Democratic Republic of the Congo

Current state of play

Only 15 per cent of the population in DRC had access to electricity in 2016.[1] 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.[2] 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.[3] 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.[4] Capacity is concentrated at the Inga dam.[5] 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.[6] However, only 2.5 per cent of domestic hydropower potential is currently exploited.[7]

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,[8] 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.[9] 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.[10]

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.[11] The Scaling Up Renewable Energy and UNDP programmes have noted the key role (mini-grid) hydropower can play in scaling up electricity access in the future.[12] Solar and renewable-diesel hybrid mini-grids also have potential.[13] In 2016, the first mini-grid solar-plus-storage project was developed in Virunga National Park,[14] and Enerdeal signed a contract to develop the largest off-grid solar project in Africa with 1MW of solar capacity and 3MW storage capacity.[15]

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

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

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

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

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

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

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

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

9 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.

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

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

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

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

14 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

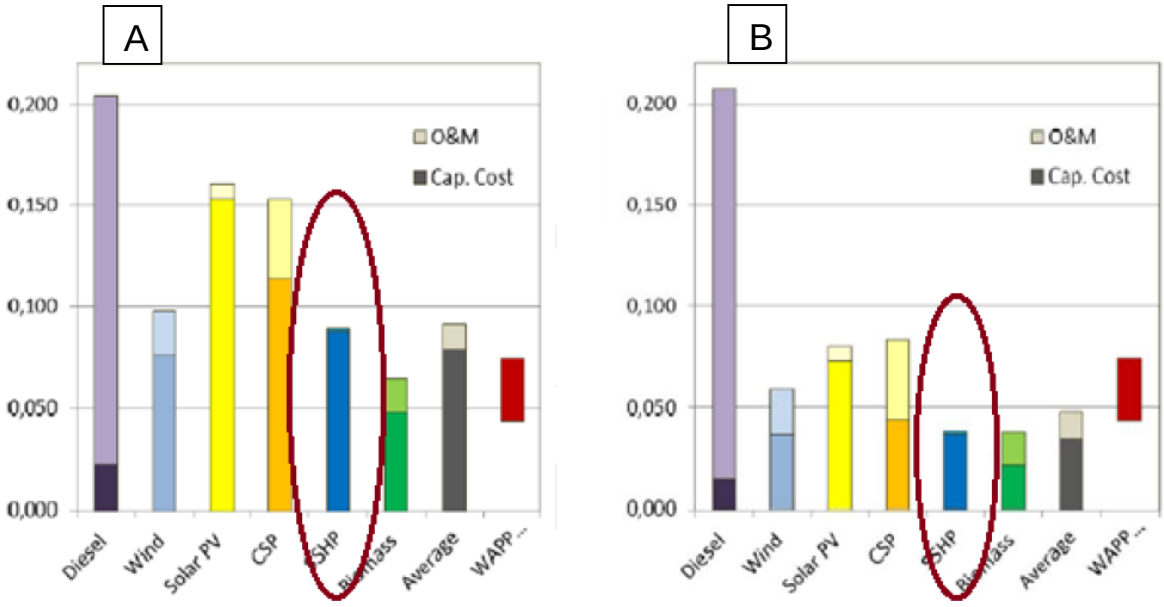
15 http://enerdeal.com/enerdeal-signs-one-of-the-largest-fully-off-grid-solar-power-plant-in-africa-with-forrest-group/

Cost-effectiveness of decentralised renewables

Evidence about the cost of electricity in DRC is available primarily for centralised renewable technologies,[16] 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.[17] 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[18]) could be lower than technologies such as diesel, wind and solar.[19] The only technology that is predicted to be cheaper in 2020 is biomass (Figure 2).[20] 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[21]).[22]

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

16 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.

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

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

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

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

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

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

In 2014, diesel costs were $1.67 per litre.[23] UNDP et al. report the operational and management costs of hydropower micro-grids are lower than more traditional systems.[24] At smaller tiers of energy access, lamps that are battery- or kerosene-based can cost up to $100 a year per household.[25] This is one-eighth of an individual's income, when compared with DRC's Gross National Income (GNI) of $790 per capita.[26] Over $1 billion is spent on kerosene annually in DRC, equivalent to 25–30 per cent of incomes according to the company NovoMoto.[27] 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.[28] 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.[29]

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.[30] Decentralised solutions could alleviate this gap. A Lighting Global project is deploying 25,000 solar lamps and home systems to social institutions, schools and healthcare centres in DRC, for day-to-day lighting.[31] 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.[32]

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.[33] 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.[34]

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

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

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

26 2016 data. Source: World Bank. (2017) World Development Indicators. Washington DC: World Bank.

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

28 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.

29 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.

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

31 Lighting Africa. (2017) Op. cit.

32 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.

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

34 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.

SDG 4 Inclusive and equitable education

More than 90 per cent of primary schools in DRC lack access to electricity.[35] 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.[36]

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.

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.[37] Conflict situations can also reduce the provision of basic services, such as electricity.[38] Access to modern lighting has been shown to contribute to an improved sense of safety and security at night (in other country contexts).[39] 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.[40] The Fundazione Madre Agnese has shown the potential role of solar panels (with batteries and pumps) for accessing clean water at home.[41] 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.[42]

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

36 EU EI. (2014) Op. cit.

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

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

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

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

41 EU EI. (2014) Op. cit.

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

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.[43] 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).[44] Where DRC's national unemployment rate still stands at 43 per cent, or 73 per cent underemployment in rural areas,[45] 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.[46]

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.[47] In Rutshuru and Mugunga, there are small enterprises developing their business thanks to solar power allowing them to refrigerate their products.[48]

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. [49] In DRC, approximately 10,000 square kilometres (km^2) were lost in 2000–2010, [50] and it is estimated that 1,900 km^2 of forested land is lost each year, equivalent to 0.08 per cent of the country's total land area. [51] 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. [52] 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.[53] 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).[54] However, reduced black carbon emissions would lead to a mitigation effect five or six times larger.[55]

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43 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.

44 Ibid.

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

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

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

48 Key informant interview.

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

50 Bergen. (2017) Op. cit.

51 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.

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

53 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.

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

55 SEforALL (2017) Op. cit.

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).[56] 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).[57] But the government does support a national programme on the deployment of solar lamps and SHS.[58] 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.[59]

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.[60] 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 investment.[61] Limited institutional capacity is another important factor.[62] 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.[63]

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.[64]

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

57 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.

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

59 Key informant interview.

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

61 Key informant interview.

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

63 Key informant interview.

64 Ibid.

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,[65] and in 2014, SNEL's losses were estimated at $330 million (or one per cent of GDP).[66] The energy sector is hence reliant on external public and private financing.[67] 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.[68]

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.	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.

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

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

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

68 Key informant interview.

	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.	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.

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 time-intensive 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.

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.

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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).