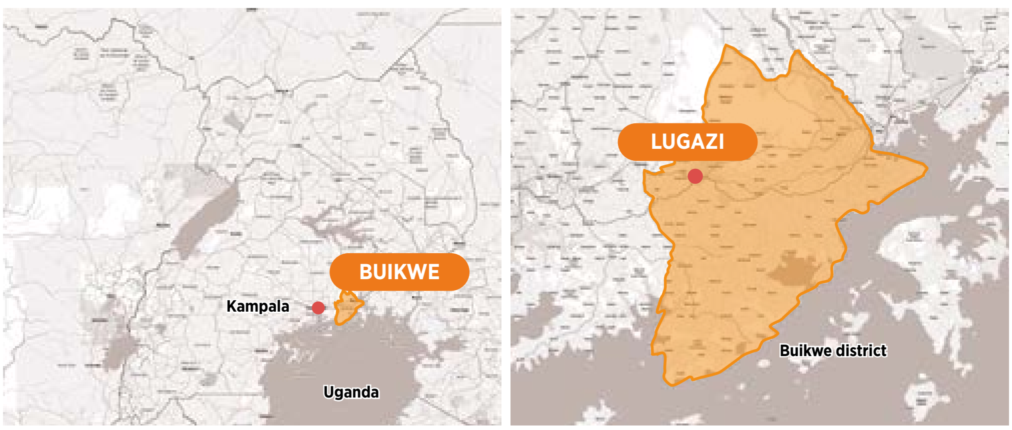
## Energy consumption in Lugazi

Energy consumption in Lugazi is dominated by traditional sources of energy, paraffin tadoobas and lanterns. Only around 37% of households in Lugazi have access to electricity[8] (see Figure 3.6). In Lugazi's Central Division, home to the city's urban core, electricity accounts for 66% of households' energy use for lighting, reflecting better infrastructure than in surrounding areas. There are no data on wider energy use, including of businesses and industries, and no separate data for cooking in Lugazi, disaggregated from what is available for the Buikwe District as a whole. This lack of data highlights the difficulty of assessing the market for different types of energy in many parts of Uganda.

Like the rest of Uganda, Lugazi is located in a region rich in renewable energy sources, including hydropower, solar energy and bioenergy. Buikwe District hosts a 180 MW hydroelectric power station on the Nile at

8 Based on data collected from the Buikwe district local government.

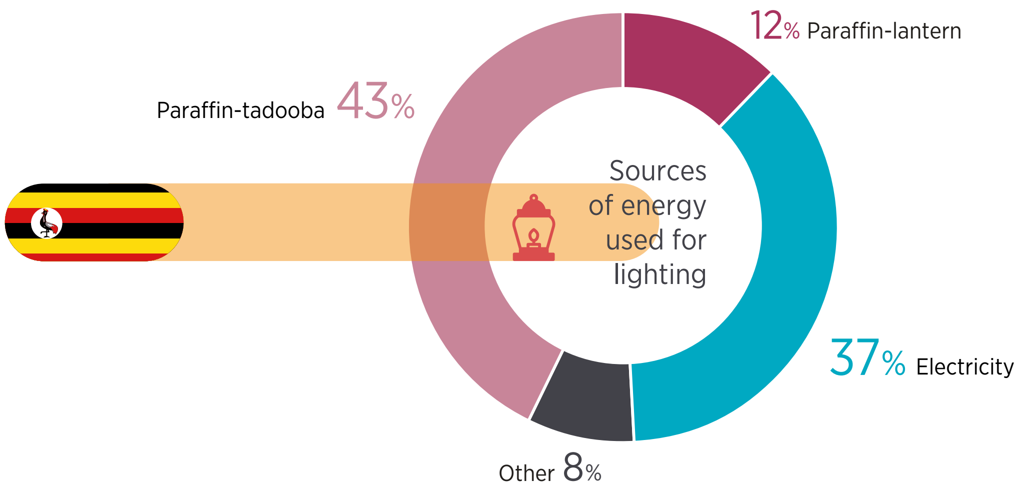
**Figure 3.5 Lugazi Municipality, 2018**




Source: © OpenStreetMap contributors | For visual purposes, maps are on different scales.

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

**Figure 3.6 Main sources of energy used for lighting in Lugazi, by number of households, 2014**




Source: BDLG, 2016a

Nalubaale. Among the potential hydropower locations in the area are Sezibwa Falls (Ngogwe), Mubeya Falls and Griffin Falls on the Musamya River in the Mabira Forest (Adeyemi and Asere, 2014).

Some 1100 households (4% of Lugazi's total) use SHSs. A small number of solar panels have been fitted on roofs of local hospitals, but all in all solar energy remains largely underexploited. Rural electrification projects and policy incentives are encouraging increased uptake (BDLG, 2015, 2018). Solar water pumps are used in small numbers in other parts of Buikwe District but have not yet entered Lugazi's market.

Given that a large portion of households make a living in crop production, crop residues and farm waste can play a major role in energy generation (Mboowa *et al.*, 2017; BDLG 2016b). Lugazi's largest industry, the Sugar Corporation of Uganda, has established a bagasse-fired co-generation plant with a capacity of 9.5 MW (MEMD, 2015). Further, an innovative initiative, Eco-Fuel Africa, converts farm and municipal waste into briquettes and biochar fertiliser, using simple, low-cost and easy-to-use technologies and with a good understanding of local fuel usage conditions (Gebrezgabher and Niwagaba, 2018).

## Deploying renewable energy in Lugazi

The smaller degree of renewable energy deployment in Lugazi compared with Kasese reflects a smaller number of stakeholders engaging in local initiatives. The availability of financing and of skilled local human resources for renewable energy initiatives has been a particularly limiting factor, which has also affected the ability of the municipality to engage in least-cost initiatives such as awareness raising. A decisive role in promoting local renewable energy deployment in Lugazi has been played by district-level planning and external development funding tied to nationwide infrastructure development, with support by a willing, but in many ways constrained, local government. Notable is the exceptional role played by local commercial renewable technology companies in Lugazi, which have turned into important bottom-up stakeholders (Table 3.3) The roles of each of the relevant stakeholders are discussed in the next sections.

**Table 3.3 Roles of stakeholders in Lugazi's renewable energy deployment**

| Roles | Stakeholders | Government | Local | Donor | NGOs |
|---|---|---|---|---|---|
| **Policy, co-ordination and oversight** | Buikwe district local government, Lugazi municipality | | X | | |
| **Regulations, standards and quality** | Ministry of Energy and Mineral Development (MEMD), Electricity Regulatory Authority (ERA), National Environment Management Authority (NEMA), Directorate of Water Development (DWD), Uganda National Bureau of Standards (UNBS), Centre for Research in Energy and Energy Conservation (CREEC), Centre for Integrated Research and Community Development Uganda (CIRCODU), Uganda National Renewable Energy and Energy Efficiency Alliance (BEETA) | X | X | X | |
| **Policy support, implementation and capacity building** | Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA), Renewable Energy Association (solar, biomass, etc.), Uganda Solar Energy Association (USEA) and Makerere University | | | X | X |
| **External project support, financing and capacity building** | World Bank (Uganda-wide USMID project finance), Royal Norwegian Society for Development (Norges Vel), GIZ and Energy4Impact. | | | X | X |
| **Awareness, mobilisation and promotion of renewable energy** | Buikwe district local government, Lugazi Municipality and international partners | | X | | X |
| **End-user technology access** | Commercial companies | | | | X |

Source: IRENA analysis.

Note: This list of stakeholders is indicative and not exhaustive, providing a snapshot of institutions that have contributed in different ways to local renewable energy deployment.

## Roles of Buikwe district government

### *Target setter and financier*

With support by Lugazi Municipality, renewable energy deployment in Lugazi has so far been largely driven by the Buikwe district government's **District Development Plan (DDP)**. Formulated in 2015 for the period 2015–2020, with the ultimate objective to improve the quality of life of people, promote sustainable enterprise and achieve a more equitable utilisation of resources (BDLG, 2015). Relevant to the promotion of renewable energy, the development plan provides funds for infrastructure development across the district of approximately UGX 55 million (approximately USD 20 000 in 2015[9]), including for the provision of streetlights for all urban authorities in Buikwe District including Lugazi (see Box 3.6). The plan also aims to promote the use of alternative sources of energy such as solar PV and biogas by 60% of the district's rural population, and to support the acquisition of solar-powered irrigation systems for small-holder farmers.

### *Financier and operator*

Another area of direct engagement by Buikwe District is through the installation of solar street lighting. Solar street lighting has a cost-saving potential while contributing significantly to public safety and an improved business environment (see Box 3.6). The Buikwe District local government has been working together with the four urban councils in the district including Lugazi on an initiative to install solar streetlights. A study to map the lighting needs of all urban councils across the district (conducted by the district local government in partnership with a private firm) resulted in the 2016/2017 Solar Street Lighting Project in Lugazi City, the first of its kind in the municipality where 22 streetlights were installed, with local funds mobilised locally. With the introduction of solar street lighting in Lugazi, trade in goods and services increased because small businesses and retail activities were now possible after sunset.

Lugazi

Although the installation of streetlights is in its early stages, the district council continues to evaluate the potential to scale up the project to service all areas in Lugazi and in other urban councils (MoFPED, 2018). The Buikwe district local government puts the number of streetlights still needed to cover basic needs in Lugazi Municipality at 294, of a total of 958 needed across the district (BDLG, 2016a).

Lugazi receives funding through the World Bank's Uganda Support to Municipal Infrastructure Development Programme (USMID). This countrywide programme aimed at enhancing institutional performance and improving service delivery in urban centres, including road construction and street lighting (see images). Channelled through the Ministry of Lands, Housing and Urban Development, Lugazi Municipality has been awarded UGX 2.6 billion (approximately USD 685 000) for five years, with payment contingent on annual performance requirements (Kissa, 2019).

9 Currency conversion as of 1 January 2015. The Ugandan shilling fluctuates considerably in value relative to the US dollar, affecting the value of foreign development aid and loans depending on the time of disbursement.

## **BOX 3.6** SOLAR STREET LIGHTING IN UGANDA

A 2019 study of solar streetlights installed in Kampala and Jinja found that such lights offer considerable local benefits to the community and businesses. They create safer streets and allow small businesses to stay open for an extra five hours per day. This is particularly important for low-income groups who can now make more money in the day.

The cities themselves save considerable costs compared with conventional lighting systems. The average cost is around USD 1600 per solar streetlight pole, with almost no operating costs, compared to USD 2150 for a conventional streetlight pole, which additionally incurs large electricity bills and higher maintenance costs because their bulbs need to be replaced more frequently.

The study concludes that

> In Jinja, solar street lighting could pay for itself through the money saved on electricity bills and generated from advertising space on poles, with the extra street lighting stimulating economic activity in more parts of the city. In Kampala, this could be particularly significant.
>
> (...) Strengthening the night-time economy in cities by providing safe spaces for workers and street lighting could therefore provide substantial benefits to national governments by stimulating inclusive national economic growth. (...)
>
> Solar-powered street lighting could also be adopted by other urban centres across Uganda as a partial solution to the high electricity costs and low revenue collection that has hampered local governments and the country's decentralisation agenda.

Moreover, the authors find that it would be at least UGX 224 billion (approximately USD 60 million) cheaper to install solar streetlights rather than conventional ones in urban areas in Uganda; and that some 14 000 more jobs could be created nationwide thanks to extended trading hours. This makes solar street lighting a high-potential investment for urban centres in Uganda that would benefit from strengthened policy focus and financing.

**Solar streetlights in Lugazi**

Source: Gillard *et al.*, 2019

## The role of national-level stakeholders

As is the case in Kasese, national institutions play an important role in shaping local energy supply and market structures in Lugazi. National policy frameworks, strategies, projects and programmes shape the deployment of modern renewable energy, and central government financial allocations determine district-level and municipal finances in the absence of local governments' own capacity. National planning also sets out policy objectives and priorities, offering local governments an opportunity to utilise national targets in local discourse for the purpose of policy making and awareness creation. Renewable energy deployment in Lugazi benefits indirectly from support of national institutions and the private sector, such as UNREEEA, REA (solar, biomass, etc.) and USEA. Lugazi's ability to benefit from World Bank funding for sustainable infrastructure projects (USMID) was also determined by national-level actors, specifically the Ministry of Lands, Housing and Urban Development, which allocates the districts and municipalities to receive development funding.

In order to make solar equipment more affordable, the Ugandan government has exempted it from value added taxes (VATs) and abolished import duty under the East African Community framework.[10] Through the REA, the government recently announced a 45% subsidy, promoted through microfinance institutions, and NGOs that provide a cash payout to those who install the solar systems or lend money that is paid back in instalments (Kulabako, 2013).

Promotional campaigns of the Ministry of Energy and Mineral Development (MEMD) include an annual energy week and a sustainable energy campaign that aims at promoting demand side management through renewable energy and energy-efficient technologies and practices. The campaign encourages district local governments and urban councils to set up renewable energy policy frameworks to increase the uptake of renewable energy.

10 Uganda exempts some solar equipment from import duty and VAT, specifically the supply of photosensitive semi conductor devices, including PV devices, whether or not assembled in modules or made into panels; light emitting diodes; solar water heaters, solar refrigerators and solar cookers; and solar power generation (UIA, n.d.; URA, 2017). Specialised equipment and accessories for the development of solar and wind energy including accessories, spare parts, deep cycle batteries which use and/or store solar power and plastic bag biogas digesters are also exempt from import duties and taxes under the fifth schedule of the East African Community Customs Management Act. This also includes penstock pipes for use in hydropower projects (UIA, n.d).

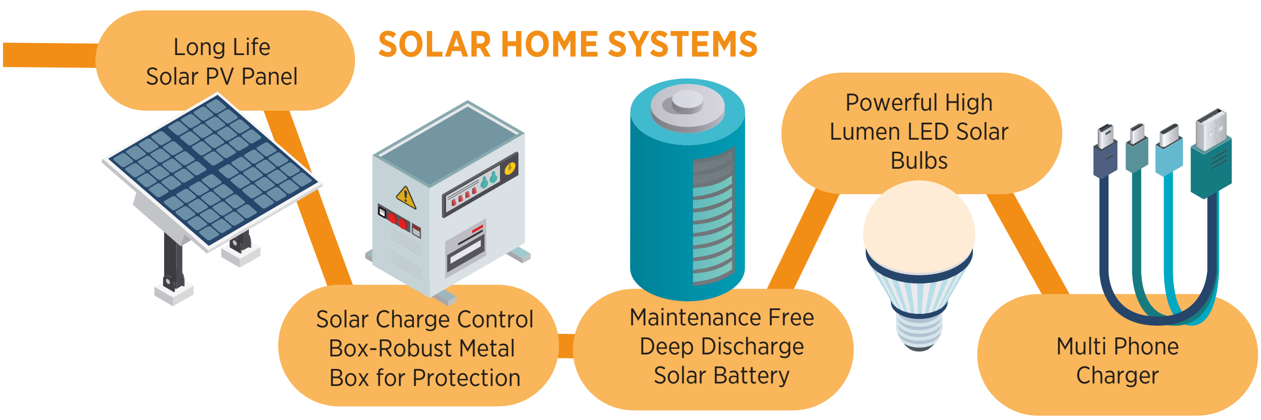
## The role of commercial companies

In the absence of significant policy initiatives in Lugazi, a number of commercial companies have become important promoters of renewable energy solutions in their own right. Facing a local market in its infancy, many of these companies take over multiple parallel roles, informing customers about their renewable energy products and financing options and answering questions related to product delivery, installation and maintenance.

Recognising that their customers are hard to reach and expensive to serve and they are subject to disruptions due to their unstable incomes, several solar companies have also taken steps to de-risk solar adoption for businesses and institutions, including through affordable payment plans and flexible credit options. Sunlabob, for example, has been working to electrify 64 schools throughout rural areas of Uganda and has expanded its Solar Lantern Rental System operations into Buikwe District and Lugazi Municipality. Its efforts include training Ugandan technicians.

Several small and medium-sized solar companies, such as Fenix International, SolarNow, Village Power Uganda, M-KOPA Solar, Jyoty Solar Power and Solar Energy Systems Limited design, sell and install a variety of solar products (see Figure 3.7) and provide credit schemes specifically designed for SMEs (Kulabako, 2013). While their motivation is commercial, they contribute to local market creation and therefore to the deployment of renewable energy solutions bottom-up.

**Figure 3.7 Examples of solar products for sale in Uganda**




Source: Village Power Africa, n.d.

A particularly successful model promoting standalone solar home systems (in Lugazi and elsewhere throughout East Africa) is a pay-as-you-go (PAYG) financing scheme offered by companies that sell and install PV kits. Customers typically pay in instalments, using mobile phone payment platforms that allow companies to diagnose devices and offer real-time customer support remotely (M-KOPA, 2015). Lugazi City and the Buikwe district local government have expressed interest in gathering energy spending data from key solar companies, to better understand energy consumption patterns and consequently generate realistic development plans based on what municipal residents and customers can afford. A UN Capital Development Fund study (UNCDF, 2019) shows that by 2016, the active number of PAYG customers in Buikwe District stood at about 1000–2000, a number that increased in 2018 by about 3000.

An altogether different project is being conducted by Eco-Fuel Africa (EFA), a Lugazi-based social enterprise. EFA trains low-income farmers, with a focus on women, to turn farm and municipal waste into briquettes and biochar fertiliser and distribute briquettes to final customers (see Box 3.7). EFA was launched in 2010, having been able to raise some grant capital from organisations like the Energy and Environment Partnership Trust Fund (EEP Africa), the United States Agency for International Development and the Swedish International Development Cooperation Agency (Theron, 2016). It seeks to create a scalable model that also addresses deforestation and air pollution. Beyond the direct benefits of the project, a portion of its income is donated to tree-planting initiatives to restore destroyed forests. EFA illustrates that city-based projects need not only focus on urban spaces but can also synergise business ideas that help surrounding areas as well.

## **BOX 3.7** 7 ECO-FUEL AFRICA (EFA)

Eco-Fuel Africa (EFA) trains marginalised farmers to turn locally sourced farm and municipal waste into clean cooking fuel briquettes and a product called 'char' using simple, locally made kilns (Clean Cooking Alliance, n.d.). For this purpose, EFA invented a simple technology, which can be used by impoverished communities without access to extensive equipment to convert farm and municipal waste into briquettes and biochar fertilisers. The briquettes, known as "green charcoal", are a carbon neutral cooking fuel made from renewable biomass waste such as sugarcane waste, coffee husks and rice husks (Gebrezgabher and Niwagaba, 2018). The briquettes function the same way as traditional fuelwood but cost 20% less, are not smoky and burn longer than fuelwood.


Lugazi

EFA selects its chain actors through partnerships with local community groups, in particular women's groups. At the end of the training, EFA builds a kiosk for each of the women, which they use as a retail shop to sell EFA's green charcoal in their local communities (Gebrezgabher and Niwagaba, 2018; Theron, 2016). The women are further trained in areas such as basic bookkeeping, marketing and customer service and are provided with the initial machinery needed to launch a briquette micro-factory in their village on a lease basis. Each micro-franchisee can make enough fuel briquettes to meet the energy needs of at least 250 local households. The micro-franchisees sell all the briquettes to EFA which are packaged and sold to its network of women retailers (Theron, 2016).

## LESSONS LEARNT

The experiences of Kasese and Lugazi provide multiple insights into renewable energy deployment in Uganda. This section first highlights benefits achieved, then explores lessons learnt and offers some observations about the replicability of the models utilised in Kasese and Lugazi.

### Renewable energy deployment benefits energy access and many other development goals

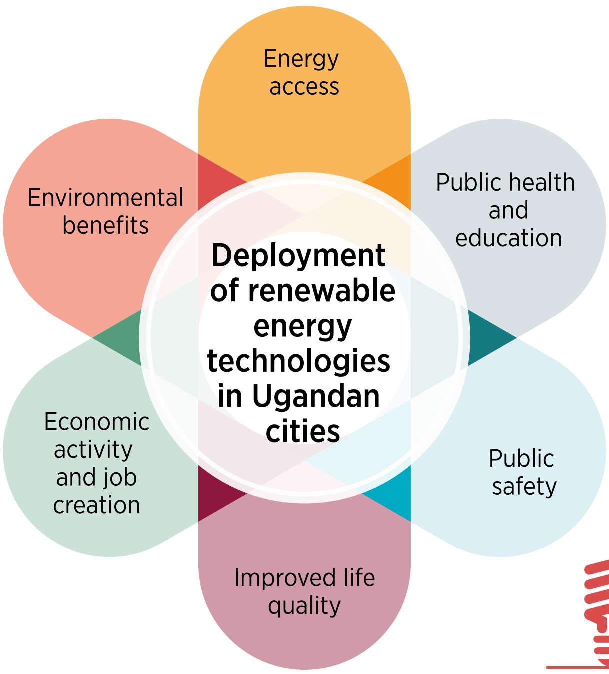
One of the overarching conclusions to be drawn from the two Ugandan case studies is that renewable energy deployment clearly benefits local communities in many different ways and advances progress across a range of socio-economic development goals (see Figure 3.8).

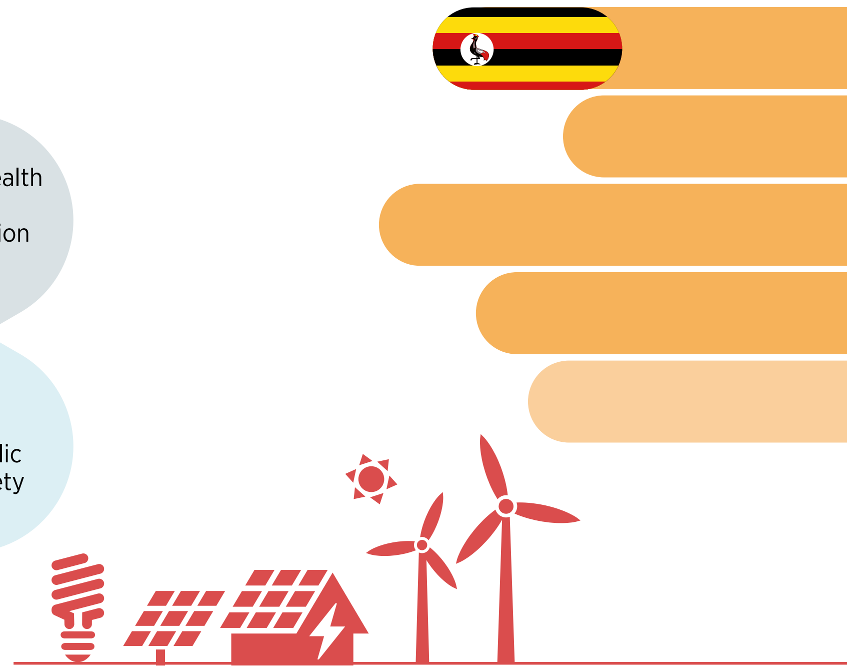
**Energy access.** One core area of benefit is energy access. Lack of access to electricity is not only a rural problem in Uganda, but also experienced by many urban residents, businesses, schools and medical centres. Solar PV applications in particular have considerable potential to supply a larger portion of electricity and to improve service quality as a stand-alone option or in combination with grid access. Small-scale solar PV is increasingly cost-effective. Studies confirm that the average urban household's electricity bill for lighting, ironing, television and radio of around UGX 50 000 (about USD 14)[11] per month could be reduced or eliminated altogether by replacing conventional technologies with solar PV panels (Kulabako, 2013; DFID and MEMD, 2016).

**Public health.** Electricity generated from renewable energy has tremendous benefits for public health in urban areas. The installation

11 Conversion as per original source.

**Figure 3.8 Renewable energy benefits in Ugandan cities**



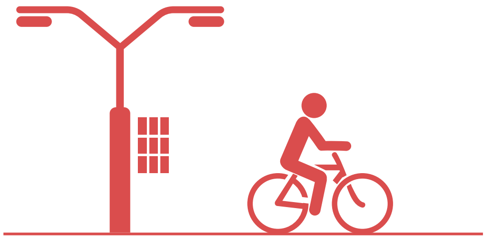
Source: IRENA urban policy analysis.

of a small number of solar panels, with a comparably small investment, at Lugazi's public hospital provides backup power for lights in operation rooms and technical equipment, including that used to analyse critical medical samples such as blood. Solar PV systems are also used to refrigerate medications and vaccines. Solar panels at Kasese District's Hamukungu Health Centre II power a refrigerator to store vaccines for a local vaccination programme. Previously, the health centre used gas cylinders to power its refrigerator. To replenish the canisters, hospital administrators would have to travel 30 km to Kasese City, with time lags if LPG was unavailable in sufficient quantities (Nantume, 2018). Technical equipment such as centrifuges and microscopes can now be used more frequently.

Clean, modern renewable energy, in particular solar home kits, also reduce the negative health effects of indoor use of traditional biomass and fuels such as kerosene. Indoor air pollution from such practices accounts for an estimated 19 700 deaths in Uganda every year (Mugalu, 2013), and presents a permanent fire hazard. Women and children, who spend more time indoors, are disproportionally affected.

**Education.** Renewable energy also offers tremendous educational benefits. Solar lighting allows children to study at home after dark and reduces the time women and children spend collecting fuelwood at the expense of education or pursuing paid work. The installation of solar energy at Kitabu Primary School in Kyarumba subcounty supported more productive schoolwork among boarders. Solar electricity systems allow pupils to experience electricity in practice while they previously only learnt about its uses in textbooks (Nantume, 2018).

**Public safety.** Lack of street lighting restricts outdoor activities to daylight hours, disproportionally affecting women and children. In both Lugazi and Kasese, the deployment of solar street lighting and solar home energy systems has generated substantial cost savings for municipalities and residential households (Mugalu, 2013).



