IRENA
International Renewable Energy Agency

Policies and Regulations for

RENEWABLE ENERGY MINI-GRIDS

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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Policies and Regulations for

RENEWABLE ENERGY MINI-GRIDS

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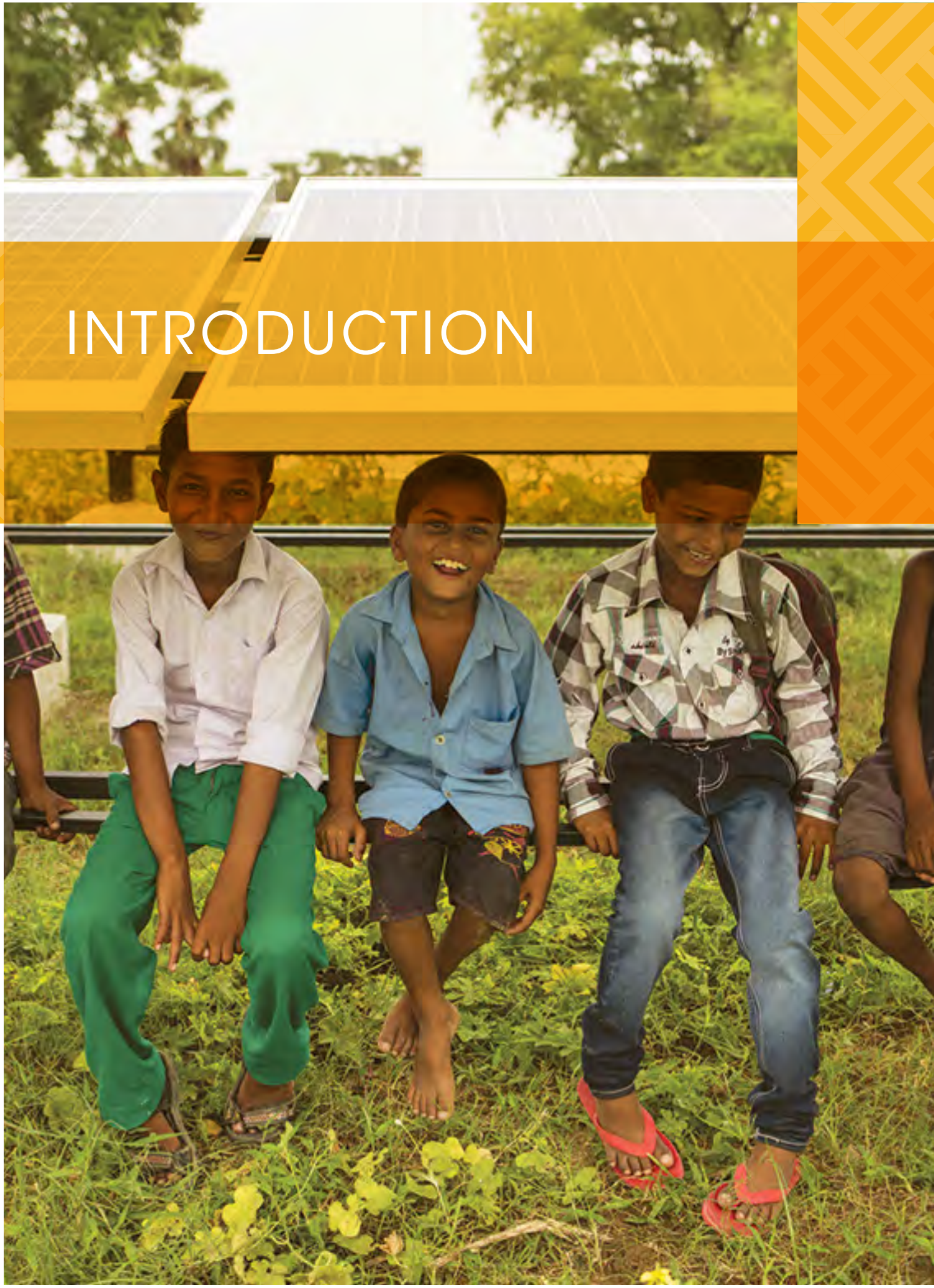

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Renewable energy mini-grids are increasingly recognised as a key solution to expand electricity access in a timely, sustainable and cost-effective manner (UN, 2018). An enabling policy and regulatory framework is a necessary pre-condition to address investment risks, scale-up deployment and ensure long-term and reliable operation (EUEI PDF, 2014; IRENA, 2016a; USAID, 2017). In recognition, several countries have introduced measures to promote renewable energy mini-grids, including setting targets and designing dedicated policies and regulations for the sector.

To capture the developments and inform policy making, the International Renewable Energy Agency (IRENA) published its *Policies and regulations for private sector mini-grids* report in 2016 (IRENA, 2016a). It analysed diverse country case studies to assess key design elements of mini-grid policies and regulations (Box 1.1).

In the two years since the launch of the report, several countries have implemented mini-grid policies and several others have introduced, or are in the process of designing, policies to support private sector participation in the sector. For selected countries (and jurisdictions), this follow-on report sets out to capture the evolution of the mini-grid policy and regulatory landscape and draw emerging trends and lessons. It analyses cases from Cambodia, India (state of Uttar Pradesh), Indonesia, Nigeria, Peru, Rwanda, Sierra Leone and the United Republic of Tanzania.

This chapter provides insights on the global and regional status and trends in the deployment of off-grid renewable energy solutions, followed by a discussion on the key components of an enabling environment required to support mini-grids. It also describes the analytical approach adopted in this analysis. Chapter 2 brings to the fore key insights and messages from the cases analysed with the detailed case studies outlined in Chapter 3.

Box 1.1 IRENA's previous *Policies and Regulations for Private Sector Mini-grids* report

The report analyses key policy and regulatory conditions for supporting private sector involvement in the mini-grid sector. These include legal and licensing provisions, cost-recovery and tariff regulation, management of the risks posed by the arrival of the main grid and measures to facilitate access to finance. The analysis finds that not all factors are equally relevant to all types of mini-grids, and policy making can benefit from a deeper understanding of various combinations of technologies, delivery models and tiers of access. Accordingly, the report assesses the influence of policy and regulatory conditions on various mini-grid approaches.

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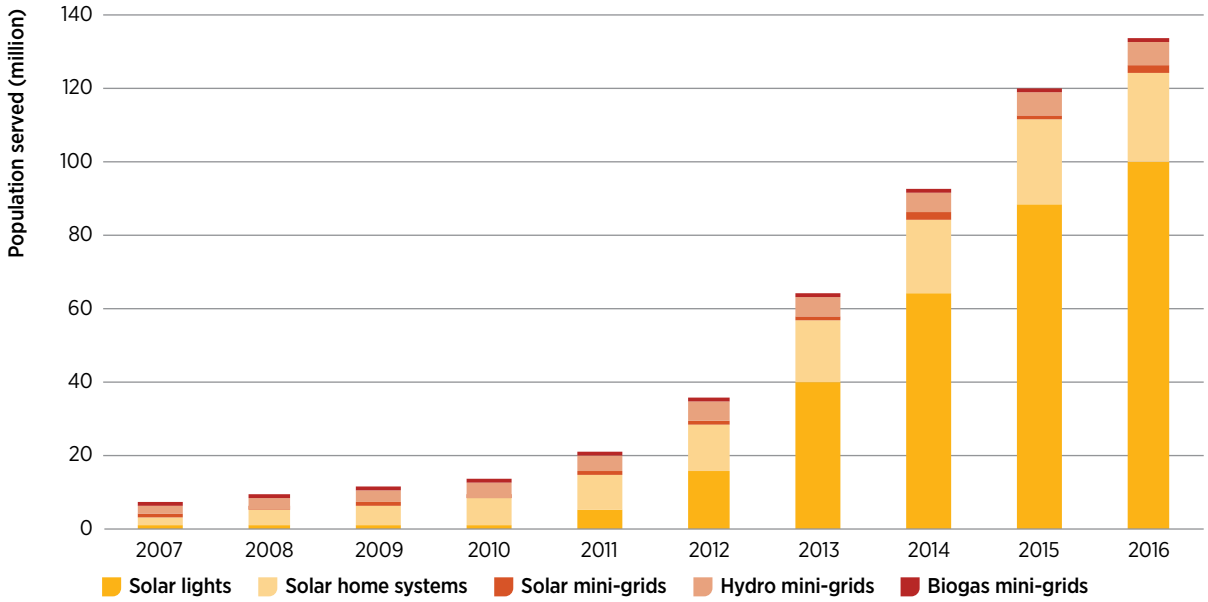
1.1 STATUS AND TRENDS

Dramatic cost reductions, technology advancements and enabling policies have driven the adoption of off-grid renewable energy technologies globally. IRENA estimates that approximately 133 million people were served by off-grid technologies in 2016. At least 9 million were connected to renewable mini-grids and 124 million utilised solar lighting solutions and solar home systems (Figure 1.1).

Stand-alone systems represent a first step in the "ladder" of electricity access. These often enable only basic services, but technological improvements and energy-efficient appliances unlock the possibility of supporting more uses. In an integrated approach to electrification, stand-alone systems could help realise the immediate economic, social and climate-related benefits of basic electricity access, as well as drive demand for larger mini-grids or grid extension.

Renewable energy mini-grids (Box 1.2) are uniquely placed between grid-based solutions and stand-alone systems. Tapping into locally available resources, such systems can deliver a wide range of electricity services ranging from basic access (*e.g.*, for lighting and mobile charging) to higher tiers of access (*e.g.*, for commercial, productive loads).

Figure 1.1 Population served by off-grid renewable energy solutions globally, 2007-2016



Source: IRENA, 2018a.

Box 1.2 Defining renewable energy mini-grids

Renewable mini-grids use technology to harness energy from solar, hydro, biogas, biomass, wind and/or hybrid sources (with the latter able to involve storage or diesel plants, for example). Their capacities range from under 1 kilowatt (kW) to up to 10 megawatts (MW) (IRENA, 2016b). A mini-grid may be interconnected to the main grid or autonomous (Table 1.1). Autonomous or isolated mini-grids are particularly relevant for unelectrified areas, and may later be interconnected to a larger grid, whenever one becomes available.

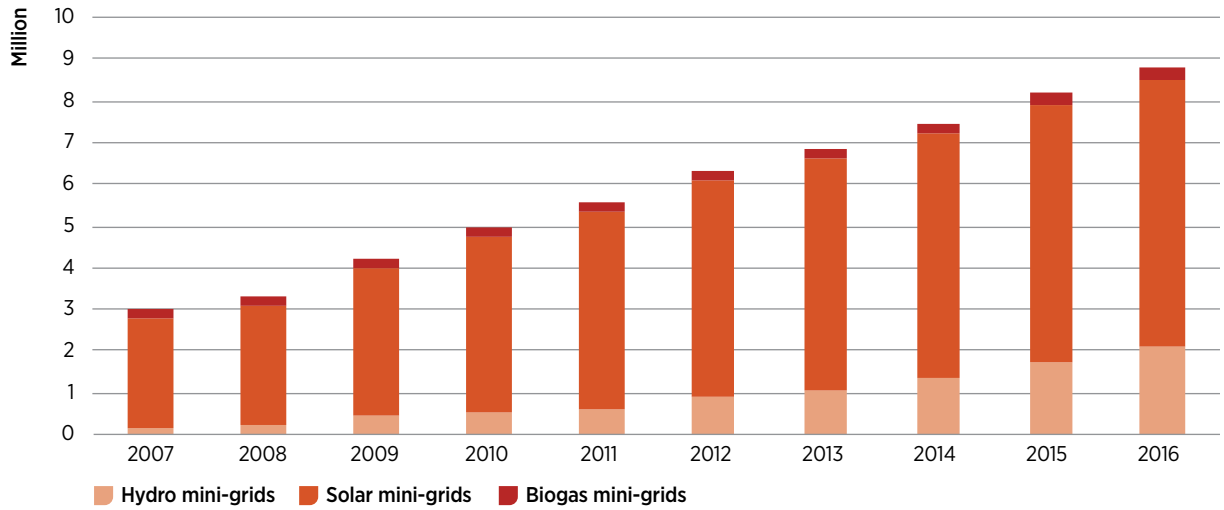
Table 1.1 Types of renewable energy mini-grids

	Lower tier of service	Higher tier of service
Autonomous	AB (autonomous basic) Non-continuous power supply (<24h, Tier 1-4) Goal: Access to electricity services in areas not served by the national grid Example: Rural electrification	AF (autonomous full service) Continuous power supply (24h, Tier 5) Goal: Larger industrial, commercial or residential consumers requiring reliable service Examples: Manufacturing companies, islands, remote communities
Interconnected	IC (interconnected community) Continuous power supply: 24h, Tier 5+, ~100% reliability Goal: Primary power supply, with grid as back-up or serving as back-up to grid; used to improve resilience and reliability of community services Examples: Universities, military campuses	ICLI (interconnected large industrial) Continuous power supply: 24h, Tier 5++, critical, uninterruptible Goal: Industrial end-users that require uninterrupted power for high-tech loads Examples: Data centres, precision manufacturing, critical military infrastructure

Source: IRENA, 2018b.

The number of renewable mini-grids has grown steadily over the past decade. Small-hydro mini-grids are the most widely deployed and responsible for connecting majority of the end-users to mini-grids (Figure 1.2). Thanks to reduced costs and improved technology, solar photovoltaic (PV) has recently experienced rapid growth, from 11 MW of capacity in 2008 to 308 MW in 2017. The number of people connected to PV mini-grids reached 2.1 million in 2016 (IRENA, 2018a). Small hydro, being a rather mature technology, experienced steady growth to 509 MW in 2017 from 418 MW in 2008, connecting over 6 million people during the period.

Figure 1.2vvz zNumber of people connected to renewable energy mini-grids, by technology, 2007-2016



Based on IRENA, 2018a.

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At a regional level, Asia has the largest number of mini-grid beneficiaries where development has mostly been led by governments, the local private sector and communities. The number of people connected to mini-grids increased three-fold in Asia between 2008 and 2016, to 8.8 million. During the same period, Africa saw a six-fold increase, from just over 0.2 million to 1.3 million. The trend is set to continue, given the growing competitiveness of renewable energy mini-grid solutions and national efforts to scale up deployment.

1.2 SCALING UP RENEWABLE MINI-GRID DEPLOYMENT

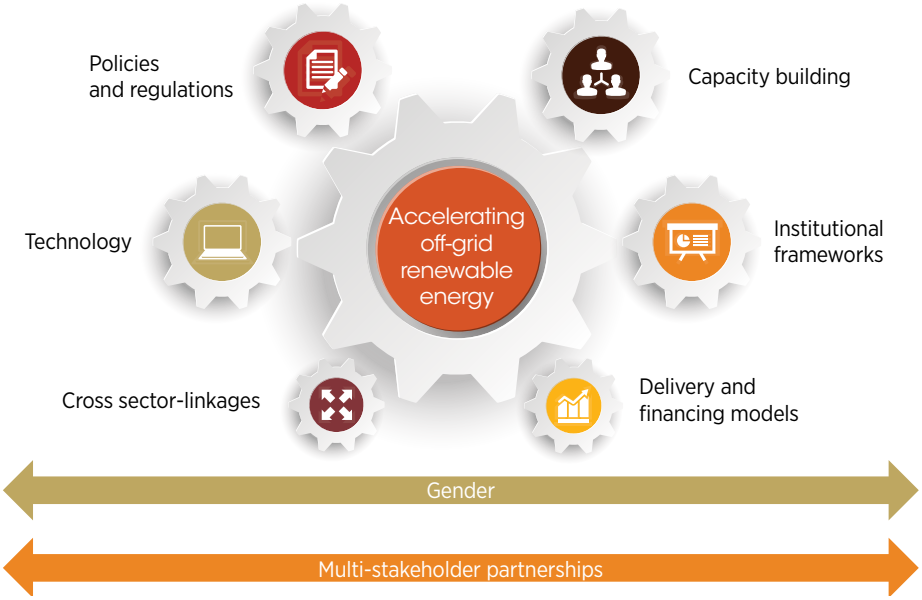
Renewable energy mini-grids are expected to play an important role in bridging the electricity access deficit in a timely manner. In fact, it is estimated that between 2016 and 2030, renewable energy sources will power around 60% of new access connections, of which approximately 40% will be through mini-grids (IEA, 2017). But to achieve this potential, current levels of deployment need to be scaled up.

As illustrated in Figure 1.3, setting up an enabling environment for renewable energy mini-grids depends on several factors. These include policies and regulations, institutional frameworks, delivery models and financing, technological solutions, capacity building and cross-sector linkages (IRENA, 2017a). Several of these factors interrelate. For instance, in many cases, dedicated mini-grid policies and regulations address not only licensing and tariffs, but also the extent and nature of public financing for projects (IRENA, 2018c).

Further, several cross-cutting issues influence the long-term sustainability and socio-economic impacts of mini-grids. First, gender considerations must be integrated into the design of policies and programmes, capacity building initiatives, technology applications and delivery and financing models. Second, adopting a multi-stakeholder partnership approach would ensure the inclusiveness and adaptability of electricity access programmes.

Approaches to renewable energy mini-grid deployment take many forms, including community-owned micro-hydro systems, privately operated solar PV direct current (DC) mini-grids and public-private partnerships (PPPs). To accelerate deployment even further would require the combined efforts of both the public and the private sector. Public financing will need to be complemented by private funding (IIED, 2014; NREL, 2015; IEA, 2017; ARE, 2018), while ensuring equitable services for the most vulnerable and marginalised communities. Several governments have sought to attract private sector involvement in the mini-grid sector with a view to access additional financing, utilise capacity to deploy and maintain infrastructure assets over the long term and encourage cost and technology optimisation (IRENA, 2016a).

Figure 1.3 Elements of an enabling environment for renewable energy mini-grids



Based on IRENA, 2017b.

One key barrier to private sector participation is an overall lack of dedicated policies and regulations (EUEI PDF, 2014). Traditional power sector policy and regulatory frameworks are not suitable for mini-grids given differences in the cost structures, size and economic profiles of consumer bases and the magnitude of electricity sales. Long payback times, low returns and limited availability of secondary markets for mini-grid assets are some of the bottlenecks for private investments (ARE, 2015). Accordingly, several countries have introduced dedicated policies and regulations for mini-grid development, and some are in the process of doing so. These countries offer valuable lessons for policy makers, regulators and other stakeholders.

1.3 A FOCUS ON POLICIES AND REGULATIONS

Mainstreaming renewable energy mini-grid solutions in national electricity access strategies through targets and plans is an important first step, provides a strong foundation for market development and incentivises different stakeholders to devise tailored solutions to provide energy services (IRENA, 2018a). Many countries have introduced targets for mini-grids, ranging from total capacity to number of systems, connections or people served. Some targets specify the technology to be used (*e.g.*, solar, micro-hydro, diesel-hybrid).

A number of countries have backed targets with dedicated policies, regulations and financial and fiscal support mechanisms. Since multiple factors influence mini-grid development (as illustrated in Figure 1.3), various measures are needed to scale up deployment as well as ensure that growth is sustainable and maximises the socio-economic benefits of electricity access. These measures may be classified in three levels (Figure 1.4):

1. **Primary measures** are intrinsically related to the national energy framework and remain under the purview of public institutions mandated with energy matters, such as ministries of energy. These include policies and regulations related to the electricity sector, rural electrification plans, regulatory frameworks, quality standards and direct financial support provided for mini-grid projects.

2. **Secondary measures** are not specific to the energy sector but greatly affect the viability of mini-grid development. These are typically implemented by non-energy ministries and associated public agencies. They include policies related to taxation, land rights, environmental protection and banking.

3. **Tertiary measures** contribute to the broader enabling environment for mini-grids. These allow for an efficient implementation of primary and secondary measures, while supporting the sector indirectly (although their effects cannot be easily measured or directly attributed). These may be implemented by local institutions or external agencies (*e.g.*, development finance institutions, non-governmental organisations [NGOs]). Examples of such measures include capacity building, data collection and efforts to increase synergies with other sectors.

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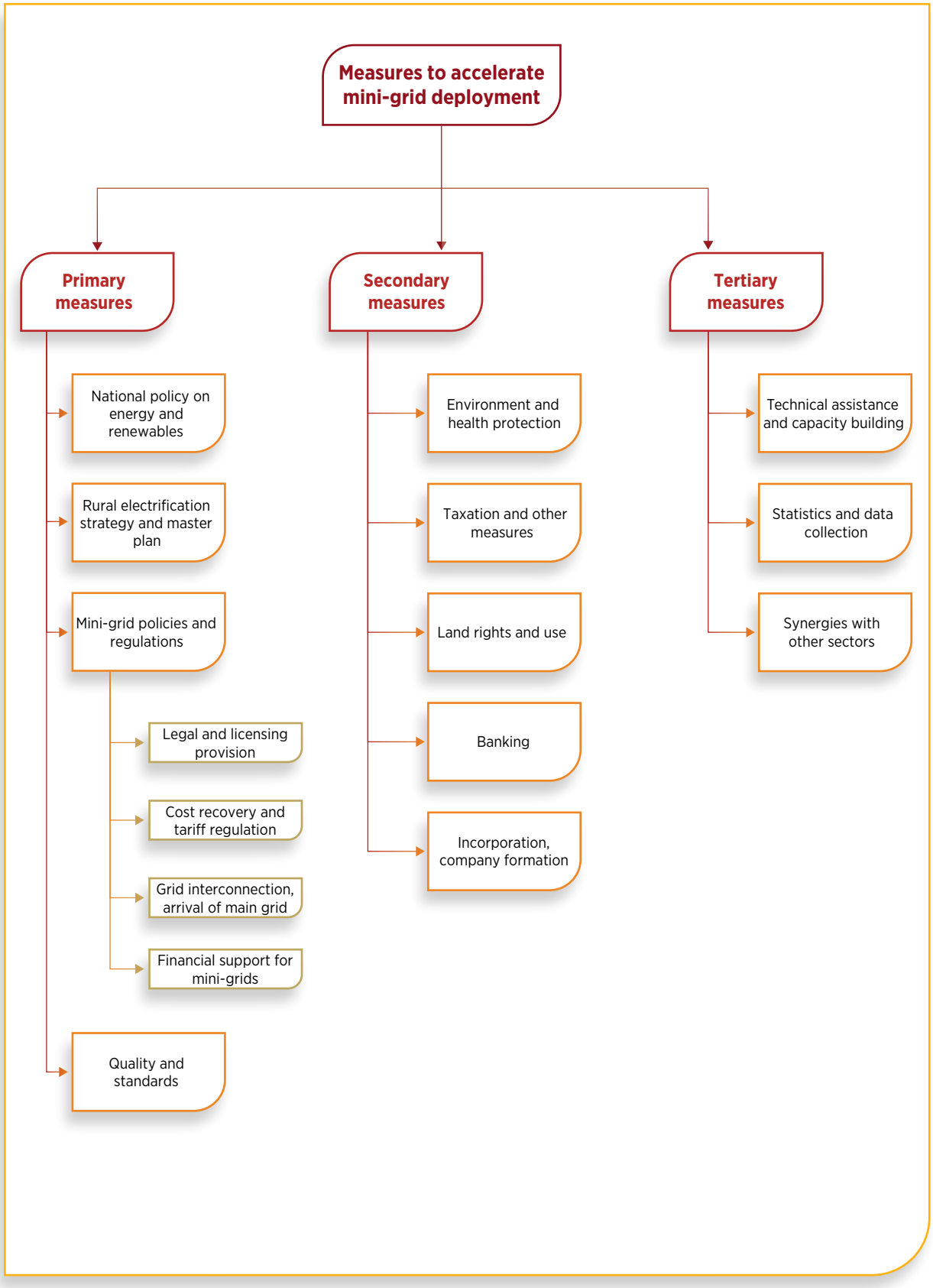
Figure 1.4 Overview of measures to scale up renewable energy mini-grids



Based on IRENA, 2016a.

