PIONEERING POWER

Transforming lives through off-grid renewable electricity in Africa and Asia

COUNTRY REPORTS

ODI

tearfund

PIONEERING POWER

Transforming lives through off-grid renewable electricity in Africa and Asia

COUNTRY REPORTS

Authors: Leah Worrall and Andrew Scott, Overseas Development Institute (ODI)

Acknowledgements

The authors would like to thank the extensive project leadership and guidance provided by Jo Khinmaung-Moore (Tearfund) and Julia Kendal (Tearfund). In-country experts provided extensive support through interviews and written feedback on the report. The authors would also like to thank the list of reviewers, including Selbol Lannap at Bols and Sels Nigeria Limited, Ify Malo and Chibuikem Agbaegbu at Power for All Nigeria, Sixbert Mwanga at Climate Action Network Tanzania, Mary Swai at Tanzania Traditional Energy Development Organisation (TaTEDO), and Joel Wengamulay at Virunga Energy.

Thank you also to Tearfund's partner organisations for their input: David Allan at Spectrum, Peter Lockwood at United Mission to Nepal, and Jonathan Shaw and Kyle Hamilton at the Congo Initiative.

Particular thanks to those at Tearfund who provided comments, input and advice: Sara Baines, Antony Bushfield, Paul Cook, Douwe Dijkstra, Sarah Edwards, Alison Fernandes, Naomi Foxwood, Tim Ingram, David McAllister, Hannington Muyenje, Ben Niblett, Justin Nyamoga, Ben Osawe, Kit Powney, Steve Prior, Jack Wakefield, Sarah Wiggins and Sue Willsher.

Cover design: Wingfinger

Cover photos (from clockwise left): Kit Powney/Tearfund, Matthew Joseph/Tearfund, Kit Powney/Tearfund, Andrew Philip/Tearfund

Tearfund

100 Church Road, Teddington, TW11 8QE, United Kingdom
T +44 (0)20 3906 3906 **E** publications@tearfund.org

Tearfund is a Christian relief and development agency building a global network of local churches to help eradicate poverty.

For further information, email: policy@tearfund.org

A shorter policy report, based on the research in this country report, can be found online, along with other Tearfund publications on climate and energy: tearfund.org/climate_energy

Overseas Development Institute

The Overseas Development Institute (ODI) is the UK's leading independent think tank on international development and humanitarian issues. Our mission is to inspire and inform policy and practice which lead to the reduction of poverty, the alleviation of suffering and the achievement of sustainable livelihoods in developing countries. We do this by locking together high-quality applied research, practical policy advice, and policy-focused dissemination and debate. We work with partners in the public and private sectors, in both developing and developed countries.

Overseas Development Institute, 203 Blackfriars Road, London, England, United Kingdom SE1 8NJ
T +44 (0)20 7922 0300 www.odi.org

Terminology

We use the term 'off-grid systems' as a collective term to refer to stand-alone systems and also to mini-grids that are not connected to a larger centralised grid.

'Stand-alone systems' refer to electrification systems for individual appliances/users that are not connected to any grid outside of the individual user premises.

'Mini-grids' to refer to small grid systems linking a number of users who are not connected to a larger main power grid.

‘ENERGY IS THE GOLDEN THREAD THAT CONNECTS ALL THE SUSTAINABLE DEVELOPMENT GOALS...THAT MEANS TRANSFORMING THE WORLD’S ENERGY SYSTEMS. IT MEANS PROMOTING MODERN TECHNOLOGIES THAT CAN FULFIL ENERGY NEEDS WITHOUT POLLUTING THE ENVIRONMENT AND PUMPING GREENHOUSE GASES INTO THE ATMOSPHERE.’

António Guterres, Secretary-General of the United Nations

‘IT IS TIME FOR DECISION-MAKERS TO FULLY EMBRACE THE TRANSFORMATIVE POWER OF DECENTRALISED SOLUTIONS – ROOFTOP SOLAR AND RENEWABLE MINI-GRIDS IN PARTICULAR –TO IMPROVE THE DELIVERY OF EDUCATION, HEALTH CARE, CLEAN WATER, IRRIGATION AND THE MANY OTHER BENEFITS.’

Adnan Amin, the Director-General of the International Renewable Energy Agency

‘WE ARE IN A RACE AGAINST TIME TO REACH OUR 2030 ENERGY GOALS AND TO GET THERE WE WILL NEED A LOT OF INVESTMENT AND A LOT OF MONEY – BOTH PRIVATE AND PUBLIC.’

Riccardo Puliti, Senior Director and Head of energy and extractives at the World Bank

Contents

List of Figures

List of Tables

1. INTRODUCTION

The *2030 Agenda for Sustainable Development* includes the goal to 'ensure access to affordable, reliable, sustainable and modern energy for all' by 2030 (SDG 7). The International Energy Agency (IEA) estimates that 1 in 7 (15 per cent) of the global population – 1.1 billion people – lacked access to electricity in 2016. This energy poverty[1] is increasingly localised in the remote, rural regions of the world. The vast majority of the world's energy-poor people reside in Africa and Asia and, by 2030, 89 per cent of the world's energy-poor people will reside in sub-Saharan Africa alone. Under business as usual conditions, 674 million people will remain without access by 2030.[2]

Since 2000, the year the Millennium Development Goals were agreed, energy access has primarily been delivered through grid connections and fossil fuelled power.[3] Developing countries in Africa and Asia are now looking for cost-effective solutions to achieve national electricity access targets. As countries continue to focus on grid connections, providing connections to increasingly remote energy-poor populations becomes more cost-prohibitive – and it also takes longer to extend the grid to remote regions. Hence energy poor households are less likely to be connected to the central grid in the short-term.

Developing country government and non-government energy actors in Africa and Asia should look towards decentralised[4] and renewable energy[5] technologies to improve electricity access[6] and ensure value for money. Renewable energy sources are increasingly cost-competitive compared with fossil fuels at the global level. Energy-poor households that currently depend on traditional energy solutions (eg kerosene and charcoal) to deliver light and heating can achieve energy expenditure savings through investments in off-grid renewable electricity solutions, such as solar lamps.

Tearfund commissioned ODI to conduct a literature review on the impact and value for money of off-grid renewable electricity for poverty reduction and economic development. The study focuses on three main questions:

- What is the value for money of investing in off-grid renewable electricity for people living in poverty in sub-Saharan Africa and Asia?
- What is the impact of off-grid renewable electricity solutions on poverty reduction, economic development and the environment?
- How does the value for money and impact compare with that of energy powered by fossil fuels?

This report provides an overview of the status of electricity in five countries: the Democratic Republic of the Congo (DRC), Myanmar, Nepal, Nigeria and Tanzania. It presents evidence on the cost-effectiveness of decentralised renewable electricity, compared to the status quo of fossil fuel electricity access. This is followed by evidence on the benefits of decentralised renewable electricity access as an enabler for poverty reduction, economic development, climate change mitigation and contributions to the Sustainable Development Goals (SDGs). It highlights, in particular, the linkages between SDG 7 (energy access) and SDG 3 (healthy lives), SDG 4 (equitable and inclusive education), SDG 5 (gender equality), SDG 8 (economic growth, employment and decent work) and SDG 13

1 Defined as the lack of access to modern energy services (i.e. electricity and clean cooking fuels and technologies).

2 International Energy Agency (IEA) (2017) Energy Access Outlook 2017: From Poverty to Prosperity. Paris: International Energy Agency.

3 IEA (2017) Op. cit.

4 Defined as electricity that is generated by small generation units, which may be connected to a transmission network or serve individual premises.

5 Defined as energy that is obtained from renewable sources (i.e. sources that can be replenished), such as sunlight, wind and geothermal resources.

6 Defined as the availability of an electricity supply to a household (or business), at any Tier of access (see Multi-Tier Framework, defined in Appendix 2). This may be distinguished from connection to an electricity grid (or mini-grid) by its focus on the actual supply of electricity, and therefore implies that electricity is used by the household.

(tackling climate change). The study also looks at the policy barriers, enablers and opportunities for off-grid renewable electricity in these five countries.

Section 2 presents the key concepts and methodology that underlie descriptions of access to electricity and its effects on broader development objectives. Section 3 presents country evidence for the five countries. Section 4 then concludes and offers recommendations. Appendix 1 provides a glossary of key terms.

> ‘The micro-hydro plant makes a big difference – like the difference between the land and the sky. Before I felt so sad. Nowadays I am happy. Before I had very difficult work. Now it is very easy.’
>
> Hari, 49, who lives close to the village of Chanitar in Nepal

2. METHODOLOGY

Information for the study was drawn from two kinds of sources: literature and key informant interviews. The literature review included publications and grey literature about the impact of access to electricity and decentralised renewable electricity specific to the five selected countries. These sources were supplemented by statistics from the International Energy Agency (IEA) and the World Bank, among others.

The five countries selected for analysis – the Democratic Republic of the Congo, Myanmar, Nepal, Nigeria and Tanzania – were identified by Tearfund. These were identified as of particular interest to Tearfund, which has programmes in these countries, as well as because of the pressing need for energy access for people in remote areas, and the fragile and conflict-affected context of the countries. With the exception of Nepal, these countries are also identified as high-impact countries by the Sustainable Energy for All *Global Tracking Framework 2017*, given the high baseline of energy poverty in these countries.[7] These countries are hence key targets for the development community that are looking to meet SDG 7.

A total of nine key informants were interviewed across the five selected countries about the challenges and opportunities in the country's enabling environment for off-grid renewable electricity. The interviews, conducted over Skype, focused on political economy and fiscal aspects, complementing factual evidence from the literature.

Time and data limitations have prevented a more comprehensive analysis of the development impacts and political economy considerations for decentralised electricity solutions in the five countries. Further research, focused on the enabling environment and political economy analysis, would help identify more specific policy recommendations.

Key concepts

This section outlines the key analytical concepts that underpin descriptions and analysis of the benefits and opportunities of access to decentralised renewable electricity.

1) Tiers of access

This section presents an overview of the tiers of access covered in this study. Appendix 2 provides more detail about the tiers of access of the Multi-Tier Framework.[8]

Solar lamps[9] (also called pico-solar products) are of 0 to 10 watts capacity, enabling access at Tiers 0 and 1. Solar lamps of less than 1.5 watts can power a single light. Above 1.5 watts they can also provide mobile phone charging, and above 3 watts they can power multiple lights. Solar home systems (SHSs)[10] are larger solar products with a capacity of 11 watts to over 100 watts. They can also provide power for radios, fans or televisions, providing access up to Tier 2. Some larger SHS can provide access at Tier 3.[11]

---

7 International Energy Agency and World Bank (2017) Global Tracking Framework 2017. Washington: The World Bank.

8 Defined as the level of access to electricity, as defined by the Multi-Tier Framework in terms of capacity, hours of service and qualitative attributes. There are five tiers of access, from Tier 1, the lowest, to Tier 5, the highest. See Appendix 2.

9 Defined as a single light (lightbulb) powered by a solar photovoltaic cell. Some solar lights also have a socket that enable the recharge of mobile phone batteries.

10 Defined as stand-alone photovoltaic system, comprising a solar panel or array connected to a charge controller, inverter and battery, which can supply appliances as well as multiple lights.

11 GOGLA, Lighting Global, World Bank Group, Berenschot. (2016). Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data: July-December 2016. Utrecht: Global Off-grid Lighting Association.

Mini-grids are described as ‘one or more local generation units supplying electricity to domestic, commercial or institutional consumers over a local distribution grid’, connected by a localised network (though some can be connected to the grid).[12] They include systems ranging in capacity from a few kilowatts to as much as 10 megawatts.[13] Renewable energy mini-grids can be based on biomass and wind, as well as solar and hydropower, but biomass and wind are not considered in detail in this report. Although mini-grids can, in principle, provide access up to Tier 5, most of those connected to mini-grids receive access up to Tier 3.

2) Linkages to SDGs and development impact

Electricity ‘services’ are experienced through what electricity enables people to do, such as lighting, heating, cooling, phone charging and production. The energy services available range from task lighting and phone charging at Tier 1 to the full range of possible energy services at Tier 5. The ‘effect’ of the energy services on individuals and households is through the change in activity that occurs as a direct result of use of such services. Examples include shifts in time use, increases in the number of study hours, reductions in household air pollution, or opportunities for communications, space or food cooling.

The ‘impact’ is a recognition that such changes will influence development opportunities, directly and indirectly. Among these benefits are reduced expenditures for energy services (such as kerosene and mobile phone-charging costs) that can be replaced by direct electricity access; more time available due to electric lights and other appliances; improvements in education, health, and communications; enhanced productivity and income levels; and reduced carbon dioxide (CO_2) and black carbon[14] pollution, which are harmful to health and contribute to climate change.

Table 1 presents some of the direct and indirect linkages between modern energy access and the SDGs. These and the various effects of electricity consumption are shown graphically in Figure 1.

Table 1 Development gains of decentralised renewable energy access

Development gains	Sustainable Development Goals
Energy access	• SDG 7 – universal access to energy • SDG 12 – sustainable consumption and production
Reducing poverty	• SDG 1 – end poverty in all its forms • SDG 10 – reduce inequality • And contributions to SDG 2 (ending hunger) and SDG 3 (healthy lives)
Access to information	• SDG 5b and 9c – enhance the use of enabling technology, in particular information and communication technology, to promote the empowerment of women and access to the internet
Boosting economic development	• SDG 8 – economic growth, employment and decent work • SDG 5 – gender equality and women’s empowerment (reducing care work)
Gender equality	• SDG 5 – gender equality and women’s empowerment (reducing care work)

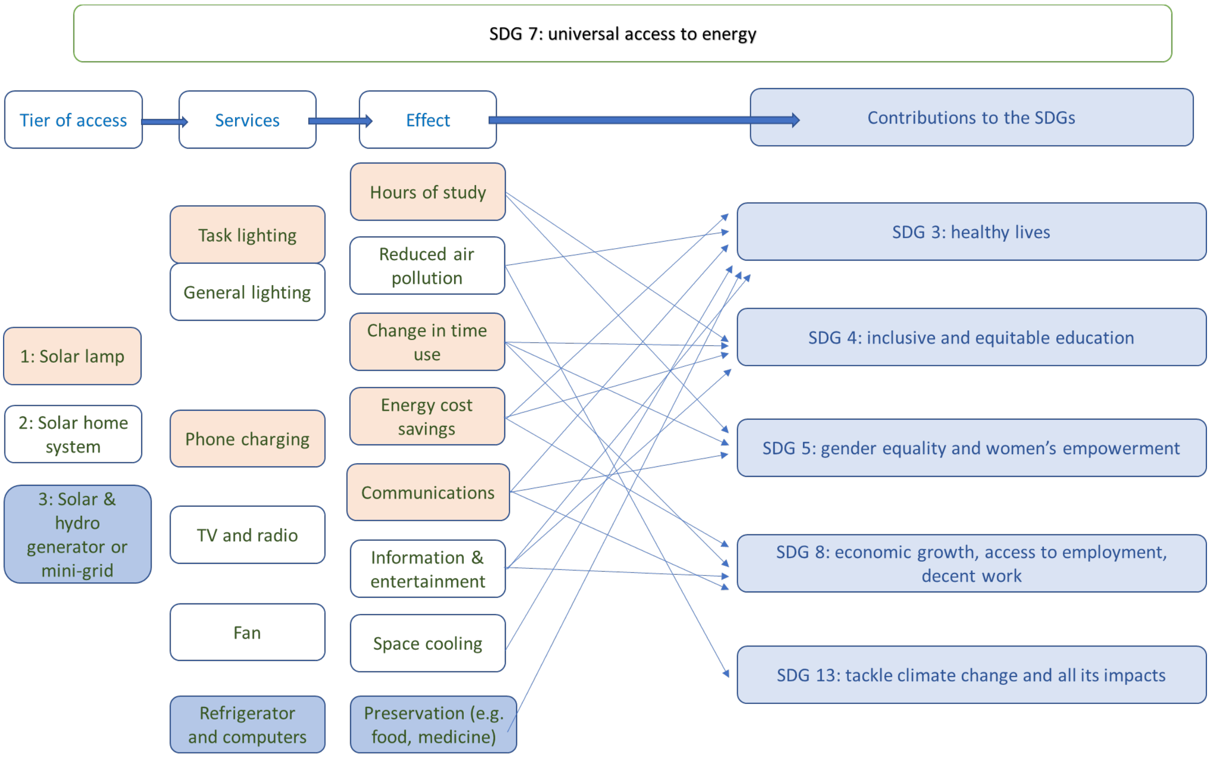
12 Deshmukh, R., Carvallo, J.P. and Gambhir, A. (2013) Sustainable Development of Renewable Energy Mini-grids for Energy Access: A Framework for Policy Design. Clean Energy Ministerial.

13 ESI (2016) Renewable Mini-Grids: Unlocking Africa’s Rural Powerhouse; SEI International (2016) Renewable energy mini-grids: An alternative approach to energy access in southern Africa. Stockholm: Stockholm Environment Institute.

14 Defined as fine soot particulate matter made of pure carbon, which is formed through incomplete combustion of hydrocarbons and biomass. It contributes to global warming by absorbing sunlight and interacting with clouds.

Improving health and education	• SDG 4 – inclusive and equitable education • SDG 10.3 – ensure equal opportunity • SDG 3.9 – substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
Tackling climate change	• SDG 13 – take urgent action to tackle climate change and all its impacts

Figure 1 Conceptual framework of impacts of decentralised access to electricity and select SDG linkages



Source: Author's own
Note: Orange corresponds to Tier 1 of energy access. Tier 2 access includes both orange and white. Tier 3 includes orange, white and blue.

3) Levelised cost of energy[15]

Comparison of the costs of electricity generated from different energy sources needs to take account of the different cost profiles of renewable and fossil fuel power generation. The cost of renewable electricity (eg from solar or hydro) is largely determined by the initial capital cost of the installation or plant, because there are no recurring fuel costs. The cost of electricity generated from coal, oil and gas is determined by the initial capital cost and the cost of fuel to operate the plant. There are also differences in capacity utilisation rates and financing costs to be considered. The levelised cost of energy/electricity (LCOE) is used to overcome these differences when comparing costs.

The LCOE, measured here in terms of dollars per kilowatt hour ($/kWh), is the total cost of generation (capital and operating costs) over the lifetime of the plant (or a defined period) divided by the total number of units of electricity (kWh) generated by the plant during this period. Costs over the lifetime of the plant are usually discounted to reflect the time value of money. The variation

15 Defined as the cost per unit of energy produced (eg kilowatt hours) over the lifetime of the plant, including all fixed capital and operating costs. Costs are discounted to reflect the time value of money.

in costs that occurs between locations means that the LCOE of alternative electricity options should be estimated for each country.

A cost-benefit analysis combines the discounted value of additional benefits from the use of electricity with the discounted costs. Unfortunately, quantitative estimation of the benefits of electricity access is difficult because of a lack of empirical data and the indirect and intangible nature of some of the benefits. In some cases,[16] the consumer surplus is used to estimate the value of benefits, but this also requires survey data about willingness to pay.

The analysis in this report therefore focuses on LCOE to assess the cost-effectiveness of decentralised renewable technologies for electricity access. The benefits of access to electricity are the same for different access options, at least at the same tier of access, so the absence of data about the quantity and value of benefits does not materially alter the assessment.

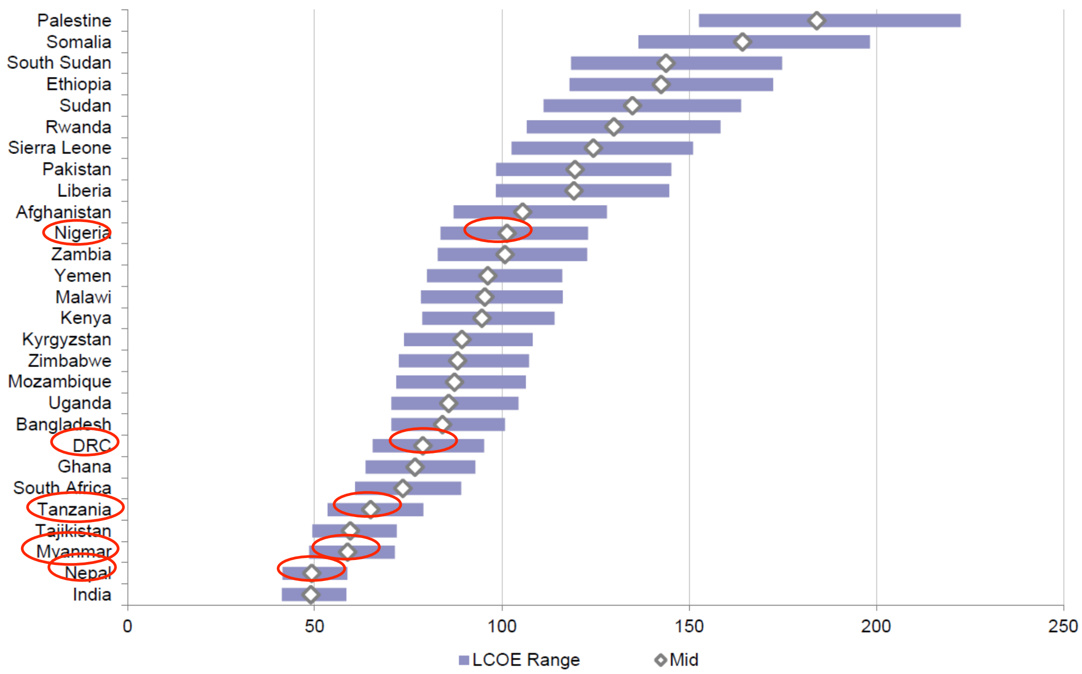
Box 1 provides a comparison of LCOE of small hydro and solar photovoltaic (PV) in the five countries addressed in this study.

Box 1: LCOE comparisons across countries, 2015

Henbest et al. (2015) carried out a levelised cost exercise for 28 DFID countries. It provides a useful study to compare the LCOE of utility-scale hydropower and solar in the five countries of DRC, Nigeria, Tanzania, Myanmar and Nepal.