**Improved life quality.** Kime (2015), for instance, reports that increasing electrification has meant that residents of Kasese are able to power radios and TVs, strengthening links to the outside world. Those who can use computers enjoy educational and work-related benefits. Low-cost domestic solar systems free up disposable income for food, clothing and education.

**Economic activity and job creation.** Lack of electricity is a considerable obstacle to investment and modern business creation. Private-sector surveys consistently point to inadequate and unreliable power supply as among the top five constraints on Uganda's economic growth (Tumwesigy *et al.*, 2011).

In the context of the local economies of Kasese and Lugazi, renewable electricity provides new telecommunication opportunities. Solar phone charging facilities and solar-run computers with internet access offer individuals and businesses access to the outside world and facilitate new business creation. Solar-based street lighting has enormous potential to create knock-on effects throughout the local economy, by helping extend business hours, creating jobs and saving local municipalities money, which in turn can be spent on other productive areas (Gillard *et al.*, 2019).

Renewable energy deployment also contributes to local job creation. In Kasese, businesses sell solar equipment, construct solar hubs and biogas systems, distribute improved cook stoves and build mini-hydro projects. Between 2012 and 2015 alone, the number of businesses in Kasese's green economy increased from 5 to 55, and at least 1 650 people have been trained in the process (Leidreiter, 2015).

**Environmental benefits.** Uganda's forests have been under severe pressure from the expansion of agricultural land, increased demand for charcoal and fuel and unchecked logging in the face of weak legal protections and even weaker enforcement of forest protection laws (Guyson, 2016). The country's forest cover as a fraction of total land area declined from 24% in the 1990s to just 8% as of 2018 (Manishimwe, 2018). By reducing reliance on firewood and charcoal, modern renewable energy can reduce the pressures on the remaining forests.

Kasese Municipality estimates that the 250 000 trees that have been planted across the district, together with the energy savings from solar lighting and improved cook stoves, have avoided around 116 000 tonnes of $CO_2$ equivalent emissions (Mugume, 2019). If such initiatives are replicated in other Ugandan cities, they can contribute to achieving Uganda's NDC pledges.

## CHALLENGES IN DEPLOYING RENEWABLES IN UGANDAN CITIES REMAIN LARGE

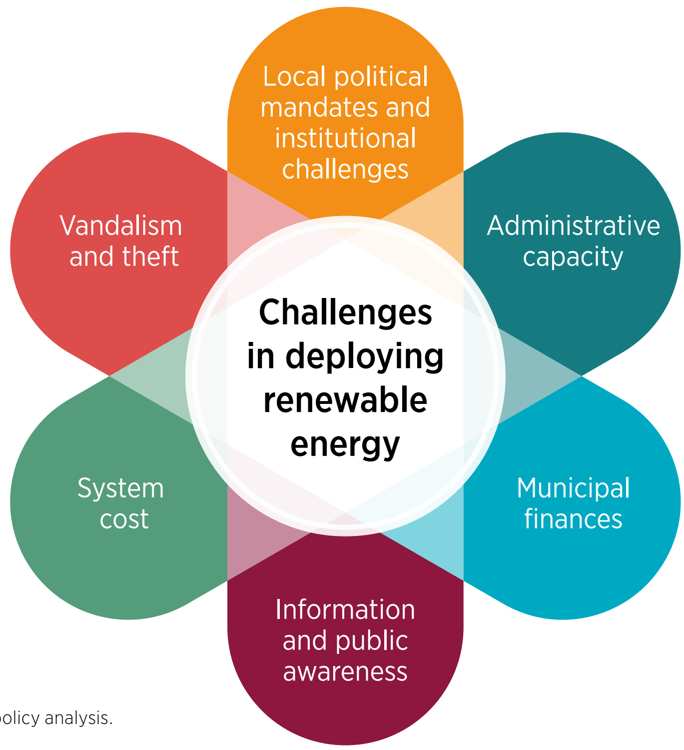
Despite the obvious benefits of renewable energy, Ugandan cities face substantial challenges in local deployment. Institutional constraints, including limits of political mandates, administrative capacity and local expertise and municipal finances all present significant obstacles to effective policy action; costs and inadequate information; operation and maintenance challenges and vandalism are additional challenges (see Figure 3.9).

This is why, in the absence of either central state action, or/and international finance and capacity building, Ugandan cities struggle to reach the level of progress that they would clearly benefit from. Experience from Uganda with central state policy also underlines that relying on national policies alone is not enough to deploy renewable energy anywhere near its localised potential, be it in the countryside or, as shown here, in urban areas.

### Local political mandates and institutional challenges

Cities can only implement policies that fall within their mandate; beyond that, municipalities depend on higher-level government policies. Cities' role in deploying renewable energy in Uganda is constrained by a variety of factors that affect the political mandate, and hence ability, of local governments to implement policies. Uganda's wider political system suffers from structural constraints, including lack of institutional capacity at all levels of government that limits the ability to plan for and monitor the energy sector effectively. Tumwesigy *et al.* (2011) point out a variety of chronic issues, including understaffing in key areas of government, lack of capacity to carry out appropriate research and development, and inadequate co-ordination and information sharing among the various projects, government institutions and the private sector.

**Figure 3.9 Challenges in deploying renewable energy in Ugandan cities**




Source: IRENA urban policy analysis.

Ugandan cities are constrained by their own limited capacity (discussed further below) as well as by the de facto restrictions inherent in the wider political context, notwithstanding municipalities' formal legal powers. Absent or unclear local mandates, for instance, affect the ability of municipalities to initiate and implement ideas. Other matters, such as product quality control, are the preserve of the central government, leaving cities dependent on national-level implementation and enforcement (Fashina *et al.*, 2017; Raisch, 2016; Scott *et al.*, 2016). Though published a decade ago, an observation made in a UN-Habitat report (2010: 1) still holds:

> ***At present, competition between various branches of government and a lack of clarity over who is actually responsible for urban planning, service provision and basic administration limits the capacity of the state to manage development... While the central government authorities have valid concerns over the administrative capacity of municipal authorities, if increasing urbanisation and a rapidly rising population are to be effectively managed, greater emphasis must be placed on local policy implementation and capacity building.***
>
> *Source: UN HABITAT*

Uganda's energy sector has long been the prerogative of central government planning and procurement, with an emphasis on the security of supply (Painuly, 2001; Tumwesigy *et al.*, 2011). Market liberalisation with more room for local engagement and private-sector involvement in energy generation has improved the investment climate but has not been accompanied by the financial resources needed so that district-level governments and municipalities are able to assume greater responsibility for local energy generation. Inadequate co-ordination and information sharing among various projects, government institutions and the private sector, along with a lack of data and information provided to local governments and the private sector, constrain effective local action (Painuly, 2001; Tumwesigy *et al.*, 2011).

## Local administrative capacity and technical expertise

Municipalities in Uganda face considerable human and administrative capacity constraints. Like other municipalities, Lugazi and Kasese are held back in their capacity to act effectively by inadequate staffing and skill levels. A 2016 report by Uganda's Ministry of Public Service puts the rate of unfilled vacancies at local governments across Uganda at 25% to 65%, a problem attributed to inadequate budget support by the central government as well as to slow hiring clearance (Ministry of Public Service, 2016). The report also notes that of those positions that are filled, 80% are administrative and related, leaving many technical positions vacant.

Recruiting skilled personnel is also hampered by the dearth of skills locally in fields such as physics; materials science; chemical, mechanical and electrical engineering; and business management (Wilkins, 2002). Few technicians are able to maintain and repair existing installations (Fashina *et al.*, 2018; Raisch, 2016). Lacking a mechanical and electrical engineer on its municipal payroll, Lugazi has repeatedly had to call on the electrical engineer at Kawolo hospital to handle routine and technical energy problems across the municipality.

Kampala

Limited municipal capacity renders renewable energy deployment projects in many Ugandan cities dependent on partnerships with the national government or external actors such as NGOs. In the case of Kasese District, such a setup has proven successful in some initiatives but leaves progress dependent on the continued presence of foreign partners.

In Lugazi, the most tangible success in renewable energy deployment is tied to international lending for a country-wide initiative (USMID), with much of the remaining, limited solar deployment left largely to local private enterprises. A recent Uganda-wide World Bank analysis (2018, p. 2) confirms these challenges, pointing to the "need for skill development among technical staff in procurement, contract management, and project monitoring, amongst others" in the context of localised infrastructure development.

Inadequate skills training and staffing also increase the cost of modern renewable energy technologies locally. Fashina *et al.* (2018: 28) point out the high operation and maintenance costs of modern renewable energy technologies in Uganda – for individual households as much as for municipalities. This, the authors argue, is due to "inadequate technically skilled human resources and limited institutional capacity in both the private and public sector that can execute and manage RE infrastructures".

## Municipal finances

Given the lack of an adequate revenue-generating capacity, Ugandan municipalities face fundamental financial constraints. The Local Government Act section 77 (1) empowers local governments including municipalities to formulate, approve and execute their budgets and to collect and spend revenue, but most local authorities are unable to finance their budgets from locally generated revenues. In the absence of national-level investment in renewable energy deployment, this is problematic.

A weak municipal tax base is paired with political interference within the local government tax collection system (Gillard *et al.*, 2019; The Independent, 2019). For instance, Section 75 (7) of the Electricity Act of 1999 recommends that royalties from the generation of hydroelectricity should be accorded to the host local government. However, there is no record to suggest that district local governments, including municipalities where the power stations are situated (such as the Kasese and Lugazi municipalities), have actually received these royalties (SEATINI, 2017).

On average, about 90% of local governments' revenue is derived from the central government, but such funds are usually earmarked for the provision of specific services only (SEATINI, 2017). For instance, intergovernmental fiscal transfers constitute approximately 95% of Lugazi's budget, but the amounts have not kept up with Lugazi's rapidly expanding population. The World Bank (2018: 2) recently concluded that:

> ***Sources of finance available to [local governments] are insufficient to meet local investment needs. While central level transfers have increased in nominal terms, this was not commensurate with the increase in service demands due to population growth. At the same time, [the local government's] own revenues plummeted over the last decade, with the abolishment of the Graduated Tax.***
>
> *Source: THE WORLD BANK*

Insufficient resources typically force tradeoffs between financing renewable energy projects or other development priorities such as infrastructure, health and education.

Although Uganda's past, highly centralised approach to energy sector development suffered shortcomings, utility market liberalisation had the effect of removing the financial and technical assistance that was provided during the 1990s and 2000s by international bodies such as the World Bank, IMF and African Development Bank (Tumwesigy *et al.*, 2011). Cities do not typically have direct access to these institutions, making project finance contingent on the presence of other development projects at higher levels of government such as the national or district level. Where renewable energy projects are supported through development assistance, initial funding for the installation of infrastructure such as rooftop panels or streetlights is not always followed by money to pay for maintenance.

## Lack of information and public awareness

The Ugandan public has inadequate knowledge of the applications and health and environmental benefits of modern renewable energy technologies, or of relevant financing options. Fashina *et al.* (2018: 28) argue that "the public sector is not provided with adequate and sufficient training required to make informed choices (*i.e.*, there is a deficiency of technical information). The absence of vital information and proper awareness has generated a disparity in the RE technology market that has given rise to a higher risk perception for potential renewable energy prospects".

In a 2014 study conducted in Lugazi City by the African Institute on Energy Governance in Uganda (AFIEGO, 2014), 70% of the respondents were willing to adopt clean, modern and sustainable forms of renewable energy, but they lacked adequate information on availability, use, costs savings and appropriate financing mechanisms.

Kampala

## System cost

The high upfront costs of new renewable energy technology, in particular solar power, remain a structural hurdle to greater deployment among individual households and municipalities. Enclude's (2014) focus on affordability as a key deterrent is confirmed by interviews conducted for this study.

Enclude (2014) observed that retailers, on average, add a 40% margin to the wholesale price of solar products (both for fixed and mobile systems). On top of this, VATs and tariffs have continued to be charged for energy-efficient appliances often sold in conjunction with a SHS, which drives up the costs of the complete system (Scott *et al.*, 2016; USEA, 2019). Extending VAT, micro-finance, and tariff exemptions to product parts and appliances could incentivise in-country assembly and push down end-user costs (Scott *et al.*, 2016).

Although central government policies have helped reduce the cost of PV panels, other components such as batteries and DC lamps still attract up to 24% duty. To compensate, some solar street lighting contractors have resorted to using substandard components. When the equipment fails within a short period after installation, the required replacement needlessly drives up overall costs (Fashina *et al.*, 2018). Still, solar technologies offer savings to households and businesses after the initial investment (see Box 3.8) – a factor that calls for more micro-financing options and awareness raising.

## BOX 3.8 SOLAR SYSTEM COSTS IN UGANDA

The costs of solar products in Uganda have fallen in recent years and carry substantial cost savings potential over a relatively short period of time. The smallest solar kit, consisting of a 1-watt panel, lantern and battery, costs about UGX 39 000 (USD 11) – roughly the amount a household is likely to spend on kerosene for lighting over five months.[12]

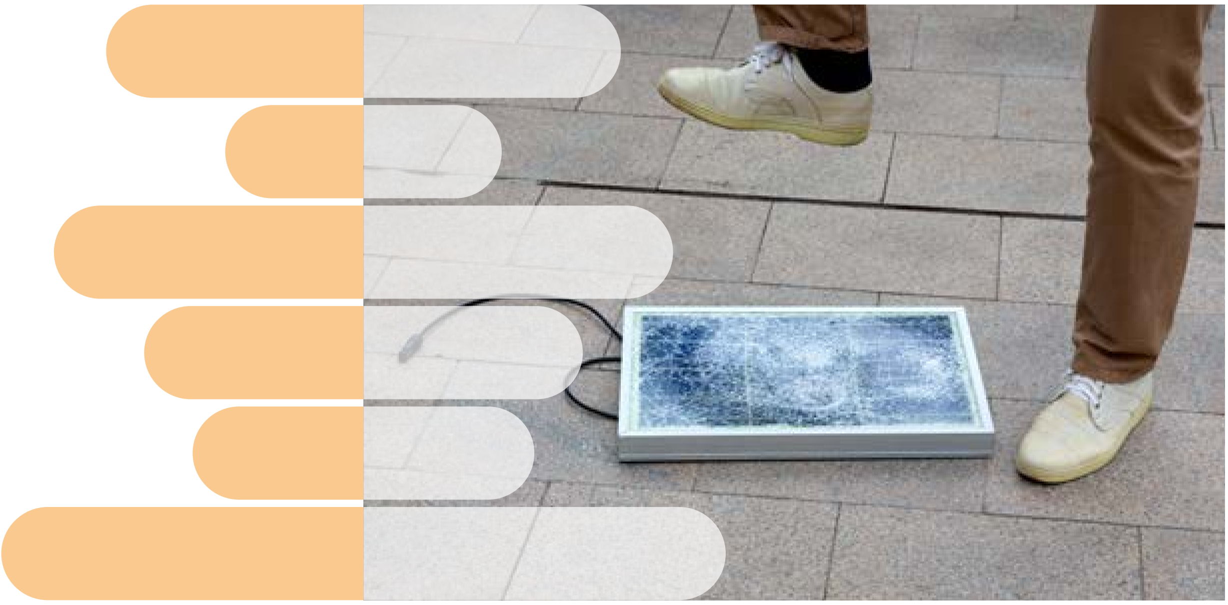
The panel has a ten-year lifespan while a lantern can be expected to last for three years. A larger, four-lamp solar kit retails at UGX 341 000 (USD 92). A village kit – consisting of four LED tubes, two matric lamps[13] and a security light – costs UGX 890 000 (USD 240), and a school kit – three LED tubes and a security light – runs to UGX 2 million (Kulabako, 2013).

12 For comparison, average Ugandan urban household income in 2016–2017 was reported at UGX 464 600 per month (UBOS, 2018).

13 A matric lamp is a LED based desk/table lamp commonly sold in Uganda as part of solar home systems.

## Vandalism and theft

Vandalism and theft pose major problems across Ugandan cities, reflecting the high value of electric products and components. Officials in Lugazi, for instance, expressed concern about the vandalism and theft of bulbs and cables affecting solar streetlights and frequently plunging the municipality into darkness (Mukwaya, 2019). Transformer oil, angle nuts, stay wires, earth wires and galvanised angle bars for the power pylons (towers) and other operational materials are also frequently stolen, causing power blackouts across the district (Mugume, 2017; UMEME, 2015).



## IMPROVING DEPLOYMENT AND SCALING UP PROJECTS WILL REQUIRE MUCH FURTHER ACTION

At the time of writing, a toolkit of lessons from Kasese District was under development by Uganda's CDI partners, to be shared primarily with the MEMD, Ministry of Local Government, private-sector parties (especially financing institutions and renewable energy technology vendors) and NGOs. The intent is to incorporate lessons from the CDI in the Sustainable Energy for All (SE4All) Action Agenda processes piloted by the central government (personal communication with government officials).

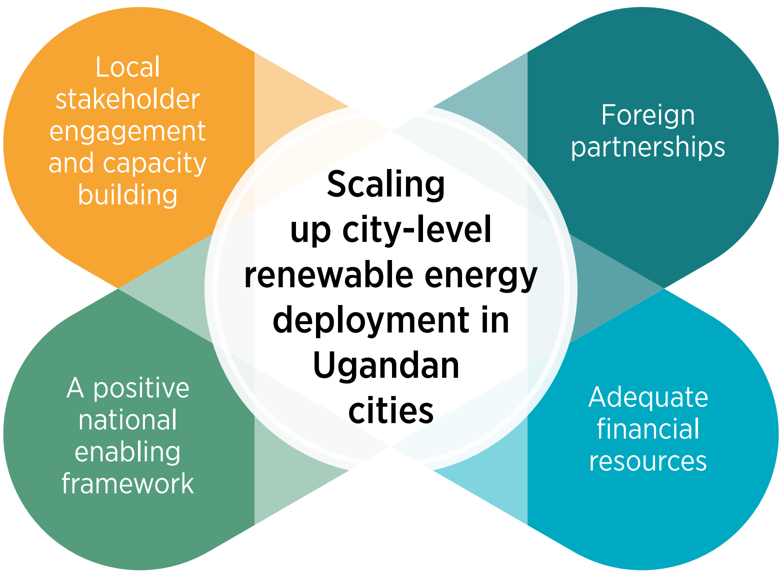
Meanwhile, based on the CDI experience in Kasese District, the WWF has rolled out a Clean Energy Project supporting district local governments in the Albertine Graben, including Koboko, Kibaale, Rubirize, Arua, Maracha, Moyo, Adjumani, Nebbi, Bundibugyo, Kyenjojo, Mitooma, Rubirizi and Masindi, to develop district renewable energy strategies (WWF, 2018) and guidelines to mainstream energy in their district development plans (Environmental Alert, 2018). These programmes benefit both rural and urban spaces.

The experiences of Kasese and Lugazi offer some insights into how cities in Uganda can devise scalable and replicable models for deploying renewable energy (see Figure 3.10).

### A positive national enabling framework

First, city-level action depends on a positive national enabling framework. Both Kasese and Lugazi have fundamentally benefited from initiatives targeting sustainable energy at the district level in particular. Kasese strongly illustrates CDI's multiple benefits for local renewable energy deployment. One benefit is access to a network of regional, national and international institutions such as think tanks and international development partners, who have helped

**Figure 3.10 Scaling up city-level renewable energy deployment in Uganda**




Source: IRENA urban policy analysis

enhance local capacity to plan, design, carry out and monitor local renewable energy deployment. The national government in Uganda supports district-level initiatives, enabling local governments to team up with national and international partners, thereby supporting local government activity. On the other hand, more effective product quality standards and enforcement at the national level would benefit renewable energy deployment across Uganda, including in cities, by increasing transparency and reducing the spread of low-quality products that increase operation and maintenance costs later on.

## Local stakeholder engagement and capacity building

Second, effective local stakeholder engagement is required to overcome skills- and capacity-related challenges.

Local skills and human resource shortages imply that many local initiatives need to be driven either by the central government or another third party. In Lugazi, local constraints leave higher levels of government in the driver's seat in initiating renewable energy projects, and third-party project funding has been largely carried out at the national and district government levels.

The case of Kasese illustrates that more proactive local engagement helps attract greater attention at the national level, and from third-party financing bodies. The city's progress also demonstrates that the localised deployment of renewable energy extends beyond city lines. Initiatives that mobilise relevant stakeholders across segments – from cultural leaders and local communities to district-level governments – have a greater chance of success than initiatives that focus on only one city and one stakeholder. Local projects benefit from the mobilisation of stakeholders across different sectors, from the government to businesses, financial institutions and citizens.

Sensitising local stakeholders – through information campaigns, efforts to generate and share knowledge, as well as political/ financial incentives at the district and national levels – is essential to rally local action. In a variety of ways, education and training programmes, and also national and local media reporting, can play an important part in strengthening local awareness and action in relevant areas such as natural resource management, energy, water and environment. Kasese's example also illustrates that the negative consequences of climate change are not a remote issue, but touch people's everyday lives and can serve as an important anchor for integrating sustainable, localised energy resource management.

The extent to which cross-sectoral stakeholder mobilisation is effective currently depends to a great extent on the political will of local governments and, in many cases, developing finance by external partners such as the World Bank. Institutional capacity building, education, training and knowledge creation, as well as more systematised, skills-based recruitment – combined with a reform of local government finances – will help increase the ability of local stakeholders to act on their own. Only where local stakeholders are truly proactive and fully engaged do local initiatives become sustainable, and hence scalable and replicable.

## Adequate financial resources

Third, cities need adequate financial resources to invest in clean energy and cost-saving technologies. At present, limited funding puts brakes on renewable energy deployment in Ugandan cities. Even though renewables offer cost savings in the medium and long runs, the substantial upfront costs often surpass the funds available to the country's municipalities and districts. Solar street lighting is a key example where scaling up city-level action across Uganda could result in significant economic benefits. Currently, such initiatives are almost without exception tied to third-party financing support, such as the World Bank's USMID initiative. Empowering Ugandan cities beyond development finance to engage in critical public procurement of clean energy will require structural improvements to municipal and district funding, as well as local capacity building and training in project delivery and financial management.

Uganda's banking sector also needs to play a much bigger role. Projects such as solar street lighting that can be expected to pay for themselves after a relatively short period are in principle ripe for support by domestic financial institutions. But Uganda's banking sector requires help to understand the renewable energy industry. National credit support programmes can play a critical role in this regard. Ugandan banks will also need to step up their involvement in end-user products such as micro-finance to support small-scale renewable energy applications (*e.g.*, solar PV panels). The national government could further help promote renewable energy at the local government level by tying budgetary allocations to clean energy projects as a priority item.

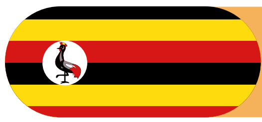
## Foreign partnerships

Fourth, foreign partnerships can drive progress not only through financing, but also by helping build local capacity. International development partners such as NGOs have historically played an important role in driving localised projects including in the area of renewable energy. International partners have been an important voice in support of renewable energy, supporting district-level governments and municipalities through workshops and local capacity building; engaging in the actual distribution of solar kits and the installation of larger PV systems in social institutions such as schools and medical centres and working in partnership with community-based organisations to improve the distribution chain of solar kits.

International partners have also been critical enablers of renewable energy deployment through policy papers advocating for government to invest more in renewable energy and by lobbying in favour of technology quality standards for renewable energy products.

There are important caveats to third-party-led approaches – in particular, issues of scalability and replicability for past one-off and demonstration projects that depend to a large degree on the availability of foreign financing. Kasese and Lugazi on the other hand demonstrate that the opposite is true as well; Uganda has seen an evolution of a range of initiatives involving international partners – from development agencies to think tanks and foreign universities – that have helped build local capacity in areas such as data collection, local market analysis, policy design and project implementation, in addition to the provision of finance for key projects. Support in policy making, regulation and capacity building across different levels of government have all contributed to the creation of lasting knowledge.

Kasese District's energy sector strategy illustrates the benefits of capacity building in knowledge creation and policy design. Future initiatives could focus further on partnerships in scientific and research and development activities, as well as focused policy design. If combined with educational and training reform at the national and district level, such initiatives hold significant potential to make a lasting impact on local communities, beyond initial project finance.



# 4. COSTA RICAN CITIES: CENTRALISATION AND PROMOTION OF E-MOBILITY

## NATIONAL CONTEXT

With a population of 5 million as of 2018 and territory of about 51 000 km$^2$, Costa Rica is the smallest of the three countries examined in this series. A highly urbanised country with some 77% of the population living in cities (Presidencia de La República, 2019a), Costa Rica has one of the highest electrification rates in Latin America. Grid coverage expanded from 47% in 1970 to virtually universal access today.

Costa Rica is well known for its large share of power generation sourced from renewable sources – 98.5% as of 2019 – based on hydro, wind and geothermal projects. This stands out internationally and in Latin America, where only Uruguay and Paraguay have rates of over 90%. In 2019 the government passed a national plan to make Costa Rica one of the world's first fully decarbonised economies to reach net-zero carbon neutrality by 2050 as established in the Paris Agreement on climate change.

The already-large share of renewable energy in Costa Rica's power sector implies that debates around deployment differ from countries where renewables contribute a minority of national electricity supply. Instead, key national challenges include the need to balance demand and supply, adjusting the overall mix of power sources in light of the variability of hydropower generation. Key questions include the role to be played by the public and private sectors and the degree to which electricity generation should be based on centralised and decentralised sources. Electrification of the transport sector, pursued in order to meet GHG emission reduction goals, will inject a new dynamic into the power sector.

Costa Rica's small size allows a high degree of centralisation in political decision-making structures. This restricts cities' ability to make autonomous policy decisions.

This chapter will examine the roles played by both national and municipal actors. It also points out the need to empower municipalities in mobility and urban planning. The national decarbonisation plan offers a new opportunity for such empowerment as the central government recognises the importance of engaging municipalities in its implementation.