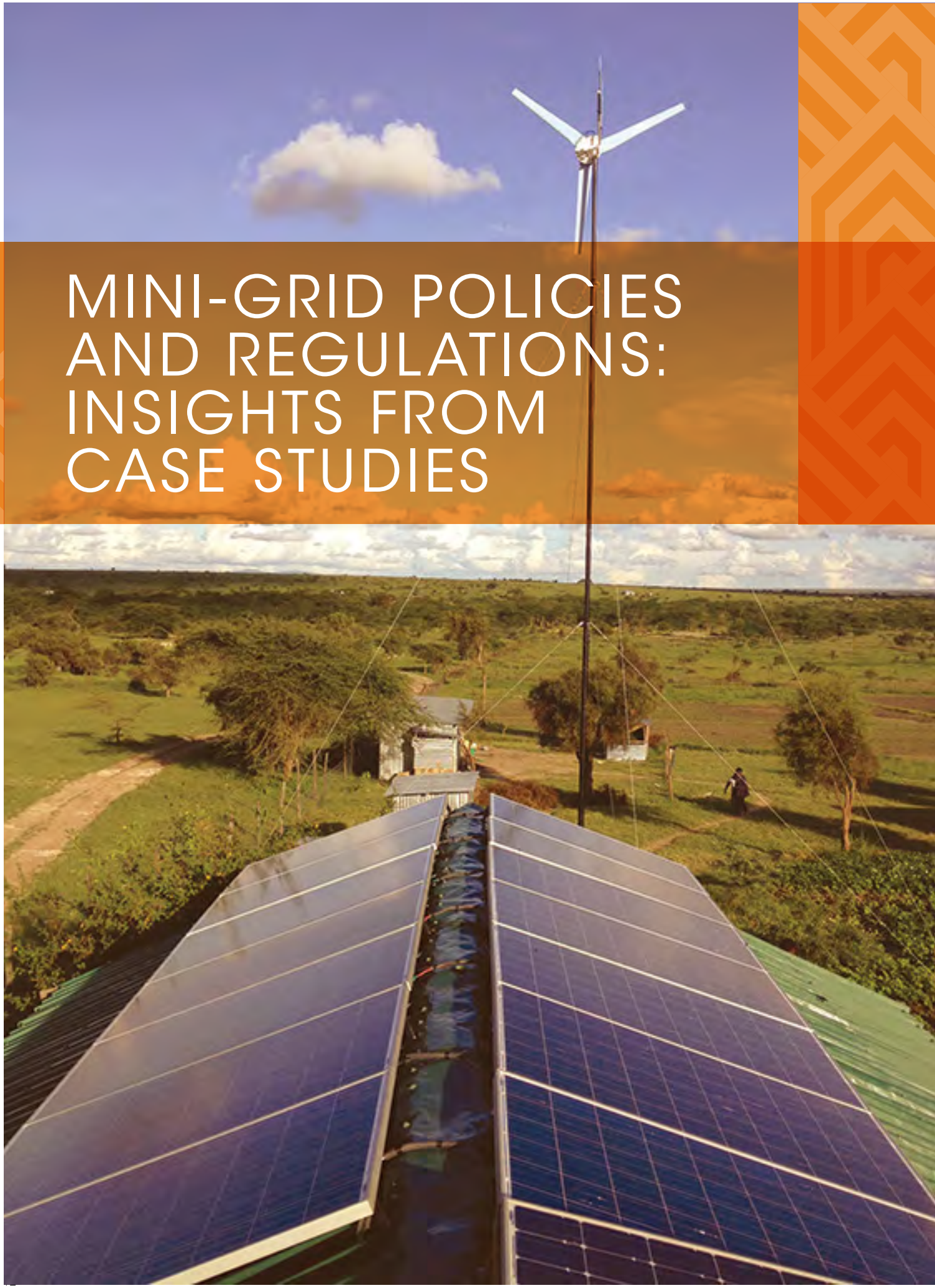
1.4 ABOUT THIS REPORT

This report analyses country case studies from Cambodia, India (specifically the state of Uttar Pradesh), Indonesia, Nigeria, Peru, Rwanda, Sierra Leone and the United Republic of Tanzania. These have been selected based on different criteria, including recent changes in the policy and regulatory landscape, maturity of the mini-grid sector, availability of data and information, and diversity of contexts.

The brief sheds light on the experience of policy makers and the private sector, and aims to explain factors underlying the evolution of the policy and regulatory landscape. It maps out the primary, secondary and tertiary measures being introduced and later examines their impact on mini-grid development and highlights remaining challenges. The analysis presented here largely follows the same analytical approach as the 2016 report with a stronger focus on project development risks (*e.g.*, licensing, tariff regulations) than on operational risks (*e.g.*, related to demand/volume, load patterns).[1]

The analysis relies on desk research of academic literature and corporate and other organisational reports, and interviews and consultations with government officials, international partners and private developers in countries of interest. An extensive review of energy-related policies, acts, regulations and plans relevant to electrification was carried out, with a focus on mini-grids.

1. *See AfDB (2018) for a discussion on operational risk mitigating policies.*



MINI-GRID POLICIES AND REGULATIONS: INSIGHTS FROM CASE STUDIES

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This report analyses several country case studies with the aim of understanding the key design elements and recent evolution of their mini-grid policy and regulatory frameworks, latest developments and lessons learnt.

Each country context analysed in this report is different in terms of the structure of its power sector, the institutions involved, the type of mini-grids installed and how national plans foresee the role of mini-grid solutions in strategies to expand and improve access to electricity. But even as the designs of policies and regulations are tailored to local conditions, these address a largely common set of challenges. Some of these include providing long-term certainty on market development, addressing risks associated with the arrival of the main grid, reducing the transaction costs of meeting various regulatory requirements (*e.g.*, licencing, permits) and providing for sustainable operation and cost-recovery through tariff regulations and financial support schemes. To address these challenges, as outlined in Section 1.2, various primary, secondary and tertiary measures may be introduced.

Table2.1 provides an overview of the mini-grid policy and regulatory landscapes (existing and proposed) of the cases analysed. As evident from the table, nearly all countries have introduced **primary measures**, including mainstreaming renewable energy mini-grids in national rural electrification plans/strategies, setting targets and introducing dedicated mini-grid policies and regulations, among others. The analysis finds that countries have adopted different approaches to this process. There are cases of government-led markets (such as Peru) where the financial provisions and targets are mainstreamed in the planning phase and the deployment is largely left to governments, which lead the procurement, commissioning, financial management and monitoring processes. The trend, increasingly, seems to be toward encouraging private sector engagement in the mini-grid sector through tailored, light-handed regulations,[2] as seen in, for instance, Nigeria, Rwanda and the United Republic of Tanzania.

The **secondary** and **tertiary measures** are not as elaborated as primary measures in many of the countries considered. Environmental protection and taxation measures are commonly adopted, while land rights, and company registration and establishment are given less attention. In several countries, development or commercial banks are mandated to support mini-grids. Only a few countries – such

2. *In the context of mini-grid development, (Tenenbaum* ***et al.****, 2014) notes that light-handed regulation should: i) minimise the amount of information a regulator requires, ii) the number of separate regulatory processes and decisions, iii) use standardised documents or similar documents created by other agencies, and iv) where possible, rely on related decisions made by other government or community bodies.*

as Rwanda, Sierra Leone and the United Republic of Tanzania – have facilities dedicated to building capacity relevant to mini-grids. Cross-sector linkages and data collection, crucial for policy making, planning and sustainability, requires greater attention. The remainder of this chapter will present key findings and recommendations drawn from the case studies, which are further detailed in the respective case studies.

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2.1 NATIONAL POLICY AND RURAL ELECTRIFICATION STRATEGIES

The socio-economic case for renewable energy mini-grids is strong in many areas unconnected to or underserved by the main grid. An important first step is to include mini-grids in national electrification plans and strategies (USAID, 2017, IRENA, 2017b). Doing so guides the public and private sector, as well as development banks and donors, to collaborate, mobilise and direct resources to off-grid, and grid-based electrification options. Countries, such as **Nigeria, Peru** and the **United Republic of Tanzania**, have all incorporated mini-grid solutions in their energy plans and strategies to provide the basis for the expansion of electricity services.

Official targets and demarcation of on- and off-grid areas also provide clarity to both developers and rural communities. **Rwanda**'s National Electrification Plan, for instance, has recently been published by the national utility which demarcates areas for for on- and off-grid expansion. The 2018-2024 Energy Sector Strategic Plan released in September 2018 aims to mitigate the risk of uncertainty around grid expansion with the implementation of the NEP as published (Mininfra, 2018).

In planning and implementation, it is important to recognise the interaction between the different electrification solutions – *i.e.*, grid extension, mini-grids and stand-alone solar systems – as well as the rapidly evolving technologies and delivery models of off-grid renewables (*i.e.*, efficiency improvements, innovations in metering and end-user financing). **Peru**'s rural electrification master plan (Plan Nacional de Electrificación Rural, PNER), for instance, is updated every two years to reflect conditions in the country and accordingly, adapt the targets and plans.

2.2 DESIGNING DEDICATED MINI-GRID POLICIES AND REGULATIONS

National rural electrification strategies should be backed by policy and regulatory frameworks specific to renewable energy mini-grids. Some of the key factors to consider include legal and licensing provisions, tariff regulations, grid interconnection/arrival of main grid, financial support and quality standards.

2.2.1 LICENSING AND LEGAL PROVISIONS

In a number of cases, including Uttar Pradesh (India) and Cambodia, mini-grids have been deployed in substantial numbers in a largely deregulated environment. In **India**, for instance, the Electricity Act, 2003 consciously exempts mini-grids from licensing and allows tariff setting via mutual negotiation between developers and consumers. As governments establish policies and regulations to improve services and scale up mini-grid deployment, attention is needed to tailor licensing requirements based on a project's size, economics and delivery model. Setting clear processes and procedures for project licensing and also streamlining requirements (particularly for smaller mini-grid projects) can reduce transaction costs. As a general guideline, fees and other development costs (including for preparatory activities such as a feasibility study, investment mobilisation, plus regulatory compliance) should not exceed 1-2% of the total cost of a project (SADC RERA, 2013).

Accordingly, policies in **Nigeria, Rwanda** and the **United Republic of Tanzania** have defined capacity thresholds for mini-grids (*e.g.*, smaller than 100 kilowatt-peak, kWp) that are either exempted from licenses or undergo simplified processes (*e.g.*, registration only). **Sierra Leone** has submitted a similar proposal for approval. In addition, Rwanda, Nigeria, Sierra Leone and the United Republic of Tanzania have provisions for securing a provisional license which provides "temporary exclusivity" to developers for a specific period of time to develop the mini-grid project (Tenenbaum *et al.*, 2014). In an effort to standardise the licensing processes, several countries, such as Nigeria and the United Republic of Tanzania, now also provide templates for documents (*e.g.*, application for permit or licence, exclusivity agreements, tri-partite contract).

Table 2.1 Measures to support mini-grids in countries and jurisdictions analysed

	Primary measures							Secondary measures					Tertiary measures		
	National policy on renewable energy	Rural electrification strategy and master plan	Mini-grid policies and regulations				Financial support	Environment and health protection	Taxation and fiscal incentives	Land rights and use	Banking	Incorporation, company formation	Technical assistance and capacity building	Statistics and data collection	Synergies with other sectors
			Arrival of main-grid	Legal and licensing provision	Cost recovery and tariff regulation	Quality standards									
Cambodia															
India															
Indonesia				X			X								
Nigeria															
Peru															
Rwanda							X								
Sierra Leone															
United Republic of Tanzania															

Proposed measures but yet to be approved Implemented measures X Specific measures to support local industry and entrepreneurs

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2.2.2 COST RECOVERY AND TARIFF REGULATION

The viability and sustainability of mini-grids depend on well-designed tariff regulations. In some cases, rural populations themselves are unable to pay a tariff that reflects the full cost of electrification (Hunt, 2017). Regulators are, therefore, tasked with ensuring, on the one hand, affordability and quality of service for (primarily rural) consumers and, on the other hand, sustainable operation and cost-recovery for private mini-grid operators.

As the cost of generating electricity from mini-grids is generally higher than from the national grid, in contexts where national uniform tariffs are applicable (for rural and urban consumers), viability gap funding often becomes necessary. The provision for viability gap funded can be provided through various measures such as capital subsidies, performance-based subsidies and cross-subsidies (USAID, 2018). In other cases, regulators allow isolated mini-grid operators to set tariffs in consultation with local community members, such that the tariffs are high enough to cover costs but aligned with consumers' ability and willingness to pay.

Increasingly, regulators are taking a tailored approach to tariff regulation for mini-grids. **Nigeria, Rwanda** and the **United Republic of Tanzania**, for instance, allow deregulated tariffs for mini-grids under certain capacity thresholds (*e.g.*, under 100 kW in the United Republic of Tanzania). Some regulators provide provisions for tariff reviews in case a pre-determined proportion of consumers registers a complaint; however, the fact that tariffs in nearby villages or urban areas are lower is often not considered grounds for review. Meanwhile, larger mini-grids are required to use standardised tariff calculation tools (such as the multi-year tariff order [MYTO] model in Nigeria), and tariffs need to be approved by the regulator (Box 2.1). Indonesia and Peru have introduced a methodology for standardising tariffs to encourage private sector participation.

2.2.3 GRID INTERCONNECTION/ARRIVAL OF THE MAIN GRID

Reducing uncertainty around the arrival of the national grid is critical to the long-term viability of mini-grids. If defined ahead of time, interconnection and/or compensation mechanisms can allay associated risks. Countries, such as **Cambodia** (Box 2.2), **Indonesia, Nigeria, Rwanda** and the **United Republic of Tanzania** (as well as some states in India), have introduced regulations that allow a mini-grid operator to relocate assets, sell parts of its assets to the utility or become a small power producer selling electricity to the main grid at a fixed renewable feed-in tariff and/or become a distributor of electricity purchased from the main grid. An important determinant of the success of such provisions is the tariff determination post-interconnection.

If a compensation mechanism is mandatory, it provides a definitive exit option for mini-grid operators. In this case, the methodology for estimating the compensation (*e.g.*, asset depreciation) becomes a key consideration. Furthermore, access to a compensation option may facilitate the negotiation of a fair power purchase agreement that allows the operator to cover both purchases from and sales to the main grid. **Tanzania**'s compensation provision, for example, is limited to five years and covers only distribution assets, leaving significant elements of risk with the private sector.

Box 2.1 Mini-grid tariff setting in Nigeria: Multi-Year Tariff Order (MYTO) model

The Nigerian Energy Regulation Commission (NERC) has established a methodology to determine electricity tariff for the sector. The Multi-Year Tariff Order or MYTO is a tariff model used to set wholesale and retail prices for electricity by employing a standardised way. Its purpose is to set cost-reflective tariffs, with minor reviews each year in tlight of changes in a limited number of parameters (such as inflation, interest rates, exchange rates and generation capacity) and major reviews every five years.

NERC has adapted the MYTO model for mini-grids and offers the tariff calculation tool online to allow both developers and customers to agree on a project-specific tariff which will be approved by NERC in the event of developer seeking a permit. The tool uses the following constraints for tariff calculation:

- A fair return on capital, based on a weighted average cost of capital determined using the capital asset pricing model.
- A fair rate of depreciation, following the method of depreciated optimised replacement cost.
- Efficient operating costs. In determining their tariffs, mini-grid operators applying for a license are allowed to assume a maximum of 10% technical and 10% non-technical losses.

Source: NERC, n.d.; World Bank, 2017a.

Box 2.2 Provision of grid interconnection for isolated mini-grids in Cambodia

Cambodia has hundreds of diesel-powered mini-grids in rural areas, built and operated by local entrepreneurs since the 1990s. When the main utility grid had not yet reached many areas of the country, these locally developed mini-grids played an important role in providing access to modern electricity. However, with the rapid expansion of grids since the early 2000s, the national utility company, Electricité du Cambodge (EdC), made efforts to connect these isolated mini-grids to the main grid. The efforts ramped up upon the formation of the Electricity Authority of Cambodia in 2006, which introduced a comprehensive programme that granted long-term distribution licenses to the local private sector. Tariffs were regulated and standardised. Subsidies, calculated annually by the electricity authority for each distributor, were designed to ensure that distributors recovered their costs.

2.2.4 FINANCIAL SUPPORT FOR MINI-GRIDS

A robust mini-grid policy and regulatory landscape plays a key role in addressing key investment risks such as those related to licensing, tariff setting and main grid arrival. These improve the attractiveness of the sector by reducing transaction costs and risks during pre-feasibility and project development phase, addressing operational risks (*e.g.*, related to demand, revenue generation) and creating conditions for long-term sustainable operations.

Sustainable private sector-led mini-grid operation requires that fixed and operational cost of the infrastructure be sufficiently recovered along with risk-equivalent returns. Revenues originate from connection fees, electricity sales, and grants or subsidies (EUEI PDF, 2014). Different tariff design and regulatory approaches are followed for mini-grids (as discussed earlier), however often these are not sufficient for the viability of operation in the long run.

The cases analysed show that both the public and private sectors have played a role in mini-grid deployment, to varying degrees, depending on the context. In **Indonesia**, a strong public financing component has supported mini-grid deployment through subsidies and grants, with the ownership, and operation and maintenance responsibilities often transferred to the community. Meanwhile, private sector efforts that have invested in mini-grid generation and distribution assets and ensured their project sustainability through tariffs drove growth in **Cambodia** and **Uttar Pradesh (India)**.

To deploy renewable energy mini-grids in line with the 2030 target, both public and private investments need to be scaled-up substantially. Public financing will continue to play an important role with tailored instruments to de-risk private sector investments, address viability gaps, and for direct infrastructure investment where needed. Different approaches are being tried and tested, of which the case studies offer several examples:

- *De-risking project preparation phase:* The provision of matching grants under the Tanzania Energy Development and Access Expansion Program (TEDAP) in the **United Republic of Tanzania** allowed mini-grid developers to share cost for feasibility studies, environmental impact assessments, preparation studies for licenses, etc. The matching grants are available for pre-investment support financing up to 80% of the costs (20% has to be matched by project developers) (World Bank, 2011). The Rural Electrification Project in **Nigeria** includes provisions for public financing for the project preparation phase (including economic and geospatial data gathering for pre-selected sites).

- *Facilitating access to finance:* In **Rwanda**, the Scaling Up Renewable Energy Plan includes a component focusing on a line of credit and direct financing for off-grid electrification. The Renewable Energy Fund would provide lines of credit to local financial institutions (*e.g.*, savings and credit cooperative organisations, commercial banks) for on-lending to households, micro, small and medium enterprises, as well as direct loans to private companies. In the **United Republic of Tanzania**, a USD 23 million credit line by the World Bank provided long-term, low-interest debt to local commercial banks to refinance up to 85% of loans on projects under 10 MW.

- *Direct investment:* Capital subsidies are offered by several countries for the development of renewable energy mini-grids. In **Uttar Pradesh (India)**, mini-grid developers have the option to

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avail a pre-determined capital subsidy although this adds several other requirements including tariff restrictions, service quality, safety and security standards. **Nigeria**'s Rural Electrification Project aims to set the capital subsidy based on a tender process inviting bids for pre-selected mini-grid locations from private sector developers and operators. Split-assets investments approach is also perceived as a form of public-private partnerships wherein public financing is used to develop the distribution grid, while the private sector finances, operates and maintains the generation asset. Examples include earlier mini-grids projects in Nigeria under the Energy Support Programme and planned projects in **Sierra Leone** under the Rural Renewable Energy Programme.

- *Performance-based incentives:* Performance grants (or results-based financing) have been introduced in different countries. The nature of the grant is largely the same (*e.g.*, USD per end-user connection), although the value varies depending on the technology (*e.g.*, under TEDAP) or tier of electricity service provided (*e.g.*, under the SIDA/DFID funded programme in the **United Republic of Tanzania**) or on a site-by-site basis to ensure financial viability for the supplier (*e.g.*, in **Nigeria**'s Rural Electrification Project).

2.2.5 QUALITY STANDARDS

Standards and technical regulations seek to ensure the safe and reliable operation of a system. In turn, compliance with a recognised set of standards allows developers and suppliers to demonstrate that their system or product will meet its design goals. Most countries have a regulatory framework that relies on standards, among other factors (IRENA, 2018b). In **Nigeria**, to be eligible for a permit, mini-grids have to comply with the Nigerian Energy Regulation Commission (NERC)'s Distribution Code for the Nigeria Electricity Distribution System. The commission also offers recommendations for all mini-grid operators, whether or not they have a license. Similarly, in the **United Republic of Tanzania**, the Tanzania Bureau of Standards works together with the regulatory body and international partners to establish quality standards for mini-grids. **Indonesia** is a unique case among the countries analysed in this report: components have to meet not only national/international standards, but be locally manufactured (*e.g.*, for solar PV mini-grids, 34% of the materials have to be domestically sourced).

2.3 ASSESSING BROADER (SECONDARY AND TERTIARY) MEASURES TO CREATE AN ECOSYSTEM FOR DEPLOYMENT

The analysis finds that the mini-grid policy and regulatory landscape still does not adequately address secondary and tertiary aspects such as taxation, regulatory processes related to environmental and social impact assessments, capacity building and linkages with other sectors. All of these have a strong bearing on the scalability of renewable energy mini-grids and the socio-economic outcomes of deployment policies.

Several countries analysed, including **Indonesia, Nigeria** and **Rwanda** have introduced fiscal incentives such as value added tax and import duty exemptions on renewable energy equipment. Additional incentives, such as preferential corporate tax rates and tax holidays, are also being extended for investments in renewable energy projects and domestic manufacturing capacity. Specific attention is needed to ensure the effective implementation of such incentives, including raising awareness among relevant non-energy public institutions on the different facets of mini-grid technologies. This is particularly relevant for institutions involved in the various stages of mini-grid project development. For instance, streamlined Environment and Social Impact Assessments (ESIA) is often highlighted as an important measure to reduce transaction costs and speed up project implementation, especially for systems larger than 100 kW (Nigerian Economic Summit Group, 2018).

Complementary efforts are needed to build adequate capacity across the value chain (*e.g.*, government, financiers, communities) and identify cross-sector linkages (*e.g.*, productive end uses) to further enhance the sustainability of interventions. Interestingly, **Sierra Leone**'s approach to mini-grid development is anchored to the electrification of rural health facilities. International partners, such as the Department for International Development (DFID) and the United Nations Office for Project Services (UNOPS), are working with the government to develop enabling conditions for a public-private partnership model to support mini-grid development. This example demonstrates the possibility of identifying anchor loads, whether public services or productive activities (*e.g.*, agro-processing), which could provide predictable off-take guarantee for private sector mini-grids operators and de-risk part of the operational risk.

Indonesia's experience with mini-grids also offers valuable insights into the development of a local mini-grid industry, and the design of policies and regulations compatible with mini-grid deployment models that maximise socio-economic development. Indonesia has hundreds of mini-grids utilising micro-hydro and solar technologies. Most have been established through community-led efforts that foster local income generation businesses. Some export excess electricity to the main grid. Although the mini-grid market is not devoid of challenges, continued efforts in training and capacity building (*e.g.*, through the ASEAN Hydropower Competence Centre), cross-sectoral linkages and policies that support local industries (*e.g.*, mandatory local sourcing requirements) have played a role in enhancing local value creation.

A sound base of information on markets enables informed decisions related to policies, site assessments, investment opportunities and the design of delivery mechanisms. Countries such as **Nigeria, Rwanda** and the **United Republic of Tanzania** are working together with international partners to ensure that market information is available.

2.4 ADAPTING POLICIES AND REGULATIONS TO LOCAL CONDITIONS AND LESSONS

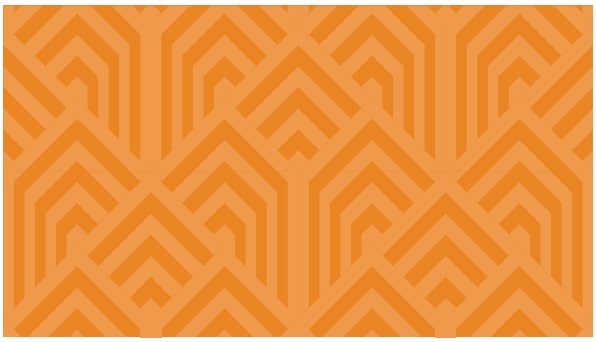
A policy and regulatory framework is key to accelerate mini-grid implementation considerably, prevent conflicts (*e.g.*, in case of main-grid connection) and maximise the socio-economic benefits (*e.g.*, by defining technical standards for main-grid compatibility or by indicating which sites are priorities for mini-grids). Yet, there is no one-size-fits-all solution and the case of Cambodia and Uttar Pradesh (India) point to that fact.

Both **Cambodia** and **Uttar Pradesh (India)** have seen the development of several hundred-isolated mini-grids in a largely deregulated environment. The technology solutions and contexts were largely different: large, diesel-powered mini-grids in Cambodia, and solar- or biomass powered, smaller grids delivering mostly basic electricity services in India. But policy makers and regulators in both cases focused on leveraging the existing mini-grid sector to scale up deployment, improve electricity services and reduce tariffs. Cambodia has largely been able to transform isolated mini-grids into regulated ones. Mini-grid licensees added almost 1 million new connections between 2005 and 2015. In Uttar Pradesh, a policy launched in 2016 provided specific guidance on the treatment of mini-grids but it has had a limited impact on the uptake of mini-grids.

Governments are encouraged to implement mechanisms such that lessons are captured and formally integrated into the policy review and design processes. **Tanzania**'s Small Power Producers framework, for instance, has evolved since 2008 with the aim to attract private sector participation in the development of both isolated and grid-connected mini-grids. The third generation of the framework is now in force and provides tailored licensing requirements and tariff regulations depending on capacity. Tanzania's experience has also shown the importance of looking at secondary and tertiary measures to improve conditions for mini-grid development. It facilitates investment by simplifying the environmental regulatory requirements for mini-grid development, and provides a single-window clearance facility and a dedicated portal for all information pertaining to mini-grid policies and regulations.

Nigeria's mini-grid regulation, launched in 2017, for instance, benefits from the lessons learned by other countries in the region, and was developed with extensive stakeholder engagement. It includes key provisions for tariff determination/regulation and compensation mechanisms in case of main-grid connection, among other aspects.

The next chapter analyses the case studies in greater depth. Readers will note the deployment of a wide range of policies, instruments and financing modalities to catalyse private sector investment in mini-grids. While common themes emerge, each case offers a unique set of lessons, further illustrating the importance of a tailor-made context-specific approach to mini-grid development.



CASE STUDY 1: NIGERIA

Population (2017)

Total installed capacity (2017)

Rural electrification rate (2016)

Electricity consumption per capita (2013)

In Nigeria, nearly 60% of the population has access to electricity, ranging from 41% in rural areas to 86% in urban areas (ESMAP, 2018). At the national level, demand for electricity largely exceeds supply. In 2015, for instance, only 6 gigawatts (GW) of the 10.4 GW of total installed generation capacity was available. Meanwhile, demand was estimated at 31 GW (Energy Commission of Nigeria, 2015). In this context, where the technical and economic case for grid expansion to rural areas is weak, off-grid solutions, such as stand-alone systems and mini-grids, have an important role to play in furthering electricity access.

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

To meet growing demand, Nigeria has identified mini-grids as one of the key solutions to electrify rural areas. Ten thousand mini-grid sites with a total capacity of 3 000 MW have been identified for possible development by 2023 (REA, 2017a). Estimates suggest that at least 30 solar mini-grids are operational with a total installed capacity of 1 MW, serving 6 000 customers. The increased competitiveness of mini-grid solutions and demand for electricity services in rural areas are likely to drive the adoption of mini-grids. The government's commitment to supporting a rapid scale-up is evident through on-going processes to introduce dedicated policies and regulations, latest among them being the Nigerian Electricity Regulatory Commission Mini-Grid Regulation, 2016 as detailed later.