The findings show that the LCOE of small hydro are smallest for Myanmar and Nepal (see Figure A). In Nepal the LCOE of hydro is the lowest at US $50 per MWh. This is not necessarily surprising given the reliance on hydropower in these countries. The costs are highest in Nigeria, at over $100 per MWh. DRC, whilst also being 99% reliant on hydroelectricity, has the second highest LCOE of small hydro in the country sample.

Figure A: LCOE of small hydro ($ per MWh, nominal[17])



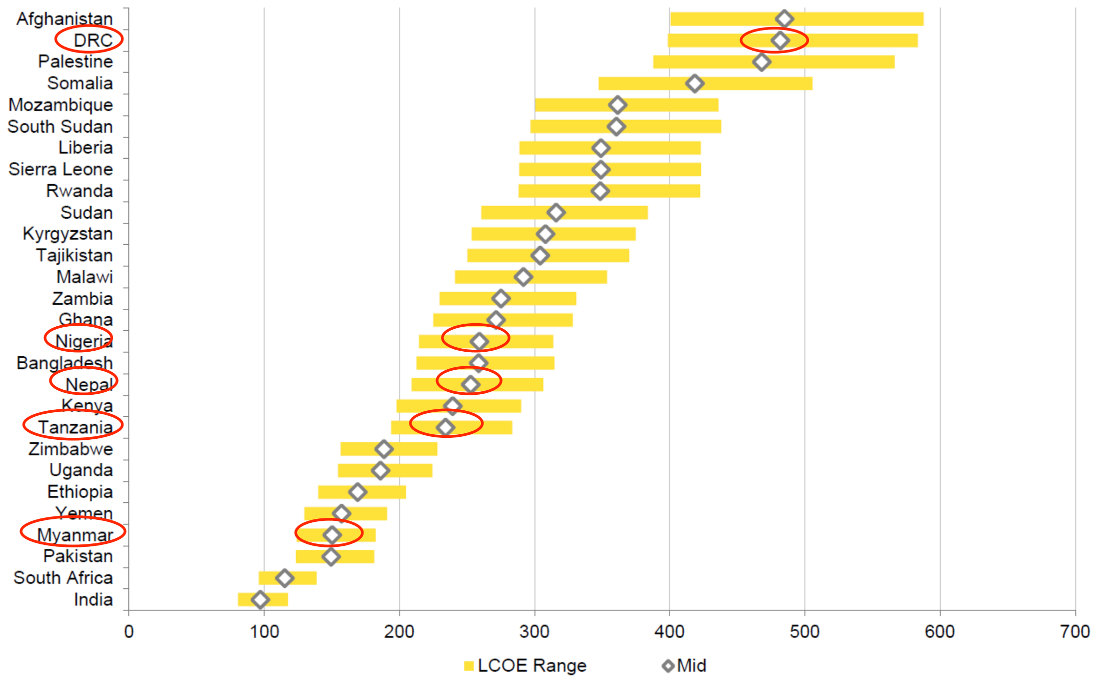
16 Eg Martinez, N., Oliver, P. and Trowbridge, A. (2017) Cost-Benefit Analysis of Off-Grid Solar Investments in East Africa. Washington, DC: United States Agency for International Development.

17 This assumes the rate of return an investor needs to make the investment worthwhile.

Box 1 (Cont.): LCOE comparisons across countries, 2015

The range of the LCOE of solar PV is wider than for small hydro, ranging from an average US $100 – 500 per MWh, compared with $50–200 per MWh, on average. DRC has the highest LCOE per MWh, falling below US $500 per MWh. See Figure B. Myanmar has the cheapest LCOE at lower than $200 per MWh on average. In the other countries – of Nigeria, Nepal and Tanzania – the LCOE occupy a space between $200 and $300 per MWh, on average.

Figure B: LCOE of solar PV (US $ per MWh, nominal)



The study also analyses the LCOE of gas (combined cycle gas turbines) and coal. In the case of gas, the average LCOE in DRC is $100 per MWh, just under $100 per MWh in Tanzania and averaging $90 per MWh in Myanmar (estimates for Nepal and Nigeria are missing). The average LCOE of coal in DRC, Nigeria and Tanzania is estimated at between $100–120 per MWh, $80–100 per MWh in Nepal and just under $80 per MWh in Myanmar. The LCOE of hydropower is lower than these coal and gas estimates in all of these countries, with the exception of Nigeria (where the LCOE of hydropower falls in the same range).

Source: Henbest et al. (2015)

3. THE OPPORTUNITY FOR DECENTRALISED RENEWABLES IN SELECT COUNTRIES

This section provides an overview of the status and prospects for decentralised renewable electricity (micro-hydro and solar) in five countries – the Democratic Republic of the Congo (DRC), Myanmar, Nepal, Nigeria and Tanzania. The current situation, cost information and key policy issues are summarised for each country, drawing from evidence available in secondary sources and interviews with informants.

3.1 Democratic Republic of the Congo

Current state of play

Only 15 per cent of the population in DRC had access to electricity in 2016.[18] Over 67 million people in DRC are without access, almost the size of the UK population. However, estimates of the level of electrification vary. The Global Tracking Framework (GTF) estimated 42 per cent of DRC's population had access in 2014, in part because the GTF takes more account of off-grid access.[19] The energy poverty figure includes almost everyone living in rural settlements. In rural areas, access to electricity is negligible – less than one per cent of the rural population has access.[20] For those that have an electricity connection, the supply is unreliable.

DRC's electricity system is dominated by large-scale hydroelectricity, which accounted for 99 per cent of the power generated in 2015.[21] Capacity is concentrated at the Inga dam.[22] Most of the installed capacity serves three separate transmission grids: the Inga-Katanga backbone, the North Kivu grid and the South Kivu grid. There are also scattered, independent mini-grids, including towns and villages supplied by private operators, mining companies that serve neighbouring communities, and NGO and faith-based operations.[23] However, only 2.5 per cent of domestic hydropower potential is currently exploited.[24]

Decentralised electricity solutions are not well documented in DRC. Diesel generators are used to overcome a lack of electricity access and unreliable grid electricity services. Over 50 per cent of the power capacity is therefore delivered by diesel generators,[25] which is not reflected in IEA statistics. The Global Off-Grid Lighting Association (GOGLA) reports total sales in DRC of 73,920 off-grid solar products in 2016, and 46,090 in the first half of 2017.[26] A Lighting Africa pilot project distributed 20,000 solar lamps and 5,000 solar home systems in partnership with the Cellule d'Appui Technique à l'Énergie (CATE), the Ministry of Energy and Hydraulic Resources, and local retailers.[27]

Analysis on least cost electrification in DRC suggests that between 45 per cent and 85 per cent of DRC's population would be best served by mini-grids and stand-alone systems.[28] The Scaling Up Renewable Energy and UNDP programmes have noted the key role (mini-grid) hydropower can play

18 IEA. (2017) IEA Energy Access statistics. IEA website.

19 http://gtf.esmap.org/country/congo-dem-rep

20 IEA. (2017) Op. cit. and World Bank. (2017) World development indicators. World Bank statistics website.

21 IEA. (2017) Op. cit. There are minimal contributions from natural gas (0.08%) and oil (0.05%); World Bank. (2017) Op. cit.

22 DRC Ministry of Energy and Hydraulic Resources (MEHR). (2014) DRC Expression of Interest to Participate in SREP.

23 World Bank (2017): DRC Electricity Access & Services Expansion (EASE) Project, Combined Project Information Documents/Integrated Safeguards Data Sheet, PIDISDSA21011.

24 UNDP, MEHR and GEF. (2013) Project document: Promotion of mini- and micro-hydropower plants in DRC.

25 IRENA. (2011) Prospects for the African Power Sector. Paris: IRENA.

26 GOGLA (2017a): Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data, July-December 2016. And: GOGLA (2017b): Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data, January - June 2017, Public Report.

27 Lighting Africa. (2017) Democratic Republic of the Congo. Lighting Africa Website

28 Deshmukh, R., Mileva, A. and Wu, G.C. (2017) Renewable Riches: How Wind and Solar Could Power DRC and South Africa. International Rivers.

in scaling up electricity access in the future.[29] Solar and renewable-diesel hybrid mini-grids also have potential.[30] In 2016, the first mini-grid solar-plus-storage project was developed in Virunga National Park,[31] and Enerdeal signed a contract to develop the largest off-grid solar project in Africa with 1MW of solar capacity and 3MW storage capacity.[32]

Cost-effectiveness of decentralised renewables

Evidence about the cost of electricity in DRC is available primarily for centralised renewable technologies,[33] and there is limited information available on the costs of decentralised renewables. By one analysis, decentralised solar utility-scale projects, with grid connection, have a LCOE of US $0.07 per kWh. This is equivalent to, or slightly lower than, the planned Inga III hydroelectricity mega-project of $0.07-0.08 per kWh.[34] Including transmission infrastructure to the grid, the LCOE of solar could be even more cost-competitive (though data is not readily available).

By 2020, the LCOE of grid-connected hydro ($0.057–0.114 per kWh[35]) could be lower than technologies such as diesel, wind and solar.[36] The only technology that is predicted to be cheaper in 2020 is biomass (Figure 2).[37] By 2030, and accounting for declines in energy technology costs, modelling suggests that hydroelectricity will remain the dominant electricity supply source. However, other renewable energy technologies have not been well represented in the analysis (renewable energy promotion scenario[38]).[39]

29 MEHR. (2014) Op. cit.; UNDP et al. (2013) Op. cit.

30 Deshmukh et al. (2017) Op. cit.

31 Solar-plus-storage schemes use solar PV to generate electricity and batteries to store it. https://www.pv-tech.org/news/democratic-republic-of-congo-gets-its-first-solar-plus-storage-minigrid-wit

32 http://enerdeal.com/enerdeal-signs-one-of-the-largest-fully-off-grid-solar-power-plant-in-africa-with-forrest-group/

33 For example, government plans to develop the Inga III hydro mega-project (40GW) have suffered from delays due to prohibitive costs (US$ 12 billion or more). Source: Deshmukh et al. (2017) Op. cit.; and, USAID. (2017) Conceptual Plan for Enhancing Transmission Infrastructure to Expand Electricity Access in the Democratic Republic of the Congo (DRC). USAID.

34 Deshmukh et al. (2017) Op. cit.

35 Converted from Euros to USD, using the annual average Oanda exchange rate for 2017.

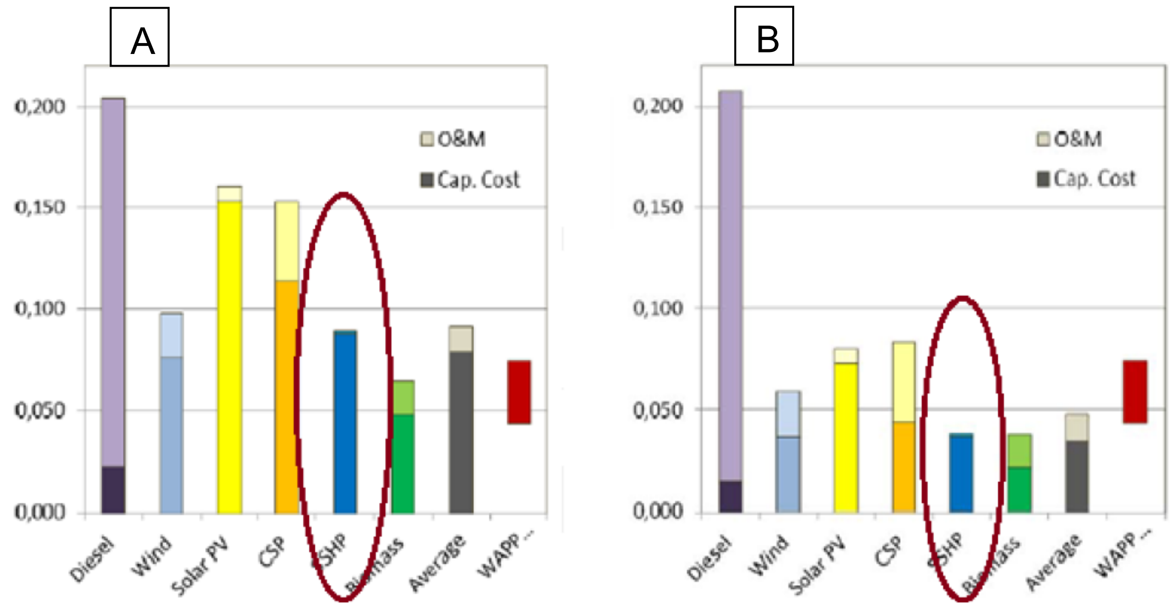
36 Note this is based on a number of cost assumptions.

37 UNDP et al. (2013) Op. cit.

38 The renewable energy promotion scenario increases the role of renewable energy through policy-driven renewable-energy cost reductions and increased fossil fuel prices.

39 IRENA. (2015) AFRICA POWER SECTOR: Planning and Prospects for Renewable Energy. Paris: IRENA.

Figure 2 DRC's LCOE of electricity by technology (€/kWh) in 2020. A: commercial conditions. B: soft loan conditions.



Source: UNDP et al. (2013).
Note: the x-axis demonstrates the *LCOE in Euros* per KWh

In 2014, diesel costs were $1.67 per litre.[40] UNDP et al. report the operational and management costs of hydropower micro-grids are lower than more traditional systems.[41] At smaller tiers of energy access, lamps that are battery- or kerosene-based can cost up to $100 a year per household.[42] This is one-eighth of an individual's income, when compared with DRC's Gross National Income (GNI) of $790 per capita.[43] Over $1 billion is spent on kerosene annually in DRC, equivalent to 25–30 per cent of incomes according to the company NovoMoto.[44] SolarAid found rural customers in Africa can spend as little as $5 on an entry-level solar lamp, depending on the country, though unit costs are increasing with demand.[45] The unit price is equivalent to one-thirteenth of DRC's average monthly income – and would save up to $95 in fuel costs in the first year of use.[46]

Contributions to the SDGs

SDG 3 Healthy lives

The civil war in DRC has destroyed much of the available health infrastructure and associated electricity and road services, resulting in patients travelling long distances to health centres that may be poorly equipped.[47] Decentralised solutions could alleviate this gap. A Lighting Global project is

40 World Bank. (2017) World Development Indicators: Pump price for diesel fuel (US$ per liter). World Bank Website.

41 UNDP et al. (2013) Op. cit.

42 Élan RDC. (2015) Bringing clarity to solar energy in North Kivu. Élan RDC Website.

43 2016 data. Source: World Bank. (2017) World Development Indicators. Washington DC: World Bank.

44 Novo Moto. (2017) The Problem. Novo Moto Website.

45 SolarAid. (2017) SolarAid's costs for delivering solar lights to Africa are going up. Here is why. SolarAid Website. And:
SolarAid. (2017) Kerosene and paraffin lamps in Africa. SolarAid Website.

46 Average monthly income is calculated from the per capita Gross National Income in 2016. Source: World Bank (2017) World Development Indicators. And:
Élan RDC. (2015) Op. Cit.

47 Relief Web. (2013) Boost for healthcare in DRC. Relief Web Website.

deploying 25,000 solar lamps and home systems to social institutions, schools and healthcare centres in DRC, for day-to-day lighting.[48] This would result in the reduced use of kerosene and diesel fuels for energy services, theoretically reducing negative health implications associated with such fuels. Kerosene and diesel fumes can contribute to respiratory illness (such as pneumonitis), burns and household fires, headaches, child poisoning, kidney damage and blood clots, for example.[49]

The same Lighting Global project – known as the Ditunga Project – has encouraged the take-up of radios, which can in turn improve health awareness. In the Lower Congo, the Fundazione Madre Agnese installed 60 watt solar panels, combined with batteries and pumps, for local homes to access clean water.[50] In the Tanganyika region, the Shamwana referral health centre were reliant on 1,000 litres of diesel per month. A solar power system (4kW) developed by Doctors Without Borders aimed to provide night-time lighting, medical equipment and an oxygen concentrator, while eliminating reliance on diesel fuel. The result is that the oxygen concentrator can now run 24 hours a day and is used for patients with respiratory diseases (eg newborn children) and during surgery.[51]

SDG 4 Inclusive and equitable education

More than 90 per cent of primary schools in DRC lack access to electricity.[52] The deployment of decentralised renewable energy systems could improve educational services through lighting and other electricity services. As an example, Bornay's Ditunga Project developed a hybrid wind turbine-solar system with battery storage, providing energy for 28 school rooms. The power enabled the use of lights, computers, printers and copiers, as well as a chicken farm providing food for the students.[53]

CASE STUDY:

The solar-powered university

Solar power has transformed the way students and staff study and work at the Bilingual Christian University of Congo (UCBC) in Beni, DRC. The university was first established in 2007 and now 360 students study there, over half of whom are women. For eight years, the campus relied on a weak diesel-powered generator for electricity. The generator only ran for four hours a day, and cost $1,500 a month to run. This limited the time during which students could use computers and study, and staff could prepare their classes.

In 2015, the university changed this by installing a 35kW solar system to power the campus; three years later, it is still the largest solar installation in the whole of North Kivu region. Solar power has been a game changer throughout the campus. Classrooms, offices and the carpentry workshop can now operate all day. The campus is safer to walk around at night due to solar-powered exterior lights. The university also saves money; after two years, the solar system was paid for and now costs nothing to run.

48 Lighting Africa. (2017) Op. cit.

49 Kerosene and diesel create indoor and outdoor air pollution, and are a major contributor to negative health outcomes that include respiratory illness (such as pneumonitis), burns and household fires, headaches and child poisoning, kidney damage and blood clots. Sources: Acumen. (2017) An Evidence Review: How affordable is off-grid energy access in Africa? London: Acumen.; BNEF, Lighting Global, World Bank Group and Gogla. (2016) OFF-GRID SOLAR MARKET TRENDS REPORT 2016; Eckley, L., Harrison, R., Whelan, G. and Timpson, H. (2014). The social value of solar lights in Africa to replace the use of kerosene: Scoping report. Liverpool: John Moores University, Centre for Public Health.

50 EU EI. (2014) EU EI. (2014) Best Practices for Clean Energy Access in Africa. Africa-EU Partnership Website.

51 Eriksson, P.E. (2017) "Lights off! And on again": Solar energy for a sustainable Shamwana. MSF Website. And: Médecins Sans Frontièrs. (2016) Democratic Republic of Congo: Lights off... and on again! Solar energy for a sustainable Shamwana. MSF Website.

52 Africa Progress Panel. (2017) Op. cit.

53 EU EI. (2014) Op. cit.

SDG 5 Gender equality

Violence against women and girls is unfortunately commonplace in DRC. ActionAid is promoting the role of the National Society of Electricity (SNEL) utility in delivering electricity to neighbourhoods to improve the safety of women and girls from rape and violence.[54] Conflict situations can also reduce the provision of basic services, such as electricity.[55] Access to modern lighting has been shown to contribute to an improved sense of safety and security at night (in other country contexts).[56] Though not a direct focus of this study, the collection of clean water and firewood (for cooking) are another key factor in the prevalence of DRC's gender-based violence.[57] The Fundazione Madre Agnese has shown the potential role of solar panels (with batteries and pumps) for accessing clean water at home.[58] In Mugunga, the Promotion and Support to Women's Initiative shelter has adopted solar energy-run batteries for power and running water using financing from the Global Fund for Women.[59]

SDG 8 Economic empowerment, employment and decent work

The SE4All Africa Hub finds that if 61 million people in DRC were newly connected to electricity services through off-grid and mini-grid solutions, the market would be worth $921 million a year.[60] Under a grid extension scenario, the market would still be equivalent to $67 million a year in 102 non-electrified towns (located too far from the grid).[61] Where DRC's national unemployment rate still stands at 43 per cent, or 73 per cent underemployment in rural areas,[62] mini-grids can also create jobs. For example, certain components of micro-hydro systems can be manufactured and installed using local labour and create employment in some of the poorest regions, which are deprived of modern electricity services.[63]

A key informant interviewed stated diesel fuel is also costlier in DRC compared with other African countries, hence rural businesses and value added activities cannot be regionally competitive. The deployment of decentralised renewable solutions can also enable the use of technologies in the workplace. For example, the first solar-plus-storage mini-grid installed in DRC, in the Virunga National Park, allowed park rangers to run security lights and radios for wildlife conservation work.[64] In Rutshuru and Mugunga, there are small enterprises developing their business thanks to solar power allowing them to refrigerate their products.[65]

SDG 13 Tackling climate change

Wood fuel is a major energy source in DRC. In Africa, between 5 per cent and 20 per cent of deforestation is the result of wood fuel harvested for energy purposes. [66] In DRC, approximately 10,000 square kilometres (km^2) were lost in 2000–2010, [67] and it is estimated that 1,900 km^2 of

54 Action Aid. (2017) International Women day celebrated in LRP Kisenso (Kinshasa). Action Aid Website.

55 ActionAid. (2017b) A hundred young people to challenge normalisation of violence in Kisenso, DRC. ActionAid Website.

56 LeMaire, X. (2016) Op. cit.

57 Bergen, M. (2017) A river lined with smoke: charcoal and forest loss in the Democratic Republic of the Congo. WRI Blog.

58 EU EI. (2014) Op. cit.

59 Global Fund for Women. (2017) Immaculee's Story: Empowering women and girls in the DRC. Global Fund for Women Website.

60 SE4All Africa Hub, AfDB and Sustainable Energy Fund Africa (2017) Mini Grid Market Opportunity Assessment: Democratic Republic of the Congo. SEforALL Africa Hub, African Development Bank.