## THE URBAN AND MUNICIPAL CONTEXT

Costa Rica has a population of only 5 million, equivalent to what in other countries is a mid-sized city run by a single municipality – for example, Bogotá's 7 million people. For this reason, the central government has traditionally made all the decisions concerning energy and transport policies. The municipal landscape, by contrast, is deeply fragmented, a feature that is increasingly seen as one of the main challenges to be tackled in order to achieve a sustainable urban future (Presidencia de La República, 2019a).

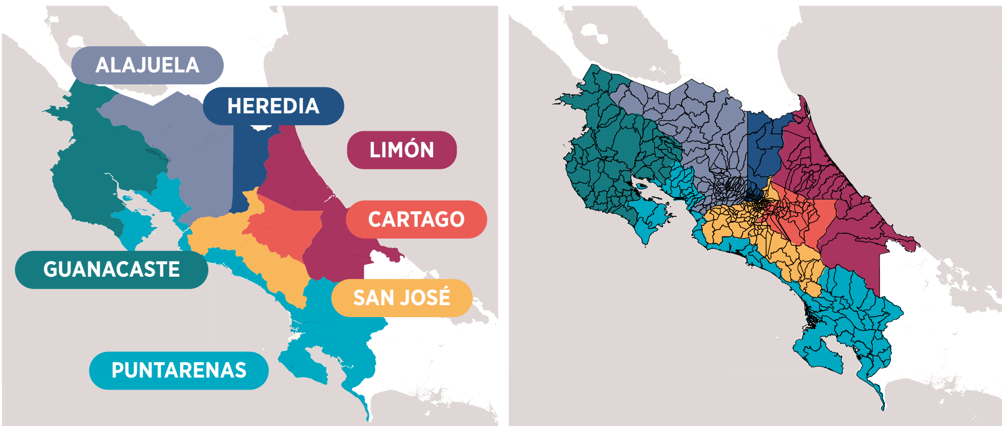
Costa Rica has seven provinces – Alajuela, Cartago, Guanacaste, Heredia, Limón, Puntarenas and San José, but no provincial governments as such. The country is split into 82 small municipalities (*cantones*, or counties)[1] (see Figure 4.1). For example, the Province of San José, where the capital is located, has 20 *cantones*. The capital is run by one municipality, and mayors oversee small slivers of the surrounding population, such as in the municipalities of Montes de Oca and Curridabat that are home to 55 000 and 32 000 people, respectively. The cantones are further subdivided into 484 districts, some with populations as small as 1 000 people.

Costa Rica's centralised governance structure mirrors the geographical concentration of the economy. The bulk of the population and economic activity is concentrated in the Grand Metropolitan Area (GAM), which represents just 4% of the country's surface area spread across the provinces of Alajuela, Heredia and Cartago (see Table 4.1). GAM is home to about 60% of Costa Rica's total population (some 2.8 million residents) and 65% of all companies, and accounts for 82% of commercial revenue nationwide (Presidencia de La República, 2019a; Arce, 2020).

Laws and provisions concerning municipalities are not always implemented. Since 1968 the country has had an urban development law in place that mandates municipalities to design and execute "regulatory plans", yet most of them are in breach of the law. Since 1971, Costa Rica has a law to support municipal development. The Municipal Advisory Institute (IFAM, Instituto de Fomento y Asesoría Municipal), was created as an independent entity that is part of the government. The president of IFAM, as well as the board, are political appointees. The role of IFAM is to advise the local governments operating in the 82 municipalities. In 1972, a National Union of Local Governments (UNGL, Unión Nacional de Gobiernos Locales) was launched to secure local governments' representation in various domestic fora. The UNGL board is made of political appointees proposed by the municipalities.

1 Costa Rica has also defined 24 indigenous territories administered by indigenous development associations.

**Figure 4.1 Costa Rica's provinces, cantones and districts**




Source: Guías Costa Rica, n.d.

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

**Table 4.1 Costa Rican provinces and main cities**

| Province | Population size | Size ($km^2$) | Population density (people per $km^2$) | Main city | Population in the main city | Number of Cantones | Number of Districts |
|---|---|---|---|---|---|---|---|
| **San José** | 1 404 242 | 4 965 | 282.8 | San José | 288 054 | 20 | 123 |
| **Alajuela** | 848 146 | 9 757 | 86.9 | Alajuela | 254 886 | 26 | 115 |
| **Cartago** | 490 903 | 3 124 | 157.1 | Cartago | 147 898 | 8 | 51 |
| **Heredia** | 433 677 | 2 656 | 163.2 | Heredia | 123 616 | 10 | 47 |
| **Puntarenas** | 410 929 | 11 265 | 36.5 | Puntarenas | 11 501 | 11 | 60 |
| **Limón** | 386 862 | 9 188 | 42.1 | Limón | 94 415 | 6 | 29 |
| **Guanacaste** | 326 677 | 10 140 | 32.2 | Liberia | 62 987 | 11 | 59 |

Source: INEC, 2011.

Note: San José, Alajuela, Cartago and Heredia are among the GAM provinces.

## A NEW IMPERATIVE FOR DECENTRALISATION

Costa Rica's centralised governance structure was designed at the end of the 1940s right before urbanisation took off, yet the municipal structures were not considered. This top-down model had many benefits – a stable welfare state, social progress in the form of a sound health-care system, free education and near-universal access to energy. But one of the downsides of this model is limited urban planning and severely restricted municipal decision making and expertise.

This paradox is openly discussed in the country. Today the imperative to rethink urban development has energised many stakeholders – ministries, independent public agencies, civil society and municipalities themselves. As sustainable-city initiatives gain momentum around the world, Costa Rica has seen the emergence of new initiatives engaging municipalities – instead of the traditional efforts centred around the Ministry of Environment, and Energy (MINAE). For example, an attempt to protect an important urban river that passes through four counties inside San José brought together the mayors from the relevant municipalities in 2018. The project would be overseen by each of the town councils, which would in turn be co-ordinating with the different institutions involved, including aqueducts and sewers administrations, the Ministry of Environment and Energy and the public or private hydroelectric plants (Gutiérrez, 2018). NGOs focused on urban development increasingly work with municipalities to build bottom-up strategies – for example, *Rutas Naturbanas* is an attempt to connect the city through pathways by the city rivers (see above).

In 2018, the central government formed a grand commission including the ministries of housing, economic planning, environment and energy; independent public institutions dealing with municipalities, such as IFAM; and several public service companies, including the power and water utilities as well as the National Emergency Commission.

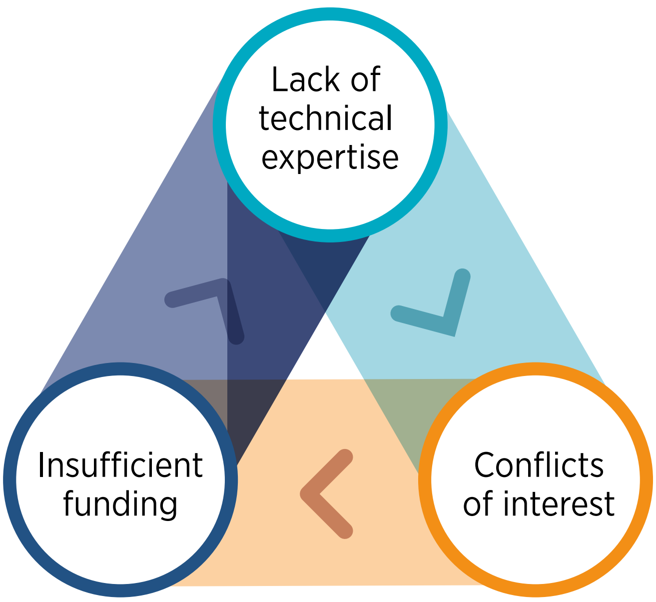
The Office of the First Lady[2] was given the presidential mandate to co-ordinate this commission with the purpose of passing a new urban development plan to 2030. A public consultation was launched in 2018 to seek feedback. The programme aims to reverse decades of delay in urban planning, particularly among municipalities. The commission highlighted both the breaches of urban development law dating back to 1968 and the low rate of execution by municipalities: only 31 out of 82 have published the mandatory "regulatory plans"[3] to deal with land use and environmental issues, and most of the existing plans are incomplete (see Box 4.1).

The breach of the law by so many municipalities for so many years explains, according to this commission, much of Costa Rica's weak urban track record. The commission also details the obstacles that municipalities encountered, including conflicts of interest, insufficient funding and lack of technical expertise (see Figure 4.2). Previous attempts to support municipalities to develop urban planning tools have failed. The core of the case for change is the need to work with municipalities to design and implement these missing regulatory plans that are mandated by law (Presidencia de la República, 2018a).

2 The Office of First Lady or First Gentleman in Costa Rica relies on private donations to cover the expenses of the office agenda. These funds support selected causes and foundations which traditionally focus on cultural, environmental and social issues.

3 The regulatory plans are instruments defined by the Urban Planning Law (Law Number 4240, 1968). They encompass development policy and plans for population distribution, land use, roads, public services, communal facilities, and construction, conservation and rehabilitation of urban areas (INVU, 2019).

**Figure 4.2 Key challenges to municipal policy making**




Source: IRENA urban policy analysis

## **BOX 4.1** MUNICIPALITIES AS A "MISSED OPPORTUNITY" TO ADVANCE DEVELOPMENT

As the central government faces fiscal constraints, there could be potential for strengthening local governments to make a palpable difference in human development.

A 2019 study by the State of the Nation (Programa Estado de la Nación, PEN)[4] identified two areas with potential to recalibrate the use of municipal social investments (in water infrastructure and waste management). There are better ways to manage these budgets so they can make a positive difference.

In addition, the analysis looked into the municipalities' legal mandates (for environmental management and land-use decisions) that could also make a difference if implemented with proper policy instruments.

The study confirms the lack of tools to carry out municipalities' environmental performance duties and points out that only 40 of the 82 municipalities have land-use plans; where plans exist, they are often incomplete. The election of new mayors in February 2020 was seen as a concrete opportunity to have a national debate about the future of local governments.

PEN developed a new online tool (at www.dcifra.cr), calling on citizens to "decipher their municipality" prior to the elections of 2 February 2020 and to increase the level of public scrutiny of poor performance over the years. Many mayors have been in power for decades; for example, the mayor of San José has been in office for 30 years.

Source: Estado de la Nación, 2019.

4 The State of the Nation Programme (PEN) is a think tank that belongs to the National Council of Rectors (CONARE, by its Spanish acronym), composed of Costa Rica's five public universities. PEN aims to conduct research and innovation for the promotion of sustainable human development, in its economic, political, environmental and social dimensions, by engaging with public and private organisations, as well as with international co-operation agencies. PEN also has the support of the Defender of the Citizens of the Oficina de la República (Office of the Republic).

San José

## COSTA RICA'S ELECTRICITY SECTOR AND ENERGY INSTITUTIONS

The peculiarities of Costa Rica's governing structures accord high importance to national-level institutions even when it comes to city-level decision making and actions. It is therefore critical to understand the country's broad energy institutional framework and to identify key actors and stakeholders. This section also considers the mix of sources and other relevant attributes of the country's energy and electricity sectors.

### The energy institutional framework

National-level authorities, the state-owned utility and regulators play central roles in energy policy:

- The **MINAE** governs Costa Rica's energy sector through the Vice Ministry of Energy, which is organised into technical divisions that manage energy issues and fuels for transport and industry.[5]
- The **Vice Ministry of Energy** drew up a national energy plan 2015–2030, currently under revision. MINAE's energy planning secretariat (Secretaría de Planificación del Subsector Energía, SEPSE) engages main stakeholders (discussed in the next section) such as the Costa Rican Electricity Institute (in Spanish, the Instituto Costarricense de Electricidad, or ICE), distribution companies, private generators, the national oil refinery and electrification co-operatives. In addition to SEPSE, an energy directorate focused on implementation became operational.
- The **Public Authority for the Regulation of Public Services (ARESEP)** sets the technical standards guiding electricity services and electricity tariffs and monitors the application of regulations.
- The **Costa Rican Electricity Institute, the state-owned utility known as ICE**, manage and operates the electricity sector and draws up 20-year plans for the electricity sector.

San José Province

In contrast to many other countries, Costa Rica's highly centralised model leaves cities with close to no role in generation projects or energy-relevant sectors such as public transport.[6] Their main function is often limited to administrative tasks such as granting permits associated with energy projects. Lively debates are ongoing about the need to strengthen the role of cities and municipalities.

### Key stakeholders in the electricity sector

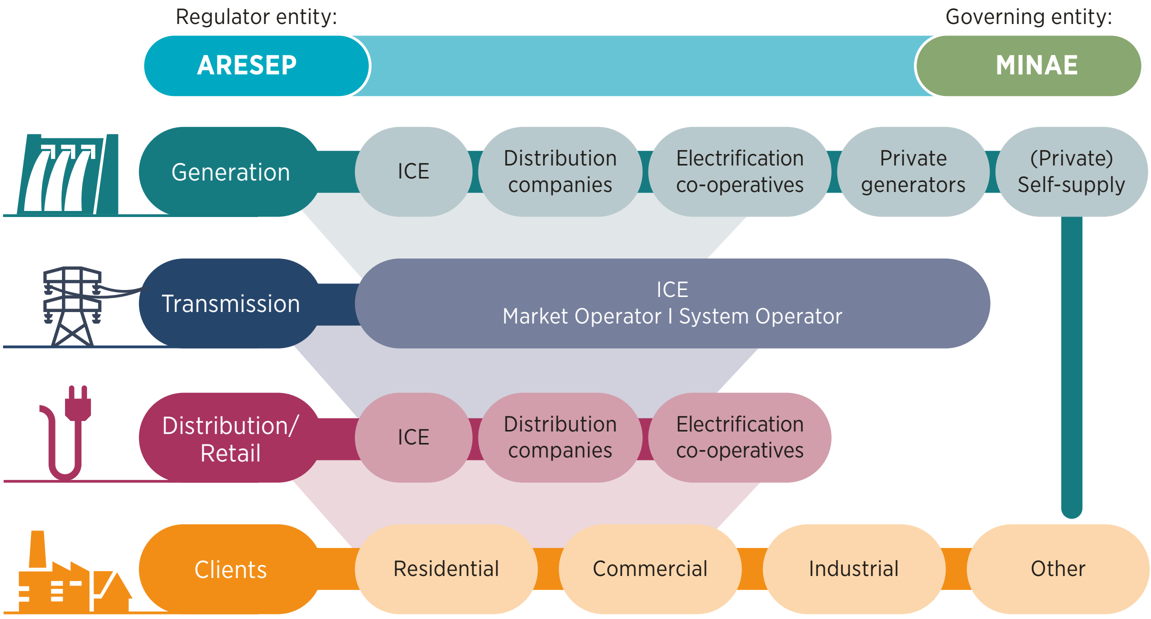
ICE, Costa Rica's state-owned utility, controls generation, transmission and distribution grids through a vertically integrated, non-competitive regime (see Figure 4.3). New players seeking entry to the Costa Rican electricity value chain must have an enabling legal title or a public service concession.

From generation to transmission and distribution, there are few major actors.

5 Originally created as the Ministry of Natural Resources, Energy and Mining (MIRENEM) in 1988, this ministry has been reformed several times, most recently in 2013 when it became the Ministry of Environment and Energy (MINAE).

6 Cities have a say in bike lanes and shared transport systems (one is being tested by the municipality of Cartago) and exclusive lanes for buses. For personal vehicles, all decisions are taken by the national government.

**Figure 4.3 Main stakeholders in Costa Rica's electricity system**



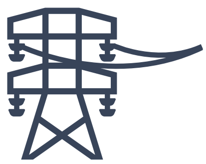

Source: Utgard and Forn, 2016.

***Generation:***

ICE owns most generation plants. Two distribution companies control the remaining plants, four rural electrification co-operatives grouped under conelectricas R.L., 37 private companies operating hydro plants, wind farms and solar[7] projects (grouped under the industry association, ACOPE) as well as individuals who self-generate their electricity. In general, ICE generates 70% of the country's electricity, while 20% comes from private generators.[8]

***Transmission:***

Only ICE can legally provide transmission services. ICE's National Centre for Energy Control (CENCE) is responsible for the operation of the transmission system, known as SEN, which is part of the Central American Electrical Interconnection System (SIEPAC) facilitating regional electricity exchanges.



7 ACESOLAR, the Costa Rican Solar Energy Association, was established in 2012 and brings together around 70 national and international companies including solar energy generation companies and technology providers. They have played an active role in promoting distributed energy solutions and modern regulation to boost Costa Rica's solar power generation.

8 Private generators can be subcontracted within the 30% cap that is established by the law. The two distribution companies operate plants reaching 10% of installed capacity.

***Distribution:***

ICE is again the primary distribution agency and controls nearly 80% of the market together with its subsidiary National Company of Power and Electricity[9] (CNFL, by its Spanish acronym). Two public service companies operate in Cartago (JASEC) and Heredia Public Services Company (ESPH), each with about 10% of the market. They operate independently of the municipalities.

***Clients:***

The largest electricity consumer in Costa Rica is the residential sector (38% of demand as of December 2017) followed by the commercial sector (36%) and industries (21%) (Grupo ICE, 2019). Others include churches and schools. The regulator sets the tariffs for ICE sales to the distribution companies, for sale by distribution companies to their clients and customers selling their electricity to the distribution companies (Grupo ICE, 2019).

## Diversifying Costa Rica's electricity system

As of December 2017, Costa Rica's installed power-generating capacity was 3 530 MW, of which hydropower accounted for 66%, wind power for 11%, thermal plants for 16%, geothermal plants for 6%, with the remaining 1.2% from biomass and solar. Generation was 11 210 GWh, of which ICE produced 66%, private companies 24% and distribution companies 10% (Grupo ICE, 2019).

In 2019, Costa Rica reached more than 98% of clean production for the fifth consecutive year (Presidencia de La República, 2019a). This generation comes from five renewable energy sources: hydropower, geothermal, wind, biomass and solar (see Table 4.2).

Hydropower dominates the electricity supply in Costa Rica, but climate change (and increasing drought conditions) will likely reduce the reliability of hydropower generation. There is a growing awareness, for example, in the National Energy Plan of 2015, of Costa Rica's vulnerability to climate change and the link to hydropower production. Efforts have been underway to

9 Compañía Nacional de Fuerza y Luz S.A.

**Table 4.2 Electricity generation in Costa Rica, June 2014–2018**

| | | GWh | % |
|---|---|---|---|
| **Renewable energy** | Hydro | 33 125 | 74.76 |
| | Geothermal | 5 289 | 11.94 |
| | Wind | 4 909 | 11.08 |
| | Biomass | 322 | 0.73 |
| | Solar | 12 | 0.03 |
| **Fossil fuel** | Bunker fuel and diesel | 653 | 1.47 |
| **Total** | | **44 309** | **100%** |

Source: Grupo ICE, 2018a.

diversify the power matrix since the 1990s with a focus on wind and geothermal.

In 1996 Costa Rica inaugurated the first wind energy project in Latin America (Revista Summa, 2019). With 18 operational wind energy plants, Costa Rica reached over 400 MW in installed capacity in 2019 – compared with 66 MW ten years previous. Over 15% of annual production (1.8 GWh) came from wind, which is the highest percentage ever reached in Costa Rica (Revista Summa, 2019).

Geothermal energy contributes around 10% of electricity production. The addition of a new plant, Las Pailas II, operational since June 2019, lifted geothermal power capacity to 262 MW, the second largest in Latin America. Generation reached 132.7 GWh, the highest level since 2014 and equivalent to 13.3% of total electricity generated. The ICE attributes this development to its decision to rely more strongly on non-hydro renewable sources, driven by the experience in arid years such as 2014 and 2019 (Richter, 2019).[10]

Cachi, Cartago

## The dominance of fossil fuels in transport

While Costa Rica is exceptional in terms of electricity generation based on renewable sources, its end-use sectors are, like those of most other countries, heavily reliant on fossil fuels, particularly oil for transport. Oil represents nearly 70% of energy consumption and is therefore the primary source of carbon emissions given its growing use in private, public and freight transport (Presidencia de La República, 2019a). The carbon dioxide ($CO_2$) emissions generated by the combustion of gasoline and diesel grew 43% between 2002 and 2012.

Relative to GDP, the weight of oil imports doubled between 2000 and 2010. However, instead of attempting to substitute imports with domestic supplies, a strong consensus has developed in favour of a moratorium on domestic oil exploration and exploitation. As maintained by five successive presidents from three different political parties since 2002, the Alvarado administration recently extended the moratorium to 2050, and a bill in Congress (Expediente No. 20.641) would make this ban permanent (Poder Ejecutivo, 2017).[11] An opinion poll by the State of the Nation, an independent academic entity, showed active citizen backing for the ban on oil drilling (Estado de la Nación, 2017).

For years the energy and transport debates have taken place on separate tracks, but the National Energy Plan 2015–2030 set joint goals for the first time to decrease dependence on oil by calling for cleaner forms of transport and fuels. In 2018 a law to promote zero-emission e-mobility was passed.

In October 2019, the government presented a set of adjustments in the National Energy Plan to 2030 to accelerate the implementation of actions to decarbonise the economy, in alignment with the National Decarbonisation Plan to 2050.

10 Most of the high-capacity reservoirs are located inside national parks. There is potential for low-enthalpy geothermal projects in other parts of the country, for example, Cartago or Golfito (Bermudez, 2019).

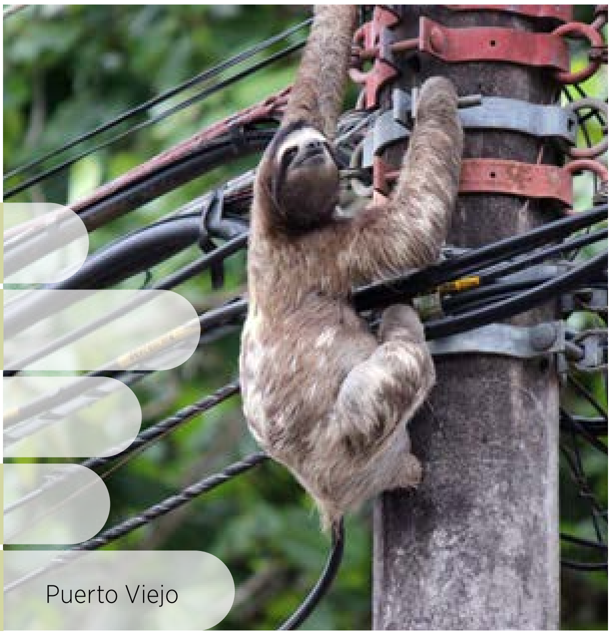
11 The official name of the bill is “Ley para avanzar en la eliminación del uso de combustibles fósiles en Costa Rica y declarar el territorio nacional libre de exploración y explotación de petróleo y gas”. The proposal aims to terminate the previous law on hydrocarbons (Number 7399, from 1994). The official text is available at: https://www.imprentanacional.go.cr/pub/2018/06/29/ALCA125_29_06_2018.pdf.

## EFFORTS TO ADDRESS NEW REALITIES

To diversify the country's energy mix requires both a change in the types of energy sources used and careful planning to avoid repeating missteps, as when erroneous projections of future electricity demand led to excess capacity. In this context, this section examines the relevant policy discussion and the work to draw up new rules for distributed generation. The section concludes with a discussion of Costa Rica's National Decarbonisation Plan.

### Adjusting to weaker-than-expected demand growth

Costa Rica's annual electricity growth is 0.8%, according to 2017 data by the National Centre for Energy Control, CENCE (Lara, 2018a). This is much lower than the medium-growth projection of 4% and high-growth projection of 5.3% underpinning ICE's 20-year energy expansion plans (Lara, 2018b). Several factors help explain weaker than expected growth in demand: gains in energy efficiency across the economy, lower population growth and slower economic growth (Cañas, 2018).



Puerto Viejo

The resulting excess capacities have financial consequences for ICE and for public finances because lower-than-projected demand translates into lower revenues to pay for the expansion of capacity. ICE's total debt increased 41% in 2018 compared to 2013 (Lara, 2018c) and this had become a topic of public debate, especially since 2018, when fiscal reform debates came to dominate politics and experts called for cost-reduction measures and new taxes to avert an economic crisis. In December 2018, a budgetary reform was passed after years of failed attempts, and 2019 featured greater scrutiny of public debt.

Media scrutiny of ICE's performance has provided fresh impetus to debates of the pros and cons of liberalising the electricity market and of new ways to lower electricity tariffs. Thus far, municipalities have not been active in efforts to decentralise generation mostly driven by solar companies. ICE highlights the achievement of 100% renewable energy generation, the reliability of the system (for example, during natural disasters) and the access that over 99% of Costa Ricans have to energy. The private sector stresses the drag on competitiveness of high electricity prices and argues in favour of increased private-sector participation in power generation and a more diversified energy mix, including solar energy projects. It has been pointed out that the legal framework is unfriendly to new private-sector generation.

The subject of private electricity generation is controversial in Costa Rica. Past government efforts to privatise segments of the sector prompted protests that eventually forced the government to abandon its plans (Alfaro, 2017).

ICE is under pressure to reduce costs and create new revenue streams and is aware of the consequences of low demand growth. Excess capacity in the power sector means the need to review expansion plans. One consequence of this situation is the decision to cancel the 650 MW Diquís hydropower project, which would have been ICE's largest-ever (Lara, 2018a).[12] The project costs had escalated from USD 1.8 billion in 2010 to nearly USD 3.7 billion by 2015.

12 Diquís would have flooded indigenous territory. It faced opposition from several stakeholders, including local community members, ecotourism businesses and energy experts. One indigenous community member took the State to court in April 2019, asking the courts to reverse the 2008 executive order declaring Diquís a "project in the national interest". The Minister of Environment and Energy at that time stated publicly that he sided with the citizen's request – the national interest decree was unjustified, he argued – and declared in May 2018 that he too opposed the project (Lara, 2018b).

