IRENA
International Renewable Energy Agency

RENEWABLE ENERGY POLICIES FOR CITIES

EXPERIENCES IN UGANDA

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag

IRENA
International Renewable Energy Agency

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

ISBN: 978-92-9260-312-0

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 (Laura El-Katiri, Michael Renner, Jinlei Feng and Celia García-Baños (IRENA)), 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 consultant Paul Mukwaya.

Valuable external review was provided by Michael Ahimbisibwe (Ministry of Energy and Mineral Development, Uganda) and Nelson Tashobya (consultant).

Valuable review and feedback were also provided by IRENA colleagues Benson Zeyi, Nopenyo Dabla, Elizabeth Njoki Wanjiru, Binu Parthan, 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, in combination with the other studies published under the series "Renewable Energy Policies for cities", 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. Chapter 2 presents case studies in the Ugandan context, with highlights of the cities of **Kasese** and **Lugazi**.

Together with studies from the series regarding the experiences of selected cities in China and Costa Rica, they highlight the reality of cities that either have effective policies in place or they have untapped renewable energy resources that could contribute to their sustainable development. The experiences 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.

The 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

About this study 03
Abbreviations 06

RENEWABLE ENERGY AND CITIES 08

Motivations and drivers of municipal action on energy 12

Municipal needs and capabilities 14

The significance of cities in deploying renewable energy 16
Cities' roles in energy generation and procurement 17
Cities' roles in regulation and urban planning 20
The role of cities in target setting, engagement and capacity building 27

UGANDAN CITIES: KASESE AND LUGAZI 30

National context 30
The context for renewable energy in Uganda 32
Uganda's renewable energy potential 33
Renewable energy and opportunities for Ugandan cities 35

Case study 3: Kasese 37
Background 37
Deploying renewable energy in Kasese 38

Case study 4: Lugazi 47
Background 47
Deploying renewable energy in Lugazi 48

Lessons learnt and considerations for replicability 55

WRAP-UP 66

References 70
Photo Credits 75

FIGURES

Figure 1 Motivations and drivers of municipal decision making on energy 13
Figure 2 Factors shaping city energy profiles 14
Figure 3 Roles of municipal governments in the energy transition 16
Figure 4 Electric bus adoption in Shenzhen, China 26
Figure 5 Total primary energy supply in Uganda (TJ), 2015 32
Figure 6 Installed electricity generation capacity (MW) in Uganda, 2018 33
Figure 7 Kasese City, 2018 37
Figure 8 Energy consumption in Kasese, by source and sector, 2018 38
Figure 9 Lugazi Municipality, 2018 47
Figure 10 Main sources of energy used for lighting in Lugazi, by number of households, 2014 48
Figure 11 Examples of solar products for sale in Uganda 53
Figure 12 Renewable energy benefits in Ugandan cities 55
Figure 13 Challenges in deploying renewable energy in Ugandan cities 58
Figure 14 Scaling up city-level renewable energy deployment in Uganda 63
Figure 15 Factors and drivers motivating municipal energy policies and cities' roles in the energy transition 67

TABLES

Table 1 Roles of stakeholders in Kasese's renewable energy deployment 39
Table 2 Features of solar loans offered by Uganda's credit support facility based on two examples 45
Table 3 Roles of stakeholders in Lugazi's renewable energy deployment 49

BOXES

Box 1 What is a city? 11
Box 2 Municipal efforts to promote renewable energy in Cape Town 17
Box 3 Corporate sourcing of renewable energy 18
Box 4 District heating and cooling pioneers 19
Box 5 Examples of rooftop solar photovoltaic in cities 20
Box 6 Net metering across the world 21
Box 7 Solar thermal ordinances in practice 22
Box 8 C40 fossil fuel free streets declaration 24
Box 9 Pioneering electric bus use in Shenzhen (China) 26
Box 10 Community choice in Athens, Ohio (United States) 28
Box 11 Irena's solar city simulator for Kasese City 35
Box 12 Devolution of powers and city-level governance in Uganda 36
Box 13 The champion district initiative (CDI), 2012–2016 41
Box 14 Explaining SACCOs and CBOs 42
Box 15 Supporting African municipalities in sustainable energy transitions (SAMSET) 43
Box 16 Solar street lighting in Uganda 51
Box 17 Eco-fuel Africa (EFA) 54
Box 18 Solar system costs in Uganda 62

ABBREVIATIONS

ABPP	Africa Biogas Partnership Programme
BEETA	Uganda National Renewable Energy and Energy Efficiency Alliance
BSU	Biogas Solutions Uganda
CBOs	community-based organisations
CDI	Champion District Initiative [Uganda]
CIRCODU	Centre for Integrated Research and Community Development Uganda
CO_2	carbon dioxide
CREEC	Centre for Research in Energy and Energy Conservation [Uganda]
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]
ERT	Energy for Rural Transformation [Uganda]
EV	electric vehicle
GDP	gross domestic product
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit [Germany]
GW	gigawatt
GW_{th}	gigawatt thermal
GWh	gigawatt-hours
IEA	International Energy Agency
IMF	International Monetary Fund
KDRES	Kasese District Renewable Energy Strategy [Uganda]
KfW	Kreditanstalt für Wiederaufbau
kg	kilogramme
km	kilometre
km^2	square kilometre
KRW	Republic of Korea won [currency]
kW	kilowatt
kWh	kilowatt-hours
LCOE	levelised cost of electricity
m^2	square metre
MEMD	Ministry of Energy and Mineral Development [Uganda]
MW	megawatt
NDC	Nationally Determined Contribution
NDP	National Development Plan [Uganda]
NEMA	National Environment Management Authority [Uganda]
NGO	non-governmental organisation
PSFU	Private Sector Foundation Uganda
PV	photovoltaic
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
SHS	solar home system
SOPEC	Southeast Ohio Public Energy Council [United States]
SWH	solar water heating
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
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

RENEWABLE ENERGY
AND CITIES

Given that cities are dynamic agglomerations of people and their many activities, they are not easily defined (see Box 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).

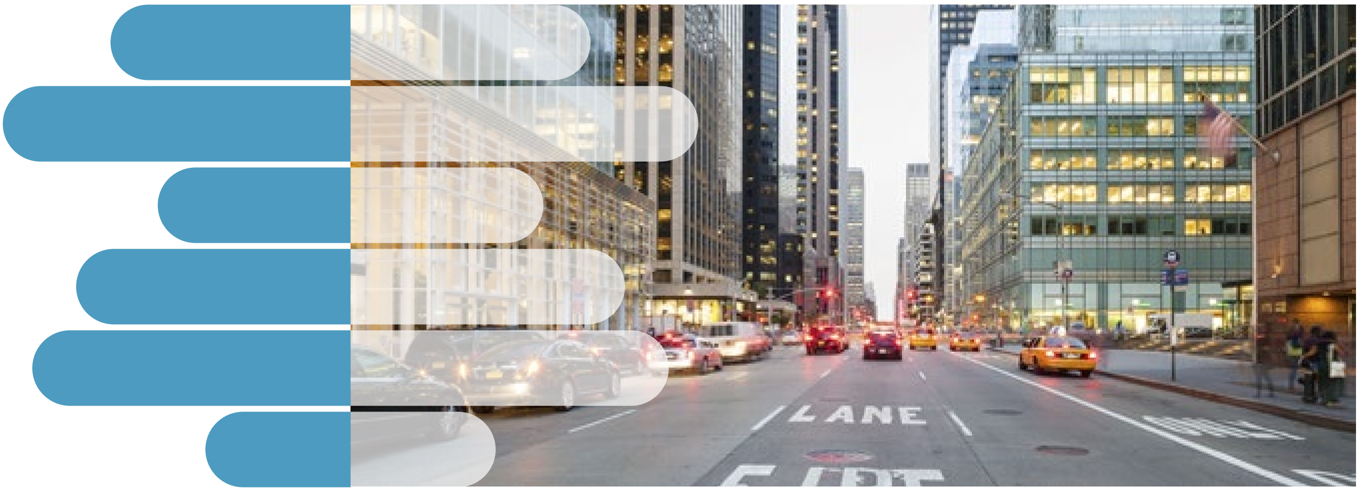
55% of the total population are in cities

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 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.

