Strategies to increase the deployment of distributed renewables in Sub-Saharan African cities

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Introduction

This guide aims to help city governments in Sub-Saharan Africa (SSA) to implement policies and actions that will increase the use of distributed renewables across their jurisdictions. It highlights the barriers to deploying distributed renewables and offers strategies to overcome these barriers, supported by case studies showcasing successful initiatives. The intention of this guide is to encourage cities to implement more ambitious energy transitions, through promoting distributed renewables, which are central to most climate action plans (CAPs).

What are distributed renewables?

Distributed renewables are small-scale power generation systems located near the point of use in the form of solar home systems, micro- or mini-grids. These systems generate, store and distribute energy from renewable sources independently of, or to enhance, the traditional, centralised national grid. Battery storage technology may be used to store power in the absence of a grid, helping to balance demand with power supply.

Distributed renewables are decentralised, modular and flexible systems. They may provide energy to communities where the grid is absent or where power supply is unreliable and unaffordable, and are increasingly a part of the global trend towards sustainable power systems. As global demand rises, the cost of distributed renewables and battery storage technology is rapidly decreasing. Table 1 provides an overview of the common distributed renewable systems found in SSA.

"Distributed renewables are decentralised, modular and flexible systems."

Table 1: Types of distributed renewable systems by size

Solar home system	Micro-grid	Mini-grid
<1 kW	1–10 kW	10 kW–10 MW
Basic energy services in the absence of a grid.	Essential loads (lights, devices, refrigeration) for around 1–5 homes, not including cooking.	Fully electrified building, community or business; off-grid *or* grid connected.

Source: SEforALL (2020)

ELECTRICITY CONSUMPTION IN URBAN SSA HOUSEHOLDS IS ON AVERAGE LESS THAN 1,000 kWh/YEAR. THIS IS ONE SEVENTH OF HOUSEHOLDS IN ADVANCED ECONOMIES[1].

LACK OF ENABLING POLICY AND REGULATION IS THE SINGLE MOST IMPORTANT BARRIER TO THE DEPLOYMENT OF DISTRIBUTED RENEWABLES IN SUB-SAHARAN AFRICAN CITIES

Benefits of distributed renewables

SSA has the lowest rate of access to electricity in the world. In urban areas access is higher, but still millions of people live "under the grid", in areas where electricity is available but where the power supply is unreliable and of low quality, or where grid connection is unaffordable. Access to a reliable and constant supply of electricity is crucial for development, as modern economic activities, new technologies and the provision of public services all depend on power.

With adequate electricity, children are able do their homework, families can listen to the radio or watch television. Distributed renewables can reduce indoor air pollution, responsible for respiratory illness and deaths across the region, by decreasing the need to rely on fossil fuel generators. The recent COVID-19 pandemic has highlighted the crucial role of electricity in health centres, powering ventilators and other critical equipment and ensuring that vaccines are refrigerated. Distributed renewables combined with storage can strengthen power supply in those and other critical infrastructure, contributing substantially to the resilience of our urban centres.

Servicing underserved areas often results in substantial commercial and technical losses for utilities, due to the poor metering, low collection rates and electricity theft. This is the case in Johannesburg where informal settlements account for 13% of power losses, largely as a result of illegal electricity connections. Electrification of informal areas is challenging due to the ad hoc nature of the settlement, its low density and lack of secure tenure. Distributed renewables may increase access to electricity by offering more modular, easy to roll-out, distribution infrastructure and increasing supply reliability, thereby strengthening customer relations and willingness to pay.

The plummeting cost of battery storage allows distributed renewables to be used for a variety of applications, globally paving the way for higher renewable energy integration in future power systems. Together with energy efficiency, distributed renewables are a key lever for cities to achieve a wide range of objectives such as reducing air pollution (and so improving public health), mitigating climate change, supporting the local economy, creating more liveable urban areas and enabling a better quality of life.

Barriers to distributed renewables

- **Policy and regulatory barriers.** Many SSA countries lack specific policies for distributed renewable generation, which increases the risks for private developers. Even when regulations are in place, the requirements are often expensive, complex and difficult to navigate. Applying for licenses, permits and site approvals may also take a long time, which delays projects.