## Expansion plans and engagement with municipalities

The 2019 edition of ICE's national expansion plan (2018–2034) reflects the Diquís cancellation and foresees no new capacity additions until 2026 but plans for additions of up to 653 MW by 2034 (Grupo ICE, 2019). Wind (280 MW) and geothermal (165 MW) are expected to contribute the most to this expansion, with additional hydro capacity limited to 47 MW, while increasing solar to 150 MW.

Other changes include the delay of a geothermal plant project in Guanacaste from 2024 to 2026, the closing of two old bunker-fuel plants (saving USD 5 million in operations) and a decision to halt any new investments in backup plants using fossil fuels (Lara, 2018c).

Costa Rica has no history of external stakeholder engagement in electricity sector planning and policy design, including local governments. This implies municipalities until today have limited decision making, and urban policies remain under the national authority.

ICE unveiled a new strategy in 2019 that is organised around five areas of work until 2023: (1) stabilisation and financial sustainability; (2) business evolution and customer experience; (3) operational efficiency, modernisation and digital transformation; (4) effectiveness of human talent; and (5) equity and sustainability. The framing vision is of a globalised society that is responsible, inclusive and sustainable. Smart cities are discussed as a global trend.

Modernisation entails the embrace of good governance practices such as accountability, transparency and fair treatment of stakeholders. Municipalities are, listed among the critical counterparts for ICE, along with banks, academia and manufacturers. While working with local governments does not feature in the strategy, this leaves hope for scope to revisit the role of local governing institutions in the future.

## The national energy plan's stakeholder consultation

Calls for greater stakeholder engagement in energy policy have come from the Ministry of Environment and Energy. In 2015, for the first time, it asked for feedback in preparation for the National Energy Plan 2015–2030 – mostly concerning NGOs, the business sector, political parties and other government ministries. No municipality participated in this process.[13] In October 2019, the ministry shared a draft version of proposed changes with a variety of stakeholders. Municipalities are not formally excluded, but in practice they are not engaged in these debates.

In other countries where cities engage actively in energy governance, local authorities make decisions about net metering, community-organised energy projects, provide feedback to national policy makers and propose ordinances. The overarching goal tends to be to promote renewable energy. Because the share of renewables in power generation is nearly 100%, municipalities have not been tasked with roles seen as routine in other countries – for example, setting up renewable energy targets, regulations to promote renewable energy use, fees and taxes as incentives for greater renewable energy use or engaging in citizen campaigns to encourage citizens' use of renewable energy.


Tortuguero

13 The list of participants in the 2015 energy dialogue process is available in Gobierno de La República (2015: 135 139).

## New rules for distributed generation

Another opening for broader participation in power generation – and arguably policy formation – occurred in the context of distributed generation and solar projects. New regulations allow self-supply net metering in Costa Rica (La Gaceta Diario Oficial, 2015). Back in 2010, ICE had launched a pilot project to test self-supply distributed generation. The programme had a maximum capacity of 10 MW, and ICE clients could apply (366 users were accepted out of 416 applications) with 99.5% of the projects deploying solar PV but a single biomass power project making up 45% of the installed capacity (Utgard and Forn, 2016).

The pilot solar energy project was successful, but ICE terminated it in February 2015, stating that grid-connected distributed generation should be considered a public service. Ruling in June 2015 that self-supply was not a public service, the state attorney clarified the rules for two distributed generation categories. Under simple net metering for self-supply, up to 49% of monthly electricity generation can be fed into the grid without payment. Under complete net metering, electricity sold to the electricity company is considered a public service and permits are needed for grid connection.

The requirements for this second category are higher and more complex than for the first category. Setting a capacity limit of up to 49% for the monthly power generation, subject to payment, is still controversial as it arguably makes distributed generation less attractive for clients with high seasonality, for example, hotels. Costa Rica has a strong tourism sector, and some hotels have been exploring solar generation options. Thus far cities have not been active in these debates.

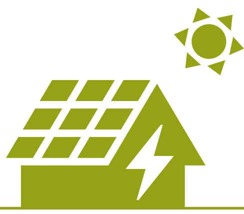
ICE has installed around 159 kW through rural electrification programmes that offer PV modules and direct current appliances to unserved clients in areas where extending the grid would be too expensive. Unlike municipalities, local entities were in these cases able to cater to themselves given that their customers need electricity in geographical areas that ICE does not reach.

Uncertainty remains, and efforts will be needed to avoid reducing distributed energy to one approach – for example, installing solar panels – without considering the wider spectrum of options such as demand management, energy efficiency and energy storage.[14]

One positive step would be to increase demand flexibility such as time of use (ToU) tariffs to incentivise large commercial and industrial energy consumers to reduce demand during peak hours. Thus far, one distribution company (CNFL) offers residential customers ToU tariffs. So far, the adoption of this voluntary scheme is marginal. Energy efficiency approaches are in place since 1994 and the National Energy Plan calls for stronger measures for end-use energy efficiency.

The main form of energy storage is large-scale hydropower dams connected at the transmission level. Fossil fuel–based power plants are the other backup for the electricity system. Most new buildings for offices and apartments have diesel generators to provide backup power for critical equipment in the event of power outages.

Once again, it is worth highlighting that municipalities are not yet part of this debate as they do not operate any power generation projects.



14 For an extensive discussion of distributed energy options in Costa Rica, see Utgard *et al.* (2016).

## The National Decarbonisation Plan

Costa Rica is one of the first developing countries to establish an official target to fully decarbonise the economy by 2050 and to publish an official plan for each sector of the economy.[15]

Led by the Ministry of Environment and Energy, the National Decarbonisation Plan 2018–2050 envisions three implementation periods (2018–2022, 2023–30 and 2031–2050). It aims to send a signal to the private sector, the public and municipalities by identifying transformation routes for each sector, including areas of work that could open opportunities for city-level action. The actions are presented in ten sectoral focus areas for the next three decades and organised in four clusters:[16]

**Cluster 1.** **Transport and sustainable mobility has three sectoral focus areas:**

- Collective transport,
- Fleets and passenger cars, and
- Freight.

**Cluster 2.** **Energy, green buildings and industry also has three sectoral focus areas:**

- Power sector,
- Buildings and
- Industry.

**Cluster 3.** **Integrated waste management has one sectoral focus area:**

- Waste management.

**Cluster 4.** **Agriculture, land-use change and nature-based solutions has, like clusters 1 and 2, three sectoral focus areas:**

- Agriculture,
- Livestock and
- Biodiversity.

Because three of the ten focus areas include clean transport, e-mobility is a central pillar of the decarbonisation vision.

In 2018, the decarbonisation of the economy became one of the three pillars of the National Development Plan, the official document guiding the central government. This plan tasks the Ministry of Economic Planning (MIDEPLAN 2018) to integrate decarbonisation into the activities of the line ministries.

Because Costa Rica has already effectively decarbonised its power generation, tackling its oil dependence is essential – a challenge mostly centred on the transport nexus. Table 4.3 discusses three focus areas in the National Decarbonisation Plan with direct relevance to transport and sustainable mobility.

The ministers of Environment and Energy, and Public Works and Transportation signed a transport sector agreement to reduce four megatons of $CO_2$ equivalent by 2050. This was announced the day the National Decarbonisation Plan was launched. The agreement's measures include public transport and active modes of transport such as biking and walking as well as cargo logistics (Cruse, 2019). Some municipalities are participating in the stakeholder engagement process surrounding this sectoral agreement.

Corcovado National park

15 In addition to the Decarbonisation Plan to 2050, Costa Rica's NDC under the Paris Agreement is to reduce GHG emissions by 30% between 2015 and 2030. In response to the Intergovernmental Panel on Climate Change (www.ipcc.ch/sr15/) Special Report on 1.5°C, the government is working on a revised NDC to make it compatible with a 1.5°C target. It will require deeper carbon emission reductions to 2050 and will be revisited in 2030.

16 The plan also establishes eight cross-cutting areas, for example, a green fiscal reform, digitalisation and equitable transition strategies for workers. These reforms are needed to achieve a zero-emissions society.

**Table 4.3 Cluster 1: Transport and sustainable mobility in the National Decarbonisation Plan**

| Three focus areas (out of 10) | Transformational vision to 2050 | Examples of mid-term goals |
|---|---|---|
| **Collective mobility**<br>Development of a mobility system based on safe, efficient and renewable energy in public transport, and active and shared mobility schemes. | The public transport system (buses, taxis, rapid transit) will operate in an integrated manner, replacing the private car as the first mobility option for the population.<br>By 2050, 100% of the buses and taxis will be zero emissions. | By 2035, 70% of buses and taxis will be zero emissions and passenger trains will be 100% electric.<br>An increase of at least 10% in trips in non-motorised modes within the main urban areas of the Great Metropolitan Area (GAM). |
| **Light-duty and passenger vehicles**<br>Transformation of the light-duty vehicle fleet to a zero emissions one, using energy that is renewable and not of fossil origin. | 60% of the fleet of light private vehicles will have zero emissions, with a higher percentage for those in commercial and governmental use.<br>100% of sales of light vehicles will generate zero emissions by 2050, at the latest. | In 2035, 25% of the fleet will be electric. |
| **Freight transport**<br>Promotion of freight transport that adopts modalities, technologies and energy sources that emit zero or the lowest possible emissions. | At least half of cargo transport will be highly efficient and will have reduced emissions by 20% compared to 2018 emissions. | By 2022 the country will have public data on carbon emissions (and certain pollutants) of the cargo truck fleet, and pilot projects will be carried out to increase the efficiency of trucks through an intelligent logistics approach. |

Source: Presidencia de La República, 2019a.

## The decarbonisation plan and municipalities

Costa Rica has gained awareness of the limits of a highly centralised governance structure. The need to actively engage municipalities in the design of cities of the future has entered the public debate. This may be observed in the vision of a "bioeconomy, green growth, inclusion and improvements in the citizens' quality of life" as stated in the National Decarbonisation Plan (Presidencia de La República, 2019a: 1).

The plan sent a new signal to municipalities. Sustainable urbanisation is key to decarbonisation, and the plan's implementation will require a stronger role for cities and local governments. In particular, the 2050 vision for focus area 1 (public mobility) embraces the goal of "compact cities in the main urban areas of the GAM and a 10% increase of non-motorised mobility in secondary cities" (Presidencia de La República, 2019a:32).

While the central government has primary responsibilities under the plan and is required by law to make transport-related decisions, the plan sets two goals for municipalities for the 2018–2022 period. First, at least 3 municipalities are to adopt a "transit-oriented development" vision in their planning and management practices and, second, 16 municipalities must join the Carbon Neutrality Programme 2.0.

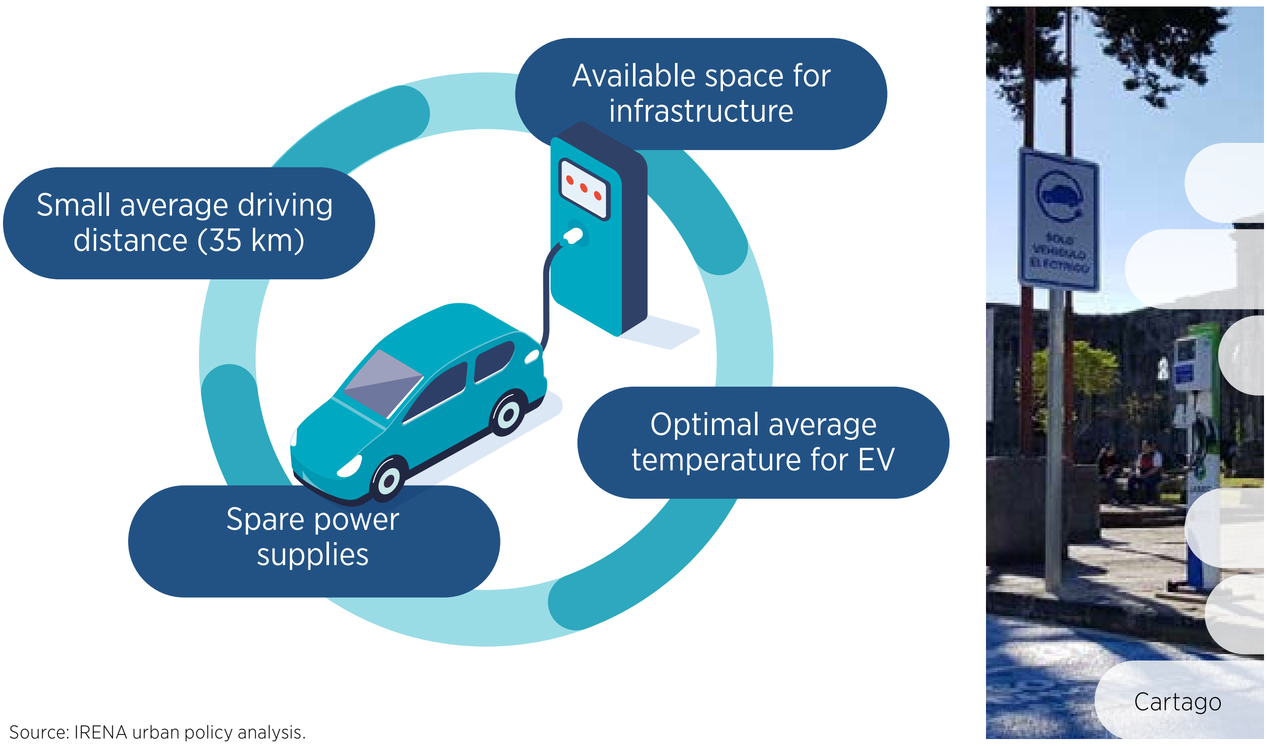
In terms of current administration activities (2018–2022), the focus will be on integrating the decarbonisation imperative into urban planning tools and manuals for municipalities and promoting compact city models by designing programmes and incentives for compact-city decisions. Enhancing infrastructure for bicycling and walking is a focus. There are also new restrictions on cars beyond San José and stricter parking rules. The government commits to include municipalities in decisions concerning bike paths and e-mobility.

## ELECTRIC MOBILITY AS THE NEXT FRONTIER

While Costa Rica's decarbonisation plan raised the visibility of e-mobility both nationally and internationally, the initial impetus came in 2015, when Congressional representatives and civil society advocacy groups pushed for the decarbonisation of the transport sector in the context of the Paris Climate Agreement. Costa Rica is a natural candidate for e-mobility for several reasons (Utgard, 2017).

First, nearly 99% of electricity comes from renewable sources, and the country has spare power supply. Second, because most private houses and other buildings have garages (unlike European cities such as Amsterdam, the Netherlands, or Madrid, Spain), most EV charging can happen there, limiting the need for street charging infrastructure principally for longer trips and for tourist services. Third, Costa Rica is a small country, where the average driving distance is 35 km per day. This means that even electric cars with limited range can easily be used for everyday driving needs in the metropolitan area, where most Costa Ricans live. Finally, the country's average temperature is 24.7°C, an optimal operating temperature for EVs (see Figure 4.4).

**Figure 4.4 Enabling factors for e-mobility**




Source: IRENA urban policy analysis.

This context is important because Costa Rica has seen the emergence of an ecosystem of e-mobility stakeholders from different sectors that successfully pushed for legislation in the previous legislature. At the end of 2017, the Congress voted in favour of providing incentives for zero-emission e-mobility as well as hydrogen technologies for use in cars, buses, motorbikes and e-bikes. When the Solís Administration (2014–2018) published Law 9518 in February 2018, Costa Rica became the first Latin American country to provide this type of incentive.

The main implication for municipalities is the call to provide free parking for EV drivers. They are not obliged to do so, but already one municipality has agreed to do so voluntarily (discussed later).

By February 2019, the National Plan for Electric Transport (Executive Order 41579) was published, setting up the basic rules for the deployment of EV infrastructure, and tax benefits for cars and spare parts. The plan also sets regulations to facilitate future manufacturing and assembly of EVs in Costa Rica (Lara, 2019). The main implication for municipalities is that they are encouraged to electrify fleets and to provide parking benefits for EVs.

The president appointed a commissioner for electric mobility – a technical expert from the ICE Group – to coordinate governmental activities around e-mobility, engage with the private sector and users and to liaise with municipalities.

Building on the Norwegian e-mobility example, the government unveiled a special "green plate" in February 2019 to make it easier to differentiate 100% electric cars from petrol and diesel cars and to facilitate the granting of benefits, for example, free parking and no driving restrictions.

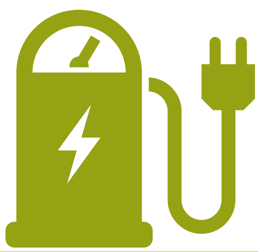
The current legislature (2018–2022) is exploring additional support measures, including extending EV incentives beyond the five years stated in the current law (Roque, 2019). Another proposed bill would put an end to the sales of internal combustion engine cars by 2025.

## Progress on EV infrastructure

The Electric Mobility Law 9518, discussed above, obliges the state to deploy charging infrastructure by 2020 and to develop a standard for charging stations, among other implementing measures. ICE invests in and oversees the growth of a fast-charging infrastructure. At the beginning of 2020, more than 100 public chargers (known as "L2 chargers", of 7 kWh) were available across the country. The government planned to complete the first phase of a network of 34 chargers by July 2020 to satisfy basic long-distance needs (Presidencia de La República, 2019a).

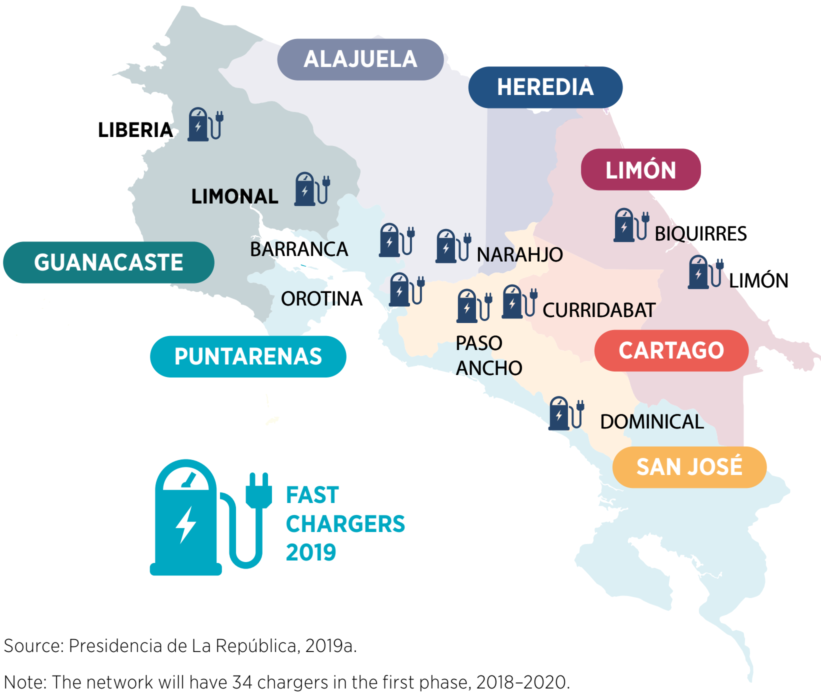
ICE considers itself the main provider of these services, arguing that the private sector would not be able to install fast-charging services and charge a fee to customers given the legal prohibition of private sales of electricity to consumers. Thus far, private companies have installed dozens of chargers, at business establishments such as shopping malls and car dealerships, intending to attract customers and polish their environmental credentials. They offer these services for free. The inauguration of new charging stations is often a public event.[17]

Other countries set the legal restriction to sell electricity as a private service. They found a compromise: the government and state-owned utility allowed the private sector to provide fast charging services and to charge a fee based on the time it takes to charge an EV (see Figure 4.5). But the electricity itself is provided for free so there is no breach of the law. This solution helps the private sector recover its investments in fast chargers, accelerates the deployment of infrastructure and encourages competition (several companies provide the services).



17 Local users of e-mobility have put together a public map with all the chargers (see www.conectaev.com).

**Figure 4.5 The top ten fast chargers for EVs in 2019**




Source: Presidencia de La República, 2019a.

Note: The network will have 34 chargers in the first phase, 2018–2020.

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

***Stimulating demand for zero-emission e-mobility***

Several initiatives aim to stimulate demand for e-mobility in the public and private sectors. Since 2017 civil society advocates have urged decision makers in both spheres to take action. Since then, four e-mobility festivals have helped to raise public awareness (Box 4.2). The first event was organised in collaboration with the municipality of San José. The ICE Group has also become a very active promoter of e-mobility through videos and educational activities and by collaborating with the Costa Rican Association of Electric Mobility (ASOMOVE).

Given that Costa Rica has an ageing fleet of buses and trains and faces severe road congestion,[18] the electrification of public transit has become an attractive proposition not only to meet decarbonisation objectives but also to modernise public transport and improve the quality of life.

The National Railroads Institute, INCOFER, has pledged to develop an electric train for the GAM (see Figure 4.6), but it should be noted that similar promises have failed to materialise throughout several administrations (Presidencia de la República, 2018b). The current proposal envisions a system that connects 4 provinces and 15 counties, covering a 72-km stretch. With the potential to move 200 000 persons daily, preliminary estimates suggest this train would cost around USD 1.3 billion. The Central American Economic Integration Bank (BCIE) has donated USD 1.3 million to conduct a feasibility study (Rodríguez, 2019).

The Decarbonisation Plan mandates a bidding process for the system by May 2022. In October 2019, a three-month virtual tour of the electric train was launched to educate the public about the attributes of the future electric train (Presidencia de la República, 2019b).

18 According to the State of the Nation, the cost of congestion in the GAM is about 3.8% of GDP per year (Arrieta, 2018).

**Figure 4.6 The most ambitious e-mobility project in Costa Rica to date: Electric train system of the Greater Metropolitan Area of San José**


Source: Presidencia de la República, 2018b.

Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.

Several initiatives are underway to promote electric buses. First, the government, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ, Germany's development co-operation agency) and the Costa Rica–US Foundation (CRUSA) have developed an e-bus pilot project (Blanco, 2020)

A working group includes the Ministry of Environment and Energy, Ministry of Transportation, public service regulator, ICE Group, UN Environment Programme and Inter-American Development Bank (CRUSA, 2019). Second, the ICE Group and the Chinese bus manufacturer BYD started another project in October 2019 to test an electric bus at the campus of national universities (BYD, 2019). Third, a private-sector company is testing a fuel-cell electric bus in the province of Guanacaste (Ad Astra Rocket, 2018).


In parallel, several technical assistance projects are being implemented to address capacity and knowledge gaps and provide instruments for decision making and scale-up of electric public transport.

An app-driven and privately run e-bicycle-sharing scheme, OMNIBicis, operates in the main metropolitan area with a current fleet of 400 bikes and a goal of 5 000 (Campos, 2019).

### *Promoting electric vehicles*

Costa Rica has about 1.1 million cars, and the average fleet age is 16 years (Arrieta, 2018). While public transit is a priority, there are also efforts to promote the purchase of EVs by public institutions, companies and private users (see Table 4.4). The government estimates that an EV fleet would save about 75% in operational costs compared to petrol or diesel cars (Estrategia y Negocio, 2018).

**Table 4.4 Efforts to promote electric vehicles**

| | |
|---|---|
| Public utility EV fleets | ICE acquired 100 electric cars for its fleet together with 110 EV chargers, the largest purchase of institutional fleet EVs in Latin America (Estrategia y Negocio, 2018).<br>Other public entities planned follow suit in 2020 (Blanco, 2020). |
| Postal zero-emission deliveries | The postal service aims to electrify its fleet of 348 motorbikes by 2023, with an intermediate goal of 70 by 2020 (Presidencia de la República, 2019b). |
| Electric motorbikes for the police and security companies | The national police force plans to electrify its fleet; a first phase began in October 2019 with ten electric motorcycles (Arce J. M., 2019).<br>One of the leading security companies in the country has electrified half of its fleet and aims to electrify the entire fleet in the future (Marin, 2019). |
| National insurance company's EV discount | The national insurance company (Instituto Nacional de Seguros, INS) offers a 15% discount on insurance of all EVs (Grupo INS, 2019). |
| Executive order #41426 to give incentives to second-hand EVs | To complement the *Electric Mobility Law 9518* (focused on new EVs), this decree authorises discounts for second-hand EVs (certain taxes are waived) that are not older than five years and do not exceed USD 30 000 in cost (Presidencia de la República, 2018c). |
| Banks credit line for electric taxis, e-buses and private electric cars | Three state-owned banks (Banco Popular, Banco National and Banco de Costa Rica) will provide special credit lines for EVs, electric taxis and electric buses that include favourable interest rates and some discounts (Presidencia de la República, 2019b). |

Tourism is a key economic activity in Costa Rica, and e-mobility represents an opportunity for boosting eco-tourism (Utgard, 2017). Several efforts are underway by EV advocates in civil society and the private sector (see Table 4.5). Integrating e-mobility fleets in this sector can help stimulate demand. Municipalities are not yet engaged in this opportunity, but the Monteverde Electric Route offers a pioneering example of a community-run initiative engaging the local government.

Most local governments in Costa Rica have been silent in the e-mobility debate. One reason is the lack of requisite technical expertise. In the absence of a legal mandate to manage transport, their teams have never developed expertise in this area. Yet there are several pioneering municipal efforts to learn from.