61 Ibid.

62 IMF. (2015) Democratic Republic of the Congo: Selected Issues. Washington DC: IMF.

63 UNDP et al. (2013) Op. cit.

64 https://www.pv-tech.org/news/democratic-republic-of-congo-gets-its-first-solar-plus-storage-minigrid-wit

65 Key informant interview.

66 Yale (Global Forest Atlas) (2017) Woodfuel in the Congo Forest. Global Forest Atlas Website.

67 Bergen. (2017) Op. cit.

forested land is lost each year, equivalent to 0.08 per cent of the country's total land area. [68] Consequently, forestry and land use change account for most of the country's greenhouse gas emissions. Total emissions in 2014 were 206.7 million tonnes CO_2e, but emissions excluding land use change and forestry totalled 41.2 million tonnes CO_2e. [69] Shifts to modern energy services, electricity and improved cookstoves can help to decrease the pressure on forests, as well as reduce the use of diesel and kerosene.

It is estimated that one kerosene lamp alone emits around 100kg CO_2 a year.[70] UNDP et al. estimated the installation of 10 MW of mini- and micro-grid hydroelectricity installations could decrease DRC's CO_2 emissions by 688,536 tonnes (ie less than 0.5 per cent of total annual emissions).[71] However, reduced black carbon emissions would lead to a mitigation effect five or six times larger.[72]

Political economy of decentralised renewables

A summary of DRC's energy sector governance and major findings are presented in Tables 2 and 3. The World Bank's Regulatory Indicators for Sustainable Energy (RISE) rank the energy access and renewable energy policy environment as average (46 per cent and 34 per cent, respectively).[73] Despite this, implementation is poor. A key informant interviewed commented on the generally low level of access and renewable energy access.

Different stakeholders have different perspectives on the role of decentralised renewables. The primary focus of the government is to develop large-scale hydropower solutions, with electricity exports to other countries (eg South Africa and Burundi).[74] But the government does support a national programme on the deployment of solar lamps and SHS.[75] Meanwhile, the private sector, combined with development finance institutions, is engaging with the decentralised renewable sector. For example, the Special Techniques Company are developing run-of-river hydropower projects. Virunga Energy, in partnership with the CDC Group, are installing hydropower mini-grids along the Virunga Park Rim to promote peripheral economic activity. At lower electricity tiers, private sector companies include Novo Moto with a focus on micro-grids, solar home and business systems, and Go Shop providing household solutions. Mining companies also participate in rural areas, as major energy consumers, in the financing or development of mini-grids.[76]

A key informant interviewed stated that governance gaps persist and are not isolated to the energy sector. The government aimed to privatise the electricity sector under the 2014 Electricity Law, but progress has been slow. For example, the procedures and guidelines to obtain concessions, leases or management contracts have yet to be developed.[77] These are particularly important to enable independent power producers to enter the market, including for decentralised solutions. As a result of poor energy governance, the business climate remains hostile and negatively impacts

68 Kusakana, K. (2016) A Review of Energy in the Democratic Republic of Congo. Research Gate. Calculation based on 2,267,050km2 total land in DRC. The data is from: World Bank (2017) World Development Indicators.

69 WRI CAIT. (2017) CAIT Climate Data Explorer. WRI Website.

70 Actual emissions vary by type of lamp and conditions of use. SEforALL (2017) Why Wait? Seizing the Energy Access Dividend; Mills (2003) Technical and Economic Performance Analysis of Kerosene Lamps and Alternative Approaches to Illumination in Developing Countries. Lawrence Berkeley National Laboratory, University of California.

71 UNDP et al. (2013) Op. cit.

72 SEforALL (2017) Op. cit.

73 ESMAP. (2017) World Bank's Regulatory Indicators for Sustainable Energy (RISE). World Bank Website.

74 Data from 2015 reveals that electricity exports are negligible. Electricity imports however cost $73.6 million and accounted for 1.3% of the country's imports. Source: Observatory of Economic Complexity (OEC). (2015) Democratic Republic of the Congo. OEC Website.

75 Dalberg Advisors, Lighting Global, GOGLA and ESMAP. (2018) Off-grid solar markets trend report 2018. Washington DC: International Finance Corporation.

76 Key informant interview.

77 SE4All Africa Hub. (2017) Op. cit.

investment.[78] Limited institutional capacity is another important factor.[79] This is in part due to the high turnover in the Ministry of Energy and politically-motivated government appointees, who are not necessarily energy sector experts.[80]

DRC remains a country plagued by conflict, poor governance and low levels of accountability. A key informant stated that poor governance persists in particular in the Energy Administration arm of the government. The DRC energy stakeholder also argued that governance failures have a greater impact on grid-connected energy. In comparison, decentralised renewables reduce government capture and the ability to prioritise energy export over domestic provision. The decentralised renewable sector also encourages the entrance of private sector actors, encouraging competition in the fledgling market. From a conflict angle, there remains risk of increased regional instability should enemy groups cut grid transmission lines attached to large-scale hydropower plants. In contrast, it is more difficult to disrupt smaller-scale distributed energy infrastructure.[81]

From a financial perspective, the National Society of Electricity (SNEL) – the previous state-owned electricity utility incumbent – failed to charge electricity prices at sufficiently high rates for the effective supply of electricity. SNEL has also faced a long track record of financial underperformance,[82] and in 2014, SNEL's losses were estimated at $330 million (or one per cent of GDP).[83] The energy sector is hence reliant on external public and private financing.[84] However, increasing electricity service charges could increase rents into the energy sector, and any regressive impacts could be offset by support programmes that target low-income households.

At the fiscal level, there is an exoneration of tax levies on renewable energy products in DRC. Implementation problems persist, however, at the sub-national level. For example, the Ituri province undertook a provincial decision that now enables the taxation of households with solar home systems on a monthly basis, making them less affordable.[85]

78 Key informant interview.

79 SE4All and UNDP. (2013) Pays: République Démocratique du Congo (RDC). Evaluation rapide & Analyse des Gaps. Stratégie nationale SE4ALL-RDC. Sustainable Energy For All.

80 Key informant interview.

81 Ibid.

82 SE4All Africa Hub. (2017) Op. cit.

83 Climate Scope. (2016) DR Congo. Climate Scope Website.

84 SE4All and UNDP. (2013) Op. cit.

85 Key informant interview.

Table 2 Energy sector governance in DRC

Governance	**Generation**	The vertically integrated electricity utility, National Society of Electricity (SNEL), is charged with the production of energy, including from hydro and thermal power plants.
	Transmission	SNEL is responsible for the transport (transmission) of electricity.
	Distribution	SNEL is responsible for the transport (distribution) and sale of electricity. The National Agency for the Electrification of Rural and Peri-Urban Areas was established by law in 2014, but has yet to become operational.
	Regulator	The Electricity Regulation Authority was established by law in 2014, but has yet to become operational.

Source: SE4All et al. (2017); SE4All and UNDP (2013); key informant interview

Table 3 Policy issues and recommendations for DRC

Policy barrier	Challenges and opportunities	Potential policy actions
Policy framework and implementation	Energy access and rural electrification targets exist. The government focus is on on-grid solutions. In particular, large-scale hydropower for export. Poor energy governance, including slow progress to privatise the electricity sector, means that the business climate remains hostile and negatively impacts investment. There is limited institutional capacity, in part due to the high turnover in the Ministry of Energy, and government appointees, who are not necessarily energy sector experts.	Prioritise investment and policies in micro-hydro and solar mini-grids as cost-effective electricity access solutions that can increase energy access in rural areas. This would help to reduce the risks of energy supply being cut off and infrastructure disrupted during conflict and instability. Improve energy governance and policy frameworks to accelerate the privatisation of the electricity sector and to enable independent power producers to enter the market, including in decentralised solutions. Improve governance of the Energy Administration. Increase the institutional capacity of government expertise in energy and improve staff retention.
Access to finance	Off-grid financing facilities are not readily available. Large-scale hydropower projects attract the majority of financing (eg by development banks). But even these projects can struggle to attract financing.	Mobilise access to finance for off-grid actors across the value chain, in cooperation with financial institutions and other funding organisations (eg development banks and Impact Investing Funds).

Fiscal barriers	Tax levies are exonerated for renewable energy projects and products (eg solar lamps, SHS). These are not necessarily implemented at sub-national level: eg provincial taxation of such products can occur.	Apply measures to facilitate the import of solar panels and solar/hydro mini-grid equipment. Ensure effective implementation at the sub-national level by ensuring that national tax levies are adhered to.
Consumer protection and quality assurance	Quality standards exist for stand-alone systems, in the regulatory framework (eg solar lamps, SHS). But informal vendors selling low-quality products have reduced trust in the potential market.	Improve the implementation of quality standards, including through training and awareness-raising.
Level playing field	Available evidence suggests subsidies are not consistently applied to kerosene or diesel at the national level.	Review the application of subsidies for emissions-intensive fuels, including kerosene and diesel.
Consumer awareness	The DRC off-grid market is fledgling. There is growing awareness of solar products in certain regions.	Raise consumer awareness of solar products across all of DRC's regions.
Consumer financing	Pay-as-you-go schemes and long-term leases are made available to consumers. Such solutions are still in their early stages.	Scale up mechanisms for consumer finance by promoting mobile payment mechanisms, as well as enabling micro-finance for long term leases at an affordable interest rate.
Level of local skills	Few local skills in rural areas are built through on-the-job training.	Build a qualified workforce for the off-grid and mini-grid energy sector. Increase domestic value creation by developing relevant training capacity, in particular for the maintenance of decentralised solutions in rural regions.

Source: Various references op. cit. and key informant interviews.

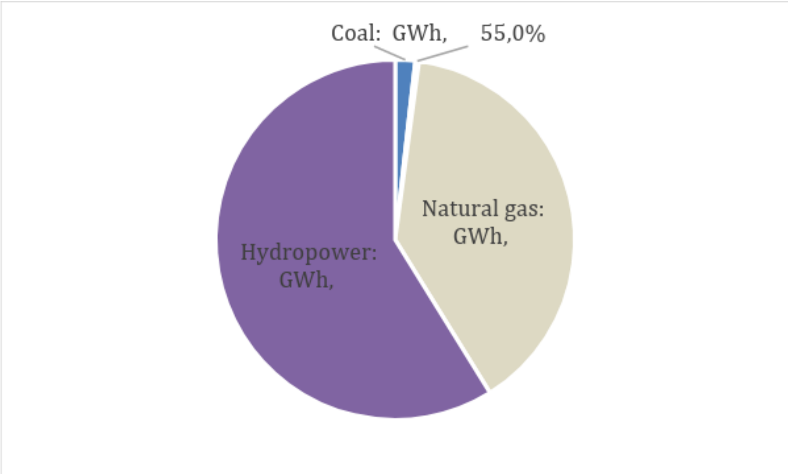
3.2 Myanmar

Current state of play

The IEA estimates that 59 per cent of Myanmar's 53 million people had access to electricity in 2016.[86] In rural areas, the level of access was 43 per cent, compared with 79 per cent in urban areas.

The country has abundant energy resources, including rivers, solar energy, and coal and natural gas reserves.[87] The government has focused on power sector development through the deployment of large-scale hydropower projects. Domestic electricity supply is therefore primarily from hydroelectricity (59 per cent) and natural gas (39 per cent) (see Figure 3).

Figure 3 Myanmar. Electricity supply 2015.



Source: IEA statistics, 2017

In 2016, there was 135 MW of off-grid generation capacity installed in Myanmar,[88] with the majority being diesel generator sets. However, between 2012 and 2017, 26 micro- and nine mini-hydropower projects were developed by the Myanmar Electrical Power Enterprise (of 24 kW–5,000 kW). The national electrification plan envisages investment in mini-grids to serve 344 villages (33,790 households) by 2020/21. In 2016/17 (Table 8), eight mini-grids were installed, serving ten villages. The Asian Development Bank is developing solar PV mini-grids in Mandalay, Magway and Sagaing, and by 2017 had reached 12 villages (10,829 people).[89]

Myanmar's cumulative sales of off-grid solar products reached 2.2 million by 2016, with some negative annual growth over this period.[90] A number of solar PV pilot projects are being developed by the government and other partners, focused on electricity services in remote regions, in particular in schools and technical institutions.[91] In 2016/17, 141,465 households were supplied with SHS under government programmes. This is significantly greater than GOGLA's sales figure for Myanmar in 2016, 24,055 solar units. By 2020/21, approximately 500,000 more households are to be supplied with SHS (Table 4).

86 IEA. (2017) IEA statistics. IEA Website.

87 Dobermann, T. (2016) Energy in Myanmar. London: International Growth Centre. And: Thorncraft, S., Wang., P., Travill, P. and Tham, H.D. (2017) Part B – IES Scenarios |Page 69. In: WWF, REAM, Spectrum and IES. (2017) Myanmar's Electricity Vision: Updating National Master Electrification Plan. World Wildlife Fund.

88 Dobermann, T. (2016) Op. cit.

89 Jung, C.S. (2017) ADB Off-Grid Renewable Energy Demonstration Project in Myanmar. Asian Development Bank.

90 Dalberg Advisors et al. (2018) Op. Cit.

91 Thorncraft et al. (2017) Op. cit.

Table 4 Status of off-grid electrification plan 2016-2021

	Fiscal year	SHS		Mini-grid		Total		Estimated cost (million $)	Remark
		Village	HH	Village	HH	Village	HH		
1	2016/17	2,708	141,465	10	1,081	2,718	142,546	34.910	Complete
2	2017/18	1,199	110,000	34	5,184	1,233	115,184	24.945	On-going
3	2018/19	1,500	133,275	100	11,050	1,600	144,325	50.508	Plan
4	2019/20	1,500	122,950	100	9,095	1,600	132,045	46.355	Plan
5	2020/21	1,500	128,550	100	7,380	1,600	135,930	46.394	Plan
	Total	8,407	636,240	344	33,790	8,751	670,030	203.121	

Source: Zaw (2017)

Cost-effectiveness of decentralised renewables

Grid connections in Myanmar have in the past cost approximately $250 per household, equivalent to double their average monthly income.[92] As those living in energy poverty are increasingly located in remote regions, average grid connection costs can be expected to rise. In 2016, the average household connection cost was $900.[93] The average projected cost of future household grid connections is estimated at $819, compared with the average connection cost of pilot solar mini-grid projects of $357 (under the National Electrification Plan).[94] Another estimate finds grid connection increases to $1,200 for remote households.[95] This creates a strong financial case for the deployment of solar mini-grids to reduce the cost of energy poverty reduction in Myanmar.

Myanmar's National Energy Policy assumes the LCOE of installed on-grid services at $0.13 per kWh and new grid connections at $0.18 per kWh. Renewable mini-grids are cost competitive in this cost range. For example, the ADB Off-Grid Renewable Energy Investment Plan finds pilot solar mini-grids cost $0.20–0.26 per kWh, excluding battery replacement.[96] Technology improvements in distributed solar PV and pico-hydropower have made these technology options cheaper than diesel generators.[97] As demonstrated in Table 5, micro- and mini-hydro is the most cost-competitive, followed by solid biomass gasifiers.[98]

92 Dobermann. (2016) Op. cit.

93 IIED. (2016) Energy poverty in Myanmar: only 34% of the population have grid quality electricity. London: International Institute for Environment and Development.

94 Nexant. (2017) ADB Off-Grid Renewable Energy. Investment Forum, 9 May 2017.

95 Earth Institute and Colombia University. (2014) find ref.

96 Nexant. (2017) Op. cit.

97 BNEF, 2011; in WWF et al. (2017) Op. cit.

98 Dipti. (2017) Mini-Grid Technologies. Powerpoint presentation.

‘It would be expensive to burn enough candles to get the same amount of light as from solar.’

Biak Ku from Ma Kyauk Ar village, Myanmar

The average household in the area spends a quarter of their monthly income on candles.

Table 5 LCOE of decentralised electricity solutions ($ per kWh), in Myanmar

Technology	Micro/mini hydro	Solar-battery	Solar-battery + diesel	Solid biomass gasifier	Wind-battery	Diesel
LCOE ($) per kWh	0.05-0.3	0.4-1.0	0.5-1.0	0.05-0.5*	0.6-1.0	0.6-1.2**

Note: *Includes biomass cost. **Includes fuel price and transport. Source: Dipti (2017)

Contributions to the SDGs

SDG 3 Healthy lives

Myanmar’s maternal and child mortality rates are among the highest in the Asia region.[99] Solar and hydropower electricity can help to power healthcare services, from lighting to refrigerators, particularly in rural regions, while mobile phones can support the provision of pertinent health information. Sunlabob has installed solar mini-grids in 11 villages in Shan and Chin provinces, which are powering mobile phones and TVs,[100] which can be a major source for healthcare information. A social enterprise, Koe Koe Tech, are also using mobile phones to provide information and consultations to pregnant women remotely, as well as delivering medicines.[101] In Yin May Chaung, a community centre recently obtained a solar-powered refrigerator for storing anti-venom for Russell’s vipers that cause 500 deaths every year.[102]

‘Solar is safe because the fuel is sunlight.’

Man No in Saw Chaung village, Myanmar

SDG 4 Inclusive and equitable education

A study undertaken in the Karen and Kachin regions of Myanmar demonstrates that household lighting assists with child education. Civil society groups surveyed found that lighting enables after-school classes, study sessions (organised by religious or civil society organisations) and computer classes. Electricity services beyond household lighting did not, however, seem to have any additional

99 Walker, B. (2017) 'A company of my own': the rise of Myanmar's tech pioneers. Guardian Website.

100 Balch. O. (2016) Off-grid solar to help Myanmar bring electricity to all by 2030. Guardian Website.

101 Walker, B. (2017) Op. cit.

102 Balch, O. (2016) Op. cit.

benefits for educational outcomes.[103] Other constraints beyond electricity may also be important, such as the availability of trained teachers or teacher salaries.[104]

The World Bank reports that rural children in Myanmar often need to share a single light bulb between multiple family members, or use candles, with a risk of fire or burning. The World Bank is hence building 23,000 new solar-based community connections for clinics, schools and religious buildings (under the National Electrification Plan),[105] and the Asian Development Bank (ADB) has invested in decentralised solar-PV and biomass systems in schools in 25 villages.[106] Meikswe Myanmar, a civil society organisation, distributed solar lanterns to schools in the Ayeyarwady, Rakhine and Tanintharyi regions. Anecdotal evidence finds this has offset the need for schools to collect money from parents for diesel generators for night-time study classes, while extending study time.[107]

> ‘Children who have access to electric lighting are doing better [in school] than the ones who do not have access.’
>
> A school teacher in Ma Kyauk Ar village, Myanmar

SDG 5 Gender equality

Differences between women’s and men’s perceptions and expectations of the benefits of access to electricity were identified in a study undertaken in the Karen and Kachin regions of Myanmar.[108] For 50 per cent of women and 25 per cent of men, the main benefit is the potential to enhance the education of their children. One third of women want to use electricity for care work, such as cleaning or the care of children. Public lighting would improve their security. The study found that 36 per cent of women and 54 per cent of men want to use electricity to start a business. While women typically want to start businesses in or near the home, using electric lighting to increase the hours available for work, men want to operate more energy-intensive businesses, such as carpentry or welding.[109] Solar lamps and SHS may not lend themselves to men’s business interests because of their limited capacity. Meanwhile, village electrification committees, which are the point of contact between the Department for Rural Development (DRD) and unconnected villages, have the potential to discriminate against women and marginalised groups within a community.[110]

SDG 8 Economic empowerment, employment and decent work

With Myanmar’s energy-poor population increasingly located in remote rural regions, the costs of grid electricity connection and diesel distribution rise, improving the financial case for solar-based

103 Spectrum. (2017) Electricity: The View from CSOs and Intra-Community Issues. Yangon: Spectrum.

104 Ibid.

105 World Bank. (2015) Electricity to Transform Rural Myanmar. Washington DC: World Bank. And: World Bank. (2017) Turning on the Lights in Rural Myanmar. Washington DC: World Bank.

106 ADB. (2014) MYA: Off-grid renewable energy demonstration project (previously called Off-grid renewable energy programme). Technical assistance concept paper. ADB Website.

107 Panasonic. (2017) Myanmar: Precious Light Supports Children's Education in Off-grid Villages. Panasonic Website.

108 This surveyed opinions from 20 focus groups and 40 interviews - 20 with civil society representatives and 20 with leadership – across 6 villages in Karen and 5 villages in the outer areas of Myitkyina township, Kachin. Source: Spectrum. (2017) Electricity: Women and Electrification: What Women Want Electricity For. Yangon: Spectrum.

109 Ibid.

110 Ibid.

electricity.[111] Mini-grids can help support the sustainability of Myanmar's economic progress by enabling entrepreneurship and community jobs, as well as leveraging international investments.[112] The role of electricity in enabling mobile phone services is also noted in the literature. In opening up opportunities for financial or agricultural information, it can, for example, help Myanmar's farmers to adopt sustainable farming techniques.[113] A not-for-profit renewable energy firm, Myanmar Eco Solutions, has also developed a solar-powered irrigation system for rice farmers in the Ayeyarwady region. This is mounted on a raft and can support businesses in several villages connected to the river.[114]

SDG 13 Tackling climate change

Compared with business-as-usual, 100 per cent power generation from renewables would reduce emissions by 75 million tonnes a year by 2050.[115] Hydroelectricity solutions, pertinent to Myanmar's energy future, have no ongoing carbon or particulate emissions.[116]

Despite this, hydrological resources may be susceptible to the impacts of climate change,[117] and national water sustainability measures are important for future energy security. The International Center for Environmental Management is leading a national strategic environmental assessment – to promote sustainable hydroelectricity development across five major river basins – and is being led by the Ministry of National Resources and Environmental Conservation and Ministry of Electricity and Energy, in Partnership with the International Finance Corporation. (As of January 2018, stakeholder consultations were taking place.)[118]

The International Finance Corporation estimates 4.5 million of Myanmar's households use candles, kerosene, diesel or batteries.[119] Substitution of solar lighting for kerosene in all households without access to electricity would reduce greenhouse gas emissions by 600,000 tonnes to 1.2 million tonnes CO_2 a year, equivalent to less than 0.5 per cent of total annual emissions.[120]

Political economy of decentralised renewables

An overview of Myanmar's energy sector governance and political economy findings are presented in Tables 6 and 7. The World Bank RISE indicators score Myanmar's policy environment for energy access and renewable energy at 59 per cent and 43 per cent respectively.[121]

The National Energy Policy (NEP) of 2014 provides the framework for development of on-grid and off-grid electricity in Myanmar. A key informant noted that this document is out of date, necessitating an update in policy to better reflect Myanmar's energy situation. A draft Renewable Energy Policy provides more specific objectives for renewable electricity, including decentralised renewable energy. The Renewable Energy Policy, for example, envisages 3,995 MW installed

111 Balch. O. (2016) Op. cit.

112 GIZ. (2017) Promoting Rural Electrification through Mini-grids: Supporting Myanmar's untapped mini-grid market. Bonn: GIZ.

