Renewable energy mini-grids: An alternative approach to energy access in southern Africa

Southern Africa faces a number of severe energy pressures. Power production falls far short of demand. Electricity access rates are relatively low, primarily in rural areas, making it difficult for power producers to cover costs. And the electricity sector depends heavily on fossil fuels and hydropower, making it vulnerable to oil price volatility and the effects of climate change. There is an urgent need to diversify the generation mix by tapping into the region's vast renewable energy potential.

Achieving a larger, diverse, secure and low-carbon energy sector requires a variety of solutions. It is important to strengthen and expand the supply and distribution of electricity through the national grid, especially as regional interconnection increases stability and security. But that is not the only solution. Decentralized options such as mini-grids are needed to complement grid-based electrification, particularly in areas where grid extension is not technically or financially feasible

This discussion brief highlights the energy pressures faced by member states within the Southern Africa Development Community (SADC)[1] and explores how renewable energy mini-grids might provide an alternative and additional energy solution to relieve these pressures. The brief is based on a desk study comprising a review of recent research and policy documents on mini-grids in the SADC region.

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A boy stands under an electricity pylon in rural Tanzania

Key messages

- There is growing interest in southern Africa in using renewable energy and hybrid mini-grid solutions to increase access to electricity in the short to medium term for rural populations in sparsely populated areas far from the national grid.
- Mini-grids are still mostly in the pilot phase in most countries, and their contribution to southern Africa's electricity mix remains minimal. Existing mini-grid solutions vary widely depending on size, location relative to the grid, technology, ownership and operation models.
- Scaling up the use of mini-grids is a major challenge, as countries have yet to find sustainable business models. Barriers to wider deployment include the relatively small size of the off-grid market, the low incomes of end-users in rural areas, low electricity tariffs that are unattractive to the private sector, lack of supportive policy and regulatory frameworks, and limited access to affordable longer-term finance.
- There is no single solution to these challenges. Instead, mini-grid systems must be tailored to the local social, economic and cultural context, as otherwise they may not be fit for purpose. Mini-grids should also be designed around a reliable customer base.
- A supportive policy and regulatory environment that encourages private investment is necessary to build confidence among investors and project developers.

Energy pressures in SADC countries

Despite efforts to increase electricity generation, the SADC region still struggles to meet rising demand. Real GDP growth of more than 5% per year from 2001 to 2014 has resulted in unprecedented growth in electricity consumption and demand.[2] Electricity demand is projected to increase by an average of 3.1% per year from 2015 to 2027, to almost 540 TWh.[3]

By 2007, demand growth had outpaced the expansion of the power supply (Ngwawi 2012). In 2015, Southern African Power Pool (SAPP) installed capacity was 61,859 MW, and available capacity was 52,589 MW; taking into account generation capacity reserve requirements, that left a shortfall of 8,247 MW.

Planned increases in generation capacity have been expected to bridge this gap: the SADC *Regional Infrastructure Development Master Plan 2012*, its Energy Sector Plan, and the *Southern Africa Power Pool (SAPP) Master Plan 2009* all identified a range of priority energy infrastructure to be built. However, there have been significant delays in the implementation of planned generation and transmission projects. Investments have been hindered by a range of issues, including electricity tariffs that do not reflect costs; poor project preparation, lack of standardized power purchase agreements (PPAs), and inadequate policy, regulatory and institutional frameworks.[4]

The inadequacy of the power supply is widely recognized as a barrier to economic growth. For instance, the *African Economic Outlook 2016* notes that "inadequate or unreliable access to electricity remains one of the biggest binding constraints on economic development", citing frequent outages and the high cost to businesses of purchasing generators, among other issues.[5]

The power deficit is also a major concern because in several SADC countries , large shares of the population still lack access to modern energy services. Of the roughly 298 million people who live in the SADC countries, only 42% had access

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A wind turbine in Seychelles, an archipelago nation that has achieved near-universal coverage entirely with mini-grids

to electricity in 2012 – including about 60% in urban areas and 30% in rural areas.[6]

As Figure 1 shows, electricity access rates vary widely between countries, from very low levels in the Democratic Republic of the Congo (18%) and Malawi (12%) to very high levels in Seychelles (98%) and Mauritius (100%). There are also wide disparities in access between urban and rural areas in countries such as Angola and Zambia: 69% vs. 6% and 62% vs. 5%, respectively. In addition, a large share of the population still relies mainly on traditional biomass for cooking and heating, which represents more than 45% of final energy consumption in the region.