INSTITUTIONAL FRAMEWORK

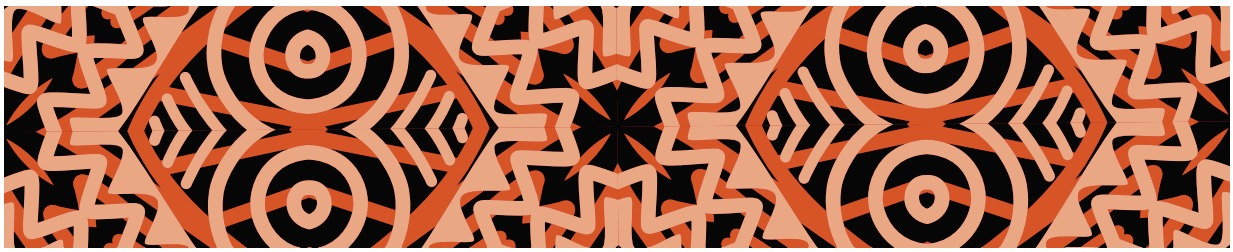
Following the enactment of the Electric Power Sector Reform Act (EPSRA) in 2005, Nigeria's power sector was unbundled and the vertically integrated entity National Electric Power Authority was divided into 6 generation companies, 11 distribution companies and the government-owned Transmission Company of Nigeria. The privatisation of generation and distribution companies concluded in 2013. Table CS 1.1 provides a brief overview of the major stakeholders involved in the mini-grid sector.

Table CS 1.1 Overview of Nigeria's mini-grids institutional landscape

	Topics	Institution	Description
PRIMARY MEASURES	Planning	Energy Commission of Nigeria	Responsible for strategic planning and co-ordination of national policies in the field of energy.
	Policy	Federal Ministry of Power, Works and Housing (FMPWH)	Drafts and implements policies and strategies for the power sector.
	Regulation	Nigerian Energy Regulation Commission	Undertakes technical and economic regulation, licenses operators, determines operating codes and standards, establishes customer rights and obligations and sets cost reflective tariffs.
		Nigerian Bulk Electricity Trading Plc.	Indirectly regulates the bulk energy trading between distribution companies and interconnected mini-grid operators by allocating power to distribution companies.
	Implementation	Rural Electrification Agency	Co-ordinates and supports electrification initiatives in rural and unserved areas.
		Distribution companies (40% state owned)	Responsible for the distribution of power to end consumers.
	Financing	Rural Electrification Fund managed by the Rural Electrification Agency	Administers and manages public funds from different sources to support rural electrification.
SECONDARY MEASURES	Environmental and health protection	Federal Ministry of Environment	Regulates the implementation of environmental and social impact assessments as a mandatory part of development projects in Nigeria.
	Quality standards	Standards Organization of Nigeria	Develops and adopts standards.
		Nigerian Electricity Management Service Agency	Enforces the application of standards in the Nigerian electricity sector.
		Nigerian Energy Regulation Commission	Makes existing standards mandatory through regulation.

POLICY AND REGULATORY UPDATES

The National Electric Power Policy of 2001 established the basis for the EPSRA, the overarching law governing the power sector. There have been numerous policy updates over the years, among them being the establishment of the Rural Electrification Agency (REA) in 2008. Figure CS 1.1 shows a detailed timeline of the introduction of policies and regulations relevant to mini-grids.



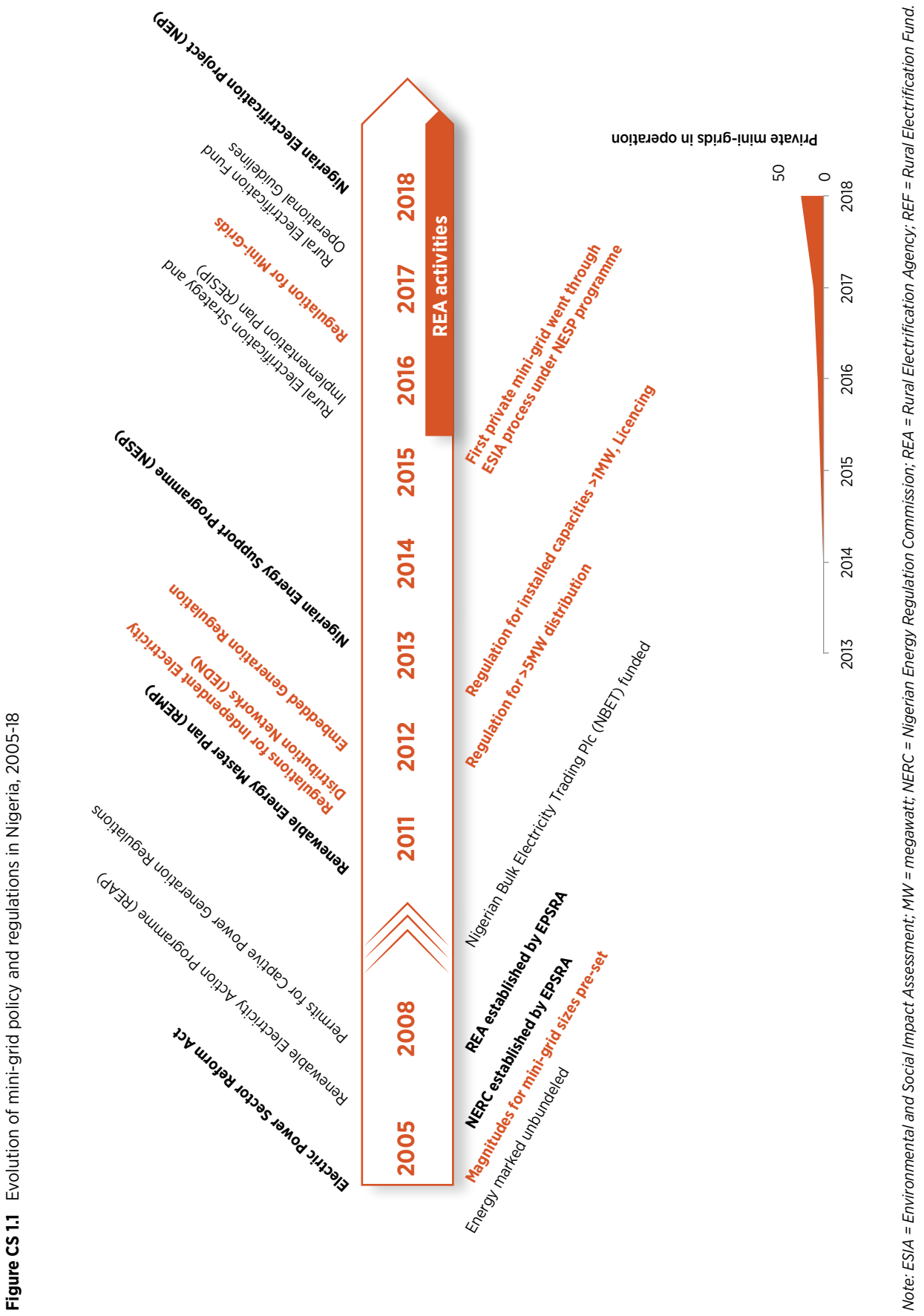


Figure CS 1.1 Evolution of mini-grid policy and regulations in Nigeria, 2005-18

Note: ESIA = Environmental and Social Impact Assessment; MW = megawatt; NERC = Nigerian Energy Regulation Commission; REA = Rural Electrification Agency; REF = Rural Electrification Fund.

Primary measures

National policy on energy and renewables

The **Electric Power Sector Reform Act** that liberalised the power sector was a key building block needed to create a favourable environment for rural electrification through privately operated mini-grids. The Act recommended the creation of the **Nigerian Energy Regulation Commission** (NERC) as an independent regulating body and the creation of the REA to co-ordinate electrification in rural areas and administer the **Rural Electrification Fund** to provide financial assistance.

Furthermore, in 2011, the government issued the **Renewable Energy Master Plan** to promote renewable energy in the power sector. This plan does not explicitly discern between on-grid and off-grid generation, but it aims to increase the contribution of renewable technologies to account for 10% of the Nigerian total energy consumption by 2025 (Energy Commission of Nigeria, 2011).

Rural electrification strategy and master plan

The first phase of the **Nigerian Energy Support Programme (NESP)** (2013-2017), implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) with funding from the European Union and the German government, supported the Nigerian Federal Ministry of Power, Works and Housing to improve access to sustainable energy. Key activities included producing electrification plans and developing a data management system (*i.e.*, suitability studies to identify potential mini-grid sites), supporting the development of a dedicated regulation for mini-grids, piloting public-private partnership model for mini-grid deployment, as well as institutional capacity building (GIZ, 2017). The programme ended with the development of six solar mini-grids in five partner states using the public-private-partnership and split-asset model, within which the private sector covered 50% of the project's capital costs (Nigerian Economic Summit Group, 2018).

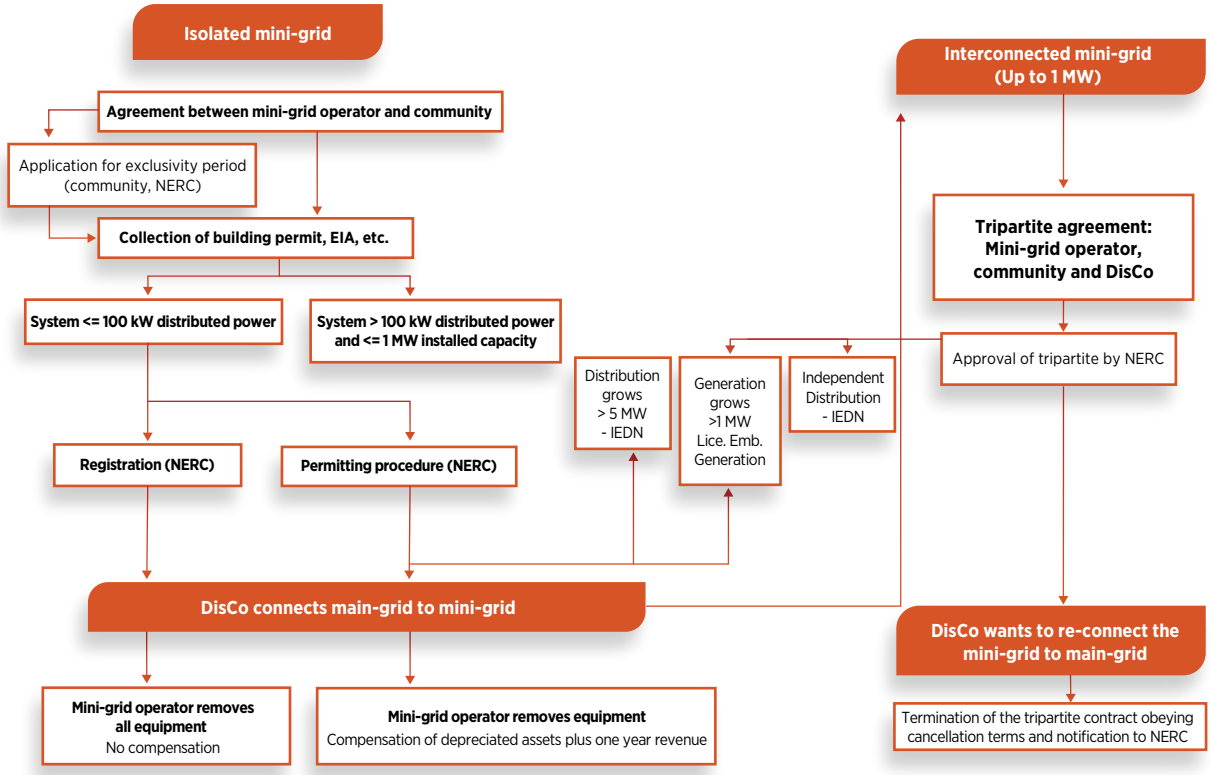
As a further building block of the process enhanced by the EPSRA, the **Rural Electrification Strategy and Implementation Plan** was released by the REA in 2016 to promote a full catalogue of rural electrification options for on-grid and off-grid solutions. This highlights the importance of community and privately owned mini-grids for accomplishing electrification goals (FMPWH, 2016).

Mini-grid regulations

The **Regulation for Mini-Grids** released in 2017 by the NERC stipulates a comprehensive and safe regulatory environment for mini grid projects (NERC, 2016). To ensure the needed institutional framework, new Rural Electrification Fund Operational Guidelines 2017 were developed and implemented. The guidelines specify a grant award process, including timelines, selection criteria and support to bidders during the application process.

Figure CS 1.2 provides an overview of the mini-grid deployment process and the associated regulatory framework.

Figure CS 1.2 Mini-grid deployment, including roles of key stakeholders



Note: DisCo = distribution company; EIA = environmental impact assessment; IEDN = Independent Electricity Distribution Networks; kW = kilowatt; MW = megawatt; NERC = Nigerian Energy Regulation Commission.
Source: NERC, 2016

Licensing and legal provisions for mini-grids are well established in the country. An unserved area is defined as an area that has not been connected to the distribution network of any distribution licensee, or is not part of an NERC-approved (five-year) expansion plan of a distribution company. Upon the identification of an unserved area, the developer has to negotiate with the community and NERC for a potential exclusivity period of a maximum 24 months for the feasibility study and project development phase.

The developer should then start the collection of required permits (building permit, environmental and social impact assessment, etc.), and perform the technical design and evaluate the options for the NERC registration and permits. For mini-grids with a distributed capacity above 100 kW and an installed capacity of less than 1 MW, obtaining a permit is mandatory. For mini-grids with a distributed capacity below 100 kW, registration with NERC is sufficient although developers may apply for a permit voluntarily (World Bank, 2017a). The NERC is to grant or deny a permit or license within 30 days upon receipt of the application and it must state in writing its reasons to the applicant in the event of an objection or denial.

Meanwhile, **interconnected mini-grids** (up to 1 MW generation capacity) are eligible for permits in underserved areas, defined as areas within a distribution licensee's network but with a poorly supplied or non-functional distribution system. In case the distributing company connects the main grid to a mini-grid, a tripartite agreement between the mini-grid developer, the distributing company and the community is required, which has to be approved by the NERC. Following this, the mini-grid operator either becomes a generator under a licence for embedded generation or an independent distributor under the IEDN regulation. The permit not only implies that the tariff must be calculated with the Mini-grid Multi-Year Tariff Order (MYTO) tool but it also includes a guarantee for compensation in case of grid arrival. Recently, a renewable energy firm has signed a MoU with a distribution company to develop interconnected mini-grids (NNodim, 2018).

Tariff setting. Registered mini-grid companies with distribution capacity below 100 kW are allowed to set their own tariffs as long as they do not voluntarily apply for a permit. However, mini-grid operators that apply for a permit must use the mini-grid MYTO (cost-

plus/cost of service method) tariff calculation tool, and their tariff has to be approved by the NERC. For interconnected mini-grids, developer agrees with the distribution company and the community on retail tariff, usage right for the network infrastructure, and tariff for electricity generated by the mini grid and fed into the distribution companies' network. MYTO is to be only used to calculate retail tariff. Online forms and tools are provided to facilitate the process and lower associated costs.

Arrival of the main grid. The latest policy on mini-grids guarantees that operators holding a permit will be compensated once the main grid arrives. They may either convert their operation into an interconnected mini-grid or sell their assets at the depreciated price plus 12 months of revenue.

Access to funding. The REA is the implementation agency for the five-year **Nigeria Electrification Project,** which is a USD 350 million facility from the World Bank. It includes a dedicated component for the development of solar hybrid mini-grids amounting to USD 150 million (World Bank, 2018b). The direct support for the mini-grid sector consists of the following two components: USD 70 million as support in a competitive bidding for a portfolio of mini-grid sites and USD 80 million as a results-based financing, disbursing a fixed grant amount per new customer connected to a mini-grid (REA, 2018).

The first component (minimum subsidy tender) focuses on high-potential sites identified by the REA to provide the scale needed by larger or international developers to participate in the sector (World Bank, 2018b). Private developers will be invited to bid for capital cost subsidies to build, own and operate a portfolio of mini-grids across 100 pre-selected sites. For these sites, detailed economic and geospatial data will be made available to developers which includes potential anchor loads (*e.g.*, telecom towers, agricultural loads, rural enterprises). Additional mini-grids are also foreseen in high-risk environments (*e.g.*, conflict areas) which will be fully publicly financed, with the private sector constructing and operating the systems (REA, 2018).

Meanwhile, the second component (performance-based grants) is designed for developers who have independently identified and developed sites with sustainable business plans. The grants are designed to incentivise operators to deliver electricity services to new customers (*e.g.*, USD per end-user). The value of the grant is expected to be set to ensure both financial viability for the supplier and affordability for the consumer (REA, 2018).

Quality standards. To be eligible for a permit, mini-grids have to comply with the NERC Technical Codes and Standards, terms and conditions of the Permit or the Tripartite Contract. This applies to the design, construction, commissioning, operation and maintenance and decommissioning of the distribution network and related facilities. Meanwhile, registered operators are not bound by the Technical Codes and Standards but may apply the minimum technical requirements prescribed in the regulation. Basic guidance on cable cross-section, circuit breaker and fuses specification, grounding standards, guidance on IP-ratings and limits for voltage and frequency fluctuation is provided.

Secondary measures

Environmental protection measures

Performing an environmental and social impact (ESIA) assessment is mandatory for any development project in Nigeria, mini-grids included. The process is regulated by the Federal Ministry of Environment. In 2015, the first private mini-grid project under the NESP completed an ESIA assessment successfully. But the process is seen as a financial burden for mini-grid developers, and time-consuming, keeping them away from undertaking larger mini-grid projects (Nigerian Economic Summit Group, 2018).

Taxation and other fiscal measures

The Nigerian government has created several incentive schemes to stimuate private sector investment. One of these, "Pioneer Projects" grants tax holidays for upto five years to companies that manufacture solar panels, batteries, solar home systems, light emitting diodes, and other components that support solar energy production (EY, 2017).

Another financing programme is the Micro, Small and Medium Size Enterprise Development Fund of the Central Bank of Nigeria, established in 2013 with the objective of channelling low-interest credit. Since most mini-grid companies are small or medium-sized, and renewable energy and energy-efficiency products are eligible (CBN, 2015), mini-grid operators would be able to benefit from low-interest loans for their assets.

Tertiary measures

The **Nigeria Electrification Project** has a dedicated component focusing on technical assistance and capacity building aimed at improving the overall ecosystem for renewable energy mini-grids. The focus is on strengthening implementation capacities within the different institutions involved in mini-grid development, including the REA, NERC and FMPWH, and other stakeholders (World Bank, 2018b).

RESULTS AND CHALLENGES

The Electric Power Sector Reform Act set in motion the development of an enabling institutional, policy and regulatory landscape for renewable energy mini-grids. It provided the legal basis for the setting up of the Rural Electrification Agency in 2006, a public body charged with designing and implementing strategies to expanded electricity access. The policy and regulatory framework has since evolved with further guidance and specificity for mini-grids, including the RESIP in 2016 and the Regulation for Mini-Grids released in 2017 by the NERC.

Presently, Nigeria provides mini-grid developers with a tailored policy and regulatory environment addressing common investment risks associated with licensing, tariff setting, risk of main grid arrival and financial support. As the Nigeria Electrification Project (implemented by the REA) is quite recent, along with technical and financial support from the next phase of NESP and the Rural Electrification Fund, substantial learnings will be gathered as these programmes are implemented.

Based on recent developments, some key areas that require attention include:

- Facilitating access to financing for the mini-grid sector and addressing prevalent risks mainly related to foreign exchange.
- Streamlining administrative processes covering, especially those related to non-energy sector related regulatory requirements such as those related to Environmental and Social Impact Assessments.
- Expanding the scope of fiscal incentives (*e.g.*, tax and duty exemptions) to cover additional key assets of mini-grids, apart from the generation components.
- Furthermore, communicating grid expansion plans in a timely manner, streamlining the permitting process and setting up a dedicated financing facility to complement the results-based grants could also potentially address some of the key existing challenges. Local governments could support developers by raising local awareness of electrification projects.

RESOURCES

- Electric Power Sector Reform Act (2005)
  http://kyg.nigeriagovernance.org/Attachments/Organization/Act/142_Electric%20Power%20Sector%20Reform%20Act%20of%202005.pdf
- Rural Electrification Strategy and Implementation Plan (2016)
  http://rea.gov.ng/download/rural-electrification-strategy-implementation-plan-resip/
- Regulation for Mini-Grids (2016)
  http://rea.gov.ng/inc/uploads/2018/07/NERC-Mini-Grid-Regulation.pdf
- Rural Electrification Fund Operational Guidelines (2017)
  http://rea.gov.ng/inc/uploads/2017/11/Approved-Operational-Guidelines-for-the-REF-2017-v3.pdf
- Nigerian Electrification Project (2018)
  http://rea.gov.ng/inc/uploads/2018/08/OVERVIEW-OF-THE-NIGERIA-ELECTRIFICATION-PROJECT-NEP.pdf

CASE STUDY 2: RWANDA

Population (2017)

Total installed capacity (2017)

Rural electrification rate (2018)

Electricity consumption per capita (2014)

The power sector in Rwanda is vertically integrated, involving primarily state-owned institutions: the Rwanda Energy Group, Ltd., and its two subsidiaries, the Energy Utility Corporation, Ltd., and the Energy Development Corporation, Ltd., which are entrusted with energy development and utility service delivery (USAID, 2016). The retail tariff for household customers is USD 0.12-0.28/kilowatt hour (kWh), depending on their consumption levels. Households are the major consumers of electricity, consuming 51%, followed by industry at 42% and public services (*e.g.*, street lighting, water pumping, schools and health centres) at 7% (Mininfra, 2015a).

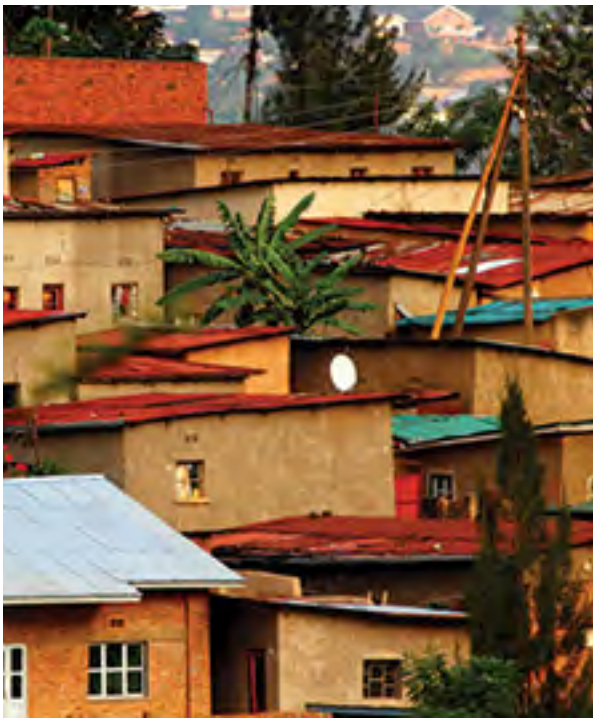
The current electrification rate of Rwanda is 46%, of which 11% is provided through off-grid solutions and 35% accessed through on-grid connections (REG, 2018). In rural areas, where over 70% of the population resides, only 18% of the population has access to electricity (ESMAP, 2018). The government of Rwanda has set a target to achieve universal electricity access by 2024. It expects to meet that objective through both on-grid (52%) and off-grid (48%) solutions (Mininfra, 2015a).

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

In terms of rural electrification, the off-grid market has been generally dominated by solar lanterns and solar home systems, which are well suited to sparsely populated rural areas marked by low energy demand of around 2-7 kWh/month (Endev and EPD, 2017). In the past few years, there has been a steady increase in the deployment of mini-grids in the country, especially resulting from private sector initiatives. In 2017, four private entities were commissioning and operating hydro and solar (DC) and (AC) mini-grids. There are around 80 solar DC PV mini-grids with a 1 kW PV system and batteries providing basic lighting and other services to clusters of up to 50 households per system. The micro-hydro installations are significantly larger (World Bank, 2017b).

The potential for renewable energy mini-grids is high. A study performed by the Energy Development Corporation, Ltd., and funded by the Sustainable Energy Fund for Africa (SEFA), identified over 200 potential mini-grid sites. The recently approved National Electrification Plan by the Rwanda Energy Group, Ltd., foresees 10% of off-grid targets to be met

by mini-grids connecting over 300 000 households. Feasibility studies for 20 micro-hydro sites have been financed by SEFA (Endev and EPD, 2017). A wide range of productive loads across Rwanda, including agro-industries, could serve as anchor customers for mini-grids (World Bank, 2017b).



INSTITUTIONAL FRAMEWORK

Table CS 2.1 provides an overview of the relevant public institutions and stakeholders involved in the policy, regulation and implementation of mini-grids.