113 Taylor, J. (2014) 5 things to know about working in rural Myanmar. Devex Website.

114 Balch, O. (2016) Op. cit.

115 WWF et al. (2017) Op. cit.

116 Dapice, D. (2014) Electricity Supply, Demand and Prices in Myanmar – How to Close the Gap?. Harvard University.

117 WWF et al. (2017) Op. cit.

118 IFC. (2017) Getting to know the SEA in Myanmar. IFC Website. And: IFC. (2018) IFC and Myanmar Government Discuss Strategic Environmental Assessment Findings with Stakeholders. IFC Press Release.

119 Win, T.L. (2017) Waiting for grid to arrive, Myanmar villages switch on solar. Reuters Website.

120 Authors' own estimates, assuming 100 kg CO2 per year per kerosene lamp.

121 ESMAP. (2017) Op. cit.

renewable generation capacity, excluding large-scale hydro, by 2030.[122] This includes 745 MW of off-grid generation capacity. Total renewable energy capacity, excluding large hydro, will be 27 per cent of total capacity by 2030.

Electrification and expansion of the power sector follows a least-cost analysis prepared for the government, using geospatial planning techniques. This analysis included off-grid electricity. The government's focus is the target of universal access to electricity by 2030. The long-term aim is grid access throughout the country, but the government recognises that off-grid access will be necessary to meet the universal access target. The government expects a 5–15 per cent community contribution for village electrification. Public finance meets most of the costs, and will be used to ensure universal access in villages that struggle to pay the community contribution.[123] There is also a national government programme to promote access to solar lamps and SHS. Beyond these public sector efforts, a number of companies are operating in the decentralised renewable space, including solar lamp and SHS companies such as SolarHome and Greenlight Planet.[124]

From a financial perspective, the government of Myanmar subsidises on-grid electricity prices by up to $250 million (or 333 billion Kyat) annually. The government thus keeps electricity prices artificially low, disincentivising private sector investment.[125] From a private sector perspective, there are few incentives to encourage either on-grid or off-grid electricity provision. Regulations on tariffs and the absence of a policy framework or regulations for mini-grids have been barriers. For example, revisions to the code for the grid overlooked provision for connecting mini-grids. A mini-grid policy has been drafted, however.[126] Other barriers to investment in mini-grids include the absence of site-specific feasibility studies and lack of consumer, or community, awareness about electrification.

The Ministry of Electricity and Energy has primary responsibility for development of the power sector. However, the Department for Rural Development of the Ministry of Agriculture, Livestock and Irrigation is responsible for implementation of off-grid electrification. This separation of functions, not unique to Myanmar, may be a major factor contributing to compartmentalisation in policy implementation.

122 ADB. (2014) MYA: Off-grid renewable energy demonstration project (previously called Off-grid renewable energy programme). Technical assistance concept paper. ADB Website.

123 Key informant interview.

124 Dalberg Advisors et al. (2018) Op. cit.

125 This is based on the Oanda currency conversion rate: 1 MMK = 0.000752329 USD. Source: Yine and Tun. (2017) Electricity subsidies face axe. Eleven Myanmar.

126 Ibid.

Table 6 Energy sector governance in Myanmar

Governance	**Generation**	The Electricity Supply Enterprise is responsible for power generation. The exceptions are the Yangon Electricity Supply Corporation (YESC), responsible for power generation in Yangon, and the Mandalay Electric Corporation (MEC), responsible for power generation in Mandalay.
	Transmission	The Electric Power Generation Enterprise is responsible for the national transmission system. It is the single buyer of electricity.
	Distribution	The Electricity Supply Enterprise is responsible for electricity distribution. The exceptions are the YESC and MEC that are responsible for electricity distribution in Yangon and Mandalay respectively.
	Regulator	The Electricity Regulatory Commission is responsible for regulation of the power sector.

Source: Governmental websites; and ADB (2014)

Table 7 Policy issues and recommendations for Myanmar

Policy barrier	Challenges and opportunities	Potential policy actions
Policy framework and implementation	There is a target of 2030 universal access to electricity. The electrification plan provides for decentralised solutions. But there is inadequate policy for private sector investment in mini-grids. The National Energy Policy is out of date and requires updating. The Ministry of Electricity and Energy has primary responsibility for development of the power sector, while the Department for Rural Development of the Ministry of Agriculture, Livestock and Irrigation is responsible for off-grid electrification. This creates a strong compartmentalisation of energy policy.	Prioritise investment and policies in solar panels and solar/hydro mini-grids as more cost-effective than electricity connections and diesel generators. Update national electrification strategy, policy, regulation and plans, to improve energy policy certainty. Develop mini-grid regulations and tariffs that encourage private investment. Improve coordination of energy policies between relevant Ministries and Departments.
Access to finance	Off-grid financing facilities exist. The short-term loans and inflexible rates provided by banks, however, reduce investment. The World Bank is helping to finance the 2030 universal access target.	Mobilise access to finance for actors across the value chain, in cooperation with financial institutions and other funding organisations.
Fiscal barriers	Duty exemptions are available for mini-grid generators and solar modules, as well as charge controllers.	Expand fiscal incentives to include all decentralised equipment, and facilitate implementation of such fiscal incentives.
Consumer protection and quality assurance	Standards are not widely applied to decentralised technologies. Therefore, the average quality of off-grid solar lamps and SHS is low. The exception is mini-grid standards, which exclude provisions for grid connection.	Protect consumers by ensuring providers are accountable through legal provisions. Update the mini-grid standard to include provisions for future grid connectivity.
Level playing field	Public subsidisation of electrification and electricity use discourages private investment. Kerosene and diesel subsidies are not consistently applied. Subsidies exist for standalone systems (eg	Slowly reduce subsidies to on-grid electricity and re-distribute to social spending purposes (including national awareness campaigns). Reduce subsidies provided to kerosene and diesel.

	solar), up to 100 per cent of costs.	
Consumer awareness	A lack of consumer, or community, awareness about electrification is hampering the deployment of off-grid solutions. This includes pico-solar lamps and SHS systems.	Raise consumer awareness through campaigns on decentralised electricity products, especially in rural areas.
Consumer financing	National support programmes are provided (see 'Level playing field' box above). Financing mechanisms are available to consumers for standalone systems.	Ease access to end-user and consumer finance options, particularly through mobile payment mechanisms and micro-finance provision.
Level of local skills	Limited training – and limited trained staff – are present in rural areas, resulting in a lack of human capital for the operation and reparation of decentralised technologies.	Build a qualified workforce for the off-grid and mini-grid sector. Increase domestic value creation by developing relevant training capacity, especially for maintenance services in rural regions.

Source: Various references op. cit. and key informant interviews.

3.3 Nepal

Current state of play

The IEA estimate that 77 per cent of Nepal's population had access to electricity in 2016.[127] The Global Tracking Framework (GTF) estimate, for 2014, is higher at 85 per cent.[128] The latter takes more account of off-grid access. The level of access in urban areas is higher than in rural areas: 97 per cent according to the IEA and 85 per cent according to the GTF. In rural areas, where most of the population live, the level of access is 72 per cent or 82 per cent, according to the IEA or GTF, respectively.[129]

Electricity production in Nepal is almost entirely by hydropower (99.8 per cent in 2015).[130] However, the country's electricity system is unreliable, experiencing frequent load shedding (up to 12 hours a day).[131] Almost a third of the electricity supply is imported and a quarter is lost in transmission.[132] World Bank data places system losses as even higher (32 per cent of electricity output), and the highest when compared with the other countries in this study (averaging 19 per cent) (see Figure 4).

127 IEA (2017) IEA Energy Access Statistics. IEA website.

128 http://gtf.esmap.org/country/nepal

129 IEA (2017) Op. cit.; IEA and World Bank (2017) Op. cit.

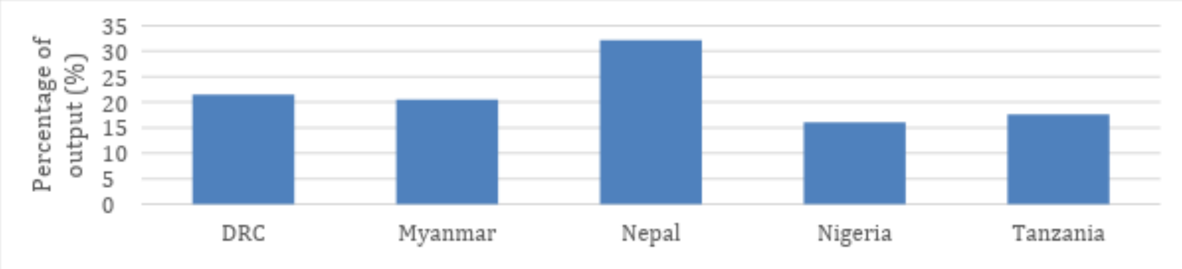
130 IEA Statistics.

131 Dhital, R.P. (2017) National Energy Access Policies and Plans: Government Plans. Alternative Energy Promotion Center. And: SREP. (2017) Upscaling Mini-grids for Least Cost and Timely Access to Electricity Services. SREP round table [NEPAL], Myanmar, Feb 6, 2017. And: World Bank. (2017) SUMMARY. Nepal: Scaling Up Electricity Access through Mini and Micro Hydropower Applications. A strategic stock-taking and developing a future roadmap. Washington DC: World Bank Group.

132 IEA Statistics.

Investments in the transmission and distribution infrastructure are required to reduce such system losses.

Figure 4 Transmission and distribution losses in select countries (2014)



Source: World Bank (2017) *World Development Indicators.*

Nepal has abundant renewable resources and 15 per cent of the population has access to renewable energy services (excluding large hydro).[133] Micro-hydropower development has been a pivotal energy development pillar since the 1960s.[134] As of 2017, 30 MW of micro-hydropower had been deployed and 20 MW of decentralised solar solutions, in particular solar home systems. Under the Scaling Up Renewable Programme this includes solar-wind hybrid mini-grids.[135] By 2012, the government's Alternative Energy Promotion Centre (AEPC) had provided 229,000 solar home systems. These dominate the market, compared with solar lamps, because of a high level of subsidy.[136] Since then, more than 200,000 more SHS have been installed by the AEPC. GOGLA reported sales of 36,162 Lighting Global-certified solar lamps and SHS in 2016.[137]

> 'A lot of areas still aren't connected. Trying to connect villages to the national grid is a long way off. There's a lot of capacity in terms of putting in micro-hydro plants that will help a village area.'
>
> Peter Lockwood, Programme Advisor for United Missions of Nepal

Cost-effectiveness of decentralised renewables

The levelised costs of renewable energy options demonstrate that Nepal is relatively cost-competitive, in particular in the small-hydropower market, when compared with other developing countries (see Box 1 above). The cost of electricity delivered in Nepal's rural hills through the central grid averages $0.17–0.25 kWh, compared with $0.09–0.15 through a local micro-hydropower plant connection (of 50–100 kW).[138] This may be in part due to the difficult topology of Nepal's remote regions.[139]

133 SREP (2017) Op. cit.

134 Deshmukh (2013)

135 SREP (2017) Op. cit.

136 Lighting Asia (2012) Lighting Asia: Solar Off-Grid Lighting. India, Bangladesh, Nepal, Pakistan, Indonesia, Cambodia and Philippines. Washington DC: International Finance Corporation.

137 GOGLA, Lighting Global, World Bank Group and Berenschot. (2016) Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data. And: GOGLA (2017a): Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data, July-December 2016. And: GOGLA (2017b): Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data, January - June 2017, Public Report.

138 These cost estimates adopt the exchange rates in the study by World Bank (2017) Op. cit.

139 Deshmukh, R., Carvallo, J.P. and Gambhir, A. (2013) Sustainable Development of Renewable Energy Mini-grids for Energy Access: A Framework for Policy Design. Lawrence Berkeley National Laboratory, University of California Berkeley and Prayas Energy Group Pune.

From the decentralised perspective, the unit costs of SHS ranged from $50–70 for small systems (3–5 Wp), $220 for medium systems (20 Wp) – both providing Tier 1 access – and $565 for larger Tier 2 systems (60 Wp) (2012 data).[140] For the Scaling Up Renewable Energy Programme (2011), a medium solar home system (20 Wp) is estimated to cost $250, while a micro-hydropower project is estimated to cost $4,444 per kW.[141] However, these cost estimates predate large falls in the costs of solar. More recent LCOE estimates by the World Bank place costs for a medium solar home system (20 kW) at $0.55 per kW, a micro-hydropower plant (20 kW) at $0.24 per kWh, and a diesel generator set (20 kW) at $0.60 per kWh.[142]

Contributions to the SDGs

SDG 3 Healthy lives

One third of rural health centres in Nepal lack access to reliable power.[143] Power cuts in rural Nepal can last nine hours, putting patients' lives at risk from an absence of lighting or the failure of oxygen machines. Following the installation of solar systems in six clinics, medical staff were able to deliver babies during the night, using solar-powered illumination (where they had previously relied on torches or costly diesel generators).[144] Following installation of solar units – called 'suitcases' – in Pandavkhani, maternal and child deaths were reduced to zero.[145]

There was also a notable role for decentralised solar systems in the aftermath of the Kathmandu earthquake in 2015. For example, Gham Power crowd-sourced financing for distributed solar systems, providing them to relief workers for healthcare purposes. This reduced the reliance on expensive diesel generators or kerosene and candles, the latter presenting a fire hazard.[146] SunFarmer also funded, alongside other NGOs, distributed solar-powered water purifiers and other systems to remote rural regions following the earthquake.[147]

> Priya, 33, is a volunteer at a medical health post in Saleri, Nepal, which uses solar power for light, mobile charging and to heat water for sterilising medical equipment. Now that they have light, the medical staff and volunteers can help patients at night. Priya says, 'There's a brightness now – there are no dark corners, everything can be seen. It makes life easier and happier.'

SDG 4 Inclusive and equitable education

Access to decentralised electricity solutions can create opportunities for improved education. The company SunFarmer found access to such electricity can improve school attendance and enhance literacy rates and study habits.[148] The impact of electricity on education is perceived differently according to the technological solution adopted, and decentralised solutions may have a greater impact on education.

140 Lighting Asia. (2012) Op. cit.

141 SREP (2011) Scaling up renewable energy program investment plan for Nepal. Scaling up Renewable Energy Program.

142 World Bank. (2017) Op. cit.

143 Wheeler, (2017) Op. cit.

144 Balch, O. (2014) Rent to own solar systems hope to prevent blackouts in Nepal's hospitals. The Guardian, 18 August 2014.

145 Wheeler (2017) Op. cit.

146 Lohan, T. (2015) How Solar is Lighting the Way for Recovery in Nepal. The American Prospect website.

147 Tweed, K. (2015) How Solar is Playing a Role in Nepal's Disaster Relief. GreenTech Media website

148 http://www.sunfarmer.org/blog-full/the-challenges-and-opportunities-of-electricity-access-in-nepal

In Kavre and Sindhuli, regions to the southeast of Kathmandu, 82 per cent of respondents in a survey agreed that grids have had a positive impact on child education, compared with 98 per cent for micro-grids and 97 per cent for stand-alone solar solutions.[149] The role of decentralised solar is also noted in the electrification in schools that are distant from the national grid. In Matela, decentralised solar is being used to electrify two schools, to offer night-time classes and launch computer classes. This enables the schools to provide night-time education for children and adults who are engaged in care or business activities during the day. SHSs are also being adopted to enable children to study at night in their homes.[150]

SDG 5 Gender equality

Decentralised electricity solutions can provide job opportunities for women. For example, Empower Generation – operating in the districts of Bardiya, Rupandehi, Chitwan and Siraha – is run by 23 female chief executive officers (CEOs). These CEOs receive financial and managerial training. In addition, the CEOs employ up to 170 agents, male and female, which distribute solar lamps and home systems, as well as clean cookstoves and water filters. The agents receive sales and marketing training to distribute their products. By 2020, the aim is to empower 100 female CEOs and 1,000 sales agents.[151]

Other evidence points to the role of electricity services in reducing time spent on cooking, though not a direct focus of this study. Anecdotally, small hydro can create opportunities for rice cooking, which has high energy requirements, or the powering of mills, which reduces the burden of grounding flour, for example.[152]

149 https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2015/06/Anjana_Minigrid.pdf

150 http://www.globalelectricity.org/upload/File/the_nepal_energy_for_education_project_publication.pdf

151 Purvis, K. (2017) Woman led company wins award for lighting up Nepal. The Third Pole Website.

152 Key informant interview.

CASE STUDY:

Phul Kumari is starting a business, powered by hydroelectricity, so her children can become engineers

Phul Kumari is 32 years old and lives with her husband, three daughters and a son in Kalanga, a village in Nepal. In the past, the village had no electricity. Phul Kumari had to get up at 4am to grind maize, wheat and corn by hand. It took so long that the whole family had to be involved.

Her family relied on kerosene for light. Phul Kumari had to walk a long way to buy it, travelling up to four hours on foot. It was expensive; sometimes she could not afford it. To help make ends meet, her children also got up early in the morning to work. At night, they had only the dim, smoky light of the kerosene lamp to study by. They didn't finish their homework.

Now that the village has a micro-hydropower plant, Phul Kumari can bring the family's grain to the newly opened mill – which uses water run-off from the micro-hydro plant – where the mill owner will grind it in just an hour. The whole family saves time.

'Before having hydroelectricity, our community felt like our lives were on a hard trajectory, but after having electricity, we feel very happy because we are inside the light.'

Now she that has the time – and the inspiration from other businesses opening in the village – Phul Kumari is starting her own poultry and vegetable farm. The micro-hydro plant will provide light for the farm and heating to keep the chickens warm.

'Now I can engage in business. I support my children so they can go to school.'

With electric lights at home, her children can now complete all their homework. Phul Kumari is a member of the school management committee and regularly hears from teachers about her children's good progress at school.

'I support my children so they can go to school. The rate of school attendance is increasing because they can do their homework. I want my children to have a different life. They might be engineers or doctors. I hope my children will be good in the community.'

SDG 8 Economic empowerment, employment and decent work

As seen in the SDG 5 section above, distributed technologies can create economic opportunities for women, as well as men. Anecdotally, solar systems in the Chitwan National Park enabled tourists to stay overnight, providing further income opportunities in the tourism sector. Rangers were also able to stay in touch with park authorities and power spotlights using solar power.[153] A key informant interviewed also outlined the role of decentralised renewables in creating additional rural industries. For example, hydroelectricity opens up opportunities in carpentry workshops, for manufacturing household goods.[154]

'The micro-hydro plant makes a big difference – like the difference between the land and the sky. Before I felt so sad. Nowadays I am happy. Before I had very difficult work. Now it is very easy. I am working full-time at my business, and I am enjoying it and earning enough money.'

Hari, 49, lives close to the village of Chanitar in Nepal. From early childhood, he wanted to work as

153 PennEnergy. (2017) Solar Energy Empowers Villagers and Saves Wildlife in Nepal. Renewable Energy World Website.

154 Key informant interview.

a carpenter. Since the micro-hydropower plant was installed, he has been able to open a sawmill.

SDG 13 Tackling climate change

Domestic emissions were equivalent to 44.06 million tonnes of CO_{2e} in 2014.[155] The replacement of traditional fuels, such as kerosene, and diesel can create emissions savings domestically. In 2007–2014, 400 micro run-of-river hydropower plants[156] were built, which are estimated to have abated 66,345 tonnes of carbon dioxide (the equivalent of taking 14,000 passenger vehicles off the road for one year).[157] Despite this, Nepal is not a significant contributor to global emissions.[158] As with Myanmar, a reliance on hydroelectricity results in a vulnerability to climate change impacts, with possible implications for security of supply.

Political economy of decentralised renewables

An overview of Nepal's energy sector governance and major political economy findings is presented in Tables 8 and 9. According to the World Bank RISE indicators, Nepal's policy environment for energy access and renewable energy is scored at 43 per cent and 45 per cent, respectively.[159] According to one key informant, one of the largest obstacles for the country's energy policies is their implementation. It was mentioned that such policies have been developed in a 'vague manner', allowing for government interpretation, bureaucratic impediments and misaligned incentives.[160] Renewable energy policy has also suffered from an 'identity crisis' – where renewables (excluding hydropower) have been viewed as a solution to rural energy access, but now are increasingly seen as an option for on-grid solutions also.[161]

A number of actors oversee energy governance. The government and donor communities' focus has largely been on on-grid hydroelectricity opportunities. The government perspective on the decentralised opportunity is seen as an interim solution, until the grid arrives.[162] It follows that the state-owned electricity utility, the Nepal Electricity Authority's, project pipeline is exclusively large-scale projects. The exception is the Alternative Energy Promotion Centre, focused on small-scale renewables in rural centres, including micro- and pico-sized electricity solutions (eg solar).[163] Notably, interviewees commented there is very little private sector involvement, despite the fact that policies are trying to promote private sector inclusion. This is in part due to cumbersome bureaucratic procedures.

A private sector stakeholder interviewed identified the need to address how decentralised solutions will integrate with the national grid, when it arrives.[164] For larger infrastructure, such as schools, electricity generated during weekends and holidays creates opportunities for selling electricity back to the grid. However, it is unclear whether this is a viable option for smaller buildings, such as

155 WRI CAIT (2017) Op. cit.

156 Run-of-the-river hydropower plants rely on little to no water storage, instead relying on the movement of water to generate electricity.