**Table 4.5 Efforts to connect e-mobility with eco-tourism**

| | |
|---|---|
| Electric rent-a-car | In August 2019, a key rent-a-car company announced its first EV for rent and plans to electrify its fleets (Herrera, 2019).<br>A Dutch tourist company planned a "Green Circle" EV driving tour of a dozen eco-lodges that meet the highest environmental standards in Costa Rica. About 20 EVs will be available for the tour, and the first units are already in operation (Smit, 2019). |
| Charging EVs at iconic destinations | The minister for environment and energy announced that the government would install 12 L2 chargers in national parks (Cerdas, 2019). |
| Hydrogen cars for eco-tourism | Toyota Costa Rica (Purdy Motors) and Ad Astra are partnering with premium car rental services to offer zero-emission driving in Guanacaste (Castro, 2019). |
| Electric shuttles for tourists | Nosara, a prime tourist destination, has commissioned a study of the benefits of replacing its fleet of motorbikes with electric buses (Presidencia de La República, 2019a). |
| Eco-tourism in Monteverde | CORCLIMA (Comisión para la Resistencia al Cambio Climático) launched an electric route for ecotourists in the Puntarenas Province, in collaboration with Costa Rica Limpia (Costa Rica Limpia, 2019).[19] It aims to inspire electric tours nationwide (Dvrgente, 2019). |

Cariari

## DECARBONISING CITIES

The growing recognition of limitations inherent in highly centralised governance (Presidencia de La República, 2018a) has triggered demands for change by citizen groups and others seeking improved and more sustainable mobility and, more broadly, better urban planning. The current gaps are well documented in the State of the Nation report, an independent annual assessment (see Box 4.2).

These expert discussions used to focus on the role of the central government, not that of local governments. But this is changing. As congestion and air pollution worsen, new

19 Monteverde, an iconic destination and arguably the first eco-tourist destination in the country (Van Dusen, 2019), is working with businesses and the local government, through the platform CORCLIMA, to engage over 50 small and medium enterprises – restaurants, hotels, lodges and tourist destinations – in the "the first EV friendly community" for tourist travel in Costa Rica. The town offers free charging to electric drivers and a digital map with information about EV-friendly companies and places to visit. The long-term goal is to signal to car rental companies that Costa Rica's eco-tourism industry requires a strong offering of electric car rentals (CORCLIMA, 2019) and to motivate other local communities and governments to follow suit.

## **BOX 4.2** THE IMPORTANCE OF ADVOCACY IN SCALING UP E-MOBILITY IN COSTA RICA

In addition to legislation, the promotion of e-mobility is a cultural challenge that involves addressing myths, resistance to change and scepticism. In Costa Rica, citizen groups have played an active role and could in the future combine forces with new stakeholders such as municipalities.

Among other things, citizen groups proposed the first pathway to e-mobility in Costa Rica. In 2017, the advocacy group Costa Rica Limpia modelled the required infrastructure to 2030 and provided answers to frequently asked questions and ideas about smart charging solutions, informing decision makers and stakeholders such as car companies; mobility, climate and energy experts; financial institutions and others. ASOMOVE was set up to accelerate the shift to zero-emission transport.

Costa Rica Limpia and ASOMOVE pioneered "electric mobility citizen festivals". The first festival took place at the municipality of San José. This annual event is sponsored by the private sector (through participants' fees) and features exhibits, test drives, talks and media engagement. About 5 000 people attend over two days. Special awards have been given to early adopters, for example, the first-ever electric taxi driver in Costa Rica. ASOMOVE has also created a platform for interaction among community members to stimulate demand and address prejudices against EV adoption (Rivera, 2019). In October 2019, ASOMOVE signed a memorandum of understanding (MOU) with the Solar Energy Association (ACESOLAR) to promote joint activities, advocacy, and consumer and media outreach.

The engagement of users and consumers is part of a broader pattern to influence society from a bottom-up perspective. Many of these efforts also aim to engage cities and local governments to help speed up change and send signals to the central government about the need to integrate cities and local governments in a fossil-free society.

Sources: ASOMOVE, n.d.; Costa Rica Limpia, n.d.; Utgard, 2017.


questions have emerged around the need to engage municipalities (at least those in the GAM) on urban planning issues, waste management, water and e-mobility.

The country will need to address the chicken-and-egg dynamic around governing competence: on the one hand, new powers are withheld from the municipalities because they are deemed ineffective (according to the Municipal Performance Index [20]), yet on the other hand, the more disconnected they are from planning their own future, the less they are able to build the skills and expertise needed to take charge and improve cities.

Some programmes seek to engage in climate debates and to develop municipal inventories to become familiar with the sources of their carbonisation.

Cartago

## Municipal engagement in carbon neutrality

In the context of Costa Rica's NDC in response to the Paris Climate Agreement, the Ministry of Environment and Energy has engaged municipalities in the National Carbon Neutrality Programme 2.0 by developing a specific programme for them (Programa País Carbono Neutral Cantonal) (Presidencia de la República, 2017). The programme aims to contribute to Costa Rica's climate action agenda, through the development of GHG inventories at the municipal level, together with the implementation of a measurement, reporting and verification (MRV) system. Is also aims to identify main GHG emissions contributors in the municipalities, and to develop concrete mitigation actions in the identified sectors (Ministry of Environment and Energy, 2017).

The country had set the goal of 16 municipalities measuring their GHG emissions by 2022. Initially, a pilot phase was established for five municipalities and two districts.[21] Between 2018 and 2019, 15 additional municipalities joined the programme.[22] The 22 municipalities participating represent 38% of the Costa Rican territory and 43% of the population (Elpais.Cr, 2019).

20 According to the Municipal Performance Index of 2018, only 25 of 82 municipalities met performance indicators (Contraloría General de la República 2019). The most problematic areas are waste management, planning, internal controls, citizen participation and accountability. During 2018, municipalities set up plans to improve their performance – as requested by the evaluator – and 65 municipalities improved their indicators with respect to 2017. Ten municipalities, however, have shown no progress. The index highlights areas where progress has occurred, such as citizen engagement, and where no progress can be observed, such as public service user satisfaction. A new survey of municipal websites indicates that 77 of 82 fail to fulfil key transparency criteria (yet in terms of public participation and open data there have been some improvements) (Defensoría de los Habitantes, 2019).

21 Belén, La Unión, Desamparados, Golfito, San José, Monteverde District and Puntarenas District.

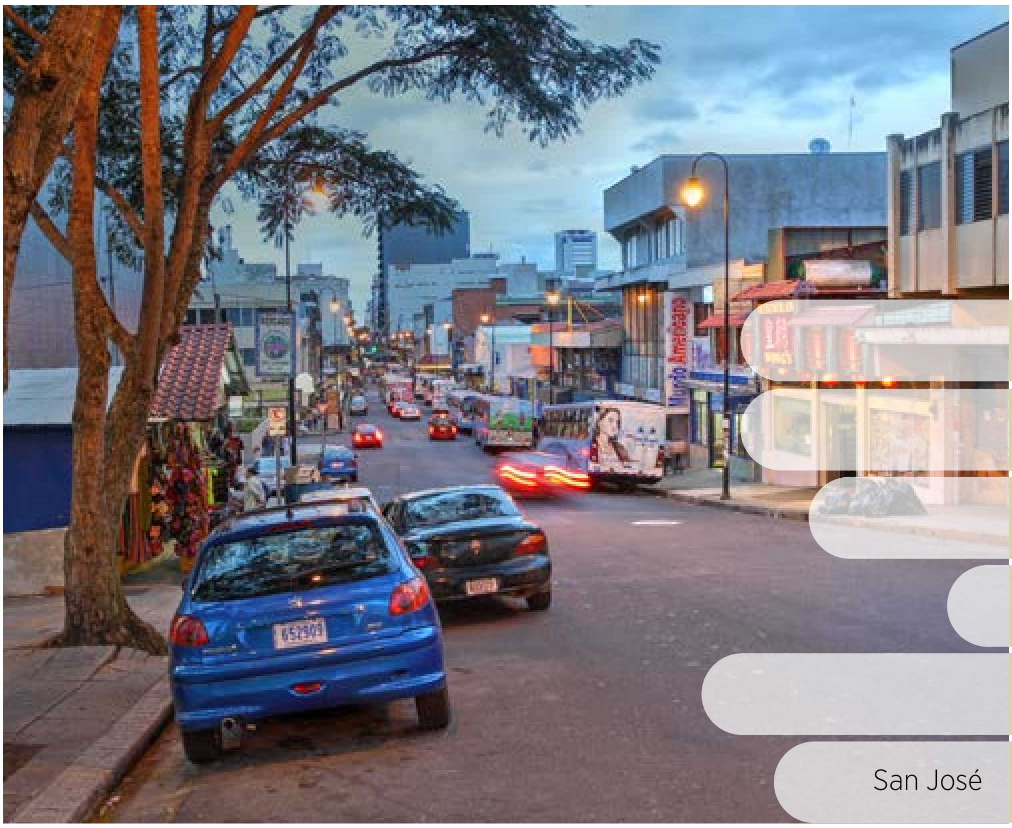
22 San Carlos, Cartago, Pérez Zeledón, Pococí, Goicoechea, San Ramón, Santa Cruz, Nicoya, Montes de Oca, Oreamuno, Osa, Quepos, Cañas, Parrita and Zarcero.

The programme was started to teach teams to develop GHG inventories. Cities had to compete to get support to design their inventory (Berlin, 2018). Once the results were analysed, the government launched a second contest, and 14 additional municipalities were selected (Rodríguez, 2019).

Cities played a major role in developing this programme to track their carbon footprint (Bermudez, 2019). Costa Rica's largest city, San José, found that transport accounts for 55% of its total carbon emissions (Salazar, 2018). Transport is also a significant source in smaller cities; much of this impact stems from vehicles that merely pass through a particular canton, adding to air pollution and congestion but not contributing to the local economy.

Between 2017 and 2019, 139 institutions participated in this programme, which has trained 1 400 people and 300 city governments and districts to measure and mitigate the local carbon footprint (Elpais.Cr, 2019).

IFAM participated in the preparatory consultations for this programme. It is undergoing internal changes to better support municipalities in tackling climate change issues, including e-mobility, together with efforts to link municipalities to international initiatives (see Box 4.3). This is happening as the Ministry of Environment and Energy's climate change directorate also seeks to engage cities and municipalities in the national decarbonisation plan.



San José

## **BOX 4.3** IFAM'S NEW URBAN AGENDA

Together with the Ministry of Environment and Energy and the European Union delegation to Costa Rica, IFAM (the Municipal Advisory Institute) hosted the Global Covenant of Mayors for Climate and Energy in 2018. Thirteen municipalities joined the Latin American pact of this covenant to promote good practices. The IFAM president has highlighted the importance of investing in local development (Guerrero, 2018) and engaging municipalities in e-mobility education.

In August 2019, IFAM co-organised the first-ever workshop with ASOMOVE to train municipalities and share insights from international experience and lessons from the municipalities of Cartago and Grecia (Case 1). The institute is developing a how-to manual for municipalities on climate issues and will cover some basic e-mobility elements.

IFAM set up a national mobility event in December 2019 to showcase best practices. It is also working with the National Union of Local Governments (UNGL) on the MUEve project in collaboration with the Office of the First Lady. The project consists of a subregional plan for urban development oriented to transport that counts on the engagement of 15 municipalities. It proposes safety improvements at the cantonal level, complementary infrastructure near train stations (including sidewalks), public spaces, and pedestrian and bicycle paths. The European Union awarded USD 5.1 million in August 2019 to the Government of Costa Rica to support IFAM's technical dimension.

Source: IFAM.go.cr.

## Case 5: Municipal engagement in e-mobility in Cartago and Grecia

Municipalities could play a more active role in stimulating e-mobility choices, beyond granting permits. Two Costa Rican cites, Cartago and Grecia, have become pioneers in promoting e-mobility, and both report broad public acceptance (ASOMOVE, n.d.).

The municipality of Cartago developed a co-operation agreement on e-mobility with JASEC, the Cartago Board of Public Services. In 2019, the municipality initiated the first phase of "Cartago Green Transport", promoting the decarbonisation of transport and the education of citizens about the importance of reducing carbon emissions (Calderon, 2019). The strategy involves the following elements:

- **Free EV charging stations:** By working with JASEC and private sector companies, four semi-fast charging stations were installed in the main mall, the JASEC headquarters and two public spaces.
- **EV fleet:** The municipality plans to substitute its internal combustion cars with EVs.
- **Electric bikes:** The municipality acquired 25 electric bicycles for free public use at the train station, the main university and the technical college. Cartago is the only city where a bike path operates since 2016 and 100 bikes are already available for public use (ASOMOVE, n.d.).
- **Fast chargers:** The installation of fast chargers in collaboration with JASEC started with two units in December 2019, as part of an approved government plan specifying locations for fast-charging infrastructure (Municipalidad de Cartago, 2019).

Grecia is home to about 80 000 people in the province of Alajuela, Costa Rica's second-largest province, and the capital city has a population of about 38 000. A campaign to brand the city as "Grecia: We Are Progress" has the mission to make it "a model city and a county of opportunities, under a sustainable and inclusive development approach. With vibrant and progressive people, with participatory citizenship, linked and proud of their identity" (Municipalidad de Grecia, 2019).

The campaign seeks to attract investments and tourism, promoting a healthy environment and the use of smart technologies. In 2017, the municipality signed an MOU with the Korea Advanced Institute Science and Technology (KAIST) to collaborate on intelligent lighting and EV charging, among other initiatives (Municipalidad de Grecia, 2018). This is the first municipality in the country to install smart parking meters (Municipalidad de Grecia, 2020) as a result of an MOU with ESPH, the municipal company of Heredia, Costa Rica.

The municipality is now taking initial steps to promote e-mobility, including the installation of chargers, acquisition of electric motorbikes for parking meter inspectors and free parking for EVs as suggested by the Electric Mobility Law of 2018.

Grecia

## Case 6: Guanacaste as a "decarbonisation hub"

Guanacaste is considered Costa Rica's "capital of renewable energy" and sets a precedent for towns outside the GAM. Since the 1990s, Guanacaste generates nearly 40% of Costa Rican electricity and is home to 27 plants with 978 MW of installed capacity. The Arenal, Dengo and Sandillal plants – known as the "Ardesa" complex – form the core of the Costa Rican electric system (Grupo ICE, 2018b). The electricity produced in Guanacaste comes from a mix of ICE Group plants, private-sector projects and Coopeguanacaste[23], the local, independent electrification co-operative.

Guanacaste has hosted several trailblazing projects in the fields of wind, solar and geothermal. The first-ever wind power plant in all of Latin America was set up in the area in 1996. Today, the Guanacaste Province is also home to 16 of Costa Rica's 18 wind power plants. In 2019, the wind parks accounted for 11.5% of the country's electricity mix, becoming the second source of production behind hydropower. It is important to mention that as the wind resource is concentrated mostly in Guanacaste, the transmission capacity needs to be increased to distribute the electricity across the country (Teske, Morris and Nagrath, 2020).


Similarly, the first PV electricity generation plant in Central America, Solar Miravalles, was installed in Guanacaste in 2012. While biomass barely plays a role in Costa Rica's matrix, two out of the four existing plants are located in Guanacaste: the Taboga and El Viejo sugar mills have been feeding electricity into the national system since the mid-1990s (Taboga, n.d.; FAO, n.d.; Azucarera El Viejo, n.d.).

The integration of geothermal and wind has played an essential role in diversifying the electricity matrix. After more than 20 years of studies in Bagaces County, the 55 MW Miravalles I Geothermal Plant was inaugurated. Hand in hand with this resource, ICE decided to convert grasslands into secondary forests. Next to the second geothermal field of the country – Las Pailas – today 1869 hectares of forest are protected and recovered, and species of flora and fauna that had almost vanished amidst livestock and timber are once more visible.

Guanacaste has many solar projects. Coopeguanacaste developed and operated Costa Rica´s largest solar park – Parque Solar Juanilama with 5 GW – reaching 2100 homes. Occupying 5 hectares and featuring 15 456 PV panels, it generates 9 GWh per year. The project was launched in September 2017 with USD 8.6 million from a private-sector fund, MSEF, resulting from a bilateral agreement between Japan and Costa Rica (Coopeguanacaste R.L., 2019).

In January 2018 Coopeguanacaste installed the first EV charger in the province to attract EV users to this popular tourist destination (Coopeguanacaste R.L., 2018). Other chargers have since been installed. The co-operative sells electricity and wants to develop new business opportunities around e-mobility. These first chargers signal the

23 Coopeguanacaste R.L. provides electric and commercial services to a large area of the Guanacaste Province.

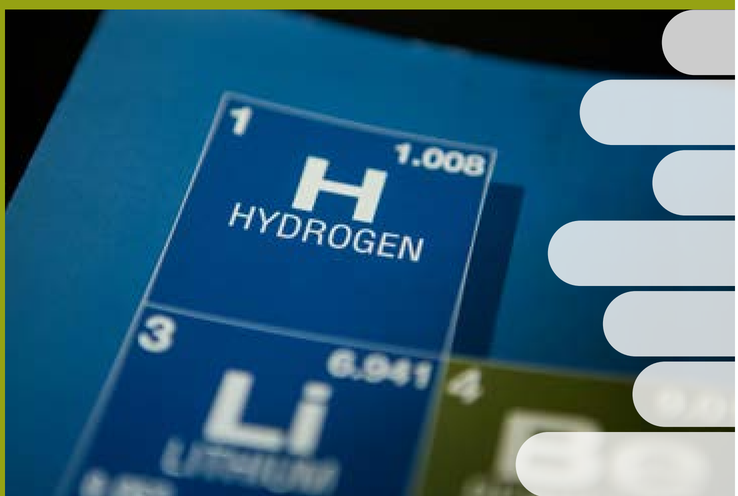
co-operative's effort to provide charging services outside the GAM. The ICE Group has also installed fast chargers in this province. Both electricity companies aim to encourage consumers to consider switching to electric options and to signal the emergence of an electric market in Guanacaste. In August 2019, the ICE Group installed the first fast charger outside the GAM at a popular restaurant in Limonal, Guanacaste.

Guanacaste is also at the forefront of Costa Rican forays into developing hydrogen as an alternative transport fuel. An alliance to establish a hydrogen economy (see Box 4.4) grew out of initial efforts by a private firm, Ad Astra Rocket Company (based in Liberia, the main city in Guanacaste), to launch local fleets of hydrogen buses and cars, in co-operation with Purdy Motor (Toyota), Relaxury and Las Catalinas. Guanacaste is currently the only place in Latin America where hydrogen cars are being tested (Castro, 2019). Unlike many other hydrogen projects around the world that use natural gas, this initiative relies on renewable energy sources. Ad Astra is also involved in efforts to develop hydrogen refuelling infrastructure in Liberia, with support from the Toyota Mobility Foundation and the Innovation Laboratory of the Inter-American Development Bank (IDB Lab), respectively.[24]

## **BOX 4.4** AN ALLIANCE TO DEVELOP THE HYDROGEN ECONOMY IN COSTA RICA

An alliance to promote the hydrogen economy was launched in July 2019 (CRUSA, 2019) by Ad Astra, the Innovation Laboratory of the Inter-American Development Bank (IDB Lab) and the CRUSA. While this is not a project led by a city, it does establish a positive precedent for innovative, decentralised models that are not run from San José but create their own ecosystem of non-state actors. The alliance also involves companies like Purdy Motors, Linde, 21st Century Strategy, Electrotechnical Group, Matelpa, Siemens, Cummins and Relaxury. ICE joined the alliance in 2019.

This alliance seeks to develop a Costa Rican hydrogen ecosystem in support of decarbonisation efforts. It promotes the use of hydrogen as a clean energy vector in road transport (cars, cargo trucks, public transport and light industrial vehicles) and potential energy storage in the industrial, commercial and residential sectors. As a facilitator of the energy transition, it will seek high-level technical assistance to quantify the impacts and benefits of hydrogen in the country, as well as to develop proposals for regulatory frameworks that allow the development of the hydrogen market.




24 This laboratory supports early-stage ventures that can improve the lives of populations vulnerable to economic, social or environmental challenges.

## LESSONS LEARNT

Costa Rica has several defining attributes that set it apart from other locations. These include a large percentage of renewable energy sources in power generation and a highly centralised governance structure for both energy and transport. Cities do not make energy and transport decisions, but rather play a marginal role in local decision making and implementation, from power production to the operation of electric bus fleets.

As cities become central protagonists of the efforts to promote sustainable urban practices and liveable cities in many parts of the world, municipalities in Costa Rica, too, may become more interested in taking part in their country's ongoing energy transformation. In many ways, this is also about better urban governance, and local choice. Although it is unlikely that cities will be running energy projects themselves, the demand for more decentralised energy systems, and in particular for solar energy solutions, is hardly going to end. Capacity building as part of the GHG inventories under Costa Rica's Carbon Neutrality Programme could be a first step towards empowering Costa Rican cities in developing their own mitigation strategies and playing a more relevant role in the decarbonisation process.

Governance adjustments are more likely in the realm of public transport. As other Latin American cities like Medellin and Cali in Colombia, Panama City in Panama and Santiago in Chile advance with their e-mobility projects – in particular, electric buses – the contrast with Costa Rica (*i.e.*, with its lack of municipal transport authorities) becomes clearer. One possible step forward is to develop the role cities play in waste and building management, including through local policies designed to boost energy efficiency and distributed generation, both pillars of the national decarbonisation plan.

For now, encounters with representatives of cities elsewhere in the region are informal. Indeed, Costa Rican local governments would benefit from developing "sister city" approaches or co-operation agreements with other cities that are pursuing similar tasks. The Decarbonisation Plan to 2050 offers a concrete opportunity to rethink the role of cities and to make proposals for engaging cities in the implementation of actions in the short, medium and long term.

Solving the energy-transport conundrum in Costa Rica will require rethinking the role of urban planning and the greening of cities. The current level of centralisation may present a barrier to the successful implementation of the National Decarbonisation Plan. The transformation of public transport holds great promise because of the high cost of the current model.


The integration of e-mobility – given the country's large share of renewable electricity – interfaces with the importance of eco-tourism to the economy. There is a need to offer new experiences and value propositions, and zero-emissions tourist experiences open a new space for decentralised, in-situ projects where municipalities can engage and perhaps even propose their own projects.

Having a formal economy-wide decarbonisation plan sent a powerful signal to companies and municipalities. Today the question is how to engage non-state actors and local governments. The country's current administration has prioritised decarbonisation as one of the top pillars of the development strategy, realising that the involvement of the private sector, municipalities and citizens is essential. In parallel, a new ecosystem of stakeholders is emerging around sustainable mobility, cities and climate action.

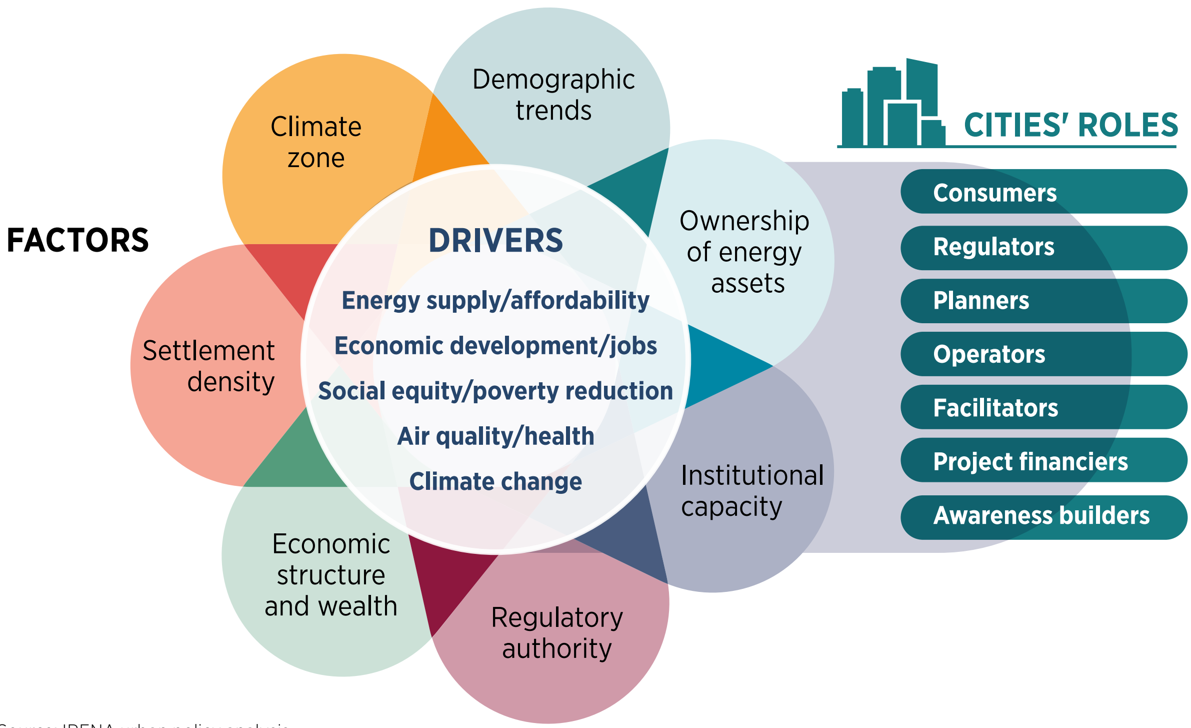
Collaboration with a diverse set of actors is key to success, the Guanacaste renewable energy hub – featuring renewables, e-mobility and a hydrogen ecosystem – confirms the critical importance of multi-stakeholder engagement in pioneering initiatives. In a country where energy and transport decisions are centralised in San José, the Guanacaste developments might pave the way for new modes of achieving goals in renewable energy and clean transport in Costa Rica and beyond.

Promoting international best practices among municipalities will be essential: because local governments are weak, learning from other countries and cities will encourage them to avoid mistakes and to learn from successful policies. New initiatives, such as how to promote e-mobility at the municipal level or how to measure emissions, are helping municipalities gain insights into how to manage these emerging agendas.