Diversifying generation and transitioning to low-carbon energy systems

As shown in Figure 2a, by 2015 the electricity mix within SAPP was largely dominated by coal, which accounted for 62% of the total installed capacity, followed by hydropower, at 21%. The remaining balance is accounted for by oil, wind, nuclear, solar PV, concentrated solar power, natural gas, biomass and landfill gas.[8]

The dominance of coal reflects the dominance of South Africa as the region's main producer and consumer of electricity, most of which is coal-based (see Figure 2b). Other southern countries in SADC, such as Zimbabwe and Botswana, also rely mainly on coal for electricity generation.

Yet there is growing controversy over the continued use of abundant coal resources for electricity generation, given increasing global pressure to mitigate the effects of climate change.[9] This is a particular issue for South Africa, where annual GHG emissions from coal are already high: 231.9 Mt CO_2 in 2012.[10]

The more northern countries in SADC rely mainly on hydropower, which faces a different set of concerns related to climate change.[11] Increasingly irregular rainfall patterns and seasonal droughts pose significant threatens to availability and reliability of hydropower in the long run. The present drought conditions and falling hydropower output in both Zambia and Namibia are two cases in point.

Therefore, there is an urgent need to tap into the region's vast renewable energy potential, to diversify the power mix and thus increase electricity access and ensure the security and reliability of the supply. The International Renewable Energy Agency (IRENA) estimates the potential of generation from identified large-scale hydropower projects in the region (excluding the Grand Inga in DRC) at 38,657 MW, while small-scale hydro potential is 3,520 MW, biomass is 8,470 MW and wind energy is 117,090 MW. Meanwhile, annual solar potential is estimated at 2,195 TWh for solar PV and 1,093 TWh for solar thermal .[12]

Need for alternative solutions

For many years, the SADC Member States have expanded electricity access mainly by extending the national grid. Supplying