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. 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). 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.

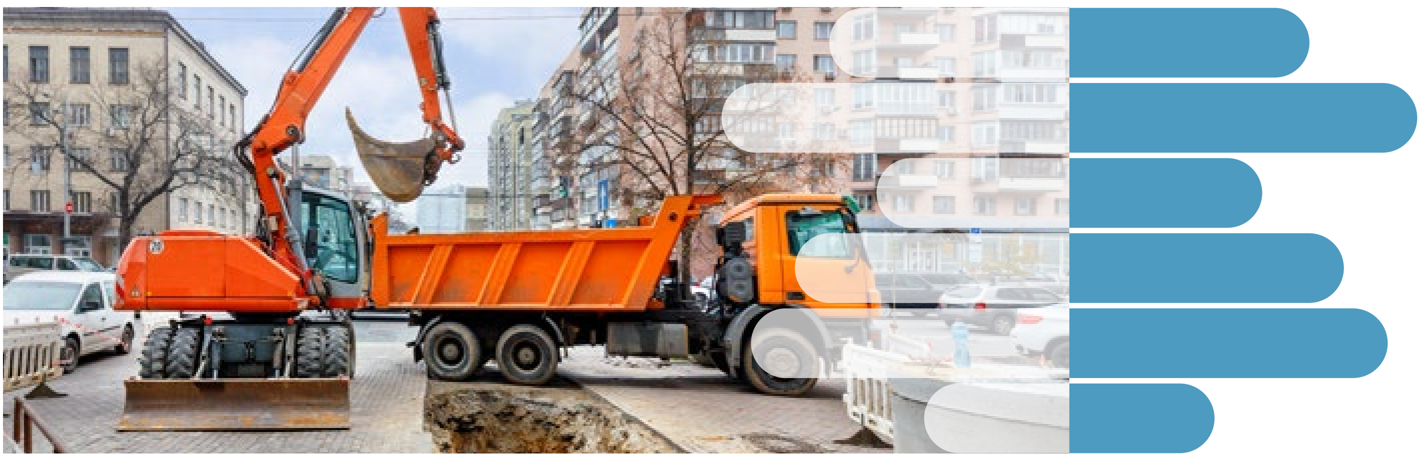
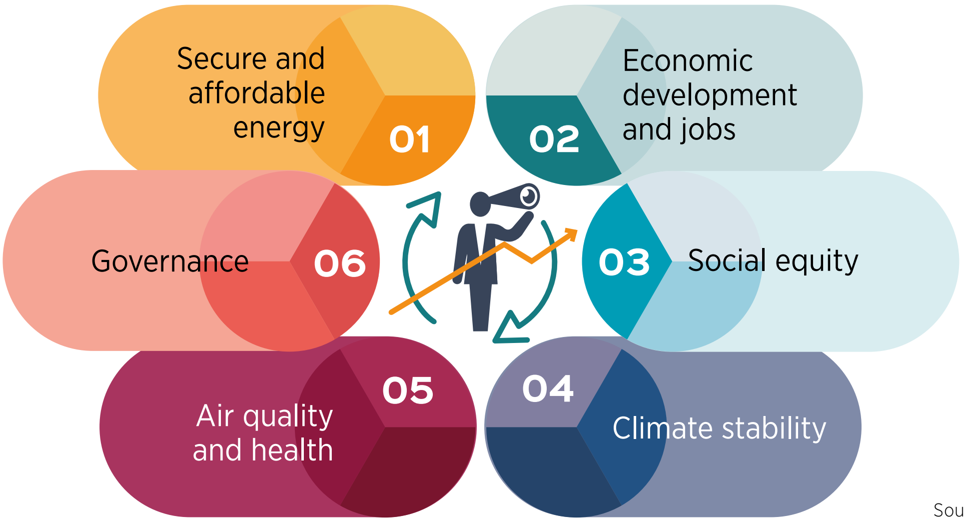


Figure 1 Motivations and drivers of municipal decision making on energy



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.

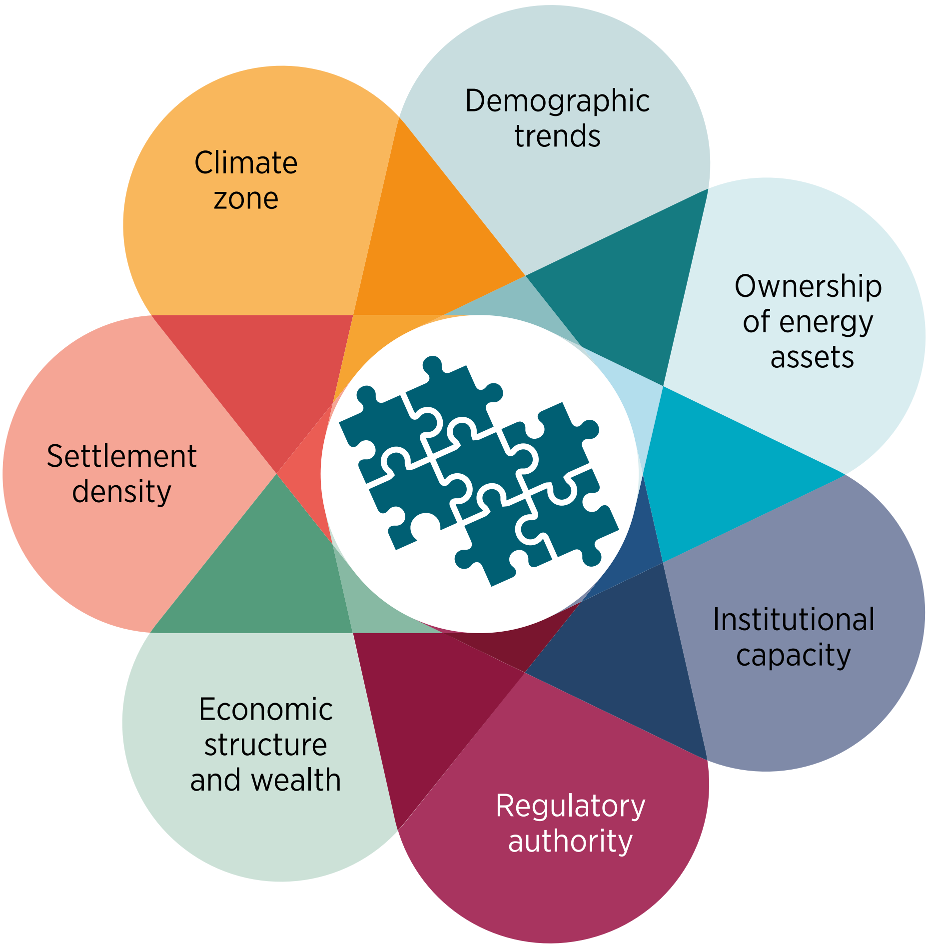
Local energy transition strategies are driven by multiple actors whose significance varies from city to city (and country to country), reflecting different administrative and policy making structures, as well as civic cultures. Mayors, city councils and municipal agencies are key actors in planning, 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 2 provides an overview of the key factors – many of them interconnected – that shape cities' energy profiles.