157 World Bank. (2015b) Micro-Hydros Earn First Carbon Revenue in Nepal. Washington DC: World Bank.

158

159 ESMAP (2017) Op. cit.

160 Key informant interview.

161 Ibid.

162 Ibid.

163 Ibid.

164 Ibid.

households.[165] Although solar played a strong role in urban centres facing unreliable grid electricity supply, it is also unclear how improvements in the grid-connected electricity supply in cities will impact the urban solar market.

The absence of decentralised energy governance leads to an absence of integrated planning.[166] Focusing on the project level, project development is relatively cumbersome and developers need to obtain a licence to survey, followed by a power purchase agreement, and a licence for building to commence. It has been known for private sector developers to proceed without getting the necessary approvals,[167] given the lengthy process. Another barrier is bureaucratic impediments. It is rumoured that the private sector has in the past provided incentives to the Nepal Electricity Authority to speed up approval processes. The lack of reliable hydrological data offers some 'room for manoeuvre' when private sector and government project negotiations take place.[168] This is understood as the ability for government to provide undue influence.

Despite these challenges, governance opportunities are emerging. Recently, the Nepalese government held state-level elections, with plans to also carry out provincial or local-level government elections. If adequately implemented, this would decentralise political decision-making from the central government elite in Kathmandu to the local level.[169] This creates an opportunity for stakeholders to influence local municipalities, in particular towards the role of decentralised renewables in energy access (and particularly in rural areas).

From a technological perspective, baseline energy technologies in Nepal remain seven to eight years behind the global frontier, according to a key informant interviewed. From a financial perspective, the private sector has been crowded out by government and donor funding. When public financing dries up, the sector therefore becomes idle. In addition, the political narrative that decentralised solutions act as an interim for grid connection negatively impacts the investment climate.[170] As an example, Alternative Energy Promotion Centre projects are largely reliant on external and government funding.[171] Diversifying the sources of investment will hence be necessary for the long-term success of the decentralised renewable sector.

165 Key informant interview.

166 Ibid.

167 Ibid.

168 Ibid.

169 Ibid.

170 Ibid.

171 Ibid.

Table 8 Energy sector governance in Nepal

Governance	**Generation**	The Nepal Electricity Authority (NEA) – the state-owned energy utility incumbent – is responsible for power generation, both on-grid and off-grid. The government plans to unbundle the NEA. The Alternative Energy Promotion Centre (AEPC) is a state-owned energy body responsible for renewable/alternative energy generation.
	Transmission	The NEA is responsible for the transmission of electricity.
	Distribution	The NEA is responsible for the distribution of electricity. The AEPC is also responsible for distributed renewable energy solutions.
	Regulator	The Nepal Electricity Regulatory Commission is mandated to regulate the power sector. This follows the Electricity Regulatory Commission Bill 2017, approved by Parliament in August 2017.

Source: Nepal Electricity Authority and Alternative Energy Promotion Centre websites; SARI (2013); Kathmandu Post (2017)

Table 9 Policy issues and recommendations for Nepal

Policy barrier	Challenges and opportunities	Potential policy actions
Policy framework and implementation	The government focus is on on-grid hydroelectricity. The decentralised opportunity is seen as an interim solution until the grid arrives. Implementation of national energy policies is a key barrier as policies have been developed with 'vague wording'. The Alternative Energy Promotion Centre is focused on small-scale renewables in rural centres, while the Nepal Electricity Authority focuses exclusively on large-scale projects. Cumbersome bureaucratic procedures restrict private sector involvement. This is against a backdrop of government plans to decentralise political representation through provincial elections.	Increase the role of decentralised energy solutions in future energy policy, in particular in rural regions (including cost-effective solar lamps, SHS and mini-grids). Policy standards should ensure mini-grids can be connected to the grid in the future. Government efforts should also focus on strategic and coordinated implementation of energy policy. Promote policies to incentivise private sector investment in decentralised energy. Encourage technological advances in these technologies, and the simplification of bureaucratic procedures for project development. Facilitate private sector and civil society investment in distributed solar systems in humanitarian situations (eg earthquakes and flooding).
Access to finance	Off-grid financing facilities exist. Complex procedures and high rates, however, reduce lending to lower income households and SMEs. Donor and government financing can crowd out private financing to decentralised energy projects.	Mobilise access to finance for actors across the value chain, in cooperation with financial institutions and other funding organisations. Review the high interest rates applied to lower income households and SMEs. Explore ways to reduce public financing crowding out private financing (eg public-private partnerships).
Fiscal barriers	Duty exemptions are applied to mini-grid generators/systems and their storage, as well as distributors. Tax exemptions for stand-alone systems are not apparent.	Apply tax exemptions and other measures for stand-alone renewable energy systems.
Consumer protection and quality assurance	Quality standards are applied to stand-alone systems (eg pico-solar products). Government certification is applied to mini-grid equipment.	Protect consumers' rights by ensuring solar off-grid and mini-grid system providers are accountable through legal provisions and internationally recognised quality standards.
Level playing field	Subsidies are provided to mini-grid generators, as well as stand-alone solutions. Subsidies are also provided	Review subsidies for kerosene and diesel and their potential elimination (eg reallocate subsidies to other

	for diesel and kerosene.	social sectors, such as health or education).
Consumer awareness	There is relatively small growth in the Nepal solar market, which is dominated by SHS.	Raise consumer awareness about the benefits of decentralised renewable solutions (eg solar lamps, renewable based mini-grids) to encourage market growth.
Consumer financing	[No specific information available.]	
Level of local skills	[No specific information available.]	

Source: Various references op. cit. and key informant interviews.

3.4 Nigeria

Current state of play

According to the IEA, approximately 61 per cent of Nigeria's 186 million people had access to electricity in 2016,[172] while the Global Tracking Framework estimated this at 58 per cent in 2014.[173] In rural areas, about two-thirds of the population lacks access to electricity, but there are big differences between access rates and electrification rates in different states. Northern and eastern states have much lower levels of access than the rest of the country. In urban areas, 86 per cent of the population had access in 2016.[174]

Nigeria is Africa's largest oil exporter and the fourth largest liquefied natural gas exporter in the world (2012 data).[175] Yet a lack of refineries results in a petroleum import dependence. The electricity sector relies on natural gas plants and hydroelectricity (see Figure 5). Natural gas supply shortages due to excessive gas flaring and an inadequate gas evacuation and distribution infrastructure, as well as inadequate water management, cause frequent power outages.[176]

Data collected during the interview and scoping missions suggest that independent decentralised generators generate between two and three times more electricity than the central grid.[177] In total in urban areas, 8–14 GW of off-grid diesel and gasoline generators serve as back-up power during power outages. In rural communities, kerosene, candles and biomass form the prevalent source of energy.[178] The Rural Electrification Agency (REA) lists 445 rural electrification projects that have been developed to date, but fewer than ten per cent have been completed.[179] And in July 2016, the state-owned Nigerian Bulk Electricity Trading company provided the first power purchase agreements for

172 IEA. (2016) IEA Energy Access Database. IEA website.

173 http://gtf.esmap.org/country/nigeria

174 IEA. (2017) IEA statistics. IEA website.

175 Emodi, N.V. (2016) Chapter 2: The Energy Sector in Nigeria. Energy Policies for Sustainable Development Strategies, Frontiers in African Business Research, DOI 10.1007/978-981-10-0974-7_2. Springer Science+Business Media Singapore.

176 GIZ. (2015) Nigerian Energy Sector: An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification. Bonn: GIZ. And: Emodi (2016) Op. cit. And: World Bank. (2017) World Development Indicators. World Bank Website.

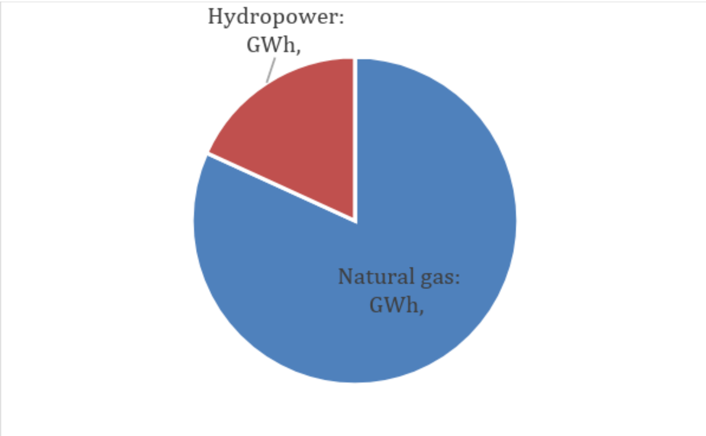
177 Key informant interview.

178 Key informant interview.

179 http://rea.gov.ng/projectdashboard/

solar projects, with a combined capacity of 1,200 MW (involving 14 companies).[180] The federal government plans to deploy 10,000 renewable energy mini-grids across the country,[181] and launched the National Solar Programme in February 2017 to electrify 20,000 off-grid rural households.[182] A number of initiatives by renewable energy companies are also contributing to decentralised electricity access, including for example Solar Sisters, which is deploying a female sales workforce as agents.[183]

Figure 5 Nigeria. Electricity supply 2015



Source: IEA Statistics (2017)

Cost-effectiveness of decentralised renewables

On-grid electricity costs are lowest for hydropower and gas in Nigeria (at less than approximately $0.075 per kWh), which is not necessarily surprising given these are the dominant technologies. At grid-scale, solar PV and concentrated solar power (CSP) are not necessarily cost-competitive with the LCOE of fossil fuels, with costs ranging upwards of approximately $0.1 per kWh. It is worth noting that large hydropower is cheaper on average than fossil fuel alternatives (see Figure 6).[184]

Nigeria's off-grid households spend between $156 and $228 on traditional lighting sources and mobile charging (2015 data).[185] Focusing on decentralised solutions, small-scale hydropower and off-grid natural gas are the cheapest technologies (at just over $0.1 per kWh). The LCOE of small-scale hydropower and solar PV are both lower than decentralised diesel (see Figure 6).[186] For lower energy tiers, LCOE estimates are not readily available. A kerosene lamp with a glass cover ($5.80) is, however, a third of the cost of a small solar lamp ($18), or a sixth of a large solar lamp ($35), in Nigeria.

An interview conducted with a Nigerian solar PV stakeholder noted the installation of a solar PV system at their place of work resulted in the avoided expenditure of $22 a day (or 8,000 Nigerian naira per day), for a year.[187] Power For All cites the work by some stakeholders in the decentralized

---

180 http://www.pv-tech.org/interviews/pv-talk-nigerias-20-renewables-target-could-be-met-just-with-solar. And: Key informant interview.

181 Key informant interview.

182 Ibid.

183 GIZ. (2015) Nigerian Energy Sector: An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification. Bonn: GIZ.

184 Boell (2017) True Cost of Electricity: Comparison of Costs of Electricity Generation in Nigeria. Boell Website.

185 Dalberg Advisors et al. (2018) Op. Cit.

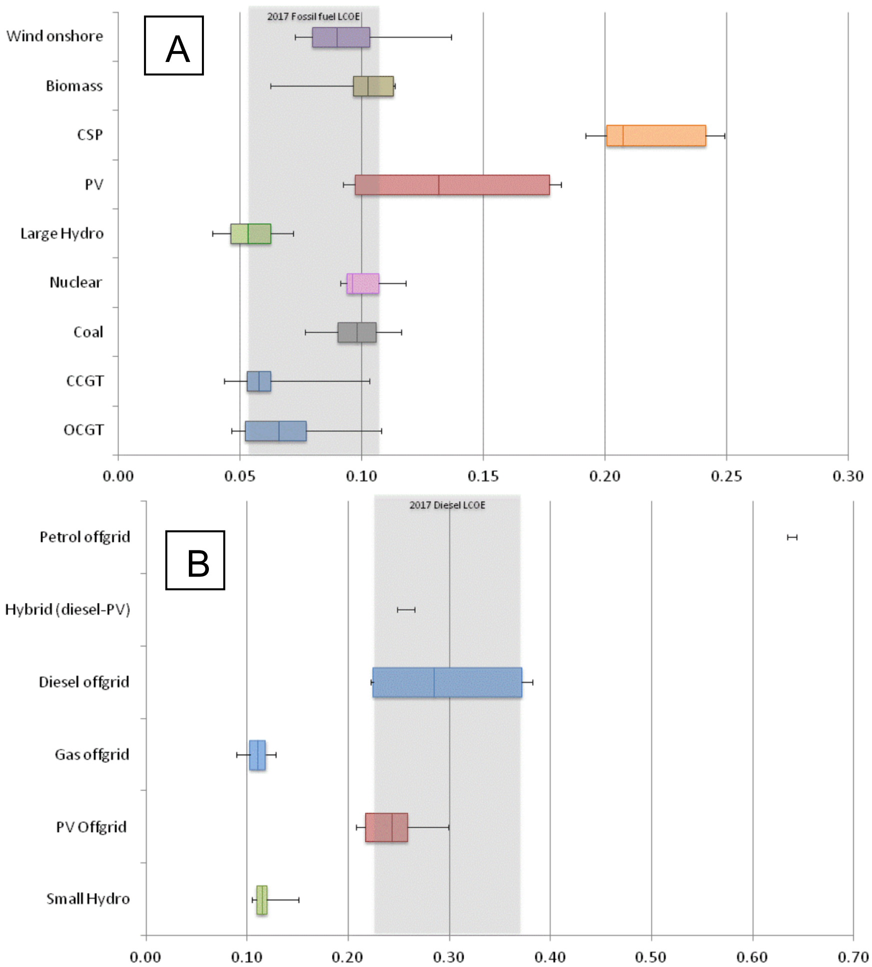
186 The analysis shows that small-scale energy solutions remain more expensive than large-scale solutions. However, with prohibitively high grid connection costs in remote and rural regions, they remain essential for meeting SDG 7. Source: Boell (2017) Op. cit.

187 Based on a conversion rate of 1 NGN = 0.00277041 USD. Source: Key informant interview.

renewable energy space who have adopted innovative business models to use solar PVs for productive use. In one of their cited case studies, they highlight work done by a company providing PV solar to barber shops which led to about 100 barbers saving between $5.5 and $13.9 weekly (or between 2,000 and 5,000 Nigerian naira) by shifting from petrol generators to solar pay-as-you-go schemes.[188]

Towards 2035, the levelised costs of decentralised solar PV and hybrid systems are expected to continue to decline, while off-grid gas technology costs increase (see Figure 7).[189] Along a similar theme, GIZ commented that shifting diesel and gasoline generators to hybrid solar systems could also reduce future fuel price risks.[190]

Figure 6 LCOE of energy technologies in Nigeria ($ per kWh), data from 2017. A: on-grid. B: off-grid (unsubsidised).



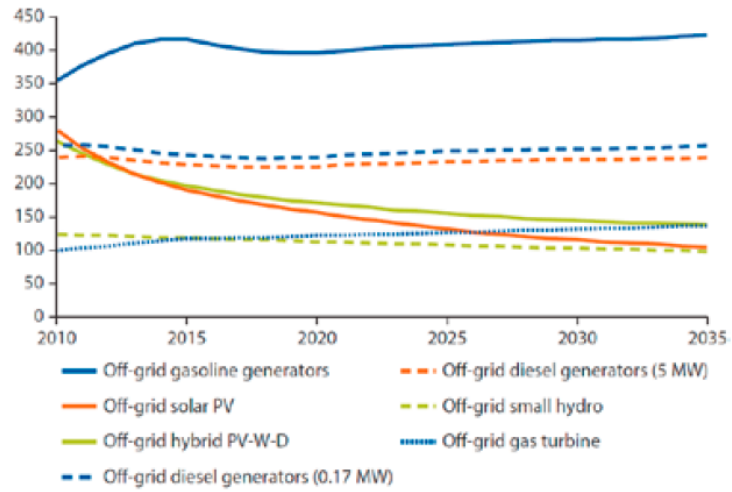
Note: Assumes 11% weighted average cost. Source: Boell (2017)

Figure 7 Nigeria LCOE of off-grid technologies (US $ per MWh), to 2035

188 Installed by Consistent Energy. Source: key informant interview.

189 This is likely to be the result of natural gas price assumptions.

190 GIZ (2015) Op. cit.



Source: GIZ (2015).

Contributions to the SDGs

As noted by one Nigerian stakeholder, 'We have seen evident impact of renewable energy contributing positively to the development of our people.'[191]

CASE STUDY:

The engineer bringing clean energy to his home village

Augustine Otuokwa Ogar grew up in Mgbaeshuo village in Eastern Boki, Nigeria, a village that was not connected to the electricity grid. Despite the challenges this caused, Augustine went on to study Electronic and Computer Technology at the University of Calabar, a few hundred miles away from the village where he grew up. After graduating, Augustine returned to his village – which still did not have access to electricity.

There is a small, slow-flowing stream in the village. Using the skills and knowledge gained from his degree, along with locally sourced materials, Augustine developed an innovative hydropower generator that could turn that low flow rate into enough energy to generate 2kW of power – enough to light up local business centres so they can now sell their products at night. Young people are now able to charge their phones, laptops and batteries.

Augustine has plans go beyond this 2kW generator. He says, 'The people are waiting expectantly to see the community electrified by a power generator I will make with a higher capacity – to light up the entire village, state and nation.'

SDG 3 Healthy lives

In Nigeria, an estimated 30 per cent of hospital burn cases are due to kerosene lamp explosions.[192] Heating services, as well as cooking (though not a direct focus of this study), create household air pollution that leads to respiratory illness and kerosene poisoning. The latter is the most prevalent

191 Key informant interview.

192 BNEF et al. (2016) Op. cit.

form of child poisoning in Nigeria.[193] With 136 million Nigerians affected by household air pollution, primarily from cooking energy, 64,500 people die annually.[194]

Decentralised renewables can provide opportunities for improved healthcare, particularly in rural regions. SolarAid and Sunnymoney have reported that midwives in Nigeria find that solar lights and home phone charging contribute to better patient care.[195] Under the Kaduna Solar Clinics project, a part of the Solar Nigeria Programme, and the Lagos Solar Project, decentralised solar systems have been deployed in 45 primary health centres in the Kaduna and Lagos states. A key informant noted improved night-time care, capabilities in vaccine and medicine refrigeration and an increase in the number of patients seen.[196] In Gukuru, in Nasarawa state, the installation of a solar power system greatly improved night services and healthcare provision at the Gukuru medical centre. In the Dakwa community, in the outskirts of Abuja, the installation of a solar energy system (3 kW) has displaced kerosene lamps, helping to reduce accidents and safety risks from kerosene use.[197]

SDG 4 Inclusive and equitable education

For the Nigerian electorate, electricity was the primary issue for the incoming administration (under President Buhari) in 2015, while education was the third.[198] These issues are linked. Nigeria's schools regularly go without electricity and the more affluent schools rely on diesel generators, with the associated fuel costs.[199] The absence of electricity in 65 per cent of primary and secondary schools prevents their use of technology-based educational services.[200] The majority of schools without electricity are in rural areas, where decentralised renewables could play a vital role. But decentralised electrification initiatives for schools are underway. For example, the Lagos Solar Project (as part of the Solar Nigeria Programme) has provided decentralised solar to 175 schools in Lagos state. The result has been extended study hours and computer usage, as well as increased child enrolment and better school performance.[201]

SDG 5 Gender equality

Women are in the majority among Nigeria's poor, and improved decentralised energy services can help support female-led rural development.[202] Women are the most affected by energy poverty and are the prime beneficiaries of decentralised energy solutions. Savings from kerosene use and renewable energy entrepreneurship are creating opportunities for women.[203] For example, Solar Sister Nigeria employs a network of female entrepreneurs to distribute such solutions. Power For All Nigeria's gender programme is also empowering women to adopt decentralised solutions.[204]

Decentralised solutions can improve health outcomes for women. Every day across the world, 830 women die from preventable causes related to pregnancy and childbirth, half of them in sub-Saharan Africa.[205] In Nigeria, the Rural Women Energy Security Initiative is using small-scale renewable energy projects to target rural energy-poor women with the highest incidence of health-

193 Key informant interview.

194 Global Alliance for Clean Cookstoves. (2017) Nigeria. Global Alliance for Clean Cookstove Website. And: key informant interview.

195 SolarAid and Sunnymoney (2015) Op. cit.

196 Key informant interview.

197 Ibid.

198 Quartz Africa. (2017) Nigerians say reliable electricity should be president Buhari's top priority—not corruption. Quartz Africa Website.

199 USAID. (2017) Nigeria: Power Africa Fact Sheet. Washington DC: USAID.

200 UN Nigeria Resident Humanitarian Coordinator. In: ThisDayLive. (2017) 65% of Nigerian Schools Lack Electricity. ThisDayLive Website.

201 Key informant interview.

202 Chukuezi, C.O. (2009) Gender and renewable energy in rural Nigeria. International NGO Journal Vol. 4 (7), pp. 333-336, July, 2009.

203 Key informant interview.

204 Key informant interview.

205 WHO. (2017) Maternal mortality. WHO Website.

related issues from ‘harmful energy practices’.[206] Such energy practices can include the use of kerosene, diesel and charcoal.

Access to lighting can also be one contributing factor to improved perceptions of safety and security at night in conflict-affected states. In north-eastern Nigeria, Boko Haram has been responsible for the kidnapping of women and girls. Anecdotally, it has been argued the night-time abduction of girls from Chibok secondary school, in Borno state, was in part due to the sense of confusion through a lack of lighting.[207] The Safe School Initiative launched by the previous administration provided solar lighting to schools in north-east Nigeria to improve lighting services and security, in the aftermath of the kidnapping.[208] Such decentralised solutions are likely to play an important role, given central grid extension is unlikely to reach these remote regions.[209]

SDG 8 Economic empowerment, employment and decent work

A major constraint for Nigerian businesses is a lack of access to electricity, resulting in a loss of competitiveness and profitability.[210] A recent energy needs assessment found that 14.2 million households and 4 million small and medium-sized enterprises in Nigeria have no access to electricity.[211] Other estimates suggest there are 37 million micro-, small and medium-sized enterprises experiencing energy poverty or a reliance on expensive petrol/diesel generators.[212] The provision of electricity services can help overcome these business constraints, and may be particularly important in rural regions far away from the grid.