1 IEA (2019), Africa Energy Outlook 2019, IEA, Paris https://www.iea.org/reports/africa-energy-outlook-2019

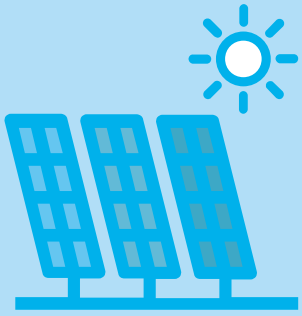
- **Capacity barriers.** Most SSA countries have fairly centralised modes of governance, which limits the role or mandate of local or city government to drive the uptake of renewables. There is often limited capacity at local government level, with staff lacking the skills and experience needed to deal with the complexities of the distributed renewables regulatory environment.
- **Financial and market barriers.** In SSA countries, capital is costly. Return on investment for distributed renewables is also not yet established, particularly given current levels of demand for electricity in cities (low/uncertain) due to household poverty and low levels of economic activity. Weak fiscal decentralization sets major constraints on revenue mobilization and spending powers of local governments to support distributed renewable generation project development. As a result, nearly all renewable energy projects rely on some form of non-commercial grant or equity investment, with funding largely coming from development finance institutions, donor agencies, foundations and governments.[2]
- **Data barriers.** The lack of data available in SSA countries, particularly at city level, means that private investors are not able to obtain the key parameters needed to inform investment and project decisions. These include demographics (population size) and economics (income of household and willingness to pay); metered vs unmetered customers; energy consumption data; location and type of productive businesses; and information about regulations.

CASE STUDY 1:

Electrifying informal settlements in Johannesburg[3,4]

The City of Johannesburg (CoJ) is the economic powerhouse of South Africa, attracting 12,000 new immigrants (local and international) on a monthly basis. This has led to a rapid growth of informal settlements currently estimated to contain 180,000 households, resulting in backlogs in the distribution of basic services such as electricity, water and refuse removal. Households in these settlements are primarily connected via illegal and often rudimentary means, accounting for 13% of power losses in the City and frequent cases of fatal electrocutions, fires and damage to transmission infrastructure. It's also common for these households to use unclean fuels for cooking like paraffin, wood and coal.

To reduce these risks and minimize loss of revenue caused by illegal connections, CoJ embarked on an ambitious electrification programme. Where an extension of the grid was not possible, due to prohibitive network upgrade costs or challenging land tenure issues, the City looked to deploy a combination of grid and distributed renewables and/or alternative energy sources. This included the installation of independent power grids powered by renewable energy. In 2018, CoJ reported that 12,850 homes in informal settlements had been electrified of which 1,600 are from the Setjwetla informal settlement. The electrification of Setjwetla is a brilliant example of how a mix of solar power (grid enhancing PV system) and gas stoves was successfully utilised to stop unnecessary electrocutions, regularise power supply and prevent the loss of revenue caused by illegal connections. This also significantly reduced devastating fires caused by hazardous cooking and heating appliances.



THE CITY LOOKED TO DEPLOY A COMBINATION OF GRID AND DISTRIBUTED RENEWABLES AND/OR ALTERNATIVE ENERGY SOURCES.

2 SEforAll 2020. Minigrids market Report 2020. https://minigrids.org/wp-content/uploads/2020/06/Mini-grids_Market_Report-20.pdf

3 City of Joburg, 2018. More informal settlements in Joburg get electricity. https://www.joburg.org.za/media_/Newsroom/Pages/2016%20&%202015%20Articles/More-informal-settlements-in-Joburg-get-electricity.aspx

4 C40, 2018. Johannesburg: Benefits of the electrification of informal settlements

Actions to accelerate the deployment of distributed renewables

Despite barriers, local government can act to accelerate the deployment of distributed renewables, and bring distributed renewable power generation into the cities.

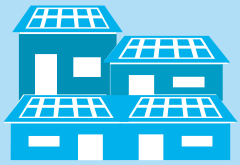
1. Municipal leadership through pilot and demonstration projects

SSA municipal governments can lead by example through pilot projects on municipal assets, which is an important step as it begins work where the local government has clear control and opportunity to drive uptake. Demonstration projects rely on local government dedicating budget, or raising funding, for procurement of renewable energy assets within their facilities or infrastructure.

Demonstration projects should be located in visible and accessible facilities such as hospitals, schools, municipal buildings and street lighting. Such projects raise awareness of the technology among communities and businesses, and build capacity within local government. Demonstration projects should have the following aims:

- **To educate the community**, through holding open houses for the public at the project site, awareness campaigns about distributed renewables work, and training workshops with community organisations and local entrepreneurs.
- **To build confidence in the technology**, through ensuring good quality installation and maintenance to avoid any negative backlash. This will equally help to build the local market and capacity and create demand for the technology.
- **To showcase the business case,** through communicating the cost saving benefits and addressing regulatory and other installation challenges that might deter the private sector.