Figure 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 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 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 2).

BOX 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 3).

BOX 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 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 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 5 offers some examples of such policies.

BOX 5 EXAMPLES OF ROOFTOP SOLAR IN CITIES

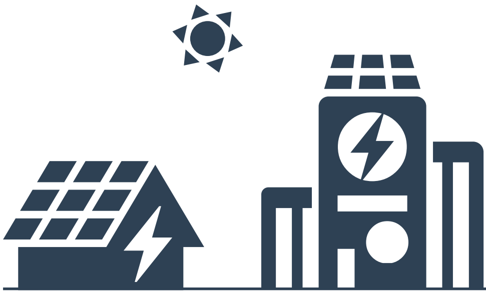
Chinese cities have been at the forefront of solar rooftop efforts. The city of **Dezhou**, in Shandong Province (northwest China), launched its "Million Roof Project" in 2008, requiring that all new residential buildings be equipped with solar water heaters. Solar thermal or solar PV technology is integrated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



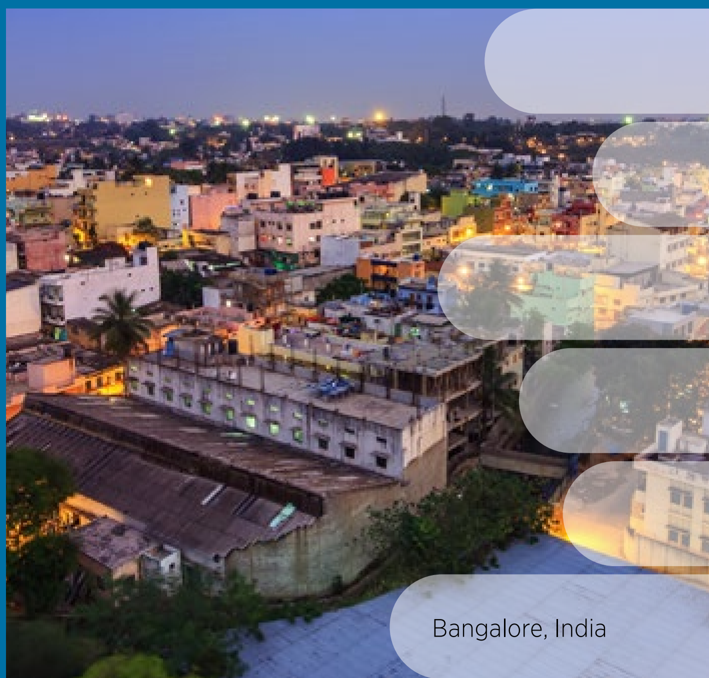
Through net metering, local or national authorities can encourage solar PV deployment, allowing households or businesses that generate their own electricity to feed any surplus back to the grid, thus turning them from consumers into "prosumers". They can either receive a credit against future consumption 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 6 for examples.

BOX 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 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 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

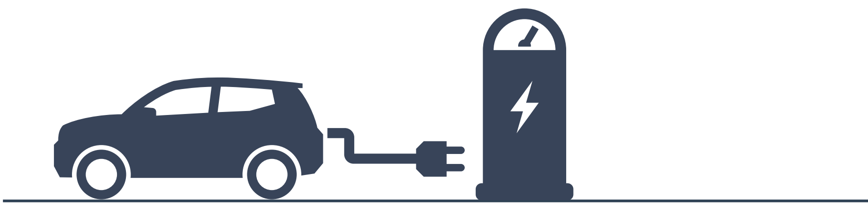
Accounting for one-third of total final energy consumption worldwide, the transport sector is one of the largest energy users in the urban environment, making it an important, yet often neglected target of renewables-focused policy. Energy demand in the transport sector is growing fast, and a significant 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[2] around the world have signed the C40 Fossil Fuel Free Streets Declaration (see Box 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.



2 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 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.

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 9).

Oslo, Norway

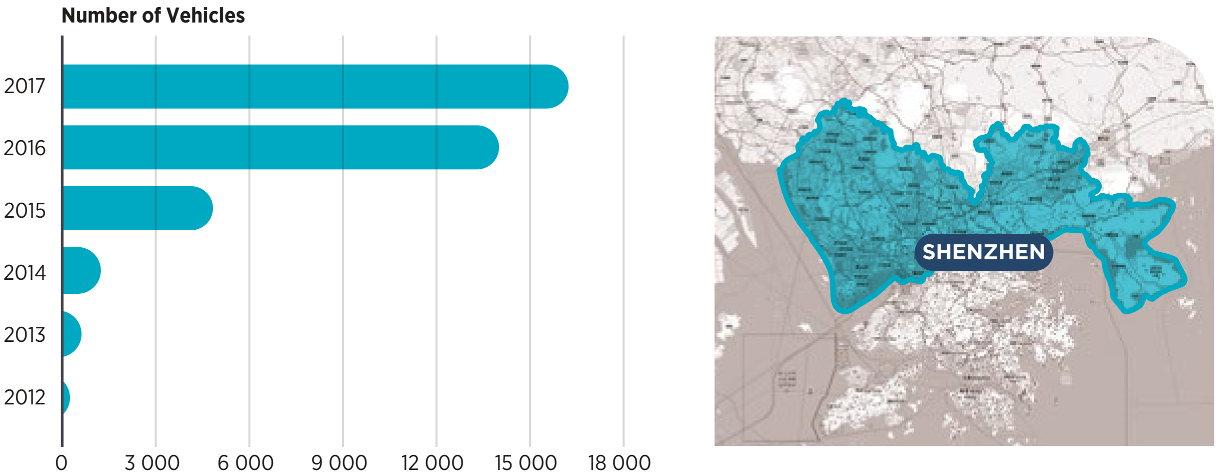
BOX 9 PIONEERING ELECTRIC BUS USE IN SHENZHEN

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 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[3] 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,[4] 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 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.

3 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).

4 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. 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 10).

BOX 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

STRUCTURE OF THIS REPORT

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 in the Ugandan context. The next chapter begins with a sketch of the national context and how it frames what Ugandan cities can and cannot do. In the final chapter, a discussion of relevant initiatives and experiences is followed by a set of lessons learnt and a wrap-up with some broader conclusions.