# 5. WRAP-UP

Cities are promoting the use of renewable energy even as a complex set of circumstances determine their energy needs and their capacity to act. Diverse factors shape the many roles that cities can fulfil, and diverse drivers, likewise, inform the policies actually formulated in pursuit of renewables for electricity, heating and cooling, and transport (see Figure 5.1).

**Figure 5.1 Factors and drivers motivating municipal energy policies and shaping cities' roles in the energy transition**




Source: IRENA urban policy analysis

Costa Rica

While the particular mix of **drivers and motivations** regarding the energy transition varies from city to city, a secure and affordable energy supply is an objective held in common by all cities. Other drivers include economic development (job creation); social equity (including improved energy access and reduced energy poverty); and air quality and health as vital components of a better urban quality of life and concerns about climate change impacts.

But the needs and capacities of cities are far from uniform. Strategies to promote renewables need to be tailored to each city's specific conditions. These conditions determine whether overall energy demand is growing or falling; they also shape the ability of cities to act.

Some of these **factors** are fixed and therefore impossible to alter. A given city's climate zone cannot be changed, and it shapes a city's heating and cooling needs). Other factors, such as settlement density and the built infrastructure can be altered only over time. Demographic and socio-economic profiles are more dynamic and malleable factors, but cities with rapidly growing populations face greater challenges than those with stable populations, and wealthier cities have greater leeway to act than poorer ones.

Another set of factors concern cities' institutional capacity and authority to act. Regulatory authority, vis-à-vis national and/or provincial governments varies tremendously. Some cities may have limited powers to generate their own revenue streams or to decide how to spend them. Furthermore, cities may not have the full technical know-how they require. In general, cities that own their own power-generating assets have far more direct influence on energy policy than those that do not.

These background factors and drivers interact and influence one another. Together, they determine the specific **roles** cities can play in the energy transition, whether it be as regulators, planners and operators, energy consumers, project facilitators and financiers, or as facilitators of raised public awareness. These different roles require different policy toolboxes. They are driven by energy and climate ambition, by local institutions' capacity to act, by interactions between energy and other sectors of the local economy and by alliances among different local or non-local actors.

This means that any analysis of cities' renewable energy policies needs to assess not only the local resource endowment (and the technical feasibility or financial viability of projects) but also a range of socio-economic and political factors, including which key actors and stakeholders set the stage for policy making.

The city case studies from three countries featured in this report provide in-depth assessments of specific conditions and circumstances. They indicate that both national and local factors are of crucial importance, both in terms of the challenges and opportunities faced by municipal-level decision makers. Governmental structures in all three countries are quite different from each other, with unique, and as such they illustrate the broad range of political and administrative realities around the world.

The huge scale of Chinese cities stands out. Costa Rica is tiny by comparison. Still, size notwithstanding, both China and in Costa Rica feature strong centralised governance patterns; in Costa Rica, local administrations are limited in what they can do. Whereas Chinese cities are powered largely by coal, an unsustainable energy source, Costa Rican cities already rely on a renewable source – hydropower – for their electricity needs. Their challenge is to effect an energy transition in the end-use sector of transport. In Uganda, cities are far more concerned with improving energy access.

Lessons learnt and best practices are worth sharing among cities, domestically and internationally. Indeed, many are collaborating with like-minded cities and public and private actors in peer-to-peer networks devoted to energy and climate objectives. They share information and insights, exchange suitable policies, pool technical capacities and broadly compare notes on lessons learnt.

A range of policies in support of renewable energy is relevant to cities, but it is clear that there is no simple one-size-fits-all approach. 'Replicability' is a familiar term in policy analyses, but real-world replicability has practical limitations owing to the variable conditions and circumstances of cities worldwide.

It is important for cities to ensure that collaboration with national governments is effective. Just as critical is proactive engagement with local residents, community groups and businesses. The mix of local drivers and factors and the way in which various urban stakeholders are being involved shape the roles cities can realistically fulfil. Policy ambition is critical (as is the local capacity to act). Also critical: a strong understanding of how energy interacts with other sectors of the urban economy.

China

## REFERENCES


**ABRAVA (2015),** "Research Report Production of Solar Collectors for Water Heating and Thermal Reservoirs in Brazil Year 2014, *(Relatório de Pesquisa Produção de Coletores Solares para Aquecimento de Água e Reservatórios Térmicos no Brasil Ano de 2014)*", Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating, São Paulo, www.solarthermalworld.org/sites/gstec/files/news/file/2015-07-27/market_statistics_2014_brazil.pdf.

**Ad Astra Rocket Company (2018),** "San José has a special guest on May 8th", press release, 7 May http://adastrarocket.com/pressReleases/2018/PresidentialInnaugurationMay-7-2018-final-EN.pdf.

**Adeyemi, K.O. and A.A. Asere (2014),** "A review of the energy situation in Uganda" *International Journal of Scientific and Research Publications*, Vol. 4, Issue 1, January 2014 https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.407.4007&rep=rep1&type=pdf.

**AFIEGO (2014),** *Energy Poverty in Uganda: The Role of Renewable Resources*, Africa Institute for Energy Governance, Kampala.

**Agar, B. and Renner, M. (2016),** "Is 100 percent renewable energy in cities possible?", in *State of the World. Can a City Be Sustainable?* Worldwatch Institute: Island Press, pp. 161-170.

**Alfaro, J. P. (2017),** The "combo" that shudder the country, (El combo que estremeció al país)", *La Nación*, 25 March, www.nacion.com/el-pais/el-combo-que-estremecio-al-pais/XPNTNN5GIFFVFCZ7AVOTCP74W4/story/.

**Arce, J. M. (2019),** "Electric motorcycles join the traffic pólice, (Motos eléctricas se unen a la policía de tránsito)", *PuroMotor*, 24 November, https://puromotor.com/industria/motos-electricas-se-unen-a-la-policia-de-transito/.

**Arce, M. A. (2020),** "Economic slowdown hits each of the country's regions with different intensity, (Desaceleración económica golpea con diferente intensidad a cada una de las regiones del país)", El Financiero, 3 January www.elfinancierocr.com/economia-y-politica/desaceleracion-economica-golpea-con-diferente/57PTN3RXONBBZHKVSZ3FEX5GVQ/story/.

**Arrieta, E. (2018),** "Costs derived from road congestion in the Great Metropolitan Area (GMA), represent around 3.8% of GDP, (Costos derivados del congestionamiento vial en la GAM, representan alrededor de un 3,8% del PIB)", *LaRepublica*, 14 November www.larepublica.net/noticia/costa-rica-es-el-tercer-pais-con-mayor-densidad-vehicular-de-latinoamerica.

**ASOMOVE (n.d.),** "Costa Rican Electric Mobility Association, (Asociación Costarricense de Movilidad Eléctrica)", www.asomove.org.

**Asiimwe, W. (2010),** "Rwenzururu kingdom in cash appeal," *The Observer*. Available online: www.observer.ug/component/"content/article?id=7922:rwenzururu-kingdom-in-cash-appeal (Accessed 22 September 2019) .

**Azucarera El Viejo (n.d.),** "Electric Power, (Energía eléctrica)", www.azucareraelviejo.com/es/energia-electrica.

**Baluku, G. K. (2015),** "Uganda Mayor: 'My district will be 100% renewable by 2020'". The Guardian, Tuesday, 20 October. Available online: www.theguardian.com/global-development-professionals-network/2015/oct/20/ugandan-mayor-my-district-will-be-100-renewable-by-2020 (Accessed 3 June 2019).

**BDLG (2016a)**, "Statistical Abstract", Buikwe District Local Government, Uganda, https://buikwe.go.ug/sites/default/files/Buikwe%20District%20Statistical%20Abstract%20Fy%202015-16.pdf.

**BDLG (2016b),** "Buikwe District Local Government: Profile", Buikwe District Local Government, Uganda https://buikwe.go.ug/sites/default/files/District%20Profile%202016%20Buikwe%20final.pdf.

**BDLG (2015),** *District Development Plan (DDP II)* 2015/16 2019/20, Buikwe District Local Government, Uganda https://buikwe.go.ug/sites/default/files/media/FINAL%20DDPII-BUIKWE%202015%20-%202020_0_0.pdf.

**Beard, K. (2019),** "Solar firm installs rooftop panels at Fed-Hock school", The Athens News, 7 April, https://www.athensnews.com/news/local/solar-firm-installs-rooftop-panels-at-fed-hock-school/article_ed5215b2-595e-11e9-b3b5-5fb568b33697.html.

**Berlin, A. (2018),** "Municipalities Against Climate Change, (Municipios contra el Cambio Climático)", presentation by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, San José, Costa Rica, March 21 http://ledslac.org/wp-content/uploads/2018/03/Presentacio%CC%81n-Municipios-Costa-Rica_AnnikaBerlin_LEDSLAC.pdf.

**Bermudez, E. (2019),** "Personal communication by IRENA consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Binego, A. K. (2014),** "Causes of River Nyamambwa floods", *New Vision*, 19 August www.newvision.co.ug/new_vision/news/1336451/causes-river-nyamambwa-floods.

**Blanco, A. (2020),** "Personal communication by IRENA consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Bloomberg (2019),** "The U.S. has a fleet of 300 electric buses. China has 421,000", *Bloomberg News* 15 May, www.bloomberg.com/news/articles/2019-05-15/in-shift-to-electric-bus-it-s-china-ahead-of-u-s-421-000-to-300.

**BNEF (2018),** *Electric Buses in Cities: Driving Towards Cleaner Air and Lower $CO_2$, Bloomberg New Energy Finance*, 29 March https://data.bloomberglp.com/professional/sites/24/2018/05/Electric-Buses-in-Cities-Report-BNEF-C40-Citi.pdf.

**BYD (2019),** "BYD launches its first electric bus for pilot operation in Costa Rica", BYD News Center, 11 October www.byd.com/en/news/2019-10-11/BYD-Launches-Its-First-Electric-Bus-for-Pilot-Operation-in-Costa-Rica.

**C40 (2017),** "Fossil fuel free street declaration", www.c40.org/other/green-and-healthy-streets.

**C40 Cities (n.d.),** "Fossil fuel free streets declaration" www.c40.org/other/green-and-healthy-streets, accessed 26 August 2020.

**C40 Cities, GCMCE, UCCRN and Acclimatise (2018),** "The future we don't want: How climate change could impact the world's greatest cities," Technical Report, Urban Climate Change Research Network, February https://c40-production-images.s3.amazonaws.com/other_uploads/images/1789_Future_We_Don't_Want_Report_1.4_hi-res_120618.original.pdf.

**Calderon, K. (2019),** "Cartago welcomes four charging points, (Cartago da la bienvenida a cuatro puntos de recarga)," *La Nación*, www.nacion.com/el-pais/infraestructura/cartago-da-la-bienvenida-a-carros-electricos-con/K63C4PW5SRFIDAOYO4O2YTDIKE/story/

**Campos, C. S. (2019),** "Rental bikes are here to stay in San José (even if they try to steal them), (Las bicicletas de alquiler llegaron para quedarse en San José (aunque intenten robárselas))", *La Nación*, 2 November www.nacion.com/revista-dominical/las-bicicletas-de-alquiler-llegaron-para-quedarse/PLQUZMGM7VEGDNCCGNSOSCW6IQ/story/.

**Cañas, I. (2018),** "Personal communication by IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Cardoso, D., Mugimba, C. and Maraka, J. (2018),** *Fiscal Policy Analysis*, Uganda Off-Grid Energy Market Accelerator (UOMA), Kampala https://shellfoundation.org/app/uploads/2018/12/Uganda-Fiscal-Policy-Analysis-Nov-18.pdf.

**Castro, J. (2019),** "Personal communication by IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**CEPPEI (2019),** *China Energy Development Report 2018* (in Chinese) (中国能源发展报告2018), China Electric Power Planning & Engineering Institute, Beijing, China www.eppei.com/achievements.aspx?PartNodeId=198 ht

**Cerdas, D. (2019),** "44 electric stations in Costa Rica: ICE secures recharging points for electric vehicles ,(44 electrolineras en Costa Rica: ICE asegura puntos de recarga para vehiculos eléctricos)", *La Nación*, 20 December www.nacion.com/el-pais/servicios/44-electrolineras-en-el-pais-ice-asegura-puntos/DXC6GAPJEZDYBA27KIPW6NLLAI/story/.

**Chongli District Government (2020),** "Introduction on Chongli District of Zhangjiakou City" (in Chinese) (张家口市崇礼区情况简介) www.zjkcl.gov.cn/syscolumn/zjcl/clgk/index.html

**Chongli District Government (2018),** "Implementation assessment on national economic and social development plan 2017 of Chongli District pf Zhangjiakou City and the plan for 2018" (in Chinese) (关于张家口市崇礼区2017年国民经济和社会发展计划执行情况与2018年国民经济和社会发展计划) http://www.zjkcl.gov.cn/govaffair/content.jsp?code=000224151/2018-00932&name=%E6%94%BF%E5%BA%9C%E6%96%87%E4%BB%B6

**Chongli District Government (2016),** "Statistical communique of Chongli County on the 2015 economic and social development" (in Chinese) (崇礼县2015年国民经济和社会发展统计公报) http://www.zjkcl.gov.cn/govaffair/content.jsp?code=000946605/2016-00928&name=.

**Christenen, D. (2014),** "Innovation in multi-actor partnerships: A waste management initiative in Vietnam", in *Technologies for Sustainable Development: A Way to Reduce Poverty?* (pp. 147 158), Ed. by J.-C. Bolay, S. Hostettler and E. Hazboun, Springer, Switzerland 10.1007/978-3-319-00639-0_13.

**Clean Cooking Alliance (n.d.),** "Eco-fuel Africa Limited", www.cleancookingalliance.org/partners/item/21/772.

**CLFG (2018),** "Country profile – Uganda", Commonwealth Local Government Forum www.clgf.org.uk/default/assets/File/Country_profiles/Uganda.pdf.

**CNREC (2019),** "China energy policy newsletter August 2019", China National Renewable Energy Centre http://boostre.cnrec.org.cn/index.php/2019/09/05/china-energy-policy-newsletter-august-2019/?lang=en.

**Contraloría General de la República (2019),** "Índice de gestión municipal 2018" https://cgrfiles.cgr.go.cr/publico/docsweb/documentos/publicaciones-cgr/igm/2018/igm-2018.pdf.

**Coopeguanacaste R.L. (2019),** "Generación distribuida" www.coopeguanacaste.com/es/servicios/generacion-distribuida.

**Coopeguanacaste R.L. (2018),** "Coopeguanacaste, R.L. places first charging centers for electric vehicles in Guanacaste , (Coopeguanacaste, R.L. coloca primeros centros de carga para vehículos eléctricos en Guanacaste)" www.coopeguanacaste.com/es/la-coope-informa/noticias/item/570-coopeguanacaste-r-l-coloca-primeros-centros-de-carga-para-vehiculos-electricos-en-guanacaste.

**CORCLIMA (2019),** *The Monteverde electric route, (La Ruta eléctrica Monteverde)* http://corclima.org/ruta-electrica-monteverde/.

**Costa Rica Limpia (2019),** "Lanzamiento oficial de la ruta eléctrica Monteverde, (Lanzamiento oficial de la ruta eléctrica Monteverde)", www.costaricalimpia.org/publicaciones/2019/8/8/lanzamiento-oficial-de-la-ruta-elctrica-monteverde.

**Costa Rica Limpia (n.d.),** www.costaricalimpia.org/.

**Courtright, J. (2019),** "How two Eritrean brothers built a solar power business in some of Africa's riskiest markets", *Quartz Africa*, 22 February https://qz.com/africa/1557058/eritrean-solar-startup-builds-in-south-sudan-uganda-dr-congo/.

**CREEI (2019),** China Renewable Energy Development Report 2018 (in Chinese) (中国可再生能源发展报告2018), China Renewable Energy Engineering Institute, Beijing, China.

**CRUSA (2019),** "14 municipalities are selected to account for their greenhouse gas emissions , (14 municipalidades son seleccionadas para contabilizar sus emisiones de gases de efecto invernadero)" https://crusa.cr/14-municipalidades-son-seleccionadas-para-contabilizar-sus-emisiones-de-gases-de-efecto-invernadero/.

**Cruse, K., et al. (2019),** 20 August www.ambientico.una.ac.cr/pdfs/art/ambientico/270_4 0-44.pdf.

**Cumbers, A. (2016),** "Remunicipalization, the low-carbon transition, and energy democracy", in *Can a City Be Sustainable?* (State of the World) (pp 275-289), Washington, DC: Island Press https://doi.org/10.5822/978-1-61091-756-8_23.

**Danigelis, A. (2018),** "City of Vancouver and Suncor sign 100% renewable diesel deal", Environmental Leader, 20 August www.environmentalleader.com/2018/08/vancouver-suncor-renewable-diesel/.

**Defensoría de los Habitantes (2019),** "Transparency Index of the Costa Rican Public Sector, 2019 Results, (*Índice de transparencia del sector público Costarricense, Resultados 2019*)" www.dhr.go.cr/Red_de_transparencia/indice_transparencia/resultados_itsp/2019/resultados_its_2019.pdf.

**DFID and MEMD (2016),** *Energy Africa – Uganda*, UK Department for International Development and Ministry of Energy and Mineral Development https://assets.publishing.service.gov.uk/media/5aec184f40f0b63154caae6c/Energy_Africa_-_Uganda_Compact_development_-_FINAL_REPORT.pdf.

**Dixon, T. (2017),** "Shenzhen completes its bus fleet transitions to 100% electric buses", *EV Obsession*, 29 December, https://evobsession.com/shenzhen-completes-its-bus-fleet-transitions-to-100-electric-buses/.

**Du Can, S. R., Pudleiner, D., Jones, D. and Khan, A. (2017),** "Energy efficiency roadmap for Uganda: Making energy efficiency count", Power Africa / Lawrence Livermore Berkeley National Laboratory www.usaid.gov/sites/default/files/documents/1860/Energy_Efficiency_Roadmap_for_Uganda_FINAL.pdf.

**Dvrgente (2019),** "The first electric route for ecotourism , (La primera ruta eléctrica para el ecoturismo)", *Ponerse Las Pilas*, ep. 8 https://dvrgente.com/podcasts/ponerselaspilas/8.

**Elmundo.cr (2019),** "36 thousand families in Upala will benefit from a new hydroelectric plant, (36 mil familias en Upala se beneficiarán con nueva planta hidroeléctrica)", Elmundo.cr, 1 April www.elmundo.cr/costa-rica/36-mil-familias-en-upala-se-beneficiaran-con-nueva-planta-hidroelectrica/.

**Elpais.cr (2019),** "The impact of organisations and municipalities against the climate crisis, (El impacto de organizaciones y municipalidades contra la crisis climática)", Elpais.cr, 8 October www.elpais.cr/2019/10/08/el-impacto-de-organizaciones-y-municipalidades-contra-la-crisis-climatica/.

**Enclude (2014),** "Market assessment of modern off grid lighting systems in Uganda," Final Report, produced for Lighting Africa, Washington, DC, Enclude Solutions www.lightingafrica.org/wp-content/uploads/2016/12/Uganda-2.pdf.

**EnDev (2018),** "Biogas business boost benefitting farmers (4B-F)", Energising Development, information sheet https://endev.info/content/Biogas_Business_Boost_Benefitting_Farmers_(4B-F).

**Energy Foundation China (2018),** "From cradle to grave: Are electric vehicles the most efficient and low carbon in the whole lifetime? (从 '出生' 到 '死亡' 电动车这 '一辈子' 真的是最节能低碳的?)" www.efchina.org/Blog-zh/blog-20180626-zh.

**Environmental Alert (2018),** *Increasing Financing and Investments for Clean and Renewable Energy Access in Uganda; Policy and Practice Recommendations for Implementation at National and Local levels.* A Civil Society Organizations (CSOs) and Networks Position Paper, July, http://envalert.org/wp-content/uploads/2018/10/Final-CSO-position-paper-on-financing-in-RE.pdf.

**ERA (2012),** *Developments and Investment Opportunities in Renewable Energy Resources in Uganda*, Electricity Regulatory Authority, Kampala https://searchworks.stanford.edu/view/10676462.

**Utgard, B. and Forn, E.B., (2016),** "Distributed energy innovation: International best practices and four proposals for Costa Rica," San José www.researchgate.net/publication/312028076_Distributed_Energy_Innovation_International_best_practices_and_four_proposals_for_Costa_Rica.

**Estado de la Nación (2019),** *Estado de la Nación*, Programa Estado de *la Nación*, San Jose, Costa Rica https://estadonacion.or.cr/wp-content/uploads/2019/11/informe_estado_nacion_2019.pdf.

**Estado de la Nación (2017),** *Estado De La Nación* en *Desarrollo Humano Sostenible*, Programa Estado de *la Nación*, San Jose, Costa Rica www.asamblea.go.cr/sd/Documents/Estado%20de%20la%20Naci%C3%B3n%202017%20%20N%C2%B0%2023.pdf.

**ESTIF (2018),** "Solar ordinances", European Solar Thermal Industry Federation www.estif.org/policies/solar_ordinances/.

**Estrategia y Negocio (2018),** "(Grupo Q vende 100 autos eléctricos al ICE en Costa Rica)" www.estrategiaynegocios.net/empresasymanagement/1240353-330/grupo-q-vende-100-autos-el%C3%A9ctricos-al-ice-en-costa-rica.

**European Commission (2020),** "Green public procurement" https://ec.europa.eu/environment/gpp/index_en.htm, viewed 17 November.

**FAO (n.d.),** "Electric cogeneration in the sugar factory El Viejo S.A, (Cogeneración eléctrica en la azucarera el Viejo S.A.)" www.fao.org/3/t2363s/t2363s0j.htm.

**Farrell, J. (2018),** "Ohio residents exercise community choice to bill themselves for public solar", Institute for Local Self-Reliance (ILSR), 5 July https://ilsr.org/ohio-community-choice-ler-episode-56/.

**Fashina, A. et al. (2018),** "The drivers and barriers of renewable energy applications and development in Uganda: A review", *Clean Technologies*, Vol. 1/1, pp. 9 39 https://doi.org/10.3390/cleantechnol1010003.

**Fashina, A. et al. (2017),** "A study on the reliability and performance of solar powered street lighting systems", *International Journal of Scientific World*, Vol. 5/2, pp. 110 116 10.14419/ijsw.v5i2.8109.

**Feng Hongli (2019),** "Survey on situation of comprehensive energy service centres in China" (in Chinese) (国内综合能源服务发展现状调研) www.china5e.com/energy/news-1054867-1.html.

**Gebrezgabher, S. A., and Niwagaba, C. B. (2018),** "Briquettes from agro-waste and municipal solid waste (Eco-Fuel Africa, Uganda) – case study" https://cgspace.cgiar.org/handle/10568/93335.

**Gillard, R. et al. (2019),** "Sustainable urban infrastructure for all: Lessons on solar-powered streetlights from Kampala and Jinja, Uganda". Coalition for Urban Transitions, London and Washington, DC https://newclimateeconomy.report/workingpapers/wp-content/uploads/sites/5/2019/03/CUT19_frontrunners_streetlighting_final.pdf.

**Gobierno de La República (2015),** VII National Energy Plan 2015-2030. Ministry of Environment and Energy and United Nations Development Program, (VII Plan Nacional de Energía 2015-2030. Ministerio de Ambiente y Energía y Programa de las Naciones Unidas para el Desarrollo PNUD). – 1 ed. – San José, Costa Rica.

**GOU (2013),** "Uganda vision 2040", Government of Uganda www.gou.go.ug/content/uganda-vision-2040.

**GOU/NCEP (2016),** "Achieving Uganda's development ambition – the economic impact of green growth: An agenda for action", Report by the Government of Uganda and the New Climate Economy Partnership http://newclimateeconomy.report/workingpapers/wp-content/uploads/sites/5/2016/11/Ugandas-development-ambition.pdf.

**Grupo ICE (2019),** "Electric generation expansion plan , (Plan de expansion de la generacion eléctrica)" www.grupoice.com/wps/wcm/connect/d91d6f4f-6619-4a2f-834f-6f5890eebb64/PLAN+DE+EXPANSION+DE+LA+GENERACION+2018-2034.pdf?MOD=AJPERES&CVID=mIeNZKV.

**Grupo ICE (2018a),** "Costa Rica electricity matrix: unique sustainable model in the world, (Matriz eléctrica de Costa Rica: modelo sostenible único en el mundo)" www.grupoice.com/wps/wcm/connect/8823524c-7cc7-4cef-abde-a1f06e14da0e/matriz_folleto_web2.pdf?MOD=AJPERES&CVID=l8SK4gG.

**Grupo ICE (2018b),** "Guanacaste produces almost 40% of national electricity since 1991, (Guanacaste produce casi 40% de electricidad nacional desde 1991)"

**Grupo INS (2019),** "INS ofrece descuentos de hasta un 45% en la prima de su seguro" https://sevins.ins-cr.com/NoticiasWeb/frmNoticias.aspx?idNoticia=91.

**Guerrero, M. (2018),** "Personal communication with IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Guias Costa Rica (n.d.),** "Costa Rica cantonal atlas, (Atlas cantonal Costa Rica)" https://guiascostarica.com/atlas-cantonal-costa-rica/ ]

**Gutiérrez, T. (2018),** "Municipalities unite to recover the María Aguilar river , (Municipalidades se unen para recuperar el río María Aguilar)", 7 March, www.larepublica.net/noticia/municipalidades-se-unen-para-recuperar-el-rio-maria-aguilar.

**Guyson, N. (2016),** "Land grabs continue to destroy Uganda's forests", *Earth Island Journal*, 12 July www.earthisland.org/journal/index.php/articles/entry/land_grabs_continue_to_destroy_ugandas_forests.