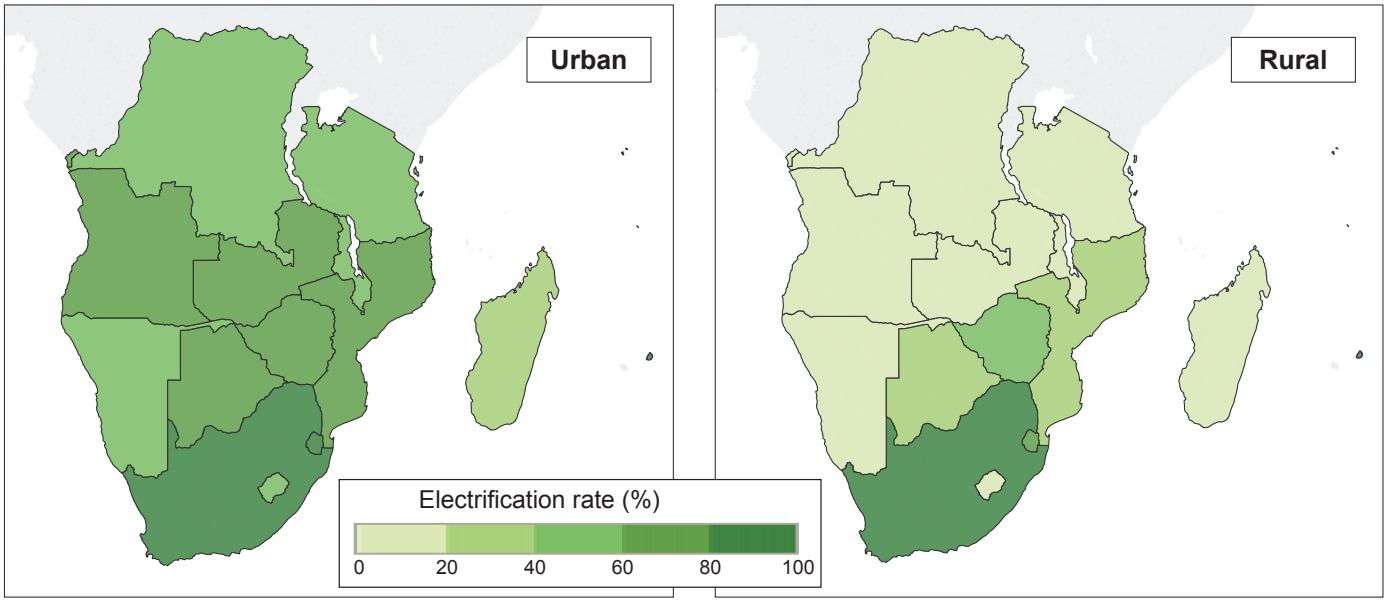
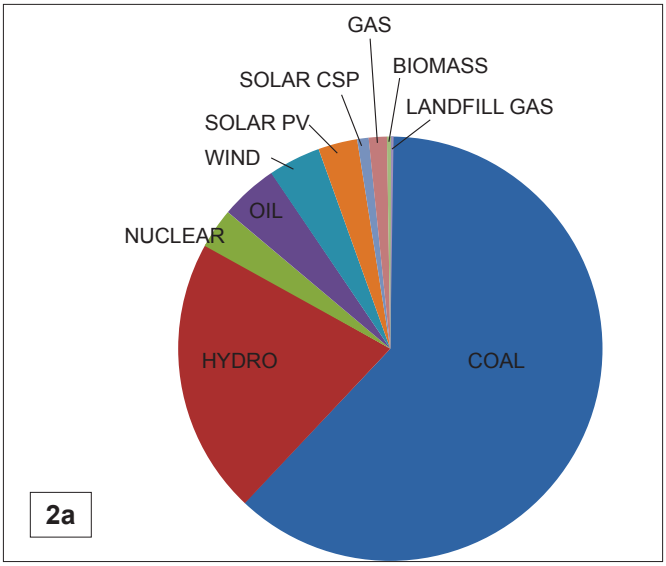


Figure 1: Electricity access in SADC Member States

Sources: IEA (2016).[7]



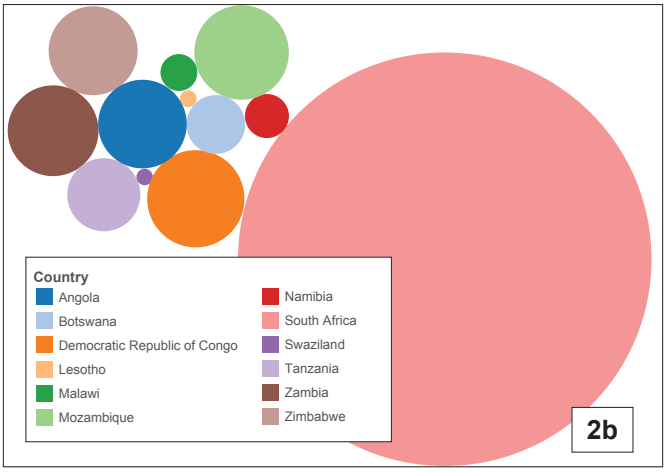


Figure 2: a. SAPP installed capacity by MW, b. SAPP installed capacity by country Source: SAPP (2015), p.36.

electricity through the national grid is important – especially as regional interconnection increases stability and security – but achieving a larger, diverse, secure and low-carbon energy sector requires a variety of solutions.

This is where mini-grids can play a key role. Mini-grids involve small-scale power generation (as little as 10kW or as much as 10MW) and a distribution grid that can provide national grid-quality service to a limited number of customers in a concentrated area, without having to connect to the national grid.[13] "Micro-grids" are similar, but on a smaller scale, with as little as 1–10 kW of generation capacity.