Country Case

- National Context
- Initiatives and Experiences
- Lessons learnt

Kampala, Uganda

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[5] 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[6] 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.

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

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

THE CONTEXT FOR RENEWABLE ENERGY IN UGANDA

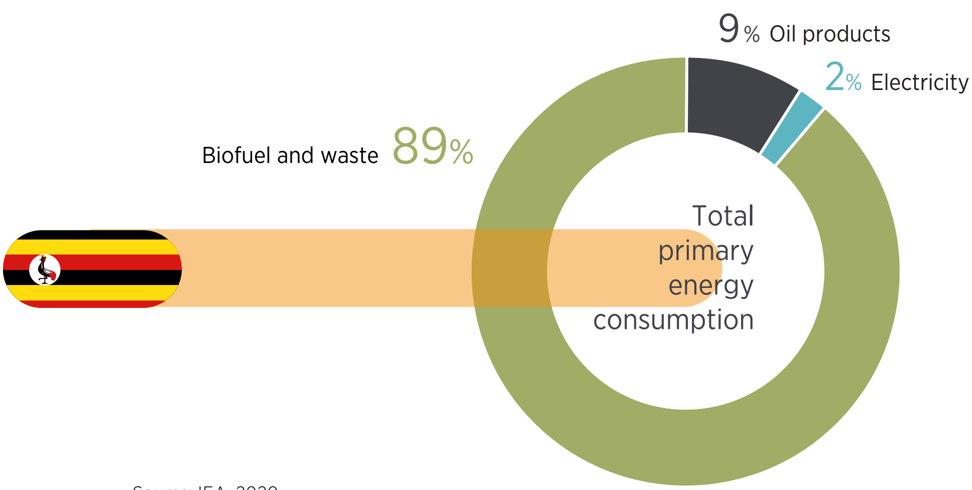
Although Uganda is endowed with a variety of energy resources – including hydropower, biomass, solar, geothermal, peat and fossil fuels – only around 20% of the population has access to electricity; access to clean cooking fuels and technologies is estimated by the World Bank to be as low as 2% (World 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 5).[7] 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 5 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

7 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 5 Total primary energy supply in Uganda (TJ), 2015



Source: IEA, 2020.

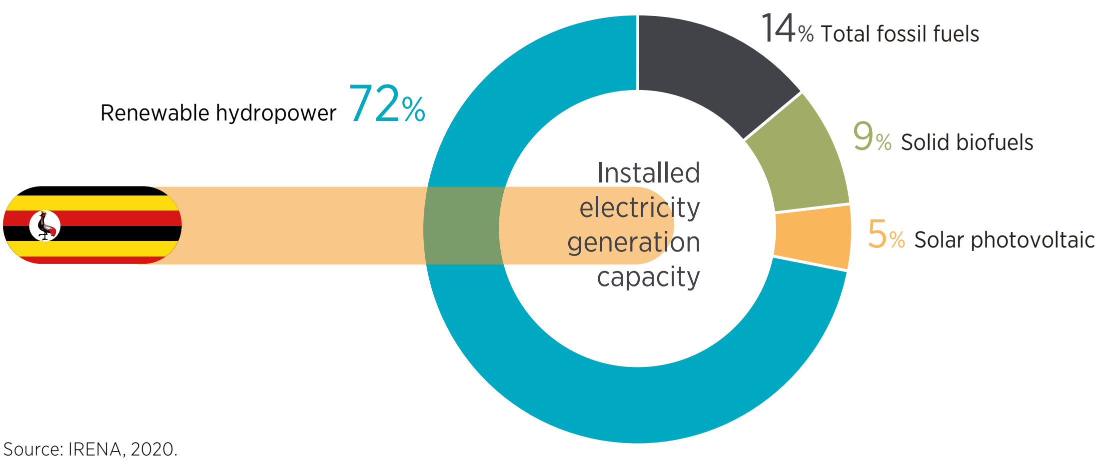
in Uganda but also an urban challenge that residents, businesses, schools and medical centres all face. There are insufficient sources of energy to power modern technologies such as lighting, refrigerators and technical equipment for use in medical facilities, for instance. Around 80% of Uganda's electricity generation is based on renewable energy, in particular hydropower (see Figure 6).

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 6 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[8] 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 11).

In addition to hydropower and solar energy, initiatives such as the Uganda Domestic Biogas Programme and the Africa Biogas Partnership Programme (ABPP)[9] 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 (Christenen, 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).

8 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).

9 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 11 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 12).

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 12 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 7) 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.

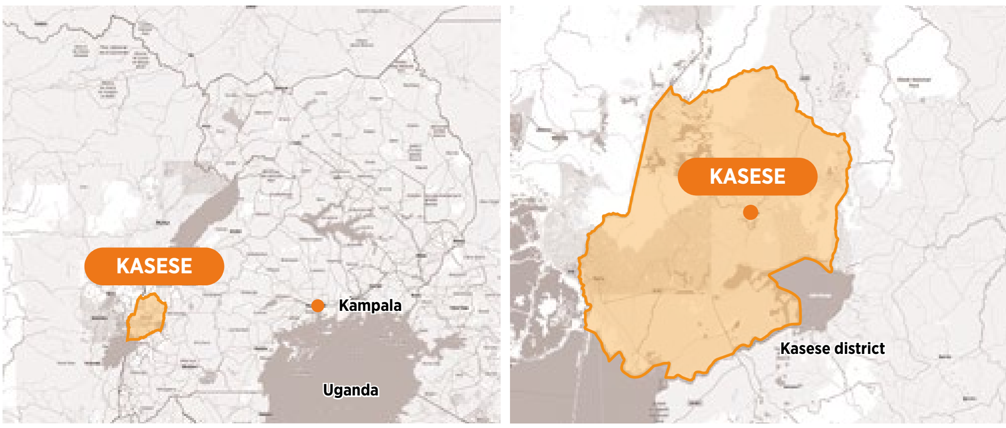
Kasese's population expanded by about 18% between 2002 and 2014 (Binego, 2014; UBoS, 2014), reflecting Uganda's countrywide trend of very fast population growth as well as high rates of rural–urban migration. Much of this urbanisation is a result of increased economic activity tied to trade, mining and 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)

Figure 7 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.