For every additional megawatt of renewable electricity deployed in Nigeria, it has been estimated more than 3,000 jobs could be created.[213] The National Solar Programme launched by the government and enterprise Azuri in February 2017 is aiming to create 500 direct jobs (eg solar installers and agents) and 5,000 indirect jobs.[214] Mini-grid solutions provided by GVE Group in Egbeke-Etche Rivers state (24 kW) and Bisante-Katcha (34 kW) to 3,520 rural dwellers have created 182 new jobs.[215]

Economic benefits can also be gained from the use of decentralised electricity. For example, in Plateau state, plans to use abandoned mining sites as water reserves for agriculture could use solar power to pump water to nearby farms. This could significantly increase productivity and reduce emissions.[216]

SDG 13 Tackling climate change

In Nigeria, more than 60 million people use petrol and diesel generators for alternative power supply.[217] By one estimate, the full transition to decentralised renewable energy technologies could generate 6.4 million tonnes of carbon dioxide emissions reductions a year for the country, the equivalent of 1.6 million mid-sized cars removed from roads.[218] These savings would be equivalent

---

206 Climate Investment Funds. (2017) Gender and Renewable Energy: Entry Points for Women’s Livelihoods and Employment.

207 Lilienthal, P. (2016) Renewable Energy for Security: Electricity and the Boko Haram Kidnapping. Renewable Energy World Website. And: de Lama, G. (2016) 2 years later, vigil for Nigeria's kidnapped girls goes on. The Philadelphia Enquirer.

208 Key informant interview.

209 Lilienthal, P. (2016) Op. cit.

210 USAID (2017) Op. cit.

211 All-On and Shell. (2016) Nigeria: Energy needs assessment and value chain analysis. All-On Website.

212 Key informant interview.

213 Okafor. (2016) Nigeria: Onuoha - Renewable Energy Can Add 10,000 Megawatts to the Grid. All Africa Website.

214 Key informant interview.

215 Boateng and Owunna. (2015) P40 GVE Projects Ltd. CTI-PFAN WAFCEF-2 Investment Forum; September, 2015.

216 Key informant interview.

217 Key informant interview.

218 UNEP (2013) Op. cit.

to 1.3 per cent of Nigeria's total emissions in 2014.[219] Annual kerosene savings from the full transition to decentralised renewable technologies in Nigeria are estimated at 2.3 billion litres of kerosene.[220] UNEP estimates a single kerosene lamp is responsible for 200kg CO_2.[221] This could contribute to Nigeria's Nationally Determined Contribution of unconditionally reducing carbon emissions 20 per cent by 2030. In Plateau state, government stakeholders have been advocating for the introduction of a green cities policy framework to increase renewable energy deployment in municipalities and reduce emissions.[222]

The adoption of solar lamps in rural communities can also reduce pressure on forests, contributing to climate change mitigation and combat against desertification. Anecdotally, the Great Green Wall programme deployed 92 solar-powered boreholes in 92 communities in North Nigeria and has reduced water stress, by increasing irrigation and helping to combat the effects of climate change and desertification.[223]

Political economy of decentralised renewables

An overview of Nigeria's energy governance and major political economy findings are presented in Tables 10 and 11. The World Bank RISE indicators rate the Nigeria's policy environment in relation to energy access and renewable energy poorly (at 22 per cent and 29 per cent, respectively).[224] However, Nigerian stakeholders have argued such assessments are out of date and recent policy developments have improved the policy environment towards these aims.[225] In particular, in 2015–2016, the National Renewable Energy Action Plan and the Renewable Energy and Energy Efficiency Policy were both introduced.[226]

State-level policy-making is in some cases proving to be an enabler of decentralised renewable energy opportunities also, in inviting the entrance of private investors. As an example, Plateau state developed a renewable energy policy and strategy, with public-private partnership guidelines and an off-grid implementation plan (Rural Electrification Plan based on renewable energy), in partnership with donors (eg GIZ, EU). Other states are planning similar policies.[227]

The federal government remains focused on large-scale grid-connected power projects, and is still investing in hydrocarbon exploration in the Lake Chad Basin and other inland basins in Nigeria, spending more than $340 million in the last three decades. Though the government is beginning to recognise the potential role of decentralised solutions, it creates mixed signals for investors.[228] Some positive examples include the fact that in 2017 the government launched the Mini-Grid Policy and a $350 million World Bank/Rural Electrification Agency (REA) electrification facility, with $100 million dedicated to the deployment of mini-grids. The REA under the Rural Electrification Strategy and Implementation is also aiming to mobilise off-grid technologies in last-mile communities (including

219 Authors' calculation, based on CAIT (2017).

220 Ibid.

221 SolarAid (2014) Op. cit.

222 Key informant interview.

223 According to the National Agency for the Great Green Wall in Abuja. Source: Mamman. (2015) Combating desertification in Nigeria with a "Green Wall". Daily Trust.

224 ESMAP (2017) Op. cit.

225 Key informant interview.

226 (Nigeria) National Council on Power. (2015) National Renewable Energy Action Plans (NREAP) (2015-2030): First Version. Federal Ministry of Power, Works and Housing. And: (Nigeria) Ministry of Power. (2015) National Renewable Energy and Energy Efficiency Policy (NREEEP). Federal Ministry of Power, Works and Housing.

227 Key informant interview. And: http://rea.gov.ng/projectdashboard/.

228 Another example is the Federal Ministry of Power that launched a solar park project in Jigawa in 2017. This is also serving as a research institute for innovation in the Nigerian solar energy technology market.

through platforms for Energizing Education, and Energizing Economies, for example).[229] In addition, there are a number of government agencies claiming authority over national renewable energy policies, resulting in different targets and creating mixed signals for the sector.[230]

It can be argued, though, that donors and private sector entrepreneurs are helping to lead the decentralised agenda in Nigeria. For example, GIZ has been working with the government on pilot solar PV mini-grid projects. Other players include the UK Department for International Development, International Finance Corporation, and Japanese and US governments, supporting off-grid solar activities.[231] The Renewable Energy Association of Nigeria, a national trade association for developers and distributors, has also been instrumental, giving the industry a seat at the table to help the government develop the market and unlock financing.[232] In 2017, the Nigerian Bank of Industry launched a $3.3. million (1 billion naira) fund for decentralised rooftop and mini-grid solar systems for micro-, small and medium-sized enterprises, supported by the United Nations Development Programme.[233]

Companies in the decentralised renewable energy market include Lumos Nigeria and the telecom company MTN. Mini-grid companies include the leading indigenous company, GVE technologies, as well as SOSAI Renewables, Solarmate, Havenhill Energy and Vaya Energy and Rubitec Solar, while players in the SHS market include A-Stevens Solar, Arnergy, Blue Camel, Protergia Energy Creeds Energy and Solar-Centric Technologies.[234]

Policy and implementation gaps persist. Developers are restricted in mini-grid developments by a one MW project capacity limit, after which developers are required to undergo licensing procedures; an inability to develop in municipal areas; the fact that project sites are not permitted to be within a distribution company's (DISCO's) five-year expansion plan (and if they are, the mini-grid operator must obtain permission from the DISCO to operate); and the necessity for operators to obtain support from local communities.[235] Although projects remain risky, obtaining mini-grid permits reduces risks for the operator by guaranteeing private sector developers the bargaining power to engage with distribution companies (DISCOs), where DISCOs' expansion plans overlap with mini-grid operation areas, and enabling them to negotiate favourable terms. Hence, as DISCOs decide to undertake rural electrification in the area, the risk of being sidelined or losing out is greatly reduced. As of September 2017, the National Council on Power developed a policy enabling bilateral electricity trading (for larger-scale renewable energy). Policies were applied to embedded generation regulation,[236] captive power[237] regulation and mini-grid regulation.[238] Captive or embedded power generation can now be sold directly to consumers, allowing negotiation with communities that are ready to purchase energy, where before it was sold to DISCOs.[239]

Financing is not always readily available. Investors are concentrated on larger-scale project opportunities. At lower tiers of access, household solutions can be too costly and private sector investors need to enter the market to enable payments via pay-as-you-go schemes.[240] Owner equity

229 Key informant interview.

230 Ibid.

231 http://www.offgridnigeria.com/new-era-nigerias-decentralized-renewable-energy/

232 Key informant interview.

233 Key informant interview.

234 Ibid.

235 Ibid.

236 Electricity generation that is connected to a decentralised distribution network.

237 Electricity generation that is set up to generate electricity for personal use (eg by a business, community).

238 Key informant interview.

239 Ibid.

240 Ibid.

financing remains the dominant form of financing for decentralised electricity solutions (at Tiers 1–3).[241] More generally, local financing is also needed to match international financing, to make it cheaper for borrowers and reduce exchange risks.[242] Stringent banking regulations limit mobile money providers, seeking operation outside or in the grey areas of regulatory space. Incumbent banks therefore monopolise banking services and mobile money.[243] Despite this, mobile money penetration remains low (at one per cent of mobile users).[244] Multilateral development banks, such as the African Development Bank, also provide funding, though the conditions can often be too stringent for local entrepreneurs.[245] There is also a growing appetite among bilateral donors and philanthropic organisations towards the financing of decentralised electricity solutions (Tiers 1–3).[246]

From a fiscal perspective, while zero tariffs exist on solar panels, these rise to 35 per cent for batteries. A key informant has noted that this was in part the result of lobbying by actors with an interest in promoting diesel generators in the Nigerian energy market. In addition, solar lanterns and home systems are difficult for customs officers to categorise (as either renewable energy components or complete products, which have different tax implications). The result is a large fiscal burden, which is placed on distributors of such technology solutions.[247]

241 SEforALL. (2017) Energizing Finance. Scaling and refining finance in countries with large energy access gaps. Sustainable Energy For All.

242 Key informant interview.

243 Mele, P. and Couture, T. (2017) Taking the Pulse: Understanding Energy Access Market Needs in Five High-Impact Countries. Sustainable Energy For all.

244 SEforALL. (2017) Op. cit.

245 Key informant interview.

246 SEforALL. (2017). Op cit.

247 Key informant interview.

Table 10 Energy sector governance and policy in Nigeria

Governance	**Generation**	In 2013, the public utility, the Power Holding Company, was fully privatised, with generation activities handed over to six generation companies (GENCOs), which operate the power plants.
	Transmission	The state-owned Transmission Company of Nigeria is responsible for transmission activities. There is a single control centre in Oshogbo. The government set up an agency, the Nigerian Bulk Electricity Trading Ltd, to buy electricity from GENCOs and sell it to DISCOs. They are the operators of the Nigerian Electricity Market, and are responsible for the wholesale market and payment settlements within the Nigerian electricity industry.
	Distribution	During the privatisation process, distribution activities were handed over to 11 distributed energy companies (DISCOs). Severe financial problems have pushed certain DISCOs to the point of bankruptcy, while also worsening electricity supply.
	Regulator	The Nigerian Electricity Regulatory Authority regulates the sector. Other supportive regulatory oversight roles are performed by the Nigerian Bulk Electricity Trading Ltd, Nigerian Electricity Management Services Agency and National Power Training Institute of Nigeria.

Note: The Federal Ministry of Power is in charge of policy setting and the Rural Electrification Agency is responsible for the coordination of rural electrification. Source: Emodi (2016); GIZ (2015); key informant interviews.

Table 11 Policy issues and recommendations for Nigeria

Policy barrier	Challenges and opportunities	Potential policy actions
Policy framework and implementation	The government's primary focus is on centralised grid electricity, but there is increasing commitment by the government and other actors to increase decentralised renewable generation. This includes creating a space for the private sector to operate. Recent positive decentralised energy policy progress has also been achieved at the state level (eg Plateau state). Governance overlaps persist, with energy mandates across different government agencies. Governance remains a challenge along the generation, transmission, distribution and regulation chain. Policy implementation also remains a challenge (eg restrictions on the development of mini-grids).	Demonstrate political will by increasing the emphasis on cost-effective decentralised renewable energy solutions in energy policy, and clear pathways of commitment. In particular, encourage investment in renewable energy-based mini-grids (under the Mini-Grid Policy) by reducing restrictions on mini-grid development. Improve coordination on renewable energy policies and targets across relevant government agencies. Empower the Rural Electrification Agency to oversee renewable energy plans, policies and targets, in particular decentralised energy services. Encourage effective governance in agencies responsible for electricity generation, transmission, distribution and regulation.
Access to finance	High interest rates and very low levels of access to banks affect finance for SMEs and rural area consumers. This is largely because the renewable energy sector is seen as high-risk.	Facilitate access to finance for actors across the value chain, in particular SMEs and rural consumers. This should include low-interest loans and pay-as-you-go schemes, in cooperation with financial institutions and other funding organisations. Take measures to reduce the perception of risk in the renewable energy sector and to attract investment, patient capital and venture capital (eg credit guarantees and first-loss facilities).
Fiscal barriers	Zero tariffs exist for solar panels, but high-cost tariffs remain for the import of solar batteries, inverters, charge controllers, SHS and other renewable energy system components. This reduces their cost-competitiveness.	Apply measures to reduce import duties for solar batteries, lanterns and SHS and other system components (ie tax incentives). Train relevant agencies such as the Customs and Standards Organisation of Nigeria in implementing standards.
Consumer protection and quality assurance	There is non-existent consumer protection or quality assurance for decentralised renewable energy, including solar products. This may	Adopt international quality standards for renewable energy products to reduce market spoilage (applied by the Customs and Standards

	already have caused poor reputation and market spoilage.	Organisation of Nigeria, and during energy contract bids). Protect consumers' rights by ensuring providers of decentralised renewable products are accountable through legal provisions.
Level playing field	Very high subsidies are provided to kerosene and petrol fuels. This is seen as a welfare measure and is highly supported by Nigerians.	Review subsidies for kerosene and petrol fuels, or apply the waivers and incentives for fossil fuels to renewable energy technologies. Tackle the perception of these being a welfare measure through awareness campaigns (eg earmarking fiscal savings for other social goods, such as health or education).
Consumer awareness	Low levels of awareness, with up to 40% of population unaware of the advantages of decentralised renewable energy. A poor existing reputation is evident in certain areas, due to previous failed solar programmes.	Develop a government narrative on the transition to renewable energy. Create citizen buy-in through raising awareness of the benefits of renewable energy technologies, including job creation opportunities (eg national awareness campaigns through the media, civil society advocacy etc). Adopt best practice models to improve the reputation of decentralised renewable energy projects, in particular solar projects.
Consumer financing	Very low access to finance for SMEs and the rural population. Only 0.1% of Nigerians have access to mobile financing.	Improve access to consumer finance, especially for SMEs and the rural population (eg mobile pay-as-you-go schemes and micro-finance). Relax stringent banking regulations that limit mobile money providers. Ease the stringent conditions of development banks for local entrepreneurs. Increase ease of borrowing and lower exchange rate risks by enabling local financing to match international financing.
Level of local skills	Skilled renewable energy technicians are rare due to low national experience in solar PV systems and concentrated solar power.	Increase domestic value creation by building a qualified workforce for the renewable energy sector, especially technicians for solar PV systems and concentrated solar power. Focus efforts in rural, decentralised regions. Earmark public financing for current renewable energy training programmes and technician certification schemes.

Source: Various references op. cit. and key informant interviews.

3.5 Tanzania

Current state of play

In 2016, access to electricity in Tanzania varied from 16.9 per cent in rural to 65.3 per cent in urban areas, but certain rural regions have yet to achieve 10 per cent local population access.[248] With one of the highest rates of population growth,[249] and with rapidly growing energy demand, it will be increasingly difficult to maintain and increase energy access. Biofuels and waste dominate primary energy supply (at 94 per cent).[250]

Over half of the on-grid electricity supply is from fossil fuels. While oil and hydropower generation used to dominate the electricity sector, natural gas is now the leading source of electricity supply (42.2 per cent) (see Figure 8).[251] The country also has significant natural gas reserves and renewable energy sources, but is reliant on expensive oil imports (25 per cent of total imports).[252]

The country has a history of decentralised diesel generators and hydropower mini-grids (or 'multi-function platforms').[253] As of 2017, 300 MW of decentralised power generation capacity exists in Tanzania, and 93 mini-grids have been installed (off-grid).[254] New initiatives are in the pipeline. Engie and E.ON have launched solar mini-grid business units in Tanzania.[255] These mini-grids vary from less than 10kW to 10,000kW (see Figure 9).[256] At lower tiers of electricity access, Tanzania houses the second largest African market after Kenya for solar lamps and home systems. It is estimated that 661,000 solar lamps and home systems were sold in the year leading up to June 2016.[257]

Figure 8 Tanzania. Electricity supply 2015

248 United Republic of Tanzania (2017) Energy Access Situation Report 2016, Tanzania Mainland. National Bureau of Statistics and Rural Energy Agency.

249 Worrall, L., Colenbrander, S., et al. (2017) Better Urban Growth in Tanzania: a preliminary exploration of the opportunities and challenges. London: NCE Cities [Global Coalition on Urban Transitions].

250 IEA. (2017) IEA statistics.

251 IRENA. (2017) Renewable Readiness Assessment: United Republic of Tanzania. Abu Dhabi: IRENA. And: World Bank (2017) World Development Indicators. World Bank Website.

252 IRENA (2017) Op. cit.

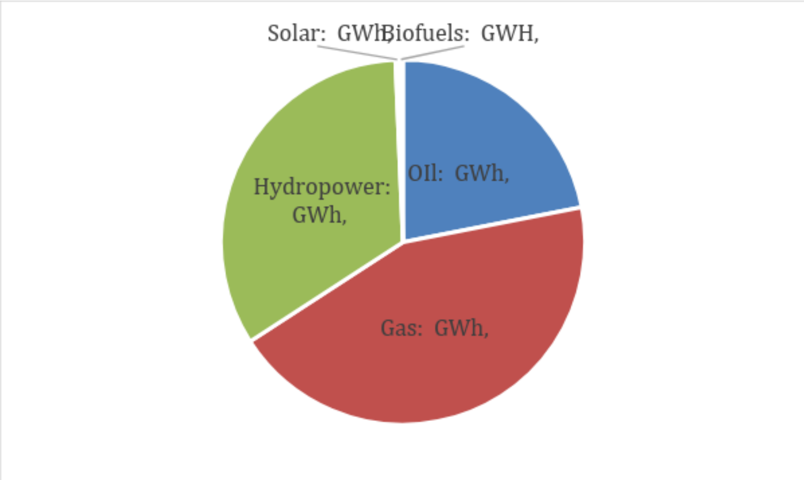
253 RECP, EU EI and Africa-EU Energy Partnership. (2013) Workshop 'Mini-grids: Opportunities for Rural Development in Africa'. Arusha, Tanzania, 5 September 2013.

254 IRENA. (2017) Op. cit. And: TaTEDO and WRI. (2017) Accelerating minigrid deployment in sub-Saharan Africa: Lessons from Tanzania. Washington DC: World Resources Institute.E

255 Tice, D. (2017) Energy Africa – Plan of Action Tanzania. Evidence on Demand.

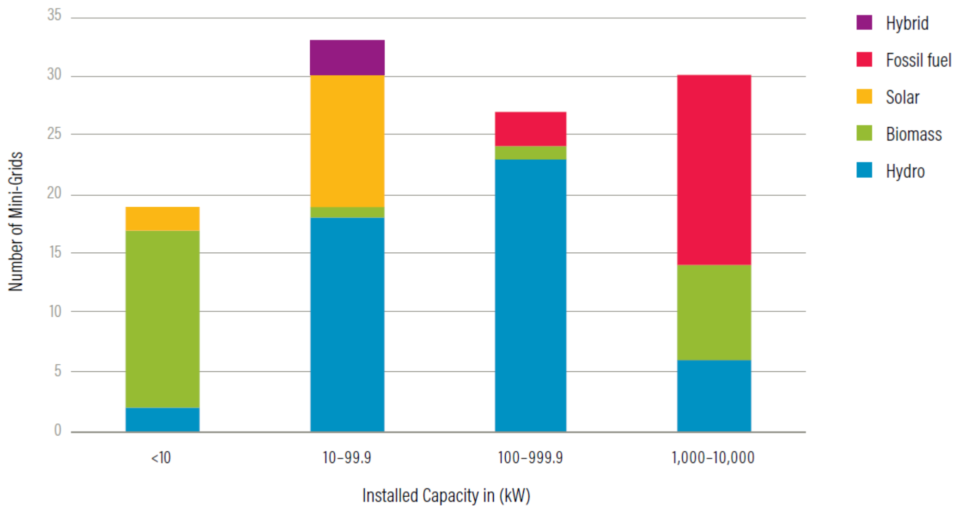
256 TaTEDO and WRI. (2017) Op. cit.

257 Solar lamp companies include: d.light and Greenlight Planet. Zola and Mobisol lead the solar home market. Source: Tice, D. (2017) Op. cit.



Source: IEA Statistics (2017)

Figure 9 Capacity of Tanzania's mini-grids



Source: WRI and TaTEDO (2017)

Cost-effectiveness of decentralised renewables

Tanzanian off-grid households spend between $151 and $223 annually on traditional lighting sources and mobile charging (2015 data).[258] In line with global trends, the levelised costs of renewable energy technologies in Tanzania are declining. In 2015, Tanzania's solar PV costs ($0.118–0.14 per kWh) were in the middle range of the global LCOE of fossil fuels in 2017 ($0.05–0.15 per kWh).[259] The costs of concentrated solar power (CSP) technology are slightly higher ($0.214–0.22 per kWh) and wind costs can vary significantly (from $0.065–10 per kWh).[260] (The latter likely indicates the large differences in deployment conditions with regards to scale, grid connectivity and other factors.) On top of this, there are significant connection charges. These impact urban areas mostly, given the Rural Energy Agency's decision to cap rural connection charges at $12 (or 27,000 Tanzanian shillings).[261]

258 Dalberg Advisors et al. (2018) Op. Cit.

259 IRENA. (2014) Renewable Power Generation Costs in 2014: Executive Summary. Paris: IRENA. And: IRENA. (2018) Renewable Power Generation Costs in 2017. Paris: IEA.