Mini- and micro-grids can be a valuable complement to grid-based electrification, particularly in areas where grid extension is technically or financially unviable. The International Energy Agency (IEA) has estimated that nearly 60% of the additional generation required to achieve universal access to electricity in Africa will need to come from off-grid solutions.[14] Of the roughly 315 million rural Africans that the IEA envisions gaining electricity access by 2040, about 80 million would use off-grid systems, and 140 million would be served by mini-grids.[15]

For Southern Africa, IRENA's preliminary analysis indicates that 59% of rural electricity demand would be met through decentralized generation by 2030. Mini-hydro and solar rooftop systems using batteries would meet half of rural demand, with the rest coming from the grid.[16]

Decentralized electricity solutions in SADC today

SADC countries, particularly those with low rural electrification rates, are increasingly promoting renewable energy-based mini-grids as an alternative to grid extension in sparsely populated rural areas that will not be connected to national electricity grids in the short to medium term.[17] Each country uses a different set of energy resources and business models, but in nearly all countries, penetration of these solutions in the total energy mix remains low.

Existing mini-grids systems are powered by a range of energy sources:[18]

Mini- and micro-hydropower plants: All SADC Member States, except Botswana, have significant hydropower potential. Although most existing and planned hydropower projects are mainly large and medium-scale, mini- and micro-hydro-based mini-grids already exist in most countries. There is also a growing interest in developing mini-hydro plants and rehabilitating small older dams.[19] Several countries, including Angola, the Democratic Republic of the Congo (DRC), Tanzania, Zambia, Zimbabwe and Mozambique, have identified potential mini-hydro sites and started implementing a number of planned mini- and micro-hydro projects.

Solar mini-grid systems: Off-grid rural electrification programmes in the region have mainly been based on solar power. Solar photovoltaic (PV) mini-grids have been or are being established in rural communities in all SADC countries. South Africa has invested primarily in large-scale solar projects, while the DRC has underutilized its solar power potential.[20]

Wind and solar-wind hybrid mini-grids: Countries with wind energy potential, such as Namibia, Malawi, South Africa, Madagascar and Mozambique, have piloted decentralized wind and wind-solar hybrid systems, which are generally used for power generation and water pumping for farms. Mauritius currently has a 1.28 MW wind mini-grid on Rodrigues Island and is constructing a 9 MW grid-connected facility at Plaine des Roches. Seychelles has a 6 MW grid-connected wind farm supplying around 2.2% of the country's power needs.

Biomass and biomass-solar PV-diesel mini-grids: A number of small-scale biomass power generation projects have been implemented in South Africa, Tanzania, Zimbabwe, Zambia, Mauritius and Mozambique, among others. Mostly,

The 750 kW Zengamina run-of-river mini-hydro scheme, in North West Province, Zambia, is a privately developed community initiative that serves a hospital, several schools, small businesses and households, about 550 customers in total, who are more than 100 km away from the national grid.

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Working with development partners, Zambia built a 60 kW solar PV mini-grid in Mpanta, providing power to a rural area not served by the national grid.

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A local resident poses with the electrical devices she can use thanks to the Mpanta mini-grid.

in these countries, sugar companies and timber companies use bagasse or wood fuels to generate power for their own needs; they may also sell excess power to the national grid (e.g. in Zimbabwe, Tanzania and Mauritius). Tanzania is developing four biomass-solar PV-diesel hybrid mini-grids in Malolo, in the Morogoro region in the southern highlands.

Diesel, diesel-solar hybrid and natural gas mini-grids: In almost all SADC countries, diesel mini-grids have existed for decades in rural areas, providing electricity to isolated communities. These diesel-based systems are progressively being replaced by renewable energy or diesel-solar PV hybrid systems in Mozambique, Malawi, Tanzania, the DRC, Namibia, Botswana and Zambia, in order to reduce fuel costs and the pollution associated with diesel. In addition, grid-connected and off-grid diesel mini-grids are used in urban and peri-urban areas (e.g. in Angola, Seychelles) for baseload power, peak supply and emergency generation.[21] Tanzania also has an isolated mini-grid powered by natural gas, the 7.5 MW Somanga Fungu Plant.[22]