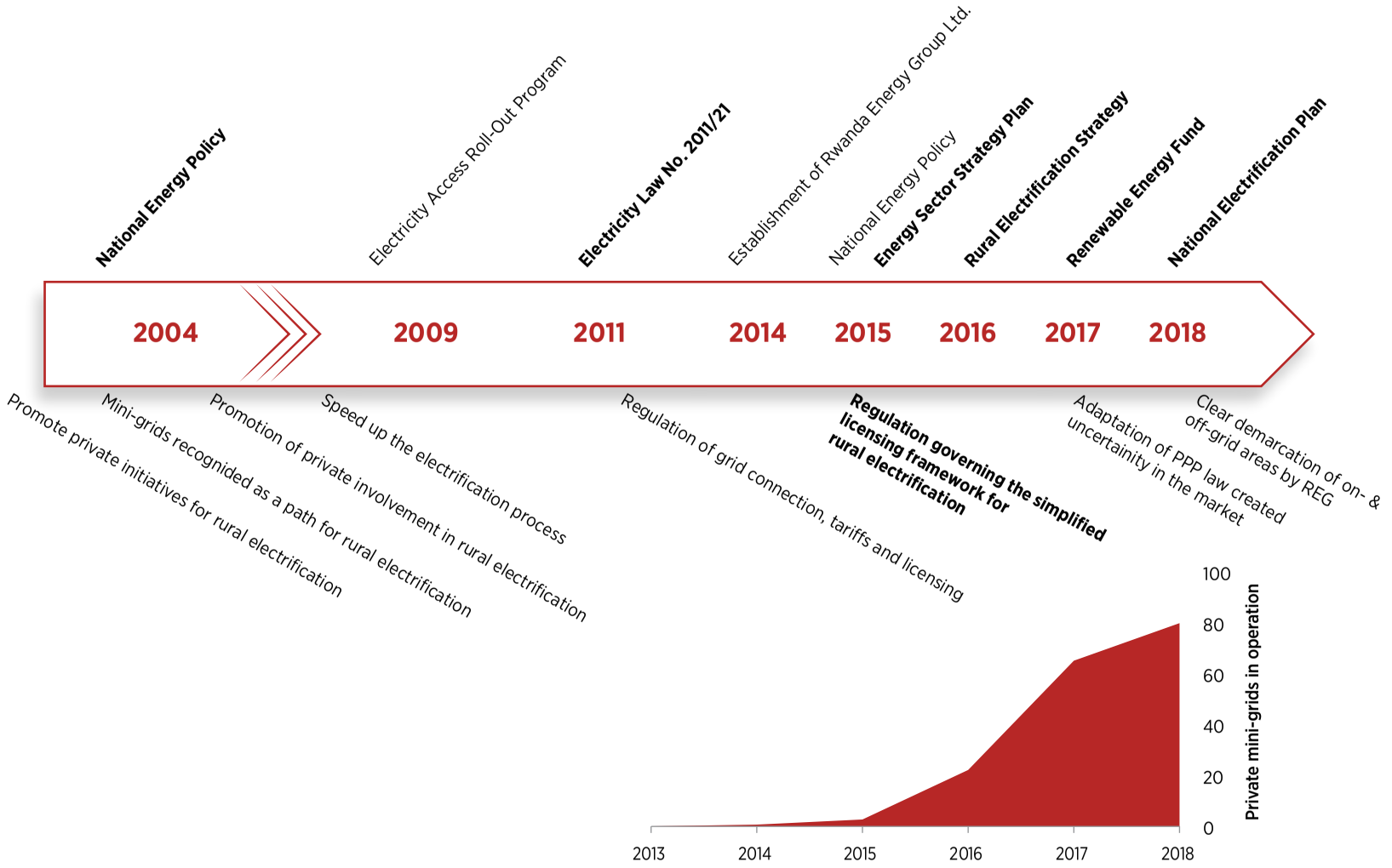
POLICY AND REGULATORY UPDATES

Mini-grids have been part of Rwanda's energy policy since 2004, and since then, the country has introduced several adaptations. However, deployment has picked up only since 2015. A complete overview of the evolution of the policy and regulatory environment is shown in figure CS 2.1.

Table CS 2.1 Overview of Rwanda's institutional landscape

	Topics	Institution	Description
PRIMARY MEASURES	Planning	Ministry of Infrastructure	Leads the National Energy Policy and is responsible for a rural electrification strategy.
	Policy		
	Regulation	Rwanda Utilities Regulatory Authority	Regulates public utilities, and is also responsible for ensuring cost-reflective tariffs, and the approval and registration of mini-grid projects.
	Implementation	Rwanda Energy Group Ltd. – state owned	Responsible for energy development, ensuring energy utility service delivery, and a plan demarcating on-grid and off-grid electrification.
	Financing	Development Bank of Rwanda	Provides loans to mini-grid projects.
SECONDARY MEASURES	Environmental and health protection	Rwanda Environment Management Authority	Approves the environmental suitability of electricity (distribution) projects.
	Tax and business registration	Rwanda Development Board	Responsible for business registration, investment promotion, environmental clearances, privatisation and specialist agencies that support the priority sectors of information and communication technology and tourism as well as small and medium enterprises and human capacity development in the private sector.
		Rwanda Revenue Authority	Charged with enforcing, assessing, collecting and accounting for the various taxes imposed in Rwanda.
	Quality standards	Rwandan Standards Board	Defines national standards.
		Rwanda Utilities Regulatory Authority	Responsible for the setting and verification of technical standards.

Figure CS 2.1 Evolution of mini-grid policy and regulations in Rwanda, 2004-18



Note: EARP = Electricity Access Roll-out Program; PPP = public-private partnership; REG = Rwanda Energy Group Ltd.

Primary measures

National policy on energy and renewables

The **National Energy Policy (NEP)** was established in 2004, and mini-grids were recognised for the first time as a complementary strategy for rural electrification. The policy was later updated in 2015 with the main objective of meeting the energy needs and challenges in Rwanda. The NEP set the basic principles for reducing business barriers, especially in rural electrification; promoting transparency with effective sector governance; and enhancing the institutional, organisational as well as legal and regulatory frameworks (Mininfra, 2015b). The NEP was further supported through the **Electricity Access Roll-Out Program**, which rolls out the construction of power networks to increase on-grid electricity access connections, focusing on high-consumption users with a special emphasis on social infrastructure – health facilities, schools and administrative offices. It was launched in 2009 by the government of Rwanda to achieve energy-specific objectives and targets set out in the Economic Development and Poverty Reduction Strategy.

Law No. 21/2011 of 23 June 2011 Governing Electricity in Rwanda was enacted in 2011 to govern activities of electricity production, transmission, distribution and trading within Rwanda and cross-borders. The **Rwanda Energy Sector Strategic Plan (ESSP)**, released in 2015, and updated in 2018, breaks down the long-term vision of full electrification formulated in the **National Energy Policy** (2015) into short-term goals and concrete measures. It is comprised of action plans for the development of seven priority sub-sectors including solar power, bioenergy and hydropower. The new ESSP targets 100% electricity access by 2024. The **National Electrification Plan** demarcates targeted areas for off-grid projects and grid connections up to 2024.

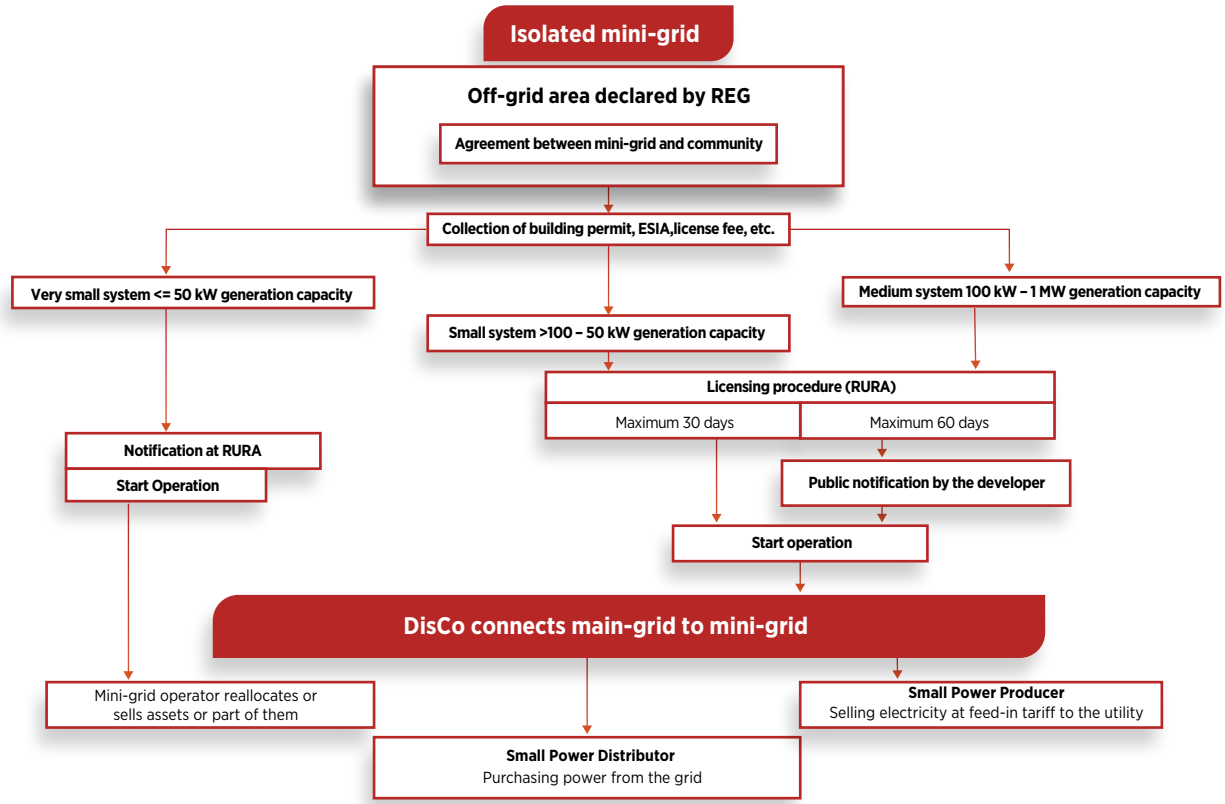
The **Rural Electrification Strategy**, released in mid-2016, includes in one of its four programmes the provision of access through sustainable mini-grids. In 2017, the Ministry of Finance and Economic Planning initiated the **Renewable Energy Fund (REF)**, financed by the World Bank and implemented by the Development Bank of Rwanda. The fund is designed as a financial intermediary providing local-currency loans, while using existing country systems and promoting private sector investments to ensure sustainability (World Bank, 2018a).

Mini-grid regulations

The **Rwanda Utilities Regulatory Authority (RURA)** was created by **Law Nº 39/2001** (in September 2001) as the regulatory body of the infrastructure sector, including energy. Its mission was later revised and specified by **Law Nº 09/2013 (in March 2013)** mandating that RURA regulate all public utilities including mini-grids (and, specifically, their registration, licensing and tariff regulation) (RURA, 2013).

RURA has developed a dedicated mini-grid regulatory framework, the first version of which was approved in August 2015 (RURA, 2015). The rules apply to mini-grid projects with generating capacity of up to 1 MW; projects with 100 kW or less are eligible for simplified and streamlined licensing, and mini-grids below 50 kW are exempt from licensing requirements. Since implementing these regulations, RURA has received positive feedback from developers and is working with the World Bank's Energy Sector Management Assistance Program (ESMAP) to develop a 2nd-generation regulatory framework based on public consultation with developers and other stakeholders. Figure CS 2.2 illustrates the procedures for the deployment of mini-grids and the involvement of key stakeholders at various stages of the process.

Figure CS 2.2 Mini-grid deployment, including roles of key stakeholders



Note: DisCo = distributing company; ESIA = Environmental and Social Impact Assessment; FI-Tariff = feed-in tariff; kW = kilowatt; MW = megawatt; REG = Rwanda Energy Group Limited; RURA = Rwanda Utility and Regulatory Authority.

Licensing and legal provisions. The areas for off-grid electrification are currently earmarked by the utility Rwanda Energy Group, Ltd., in the National Electrification Plan, which has been recently finalised and published. Mini-grid operators willing to develop a project in a designated area need to get a license from RURA. For licensing, mini-grids are divided into four categories: large, medium (100 kW to 1 MW), small (50-100 kW) and very small (<50 kW). Operators of very small, isolated grids are exempt from licensing requirements but obligated to notify RURA of their existence.

The licenses for larger mini-grids award exclusive rights for the distribution and retail of energy for 5 to 25 years in a geographically determined area, while generation remains open to competition if it is proven that the system is not meeting demand (RURA, 2015). Like the rules of the United Republic of Tanzania, the draft regulatory framework includes a provision for provisional licensing for preparatory activities such as feasibility studies and assessments. Licenses are expected to be granted for 10 years to isolated mini-grids and 15 years for small power distributors.

Tariff setting. Licensees are free to set their own tariffs. Regulation authorities have the right to review tariff calculations by mini-grid licensees to ensure fair prices for end-users while allowing "reasonable" revenue generation and return on investment for the operator (RURA, 2015).

Arrival of the main grid. The regulation provides several options to mini-grid operators in case the main grid arrives to their mini-grid site. The operator can relocate assets, sell parts of the assets to the utility, or become a small power producer selling electricity for a fixed renewable feed-in tariff and/or become a distributor of electricity purchased from the main grid. But the terms are still not explicit enough to remove all private developers' uncertainty regarding grid arrival.

RURA provides mediation or conflict resolution in case the utility and mini-grid operators cannot reach agreement on a purchase price or compensation. RURA is mandated to consider the mini-grid operator's effort in familiarising customers with electricity services over years. Any asset's sales price is to be

based on the net book value of the fixed asset indexed with the consumer price index and based on generally accepted accounting principles: the value of current assets minus the current liabilities, plus the present value of expected net profits over the remainder of the isolated grid license and based on a discount rate provided by the authority.

Access to finance. Upon the approval of the Rwanda Investment Plan, the Scaling Up Renewable Energy Plan (SREP) allocated approximately USD 50 million to accelerate the growth of off-grid electricity access through stand-alone solar systems and renewable energy mini-grids. The programme aims to catalyse private investment in the provision of off-grid electricity services through the establishment of an REF, which would be implemented by the Development Bank of Rwanda (Box CS 2.1) (World Bank, 2017b).

Box CS 2.1 Renewable Energy Fund for increased access to financing for mini-grids in Rwanda

The Scaling Up Renewable Energy Plan (SREP) of the World Bank allocated approximately USD 50 million to accelerate the growth of off-grid electricity access through stand-alone solar systems and renewable energy mini-grids. The fund has two main components of operation relevant for mini-grids:

1. Direct lending to mini-grid developers. The fund operationalises the Renewable Energy Fund (REF) which will provide direct lending in local-currency from the Development Bank of Rwanda (BRD) to eligible mini-grid developers. The financing is conceived as a 'bridge loan' for developers during the pre-commissioning stage until results-based financing is available post-commissioning through, for instance, the Energising Development (EnDev) program.
2. Technical assistance, capacity building and project implementation support. The fund will provide necessary technical assistance and capacity building to the BRD, the implementing body and participating entities (savings and credit cooperative organisations, banks and private

Source: World Bank, 2017b

Secondary measures

Taxation and other fiscal measures

The **Organic Law on Environment** (Law No. 04/2005), released in 2005, determines the modalities of protecting and promoting the environment. This law stipulates that industries importing equipment that reduces carbon dioxide emissions and thus decreases pollution are subject to lower customs duties (Mininfra, 2015b). The EAC Customs Management Act stipulates that solar-powered equipment and accessories are exempt from customs duty (RRA, n.d.).

Law No. 06/2015 of 28 March 2015 relating to Promotion and Facilitation, implemented by the Rwanda Development Board, highlights the energy sector as a priority investment area and provides specific incentives – such as preferential corporate income tax rates – to investors in renewable energy, including in solar, geothermal, hydro, biomass and wind (RDB, 2015).

Tertiary measures

The Government of Rwanda enacted the **Public-Private Partnership Law** (Law No. 14/2016 of 02/05/2016) to govern PPPs. As a follow-up, the Rwanda Development Board issued general guidelines for the procurement of PPP projects in July 2018. The guidelines, while covering renewable energy projects more broadly, explicitly note that "isolated mini-grids with no off-take commitment from Government of Rwanda do not fall under the PPP law. They will be governed by the simplified licensing procedure from RURA" (RDB, 2018).

RESULTS AND CHALLENGES

Mini-grids first appeared in Rwanda's policy after the adoption of the National Energy Policy in 2004. In that, the government recognised that main-grid extension could provide significant value, but would not meet all demand for reliable, cost-effective and universally accessible electricity supply. Since then, through various plans and programmes, such as the National Electrification Plan, Energy Sector Strategic Plan and the Renewable Energy Fund, the role of mini-grids in achieving universal access has been elaborated and strengthened.

The rural electrification strategy recognises the crucial role of the private sector in ensuring universal access. As such, the strategy lays out the government's role in creating an enabling environment for private developers by identifying eligible sites and undertaking financial and technical feasibility studies of these sites. These sites will then be tendered out to private developers. Although supportive measures are in place for private developers, the mini-grid sector currently includes only a handful of private sector developers. In the last year, four companies, MeshPower (78 mini-grids with a size of 1 kW), ECOS (1 mini-grid of 11 kW), RENERG (1 mini-grid of 30 kW) and Neseltec (1 mini-grid of 30 kW), commissioned, operated and expanded their activities in both hydro and solar mini-grids (Endev and EPD, 2017).

Several challenges, both general and specific to mini-grids, need to be addressed to scale up deployment:

- A clear demarcation of on-grid and off-grid areas set by National Electrification Plan was missing until recently. Between areas defined for stand-alone solutions and mini-grids, provision for a margin should be included that allows mini-grids to adapt their catchment depending on the availability of resources, demand and the productive loads.

- There is a lack of financing for mini-grid developers and entrepreneurs engaged in the productive end use (PUE) activities. Even though some programs such as Scaling up Off-Grid Energy Rwanda began effectively supporting developers in PUE development, a break-through in mini-grid profitability has not yet been observed.

- Developers' limited technical skills in renewable energy technologies and in business model development has hindered the market from realising its growth potential.

- Grants/subsidies (provided by EnDev) need to be complemented with access to debt and equity financing and concessionary instruments to enhance access to long-term, affordable financing.

Even though Rwanda is one of the earlier adopters of mini-grids, its market has started to make strides only recently. Donors, organizations and financial institutions are stepping up their financial support. Recent policies and regulations are aligned to support the private sector's engagement and investment in the sector. However, careful planning along with financial support is necessary to scale market development. Several specific measures such as increased attention to the productive use of energy and introduction of specific technical standards might prove crucial for the accelerated deployment of mini-grids in the country.

RESOURCES

- Energy Sector Strategic Plan (2018)
  http://www.mininfra.gov.rw/fileadmin/user_upload/infos/Final_ESSP.pdf
- Rural Electrification Strategy (2016)
  http://www.mininfra.gov.rw/fileadmin/user_upload/aircraft/Rural_Electrification_Strategy.pdf
- Energy Sector Strategic Plan (2015)
  http://www.mininfra.gov.rw/fileadmin/user_upload/new_tender/Energy_Sector_Strategic_Plan.pdf
- National Energy Policy (2015)
  http://www.mininfra.gov.rw/fileadmin/user_upload/new_tender/Energy_Policy.pdf
- Law No. 21/2011 of 23 June 2011 Governing Electricity in Rwanda
  http://www.mininfra.gov.rw/fileadmin/_migrated/content_uploads/ELECTRICITY_LAW_RWANDA_01.pdf

CASE STUDY 3: SIERRA LEONE

Population (2014)

Total installed capacity (2014)

Rural electrification rate (2017)

Electricity consumption per capita (2013)

The national electrification rate of Sierra Leone was just over 20% in 2016, and characterised by great disparity in the rates for urban (47%) and rural (3%) areas (ESMAP, 2018). There is a gap between supply and demand for power, with generation capacity at around 100 MW (based primarily on oil and hydropower) and demand estimated to be over 250 MW (EEG, 2018a). The lack of sufficient grid-based generation capacity has led to a substantial captive generation capacity among mining and non-mining businesses as well as private households (EEG, 2018a). The capacity of the power sector to meet rapidly growing electricity demand in urban areas is limited and leaves little room for investments in expanding the grid infrastructure to reach rural areas without electricity access.

To address the electricity access challenge, Sierra Leone's government, supported by the Economic Community of West African States (ECOWAS) Centre for Renewable Energy and Energy Efficiency (ECREEE) and Sustainable Energy for All SEforALL, launched an Action Agenda with the objective of achieving almost universal access to electricity (92%) by 2030 (ECREEE, 2015). The Electricity Sector Reform Roadmap (2017-30) reiterates universal access to electricity as a long-term (2026-30) objective (Ministry of Energy of Sierra Leone, 2017).

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

Renewable energy mini-grids have gained significant attention over the past few years as a viable option to improve access to electricity and complement grid extension efforts. In 2012, three solar PV mini-grids were installed, totalling 53 kWp, financed by the United Nations Industrial Development Organization. Another thirteen systems (twelve 5 kWp and one 16 kWp) were installed in 2013 (Sunlabob, 2013). These projects focused on improving electricity supply in universities, training facilities and community centres to facilitate local enterprise development through a variety of uses, ranging from agricultural and industrial training to improved internet access.

In 2016, the government launched the Energy Revolution initiative and became the first country to sign the Energy Africa Compact with the DFID, setting targets for households to be served with off-grid renewable energy solutions (Energy Revolution, 2016). This set in motion a collaborative effort between the government, the private sector and different international organisations (*e.g.*, UNOPS) to develop a pipeline of mini-grid projects through a PPP model (ECREEE, 2017).

On the policy side, the role of mini-grids in rural electrification is recognised across a majority of official road maps and laws governing the power sector, including the Electricity Sector Reform Roadmap (2017-30) which stipulates mini-grids as a complementary part of efforts to achieve full electricity access by 2030 (Ministry of Energy of Sierra Leone, 2017).

INSTITUTIONAL FRAMEWORK

Table CS 3.1 provides an overview of the different institutions that are involved in mini-grid development. Given that the market is still in its early stages of development, and deployment is presently driven in large part by donor-funded programmes, the institutional framework is likely to evolve.

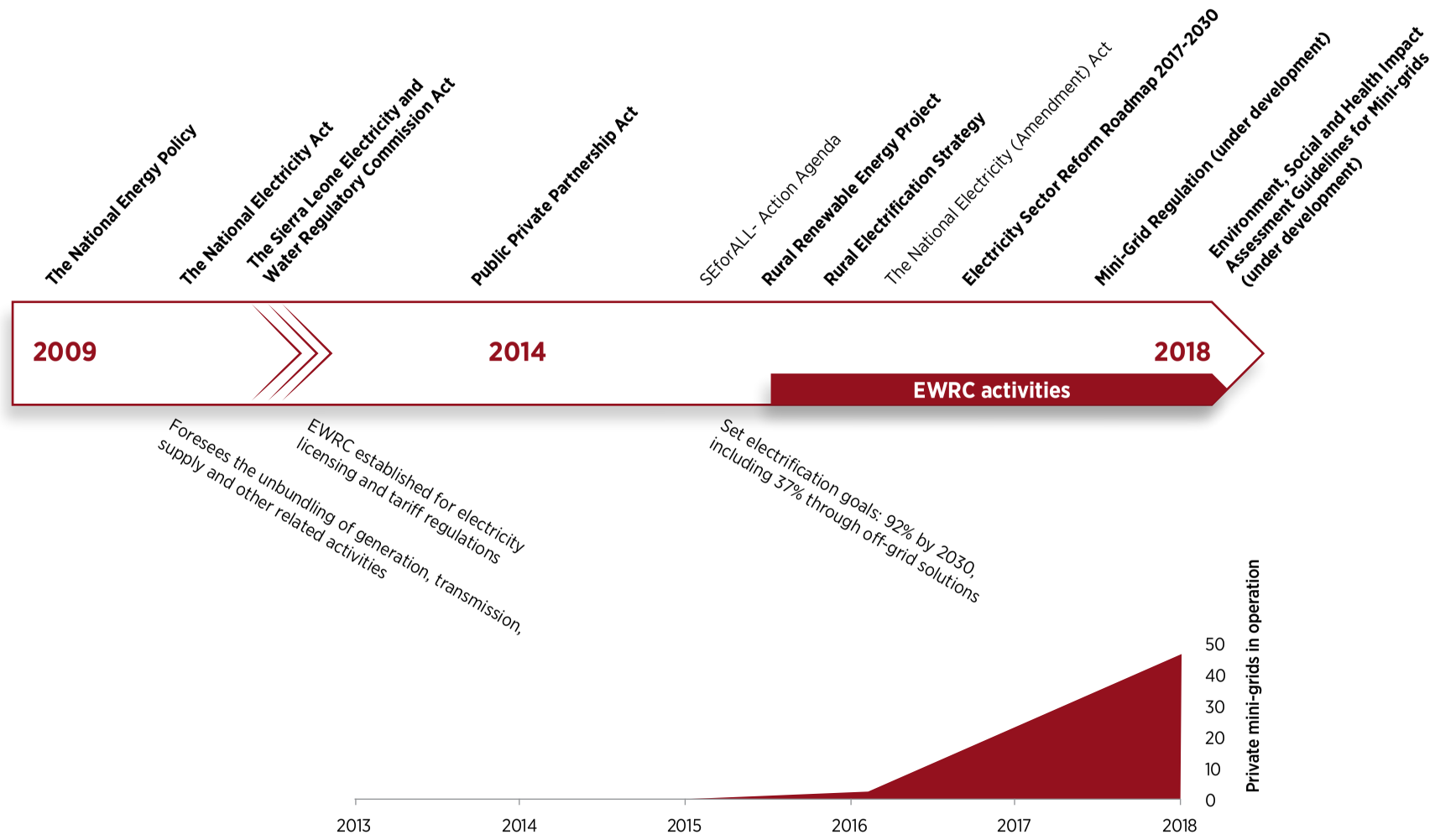
POLICY AND REGULATORY UPDATES

The policy and regulatory landscape for renewable energy in general and mini-grids in particular is continuously evolving in Sierra Leone. Figure CS 3.1 provides an overview of key updates along with recent developments in mini-grid deployment.