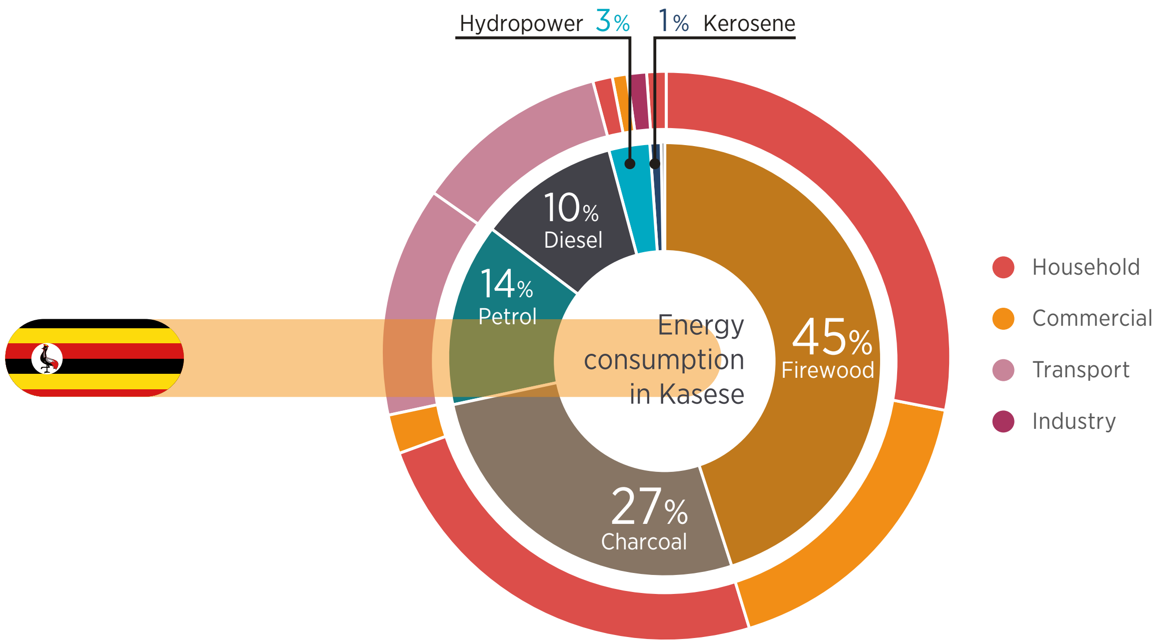
(see Figure 8). The heavy use of charcoal in particular entails considerable environmental challenges, in addition to deforestation caused by heavy fuelwood use (Ndibwami and Drazu, 2018). Transport energy use is dominated by petrol and diesel. Electricity use remains low due to absent or unreliable 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 8 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 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 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 13), 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 13 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 14). 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 14 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 15). 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 15 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,[10] 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.

10University 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:

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 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.[11]

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).

11 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 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 • Loan application processing within 48 hours • Regular and flexible repayment plans based on borrower's cash flow • Government subsidy for clients located 100 metres or farther from the grid	• No loan amount restriction • Fast loan processing • Flexible repayment period of up to 36 months • No penalty charged on early payments • Individuals will only pay up to 70% of the cost of the solar system; 30% subsidy by the Rural Electrification Agency (REA) • Guarantee on the system (batteries and panels)
Loan requirements	• Proof of regular income • Secured with a combination of securities: moveable, immoveable and guarantors	• Proof of regular income • 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 9) (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).

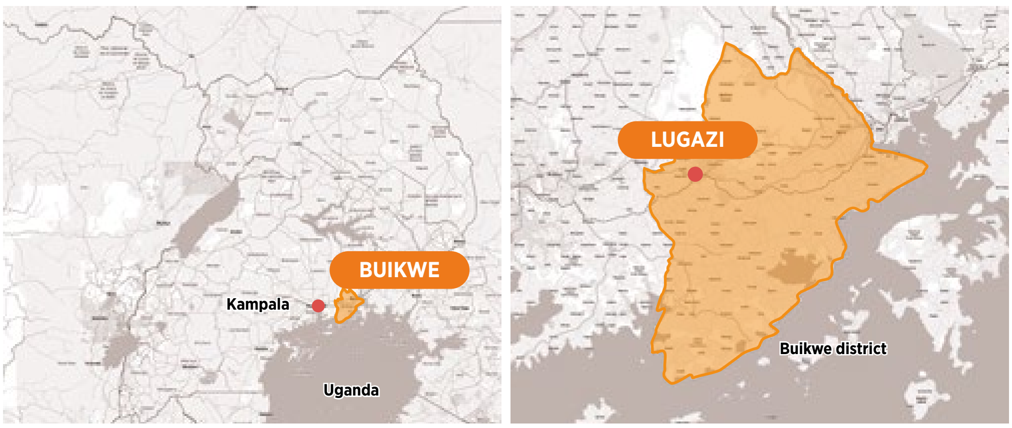
Energy consumption in Lugazi

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[12] (see Figure 10). 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

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

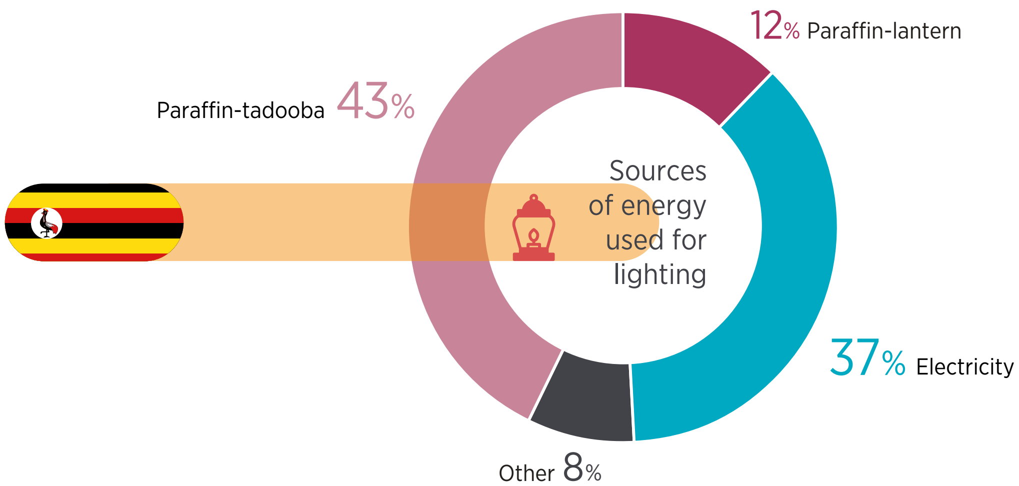
Figure 9 Lugazi Municipality, 2018



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 10 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) The roles of each of the relevant stakeholders are discussed in the next sections.

Table 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[13]), including for the provision of streetlights for all urban authorities in Buikwe District including Lugazi (see Box 16). 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 16). 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).

13 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 16 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.

Source: Gillard *et al.*, 2019

Solar streetlights in Lugazi

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.[14] 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.

14 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).

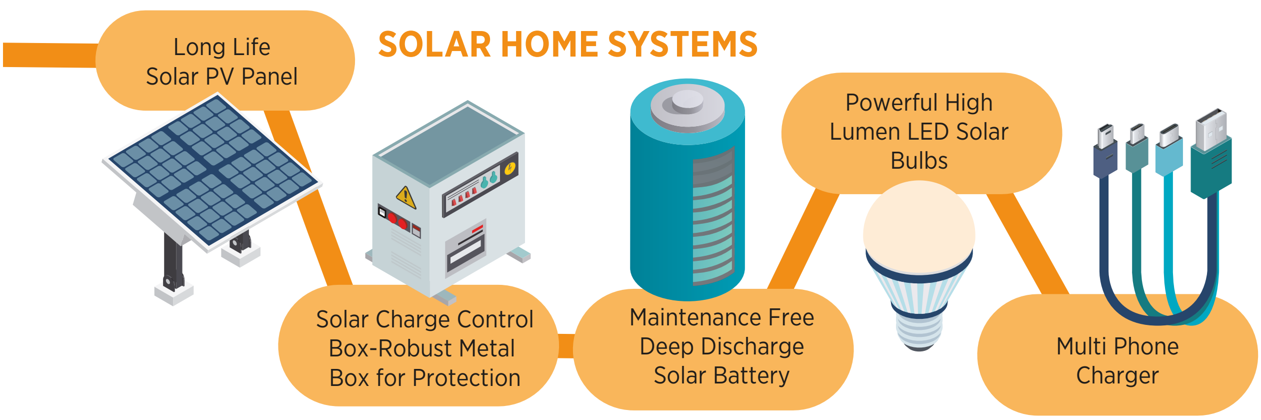
The role of commercial companies

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 11) 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 11 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 1 000–2 000, a number that increased in 2018 by about 3 000.