**Hebei Provincial Government (2019a),** "Minutes on the ninth coordination meeting for promoting renewable energy pilot work in Zhangjiakou" (in Chinese) (张家口市可再生能源示范区建设第九次协调推进工作会议纪要) http://hbdrc.hebei.gov.cn/web/web/tj_jbtb/2c9473846cb6c218016cbc706e227f47.htm

**Hebei Provincial Government (2019b),** "21 counties and districts removed from the poverty counties list" (in Chinese) (河北省21个县区退出贫困县序列), http://www.gov.cn/xinwen/2019-05/07/content_5389271.htm.

**Henderson, J. V., Storeygard, A. and Deichmann, U. (2014),** "50 years of urbanization in Africa: Examining the role of climate change", Policy Research Working Paper 6925, World Bank, Washington, DC https://openknowledge.worldbank.org/handle/10986/18757.

**Hepworth, N. (2010),** "Climate change vulnerability and adaptation preparedness in Uganda," Heinrich Böll Foundation, Nairobi, Kenya www.boell.de/sites/default/files/assets/boell.de/images/download_de/worldwide/Uganda_Climate_Change_Adaptation_Preparedness.pdf.

**Herrera, W. (2019),** "National car rental will offer a fleet of 100% electric cars in Costa Rica, (National car rental ofrecerá flota de autos 100% eléctricos en Costa Rica)" www.larepublica.net/noticia/national-car-rental-ofrecera-flota-de-autos-100-electricos-en-costa-rica.

**Hidalgo, D. (2014),** "Sustainable mobility trends around the world" www.slideshare.net/EMBARQNetwork/embarq-trends-2014-dario-hidalgo.

**Hove, A., and Watzel, D. (2018),** "China is planning provincial quotas for clean energy", *China Dialogue*, 23 April, www.chinadialogue.net/blog/10574-China-is-planning-provincial-quotas-for-clean-energy-/en.

**ICCT (2018),** "Effects of battery manufacturing", International Council on Clean Transportation, February https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf.

**ICCT (2012),** Global transportation energy and climate roadmap", International Council on Clean Transportation https://www.theicct.org/sites/default/files/publications/ICCT%20Roadmap%20Energy%20Report.pdf.

**ICLEI (2014),** "Using solar energy – supporting community", Local Governments for Sustainability (ICLEI) case study 173, Bonn, Germany www.ajsosteniblebcn.cat/solar-bcn-iclei-case-study_61656.pdf.

**ICLEI and IRENA (2018),** "Mitigating climate change", Local Governments for Sustainability, Bonn, Germany, and International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Dec/IRENA_Cities_2018b_Cape-Town.p.

**ICLEI and IRENA (2013a),** "Green economic development with renewable energy industries", Local Governments for Sustainability, Bonn, and International Renewable Energy Agency, Abu Dhabi, and www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/Jan/IRENA-cities-case-1-Dezhou.pdf.

**ICLEI and IRENA (2013b),** "Local government regulation: Ordinances and laws to promote renewable energy", Local Governments for Sustainability, Bonn, and International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/Jan/IRENA-cities-case-6-Sao-Paulo.

**IEA (2019a),** *Global Energy & CO2 Status Report 2018*, International Energy Agency, Paris.

**IEA (2019b),** *Energy Balance of China (2017)*, International Energy Agency, Paris.

**IEA (2019c),** *Global EV Outlook 2019*, International Energy Agency, Paris.

**IEA (2019d)**, *Solar Heat Worldwide (2019 edition)*, International Energy Agency, Paris.

**IEA (2019e),** "Data and statistics", International Energy Agency, Paris www.iea.org/statistics/.

**IHA (2018),** "Uganda", International Hydropower Association, Romford, U.K. www.hydropower.org/country-profiles/uganda.

**IMF (2019),** "Uganda 2019 Article IV consultation – press release; staff report; and statement by the executive director for Uganda", Country Report 19/125, International Monetary Fund www.imf.org/en/Publications/CR/Issues/2019/05/07/Uganda-2019-Article-IV-Consultation-Press-Release-Staff-Report-and-Statement-by-the-46875.

**Independent (2019),** "USMID beneficiaries want new guidelines revised", The Independent, 25 January www.independent.co.ug/usmid-beneficiaries-want-new-guidelines-revised/.

**INEC (2011),** National Institute of Statistics and Censuses of Costa Rica, Instituto Nacional de Estadística y Censos de Costa Rica. www.inec.cr/poblacion/temas-especiales-de-poblacion.

**INVU (2019),** National Institute of Housing and Urbanism, Instituto Nacional de Vivienda y Urbanismo, www.invu.go.cr/planes-reguladores.

**IQAir (2020),** *2019 World Air Quality Report* www.iqair.com/world-most-polluted-countries.

**IRENA (2020a),** *"Solar simulators: Application to developing cities,"* International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Solar_simulators_2019.PDF.

**IRENA (2020b),** *Renewable Capacity Statistics 2020*, International Renewable Energy Agency, Abu Dhabi.

**IRENA (2020c),** *Renewable Energy Statistics 2020*, International Renewable Energy Agency, Abu Dhabi.

**IRENA (2020d),** *Global Renewables Outlook 2020: Energy Transformation 2050*, International Renewable Energy Agency, Abu Dhabi.

**IRENA (2019),** *Renewable Energy Market Analysis: GCC 2019*, International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Market_Analysis_GCC_2019.pdf.

**IRENA (2018a),** based on communication with Suzhou Municipality. "Personal communication by IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**IRENA (2018b),** *IRENA: Global Atlas, Vaisala Solar and Wind Maps 2018*, International Renewable Energy Agency, Abu Dhabi.

**IRENA (2018c),** "Measurement and estimation of off-grid solar, hydro and biogas energy," International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Dec/IRENA_Statistics_Measuring_offgrid_energy_2018.pdf.

**IRENA (2018d),** "Corporate sourcing of renewables: Market and industry trends – REmade index 2018," International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/May/IRENA_Corporate_sourcing_2018.pdf.

**IRENA (2017a),** "IRENA cost and competitiveness indicators," International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Dec/IRENA_Cost_Indicators_PV_2017.pdf.

**IRENA (2017b),** "Renewable energy in district heating and cooling: A sector roadmap for REmap," International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_REmap_DHC_Report_2017.pdf.

**IRENA (2017c),** "Biofuels for aviation: Technology brief", International Renewable Energy Agency, Abu Dhabi www.irena.org/publications/2017/Feb/Biofuels-for-aviation-Technology-brief.

**IRENA (2016),** "Renewable energy in cities," International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2016/Oct/Renewable-Energy-in-Cities.

**IRENA (2015),** "Renewable energy policy brief: Brazil," International Renewable Energy Agency, Abu Dhabi www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_RE_Latin_America_Policies/IRENA_RE_Latin_America_Policies_2015_Country_Brazil.pdf?la=en&hash=D645B3E7B7DF03BDDAF6EE4F35058B2669E132B1.

**IRENA (2013),** "International off-grid renewable energy conference 2012: Key findings and recommendations," International Renewable Energy Agency, Abu Dhabi https://irena.org/publications/2013/Jun/International-Off-grid-Renewable-Energy-Conference-2012-Key-Findings-and-Recommendations.

**IRENA (n.d.),** *Global Solar Atlas*, Renewable Energy, ESMAP, World Bank 1km Global Horizontal Irradiation.

**IRENA Coalition for Action (2018),** "Community energy: Broadening the ownership of renewables", Abu Dhabi https://coalition.irena.org/-/media/Files/IRENA/Coalition-for-Action/Publication/Coalition-for-Action_Community-Energy_2018.pdf.

**IRENA, IEA and REN21 (2020),** "Renewable energy policies in a time of transition: heating and cooling", Renewable Energy Agency, International Energy Agency and Renewable Energy Policy Network for the 21st Century.

**IRENA, IEA and REN21 (2018),** "Renewable energy policies in a time of transition," International Renewable Energy Agency, International Energy Agency and Renewable Energy Policy Network for the 21st Century www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_IEA_REN21_Policies_2018.pdf.

**ITDP (2018),** "China tackles climate change with electric buses", Institute for Transportation and Development Policy, 11 September www.itdp.org/2018/09/11/electric-buses-china/.

**Jiang, Yi, et al. (2018),** *China Building Energy Use 2018*, Building Energy Research Center of Tsinghua University.

**Jiao Xiaolong (2017),** "Analysis on utilisable clean energy of Tongli Town in Jiangsu" (in Chinese) (江苏同里镇可利用清洁能源分析), Building Technique Development, 2017 www.cqvip.com/qk/94700x/201708/673046979.html.

**Jones, L., et al. (2013),** *The Political Economy of Local Adaptation Planning: Exploring Barriers to Flexible and Forward-looking Decision Making in Three Districts in Ethiopia, Uganda and Mozambique*, Overseas Development Institute, London www.odi.org/publications/7289-political-economy-local-adaptation-planning-exploring-barriers-flexible-and-forward-looking-decision.

**Kahungu, M. T. (2018),** "Govt creates 190 town councils", *Daily Monitor*, 27 February, www.monitor.co.ug/News/National/Govt-creates-190-town-councils/688334-4321648-5vmxruz/index.html.

**Kansiime, P. (2017),** "What #EnergyMeans to Ugandan biogas users," SNV blog, April. Available online: https://snv.org/update/what-energymeans-ugandan-biogas-users (Accessed 7 June 2019).

**KDLG (2013),** "Kasese District renewable energy strategy", Kasese District Local Government, https://d2ouvy59p0dg6k.cloudfront.net/downloads/kasese_district_renewable_energy_strategy.pdf.

**Kime, G. B. (2015),** "Ugandan mayor: My district will be 100% renewable by 2020", The Guardian, 20 October www.theguardian.com/global-development-professionals-network/2015/oct/20/ugandan-mayor-my-district-will-be-100-renewable-by-2020.

**Kissa, D. (2019),** "Lugazi to get Shs42b for infrastructure", *Daily Monitor*, 4 June www.monitor.co.ug/News/National/Lugazi-to-get-Shs42b-for-infrastructure/688334-5143562-1b8xe8z/index.html.

**Kulabako, F. (2013),** "Uganda slow at seizing solar energy opportunity amid high energy costs", *Daily Monitor*, 19 March, www.monitor.co.ug/Business/Prosper/Uganda-slow-at-seizing-solar-energy-opportunity/688616-1723532-ukdyjk/index.html.

**La Gaceta Diario Oficial (2015),** "MINAE Decree No. 39220, regulation of distributed generation for self-consumption with renewable sources, (Decreto MINAE N° 39220, reglamento generación distribuida para autoconsumo con fuentes renovables)" www.grupoice.com/wps/wcm/connect/583a9008-2d15-4656-bda5-105c22551d58/Reglamento+39220+MINAE+-+Gaceta+196+del+8+octubre+2015.pdf?MOD=AJPERES&CVID=lfSwnly.

**Lara, J. F. (2019),** "Electric cars will have green plates, parking privileges and will get rid of vehicular restrictions, (Autos eléctricos tendrán placas verdes, privilegios en parqueos y se librarán de restricción vehicular)" www.nacion.com/el-pais/infraestructura/

gobierno-lanza-placas-verdes-para-vehiculos/DPUASSIAKJCPTFCSKFC5HJUDBY/story/

**Lara, J. F. (2018a),** "ICE now intends to build the El Diquís plant to power countries in the region, (ICE ahora pretende construir planta el Diquís para darle energía a países de la región)" www.nacion.com/el-pais/infraestructura/ice-ahora-pretende-construir-planta-el-diquis-para/OPDTJQ6VXBG3PE3ULSGF26FDEQ/story/.

**Lara, J. F. (2018b),** "Minister of the Environment opposes the ICE project for the El Diquís hydroelectric plant, (Ministro de Ambiente se opone a proyecto del ICE de hidroeléctrica El Diquís)" www.nacion.com/el-pais/infraestructura/ministro-de-ambiente-desconozco-estudios-para/RNHHR5ZZJ5HZLA5I4EEUIVVZTY/story/.

**Lara, J. F. (2018c),** "ICE admits having 'negative balance', (ICE admite tener 'números en rojo')" www.nacion.com/el-pais/servicios/ice-admite-tener-numeros-en-rojo/5TDFIBYZY5BNTN2DQJ3HE3Y52Q/story/.

**Lei, G., *et al.* (2019),** "Suzhou to develop a sample of energy transition of a heavily industrialized city" (in Chinese) (苏州打造工业重镇能源转型样本) www.cnenergy.org/csny/csgc/201904/t20190411_754374.html.

**Leidreiter, A. (2015),** "A global shift to 100% renewables is not just cleaner – it's about equality", *Guardian*, 4 November www.theguardian.com/public-leaders-network/2015/nov/04/100-renewables-cleaner-equality-fossil-fuels-energy.

**Lennon, A. (2017),** "Seoul-ar City: South Korean capital investing US$1.5bn for 1GW of PV", *PV-Tech*, 22 November www.pv-tech.org/news/seoul-ar-city.

**Li Tie (2019),** "Li Tie: Making the super large towns to cities should be new experiment" (in Chinese) (李铁：特大镇设市，应成为新的改革试验田) www.ndrc.gov.cn/xxgk/jd/wsdwhfz/201911/t20191129_1206901.html, 2019.

**López Moreno, E. (2017),** "Concepts, definitions and data sources for the study of urbanization: the 2030 Agenda for Sustainable Development", United Nations Expert Group Meeting on Sustainable Cities, Human Mobility and International Migration, 5 September, https://www.un.org/en/development/desa/population/events/pdf/expert/27/papers/II/paper-Moreno-final.pdf.

**Lu, L., Xue, L., and Zhou, W. (2018),** "How did Shenzhen, China build world's largest electric bus fleet?" World Resources Institute, 4 April, www.wri.org/blog/2018/04/how-did-shenzhen-china-build-world-s-largest-electric-bus-fleet.

**M-KOPA (2015),** "Affordable, clean energy: A pathway to new consumer choices", Paper, M-KOPA, Nairobi, Kenya www.m-kopa.com/wp-content/uploads/2015/10/Lightbulb-series_Paper-1-2.pdf.

**Malinga, J. (2019),** "Tax incentives promoting Uganda's solar energy sector", Daily Monitor, 15 April, www.monitor.co.ug/OpEd/Commentary/Tax-incentives-promoting-Uganda-s-solar-energy-sector-/689364-5071490-oh8hdiz/index.html.

**Maloney, P. (2018),** "New York City moves to streamline energy storage permitting", *Utility Dive*, 8 May www.utilitydive.com/news/new-york-city-moves-to-streamline-energy-storage-permitting/523039/.

**Manishimwe, W. (2018),** "Uganda's forest cover depleted to 8%, environment minister warns encroachers", *New Vision*, 20 April www.newvision.co.ug/new_vision/news/1476085/uganda-forest-cover-depleted-environment-minister-warns-encroachers.

**Marin, M. (2019),** "Electric motorcycles renovate fleets and generate savings for companies , (Motos eléctricas remozan flotillas y generan ahorros para empresas)" https://observador.cr/noticia/motos-electricas-remozan-flotillas-y-generan-ahorros-para-empresas.

**Martin, S., and Ryor, J. N. (2016),** "Prosumers in Bengaluru: Lessons for scaling rooftop solar PV", Working Paper, World Resources Institute, Washington, DC, May www.climatelearningplatform.org/sites/default/files/resources/prosumers_in_bengaluru.pdf.

**Mboowa, D., Kabenge, I, Banadda, N., Kiggundu, N. (2017),** "Energy Potential of Municipal Solid Waste in Kampala, a Case Study of Kiteezi Landfill Site" *African Journal of Environmental and Waste Management*, Vol.4 (1), pp.190-194.

**McCall, B., Stone, A., and Tait, L. (2017),** Jinja LEAP Modelling Technical Report http://samsetproject.net/wp-content/uploads/2017/06/Jinja-LEAP-model-technical-report-v2.6.pdf.

**McKerracher, C. (2018),** "How city policies are reshaping auto markets", BNEF, 29 August, https://about.bnef.com/blog/mckerracher-city-policies-reshaping-auto-markets/.

**MEE (2018),** China Vehicle Environmental Management Annual Report (in Chinese) (中国机动车环境管理年报). Ministry of Ecology and Environment, China www.gov.cn/guoqing/2019-04/09/5380744/files/88ce80585dfd49c3a7d51c007c0a5112.pdf.

**MEMD (2015),** Sector Development Plan: 2015/16 – 2019/20, Ministry of Energy and Mineral Development, Uganda http://npa.go.ug/wp-content/uploads/2018/01/Energy-Sector-Development-plan-Final.pdf.

**Ministry of Environment and Energy (2017),** "Implementation Guide for the Country Carbon Neutrality 2.0 Program Cantonal Category, (Guía de Implementación del PPCN 2.0 Categoría Cantonal)", San José, Costa Rica.

**Ministry of Public Service (2016),** *Comprehensive Review of Local Governments*, Kampala, Uganda, www.publicservice.go.ug/media/resources/IFinal%20Draft-Review%20of%20%20LGS-6-2-27.pdf.

**MoFPED (2018),** *Local Government Performance Assessment, Ministry of Finance*, Planning and Economic Development, Uganda, https://budget.go.ug/sites/default/files/njeru_municipal_council_assessment_lgpa_full_report-compressed.pdf.

**MoHURD (2020),** *Urban-Rural Statistical Yearbook 2018* (in Chinese) (2018城乡建设统计年鉴), Ministry of Housing and Urban-Rural Development, Beijing, China.

**MoHURD (2018),** *Statistical Report on Urban-Rural Development in 2016* (in Chinese) (2016年城乡建设统计公报). Ministry of Housing and Urban-Rural Development, Beijing, China.

**MoLG (2019),** *Ministerial Policy Statement*, Ministry of Local Government, Uganda, www.parliament.go.ug/cmis/browser?id=e7868691-8f69-4d59-814c-55f99bd16e9b%3B1.0.

**MoLG (2014),** *Decentralisation and Local Development in Uganda,* Ministry of Local Government, Uganda, www.academia.edu/28556072/DECENTRALISATION_AND_LOCAL_DEVELOPMENT_IN_UGANDA.

**Movellan, J. (2015),** "Tokyo's renewable energy transformation to be showcased in the 2020 Olympics", Renewable Energy World, 17 June, www.renewableenergyworld.com/2015/06/17/tokyo-s-renewable-energy-transformation-to-be-showcased-in-the-2020-olympics/#gref.

**Mugalu, M. (2013),** "Kasese takes lead on clean energy campaign", *The Observer,* 27 August https://observer.ug/features-sp-2084439083/57-feature/27190-kasese-takes-lead-on-clean-energy-campaign.

**Mugerwa, Y. (2016),** "Museveni approves 11 new municipalities", *Daily Monitor,* 7 August www.monitor.co.ug/News/National/Museveni-approves-11-newmunicipalities/688334-2822934-2iawv4/index.html.

**Mugume, E. Municipal Environmental Officer, Kasese Municipality (2019),** "Personal communication by IRENA consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Mugume, P. (2017),** "Vandalism theft to delay commissioning of power transmission lines – ETCL officials", *ChimpReports,* 30 January https://chimpreports.com/vandalism-theft-to-delay-commissioning-of-power-transmission-lines-uetcl-officials/.

**Mukobi, S. (2015),** "Mayor of a major Ugandan city who has instigated and oversees an ambitious 100% renewable project, for the city and the surrounding district," Report, Kasese, Uganda, www.connect4climate.org/sites/default/files/files/publications/150930_report_Kasese.pdf.

**Mukwaya, J. (2019),** District Economic Planer, Buikwe Distric Local Government, "Personal communication by IRENA consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Municipalidad de Cartago (2019),** "Municipalidad de Cartago lanza proyecto 'Cartago transporte verde'" www.muni-carta.go.cr/electricos/.

**Municipalidad de Grecia (2020).** "Smart parking meters, (Parquímetros inteligentes)", www.grecia.go.cr/proyecto/33/parquimetros-inteligentes.

**Municipalidad de Grecia (2019),** "Grecia Tradmark, (Marca Grecia)" www.grecia.go.cr/proyecto/35/marca-grecia

**Municipalidad de Grecia (2018),** "Smart Poles and Towers in Grecia, (Postes y Torres Inteligentes en Grecia)", www.grecia.go.cr/proyecto/40/postes-y-torres-inteligentes-en-grecia.

**Nantume, G. (2018),** "Solar energy reviving villages in Queen Elizabeth National Park", *Daily Monitor,* 2 August, www.monitor.co.ug/SpecialReports/Solar-energy-reviving-villages-Queen-Elizabeth-National-Park/688342-4692596-y1jgnl/index.html.

**National Bureau of Statistics (2020),** "National database", http://data.stats.gov.cn/english/.

**Ndibwami, A., and Drazu, H. (2018),** *State of Energy Report: Kasese Municipality,* Uganda, http://samsetproject.net/wp-content/uploads/2018/11/Kasese_SOE.pdf.

**Ndibwami, A., and Drazu, H. (2017),** "Sustainable energy strategy (Jinja and Kasese)" http://hdl.handle.net/20.500.12280/481.

**NDRC (2019),** *Status of Natural Gas 2018 (in Chinese) (2018* 年天然气运行简况). National Development and Reform Commission, Beijing, China.

**NDRC (2018),** *Action Plan on Accommodating Clean Energies 2018–2020* (in Chinese) (清洁能源消纳行动计划2018-2020). National Development and Reform Commission, Beijing, China.

**NDRC (2017),** *Status of Natural Gas 2016* (in Chinese) (2016年天然气运行简况, National Development and Reform Commission, Beijing, China.

**NDRC (2016)**, *13th FYP on Renewable Energy Development in China* (in Chinese) (可再生能源发展十三五规划), National Development and Reform Commission, Beijing, China.

**NDRC and NEA (2015),** *Development Plan on Renewable Energy Demonstration in Zhangjiakou City, Hebei Province* (in Chinese) (河北省张家口市可再生能源示范区发展规划), National Development and Reform Commission and National Energy Administration, Beijing, China.

**NDRC, MoF and NEA (2018),** "Announcement on solar power generation related issues in 2018" (in Chinese) (关于2018年光伏发电有关事项的通知), National Development and Reform Commission, Ministry of Finance and National Energy Administration, Beijing, China.

**NEA (2020),** *Status of Grid Connection of Renewable Energies in 2019* (in Chinese) (2019年可再生能源并网运行情况), National Energy Administration, Beijing, China.

**NEA (2019a),** *Monitoring Report on Renewable Energy Electricity Development in China 2018* (in Chinese) (2018年度全国可再生能源电力发展监测评价报告), National Energy Administration, Beijing, China.

**NEA (2019b),** "Announcement on promoting non-subsidized wind power" (in Chinese) (关于积极推进风电、光伏发电无补贴平价上网有关工作的通知), National Energy Administration, Beijing, China.

**NEA (2018a),** *National Grid Connection of Wind Power in 2017* (in Chinese) (2017年风电并网运行情况), National Energy Administration, Beijing, China.

**NEA (2018b)**, "Solar energy increased 53.06 GW and topped renewables in 2017" (in Chinese) (2017年光伏发电新增装机5306万千瓦 居可再生能源之首), National Energy Administration, Beijing, China, www.nea.gov.cn/2018-01/24/c_136920159.htm.

**NEA (2016),** "Reply on building a new energy town in Tongli, Suzhou City, Jiangsu Province" (in Chinese) (关于江苏省苏州市同里镇创建新能源小镇的复函), National Energy Administration, Beijing, China.

**NEA (2013),** "Administrative rules on utility-scale solar PV power plants" (in Chinese) (光伏电站项目管理暂行办法), National Energy Administration, Beijing, China.

**New Indian Express (2018),** "BESCOM simplifies rooftop solar application process", The New Indian Express, 15 September www.newindianexpress.com/cities/bengaluru/2018/sep/15/bescom-simplifies-rooftop-solar-application-process-1872223.html.

**NPA (2017),** *The Uganda Green Growth Development Strategy 2017/18 2030/31,* National Planning Authority, Uganda, www.undp.org/content/dam/LECB/docs/pubs-reports/undp-ndc-sp-uganda-ggds-green-growth-dev-strategy-20171204.pdf.

**NPC (2006),** *The Renewable Energy Law of the People's Republic of China* (in Chinese) (中华人民共和国可再生能源法), The National People's Congress of the People's Republic of China, Beijing, China.

**NRDC (2014),** *Contribution of Coal Using to Air Pollution* (in Chinese) (煤炭使用对中国大气污染的贡献), Natural Resources Defense Council, Beijing, China.

**Nygaard, I., Bhamidipati, P. L., Andersen, A. E., Larsen, T. H., Cronin, T., Davis, N. (2018),** "Market for the integration of smaller wind turbines in mini-grids in Uganda".

**OECD/IEA (2018),** *Global EV Outlook 2018* (Paris: 2018), https://webstore.iea.org/download/direct/1045?filename=global_ev_outlook_2018.pdf.

**Painuly, J. (2001),** "Barriers to renewable energy penetration: A framework for analysis", https://shuraako.org/sites/default/files/Barriers%20to%20Renewable%20Energy%20Penetration%20a%20Framework%20for%20Analysis_0.pdf.

**Patel, S. (2016),** "New York City sets ambitious citywide energy storage target", *Power*, 29 September www.powermag.com/new-york-city-sets-ambitious-citywide-energy-storage-target/.

**Pedersen, M. B. (2016),** Deconstructing the concept of renewable energy-based mini-grids for rural electrification in East Africa. Wiley Interdisciplinary Reviews: Energy and Environment, 5(5), 570-587.

**Poder Ejecutivo (2017),** "Proyecto De Ley – Expediente N.º 20.641", www.aselex.cr/boletines/Proyecto-20641.pdf.

**PRB (2019),** "2019 world population data sheet", Population Reference Bureau, www.prb.org/worldpopdata/.

**Presidencia de La República (2019a),** "Synthesis: National decarbonization plan 2018-2050, (Síntesis: Plan nacional de descarbonización 2018 2050)", San Jose, Costa Rica www.presidencia.go.cr/comunicados/2019/02/sintesis-plan-nacional-de-descarbonizacion-2018-2050/.