Table CS 3.1 Overview of Sierra Leone's institutional landscape

	Topics	Institution	Description
PRIMARY MEASURES	Policy	Ministry of Energy	Develops energy sector road maps and drafts and implements national policies for the energy sector, including rural electrification.
		Local councils	Charged with planning local public service off-grid electricity supply.
	Regulation	Electricity and Water Regulatory Commission	Provides rules for end-user tariffs that assure the financial integrity of a mini-grid operator, considering the interests of consumers and investors. Additionally, issues licenses for electricity and water investments and operations.
		National Public Procurement Authority	Oversees and regulates public tender processes which are of high importance in the PPP-based mini-grid strategy of the government.
	Implementation	Public-private partnership unit	Co-ordinates and evaluates tender processes on behalf of the contracting authority and serves as an interface between the contracting authority and the private partner.
		United Nations Office for Project Services	Rolls out and manages the Rural Renewable Energy Project (Box CS 3.1).
	Financing	Department for International Development, UK	Finances the Rural Renewable Energy Project (public contribution).
SECONDARY MEASURES	Environmental and health protection	Environment Protection Agency	Responsible for environmental, social and health impact assessments. Currently developing new guidelines for the assessment of mini-grids.

Figure CS 3.1 Evolution of mini-grid policy and regulations in Sierra Leone, 2009-18



Note: EWRC=Electricity and Water Regulatory Commission.

Primary measures

National policy on energy and renewables

The **National Energy Policy** (2009) highlights as one of its objectives the provision of modern energy services for increased productivity, wealth creation and improved quality of life. Through its policy statements, it encourages the use of renewable energy sources to meet electricity needs in rural areas. It suggests greater co-operation between mining companies and power utilities to utilise renewables and serve as anchor loads, supporting the electrification of nearby communities. The policy also sets the stage for instituting a Rural Electrification Strategy and Plan, along with a Rural Electrification Fund.

A detailed formulation of the (rural) electrification strategy was launched by the government together with the SEforALL Initiative – the **Action Agenda** for Sierra Leone, published in 2015 (NREAP, 2015). The Sierra Leone government outlined goals in line with SEforALL, such as the electrification of all district headquarter towns and reaching 92% electricity access by 2030, including 37% through renewable energy off-grid solutions. The Agenda foresees a PPP approach including tender approaches where public entities are managing the site selection and thereby channelling the efforts in the rural electrification sector.

The **Renewable Energy Policy (REP) (2016)** is a further evolution of policies laid down in the NEP. The policy strives to enhance renewable energy power supply in rural areas with the active participation of the private sector, while the government provides an enabling framework for its investment. It recommends action plans for all relevant agencies for the adoption of specific policy targets such as feed-in tariffs. Furthermore, it explicitly notes several policy measures required to support mini-grid development:

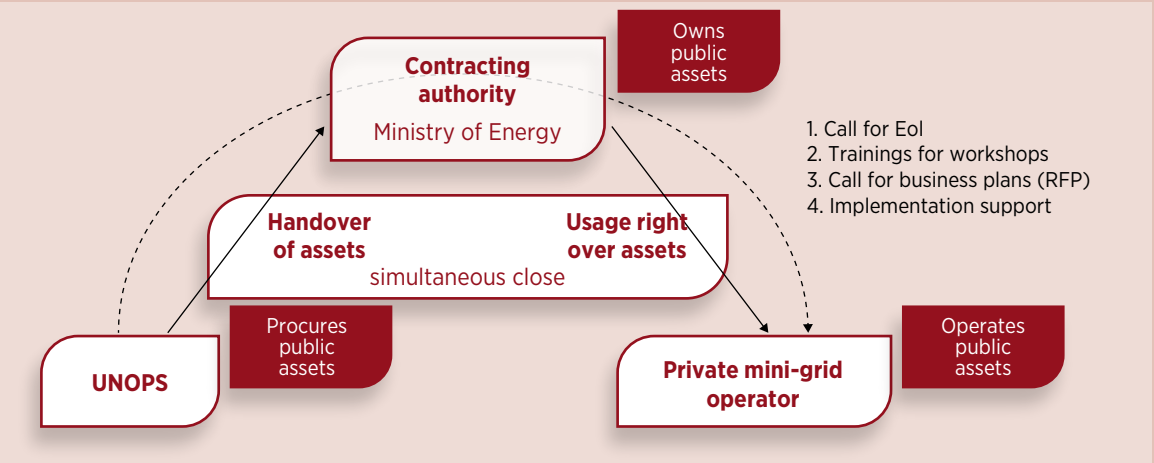
- Strengthen the capacity of state agencies to plan and implement renewable energy mini-grids;
- Develop PPP mechanisms for mini-grids;
- Showcase the benefits of renewable energy mini-grids in communities at the district and village levels; and
- Strengthen the capacity of private service providers to maintain mini-grid equipment.

In February 2016, Sierra Leone was the first African country to sign the Energy Africa Compact with the UK government. The initiative committed to reaching 250 000 households with modern solar solutions by 2018 and achieve “Power for All” by 2025. In light of this, the Rural Renewable Energy Project (RREP) was established with the aim of developing up to 5 MW renewable mini-grid capacity in rural areas with private sector involvement (MOE, n.d.) (Box CS 3.1).

Box CS 3.1 Rural Renewable Energy Project in Sierra Leone

The Rural Renewable Energy Project (RREP) has three key phases. First is the installation of solar photovoltaic (PV) systems in 54 community health centres and, using this as the anchor load, the creation of a mini-grid to connect nearby households and other public institutions. The mini-grids are to be operated by private entities or local community associations. Second is the expansion of coverage to a further 40 communities through public-private partnership and split of assets approach, taking stock of the lessons learned in the project's first phase. This involves the funding of distribution networks through public financing managed by the Ministry of Energy, with the private sector responsible for financing, constructing, installing and commissioning power generation assets. The ministry would be expected to sign an unlimited usage right contract with a private operator who would pay an annual fee for the management of the contract and related monitoring tasks.

Figure CS 3.2 Split of assets into publicly (government) and privately (operator) owned



Note: EoI = expression of interest; RFP = request for proposal; UNOPS = United Nations Office for Project Services.

The third phase of the project involves technical assistance and institutional development for both the government and private sector to facilitate mini-grid development through public-private partnerships. This work would be funded by the UK's Department for International Development (DFID) and implemented by the United Nations Office for Project Services.

Source: MOE, 2017a; MOE, 2017b; MOE, n.d.

Mini-grid regulations

The **Electricity and Water Regulatory Commission Act (2011)** established the Sierra Leone Electricity and Water Regulatory Commission (EWRC) to regulate the provision of electricity and water services. The EWRC issued draft **Mini-Grid Regulations (2017)**, which are currently being reviewed and developed for final submission to the parliament for approval. The draft regulations provide specific guidance on licensing procedures, consumer service rules, main-grid interconnection rules and commercial arrangements (*e.g.*, tariff setting), among other elements.

Licensing and legal provisions. The EWRC Act 2011 set pre-requisites for public utilities, existing and new, to secure licensing for operation. The draft Mini-Grid Regulations (2017) provide further guidance on licensing for mini-grids. The key features of the draft regulations include:

- The creation of dedicated regulations for mini-grids that consider licensing arrangements and tariff determination so as to provide a defined environment for projects and ensure service quality over time.
- Segregation of licensing arrangements, whereby mini-grids below 100 kW are allowed a simplified process.

Also, although not part of the regulations, a potential mini-grid developer may negotiate a set time period during which it may exclusively develop a site.

Under the draft regulations, two types of licences are foreseen:

- A **basic mini-grid licence** that allows isolated systems of up to 100 kW to generate and sell electricity in otherwise unserved areas.

- A **full mini-grid licence** that gives a developer authorisation to generate, distribute and sell electricity in a designated unserved area.

The commissioner will also consider cases in which a contract is signed by either a mini-grid developer or a full mini-grid licensee with the main utility to construct, install or operate an interconnected mini-grid.

For each type of license, the draft regulations provide standardised application forms with a list of accompanying documentations required.

Tariff setting. The draft regulations provide guidance on setting consumer tariffs based on the type of license:

- In the case of **basic licenses**, the tariff is to be mutually agreed on between the licensee and the consumers. In case of unsuccessful negotiations between parties on a tariff, the commission will intervene.

- In the case of **full licenses**, the tariffs are set by the commission, through a tariff determination methodology that takes into account several parameters (provided in the license application), including the cost of generating, distributing, supplying and selling electricity, and the interests of the consumer and investor. Upon payment of a flat fee, the licensee may request an inspection and audit of accounts with the commission to update its tariffs.

Arrival of the main grid. Based on the type of licence granted, the arrival of the main grid could have two different types of impacts:

- For the **basic licence** holder, the arrival of the main grid or full mini-grid licenced project would require it to decommission and remove its assets within two months without being entitled to any refund or compensation.

- For the full **licence holder**, on arrival of the main grid, the licence can be converted into an interconnected mini-grid contract or the developer can remove all its assets. If it chooses to remove its assets, the developer will get financial compensation equivalent to the remaining depreciated value of the privately financed assets. In addition, it will also be able to receive development and construction costs, as defined during the tariff determination by the commission plus one audited annual revenue generated from the mini-grid.

Secondary measures

There are several secondary measures that influence the development of renewable energy mini-grids in Sierra Leone. For instance:

- The **Finance Act (2017)** provides for duty waivers for imported solar products that fulfil the International Electrotechnical Commission standards. But, in practice, application of these are difficult for private companies, due to unclear administrative processes and long delays.

- The RREP's emphasis on PPPs to promote mini-grid development, highlighted earlier, is supported by the **Public-Private-Partnership Act (2014)**. The act provides the legal framework for PPPs, addressing crucial issues including asset ownership, the content of PPP agreements, governing laws and the operation of PPP projects.

Tertiary measures

The RREP covers broad measures, focusing on capacity building within public institutions (*e.g.*, Ministry of Energy, PPP Unit, EWRC) and the private sector (UNOPS, 2018). Following the signing of the Energy Africa Compact Agreement by the Government of Sierra Leone, the Renewable Energy Association of Sierra Leone was formed in 2016 with a focus on developing an efficient and thriving renewable energy market in Sierra Leone (REASL, 2017). A dedicated technical assistance programme was formed to support the association in order to establish an efficient operational structure and processes and build awareness among international investors and funding organisations.

RESULTS AND CHALLENGES

The RREP is currently the major programme supporting mini-grid deployment. The focus on the electrification of health centres stems from the limits imposed by a lack of reliable power generation during and after an Ebola outbreak (UNOPS, 2016). Tenders for 94 mini-grids were published by the Ministry of Energy and funded by the DFID. Of these, 50 have a high grant funding portion (*i.e.*, most assets are grant financed but operations have been tendered out), and 40 have a split assets model.

To secure private participation, PPP contracts are expected to be set up. However, the final handover of assets is still due and private mini-grid operators are yet to begin operations. The pilot projects under development will serve as models for future projects.

While policy, regulatory and programmatic developments are quite encouraging, some steps to support mini-grid growth include:

- Proposed mini-grid projects under the RREP, based on PPPs, will provide a template for future growth. Lessons from projects will need to be gathered to identify gaps in the mini-grid policy and regulatory framework.

- The adoption of the draft Mini-Grid Regulations is yet to be formalised, and would help the transition from the existing programme-level framework toward a more scalable model.

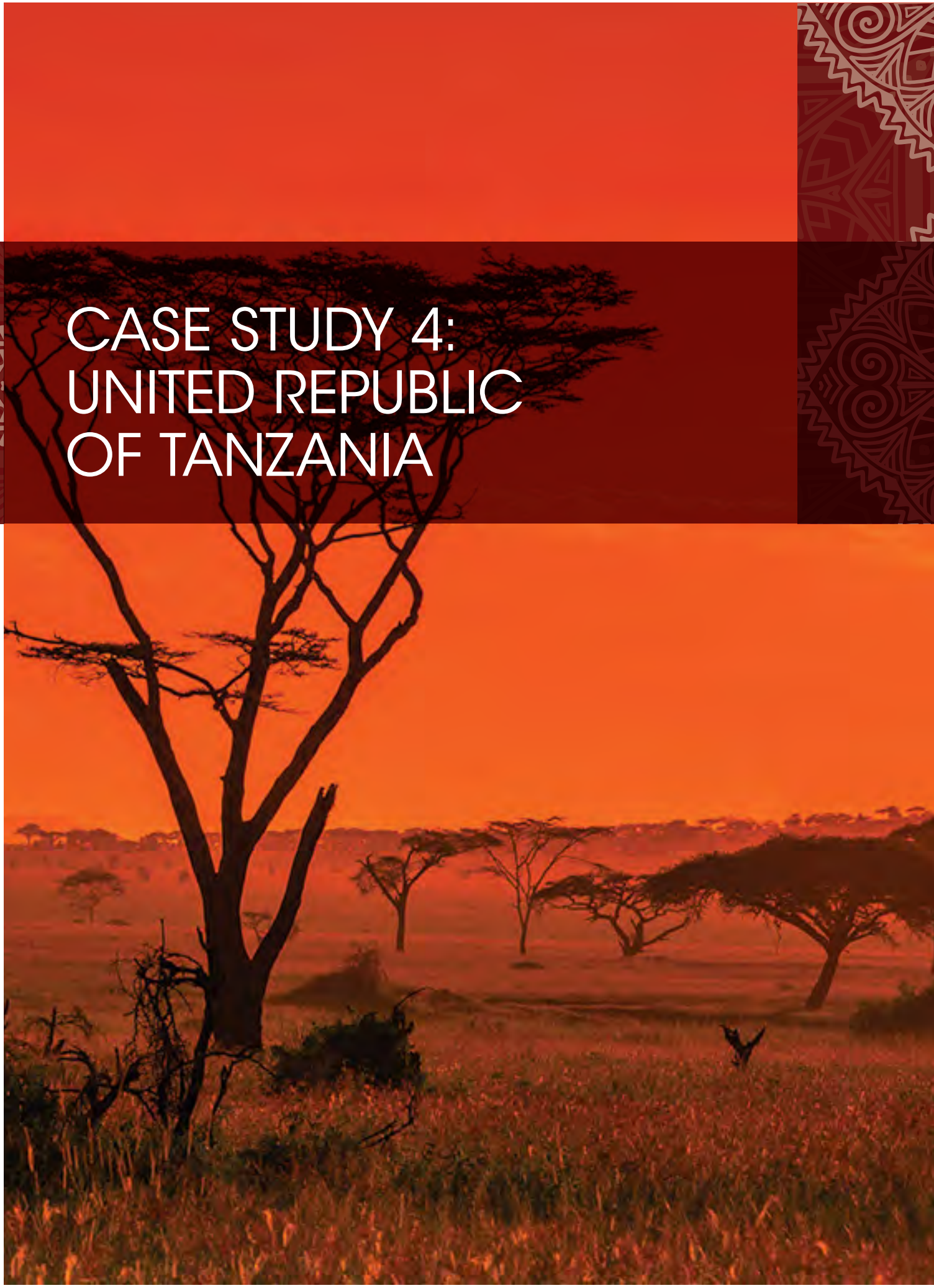
- To realise policy objectives, the capacity of several public institutions needs to be strengthened. A dedicated body responsible for rural electrification and energy access may be required to address gaps in institutional capacity across the mini-grid project development pipeline.

- The scope of mini-grid development needs to be expanded from health centres to other productive uses, including agro-processing units that could serve as effective anchor loads (EEG, 2018b).

RESOURCES

- National Energy Policy (2009)
  http://www.energy.gov.sl/NATIONAL%20ENERGY%20POLICY.pdf
- The National Electricity Act (2011)
  http://www.sierra-leone.org/Laws/2011-16.pdf
- The Sierra Leone Electricity and Water Regulatory Commission Act (2011)
  http://www.sierra-leone.org/Laws/2011-13.pdf
- Public Private Partnership Act (2014)
  http://www.sierra-leone.org/Laws/2014-11.pdf
- Action Agenda for Sierra Leone – SE44ALL (2015)
  https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_AAs/Sierra_Leone_Sustainable_Energy_For_All_Action_Agenda.pdf
- Renewable Energy Policy (2016)
  http://www.energy.gov.sl/PR_Renewable%20Energy%20policy%20of%20SL_FINAL%20for%20Print.pdf
- The Public Procurement Act (2016)
  http://www.sierra-leone.org/Laws/2016-01.pdf
- The Finance Act (2016)
  http://www.sierra-leone.org/Laws/2016-06.pdf
- Electricity Sector Reform Roadmap 2017-2030 (2017)
  https://www.dropbox.com/s/3uimezi7crgz9by/Draft%20Final%20Roadmap_06092017.pdf?dl=0
- The Mini-Grid Regulation – draft (2017)
  http://ewrc.gov.sl/wp-content/uploads/2017/12/EWRC_Mini-Grid_Regulations_2017_Draft_for_final_review.pdf

CASE STUDY 4: UNITED REPUBLIC OF TANZANIA



Population (2017)

Total installed capacity (2017)

Rural electrification rate (2017)

Electricity consumption per capita (2014)

As of 2017, approximately 67% of Tanzania's population of around 57 million lived in rural areas. Over 17% of the rural population had access to electricity through the national grid, mini-grids or a household system. In rural areas, of the electrified households, over 34% were connected to the grid while off-grid solar powered nearly 65% of the households (REA, 2017b). Mini-grids have played a growing role in expanding electricity access: at least 109 systems presently serve about 184 000 customers (WRI, 2017).

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

The number of installed mini-grids in the United Republic of Tanzania has grown substantially since 2008, when the Electricity and Water Utilities Regulatory Authority (EWURA) introduced a regulatory framework for mini-grids, referred to as the Small Power Producers (SPP) framework (IRENA, 2017c). The SPP framework has since been revised and calibrated to effectively support mini-grid development and provide key lessons for enabling private sector participation in the sector. A total of 100 000 households are expected to benefit from the Rural Energy Agency (REA) and its performance-based grant support to mini-grids, as well as other stand-alone programmes (SEforALL, 2015).

INSTITUTIONAL FRAMEWORK

The key agencies in the country's power sector have responsibilities relevant to mini-grid deployment (Table CS 4.1), while private sector actors include generation companies, independent power producers and small power producers.

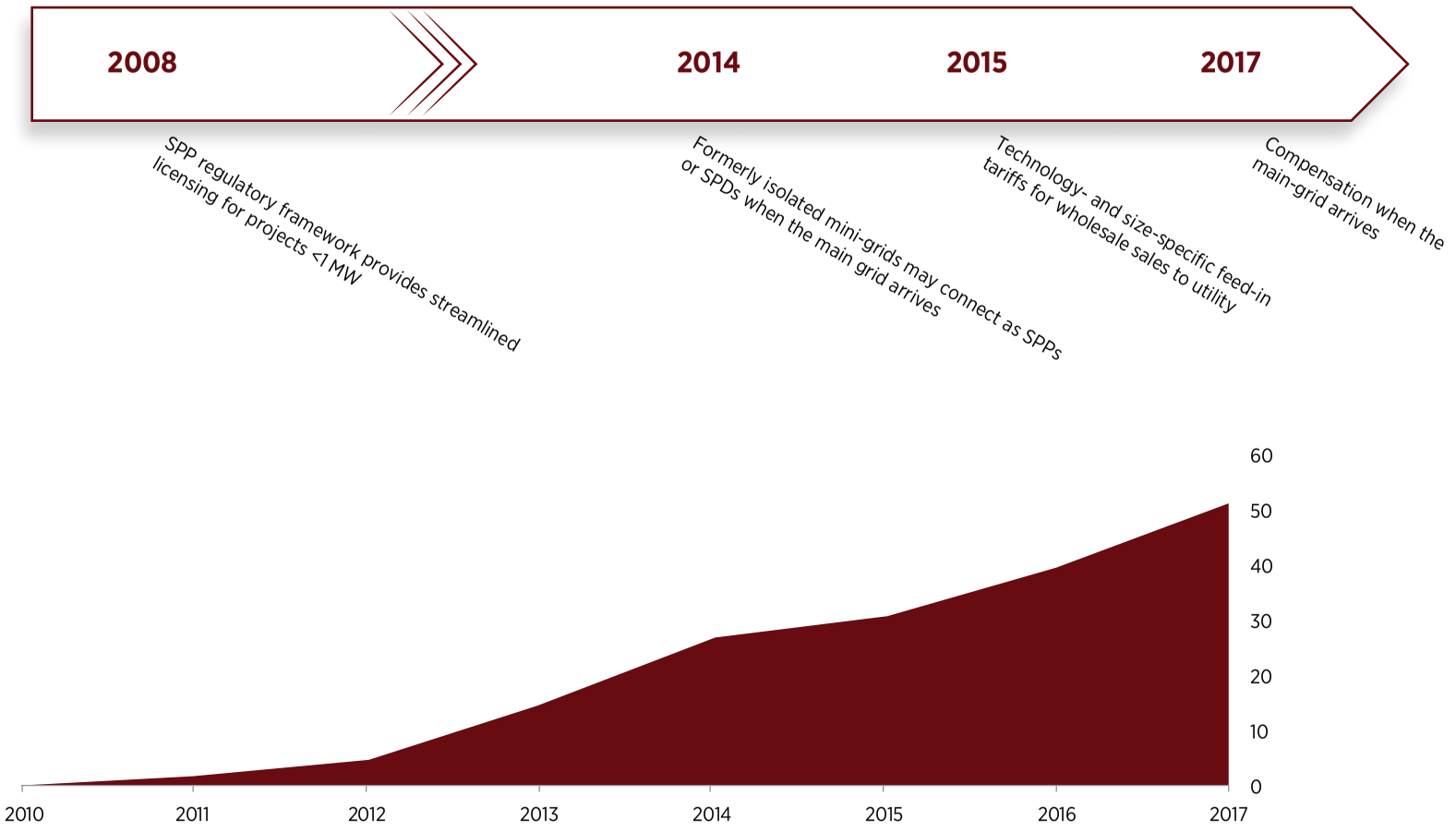
Table CS 4.1 Overview of institutional landscape of the United Republic of Tanzania

	Topics	Institution	Description
PRIMARY MEASURES	Planning	The Ministry of Energy (national planning) The Rural Energy Agency (rural areas)	The Rural Energy Agency manages the Rural Energy Fund, which provides grants to mini-grids and solar home systems as well as extensions of distribution lines. The Rural Energy Fund is funded by the government through an annual budgetary allocation, international development agencies and a levy on revenues from the generation of electricity.
	Policy	The Ministry of Energy	Issues laws and policies to guide Tanzania's energy sector and develops the country's Power System Master Plan.
	Regulation	The Energy and Water Utilities Regulatory Authority (EWURA)	Responsible for the technical and economic regulation of electricity, water, petroleum and natural gas. EWURA has regulated the mini-grid sector since 2009 through the Electricity (Development of Small Power Projects) Rules.
	Implementation	Tanzania Electric Supply Company Limited (TANESCO)	TANESCO is responsible for over 61% of electricity generated in the United Republic of Tanzania. In addition to utility-scale generation capacity, the utility also operates 21 isolated mini-grids with a total capacity of 77 MW, all but one of which is powered by diesel.
	Quality standards	Tanzanian Bureau of Standards	The Small Power Producers Rules require that regulated mini-grids conform to relevant power sector standards, as enforced by EWURA. In late 2018 the bureau further developed technical standards for mini-grid generation and distribution networks.
SECONDARY MEASURES	Environmental and health protection	National Environment Management Council	Mini-grids are required to comply with environmental regulations that include a scoping report and terms of reference for a full environmental and social impact assessment to be submitted to the council. The council determines whether a full ESIA study is required.
	Tax and business registration	Tanzania Investment Center	Registration with the Tanzania Investment Center for incentives, the Tanzania Revenue Authority for tax registration and local government authorities for business licensing and registration.
	Land clearance	Village/local government	A land lease or right of occupancy certificate must be issued by the village/local government. In the case of generation projects on private land, a sales agreement has to be entered into between the developer and the owner of the piece of land.
	Building permit	Local government	A building permit for the powerhouse and other buildings must be issued by the local government (district or municipal council).
	Water basin approval	Regional Water Basin Office	For hydropower projects, water rights must be obtained from the Regional Water Basin Office overseeing the basin in which the project is sited.

POLICY AND REGULATORY UPDATES

In the United Republic of Tanzania, primary policy and regulatory measures, including those related to national policies, the rural electrification strategy, mini-grid regulations and direct financial support have been introduced and adapted over the past decade. Successive iterations of the SPP rules issued by EWURA aim to improve the enabling environment for private sector mini grids (Figure CS 4.1).

Figure CS 4.1 Evolution of mini-grid policy and regulations in the United Republic of Tanzania, 2010-17



Note: kW = kilowatt; MW = megawatt; SPD = small power distributor; SPP = small power producer.

Primary measures

National policy on energy and renewables

The regulatory framework has evolved over four successive iterations of Tanzania's Guidelines for Development of Small Power Projects issued by EWURA under the **Electricity Act** (2008). The iterations and refinements of EWURA's mini-grid rules are the result of a stakeholder process that solicits comments from the private sector, utilities, ministries and non-governmental organisations and works to make changes in the rules to address shortcomings and outstanding issues. The framework's original focus was primarily on grid-connected, customer-owned SPPs, and over time it expanded to address issues relating to mini-grids, including licensing, tariff setting, implications of main grid arrival and access to financing.

Mini-grid regulations

Licensing and legal provisions. In 2008, when the first SPP framework was introduced, SPPs were entitled to a streamlined licensing process including a no-license registration process for projects under 1 MW. In the 2014 version, the threshold for mini-grids was revised, and mini-grids and grid-connected generators under 100 kW were exempted from the licensing process. In 2017, mini-grid developers were allowed to hold a single license for multiple sites. Also, provisional registration allows developers to proceed while awaiting environmental clearance (which has proven lengthy in the United Republic of Tanzania). The 2018 version of the regulations, however, revoked the exemption for registration of mini grids and grid-connected generators under 100 kW.

Tariff setting. The first version of the SPP framework, put forth in 2008, allowed developers to sell directly to consumers at cost reflective tariffs, and to sell electricity to TANESCO at the national utility's avoided cost (which includes high avoided cost for sales to TANESCO's diesel-powered mini grids) (EWURA, 2009).