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 17). 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 17 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 AND CONSIDERATIONS FOR REPLICABILITY

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

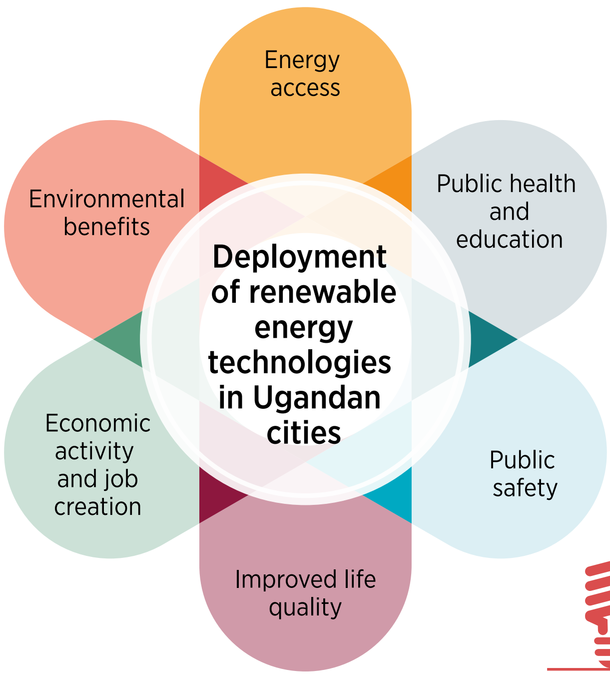
One of the overarching conclusions to be drawn from the two Ugandan case studies is that renewable energy deployment clearly benefits local communities in many different ways and advances progress across a range of socio-economic development goals (see Figure 12).

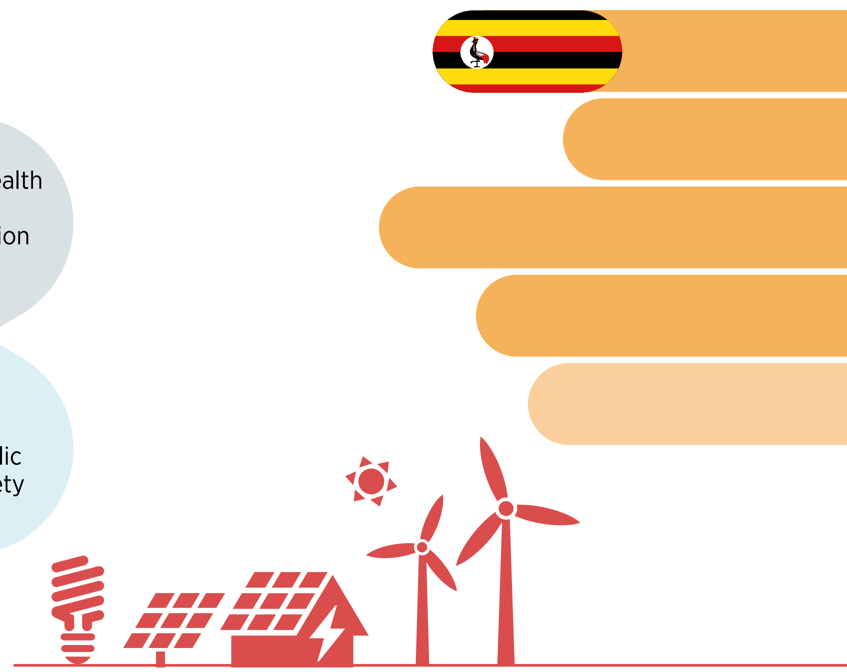
Energy access. One core area of benefit is energy access. Lack of access to electricity is not only a rural problem in Uganda, but also experienced by many urban residents, businesses, schools and medical centres. Solar PV applications in particular have considerable potential to supply a larger portion 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)[15] 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

15 Conversion as per original source.

Figure 12 Renewable energy benefits in Ugandan cities





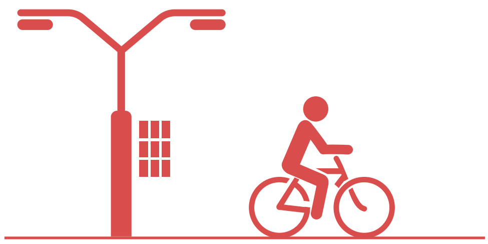
Source: IRENA urban policy analysis.

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

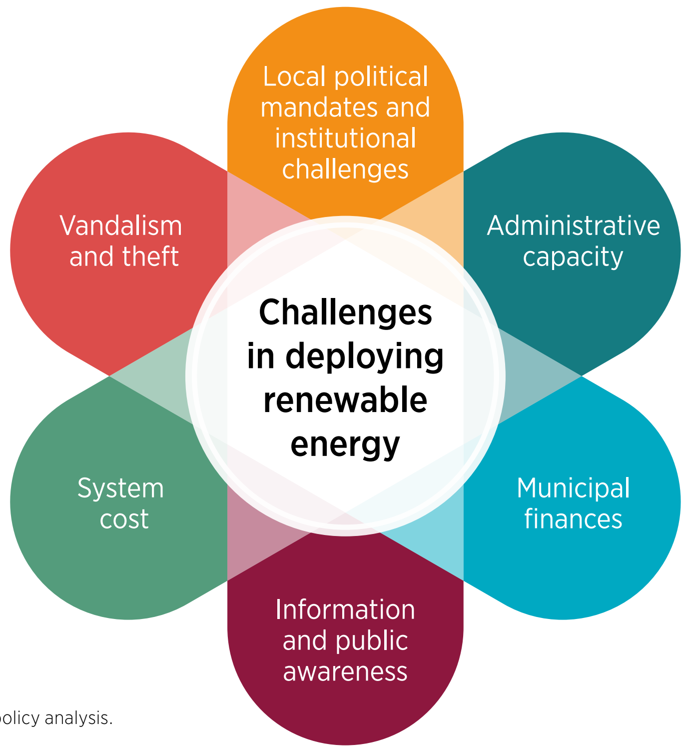
Despite the obvious benefits of renewable energy, Ugandan cities face substantial challenges in local deployment. Institutional constraints, including limits of political mandates, administrative capacity and local expertise and municipal finances all present significant obstacles to effective policy action; costs and inadequate information; operation and maintenance challenges and vandalism are additional challenges (see Figure 13).