Typical business models

The business model for mini-grids – the way they are designed, financed and operated – can vary widely, particular with regard to financing and operation. For example, investment may come in the form of donor grants or concessional loans, government budget allocations or private debt and equity. In general, the management of mini-grids typically falls into one of the following four categories:[23]

- *Utility operator:* a government or parastatal utility manages all aspects of mini-grid;
- *Private operator:* a private company manages all aspects, in a regulated or non-regulated environment;
- *Community operator:* community members organize to manage generation and distribution in a regulated environment, with support and/or coordination from an NGO or a private company;
- *Hybrid operator:* private actors generate, and a utility distributes the electricity, or the reverse; or a private entity commercializes electricity generated by and distributed through public assets.

In the SADC region, the development of mini-grids typically falls under national rural electrification programmes implemented by rural electrification agencies or state-owned utilities. They are generally co-funded by governments (by special tariff levies through rural electrification agencies or national utilities) and development partners, although the private sector is increasingly supporting the implementation of renewable energy mini-grids.

Mini-grid systems in SADC countries are owned and operated by a range of different actors: rural electrification agencies, state-owned utilities, private independent power producers, faith-based organizations, and municipalities (particularly in South Africa). A number of donor-funded mini-grids have been implemented by NGOs (e.g. Oxfam, Practical Action, World Vision). Once operational, they are left to be managed and operated by rural communities.[24] Diesel-powered mini-grids are owned funded and operated by power utilities or renewable energy agencies, independent power producers, and communities (e.g. in Mozambique).

The most successful mini-grids have tended to pursue the anchor-business-community (A-B-C) approach, widely used in the telecommunications industry. In this approach, the mini-grid prioritizes the supply of power to an “an-

Table 1: Installed capacity of mini-grid systems in SADC Member States, 2014

Country	Installed capacity (operational and under development) of mini-grid systems (MW)										Total	% of total installed capacity (MW)
	Biomass & Biomass-solar PV-diesel hybrid	Natural gas	Diesel	Diesel-solar Hybrid	Mini-hydro (1-9 MW)	Micro-hydro (100-999 KW)	Pico-hydro (< 100 KW)	Solar PV	Wind	Solar-wind hybrid		
Angola	-	-	139	-	21.3	-	-	0.051-0.085	0	0	160.35-160.38	6.8
Botswana	-	0	-	0.05	0	0	0	1.3	0	0	1.35	0.2
DRC	-	0	39	-	-	-	-	0.09	0	0	39.09	1.6
Lesotho	-	0	-	-	0	0.72	0	0.065	0	0	0.785	1.0
Madagascar	-	0	-	-	10	1	1	3	0.157	-	15.157	2.3
Malawi	-	0	1.05	-	5.9	0	0	1	-	0.02-0.024	7.97	2.2
Mauritius	-	0	-	1.2	19	0	0	18	1.28 [i]	-	39.48	5.1
Mozambique	-	0	-	-	1.85	0.428	0.1	1.2 [ii]	0.3	0.001	3.88	0.1
Namibia	-	0	1.1	0.23	0	0	0	4.5	0.29	-	6.12	1.2
Seychelles	0	0	84	-	0	0	0	0.92	6	0	90.92	100.0
South Africa	4.4	-	-	-	195.3	1.88	0.05	-	-	-	201.63	0.4
Swaziland	-	0	-	-	7.7	0	0	0.12	0	0	7.7	9.9
Tanzania	11.5 [iii]	7.5	53	-	15	2	0.01	11 [iv]	0	0	99.81	6.7
Zambia	3	0	11.3	0	25.5	0	0	2	0	0	38.8	1.7
Zimbabwe	0.5	0	-	-	6.1	0.34	0.01	5	0	0	11.95	0.6