In 2014, this was revised to allow small mini-grid (below 100 kW) developers to negotiate tariffs directly with future customers,[3] subject to possible regulatory review in case of significant customer complaints. Mini-grids connected to the main grid were entitled to backup power tariffs with no demand (kilovolt ampere, kVA) charge if the import load factor was 15% or less. A further revision in 2015 allowed bulk electricity sales to the utility, and introduced a FiT for hydro and biomass generation. The rules defined a competitive process for solar and wind projects between 1 MW and 10 MW.

Arrival of the main grid. According to the 2014 SPP framework, upon arrival of the main grid, a formerly isolated mini-grid could interconnect and operate as an SPP (selling wholesale electricity to TANESCO) or a small power distributor (purchasing wholesale electricity from TANESCO), or both. In the 2017 revision, a further compensation to mini-grid operators was introduced, for their distribution assets, if they chose not to interconnect and complied with necessary standards. Compensation is limited to those cases in which the main grid arrives within two to fifteen years of the mini grid's commercial date of operation. The compensation amount is limited to the replacement cost of based on the REA's average capital cost for installing distribution in rural areas measured on a cost per kilometre basis, minus depreciation measured from the date when the mini grid's assets when installed.

Access to finance. Access to finance for mini-grids has largely been addressed through programmes offered by the REA (matching grants and performance grants) and through commercial banks (long tenure loans). Existing programmes include the following, organised by type of instrument:

- **Matching grants.** From Financial Year (FY) 2013/14 until FY 2015/16, the REA provided matching grants on a cost-share basis to private sector mini-grid developers for feasibility studies, environmental impact assessments, preparation studies for licenses, investment studies, staff training and business plan preparation. The REA disbursed between 8 and 20 pre-investment grants per year until the Tanzania Energy Development and Access Expansion Project (TEDAP) programme closed in FY 2016/17.[4]

3. For example, in the Mpale village mini-grid in Korogwe district "service-level cost-reflective tariffs were designed and after lengthy negotiations and engagement with the community, flat-rate prepaid monthly tariffs were applied. An average customer pays USD 5 per month for a consumption of up to 10 kWh per month" (ARE, 2018).

4. Based on Rural Energy Agency, Annual Report, for FY 2013 /16.

- **Performance grants.** The first generation of performance (or results-based financing, RBF) grants from the REA were put in place under the World Bank–supported TEDAP programme, which provided up to USD 600 per new connection for hydro-based mini-grids and USD 500 for those using solar mini-grids. Connection grants totalling USD 2.3 million were ultimately awarded to three mini-grid hydropower projects connecting over 4 600 customers (REA Tanzania, 2016). Performance grants were disbursed under the programme until FY 2014/15. In 2016, a new RBF programme financed by the United Kingdom's Department for International Development (DFID) and the Swedish International Development Cooperation Agency (SIDA) was introduced. In the programme, the REA disperses connection grants based on the level of electricity service provided, with mini grids receiving USD 500 per Tier 4 connection, and USD 300 per Tier 3 connection (SIDA/DFID, 2016). Of these grants 35% are dispersed upon signing of the agreement; 35% upon materials at site; and 30% upon completion and proof of connection. If conditions are not met, funds are withheld.

- **Long-tenure loans.** A USD 25 million World Bank credit line initiated in 2010 provided long-term low interest debt to seven Tanzanian commercial banks to refinance up to 85% of the loan from a commercial bank to developers of projects of 10 MW or less. Funds flowed from the World Bank to the Tanzania Investment Bank, which, in turn, on-loaned the funds to commercial banks. Between 2010 and its termination in June 2016, the facility disbursed a total of USD 5.77 million (about 23%) in Tanzanian shillings to four small-hydropower projects totalling 7.2 MW (REA Tanzania, 2016; World Bank, 2018c).

  Despite the existence of the credit line, no projects beyond the four were able to complete the commercial bank's requirements for the loans and the funds were left unspent. The commercial banks' preference to loan to projects with power purchase agreements with the national utility TANESCO may reveal commercial banks' lack of comfort with loaning to mini grids that exclusively sell retail electricity to rural customers. . The AFD/SUNREF Credit Line with a total of USD 10 million, managed in collaboration with the Bank of Africa Tanzania, is also available to off-grid projects (Sunref, 2017).

Quality standards. The SPP rules require that mini-grids be "constructed, operated, and commissioned in accordance with the applicable laws, safety, and other relevant standards" (EWURA, 2017). These include the "TZS 1373: Power quality – Quality of supply", and "TZS 1374: Power quality – Quality of service and reliability"– both issued by the TBS in 2011 and enforced by EWURA. In late 2018, the TBS developed further technical standards for mini-grid generation and distribution networks that address safety, reliability and performance issues.

Secondary measures

Environmental protection measures

Mini-grids are required to comply with environmental regulations as laid out in the Environmental impact assessment and audit regulations 2005. It includes a dully-filled registration form and project brief to the National Environment Management Council, which determines whether a full study is required.

RESULTS AND CHALLENGES

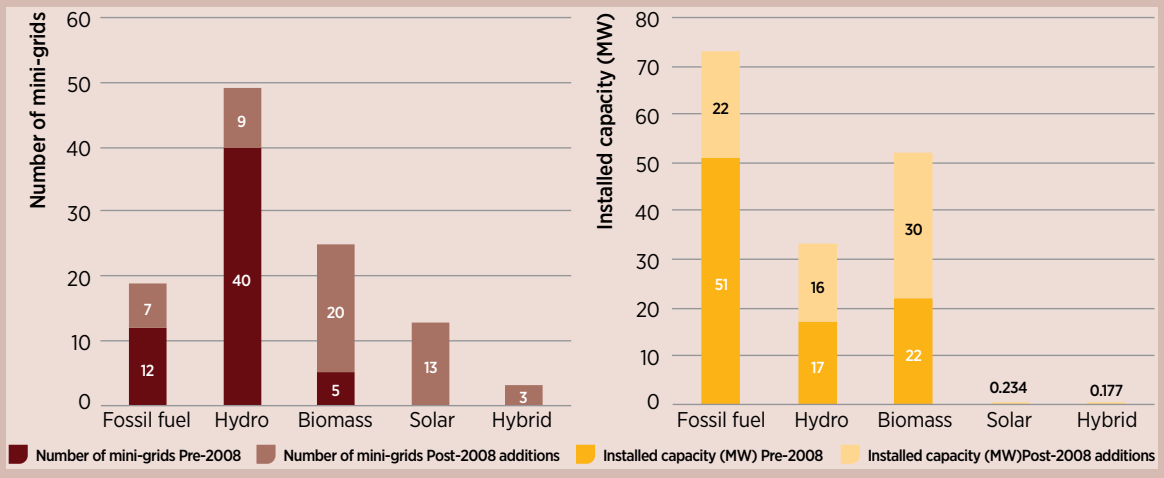
In 2008, the United Republic of Tanzania adopted the region's first comprehensive SPP regulatory framework to support mini-grids. An evolving and supportive regulatory framework, grants and credit lines from commercial banks have since helped 52 mini-grids take root, serving at least 7 500 rural customers (Box CS 4.1). While this growth is noteworthy, it falls short of the scale-up needed to achieve Tanzania's goal of universal electrification by 2021.

Box CS 4.1 Mini-grid development in Tanzania

Total mini-grids in Tanzania reached 109 in 2016, with over 50 being developed post-2008 majority being renewable energy-based (Figure CS 4.2). A minority (16) are connected to the national grid, while 93 operate in an isolated mode. Hydropower is the most common generation technology powering these mini-grids reflecting Tanzania's significant micro- and small-hydropower resource base and the relative low cost of generation. TANESCO's fossil-fuel-powered mini-grids account for the majority of customer connections and most of the installed capacity, and were installed as part of the utility's rural electrification efforts prior to the adoption of the SPP framework (WRI, 2017). Solar mini-grids remain a small but growing proportion, accounting for 13 projects and only 0.2 MW.

Despite recent decreases in solar module prices, solar mini-grids with battery storage remain expensive compared to hydropower and megawatt-scale biomass. Prospective solar mini-grid developers have been wary of entering areas where the main grid may come soon, potentially rendering their mini-grid investments redundant and uncompetitive with subsidised national grid electricity. Large-scale (often 1 MW or more) biomass and hydropower projects, on the other hand, have proceeded with less hesitation because their low costs of generation provide the possibility of continuing in a grid-connected mode, thanks to the SPP regulatory framework that provides detailed guidance for this transition.

Figure CS 4.2 Number and installed capacity of mini-grids in the United Republic of Tanzania, before 2008 and in 2016



Source: WRI, 2017. Note: kW = kilowatt.

Challenges remain for the renewable energy mini-grid sector. Limited mini-grid experience and technical expertise remain barriers to adoption and scale-up in the region. Developers are few, and potential market entrants face steep learning curves. In a nascent market, commercial banks find it difficult to estimate risk, and many decide to forego the opportunity. This in turn reduces projects' ability to raise debt financing.

A significant obstacle for the private sector is the risk associated with tariff setting. Greater awareness and transparency on mini-grid tariffs is needed among the policy makers, along with the socio-economic benefits of such solutions in rural areas. Presently, mini-grid developers submitting tariffs for EWURA approval are susceptible to backlash due to a lack of sensitization on tariff levels. The ability to negotiate tariffs directly with end-users is useful, but the "15% complaint" criteria for EWURA to consider a tariff review introduces a level of uncertainty for many business models.

Developers' ability to interconnect with the grid as SPPs has proven to be less of an assurance than expected. The 2017 (and 2018) versions of the SPP rules sets clear principles for compensation when the main grid arrives, a major concern of developers. However, these clauses are still new and no mini-grid has yet tested them by requesting compensation.

Despite efforts to streamline the SPP and mini-grids framework within EWURA, many developers find the permitting process resource-intensive – especially when it comes to permits from agencies outside EWURA. Up to 13 approvals are required, across multiple institutions outside the energy sector. Environmental clearances in particular can require many months. Streamlining the permitting approval process, particularly those elements that lie outside the purview of EWURA, would help accelerate mini-grid deployment. A focus on secondary and tertiary measures such as building technical expertise and capacity, and streamlining the process for obtaining permits from agencies other than EWURA could support on-going efforts to provide an enabling environment.

RESOURCES

- The Electricity (Development of Small Power Projects) Rules, 2018
  http://www.ewura.go.tz/wp-content/uploads/2018/06/The-Electricity-Development-of-Small-Power-Projects-Rules-2018.pdf
- The Electricity (Development of Small Power Projects) Rules, 2017
  http://www.ewura.go.tz/wp-content/uploads/2017/11/The-Electricity-Development-of-Small-Power-Projects-Rules-2017.pdf
- The Electricity (Development of Small Power Projects) Rules, 2016
  http://www.ewura.go.tz/wp-content/uploads/2016/03/The-Electricity-Development-of-Small-Power-Projects-Rules-2016.doc
- The Electricity (Development of Small Power Projects) Rules, 2015
  http://www.ewura.go.tz/wp-content/uploads/2015/08/THE-ELECTRICITY-DEVELOPMENT-OF-SMALL-POWER-PROJECTS-RULES-2015.pdf
- Electricity Act 2008
  https://www.lrct.go.tz/download/laws_2008/10-2008%20_The%20Electricity%20Act,%20Act%20No%2010%20of%202008.pdf
- Rural Energy Act 2005
  http://www.saflii.org/tz/legis/num_act/rea2005154.pdf

CASE STUDY 5: CAMBODIA

16 MILLION
Population (2017)

1.5 GW
Total installed capacity (2014)

36%
Rural electrification rate (2016)

271 kWh
Electricity consumption per capita (2014)

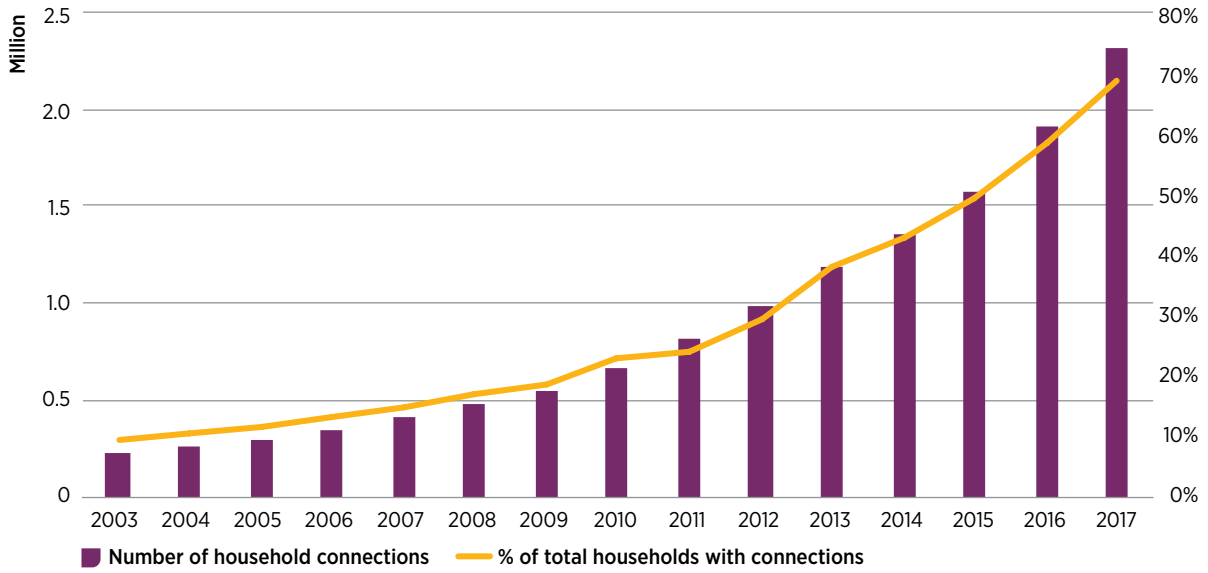
The share of Cambodia's population with access to electricity rose from under 1% in 1990 to nearly 50% in 2016 (World Bank, 2016). Local private sector-led development of diesel-fired mini-grids were responsible for the bulk of expansion through the 1990s. The Electricity Law of 2001 created the Electricity Authority of Cambodia (EAC), which focused on a regulatory approach that leveraged the existing stock of privately owned mini-grids to improve the quality of service and expand electricity access. Although primarily concerned with fossil-fuel-based mini-grids, Cambodia offers interesting lessons in how to support mini-grids' integration with the main grid while maintaining a decentralised ownership and operational structure in the power sector.

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

Rural electrification rates in Cambodia have grown rapidly over the past decades with the development of several hundreds of mini-grids. Upon arrival of the main grid, the regulatory framework enables diesel mini-grid operators to convert their distribution networks (the poles and wires side of their business) into grid-connected distribution franchises. The EAC is responsible for regulating mini-grids and their integration with the main grid. A Rural Electrification Fund provide grants and low-interest loans to enable expansion and upgrades to meet regulatory requirements. Each mini-grid has a license for one exclusive service area. In 2017, most of Cambodia's territory was covered by such licenses (World Bank, 2016).

The distribution franchisee approach has increased electrification (Figure CS 5.1), improved service and realised the twin benefits of lower and more uniform tariffs. In 2017, 348 private entities operated with a license, up from 311 in 2015 (EAC, 2018). Licensees made more than a million new connections between 2005 and 2015 and almost an additional half million between 2015 and 2017 (EAC, 2016; EAC, 2018). Most licensees (306 out of 311, or 98%) supplied 24 hour power by 2015, while in 2003 only 36 licensees (out of 85, or 42%) did so. Power tariffs have also decreased. Before 2003, the average tariff was USD 0.50/kWh. In 2015, the average tariff for mini-grids connected to the main grid was USD 0.25/kWh, and USD 0.45/kWh for isolated ones.

Figure CS 5.1 Growth in household connections, 2003-17



Source: EAC, 2018.

INSTITUTIONAL FRAMEWORK

Table CS 5.1 provides an overview of the key institutions involved in mini-grid development and, in Cambodia's case, their transformation into distribution licensees. The EAC plays a central role in the licensing, standards compliance and tariff setting for mini-grids, while the vertically integrated Electricite du Cambodge (EDC) is a key supplier for newly formed distribution licensees once the main grid arrives. The Rural Electrification Fund provides the bridge financing needed to ensure viability of systems as well their upgrade to allow for interconnection. In addition to institutional actors, private sector entrepreneurs play a key role in the development of mini-grids and operations of distribution franchisees.

Table CS 5.1 Overview of Cambodia's institutional landscape

	Topics	Institution	Description
PRIMARY MEASURES	Planning	Ministry of Mines and Energy	Responsible for Cambodia's mining and energy industries.
	Policy		
	Regulation	Electricity Authority of Cambodia (EAC)	Responsible for ensuring that "the provision of services and the use of electricity [is] performed efficiently, qualitatively, sustainably, and in a transparent manner" (Cambodia Investment 2011). Issues licenses, rules, regulations and procedures; reviews tariff costs and approves tariffs; and resolves disputes (EAC, 2016).
	Implementation	Electricite du Cambodge (EDC)	A vertically integrated, state-owned utility and the main wholesale supplier to Cambodia's hundreds of distribution franchises.
		Rural Electrification Fund	A non-profit department of the EDC responsible for dispersing grants for network expansion, interest-free loans for household connections and subsidies to cover the gap between standardised and cost-reflective tariffs.
SECONDARY MEASURES	Tax and business registration	Ministry of Economy and Finance	

POLICY AND REGULATORY UPDATES

The policy and regulatory landscape has evolved substantially over the past two decades that has influenced the development of mini-grids and the interaction with an expanding main grid.

Primary measures

Until the Electricity Law of 2001, independent mini-grid operators had essentially no regulation, despite serving thousands of households, estimated at 33% of total electrified households. The Electricity Law established the EAC and required all providers of electricity to obtain a license, implement technical standards and charge approved tariffs.[5] The EAC progressively granted exclusive licenses to mini-grids and then enabled them to become distribution franchises as the main grid arrived in their designated service areas. The licenses bind the licensees to (EAC, 2014):

- Comply with standards issued by the EAC;
    - Voltage regulation between 207 and 253 volts, and frequency between 49.5 and 50.5 hertz (Hz);
    - Safety (wiring, clearance) standards;
    - Performance standards regarding outages and responses to consumer requests;
- Ensure supply of electricity to all consumers in the licensee's service territory.
- Sell power at the price set by the EAC.
- Pay a monthly fee to the EAC, share audited financial statements and respond to requests for information.

The EAC uses incentives and penalties to ensure that mini-grids comply with the license requirements: operators who demonstrate compliance, including compliance of assets with the EAC's standards, are granted longer-term licenses and higher mini-grid tariffs. Licensees receive subsidies and technical support through the Rural Electrification Fund to help them comply with the standards and to encourage them to invest in and maintain the mini-grids. Subsidies include grants, interest-free loans and tariff subsidies (Oung, 2008).

When the main grid connects to an isolated mini-grid, the consolidated (generation plus distribution) license is converted to a distribution license (distribution only, reselling electricity purchased at wholesale from EDC or a cross-border provider). The conversion is intended to be automatic, but the process can take several months in practice.

Tariff setting

Before 2001, there was no uniform national tariff: mini-grids could charge the rates that customers were willing to pay. The EAC's mechanism for setting tariffs has been evolving since. From 2001 until 2016, the EAC regulated the tariff of each power provider individually after granting them a license. However, in March 2016 the government introduced a standard tariff that applied to all customers supplied by EDC or by a mini-grid connected to EDC (the tariff does not apply to isolated mini-grids or mini-grids that purchase power from a medium-voltage line fed by imports) (ESMAP, 2017b).

Once connected to the main-grid (required by law), the mini-grid operator charges the cost-recovery tariff calculated by the EAC, with profits equal to this tariff minus all operating costs. Until 2016, the EAC calculated the cost-recovery tariff on a case-by-case basis for each operator. In March, 2016, EAC adopted a more rigorous method that benchmarks operators by grouping them according to market size and customer density in groups of about 15. The EAC calculates the cost-recovery tariff for each group based on the cost of electricity and the cost of distribution (staff, repairs, administration and management, asset depreciation, and financing costs). The difference between the cost-recovery tariff and the mandated tariff is the amount paid by the Rural Electrification Fund (REF). With increases in connections and electricity demand, the REF is ensured to have sufficient funding with over 90% of funding from a 1% levy on electricity sales revenues and the remainder from licensing fees.

In 2015, only 8 licensees (of 311) merged with another licensee, suggesting that most operators might have been breaking even; but distribution margins were very low, with the median value between USD 0.10 and USD 0.11 per kWh in 2015, down by more than a third since 2011 (ESMAP, 2017b).

5. Kingdom of Cambodia, "Electricity Law of the Kingdom of Cambodia", articles 41, 42 and 46.

Secondary measures

Cambodia is seen to have minimal secondary regulatory framework requirements. Since mini grids and distribution franchises are small scale (*e.g.*, <100 kW), they are not required to conduct environmental impact studies under the **Law on Environmental Protection and Natural Resource Management** (ILO, 1996); however, technical standards are applied.

In 2005, the EAC noted that "most of the service providers in small towns and rural areas have [power service facilities that are] obsolete or very old, not compliant with the technical standards, unsafe in operation and use". Losses were high – 82% of mini-grids lost more than 20% of the power they generated (ESMAP, 2017b). Conforming to the EAC's requirements has led to significant improvements. For example, by 2015, 98.4% (306 out of 311 mini-grids) supplied 24 hour power every day (compared to 42% – 36 out of 85 – in 2003) (ESMAP, 2017b).

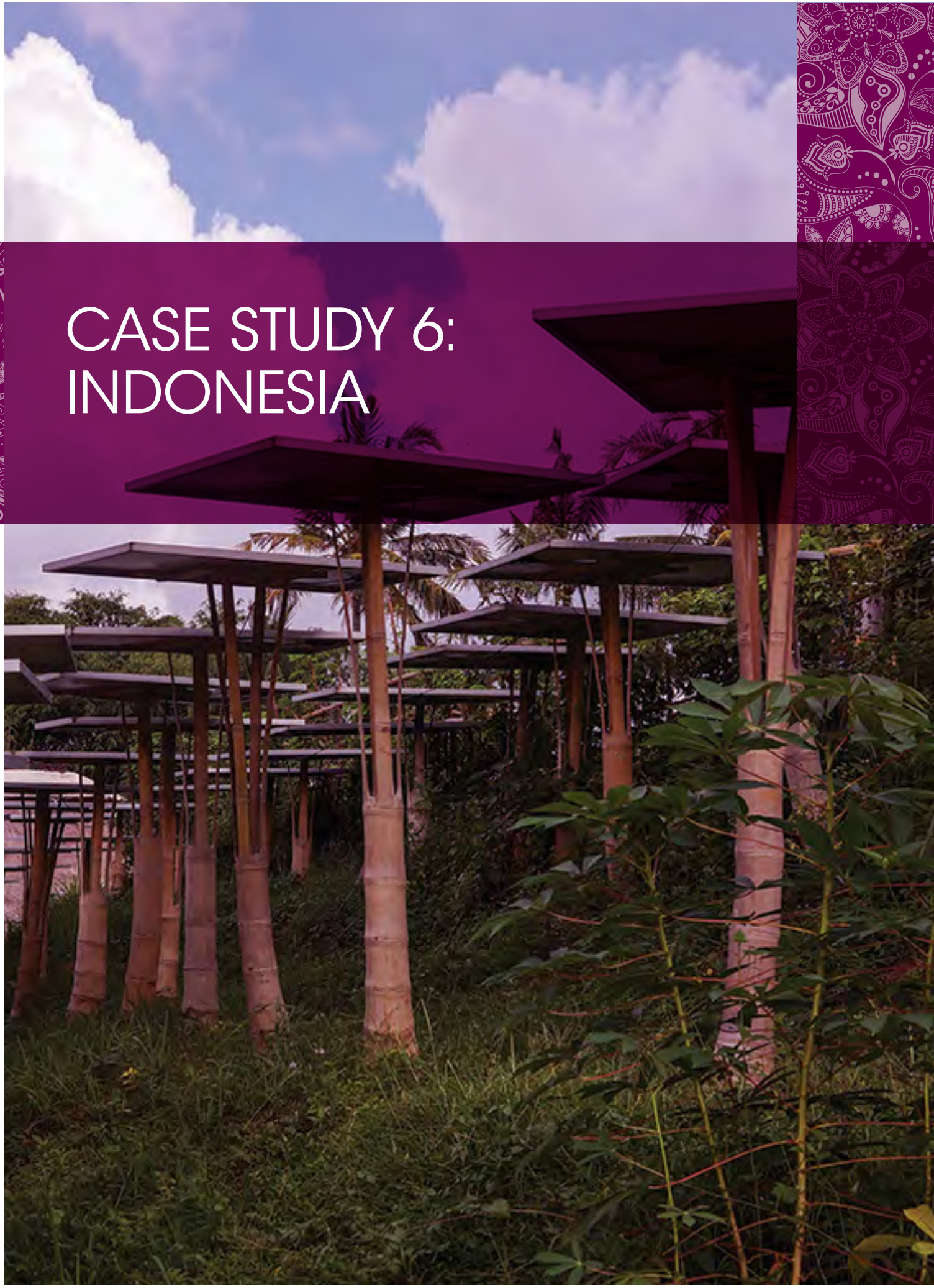
RESULTS AND CHALLENGES

The number of urban connections doubled between 2005 and 2015. During the same period, rural connections increased by a factor of four, mostly through mini-grids, a majority of which were connected to the main grid. The regulatory landscape in Cambodia has been designed to leverage on the existence of a large number of private mini-grids which offered a low quality of service and high power prices.