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 13 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*

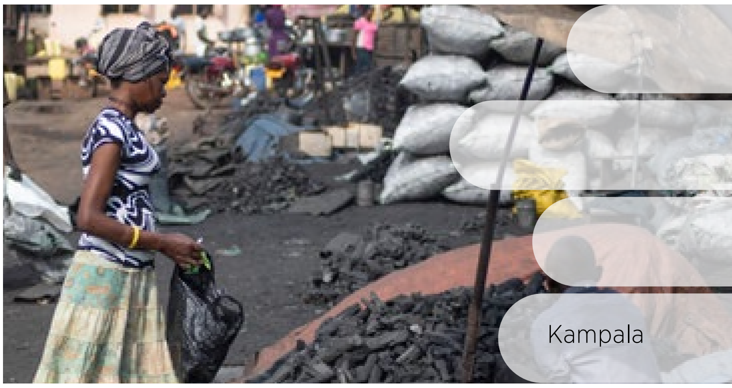
Insufficient resources typically force tradeoffs between financing renewable energy projects or other development priorities such as infrastructure, health and education.

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 18) – a factor that calls for more micro-financing options and awareness raising.

BOX 18 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.[16]

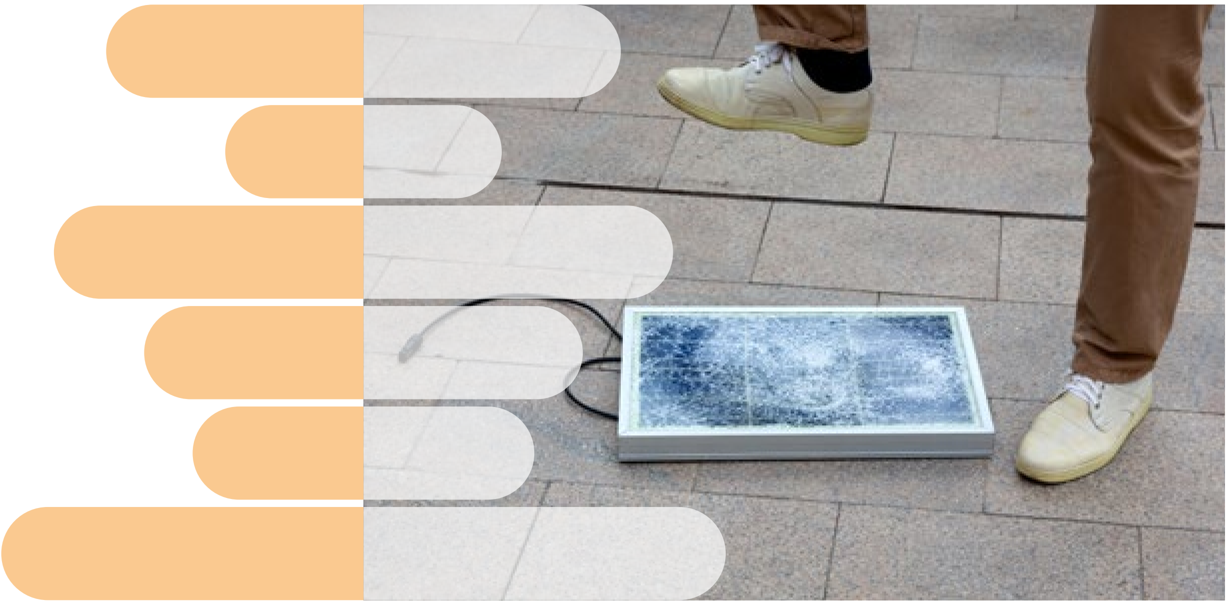
The panel has a ten-year lifespan while a lantern can be expected to last for three years. A larger, four-lamp solar kit retails at UGX 341 000 (USD 92). A village kit – consisting of four LED tubes, two matric lamps[17] and a security light – costs UGX 890 000 (USD 240), and a school kit – three LED tubes and a security light – runs to UGX 2 million (Kulabako, 2013).

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

17 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).

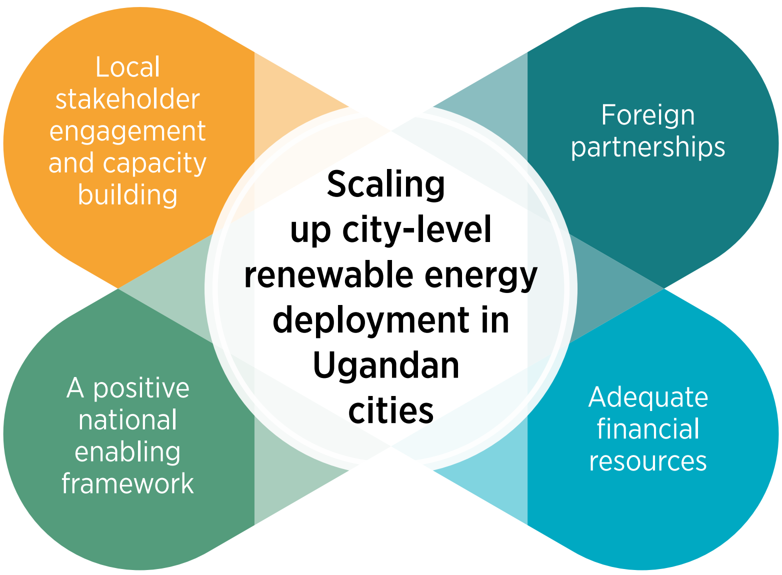
Meanwhile, based on the CDI experience in Kasese District, the WWF has rolled out a Clean Energy Project supporting district local governments in the Albertine Graben, including Koboko, Kibaale, Rubirize, Arua, Maracha, Moyo, Adjumani, Nebbi, Bundibugyo, Kyenjojo, Mitooma, Rubirizi and Masindi, to develop 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 14).

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 14 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.

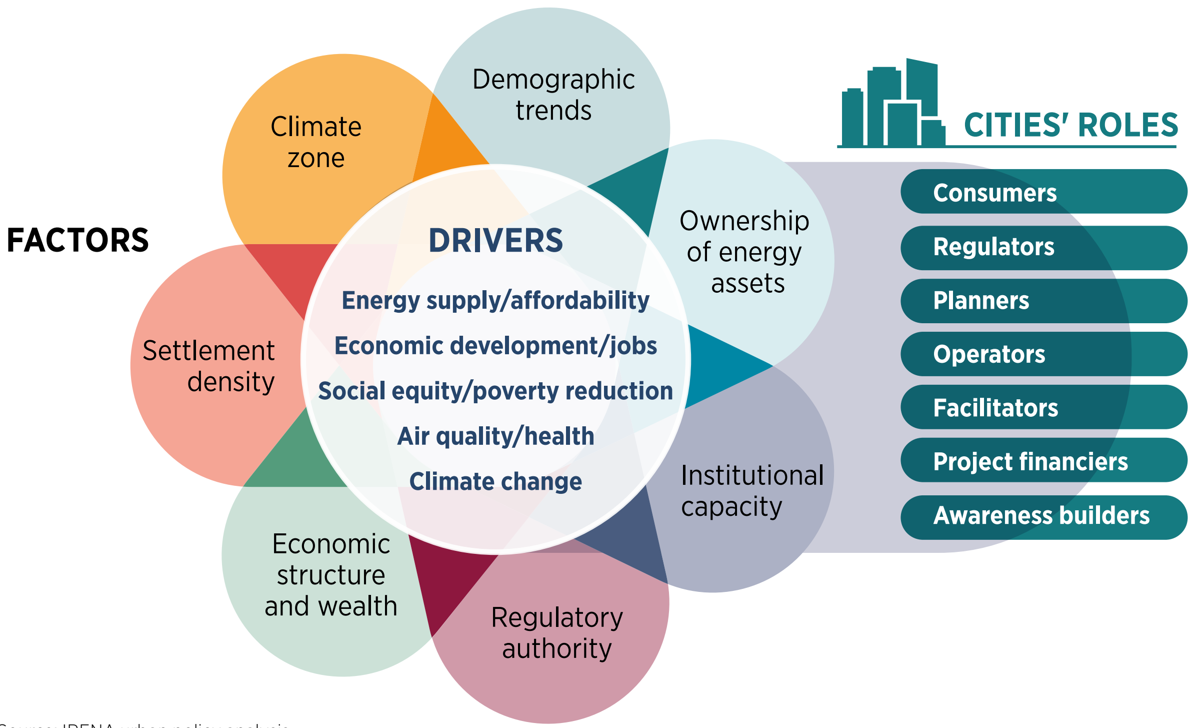
There are important caveats to third-party-led approaches – in particular, issues of scalability and replicability for past one-off and demonstration projects that depend to a large degree on the availability of foreign financing. Kasese and Lugazi on the other hand demonstrate that the opposite is true 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.