Data sources: REN21 (2015); SAPP (2015).[26]
Notes: An entry of " - " means data on installed capacity are not available. Mini-grids under development are cited in footnotes.
i Mauritius is constructing a grid-connected 9 MW facility at Plaine des Roches (REN21 2015, p.40).
ii FUNAE is currently constructing 400–500 kW off-grid solar PV plants in Mavago, Mecula, Muembe in Niassa province. With these projects, the total capacity of PV systems installed by FUNAE since 2000 will reach 2,250 kW.
iii Four biomass/solar PV/diesel hybrid mini-grids with a combined generation capacity of 300 kW are being developed in Malolo, in the Morogoro region in the southern highlands.
iv Rex Energy is also developing a 2 MW hybrid solar photovoltaic (PV) mini-grid in Lake Victoria Islands.

chor" consumer – such as a large business – that provides steady, predictable demand and reliable revenue. Surplus power is then provided to small local businesses or institutions with medium energy demand, and lastly to rural households, whose demand and ability to pay are typically less consistent.[25]

There have been many instances in the SADC region in which this approach has not been pursued, however. The result has been that the mini-grids cannot always be sustained once donor and government support has been withdrawn.

Penetration in the total energy mix

Although mini-grid development in the SADC region has increased, their contribution to total national installed capacity is still minimal (with the exception of Seychelles, whose islands are all considered to be powered by mini-grids). Table 1 provides an overview of types of mini-grid systems that are operating or actively under development in the SADC region. It includes their indicative installed capacity, as well as their share of the total installed capacity in 2014.

The table does not take into consideration planned mini-grids projects. However, it is important to note that the indicated installed capacity of mini-grids is based on the limited available information extracted from literature on mini-grid solutions and does not reflect the actual installed capacity on the ground. Furthermore, for some technologies, there are scarce data on the number of mini-grids and their capacity.

Policy framework for mini-grid development in SADC

Scaling up renewable energy mini-grids and standalone solutions requires significant policy support. Yet two main barriers to achieving this exist: existing policy frameworks are generally vague, with no specific targets or support mechanisms for mini-grids; and policy implementation is limited to or biased towards grid-based electrification.

A varied policy mix

Typically, the policy environment for mini-grids falls under a variety of policies and targets for countries' energy systems, renewable energy, and rural electrification (see Table 2).

All SADC countries have general energy policies, promoting access to electricity both through grid extensions and on- and off-grid renewable energy technologies; a few set explicit universal access targets (Botswana, Lesotho, Seychelles, Swaziland and Zimbabwe).[27] More targeted renewable energy policies are scarce: out of 15 SADC Member States, only South Africa has a renewable energy policy with specific targets for both small- and large-scale applications. Angola, Tanzania, Mauritius and Zimbabwe are currently developing theirs.

Most SADC countries also have rural electrification master plans and/or strategies to guide the implementation of rural electrification projects through grid extension and off-grid electrification. A number even include specific rural elec-

Table 2: Policies guiding development of mini-grid systems

		Angola	Botswana	DRC	Lesotho	Madagascar	Malawi	Mauritius	Mozambique	Namibia	Seychelles	South Africa	Swaziland	Tanzania	Zambia	Zimbabwe
Energy	Policy	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Universal access targets		■		■						■		■			■
Renewable Energy	Policy											■				
	Targets											■				
Rural electrification	Strategy	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Targets	■	■	■		■	■		■	■		■		■	■	■
Mini-grids	Policy													■		
	Targets															

Source:Based on review of national policy documents.[31]

trification targets (Angola, Botswana, DRC, Madagascar, Mozambique, Namibia, Malawi, South Africa, Tanzania, Zambia and Zimbabwe).

Decentralized solutions have received more specific policy support in Tanzania. Through its 2009 Small Power Producers Framework, the country has developed an advanced policy and regulatory framework for the promotion of on- and off-grid renewable energy-based mini-grids. As part of that effort, a standardized power purchase agreement and a specific tariff methodology have been developed for small power producers (100 kW to 10 MW).[28]

At the regional scale, the SADC developed the SADC Regional Energy Access Strategy and Action Plan (REASAP) in 2010, setting broad goals for improving access to modern energy sources. The REASAP provides a detailed discussion of grid-based and off-grid approaches that SADC countries can draw upon to formulate strategies to enhance access to modern energy, focusing on renewable energy-based mini-grids and off-grid solutions as alternatives to grid extension.[29] In addition, the SADC Renewable Energy and Energy Efficiency Strategy and Action Plan 2016–2030 was approved in October 2016.[30]