With the Electricity Law of 2001, the focus turned to improving access and quality of service for rural customers and reducing the prices for all customers with a strategy to transform unregulated, isolated mini-grids into regulated and connected suppliers. Incentives (including grants and loans) and penalties (including the threat of license revocation) helped improve mini-grid infrastructure and extend services. Mini-grid operators balanced an obligation to connect all consumers with the business assurance offered by an exclusive license. This resulted in mini-grid licensees adding almost 1 million new connections between 2005 and 2015 (EAC, 2016). Regulated tariffs offer the double benefit of giving entrepreneurs a guaranteed return on investment (in 2011, the average distribution margin for connected licensees was USD 0.16/kWh), while passing substantially lower power costs on to consumers.

Thinner distribution margins have put pressure on the distribution licensees, threatening to disrupt the sustainability of a business model that helped Cambodia dramatically increase electrification. Going forward, the role of mini-grid distributors will depend on how well the government can balance the positives of increasing service standards and reducing tariffs with the need to ensure mini-grids' sufficient profitability. Policy and regulatory support specific to renewables could provide fresh impetus to improve energy access in a timely and cost-effective manner, while reducing carbon emissions.

CASE STUDY 6: INDONESIA



Population (2017)

Total installed capacity (2016)

Household electrification rate (2016)

Electricity consumption per capita (2014)

Indonesia is an archipelagic nation comprising over 17 000 islands. Despite the geographical challenges, Indonesia had achieved a 95% electrification rate by 2017 (DJK, 2018). With a total installed capacity of 61 GW in 2017, the grid network is mainly supplied by the state-owned utility company (Perusahaan Listrik Negara, PLN). Meanwhile, PLN has sole ownership of the transmission and distribution system, except in particular cases (*e.g.*, concentrated industrial areas) where private power utilities can also distribute the electricity.

Despite impressive progress toward full electrification, 10 million people still lack access to electricity most of whom reside in extremely remote villages. In many such villages, electricity is sporadically generated from diesel-fuelled power plants or small private generators with high operational costs and negative impact on the environment.

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

The national grid is responsible for 93% of the electrification ratio, while the remainder is from off-grid sources, including mini-grids (DJK, 2017). Most rely on micro or mini-hydro and more recently, solar power, with installed capacity ranging from 5 to 400 kW, supplying 10 to 1 000 households per system (Remap Indonesia, n.d.). Distributed generation plants are mainly implemented by public agencies. Unfortunately, there is no aggregate information on the number of mini-grid systems that have been installed. By compiling data from various published statistics, it is estimated that over 900 mini-grids generate power using solar, micro-hydro and bioenergy sources, with a total installed capacity of over 36 MW, developed since 2011.

INSTITUTIONAL FRAMEWORK

Renewable energy mini-grids are mainly implemented by public agencies. At a national level, the Ministry of Energy and Mineral Resources (Kementerian Energi dan Sumber Daya Mineral Republik, ESDM) is the main actor in Indonesia's energy sector. Through its subsidiary, the Directorate General of New, Renewable Energy and Energy Conservation (Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi, EBTKE), ESDM has the mandate to plan, regulate, implement and oversee a mini-grid programme. ESDM also has another subsidiary, the Directorate General of Electricity, which is responsible for planning, regulating and supervising the national electrification programme in close co-operation with PLN. In practice, PLN develops its electricity supply business plan annually, which has to be approved and stipulated through a ministerial decree. Table CS 6.1 provides a synopsis of the relevant public bodies and their roles.

Table CS 6.1 Overview of Indonesia's institutional landscape

	Topics	Institution	Description
PRIMARY MEASURES	Planning	Ministry of Energy and Mineral Resources (Kementerian Energi dan Sumber Daya Mineral Republik, ESDM) Regional planning: Governors	The ministry is responsible for the national electrification plan, while local governments develop regional plans.
	Policy, regulation and implementation	Directorate General of New, Renewable Energy and Energy Conservation (Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi, EBTKE)	Formulates and implements policies related to renewable energy and energy conservation.
SECONDARY MEASURES	Environmental and health protection	EBTKE, in co-operation with the Ministry of Environment and Forestry	Compiles environmental guidelines for the management of renewable energy mini-grids.
	Tax and business registration	Tax: Ministry of Finance Business registration: ESDM/ EBTKE	The Ministry of Finance issues regulations on taxation and customs facilities for renewable energy. The Government of Indonesia provides incentives, particularly for procuring renewable energy technologies. These include an exemption from value added tax and import duty for imported renewable energy technology.
	Local content requirements	Ministry of Industry	-
	Land clearance and building permits	Governor	-
	Water basin approval	Governor, except for protected areas, which require a permit from the Ministry of Environment and Forestry	-
	Quality standards	EBTKE	Formulates and implements policies related to renewable energy and energy conservation.

In addition to those listed in Table CS 6.1, several other ministries, including the Ministry of Home Affairs, Ministry of Cooperative and Small and Medium Enterprises, and provincial governments have implemented targeted programmes to support mini-grid development (Asian Development Bank, 2016; EnDev Indonesia, 2013). Several international development agencies are playing a key role in the development of the mini-grid sector (Box CS 6.1).

In the mini-grid sector, the private sector generally acts as a service provider. Engineering, procurement and construction companies both at the national and local level play a role as contractors, based on tenders organised by the budget owner. Inspection and certification agencies are responsible for issuing operational certificates. In some cases, cooperatives and publicly owned companies have role in the operation and maintenance of the mini-grids.

Box CS 6.1 The role of international partners and non-governmental organisations

A handful of donors and international co-operation organisations are working to develop Indonesia's mini-grid sector. The World Bank–funded National Program of Community Empowerment deployed around 150 micro-hydropower systems in 2009-12 (World Bank, 2013). The Millennium Challenge Account Indonesia was active in promoting community-based renewable energy mini-grids, through a grant programme that was implemented from 2013 to 2018 (MCA-Indonesia, n.d.).

GIZ has been supporting the Directorate General of New, Renewable Energy and Energy Conservation (Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi, EBTKE) in ensuring the sustainability of mini-grids developed through various national programmes, mostly photovoltaic (PV) mini-grids. Earlier in its work in Indonesia (in the 1990s), GIZ supported the capacity development of non-governmental organisations (NGOs) and local turbine manufacturers, mainly in the Sumatra and Sulawesi islands, to produce micro-hydro turbines. This in effect triggered the development of a micro-hydropower sector. It is estimated that more than 1 000 micro hydropower plants were installed before 2001 (EnDev Indonesia, 2013).

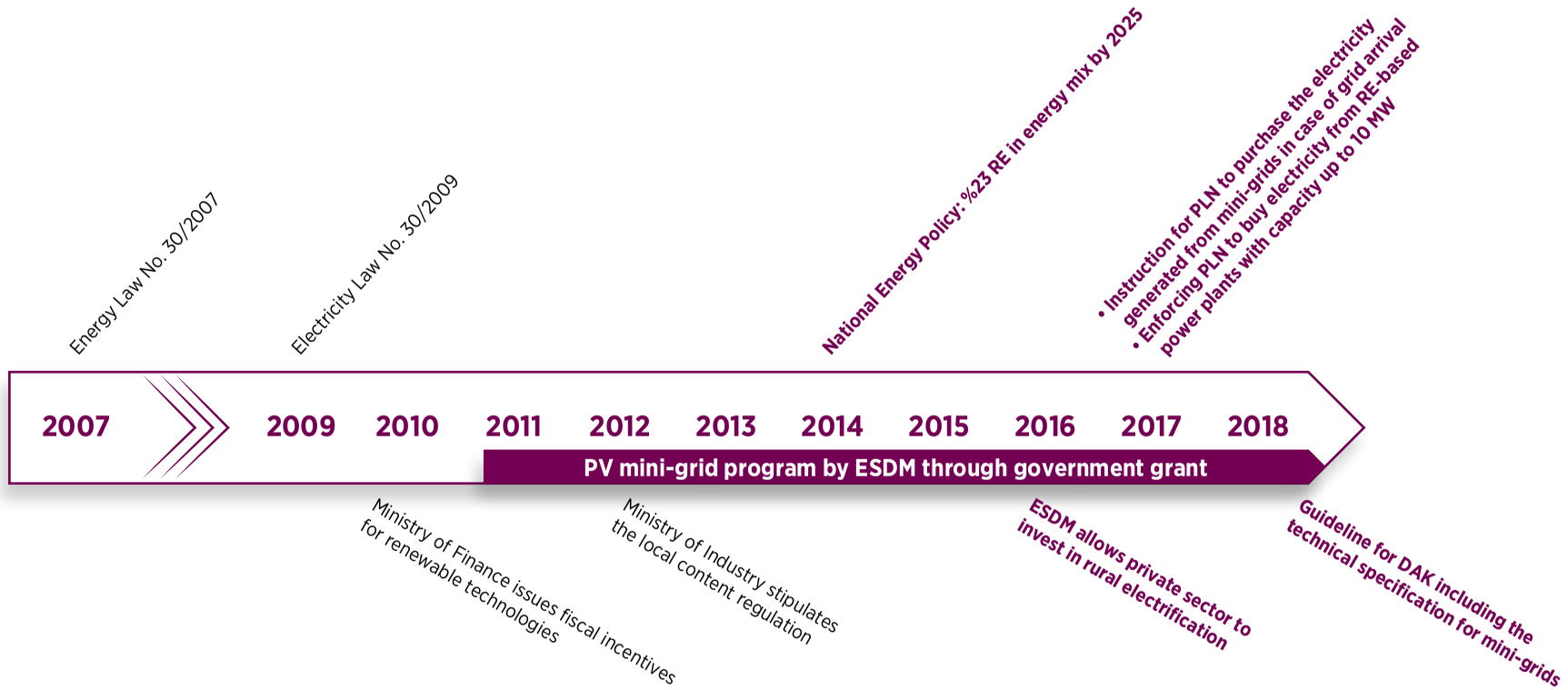
Humanistisch Instituut voor Ontwikkelingssamenwerking (HIVOS) is also engaged in the mini-grid sector, especially in East Nusa Tenggara Province, where it has installed several PV mini-grids. New Zealand Aid, through the New Zealand-Maluku Access to Energy Support project, has recently been launched to specifically support renewable energy development, including mini-grids, in Maluku Island.

Local NGOs have also been involved in Indonesia's mini-grids for a long time. The Institut Bisnis Kerakyatan, for example, has developed several community-managed micro-hydro mini-grids. Lentera Angin Nusantara installed a small-scale wind mini-grid in Sumba, East Nusa Tenggara Province, in 2011. Similarly, the People Centered Economic & Business Institute (IBEKA), a local non-governmental organisation has facilitated several community-led rural electrification projects through pro-poor public private partnerships (IRENA, 2018d). They are currently supporting over 60 micro-hydro projects (IBEKA, 2018).

POLICY AND REGULATORY UPDATES

The mini-grid sector depends heavily on the public sector, through ESDM, with EBTKE as the main implementer of those based on renewable energy. Figure CS 6.1 provides an overview of the policy and regulatory landscape for mini-grids in Indonesia.

Figure CS 6.1 Evolution of mini-grid policy and regulations in Indonesia, 2007-2018



Note: BOOT = build, own, operate, transfer; EBTKE = Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi; ESDM = Kementerian Energi dan Sumber Daya Mineral Republik; FiT = feed-in tariff.

Primary measures

National policy on energy and renewables

Energy Law No. 30/2007 is the umbrella policy for energy regulation in Indonesia. As stipulated here, the government is responsible for providing electricity to underdeveloped and isolated regions by utilising locally available energy sources. **Electricity Law No. 30/2009** gives direction to the electricity sector, with the Government of Indonesia prioritising the role of the state-owned utility, PLN, except in certain locations not yet covered by PLN's business plan. The National Energy Policy (**Government Regulation No. 79/2014**) aims at increasing renewable energy's contribution to the primary energy mix to 23% by 2025.

In 2016, ESDM officially launched the **Ministerial Regulation No. 38/2016**, which aims at accelerating electricity provision in the least developed, remote, border and inhabited islands. It targets the use of renewable energy technology of up to 50 MW capacity to electrify 2 510 villages by 2019. It also allows the private sector to distribute electricity to areas not yet covered by PLN or another concession right holder.

The Government of Indonesia made a significant policy move (April 2017) through **Presidential Regulation No. 47/2017**, which seeks to accelerate the basic electrification of remote, border, small and inhabited islands through the provision of energy efficient solar lamps. As many as 255 250 individual systems are to be distributed by the end of 2018.

Mini-grid regulations

Tariff setting. The Government of Indonesia applies a basic electricity tariff for PLN customers, categorised into residential, business and industry sectors.

In general, electricity tariffs for mini-grid customers in rural villages are unregulated. Users discuss the tariff and collectively agree to pay a monthly flat rate that is commonly seen to range between Indonesian rupiah (IDR) 5 000 (USD 0.35) and IDR 70 000 (USD 4.6). The tariff is set according to consumers' ability to pay. In some cases, the local government may play a role in determining the tariff to be paid by mini-grid customers (Hasan, 2017).

In May 2017, ESDM's **Ministerial Regulation No. 39/2017** was launched to regulate the development of renewable energy mini-grids using the national budget (APBN) including the instruction for PLN to purchase the electricity generated from mini-grids in the case of main grid arrival. The electricity purchase price for this obligatory purchase is determined in the regulation, and is to be implemented through a power purchase agreement prepared by PLN and valid for 20 years. Income from the purchase is to be used by mini-grid management for operation and maintenance purposes.

Additionally, in August 2017, ESDM launched the **Ministerial Regulation No. 50/2017**, which mandates that PLN buy electricity from renewable-energy-based power plants with capacities of up to 10 MW. The tariff is set to be equal to 85% of regional electricity generation cost,[6] if the regional electricity generation cost is higher than the average national electricity generation cost. If the regional costs are equal or lower than the national cost, the tariff is to be negotiated by the independent power producers and PLN. A build, own, operate, transfer scheme is applied in this arrangement.

Arrival of the main grid. Upon arrival of the grid, ESDM would attempt to connect the mini-grid to the main grid, if technically compatible. As grid-interconnection effort is in an early phase, there is currently an absence of specific technical standard. Overall, existing regulations offer general guidance and state that the development of renewable energy power plants shall follow national or international standards. In July 2014, PLN issued "Guidelines for Connecting Renewable Energy Generation Plants to PLN's Distribution System" (PLN, 2014). This focuses on plants with capacities of up to 10 MW. The Directorate General of Electricity released a general guideline on electricity installation that includes common standards such as for maximum voltage drop, current-carrying conductor type, grounding and lightning protection.

Quality standards. The **Ministerial Regulation No. 36/2018** includes technical specifications for mini-grid systems, regarding installation capacity, type of inverter, type of battery and daily energy allocation for end users. The regulation applies only to mini-grids funded by the government. For privately funded mini-grids, specifications may vary depending on the purpose.

6. The electricity generation cost is that incurred by PLN to generate and provide electricity. This cost is enacted through an ESDM regulation and is used as the reference for electricity purchase by PLN (ESDM, 2017).

Secondary measures

Taxation and other fiscal measures

In January 2010, the Ministry of Finance Regulation No. 21/PMK.011/2010 granted taxation and customs facilities for renewable energy. The Government of Indonesia provides several incentives particularly for procuring renewable energy technology. These include an exemption from value-added tax and import duty. The Ministry of Industry, however, sets limits on imported products (Box CS 6.2).

Box CS 6.2 Supporting local industries

Released in March 2012, **Ministry of Industry Regulation No. 54/M-IND/PER/3/2012** provides a guideline for the use of domestic components in electricity infrastructure. For photovoltaic mini-grids, a minimum 34% of materials must be manufactured locally; this share is 64% for hydro-based power plants of up to 15 megawatts (MW). The guideline aims at improving the capabilities of local industries in renewable energy technologies.

The regulation has contributed to the development of domestic micro-hydro manufacturing capacity that not only meets domestic needs, but also involves the export of generation and ancillary products. Local solar companies, meanwhile, are mostly involved in assembling products (photovoltaic modules, batteries, conductors).

RESULTS AND CHALLENGES

Since 2011, through an EBTKE electrification programme scores of mini-grid systems have been developed annually based on solar and micro-hydro. The construction is fully funded by the national budget through a tender process in which a handful of national engineering, procurement and construction companies participate. The mini-grids are then handed over to local governments and generally operated and maintained by communities, cooperatives, or local enterprises.

The government also seeks to accelerate electrification by channelling portions of the Special Allocation Fund (DAK) to be managed directly by local governments. This allows local governments to plan and implement development programmes relatively independently from the national government. The performance of the resulting mini-grids varies: some are reported to be operating well, others are operational but in poor condition and the remaining are not operational due to reasons both technical and non-technical.

Only a few private companies have deployed mini-grid projects, and these have been accomplished with heavy reliance on grants from various governments or international support. Recently a joint venture between EVI and ENGIE was announced committing to install mini-grids in 3 000 villages in Papua (Eco Business, 2017).

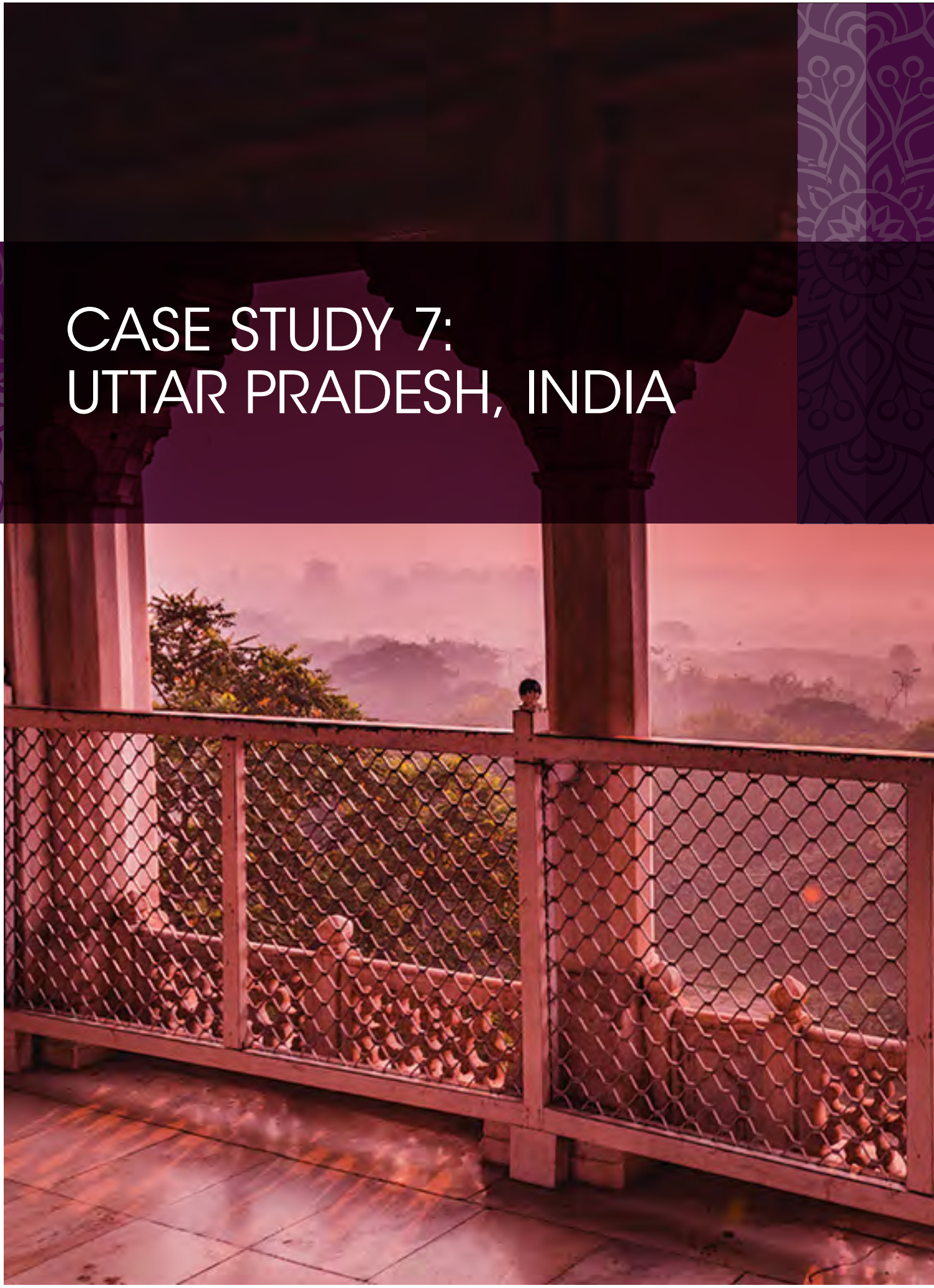
Among the measures that could be taken to support further investments in the sector include:

- Identifying and demarcating remote, unelectrified or underserved areas suitable for renewable energy mini-grids development and translating those into transparent rural electrification plans.
- Addressing uncertainty in the interconnection of mini-grids and electricity purchase tariff on main grid arrival. Setting tariffs at levels that ensure sustainable, long-term operation as well as attract private sector participation.
- Creating a level playing field for private entities, including enterprises and local communities, to participate in mini-grid development.
- Developing dedicated quality standards and regulations for the mini-grid sector aimed at reducing risks, improving services and attracting investments.

RESOURCES

- Minister of Finance Regulation No. 21/PMK.011/2010
  http://www.hukumonline.com/pusatdata/detail/lt4b7a66776d2c6/node/lt516cf67453b71/peraturan-menteri-keuangan-no-21_pmk.011_2010-tahun-2010-pemberian-fasilitas-perpajakan-dan-kepabeanan-untuk-kegiatan-pemanfaatan-sumber-energi-terbarukan
- Minister of Industry Regulation No. 54/2012
  http://www.hukumonline.com/pusatdata/detail/lt4f87e271ecc4b/node/lt511de583e7a0b/peraturan-menteri-perindustrian-no-54_m-ind_per_3_2012-tahun-2012-pedoman-penggunaan-produk-dalam-negeri-untuk-pembangunan-infrastruktur-ketenagalistrikan
- Government Regulation No. 79/2014
  http://www.hukumonline.com/pusatdata/detail/lt545b36c00c94f/node/321/pp-no-79-tahun-2014-kebijakan-energi-nasional
- Presidential Regulation No. 47/2017
  http://www.hukumonline.com/pusatdata/detail/lt58f885fb7feb8/node/534/peraturan-presiden-nomor-47-tahun-2017
- Minister of ESDM Regulation No. 38/2017
  http://jdih.esdm.go.id/peraturan/Permen%20ESDM%20Nomor%2038%20Tahun%202017.pdf
- Minister of ESDM Regulation No. 39/2017
  http://jdih.esdm.go.id/peraturan/Permen%20ESDM%20No.%2039%20Thn%202017.pdf
- Minister of ESDM Regulation No. 50/2017
  http://jdih.esdm.go.id/peraturan/PerMen%20ESDM%20NO.%2050%20TAHUN%202017.pdf
- Minister of ESDM Regulation No. 36/2018
  http://jdih.esdm.go.id/peraturan/Permen%20ESDM%20Nomor%2036%20Thn%202018.pdf

CASE STUDY 7: UTTAR PRADESH, INDIA



Population (2011)

Total installed capacity (2018)

Household electrification rate (2017)

Electricity consumption per capita (2016-17)

Uttar Pradesh is the most populous state in India and has among the largest number of unelectrified households in the country. As of October 2017, the household electrification rate stood at 73%,[7] even as all villages were classified as electrified as per the definition[8] laid out by the official government rural electrification scheme (DDUGJY, n.d.). The disparity between village- and household-level electrification results from several factors, including the lack of a technical and commercial case for distribution companies to service rural areas, reluctance on the part of households to apply for a grid connection due to high costs and unreliable electricity supply (ESMAP, 2017a). The use of kerosene for lighting is widespread, observed in around 62% of households as per the last census in 2011 (Niti Ayog, 2018).

Meanwhile, household expenditure on fuels for lighting is high, a fact that, among others, has encouraged the development of around 1 850 mini-grids (both AC and DC systems) to provide basic electricity access (including for lighting and mobile phone charging) to un/under-served areas. These mini-grids are mostly privately owned and operated in a largely deregulated regime. To support the sector, in 2016, the state government was the first in India to introduce a dedicated mini-grid policy and regulation (CSE, 2018). This case study analyses the factors that have driven renewable energy mini-grid development In Uttar Pradesh, and the lessons emerging from the introduction of dedicated policies and regulations.

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

The Electricity Act (2003) exempts decentralised distributed generation from license requirements and tariff regulations. This resulted in the rapid development of private mini-grids in Uttar Pradesh. There are now around 1 850 operational mini-grid systems mostly based on solar and biomass. The accumulated capacity is estimated to be 3 MW with the majority of mini-grids having capacities below 1 kWp (CSE, 2018). Private mini-grids have been able to operate until now as the grid has been unable to provide electricity to the majority of the population or of adequate service quality. Given the uncertainty in grid extension (and energising) programmes, majority of the systems are designed to deliver basic electricity services.

7. Saubhagya.gov.in.

8. A village is declared electrified if (1) basic infrastructure such as distribution transformer and distribution lines are provided in the inhabited locality; (2) electricity is provided to public places like schools, health centres, community centres etc. and (3) at least 10% of households are electrified.

INSTITUTIONAL FRAMEWORK

Table CS 7.1 provides an overview of the main institutions involved in renewable energy mini-grid development and operation in the state of Uttar Pradesh in India.