WRAP-UP

Political and administrative systems shape the extent to which cities are able to act autonomously, on energy policy and in other matters. In Uganda, as in other countries, 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 15).

Figure 15 Factors and drivers motivating municipal energy policies and shaping cities' roles in the energy transition



Source: IRENA urban policy analysis

Kampala, Uganda

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.

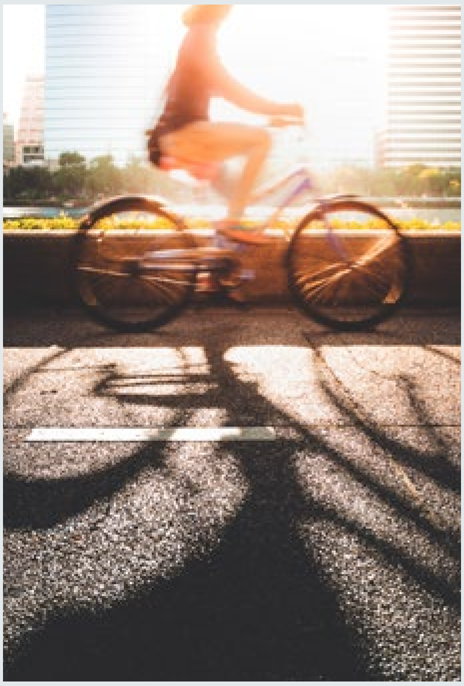
These background factors and drivers interact and influence one another. Together, they determine the specific **roles** cities can play in the energy transition, whether it be as regulators, planners and operators, energy consumers, project facilitators and financiers, or as facilitators of raised public 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.

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.

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.

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.

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.

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.

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

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.

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.

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/.

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.

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.

ESTIF (2018), "Solar ordinances", European Solar Thermal Industry Federation www.estif.org/policies/solar_ordinances/.

European Commission (2020), "Green public procurement" https://ec.europa.eu/environment/gpp/index_en.htm, viewed 17 November.

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.

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.

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.

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.

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.

Hidalgo, D. (2014), "Sustainable mobility trends around the world" www.slideshare.net/EMBARQNetwork/embarq-trends-2014-dario-hidalgo.

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 (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.

IRENA (2020b), *Renewable Capacity 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 (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/.

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.

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.

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.

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/.

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 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.

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.

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.

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.

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.

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.

PRB (2019), "2019 world population data sheet", Population Reference Bureau, www.prb.org/worldpopdata/.

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.

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.

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.

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.

SLOCAT (2018), *Transport and Climate Change Global Status Report* (TCC-GSR) https://slocat.net/our-work/knowledge-and-research/tcc-gsr/.

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/.

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.

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.

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.

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.

PHOTO CREDITS

Page 01: Soroti, Uganda; © Dennis Wegewijs; shutterstock

Page 07: Kampala, Uganda; © Tatsiana Hendzel; shutterstock

Page 08: © chuyuss; shutterstock

Page 10: New York City, USA; ©Sopotnicki; shutterstock

Page 12: © Sergii_Petruk; shutterstock

Page 14: © Bigone; shutterstock

Page 15: © BanGhoL; shutterstock

Page 17: © MrNovel; shutterstock

Page 19: Heating pipes; ©Akimov Igor; shutterstock

Page 21: Bangalore City, India; ©Noppasin Wongchum; shutterstock

Page 22: Solar water heater on roof, Barcelona, Spain; © Nanisimova; shutterstock

Page 24: Electric bus; ©ANDREY-SHA74; shutterstock

Page 25: Electric car charging station, Oslo, Norway; © Softulka; shutterstock

Page 28: Rio de Janeiro, Brazil; © Celso Pupo; shutterstock

Page 29: Kampala, Uganda; © Andreas Marquardt; shutterstock

Page 30: Kampala, Uganda; © Thipwan, shutterstock

Page 34: Kampala, Uganda; © George_TheGiwi; shutterstock

Page 35: © Sebastian Noethlichs; shutterstock

Page 36: Kampala, Uganda; © Andreas Marquardt; shutterstock

Page 40: Fort Portal, Kasese, Uganda; © henrystoryteller1; unsplash

Page 41: © Aptech Africa

Page 42: ENCOT microfinance office in Masindi. Uganda; © GODONG-PHOTO; shutterstock

Page 44: Solar panels and a rural hut in Uganda, Africa; © hindersby; shutterstock

Page 46: © PetrJanJuracka; shutterstock

Page 46: Mpigi, Uganda; © Jonathan Rosenthal; shutterstock

Page 49: Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 49: A view of the town of Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 50: Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 51: Solar powered street lights, Kampala, Uganda; © George_TheGiwi; shutterstock

Page 51: Kitwa, Uganda; © MehmetO; shutterstock

Page 52: © Aptech Africa

Page 54: Lugazi, Uganda; © Adam Jan Figel; shutterstock

Page 56: MATUGGA, UGANDA; © Robin Nieuwenkamp; shutterstock

Page 57: Uganda, Africa; © Dennis Diatel; shutterstock

Page 59: Solar powered street lights, Kampala, Uganda; © George_TheGiwi; shutterstock

Page 60: © Vadim Anokhin; shutterstock

Page 61: Charcoal market in Kampala, Uganda; © Vlad Karavaev; shutterstock

Page 62: © Belish; shutterstock

Page 64: © Sarine Arslanian; shutterstock

Page 65: Kasese, Uganda; © Anil Varma; shutterstock

Page 66: © PetrJanJuracka; shutterstock

Page 68: Kampala, Uganda; © Sarine Arslanian; shutterstock

Page 69: © ImageFoto; shutterstock

Page 69: © MyCreative; shutterstock

IRENA
International Renewable Energy Agency

RENEWABLE ENERGY POLICIES FOR CITIES

EXPERIENCES IN UGANDA

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