DEMONSTRATION PROJECTS SHOULD BE LOCATED IN VISIBLE AND ACCESSIBLE FACILITIES SUCH AS HOSPITALS, SCHOOLS, MUNICIPAL BUILDINGS AND STREET LIGHTING.



THE CITY OF CAPE TOWN NOW HAS THOUSANDS OF SOLAR PV SYSTEMS CONNECTED TO THE GRID WITHIN THEIR AREA OF JURISDICTION, WITH A CUMULATIVE CAPACITY OF OVER 50MW.

Source: City of Cape Town (photographer: Tracey Adams)

CASE STUDY 2:

City of Cape Town, South Africa

In March 2014, the City of Cape Town installed a solar PV system on the roof of one of the traffic department's buildings. The building is very visible and so able to showcase the renewable and energy efficiency interventions to the public. The installation includes a 10kWp[5] grid-tied solar photovoltaic (PV) system and the City also installed energy efficient LED lighting technology with occupancy sensors to reduce the building's energy demand. The rooftop PV system generates about 11,900 kWh per year, or about 2% of the building's energy needs. Since the building underwent its green makeover, its electricity bill decreased by some 20%, or 1,000 USD per year.

The City of Cape Town has developed the capacity to actively support customers looking to install solar PV. Its website outlines the solar energy options and the steps involved when installing a solar system, as well as how to register and sell electricity back to the City.

CASE STUDY 3:

Lagos Solar Project, Lagos, Nigeria[6]

In 2015, over 60% of the electrified households in Lagos experienced low quality and unreliable power. This was in addition to the gruelling 40% of the population that was left with no grid connection. This power deficit and unreliability equally had several repercussions on the provision of public services such as healthcare and education. Born out of the Leadership of the Lagos State Government and with financial support from the UK Department for International Development (DFID), the Lagos Solar project, a component of the Solar Nigeria Programme, was commissioned in 2014 to address these issues.

Lagos Solar is Nigeria's single largest distributed social solar project which supplies off-grid electricity to 172 secondary schools and 11 primary health care centres (PHCs) in rural, riverine, and peri-urban areas of Lagos State. This project brought an additional 5 MW of solar energy generation capacity in modular systems ranging between 5kW–25kW. The pioneering nature of this project was crucial in setting implementation guidelines for off-grid projects while creating a local market for distributed renewables in Lagos and beyond.

of grid connected households experience low quality and unreliable power

of population has no grid connection

OFF-GRID ELECTRICITY SUPPLIED 172 SECONDARY SCHOOLS AND 11 PRIMARY HEALTH CARE CENTRES

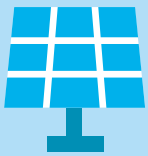
5 kWp stands for kilowatts peak which is the rate at which the PV system generates energy at peak performance

6 C40 & ARUP, 2018. Lagos Solar: Nigeria's largest distributed social solar project

2.Create an enabling regulatory environment

In most SSA countries, the national government is responsible for enacting regulations and providing electricity, but municipal governments have certain tools that they can use to encourage and promote distributed renewables, including:

- **Building permits.** Local governments could fast-track building permits for buildings that embed distributed renewables or even include renewable energy deployment as one of the building permit's requirements.
- **Drafting green building policy and requirements** (codes) for municipal buildings and private development. Local government should explore their powers and functions with regard to development planning and building approval and develop policy and/or code that requires all new development across the city to move towards efficiency and renewable source power supply. It may be that local government can influence development in 'green' directions through use of rates or tax incentives.
- **Engaging with national government**, utility companies and the private sector on key regulatory issues. This should include asking for clear regulatory frameworks, ease of licensing and permitting, clarity on tariff-setting and future tariffs, and the development of enabling policies, such as net metering. Local government has an important role as an intermediary to provide key policy-related information to the market and convey the needs of the private sector back to the policy makers.



CASE STUDY 4:

The Mokoloki Community mini-grid Project, Nigeria[7]

THE SOLAR-HYBRID MINI-GRID PROVIDED 100KW OF GENERATION, WITH ADDITIONAL LOADS TO BE ADDED, SUPPLYING 230 HOUSEHOLDS AND 48 COMMERCIAL, 11 PUBLIC, AND 1 ANCHOR CUSTOMER.[8]

Mokoloki is a rural community of about 1,000 inhabitants in Ogun State, Nigeria that struggled with intermittent and low-quality electricity, which was available for an average of four hours per day. In 2017, the Nigerian Electricity Regulatory Commission (NERC) ratified the regulation for mini-grids, which opened up a window of opportunities for the private sector. The Mokoloki mini-grid project involved a cooperative tripartite contract agreement between Nayo Tropical Technology (a private developer), the Ibadan Electricity Distribution Company (IBEDC) and the local community, with advisory support from the Rocky Mountain Institute (RMI).