260 IRENA (2017) Op. cit.

261 This is based on a conversion rate of 1 TZS = 0.000444780 USD. Source: Key informant interview.

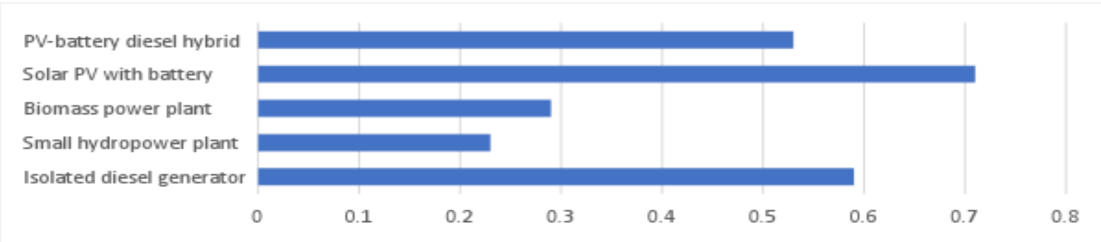
Focusing on decentralised solutions in 2013, the annualised costs of solar lamps were lower than traditional alternatives reliant on kerosene and paraffin (see Table 12).[262] For mini-grids in 2013, the annual costs of isolated diesel generators (US $0.59 per kWh) and solar PV systems with batteries ($0.71 per kWh) are among the most expensive technologies. PV battery and diesel hybrids are also costly ($0.53 per kWh). In addition, fluctuating diesel prices create cost uncertainties. Small hydropower plants ($0.23 per kWh) and biomass plants ($0.29 per kWh) are among the most cost-effective (see Figure 10).[263] They also avoid the price uncertainty of fluctuating fuel prices.[264]

Table 12 Annual costs of solar lights and traditional lights (US$) in Tanzania, 2013

	Solar lighting products			Other (traditional) lighting devices		
	Lanterns	Task light	Solar torch	Koroboi	Hurricane lamp	Mchina
Initial cost	18.0	32.2	6.2	0.2	4.8	5.3
Fuel/battery	3.1	9.3	3.1	89.3	187.2	67.9
Maintenance/ replacement	0.9	1.6	0.3	0.2	2.5	19.5*
Total cost	**22.0**	**43.2**	**9.6**	**89.8**	**194.5**	**83.7**

Note: Converted from TZS to USD (2013 rates). *2 replacements a year. Source: LAMIM (2013) in Lighting Global (2013). Traditional lighting devices are reliant on kerosene and paraffin.

Figure 10 Levelised costs of mini-grid technologies in Tanzania (US$ per kWh), 2013



Source: SREP (2013)

Contributions to the SDGs

SDG 3 Healthy lives

In Tanzania, electricity deficits are found in more than half of health facilities, a lower level of access to electricity than the sub-Saharan regional average.[265] As demonstrated by the other countries, electricity can be a strong enabler of improved healthcare.

262 Lighting Global (2013) Tanzania Market Intelligence: Final Report. Lighting Africa Website.

263 Scaling Up Renewable Energy Programme (SREP). (2013) Investment Plan for Tanzania. Climate Investment Funds Website.

264 For example, in 2017, Tanzania's energy regulator raised diesel prices (3.10%) and lowered kerosene prices (1.04%). This would affect the LCOE estimates for 2013. Source: Reuters. (2017) Tanzania Raises Petrol, Diesel Prices, Kerosene Edges Down. Reuters Website.

265 Africa Progress Panel (2017) Op. cit.

Anecdotal evidence from the Ludewa District in Tanzania shows that a community-owned hydropower mini-grid has helped improve the retention rates of medical staff and village health centres, which can now use microscopes and refrigerators to store medical supplies.[266] According to villagers, this has reduced child and maternal mortality locally, as well as decreasing disease burdens.[267] A key informant interviewed supported this view in noting that decentralised renewables can reduce the cost burdens of health staff's living expenses and transport costs.[268] Innovation Africa has found a 400 per cent increase in the number of women seeking maternal healthcare at medical clinics following the introduction of solar power.[269]

'Before I bought a solar panel I used to use a kerosene lamp. I used to have a lot of health problems; the smoke affected my chest and I felt chest pains. My eyes didn't work properly; even the atmosphere was not good.' Now Grace does not have these problems anymore: 'Now I feel that my life has changed because I have solar.'

Grace, 66, an entrepreneur in Makutupora, Tanzania

SDG 4 Inclusive and equitable education

An interview with a Tanzanian informant found an important role for better lighting (provided through, for example, solar lighting) in increasing the number of study hours, enabling basic computer lessons, and improving teacher retention rates in rural areas.[270] Anecdotally, another civil society stakeholder observed improved eye health in children with the deployment of solar lamps, evidenced by a lack of redness in their eyes when visiting rural areas.[271]

In 2014, a report documented the installation of 14 containerised solar units (15 kWp) in ten villages in the districts of Kongwa, Dodoma, Uyui, Tabora and Mlele Katavi, which are powering households and six schools. Villagers noticed increased study hours, alongside improved literacy rates and performance in national exams. The electricity has also enabled computer lessons.[272] Innovation Africa, through solar installations in Tanzanian schools, has noted a tripling in graduation rates.[273] Meanwhile, the Solar Without Frontiers charity, in partnership with the Wind and Sun company, have installed 30 off-grid solar PV panels attached to a battery in a school in Mvimwa, Tanzania – increasing the school's information technology (IT) capacity and generating annual fuel savings of an estimated £3,200, alongside additional savings in alleviating the logistical costs of transporting fuel to the remote location.[274]

266 Odarno, L. (2017) Electrifying Africa with Mini-grids: Five Lessons from Tanzania. WRI Blog.

267 WRI and TaTEDO (2017) Op. cit.

268 Key informant interview.

269 WWF and United Nations Foundation. (2015) Towards Universal Energy Access: Tanzania. Organized by the United Nations Foundation and the World Wide Fund for Nature – Tanzania Country Office. Energy Access Website.

270 Key informant interview.

271 Ibid.

272 Key informant interview.

273 WWF and United Nations Foundation. (2015) Op. cit.

274 Wind and Sun. (2017) Tanzanian School. Wind and Sun Website.

SDG 5 Gender equality

Traditional energy options – such as wick and kerosene lamps – can negatively impact the health of Tanzanian women and girls, increasing their exposure to smoke and the risk of respiratory illness.[275] Avoiding emissions therefore reduces exposure and associated health risks. Access to lighting can also support an improved sense of security among women and girls, as has already been evidenced in some of the other country evidence (eg DRC). A Tanzanian example is the deployment of 600 street lights in five districts, enabled by decentralised solar mini-grids.[276]

Access to modern electricity can reduce the time women spend on the care economy, releasing them for other tasks such as educational or income-earning opportunities. Anecdotally, a civil society stakeholder commented on the role of decentralised renewable solutions in pumping water, which is saving women time that would otherwise be needed for the collection of water, sometimes requiring travel across long distances.[277] The decentralised renewable energy value chain is also creating jobs. This is illustrated by the example of Solar Sister, which operates through a network of 1,800 women entrepreneurs in rural Uganda and Tanzania. Most Solar Sister customers have substituted solar lamps for kerosene, using the savings for school fees, farming inputs and investment in businesses.

'Light was expensive, like buying kerosene, but with electricity there are a lot of things we can do at night. I am busy in the afternoons so now I can use the time in the evenings.'

Rachel is a tailor in Makutupora in central Tanzania. Now that she has a solar light, she can work in the evenings, making clothes to sell to people in the village. By working three or four hours each evening, she has increased the family's monthly income from 70–80,000 TZS ($31–35) to sometimes as much as 150,000 TZS ($66).

SDG 8 Economic empowerment, employment and decent work

Access to decentralised energy solutions can enable productive activities in rural zones. In Mawengi, the LUMAMA hydro mini-grid has enabled barbers, butchers and restaurants to extend business hours using electric lighting, increasing the number of customers and boosting revenues.[278] New business opportunities have also emerged in the local pressing of sunflower seeds into sunflower oil, which was previously imported. Other new business activities included poultry farming and fruit processing.[279]

Access to information can also increase business rents. For example, in Rungwe, access to mini-grid electricity has enabled the use of phones, radios, TVs and the internet by the local population. This allows rural farmers to access market information, enabling them to sell more produce and receive higher prices for what they sell.[280] Anecdotally, the pumping of water with renewable power can help to support small farms. The availability of decentralised power is also retaining human capital in

275 SE4All. (2015) Tanzania's SE4All Action Agenda. SE4All Website. And: Rural Energy Agency. (undated) Rural Energy Agency and Innovation in Delivery of Modern Energy Services to Rural Areas.

276 WRI and TaTEDO (2017) Op. cit.

277 Key informant interview.

278 Key informant interview.

279 Ahlborg, 2015; in TaTEDO and WRI. (2017) Op. cit.

280 Mwakaje, 2010; in, TaTEDO and WRI. (2017) Op. cit.

rural regions. In particular, young people are opening small businesses such as charging kiosks and barber shops.[281]

CASE STUDY:
Ali has doubled his income using a solar panel

Ali is 35 years old and lives in Kinangali village in the Dodoma region of Tanzania with his wife and two children, aged 12 and 4. He moved to this village four years ago. When he arrived, Ali identified a need in the village: local people kept cattle, but had to travel a long distance to Manyoni for treatment for their animals if they became sick. He opened a kiosk selling medical supplies for cattle, such as dipping solution and antibiotics.

Ali had been thinking of moving again, until the launch of a Tearfund-initiated Pamoja community savings group persuaded him to stay. There are 19 people in the group, which Ali joined in January 2017. He took out a loan from the group, and with 75,000 TZS ($33) bought a solar panel.

The government doesn't fund the national grid to reach Ali's village and it will be some years before it arrives. In the past, Ali used a torch with batteries for light, and had to close his kiosk at 6pm, when it got dark. Now, with the solar panel, he can stay open in the evenings. He can also charge his mobile phone, which he uses to buy goods for his business. Ali used to earn 5,000 TZS ($2) a day; now he makes 10–20,000 TZS ($4–8). He saved that extra money and has bought a plot of land. He plans to buy a house and would like to expand his business. With a more powerful solar panel, he could buy a fridge to sell cold drinks or to charge other people's mobiles.

The Pamoja group enables the local community to save money together and share in one another's successes. 'I will continue to be in this Pamoja group so I can prosper, and tell others to join the group because I know for sure we will start at the bottom and go to the top – step by step we will succeed in our lives.'

SDG 13 Tackling climate change

The Institute of Sustainable Futures estimates that Tanzania's energy emissions could reach 90 million tonnes in 2050 under business-as-usual, compared with a 100 per cent renewable energy scenario reaching 24.5 million tonnes.[282] From the decentralised perspective, emissions from kerosene and diesel remain high. An estimated 0.3 per cent of Tanzania's mainland population have generators, equivalent to 27,080 people, whilst 58.4 per cent of households use kerosene lamps (National Bureau of Statistics, 2012 data).[283] A single diesel generator (10–100kW) produces approximately 1,300kg CO_{2e} emissions per MWh (Europa, undated). The distribution of 1 million solar lights in Tanzania to date has resulted in an avoided 105,700 tonnes CO_{2e} in two years (2014–2016),[284] equivalent to a small fraction of the country's total emissions (286.5 million tonnes in 2014).

281 Key informant interview.

282 Institute of Sustainable Futures. (2017) 100% Renewable Energy for Tanzania: Access to renewable energy for all within one generation. World Future Council Website.

283 Lighting Global. (2017) Tanzania. Lighting Global Website.

284 Ibid.

Political economy of decentralised renewables

An overview of Tanzania's energy sector governance and major political economy findings is presented in Tables 13 and 14. According to the World Bank RISE indicators, Tanzania outperforms the DRC and Nigeria's policy environments for energy access and renewable energy scores (79 per cent and 59 per cent, respectively).[285] Energy policy is not necessarily aligned, however. For instance, the Planning Commission's Five Year Development Plan (FYDP) II aims to increase hydropower and renewables to 70 per cent of generation capacity by 2025. Meanwhile, the Ministry of Energy's Power Sector Master Plan aims to achieve 27 per cent generation from these sources by 2040.[286]

The positive stakeholder perceptions of an effective policy environment carries through to the decentralised energy sector. In particular, the Electricity Act (2008) contains initiatives encouraging private participation in small renewable power production and distribution – and since then, the installed capacity of mini-grids has nearly doubled. In 2015, further revisions applied 'standardised power purchase tariffs' according to renewable technology, capacity and localised site characteristics, to enable an accurate reflection of costs.[287] The government has taken a number of further steps to incentivise deployment, such as the elimination of renewable energy equipment tariffs (2000); commercial loans for small power producers (2008-2014); a toolkit for training on small power producer incentives (2010-2015); and pegging feed-in tariffs to US dollars to overcome inflation and currency fluctuation (2012-2015).[288]

The government has strongly engaged with the role of decentralised solutions. The Rural Electrification Authority is deploying a programme on rural electrification, though the reach to date remains small.[289] The government also has a national programme to promote the deployment of solar lamps and SHS.[290] There has meanwhile been an acceleration in private companies in the market, in particular solar companies. These include REX, ENSOL, ZARA Solar, Mobisol, Off-Grid Electric or M-Kopa, Chloride Exide Tanzania, Umeme Jua, Tunakopesha, Greenlight Planet, Azuri and Solar Sisters, among others.[291] Donors and development finance institutions have also been important actors. As an example, GIZ has developed a mini-business plan calculator and manual for productive end-use mini-grid programmes.[292]

Energy governance challenges remain in the energy sector. Issues remain with the development and implementation of harmonised policy and strategy. There is also a need for improved coordination among actors, with government oversight to coordinate the prioritisation of decentralised projects, in line with national priorities and financing, including the creation of a centralised government database. Such a role could be carried out by the Rural Energy Agency or the Tanzanian Electricity Supply Company (TANESCO). Beyond this, the simplification of procedures for mini-grid development processes could accelerate project development. Meanwhile, capacity building is necessary for local developers during the development stage (such as in the development of initial studies, business plans and bankable project documents) and during the implementation stage (such as for the effective design, procurement, construction and management of projects).[293]

From a financial perspective, the financial challenges of TANESCO – the electricity utility – are widely acknowledged by stakeholders to be severe. This has resulted in a number of government energy

285 ESMAP. (2017) Op. cit.

286 Climate Scope. (2017) Tanzania. Climate Scope Website.

287 Key informant interview.

288 TaTEDO and WRI. (2017)

289 Key informant interview.

290 Dalberg et al. (2018) Op. cit.

291 Key informant interview. And: Dalberg Advisors et al. (2018) Op. Cit.

292 Best, S. (2017) Powering local development in Tanzania. IIED Blog.

293 Key informant interview.

actors being demoted or imprisoned over time. As of January 2017, TANESCO's debt had reached $363 million, having increased from $250 million at the end of 2015.[294] TANESCO's ability to pay agreed 'standardised power purchase tariffs' in the long term is therefore under doubt.[295]

Other financing challenges include access to financing. While small or large systems rely on standardisation or scale to keep costs down, the 'missing middle' of medium-sized systems are less profitable.[296] And overall, the total project and connection costs of mini-grids remain high. Prioritisation is therefore granted to on-grid projects with the ability to connect more people at a lower cost. Commercial investors also often consider rural electrification to be risky, given the unproven technologies, a lack of familiarity with these technologies and the low or variable incomes of rural consumers. It is therefore difficult for developers – and their sponsors – to establish the economic and financial viability of relatively small projects. In particular, access to private sector funding (eg commercial loans) remains elusive.[297]

Table 13 Energy sector governance in Tanzania

Governance	**Generation**	The Tanzania Electricity Supply Company (TANESCO) – the state-owned electricity incumbent – is responsible for the generation of electricity.
	Transmission	TANESCO is responsible for the transmission of electricity.
	Distribution	TANESCO is responsible for the distribution and final sale of electricity.
	Regulator	The Energy and Water Utilities Regulatory Authority (EWURA) regulates the energy sector.

Source: TANESCO and EWURA websites.

294 Climatescope. (2017) Op. cit.

295 TaTEDO and WRI. (2017) Op. cit.

296 Best, S. (2017) Op. cit.

297 Key informant interview.

Table 14 Policy issues and recommendations for Tanzania

Policy barrier	Challenges and opportunities	Potential policy actions
Policy framework and implementation	Strong foundations are in place for a positive enabling environment, which has accelerated private sector investment in small renewable power production and distribution. The focus is on on-grid and mini-grid solutions, and more emphasis could be placed on off-grid solutions. There are specific plans for rural areas. Policy implementation and improved coordination among government ministries remain a challenge. There are also cumbersome project development processes in some cases.	Scale up the role of off-grid targets (eg solar lamp and SHS) in energy policy to remove policy uncertainty and improve energy access. Improve coordination for energy policy development and focus on implementation. For decentralised projects, this could include prioritisation mechanisms (eg creation of a centralised government database by the REA or TANESCO). Simplify procedures for mini-grid development processes to accelerate project development.
Access to finance	Although relatively well established, the solar market is still under-capitalised and vulnerable to exchange rate volatility. Finance for established players is slowly beginning to flow, but there is a 'missing middle' of medium-sized systems. Access to private sector funding (eg commercial loans) remains elusive.	Mobilise access to finance for actors across the value chain, in cooperation with financial institutions and other funding organisations. Establish financial risk guarantees for the 'missing middle' of medium-sized projects. Put in place policy measures to attract international investors. Adopt innovative methods (eg EnDev provides Tanzanian private-sector suppliers a cash incentive based on the performance – or lumen hours – of products).[298]
Fiscal barriers	Solar products are exempt from VAT and tariffs, but batteries are not. Despite this, clearing costs remain. Financial challenges of the electricity utility, TANESCO, reduce its ability to pay agreed 'standardised power purchase tariffs' in the long term. Some of these tariffs are non-reflective of generation costs. TANESCO tariff payments may also be delayed.	Apply measures to facilitate the import of batteries for solar systems, including exemptions from VAT and tariffs. This should be coupled with ensuring that such measures account for the quality of products, product components or accessories (eg batteries).
Consumer protection and quality assurance	A huge challenge has been created by a large influx of low quality and fake solar products into the market. This has resulted in short product lifetimes and high costs for users who need to replace faulty products or sub-components.	Adopt international quality standards and raise consumer awareness about the standards for renewable energy products, to prevent market spoilage from sub-standard products. Protect consumers by ensuring solar providers are accountable through

298 Dalberg Advisors et al. (2018) Op. cit.

		legal provisions.
Level playing field	Kerosene is not directly subsidised. But public subsidies for grid access and solar products may affect the solar market. Renewable energy mini-grids are not subsidised (ie solar, hydropower and biomass).	Provide a level playing field for the mini-grid solar sector and private investment, including reviewing subsidies for grid access.
Consumer awareness	Consumer awareness is very high in certain regions (eg near Arusha, Dar es Salaam, Highlands and Lake Zones). There is low awareness of solar products in some other areas of the country.	Increase consumer awareness of solar products and their benefits in regions with low awareness.
Consumer financing	Pay-as-you-go financing for solar home systems is now common in many regions.	Improve access to end-user and consumer finance, by scaling up and promoting mobile payment mechanisms and micro-finance. Conduct campaigns to promote the productive use of electricity services to enable communities to deliver on payments (and to sustain such services).
Level of local skills	There is a relatively high level of human capital. Some training has been undertaken by Tanzania Renewable Energy Association, as well as training by other market actors. More generally, there is readily available human capacity for installing smaller systems (eg SHS). However, human capacity for the installation and maintenance of mini-grids remains a challenge.	Build the capacity of local developers during the development and implementation stage. This should in particular target capacity for mini-grid projects (eg for the effective design, procurement, construction and management of projects).

Source: Various references op. cit. and key informant interviews.

4. CONCLUSIONS

Historically, access to electricity in most countries has been achieved by extending a grid that is connected to centralised, large-scale thermal or hydropower plants. In countries where energy poverty is a major constraint to development, governments continue to focus on high-cost and timeintensive projects that prioritise grid extension. The five countries included in this study are no different. Their electrification objectives give priority to grid connections.

Although the attractiveness of decentralised electricity options is increasing, they are not always integral to policies and plans for the development of the electricity sector. Responsibility for off-grid electricity might be held by a department or ministry that is separate from the ministry responsible for the power sector, as found in Myanmar, Nepal and Nigeria. This can lead to policy compartmentalisation and confusion about responsibilities.

When decentralised renewable electricity options are included in policies and plans, as for example in Myanmar, they are regarded as an interim solution until the government or utility can extend the grid to all households and businesses. This is implicit recognition that investments in grid extension can entail very long lead-times, while the distribution and installation of solar lamps and home systems may take only a few weeks.

For those living in energy poverty in rural areas, delays in access to electricity hinder opportunities for development gains through access to modern energy services. When households lack access to electricity, because they cannot afford it or because they are still waiting for the grid to arrive, there is an opportunity cost of missed development opportunities. For example, the use of solar lamps has been shown in some countries to increase school students' hours of study. Decentralised renewable electricity avoids greenhouse gas and particulate emissions from the use of kerosene lamps or diesel generators, and thus avoids associated negative health impacts (burns and respiratory illnesses) and climate change effects. Although evidence for the impact of solar lamps and SHS on productivity and production is mixed, there is evidence of increased hours of operation of retail businesses.

The LCOE for decentralised renewable electricity is lower than the equivalent cost of grid extension in many places, and is expected to decline further. It is also lower than the cost of decentralised diesel generators. However, robust and comparable cost information is not readily available everywhere (eg the LCOE for solar off-grid in DRC and Nigeria). As the grid is extended to remote communities and thinly populated rural areas, the average investment cost of a grid connection will increase. In Myanmar, for example, grid connections are now estimated to cost approximately $1,000. Such connection costs may be prohibitive for consumers, and the revenue from new connections to low-income households unattractive for utility companies. In contrast, for solar lamp and SHS purchasers, the savings on avoided kerosene and battery expenditure can often exceed the purchase cost within a short period.