Selective/biased policy implementation

Despite at least somewhat supportive policies and growing interest in the region, the deployment of renewable energy mini-grids remains slow, as shown in Table 1. The real challenge lies in policy implementation, which is often skewed towards grid extension, with decentralized solutions to electrification only being introduced more recently.[32]

Investments in power generation infrastructure have typically been channelled to large-scale projects that will be integrated into the SAPP. Off-grid solutions, on the other hand, are often seen by policy-makers and users as temporary pre-electrification solutions.[33] Existing renewable energy mini-grid solutions are also typically subsidized by governments or donors, given that financial constraints, such as customers' low ability to pay, often hamper wider deployment. The relatively small size of the off-grid market and low income of end-users in rural areas tend to make them unattractive to private investors.[34]

Where policy support exists, it has not always translated into the development of appropriate financing mechanisms for decentralized solutions, or in improvements to the complex administrative procedures related to project implementation (e.g. concessions, environmental impact assessments, licensing, tariff-setting, etc.). As a result, most mini-grids are still considered as "pilots", driven by governments, donors and technology developers rather than by market demand. As a result, most existing projects have limited potential to be replicated or scaled up.[35]

Looking ahead

Mini-grids in the SADC region vary widely in terms of their size, the technologies used, their share of total generating capacity, who owns them, and the investment and operator models involved. Given this diversity, it is clear there is no one-size-fits-all approach to ensuring successful implementation.

Yet, given the important contribution that renewable energy mini-grids can make to increasing access to modern energy services, there is an acute need to explore further approaches that enable scaling-up beyond pilot projects. The challenge is then how to overcome the key issue of financial sustainability of mini-grids in rural areas and develop sustainable and replicable business models that are appropriate to the technology used and adapted to local context.

We recommend keeping in mind the following key issues when designing programmes to support the deployment and scaling-up of renewable energy mini-grids:

To build investor confidence, countries need to develop policy and regulatory frameworks that shows a clear commitment to catalysing private investment in mini-grids, ensuring stability, providing support mechanisms, and improving the ease of doing business.

The financial sustainability of mini-grid projects depends upon a strong, reliable anchor consumer, although sole reliance on a single consumer should be avoided.

Mini-grid systems must be designed based upon a strong understanding of the local social, economic and cultural context; otherwise they may not be fit for purpose.

Endnotes

1 There are 15 SADC member states: Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

2 This is the average across Africa; growth has slowed somewhat in the past two years, to 3.7% in 2014 and 3.6% in 2015. See AfDB, OECD and UNDP (2016). *African Economic Outlook 2016: Sustainable Cities and Structural Transformation*. African Development Bank, Development Centre of the Organisation for Economic Co-operation and Development, United Nations Development Programme, and United Nations Economic Commission for Africa. http://dx.doi.org/10.1787/aeo-2016-en.

3 SAPP (2015). *Southern Africa Power Pool Annual Report 2015*. Southern African Power Pool, Harare, Zimbabwe. http://www.sapp.co.zw/docs/SAPP%20Annual%20Report-2015.pdf.

4 Zhou, P. P. (2012). *Regional Infrastructure Development Master Plan: Energy Sector Plan*. Prepared for the Southern African Development Community Secretariat, Gaborone, Botswana. http://www.sadc.int/files/5413/5293/3528/Regional_Infrastructure_Development_Master_Plan_Energy_Sector_Plan.pdf.

5 AfDB, OECD and UNDP (2016). *African Economic Outlook 2016*. p.219.

6 REN21, UNIDO and SADC (2015). *SADC Renewable Energy and Energy Efficiency Status Report*. REN21, United Nations Industrial Development Organization and Southern Africa Development Community. http://www.ren21.net/wp-content/uploads/2015/10/REN21_SADC_Report_web.pdf.