The Mokoloki project demonstrates the potential to increase energy access in 'underserved' urban communities through "undergrid" minigrids, which leverage existing distribution infrastructure to achieve lower system cost than isolated minigrids while improving service reliability from the status quo. Within the first three months, the project resulted in:

- Reduced carbon dioxide emissions by 15,000 kg
- Cost savings for IBEDC, which prior to the project had commercial and technical losses of up to 70% in Mokoloki
- Lower electricity costs for customers, by on average 20 Naira per kWh

The Mokoloki mini-grid project shows how simple, straight-forward regulations can open up opportunities for the private sector to participate in innovative joint ventures that benefit all parties.

7 RMI 2020, Nigeria's First Commercial Undergrid Minigrid Project, https://rmi.org/insight/mokoloki/

8 RMI 2018. Under the Grid: Improving the Economics and Reliability of Rural Electricity Service with Undergrid Minigrids, www.rmi.org/insight/under-the-grid/

3. Provide incentives for distributed renewables

Cities need to explore and support ways of incentivising the deployment of renewables. These might include the following.

- **Facilitating land acquisition or access for developers.** Local governments could provide incentives for distributed renewable projects on municipal land, or reserve municipal land for renewable energy projects. They may also explore reduced property rates where the land is deployed for renewable energy development.
- **Lowering the cost of doing business.** Local government could provide subsidies or create lower interest or blended finance mechanisms in conjunction with development finance institutions. This could be in the form of subsidies on low interest loans for building-scale distributed renewables, which owners will then gradually pay back through slightly higher property taxes[9].
- **Allowing surplus electricity from distributed renewables to feed into the grid.** Local government would need to engage with their national policy-makers to create national (or utility-based) feed-in-tariffs and/or net metering policies that would enable households and businesses to feed or sell their surplus electricity to the grid.

Source: SunExchange

THE 84.40 kWp ROOFTOP SOLAR SYSTEM AT WYNBERG GIRLS HIGH SCHOOL COMPRISES 18 072 SOLAR CELLS MOUNTED IN MODULES OF 72 CELLS, OR 251 X 335W SOLAR MODULES.[11]

CASE STUDY 5:

Sun Exchange, Cape Town, South Africa

Sun Exchange demonstrates how government may enable innovative financing for distributed renewables. Sun Exchange is a South African company that crowdfunds the upfront capital cost, and installs and maintains solar power systems on schools and other organisations. They call themselves "the world's first peer-to-peer solar leasing platform".[10] Any investor can purchase solar cells for as little as US$5 per cell. Once the solar installation is "live", the school or organisation pays for the solar-generated electricity, which is cheaper than traditional grid electricity. Investors receive this money (minus insurance and servicing fees) as monthly lease payments paid either in local currency or in Bitcoin. One of their projects is Wynberg Girls High School in Cape Town, where an 84 kW solar PV system was installed and funded by 368 investors from all over the world. Investors will receive rental income over 20 years at an expected internal rate of return of 12%.

Western Cape Provincial Government played a key role in enabling Sun Exchange's business model. In South Africa, provincial governments have executive responsibility for the administration of schools. Sun Exchange worked with the Province to approve their business model and develop standardised contracts and agreements for each school, giving schools the assurance to enter into power purchase agreements. In much of SSA, local governments are responsible for the administration of schools, clinics, libraries and other public services and can use this role to enable the rollout of distributed renewables.

9 IRENA (2016). Renewable Energy in Cities. International Renewable Energy Agency (IRENA).Abu Dhabi. www.irena.-org

10 https://thesunexchange.com/about-us

11 https://d1tsx6lhcafpu4.cloudfront.net/production/6f499ca7b629406e9a7c571c02eabba5.pdf

CASE STUDY 6:

Sabon Gari market micro-utility project, Kano State, Nigeria

Sabon Gari is one of Nigeria's largest markets, with more than 12,000 shops that sell everything from vegetables to visual arts. Due to the erratic power supply, about three-quarters of shop-owners at Sabon Gari relied on petrol and diesel generators, which had resulted in a fire that destroyed NGN 10 Bn worth of goods. The market was a pilot project for the Nigerian government's Energizing Economies Initiative (EEI), which was launched in 2017 to provide off-grid power to economic clusters, such as markets and shopping complexes.