The evidence from the five countries reviewed in this study highlights several other barriers to the adoption of off-grid renewable electricity. One of the most notable of these is the overall business environment and the extent to which this discourages private investment, particularly in solar off-grid markets. In Myanmar, Nepal and Tanzania, for example, the levels of public subsidy for electrification – on and off the grid – provide limited opportunities and incentives. Bureaucratic procedures and the limited capacity of government institutions can also be a challenge. This can affect the availability of finance for consumers and businesses, and the application of product standards to protect consumers.

With the exception of Tanzania, there is a skills deficit for the off-grid renewables market. Investment in technician skills for the installation, maintenance and repair of solar lamps and SHS will be necessary. Expertise for mini-grid design, implementation and operation is also in short supply.

5. RECOMMENDATIONS

Governments; bilateral and multilateral donors, including DFID; development banks, including the World Bank; the private sector; and civil society can collectively play a significant role by promoting decentralised electrification and improving the enabling environment in low-income countries, especially those with low rates of energy access.

The following recommendations are made to accelerate uptake of decentralised renewables, and therefore improve energy access and energy security, reduce poverty, boost inclusive growth, and achieve development and climate change goals.

1) Develop an 'energy access roadmap' that sets clear national targets to achieve access to modern, sustainable and affordable energy by 2030 or earlier

National governments in low-income countries, especially with low rates of energy access, should:

- **integrate a decentralised approach of off-grid and mini-grid solutions with a centralised grid approach in energy policies and financing, and ensure that the decentralised approach is prioritised**

This would provide more policy certainty as a signal to encourage the entrance of private sector actors in decentralised technologies. It would also ensure a bottom-up and demand-led approach through off-grid and mini-grid systems, alongside planned centralised grid extension.

- **set energy access targets, in line with SDG 7, of universal access to energy by 2030, with specific sub-targets for off-grid and mini-grid renewable electricity solutions**
- **use the cost-effectiveness of different energy technologies to identify areas that are priorities for off-grid and mini-grid systems (eg through least-cost-effectiveness analysis and geospatial techniques)**

This will inform decisions on how to use scarce public finance. Targeting is key for low-access populations and remote regions of the country that would be best served by off-grid or mini-grid systems, as well as giving guidance for key actors such as private companies that are providing market-based off-grid solutions.

- **strengthen coordination and policy coherence between energy and other national government ministries and sectoral plans in order to capitalise on the development gains from off-grid renewable electricity (eg in health, gender equality, inclusive education, economic empowerment, air quality and environmental benefits)**

This could be through an empowered national task force or a champion for energy access with clout and commitment from the highest levels of government. Integrated planning and energy services at the sub-national level would help facilitate decentralised decision-making for off-grid renewables and rural development.

Bilateral and multilateral donors and international finance institutions should:

- **shift from prioritising a fossil fuel grid approach and infrastructure to prioritising decentralised renewable energy**, in line with the International Energy Agency recommendation that almost three-quarters of additional energy spending should go towards off-grid and mini-grid renewable energy in order to ensure universal access to energy by 2030 (SDG 7)

- **develop energy access plans and targets as a key pillar of their energy strategies** (or economic development strategies) to show how they will scale up their technical and financial support for off-grid and mini-grid solutions in order to meet SDG 7.

2) Build a strong business and supportive enabling environment to improve confidence for investment in decentralised renewables

Based on lessons learned in countries, national governments, donors and international finance institutions should overcome barriers by:

- **strengthening policy frameworks** and market conditions for renewable energy mini-grids that provide higher tiers of energy access, which can support productive use of electricity, for example through fast, low-cost licence and permitting processes to reduce restrictions on private investment – mini-grids also need to be designed based on the needs of end users
- **addressing governance issues** and cumbersome bureaucratic procedures to facilitate private investment
- **promoting innovative business models and pay-as-you-go mobile systems** so that low-income households can afford the upfront cost of renewable energy products more easily and pay in instalments
- **improving access to finance**, for example microfinance and financing for SMEs
- **facilitating the import of renewable energy products** with supportive tax policies, including tax exemptions and low tariffs to incentivise investment in off-grid components and technologies, and providing clarity and transparency in fiscal policies. They should also ensure effective implementation of such policies through adequate training for customs officials.
- **promoting public–private cooperation and multi-stakeholder platforms that** include civil society to improve energy planning processes and coordination and provide a united force to accelerate electrification – this will also improve policy design and implementation and spur on market growth
- **improving quality and safety standards** and accountability mechanisms so that consumers can put their trust in reliable and high-quality products
- **increasing consumer awareness** of solar and its benefits through education and product demonstrations
- **improving technical skills** in off-grid renewable energy, for example in maintenance and repair, particularly in remote and rural regions; and strengthening technical and institutional capacity in off-grid renewable energy across government departments.

See more specific recommendations for the five country case studies below.

3) Improve the monitoring and reporting frameworks for energy access

Countries and donors do not systematically track electrification through off-grid renewable electricity. This is needed to monitor progress on achieving energy access targets and to provide a fuller picture of the impact of off-grid electricity on improving energy access.

National governments, donors and international finance institutions should:

- **track investments in off-grid renewable electricity, as a share of total support for energy, and report on investments to improve transparency**
- **carry out impact assessments to improve data on the development impact of investments in energy access and poverty reduction**
- **use meaningful metrics to measure the quality of electricity access – including affordability, reliability and safety, building on the World Bank's Global Tracking Framework and Multi-Tier Framework surveys**. There should be a focus on the perspective of energy service users to provide an accurate picture of the real levels of access to electricity.

Country-specific recommendations to improve the enabling environment in the five case study countries

National governments can improve the enabling environment by taking the following actions in these countries, supported by donor governments and international finance institutions.

Democratic Republic of the Congo

- Give higher priority to investment and policies in micro-hydro and solar mini-grids as cost-effective electricity access solutions. Decentralised renewable electricity solutions could be presented as an opportunity to overcome governance challenges, and to increase the resilience of electricity supplies during conflict and instability.
- Facilitate the import of solar panels and solar/hydro mini-grid equipment and their adoption throughout DRC through consistent fiscal measures.
- Raise consumer awareness of solar products across all of DRC's regions, including awareness of quality standards.
- Improve access to finance for decentralised renewable energy businesses and consumers (eg by facilitating mobile payment mechanisms, enabling affordable micro-finance for long-term leases, and mobilising investment finance).

Myanmar

- Further develop the policy framework to give higher priority to off-grid renewable electricity options, especially for mini-grids, as cost-effective alternatives for electrification. This could include improving coordination on energy policies between relevant ministries and departments.
- Phase out the high level of public subsidy to on-grid electricity and fossil fuels, to encourage private investment in off-grid renewables.
- Ease access to consumer finance (eg through mobile payment mechanisms and micro-finance).

Nepal

- Raise the awareness of local government leaders and consumers about the costs and potential of off-grid renewable household options.
- Explore ways to reduce public subsidies for fossil fuels and renewables that discourage private finance investment in decentralised renewable energy technologies.
- Facilitate access to affordable finance for off-grid electricity for consumers and businesses.

Nigeria

- Consider revisions to banking regulations that restrict the development of mobile banking, to facilitate the development of efficient payment systems for off-grid solar systems.
- Improve access to consumer finance, especially for SMEs and the rural population (eg mobile pay-as-you-go schemes and affordable micro-finance).
- Ease the stringent conditions for local entrepreneurs; increase ease of borrowing and lower exchange rate risks by enabling local financing to match international financing.
- Reduce import duties for renewable energy system components, matching those for assembled systems, and strengthen the capacity of the relevant agencies such as the Customs and Standards Organisation of Nigeria to implement product standards.
- Review subsidies for kerosene and petroleum fuels, or apply the waivers and incentives for fossil fuels to renewable energy technologies.

- Improve coordination on renewable energy policies and targets across government agencies.

Tanzania

- Streamline procedures for the implementation of off-grid renewable electricity schemes.
- Improve access to finance for businesses and consumers in the off-grid renewables market (eg by using risk guarantees for investors, mobile payment mechanisms and micro-finance for consumers).
- Introduce effective quality standards for solar lamps and home systems (such as Lighting Global's standards) to protect consumers and facilitate expansion of the market. Consumer awareness of standards and accountability mechanisms should also be increased.
- Give higher priority to off-grid electrification objectives in energy policy, strengthen coordination of energy policy implementation (eg by making project information available across agencies), and remove uncertainty.

5. References

References are included as footnotes. The below references are for tables, figures and boxes:

Asian Development Bank (ADB). (2014) MYA: Off-grid renewable energy demonstration project (previously called Off-grid renewable energy programme). Technical assistance concept paper. ADB Website.

Bhatia, M. and Angelou, N. (2015) *Beyond Connections: Energy Access Redefined*. ESMAP Technical Report;008/15. World Bank, Washington, DC.

Boell. (2017) True Cost of Electricity: Comparison of Costs of Electricity Generation in Nigeria. Boell Website.

Dipti. (2017) *Mini-Grid Technologies*. Powerpoint presentation.

Emodi, N.V. (2016) Chapter 2: The Energy Sector in Nigeria. Energy Policies for Sustainable Development Strategies, Frontiers in African Business Research, DOI 10.1007/978-981-10-0974-7_2. Springer Science+Business Media Singapore.

GIZ. (2015) Nigerian Energy Sector: An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification. Bonn: GIZ.

Henbest, S., Mills, L., Orlandi, I., Serhal, A. and Pathania, R. (2015) Levelised Cost of Electricity: DFID 28 priority countries. London: UK Department for International Development.

IEA. (2017) IEA Statistics. IEA Website.

Kathmandu Post. (2017) Parliament enacts law to govern power sector. Kathmandu Post Website.

Lighting Global. (2013) Tanzania Market Intelligence: Final Report. Lighting Africa Website.

SARI. (2016) Existing Policy, Legal and Regulatory Framework in Nepal. SARI Energy.

Scaling Up Renewable Energy Programme (SREP). (2013) Investment Plan for Tanzania. Climate Investment Funds Website.

Scott, A. (2017) Why Wait? Seizing the energy access dividend. SEForAll and PowerForAll.

SE4All and UNDP. (2013) Pays: République Démocratique du Congo (RDC). Evaluation rapide & Analyse des Gaps. Stratégie nationale SE4ALL-RDC. Sustainable Energy For All.

SE4All Africa Hub, AfDB and Sustainable Energy Fund Africa. (2017) Mini Grid Market Opportunity Assessment: Democratic Republic of the Congo. SEforALL Africa Hub, African Development Bank.

UNDP, MEHR and GEF. (2013) Project document: Promotion of mini- and micro-hydropower plants in DRC.

TaTEDO and WRI. (2017) Accelerating minigrid deployment in sub-Saharan Africa: Lessons from Tanzania. Washington DC: World Resources Institute.

World Bank. (2017) *World Development Indicators.* World Bank Website.

Zaw, U.K. (2017) Off-grid electrification in Myanmar. Presentation at the ESMAP Conference, London, 30 November 2017.

Appendix 1. Glossary

Decentralised electricity: Electricity that is generated by small generation units, which may be connected to a transmission network or serve individual premises.

Electricity access: The availability of an electricity supply to a household (or business), at any tier of access (see Multi-Tier Framework, defined below). This may be distinguished from connection to an electricity grid (or mini-grid) by its focus on the actual supply of electricity, and therefore implies that electricity is used by the household.

Energy poverty: Lack of access to modern energy services (ie electricity and clean cooking fuels and technologies).

Energy service: The service that electricity enables to be delivered to the consumer, including lighting, heating, cooling, communications and motive power.

Levelised cost of energy: The cost per unit of energy produced (eg kilowatt hours) over the lifetime of the plant, including all fixed capital and operating costs. Costs are discounted to reflect the time value of money.

Mini-grid: A small electricity generation unit serving several premises, connected by a localised distribution network. Some mini-grids are connected to the national grid.

Multi-Tier Framework: To measure the quality of the energy supply provided, household relevant energy access finance is allocated to five 'tiers' – from Tier 1 ('very low level of access) to Tier 5 ('very high level of access'), based on the Multi-Tier Framework developed by the World Bank and supported by SEforALL (Bhatia and Angelou, 2015).

Renewable energy: Energy that is obtained from renewable sources (ie sources that can be replenished), such as sunlight, wind and geothermal resources.

Solar home system: A stand-alone photovoltaic system, comprising a solar panel or array connected to a charge controller, inverter and battery, which can supply appliances as well as multiple lights.

Solar light: A single light (lightbulb) powered by a solar photovoltaic cell. Some solar lights also have a socket that enables the recharge of mobile phone batteries.

Tier of access to electricity: The level of access to electricity, as defined by the Multi-Tier Framework in terms of capacity, hours of service and qualitative attributes. There are five tiers of access, from Tier 1, the lowest, to Tier 5, the highest.

Appendix 2. Energy tiers and the Multi-Tier Framework

The Multi-Tier Framework (MTF) was developed by the World Bank to measure the range of energy access levels, or tiers (Bhatia and Angelou, 2015). The capacity of the electricity supply determines which of these services and how much of a particular service is available to a household (see Table A2 for details). Decentralised electricity solutions, which are the focus of this report, provide access at Tier 0 through Tier 3.

Table A2. Multi-Tier Framework: services and consumption levels at different tiers of electricity access

	Tier 0	Tier 1	Tier 3	Tier 4	Tier 5
Power capacity	< 3 W	3-49 W	50-199 W	200-799 W	0.8-1.9 kW
Daily consumption capacity	< 12 Wh	12-199 Wh	0.2-0.9 kWh	1.0-3.3 kWh	3.4-8.1 kWh
Annual consumption capacity	< 4.5 kWh	4.5–72 kWh	73–364 kWh	365–1,249 kWh	1,250–2,999 kWh
Services provided	Task lighting	Task lighting Phone charging	General lighting Phone charging Television Fan	General lighting Phone charging Television Fan Medium-power appliances	General lighting Phone charging Television Fan Medium- and high-power appliances
Appliances		Task lights Phone charger Radio	Multi-point general lighting Phone charger Radio Television Computer Fan	Multi-point general lighting Phone charger Radio Television Computer and printer Fan Air cooler Refrigerator Food processor Rice cooker	Multi-point general lighting Phone charger Radio Television Computer and printer Fan Air cooler Refrigerator Food processor Rice cooker Iron Hairdryer Toaster Microwave

Sources: Scott (2017) (and based on Bhatia and Angelou (2015) and ADB (2015))

Appendix 3. Table of barriers and opportunities in the enabling environment

Table 15. Major findings from the country secondary literature and key informant interviews

Democratic Republic of Congo	
Policy framework	Energy access and rural electrification targets exist. The government focus is on on-grid solutions, in particular, large-scale hydropower for export. Poor energy governance, including slow progress to privatise the electricity sector, means that the business climate remains hostile and negatively impacts investment. There is limited institutional capacity, in part due to the high turnover in the Ministry of Energy, and government appointees who are not necessarily energy sector experts.
Access to finance	Off-grid financing facilities are not readily available. Large-scale hydropower projects attract the majority of financing (eg by development banks). Even these projects can struggle to attract financing though.
Fiscal barriers	Tax levies are exonerated for renewable energy projects. These are not necessarily implemented at sub-national levels (eg provincial taxation can occur).
Consumer protection and quality assurance	Quality standards exist for stand-alone systems in the regulatory framework (eg solar lamps, SHSs). Informal vendors selling low-quality products have reduced trust in the potential market.
Level playing field	Available evidence suggests subsidies are not consistently applied to kerosene or diesel at the national level.
Consumer awareness	The DRC off-grid market is fledgling. There is growing awareness of solar products in certain regions.
Consumer financing	Pay-as-you-go schemes and long-term leases are made available to consumers. Such solutions are still in their early stages.
Level of local skills	Few local skills in rural areas are built through on-the-job training.

Myanmar	
Policy framework	There is a 2030 universal access to electricity target. An electrification plan provides for decentralised solutions. Policies are inadequate for private sector investment in mini-grids. The Ministry of Electricity and Energy has primary responsibility for development of the power sector, while the Department for Rural Development of the Ministry of Agriculture, Livestock and Irrigation is responsible for off-grid electrification. This creates strong compartmentalisation in energy policy.
Access to finance	Off-grid financing facilities exist. The short-term loans and inflexible rates provided by banks reduce investment. The World Bank is helping to finance the 2030 universal access target.
Fiscal barriers	Duty exemptions are available for mini-grid generators and solar modules, as well as charge controllers.
Consumer protection and quality assurance	Standards are not widely applied to decentralised technologies, and therefore, the average quality of solar lamps and SHSs is low. The exception is quality standards for mini-grids, which exclude provisions for grid connection.
Level playing field	There are public subsidies for electrification and electricity use. Kerosene and diesel subsidies are not consistently applied. Subsidies exist for stand-alone systems (eg solar), up to 100% of costs.
Consumer awareness	A lack of consumer and community awareness about electrification is hampering the deployment of off-grid solutions.
Consumer financing	National support programmes are provided. Financing mechanisms are available to consumers for stand-alone systems.
Level of local skills	Limited training – and limited trained staff – are available in rural regions, creating a lack of human capital for the operation and repair of decentralised technologies.

Nepal	
Policy framework	The government focus is on on-grid hydroelectricity. The decentralised opportunity is seen as an interim solution until the grid arrives. The Alternative Energy Promotion Centre is focused on small-scale renewables in rural centres, while the Nepal Electricity Authority focuses exclusively on large-scale projects. Cumbersome bureaucratic procedures restrict private sector involvement. Government plans to decentralise political representation through provincial elections.
Access to finance	Off-grid financing facilities exist. Complex procedures and high interest rates reduce lending to lower income households and SMEs. Donor and government financing can crowd out private financing of decentralised energy projects.
Fiscal barriers	Duty exemptions are applied to mini-grid systems and their storage, as well as mini-grid generators and distributors. Tax exemptions for stand-alone systems are not apparent.
Consumer protection and quality assurance	Quality standards are applied to stand-alone systems (eg small solar products). Government certification is applied to mini-grid equipment.
Level playing field	Subsidies are provided to mini-grid generators, as well as stand-alone (decentralised) solutions. Subsidies are provided for diesel and kerosene.
Consumer awareness	There is relatively little growth in the Nepalese solar market, which is dominated by SHSs. Awareness-raising could help increase market growth.

Nigeria	
Policy framework	The government's primary focus is on centralised grid electricity, but there is increasing commitment by the government and other actors to increase decentralised renewable generation. This includes creating a space for the private sector to operate. Progress on decentralised energy policy has also recently been achieved at the state level. Energy mandates are spread across different government agencies. Governance remains a challenge along the generation, transmission, distribution and regulation chain. Policy implementation also remains a challenge (eg restrictions on the development of mini-grids).
Access to finance	High interest rates and very low levels of access to banks among the population, especially for SMEs and consumers in rural areas. Renewable energy sector seen as high-risk.
Fiscal barriers	Zero tariffs exist for solar panels, but high cost tariffs remain for the import of solar batteries, inverters, charge controllers, SHSs and other renewable energy system components. This reduces their cost-competitiveness.
Consumer protection and quality assurance	Non-existent consumer protection or quality assurance for solar products. This may already have caused a poor reputation and market spoilage.
Level playing field	Very high subsidies on kerosene and petrol. This is seen as a welfare measure and is greatly supported by Nigerians.
Consumer awareness	Low levels of awareness of solar power: up to 40% of the population have never heard of solar. Poor existing reputation due to previous failed solar programmes.
Consumer financing	Very low access to finance for SMEs and the rural population. Only 0.1% of Nigerians have access to mobile financing.
Level of local skills	Skilled renewable energy technicians are rare due to low national experience in solar PV and CSP systems.

Tanzania	
Policy framework	Strong foundations are in place for a positive enabling environment, which has accelerated private sector investment in small renewable power production and distribution. The focus is on on-grid and mini-grid solutions, and more emphasis could be placed on off-grid solutions. There are specific plans for rural areas. Policy implementation and improved coordination among government ministries remain a challenge. Also, project development processes are cumbersome in some cases.
Access to finance	Although relatively well established, the solar market is still undercapitalised and vulnerable to exchange rate volatility. Finance for established players is slowly beginning to flow, but there is a 'missing middle' of medium-sized systems. Access to private sector funding (eg commercial loans) remains elusive.
Fiscal barriers	Solar products are exempt from VAT and tariffs, but batteries are not. Despite this, clearing costs remain. The financial challenges of the electricity utility, TANESCO, reduce its ability to pay agreed 'standardised power purchase tariffs' in the long term. Some of these tariffs are non-reflective of generation costs. TANESCO tariff payments may also be delayed.
Consumer protection and quality assurance	A large influx of low-quality and fake solar products onto the market has created huge challenges. This has resulted in short product lifetimes and high costs for users who need to replace faulty products or components.
Level playing field	Kerosene is not directly subsidised. Public subsidies for grid access and solar products may affect the solar market. Renewable energy mini-grids are not subsidised (i.e. solar, hydropower and biomass).
Consumer awareness	Consumer awareness is very high in certain regions (eg near Arusha, Dar es Salaam, Highlands and Lake Zones). There is low awareness of solar products in some other areas of the country.
Consumer financing	Pay-as-you-go financing for SHSs is now common in many regions.
Level of local skills	There is a relatively high level of human capital. Some training has been undertaken by the Tanzania Renewable Energy Association, as well as other market actors. More generally, there is readily available human capacity for installing smaller systems (eg SHSs). However, human capacity to install and maintain mini-grids remains a challenge.

Source: Various (reports and websites reviewed for the country studies).

PIONEERING POWER

Transforming lives through off-grid renewable electricity in Africa and Asia

COUNTRY REPORTS

tearfund

www.tearfund.org/climate_energy

100 Church Road, Teddington, TW11 8QE, United Kingdom

T +44 (0)20 3906 3906 **E** publications@tearfund.org

Registered Charity No. 265464 (England and Wales) Registered Charity No. SC037624 (Scotland) 31959–(0418)