**Presidencia de la República (2019b),** "Come to know what the electric train will be like, (¡Vení a conocer cómo será el tren eléctrico!)" San Jose, Costa Rica, www.presidencia.go.cr/comunicados/2019/10/veni-a-conocer-como-sera-el-tren-electrico/.

**Presidencia de La República (2018a),** "Correos De Costa Rica announces electrical transformation of its motorcycle fleet, (Correos De Costa Rica anuncia transformación eléctrica de su flota de motocicletas)", San Jose, Costa Rica www.presidencia.go.cr/comunicados/2018/11/correos-de-costa-rica-anuncia-transformacion-electrica-de-su-flota-de-motocicletas/.

**Presidencia de la República (2018b),** "Incofer announces start of feasibility stage and design results for electric train , (Incofer anuncia inicio de etapa de factibilidad y resultados de diseño para el tren eléctrico)", San Jose, Costa Rica www.presidencia.go.cr/comunicados/2018/11/incofer-anuncia-inicio-de-etapa-de-factibilidad-y-resultados-de-diseno-para-el-tren-electrico/.

**Presidencia de la República (2018c),** "Government issues decrees and guidelines to encourage the use of electric vehicles in the population and institutions, (Gobierno emite decretos y directriz para incentivar uso de vehículos eléctricos en el población e instituciones)", San Jose, Costa Rica https://presidencia.go.cr/comunicados/2018/11/gobierno-emite-decretos-y-directriz-para-incentivar-uso-de-vehiculos-electricos-en-la-poblacion-y-en-instituciones/.

**Presidencia de la República (2017),** "Country refines its path to carbon neutrality with new country program, (País afina su camino a la carbono neutralidad con nuevo programa país)", San Jose, Costa Rica www.presidencia.go.cr/comunicados/2017/09/pais-afina-su-camino-a-la-carbono-neutralidad-con-nuevo-programa-pais/.

**Qingzhe, X., Jingyun Z., Xuezhen, Z. *et al.* (2017),** "Characteristics of snow season and snowfall during the Olympic winter games in Chongli of Zhangjiakou City, China", Climate Change Research, Vol. 13, pp. 223-230.

**Raisch, V. (2016),** "Financial assessment of mini-grids based on renewable energies in the context of the Ugandan energy market", Energy Procedia, Vol. 93, pp. 174 182, https://doi.org/10.1016/j.egypro.2016.07.167.

**REN21 (2020),** *Global Status Report,* Renewable Energy Policy Network for the 21st Century, www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf.

**REN21 (2018),** *Global Status Report,* Renewable Energy Policy Network for the 21st Century, www.ren21.net/wp-content/uploads/2019/05/GSR2018_Full-Report_English.pdf.

**REN21, ISEP and ICLEI (2011),** *Global Status Report on Local Renewable Energy Policies*, Renewable Energy Policy Network for the 21st Century, Institute for Sustainable Energy Policies and ICLEI, https://inis.iaea.org/collection/NCLCollectionStore/_Public/46/105/46105568.pdf?r=1&r=1.

**Renewables Now (2017)**, "Seoul seeks to add 1 GW of residential solar by 2022", Renewables Now, 23 November https://renewablesnow.com/news/seoul-seeks-to-add-1-gw-of-residential-solar-by-2022-592083/.

**Renner, M. (2016),** "Supporting sustainable transportation", in *State of the World: Can a City Be Sustainable*, pp. 177 194. Washington, DC: Island Press.

**Republic of Uganda (2015),** Second National Development Plan (NDPII) 2015/16 2019/20, http://npa.go.ug/wp-content/uploads/NDPII-Final.pdf (accessed May 2020).

**Reuters (2015),** "Oslo aims to make city center car-free within four years", Reuters, 19 October www.reuters.com/article/us-norway-environment-oslo/oslo-aims-to-make-city-center-car-free-within-four-years-idUSKCN0SD1GI20151019.

**Revista Summa (2019),** "Costa Rica supera los 400 megavatios de capacidad eólica instalada", Revista Summa, 16 January, https://revistasumma.com/costa-rica-supera-los-400-megavatios-de-capacidad-eolica-instalada.

**Richter, A. (2019),** "Costa Rica reaches record level geothermal power generation", Think Geoenergy, 9 August www.thinkgeoenergy.com/costa-rica-reaches-record-level-geothermal-power-generation/.

**Rivera, D. (2019),** "Personal communication by IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Roberts, J., Bodman, F., and Rybski, R. (2014),** "Community power: Model legal frameworks for citizen-owned renewable energy", *ClientEarth*, London, https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/model_legal_frameworks_2014.pdf.

**Rodríguez, S. (2019),** "These are the 14 cantons that will make an inventory of their emissions, (Estos son los 14 cantones que harán inventario de sus emisiones)", Ojo Al Clima, 2 July https://ojoalclima.com/estos-son-los-14-cantones-que-haran-inventario-de-sus-emisiones/.

**Rondolat, E. (n.d.),** "Lighting the way to a better world" www.philips.com/a-w/about/news/archive/blogs/innovation-matters/Lighting_the_way_to_a_better_world.html.

**Roque, V. M. (2019),** "Liberationist deputies present a bill to encourage green transportation, (Diputados liberacionistas presentan proyecto de ley para incentivar transporte verde)", Elmundo.cr, 17 June, www.elmundo.cr/costa-rica/diputados-liberacionistas-presentan-proyecto-de-ley-para-incentivar-transporte-verde/.

**Salazar M. D. (2018),** "Emissions per inhabitant in Belén are five times those of San José, (Emisiones por habitante en Belén quintuplican las de San José)", *Ojo Al Clima*, 17 August, https://ojoalclima.com/emisiones-por-habitante-en-belen-quintuplican-las-de-san-jose/.

**Scott, A. et al. (2016),** "Accelerating access to electricity in Africa with off-grid solar," Overseas Development Institute, London, January www.odi.org/publications/10200-accelerating-access-electricity-africa-grid-solar.

**SE4ALL (n.d.),** "Uganda", Sustainable Energy for All www.se4all-africa.org/seforall-in-africa/country-data/uganda/.

**SEATINI (2017),** "Addressing policy and practice challenges of local government revenue mobilisation in Uganda", www.seatiniuganda.org/publications/policy-briefs/187-addressing-policy-practice-challenges-of-local-government-revenue-mobilization-in-uganda/file.html.

**SGCC (2020),** "Three parties collaborate on a fully electrified scenic spot and protect Zhouzhuang ancient town by clean energy " (in Chinese) (三方联动打造全电景区 清洁能源呵护周庄古镇), www.js.sgcc.com.cn/html/szgdgs/col791/2020-05/09/20200509111754562830059_1.html

**SGCC (2019),** "New energy installation of Jibei grid surpass 20 GW" (in Chinese) (冀北电网新能源装机规模突破2000万千瓦), State Grid Corporation of China, Beijing, China.

**SGCC (2018a),** *Project Brochure of the Comprehensive Energy Service Centre of Tongli* (in Chinese) (同里综合能源服务中心项目手册), State Grid Corporation of China, Beijing, China.

**SGCC (2018b),** *Introduction on the Fully-Electrification Neighborhood of the New Energy Tongli Town* (in Chinese) (同里新能源小镇全电街区建设简介), State Grid Corporation of China, Beijing, China.

**SGCERI (2018),** *China Urban Energy Report General Feature and Sample Analysis* (in Chinese) (中国城市能源报告总体特征与样本发现), State Grid Energy Research Institute, Beijing, China.

**SLOCAT (2018),** *Transport and Climate Change Global Status Report* (TCC-GSR) https://slocat.net/our-work/knowledge-and-research/tcc-gsr/.

**Smit, E. (2019),** "Personal communication with IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Sseguya, D. (2019),** "Museveni assures solar energy firm bosses of support", EABW News, 1 April www.busiweek.com/museveni-assures-solar-energy-firm-bosses-of-support/.

**State Council (2014),** "Announcement on adjustment of the criteria of cities' scale" (in Chinese) (国务院关于调整城市规模划分标准的通知) www.gov.cn/zhengce/content/2014-11/20/content_9225.htm.

**Surkes, S. (2019),** "Campaign urges Israelis to put solar panels on the roof, make money...eventually", *Times of Israel*, 17 July 2019 www.timesofisrael.com/campaign-encourages-israelis-to-put-solar-panels-on-their-roofs/.

**Suzhou Municipality (2018a),** "Suzhou municipal government's reply on the adjustment of partial administrative division of Wujiang District" (in Chinese) (苏州市人民政府关于吴江区部分行政区划调整的批复) http://js.people.com.cn/n2/2018/1026/c360300-32207853.html.

**Suzhou Municipality (2018b),** "Suggestion on deployment of green energies" (in Chinese) (关于大力发展绿色能源的建议),

**Suzhou Municipality (2018c),** "Call for tender of the construction for the permanent venue of the International Energy Transition Forum" (in Chinese) (苏州同里国际能源变革论坛会址城市设计及建筑方案征集招标公告), Suzhou, China.

**Suzhou Municipality (2018d),** "Policy on further accelerating the solar PV development of Suzhou" (in Chinese) (进一步促进苏州光伏产业持续健康发展的若干意见), Suzhou, China.

**Suzhou Municipality (2017a),** *13th FYP on Energy Saving and Resources Conservation in Suzhou Institutions* (in Chinese) (苏州市 "十三五" 公共机构节约能源资源规划) ht.

**Suzhou Municipality (2017b),** "Announcement of high pollution fuels-free areas" (in Chinese) (关于进一步调整市区高污染燃料禁燃区的通告)

**Suzhou Municipality (2016),** "Concept scheme of the permanent conference venue in the new energy town of Tongli" (in Chinese) (同里新能源小镇永久会址概念规划方案), Suzhou, China.

**Taboga (n.d.),** "About us" www.taboga.co.cr/en/nosotros.

**Takouleu, J. M. (2020),** "Uganda: AMEA Power to build four solar and wind farms in two regions", Afrik21, 26 March www.afrik21.africa/en/uganda-amea-power-to-build-four-solar-and-wind-farms-in-two-regions/.

**Teske S., Morris, T., and Nagrath, K. (2020),** *100% Renewable Energy for Costa Rica*, Report prepared by ISF www.worldfuturecouncil.org/wp-content/uploads/2019/12/Costa_Rica-Report-2019-12-11-Excl_employ.pdf.

**Theron, A. (2016),** "Exclusive interview with Sanga Moses, CEO, ECO-FUEL AFRICA", ESI AFRICA, 16 February www.esi-africa.com/features-analysis/exclusive-interview-with-sanga-moses-ceo-of-the-ground-breaking-and-award-winning-company-eco-fuel-africa.

**Times of India (2017),** "Delhi's solar energy model best for power-hungry cities", Times of India, 8 September https://timesofindia.indiatimes.com/city/delhi/delhis-solar-energy-model-best-for-power-hungry-cities-says-study/articleshow/60415615.cms.

**Tumwesigy, R., Twebaze, P., Makuregye, N. and Muyambi, E. (2011),** "Key issues in Uganda's energy sector", Access to Energy Series, International Institute for Environment and Development, London https://pubs.iied.org/pdfs/16030IIED.pdf.

**UBoS (2018),** 2018 Statistical Abstract, Uganda Bureau of Statistics www.ubos.org/wp-content/uploads/publications/05_2019STATISTICAL_ABSTRACT_2018.pdf.

**UBoS (2016),** "Uganda: Demographic and health survey," Uganda Bureau of Statistics www.ubos.org/wp-content/uploads/publications/07_2018UDHS_2016_FInal.pdf.

**UBoS (2014),** 2014 Statistical Abstract, Uganda Bureau of Statistics www.ubos.org/wp-content/uploads/publications/03_2018Statistical_Abstract_2014.pdf.

**UECCC (2016),** "Six years of steadily providing credit support for renewable energy projects", UECCC Magazine, Vol. 1/1, Uganda Energy Credit Capitalisation Company www.ueccc.or.ug/version2/storage/app/media/docs/UECCC_Magazine.pdf.

**UEGCL (n.d.),** "Karuma Hydropower Project", Uganda Electricity Generation Company, Ltd. https://uegcl.com/business-operations/projects/karuma-hydro-power-project.html.

**UIA. (n.d),** "A guide on tax incentives/exemptions available to investors in Uganda. Uganda Investment Authority, Kampala Uganda." Available online: www.ugandainvest.go.ug/wp-content/uploads/2016/03/A-Guide-on-Incentives-Exemptions-available-Ugandan-Investors.pdf (Accessed 9th October 2019),

**UMEME (2015),** *Annual Report 2015* https://cdn.trombino.org/uploads/files/UMEME-Annual-Report-2015.pdf.

**UN-Habitat (2020),** World Cities Report 2020. The Value of Sustainable Urbanization.

**UN-Habitat (2019),** "Cities : A 'cause of and solution to' climate change", UN News, 18 September, https://news.un.org/en/story/2019/09/1046662.

**UN-Habitat (2018),** The World's Cities in 2018. Data Booklet.

**UN-Habitat (2010),** *Uganda: Urban Housing Sector Profile* http://newgpa.org.uk/wp-content/uploads/2014/05/Uganda_Housing-Profile.pdf.

**UNDESA (2018),** "68% of the world population projected to live in urban areas by 2050, says UN", United Nations Department of Economic and Social Affairs, 16 May www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html.

**UNEP (2018),** *2018 Global Status Report: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector.* Report prepared for the Global Alliance for Building and Construction by the International Energy Agency and United Nations Environment Programme https://wedocs.unep.org/bitstream/handle/20.500.11822/27140/Global_Status_2018.pdf?sequence=1&isAllowed=y.

**UNFCC (2016),** "Paris, Mexico City, Madrid, Athens to remove diesel vehicles by 2025", United Nations Framework Convention on Climate Change, 2 December https://unfccc.int/news/paris-mexico-city-madrid-athens-to-remove-diesel-vehicles-by-2025.

**USEA (2019),** *Uganda Solar Energy Association Handbook on Solar Taxation,* Uganda Solar Energy Association www.uncdf.org/article/4949/uganda-solar-energy-association-solar-taxation-handbook.

**Utgard, B. (2017),** "Essentially electric: How Costa Rica can champion e-mobility," 10.13140/RG.2.2.13388.72329.

**Utgard, B., and Forn, E. B. (2016),** "Distributed energy innovation: International best practices and four proposals for Costa Rica, November 10.13140/RG.2.2.21707.59681.

**Van Dusen, K. (2019),** "Personal communication by IRENA-consultant [interview]", International Renewable Energy Agency, Abu Dhabi.

**Village Power Africa (n.d.),** "Solar home systems" www.village-power.africa (accessed 19 June).

**Von Hülsen, A., Koch, S., and Huth, T. (2016),** "Village Power scaling rural electrification in Uganda", *Field Actions Science Reports*, special issue 15, pp. 104 113 https://journals.openedition.org/factsreports/4197.

**Wang Qingyi (2019),** "Energy data in 2019" (2019能源数据), Beijing: IGDP.

**Weiss, W., and Spörk-Dür, M. (2018),** Solar Heat Worldwide (2018 edition) www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2018.pdf.

**WHO (2016),** "WHO global urban ambient air pollution database" (update 2016)", https://www.who.int/airpollution/data/cities-2016/en/.

**Wilkins, G. (2002, e-published 2010),** *Technology Transfer for Renewable Energy*, Routledge, London. https://doi.org/10.4324/9781849776288.

**World Bank (2019),** "The World Bank in Uganda", Washington, DC www.worldbank.org/en/country/uganda/overview.

**World Bank (2018),** "Uganda: Support to municipal infrastructure development program – additional financing (P163515)" http://documents.worldbank.org/curated/en/946901526654169395/pdf/UGANDA-PAD-04272018.pdf.

**World Bank (2017),** World Development Indicators, Washington, DC https://datacatalog.worldbank.org/dataset/world-development-indicators.

**WRI (2018),** "Distributed solar PV in China: Developments and challenges" (in Chinese) (中国分布式光伏：发展与挑战), www.wri.org.cn/distributed-solar-pv-in-China.

**WWF (2018),** "District renewable energy strategies to increase energy access in Uganda", World Wide Fund For Nature, 5 November, wwf.panda.org/wwf_news/?337794/District-Renewable-Energy-Strategies-to-Increase-Energy-Access-in-Uganda.

**WWF-UCO (2017),** "Terms of reference for the documentation of the WWF-UCO champion district initiative", World Wide Fund for Nature, Uganda Country Office. https://d2ouvy59p0dg6k.cloudfront.net/downloads/terms_of_reference_for__documentation_of_the_champion_district_initiative_1.pdf.

**Yuan Si (2019),** Inspection Report on Implementation of Renewable Energy Law (in Chinese) (可再生能源执法检查报告), http://www.bjnews.com.cn/news/2019/12/26/666631.html.

**Zhang Rongxin (2019),** "Tongli small town: Foresee future's smart energy" (in Chinese) (同里小镇：从这里看见未来智慧能源) http://paper.people.com.cn/zgnyb/html/2019-09/23/content_1948108.htm.

**Zhang Cong (2020),** "Build a Suzhou sample for the sustainable development of global energy" (in Chinese) (打造全球能源可持续发展的苏州路径).

**Zhangjiakou Municipality (2020),** *Report on the Implementation of National Economy and Social Development in 2019 and the Plan for 2020* (in Chinese) (关于张家口市2019年国民经济和社会发展计划执行情况与2020年国民经济和社会发展计划的报告) www.zjknews.com/news/shizheng/202003/03/275351.html.

**Zhangjiakou Municipality (2019),** "GDP of all districts and counties in Q2 2019" (in Chinese) (年第二季度各区县地区生产总值) www.zjktj.gov.cn/Message.asp?AticleId=1370.

**Zhangjiakou Municipality (2018),** 2018 Municipal Report of Zhangjiakou (in Chinese) (张家口2018年政府工作报告) http://district.ce.cn/newarea/roll/201803/07/t20180307_28381078.shtml.

**Zhangjiakou Municipality (2017a),** "Chongli: Adjusting industrial structure and accelerating the upgradation" (in Chinese) (崇礼区：调整工业结构加快优化升级) www.zjktj.gov.cn/Message.asp?AticleID=537.

**Zhangjiakou Municipality (2017b),** "Main population indicators of Zhangjiakou City in 2016" (in Chinese) (年张家口市人口主要指标情况表) www.zjktj.gov.cn/message.asp?AticleId=471.

## PHOTO CREDITS

Page 1: Chongqing, China; © QinJin; shutterstock

Page 5 Kampala, Uganda; © Andreas Marquardt; shutterstock

Page 5 San Jose, Costa Rica; © Daniel Korzeniewski; shutterstock

Page 7: City of Kampala, Uganda; © emre topdemir; shutterstock

Page 10: © Amy Johansson; shutterstock

Page 11: Kampala, Uganda; © Pecold; shutterstock

Page 13: Harbin, Heilongjiang Province, China; © Tada Images; shutterstock

Page 14: Rudmer Zwerver; shutterstock

Page 14: Electric vehicle charging station, Shanghai, China; © THINK A; shutterstock

Page 15: DALI, CHINA; © woraatep suppavas; shutterstock

Page 16: Wujiang District, Suzhou, China; © LSF_3steps; shutterstock

Page 16: Liuyang, China; © Drevs; shutterstock

Page 17: BEIJING CHINA; © Sittirak Jadlit; shutterstock

Page 19: © NICOLA MESSANA PHOTOS; shutterstock

Page 21: © Paul Mukwaya

Page 22: San José, Costa Rica; ©Gianfranco Vivi; shutterstock

Page 24: © chuyuss; shutterstock

Page 26: New York City, USA; © Sopotnicki; shutterstock

Page 28: © Sergii_Petruk; shutterstock

Page 30: © Bigone; shutterstock

Page 31: © BanGhoL; shutterstock

Page 33: © MrNovel; shutterstock

Page 35: Heating pipes; ©Akimov Igor; shutterstock

Page 37: Bangalore City, India; © Noppasin Wongchum; shutterstock

Page 38: Solar water heater on roof, Barcelona, Spain; © Nanisimova; shutterstock

Page 40: Electric bus; ©ANDREY-SHA74; shutterstock

Page 41: Electric car charging station, Oslo, Norway; © Softulka; shutterstock

Page 44: Rio de Janeiro, Brazil; © Celso Pupo; shutterstock

Page 46: Tongli, the Venice of Asia, near Suzhou, Shanghai, China; © Sven Hansche; shutterstock

Page 49: Suzhou, China; © HelloRF Zcool; shutterstock

Page 54: Shenzhen, China; © StreetVJ; shutterstock

Page 56: Guizhou, China; © Grigvovan; shutterstock

Page 56: Shanghai, China; © Romas_Photo; shutterstock

Page 58: Tangshan City, Hebei, China;© Yuangeng Zhang; shutterstock

Page 59: © Jenson; shutterstock

Page 60: Zhangjiakou City, Hebei, China; © HelloRF Zcool; shutterstock

Page 61: ZhangjiakouCity, Hebei, China; © HelloRF Zcool; shutterstock

Page 62: © HelloRF Zcool; shutterstock

Page 63: ZhangjiakouCity, Hebei, China; © HelloRF Zcool; shutterstock

Page 64: Olympic Green Park in Beijing, China; © Mirko Kuzmanovic; shutterstock

Page 66: Suzhou city, China; © Evgeny Bakhchev; shutterstock

Page 67: Ancient Villages in Suzhou, Jiangsu, China; © bleakstar; shutterstock

Page 68: Jiangsu, China; © Jenson; shutterstock

Page 68: Tongli, Suzhou, China; © Silvia Campi; shutterstock

Page 70: Suzhou Industrial Park, Jiangsu Province, China; © Weiming Xie; shutterstock

Page 71: Tongli, Suzhou, China; © Shanshan0312; shutterstock

Page 73: Jiangxi, China; © humphery; shutterstock

Page 74: © KeepWatch; shutterstock

Page 76: Soroti, Uganda; © Dennis Wegewijs; shutterstock

Page 80: Kampala, Uganda; George_TheGiwi; shutterstock

Page 81: © Sebastian Noethlichs; shutterstock

Page 82: Kampala, Uganda; © Andreas Marquardt; shutterstock

Page 86: Fort Portal, Kasese, Uganda; © henrystoryteller1; unsplash

Page 87: © Aptech Africa

Page 88: ENCOT microfinance office in Masindi. Uganda; © GODONG-PHOTO; shutterstock

Page 90: Solar panels and a rural hut in Uganda, Africa; © hindersby; shutterstock

Page 92: © PetrJanJuracka; shutterstock

Page 92: Mpigi, Uganda; © Jonathan Rosenthal; shutterstock

Page 95: Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 95: A view of the town of Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 96: Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 97: Solar powered street lights, Kampala, Uganda; © George_TheGiwi; shutterstock

Page 97: Kitwa, Uganda; © MehmetO; shutterstock

Page 98: © Aptech Africa

Page 100: Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 102: MATUGGA, UGANDA; © Robin Nieuwenkamp; shutterstock

Page 103: Uganda, Africa; © Dennis Diatel; shutterstock

Page 105: Solar powered street lights, Kampala, Uganda; © George_TheGiwi; shutterstock

Page 106: © Vadim Anokhin; shutterstock

Page 107: Charcoal market in Kampala, Uganda; © Vlad Karavaev; shutterstock

Page 108: © Belish; shutterstock

Page 110: © Sarine Arslanian; shutterstock

Page 111: Kasese, Uganda; © Anil Varma; shutterstock

Page 112: © Municipalidad de Cartago, Costa Rica

Page 116: San José, Costa Rica; © oleprophoto; shutterstock

Page 117: San José, Costa Rica; © photosbychalo; unsplash

Page 117: San José, Costa Rica; © Daniel Korzeniewski; shutterstock

Page 118: © Gianfranco Vivi; shutterstock

Page 121: Dam Cachi in Cartago, Costa Rica; © ManuRivera; shutterstock

Page 122: Puerto Viejo, Costa Rica; © shell300; shutterstock

Page 123: Tortuguero, Limón Province, Costa Rica; © JulianBuijzen; shutterstock

Page 125: La Sirena station in Corcovado NP on peninsula Osa in Costa Rica; © Karel Stipek; shutterstock

Page 127: © Municipalidad de Cartago, Costa Rica

Page 130: Cariari, Costa Rica; © Matyas Rehak; shutterstock

Page 132: © Municipalidad de Grecia, Costa Rica

Page 133: © Municipalidad de Grecia, Costa Rica

Page 133: Santo Domingo, Heredia, Costa Rica; © Rebeca Bolanos; shutterstock

Page 134: © Municipalidad de Cartago, Costa Rica

Page 135: San José, Costa Rica; © Mihai-Bogdan Lazar; shutterstock

Page 136: © Jorge A. Russell; shutterstock

Page 136: San José, Costa Rica; © Bob Pool; shutterstock

Page 137: © Municipalidad de Grecia, Costa Rica

Page 138: Canas Guanacaste, Costa Rica; © Gianfranco Vivi; shutterstock

Page 139: © Intothelight Photography; shutterstock

Page 140: Costa Rica; © njaj; shutterstock

Page 141: Puerto Viejo de Sarapiqui, Costa Rica; © Marco Lissoni; shutterstock

Page 142: © PetrJanJuracka; shutterstock

Page 144: Santo Domingo, Heredia, Costa Rica; © Rebeca Bolanos; shutterstock

Page 145: © ImageFoto; shutterstock

Page 145: © MyCreative; shutterstock

IRENA
International Renewable Energy Agency

# RENEWABLE ENERGY POLICIES FOR CITIES

## EXPERIENCES IN CHINA, UGANDA AND COSTA RICA

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag

ISBN: 978-92-9260-312-0