The EEI is implemented by Nigeria's Rural Electrification Agency (REA). The 1.3 MW micro-utility project at Sabon Gari market is a public-private partnership (PPP) between the REA and Rensource, an energy specialist that raised funds, installed and maintains the project. REA managed and facilitated all interactions with the various Ministries, the Nigerian Electricity Regulatory Commission (NERC) for Permits, Approval and Licensing, Kano State Government for Right of Way and Land Title, and the Federal Ministry of Works.

Consultation with the shop-owners enabled REA to assess the energy needs of the stall holders and their willingness to pay for the electricity. The survey indicated that 51% of traders would expand their shops if given reliable power supply and nearly half believed street lighting would be beneficial. They were also able to estimate the load requirements of the shop owners, and the energy end uses (lighting, cooling and other appliances and equipment) and match the system design to power needs. After consultation with the shop-owners, the developers opted for a decentralised system split into 160 10kWh systems, each providing power for between 60 and 80 shops. The project's impacts include:

- **Employment**. The project created temporary jobs (up to 100 engineers, administrative staff, and craftsmen for the duration of the project) and permanent jobs (to maintain the solar PV system and provide customer services support).[12]
- **Lower cost of electricity for shopkeepers**. Shop owners pay 116 Naira per day for electricity, compared to 1,000 Naira for generator-produced electricity. Since 2017, mini-grid developers in Nigeria must charge cost-reflective tariffs.
- **Reduced noise and air pollution**. Without the noisy generators, noise pollution has decreased, while carbon dioxide emissions have reduced by an estimate 500.33 tCO_2 per year.[13]

The first phase allowed for 500 shops to be electrified and when completed the 12,000 small businesses will be connected.

NIGERIANS SPEND AN ESTIMATED $14 BILLION ANNUALLY ON SMALL-SCALE DIESEL GENERATORS TO OFFSET POOR OR NON-EXISTENT GRID SUPPLY.[14]

These photographs show Sabon Gari market before and after project implementation. *Source: Rensource (2018)*

12 Victron Energy 2019. Solar energy excitement in Nigeria, https://www.victronenergy.com/blog/2019/09/16/solar-energy-excitement-nigeria/

13 Estimates based on data from Ariana Market provided by REA (2019). It's assumed that shops in Ariana and Sabon Gari markets are approximately the same sizes.

14 World Bank, 2018. Leveraging finance for the Nigerian off-grid solar market, https://blogs.worldbank.org/psd/leveraging-finance-nigerian-grid-solar-market

4. Create favourable environment for the private sector

Local government can support the private sector in developing innovative business models, by using their household, business registration and energy consumption data to identify the most suitable locations for distributed renewables.

- **Identifying and engaging customer clusters.** Local government can help to establish a critical mass of customers to ensure a viable business model. They may support private developers to identify "anchor" customers. These might be larger business or industry – and could even be local government itself - who can provide a secure market for the power.
- **Facilitating develop-customer engagement.** Local government may support project development through facilitating the engagement with communities who will buy the power. Community engagement is critical in projects and a substantial cost to projects. Insufficient attention to community or customer engagement is the most common cause of project failures.
- **Provide facts and figures to support business cases.** This may include liaising with academic and research institutions or national government to source critical information, such as local solar or wind maps assessing the renewable potential of municipal geographical boundaries. This would also include research into typical electricity consumption patterns that may assist business case development.
- **Streamline the registration process.**This would require cities to work with electricity distribution companies.

A Distributed Renewables Checklist

Distributed renewable energy projects are not simple, but can be done. They require the collaboration of multiple parties, a strong business case, ongoing maintenance and a strong relationship with customers to make sure services charges are paid. The following is a simple checklist towards ensuring a successful project outcome:

- ☐ **Renewable system design closely matches the demand (load and time of use) and includes mechanisms for demand scheduling/management (battery storage technology and/or grid connection can be valuable here)**
- ☐ **The payment model is adapted to the customers' ability to pay**
- ☐ **There is a baseload or "anchor" customer**
- ☐ **All parties clearly understand the ownership and operational responsibilities**
- ☐ **All possible finance and capital/operating subsidies are identified upfront**
- ☐ **Community is well engaged, understand the project and are willing to pay**
- ☐ **The project aligns with local and national development goals.**

Useful links

1. A toolkit for developing successful green minigrids, Carbon Trust: http://www.cityenergy.org.za/uploads/resource_447.pdf
2. Under the Grid – Improving the Economics and Reliability of Rural Electricity Service with Undergrid Minigrids, Rocky Mountain Institute: https://rmi.org/insight/under-the-grid/
3. Renewables in Cities 2019 Global Status Report, REN21: https://www.ren21.net/wp-content/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf
4. http://www.minigridpolicytoolkit.euei-pdf.org/index.html