Notably, the SADC's own estimates of electricity access are much lower: just 24%, with some SADC countries said to have below 5% rural access to electricity. Lack of explicit definitions makes it difficult to reconcile this difference, but the lower number could denote a more limited definition, such as only connections to grid-based electricity. See the SADC website, http://www.sadc.int/themes/infrastructure/en/, as well as Zhou (2012), *Regional Infrastructure Development Master Plan: Energy Sector Plan* (p.6).

7 The data used here are the latest available from the International Energy Agency's Energy Access Database, for 2014: http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/ [accessed 5 December 2016].

8 SAPP (2015). *Southern Africa Power Pool Annual Report 2015*.

9 Kunambura, A. (2015). SADC in energy crisis. *The Financial Gazette*, 18 June. http://www.financialgazette.co.zw/sadc-in-energy-crisis/.

10 Cohen, B. and Winkler, H. (2014). Greenhouse gas emissions from shale gas and coal for electricity generation in South Africa. South African Journal of Science, 110(3–4). Art. #2013-0194. http://www.scielo.org.za/pdf/sajs/v110n3-4/10.pdf.

11 See SAPP (2015), *Southern Africa Power Pool Annual Report 2015*, and Zhou. (2012), Regional Infrastructure Development Master Plan: Energy Sector Plan.

12 IRENA (2013). *Southern African Power Pool: Planning and Prospects for Renewable Energy*. International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/DocumentDownloads/Publications/SAPP.pdf.

13 Franz, M., Peterschmidt, N., Rohrer, M. and Kondev, B. (2014). *Mini-Grid Policy Toolkit: Policy and Business Frameworks for Successful Mini-Grid Roll-Outs*. Africa-EU Renewable Energy Cooperation Programme, Eschborn, Germany. http://www.ren21.net/Portals/0/documents/Resources/MGT/MinigridPolicyToolkit_Sep2014_EN.pdf.

14 IEA (2010). *Energy Poverty: How to Make Modern Energy Access Universal?* Special early excerpt of the *World Energy Outlook 2010* for the UN General Assembly on the Millennium Development Goals. International Energy Agency, Paris. http://www.un-energy.org/publications/618-energy-poverty-how-to-make-modern-energy-access-universal.

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16 IRENA (2013). *Southern African Power Pool: Planning and Prospects for Renewable Energy*. International Renewable Energy Agency, Abu Dhabi, United Arab Emirates. https://www.irena.org/DocumentDownloads/Publications/SAPP.pdf.

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17 REN21 et al. (2015). *SADC Renewable Energy and Energy Efficiency Status Report*.

18 Unless otherwise noted, data and examples presented here are drawn from REN21 et al. (2015), *SADC Renewable Energy and Energy Efficiency Status Report*.

19 REN21 et al. (2015) uses four classifications for hydropower plant size that has been adopted in this study: macro (> 10 MW); mini (1–9 MW); micro (100–999 KW); and pico (<100 kW).

20 For instance, the 96 MW Jasper project in the Northern Cape of South Africa, commissioned in 2014, is SADC's largest single solar PV project.

21 ECA and Practical Action (2013). *Supportive Framework Conditions for Mini-Grids Employing Renewable and Hybrid Generation in the SADC Region: Inception Phase Report*. Regional Electricity Regulators' Association of Southern Africa (RERA) and European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF). http://www.euei-pdf.org/sites/default/files/files/field_pblctn_file/SADC%20RERA_Inception%20Phase%20Report.pdf.

Ministry of Energy and Water and UNDP (2015). *Rapid Assessment and Gap Analysis: Angola*. Sustainable Energy for All. Ministry of Energy and Water, Republic of Angola, and United Nations Development Programme. http://www.se4all.org/sites/default/files/Angola_RAGA_EN_Rel.pdf.

22 See http://www.tanesco.co.tz/index.php?option=com_content&view=article&id=85&Itemid=241.

23 See Franz et al. (2014), *Mini-Grid Policy Toolkit*.

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Solar panels power a telephone shop in Qunu, in the Eastern Cape, South Africa. Renewables have played a key role in bringing modern technologies to Qunu, Nelson Mandela's home village.

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