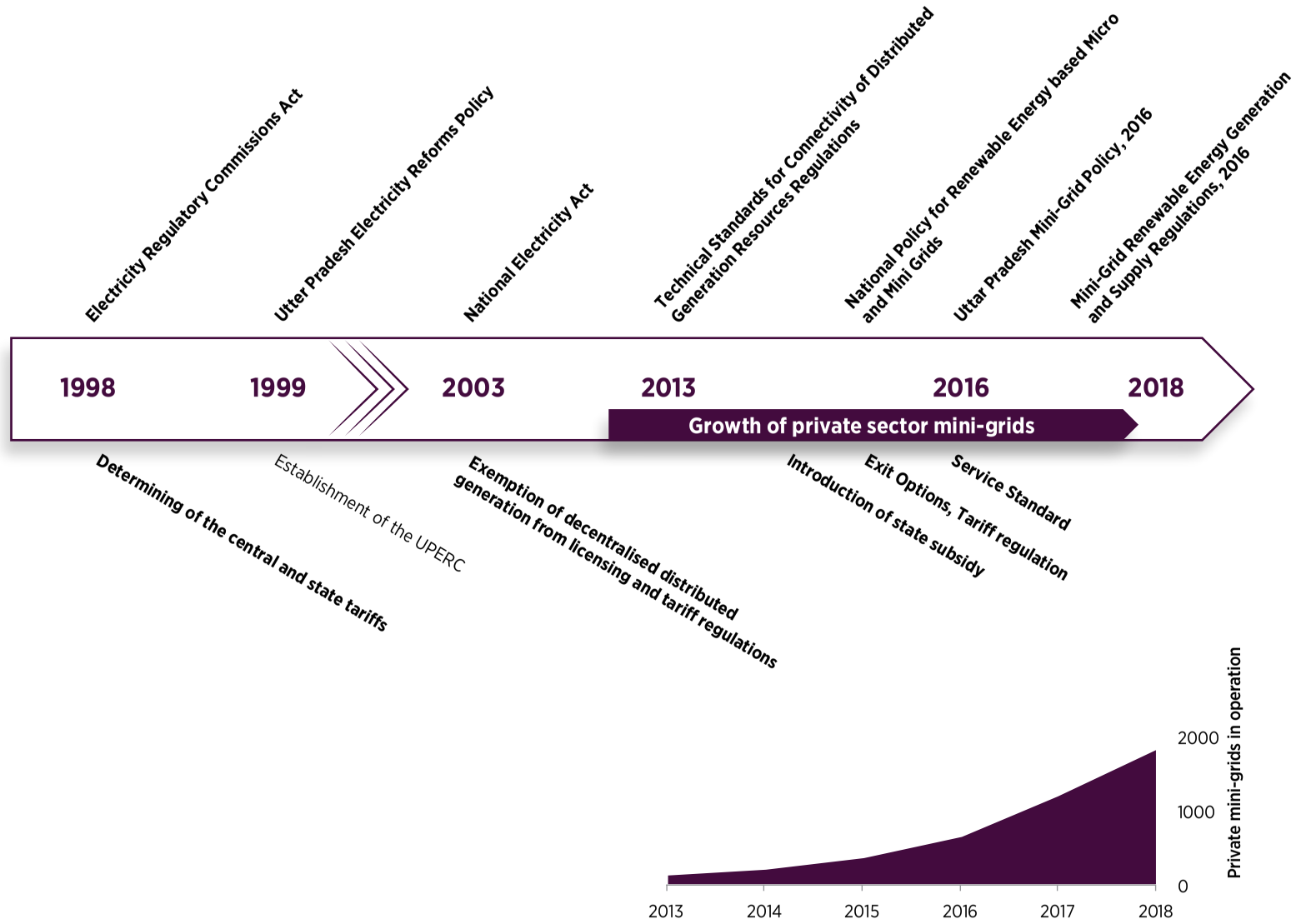
Table CS 7.1 Overview of the institutional landscape in Uttar Pradesh, India

	Topics	Institution	Description
PRIMARY MEASURES	Planning	Ministry of Power	Responsible for planning, policy formulation, monitoring projects, training and the administration and enactment of legislation in regard to thermal, hydro power generation, transmission and distribution.
	Policy	Ministry of New and Renewable Energy	Facilitates research, design, development, manufacture and deployment of renewable energy systems.
	Regulation	Central Electricity Authority	Sets regulations and guidelines for the electricity sector.
		Uttar Pradesh Electricity Regulatory Commission	Interprets policies issued by the central government and adjusts them in line with state priorities. Sets tariffs and service standards based on power sector policies and laws from both state and central government levels.
		Rural Electrification Corporation Limited	Finances and promotes rural electrification projects all over the country. Offers financial services in the form of short-, medium- and long-term loans to power utilities as well as private mini-grid developers.
		Bureau of Indian Standards	Sets standards for mini-grid systems, including specific ones for DC systems.
	Implementation	Uttar Pradesh Power Corporation Limited – Utility	Manages transmission, distribution and retail operations for grid electricity.
	Financing	Uttar Pradesh New and Renewable Energy Development Agency	Promotes the use of renewable energy to identify, formulate and implement schemes, including for mini-grids.
SECONDARY MEASURES	Environmental and health protection	Ministry of Environment, Forests and Climate Change	In charge of environmental protection and preservation. Assesses the environmental impact of mini-grid projects.

POLICY AND REGULATORY UPDATES

The evolution of the mini-grid policy and regulatory landscape along with the number of mini-grids deployed is illustrated in Figure CS 7.1.

Figure CS 7.1 Evolution of mini-grid policy and regulations in Uttar Pradesh



Note: CEA = Central Electricity Authority; kW = kilowatt; UPERC = Uttar Pradesh Electricity Regulatory Commission.

Primary measures

National policy on energy and renewables

Mini-grid development in the state of Uttar Pradesh was spurred by provisions in the National Electricity Act, 2003, which exempts entities intending to generate and distribute electricity in rural areas (as notified at the state level) from licensing requirements and tariff regulations. The National Electricity Policy (2005) and the Rural Electrification Policy (2006) also emphasised the development of decentralised distributed generation, along with local distribution networks, wherever grid-based electrification was not feasible. Around 2009, the deregulated environment provided an impetus for private mini-grids based primarily on renewable energy solutions such as solar and biomass (*e.g.*, rice husks) (ESMAP, 2017a). The mini-grids' design and services were strongly influenced by the prevalent expenditures of households on lighting solutions (including kerosene), demand for basic electricity access (lighting, mobile phone charging) and the economic sustainability of projects.

Taking stock of the emergence of private mini-grids and with the intention of building a supportive ecosystem for further development, in 2016, the Ministry of New and Renewable Energy released a draft National Policy for Renewable Energy based Micro and Mini Grids (MNRE, 2016). The draft covered different factors related to project development procedures, the role of different stakeholders and entities, performance and technical standards, exit options and interactions with the main grid, and financial and other forms of assistance. States were encouraged to refer to the national policy when developing their own programmes, policies and regulations. While the draft national policy is still under consideration by the national government (Graber *et al.*, 2018), the government of Uttar Pradesh issued its Mini-Grid Policy in 2016 with a view to providing more regulatory certainty and structure to the market (UPNEDA, 2016; ESMAP, 2017a).

Mini-grid regulations

Licensing and legal provisions. The Uttar Pradesh Mini-Grid Policy, 2016 provided clarity on the state-specific treatment of mini-grids. It covered two implementation models depending on whether developers availed themselves of the state subsidy of 30%. Developers that did not had no need to secure a license and could charge a tariff as negotiated with communities. Their projects, meanwhile, would benefit from exit plans in case of the main grid's arrival. Should developers avail themselves of the capital subsidy, several requirements relating to service quality, tariff regulations, and safety and security standards would apply. Under this regime, projects would be established on a build, own, operate and maintain basis for at least ten years.

Tariff setting. For projects developed through the capital subsidy route, tariffs are restricted to a flat monthly fee of Indian rupees (INR) 60 (~USD 0.8) for a load of 50 watts (W) and a monthly flat fee of INR 120 (~USD 1.6) for a 100 W load of eight hours daily. For loads above 100 W, the tariff can be mutually agreed upon by the consumer and developer (UPNEDA, 2016). Other projects can set tariffs at negotiated rates between the operator and the consumers. The applicable tariff regulation may change once the main grid arrives, as discussed next.

Arrival of the main grid. In case the main grid arrives, the operator has the option to: (1) continue to supply its entire generation to consumers as per a designed standard of performance (with no change in the tariff-setting requirements); (2) generate and supply electricity as per the standard of performance to consumers (with no change in the tariff-setting requirements) and sell the excess generation to the distribution licensee (or distribution companies) at the applicable FiT; or (3) generate and supply the entire generation to the distribution licensee at the applicable FiT. The FiT is determined by the Uttar Pradesh Electricity Regulatory Commission through the Regulations for Captive and Renewable Energy Generating Plants.

The mini-grid operator also has the option of transferring the ownership of the distribution network to distribution companies, provided the network conforms to the standards of the centralised system. The policy defines how the depreciated value of the assets shall be determined – applying the straight-line method on the book value of the network infrastructure as per the cost data book of the distribution company for the year of the project's commissioning.

Quality standards. The Mini-Grid Renewable Energy Generation and Supply Regulations, 2016 define different technical standards and certification for mini-grids, depending on capacity. Mini-grids with

a capacity above 50 kW either have to comply with the Uttar Pradesh Power Corporation Limited's guidelines or the security measure defined in the Central Electricity Authority (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013. Also, the CEA regulations or Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010 set rules to be respected in the mini-grids design under the mini-grid regulation.

For systems with a capacity under 50 kW, simplified standards have been defined. The Uttar Pradesh Power Corporation Limited's distribution network code and guidelines for the design and construction of distribution lines include technical standards to be respected by mini grids. Poles have to be made with Portland cement concrete, and cables must be made with aluminium and covered by polyvinyl chloride. Service connection must be in standard junction boxes mounted at the pole.

RESULTS AND CHALLENGES

The regulatory space provided by the Electricity Act, 2003 enabled around 1 850 private mini grids to develop. This leveraged on the distributed nature of renewable energy technologies to cater to basic electricity services in areas un/under-served by the main grid. Different business models have emerged, including the anchor-business-customer model (*e.g.*, OMC Power) and the micro-utility model (*e.g.*, Mera Gao Power) (ESMAP, 2017a). As seen in the case of Cambodia, the government stepped in with the intention of leveraging the mini-grid ecosystem to scale up deployment, improve service standards and generate synergies between centralised and distributed electrification. The adoption of dedicated mini-grid policies has been an important step in that direction. However, several challenges remain to be addressed.

Tariff regulation coupled with capital subsidy at present levels (prescribed in the policy) is seen to be insufficient for the private sector to break-even (Comello et. al., 2017). A transparent and uniform tariff calculation method is needed to ensure a cost-reflective tariff that protects both operators' and customers' interests. The policy must also envisage long-term roles for mini-grid projects and provide clarity on operational and commercial terms of agreement (CSE, 2018).

Risk of main-grid arrival/energising is still a key investment risk in mini-grids. In a context where main-grid distribution infrastructure (*e.g.*, transformers) have already been established in villages, distribution licensees or companies will have to play a more active role in considering the role that mini-grids can play in improving services to rural consumers and assess the most suitable model for grid-connected mini-grids (*e.g.*, tail-end generation, distribution franchisee, net metering or backup generation) (Shakti Foundation, 2017). In either case, commercial terms of agreement for the interconnection need to be established, as well as clear tariff setting regulations.

RESOURCES

- Electricity Regulatory Commission Act, 1998
  http://cercind.gov.in/ElectReguCommiAct1998.pdf
- Utter Pradesh Electricity Reforms Act, 1999
  http://www.uppclonline.com/en_GB/PowerSectorReform_Link_Document/Link1.htm
- Electricity Act, 2003
  http://www.cercind.gov.in/Act-with-amendment.pdf
- Technical Standards for Connectivity of Distributed Generation Resources Regulations, 2013
  http://www.cea.nic.in/reports/regulation/distributed_gen.pdf
- National Policy for Renewable Energy based Micro and Mini Grids, 2016 (draft)
  https://mnre.gov.in/file-manager/UserFiles/draft-national-Mini_Micro-Grid-Policy.pdf
- Uttar Pradesh Mini-Grid Policy, 2016
  http://upneda.org.in/mediagallery/Mini-Grid-Policy-2016.pdf
- Mini-Grid Renewable Energy Generation and Supply Regulations, 2016
  http://uperc.org/App_File/NotifiedUPERCMinigridregulations2016-pdf411201630132PM.pdf

CASE STUDY 8: PERU

32 MILLION
Population (2017)

14.5 MW
Total installed capacity (2016)

76%
Rural electrification rate (2016)

1308 kWh
Electricity consumption per capita (2016)

Electricity access rates in Peru have improved significantly in recent years, rising from 72% in 2000 to 95% in 2016 (ESMAP, 2018). In rural areas, the electrification rate reached an estimated 76%. Grid extension and solar PV-based off-grid solutions have both contributed to improvements in rural electrification. Among the electrified rural households, 39% are connected to the main grid, most of them consuming less than 30 kWh per month (Portugal & Ambia, 2015). The remaining households benefit from stand-alone solar home systems (SHSs), or mini-grids based on renewable energy sources or conventional fuels such as diesel.

THE ROLE OF MINI-GRIDS IN RURAL ELECTRIFICATION

The National Rural Electrification Plan (Plan Nacional de Electrificacion Rural, PNER) aims to improve electricity access in Peru. The plan also establishes support for the productive use of electricity, with the objective of facilitating renewable energy-based mini-grid deployment (Dirección General de Eficiencia Energética, 2013). The Peruvian National Energy Plan (2014-25) strives for an electrification rate close to 100%, to be achieved by focusing on rural, isolated and frontier areas.

INSTITUTIONAL FRAMEWORK

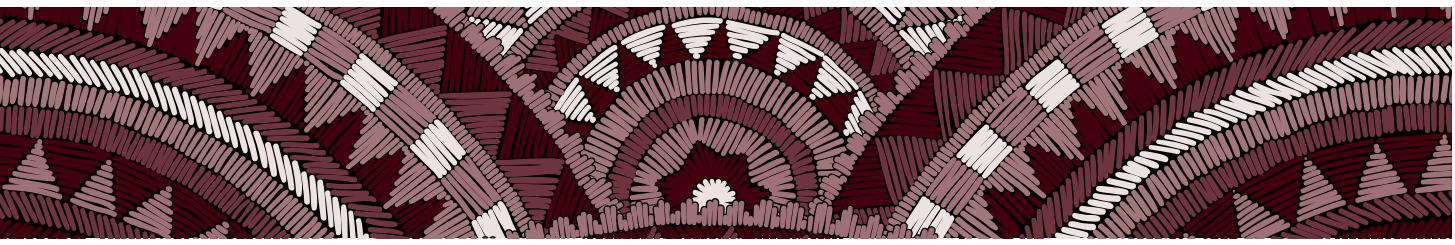
Table CS 8.1 provides an overview of the relevant public institutions and stakeholders involved in the policy, regulation and implementation of mini-grids.

Table CS 8.1 Overview of Peru's institutional landscape

	Topics	Institution	Description
PRIMARY MEASURES	Planning	The Ministry of Energy and Mines	Responsible for designing and formulating national policies in the energy and mining sector and ensuring their implementation. Also evaluates the need for auctions.
	Policy		
	Implementation		
	Regulation	Supervisor of Investment in Energy and Mining (OSINERGMIN)	Regulates and monitors the power and mining sectors.
			Sets tariffs for both urban and (off-grid) rural areas every four years based on the (1) nature of the investor (public or private), (2) size of the power plant and (3) location.

POLICY AND REGULATORY UPDATES

After the introduction of the National law of General Rural Electrification Nº28749 in 2006, followed by a national decree for the promotion of investment in renewable energies for electricity generation, introduced in 2008, the electrification of rural areas has gained pace. Figure CS 8.1 outlines growth in rural electrification rate since 1995, together with changes in the policy and regulatory landscape.



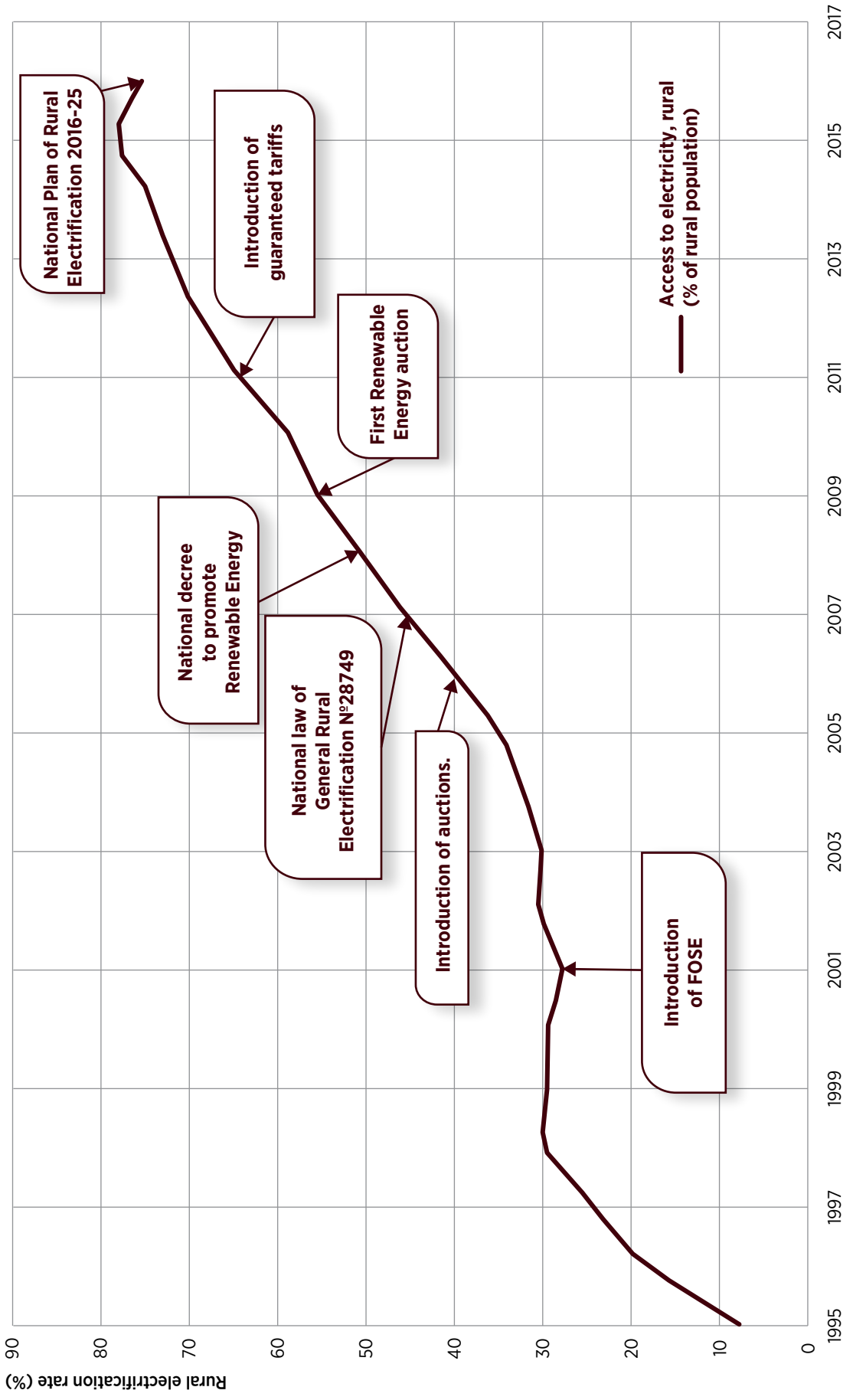


Figure CS 8.1 Evolution of mini-grid policy and regulations in Peru, 1995-2017

Based on: World Bank, n.d.
Note: FOSE = Fondo de Compensación Social Eléctrica; RE = renewable energy.

Primary measures

National policy on energy and renewables

The legislative decree number 1002, **Law for the Promotion of Electricity Generation with Renewable Energies**, identifies investment in renewable energies for sustainable development as a national priority. The law assures investors in renewable energy of a guaranteed price for the energy supplied to the grid, which is fixed through auctions.

Rural electrification master plan

The **National Rural Electrification Plan**, PNER, is the fundamental planning tool (Dirección General de Eficiencia Energética, 2013) and is prepared every two years, the latest version being the 2016 25 plan (Practical Action, Endev, EUEI PDF, n.d.). This document's core framework has remained unchanged and stable over the years, while the goals have been updated to reflect progress.

According to the master plan, in areas where grid extension is not feasible technically or economically, preference is given to the adoption of off-grid solar PV systems over small hydropower and wind-based mini-grid solutions. The latest master plan identifies the region of Los Andes as suitable for small hydro systems with an installed capacity of 20-200 kW.

Mini-grid policies and regulations

Tariff setting. The Supervisor of Investment in Energy and Mining (OSINERGMIN) sets the tariffs and prices for electricity, and oversees legal, technical and contractual compliance. Consumer tariffs vary across urban and (off-grid) rural areas and are set every four years based on the (1) nature of the investor (public or private), (2) size of the power plant and (3) location (OSINERGMIN, 2018).

All users with a monthly consumption lower than 100 kWh get a tariff discount. Those consuming up to 30 kWh are given a discount ranging from 25% to 62.5%, depending on the nature of the connection (Table CS 8.2), while consumers using between 30 and 100 kWh see a net reduction of their monthly bills ranging between7.5 and 18.75 kWh.

The financing mechanism employed is a combination of community and government subsidies, where a share of the tariffs imposed on consumers above 100 kWh is used to cross-subsidise small consumers. In addition to the part of the tariff from grid connected consumers, FOSE also receives funds from sources such as the national budget, development aid and fines to utilities.

Table CS 8.2 Support for low-level energy consumers

Residential Users	Sectors	Monthly discount on consumptions equal or lower than 30 kWh	Monthly discount on consumptions higher than 30 kWh and up to 100 kWh
INTERCONNECTED SYSTEMS	Urban	25% of the energy charge	7.5 KWh
	Urban rural & rural	50% of the energy charge	15 KWh
ISOLATED SYSTEMS	Urban	50% of the energy charge	15 KWh
	Urban rural & rural	62.5% of the energy charge	18.75 KWh

Source: OSINERGMIN, 2018
Note: kWh = kilowatt hour.

Arrival of the main grid. In the planning phase, the government defines the location and technology of a particular project, awarded to a specific company through auctions under the concession model. In the case of off-grid projects, special focus is given to regions where the main grid is not expected to arrive in the next ten years (República del Perú, Ministerio de Energía y Minas, 2015). This is possible due to a coherent top-down approach by which the same institution, OSINERGMIN, is responsible for both auctions and grid expansion plans, thus guaranteeing the reliability of the electrification strategy.

Access to funds/finance. The National Fund for Rural Electrification (FONER), developed in 2006-13, supports rural electrification through both grid extensions and off-grid renewable energy solutions (República del Perú, Ministerio de Energía y Minas, 2015). In June 2011, the government approved an USD 50 million loan from the International Bank for Reconstruction and Development for the FONER II. It committed to funding projects, but also conducted technical, economic, social and ecological studies to promote small hydropower plants (World Bank, 2018d; and IBP, 2017).

The Electric Social Compensation Fund (Fondo de Compensación Social Eléctrica, FOSE) was introduced in 2001 as part of a social inclusion policy and benefits small electricity customers (World Bank Group, 2004). Any company installing a small power plant can receive FOSE subsidies to cover the monthly investment amortisation and operating costs of its assets, or the state can acquire the equipment and the FOSE subsidy be used to cover only the investor's operating costs.

Moreover, the state offers capital cost subsidies for projects targeting rural electrification of between 200 to 5 000 connections as well as partial coverage of operating and maintenance costs (García, 2016). Once the application for a project is filed, the regulatory entity reviews it and subsidies are set individually for each project to cover the capital costs.

RESULTS AND CHALLENGES

The first rural electrification planning document in 2008 was able to push up the electrification rate from 38% to 50% in a two-year period. Recent data indicate that the rural electrification rate in rural areas has reached 76%. The National Rural Electrification Plan (PNER) 2016-2025 sets a goal of achieving 99% electrification by 2025 with substantial investments envisaged in small-hydropower plants and stand-alone solar PV systems (RVO, 2018).

The flexibility of the planning and strategy tool adopted by the country (PNER) allows it to adjust projects' priority level and introduce new projects depending on the self-financing or co-financing that the interested parties obtain. The PNER covers identified projects and programmes at the national level (managed by DGER-MEM, electricity companies and other state entities) and also by regional and local governments.

The most recent programme, FONER II, ended in December 2017 and provided nearly 37 000 households with new connections. As part of the programme, almost 12 000 stand-alone solar systems were provided (World Bank, 2018d). Public private partnership models are also being tested for the development of stand-alone solar systems, with a private sector responsible for identification of users, installation and the operation and maintenance for 15 years, while the public sector is responsible for administration (*e.g.*, tariff collection) (Feron and Cordero, 2018). Recent policy developments have focused largely on SHSs, rather than mini-grids (RVO, 2018). However, various international partners and non-governmental organisations have been involved in the promotion and deployment of mini/micro-hydro (Box CS 8.1).

Box CS 8.1 Non-governmental organisations' support of renewable energy mini-grids in rural areas

Non-governmental organisations have largely relied on international financial support and have focused on the use of mini/micro-hydro mini-grids. In 1992 the Intermediate Technology Development Group received financing from the Inter-American Development Bank to create a financing project for hydropower micro-grids in combination with technical training and support (Campos, 2000). To promote the productive use of electricity, these projects targeted low-income communities. Mini-grids were deployed across nine sites in the 2000s with a generating capacity between 25 and 80 kW (Practical action, 2008). One organisation (Practical Action) paved the way for mini-grids by deploying over 50 micro-hydro systems across the country, in addition to developing a series of programmes and handbooks. Among its projects, those in the regions of Pucará and Chambamontera can be highlighted, where not only technical, but also extensive socio-economic and impact assessments were conducted (Carrera, 2011).

Opportunities for mini-grid development are potentially in the Andes and northern and central coasts, as well as in isolated mining areas (RVO, 2018). Scaling-up deployment requires dedicated policy and financial support (ARE, 2014). These to support addressing investment risks and reducing the cost of connection for end consumers to ensure the inclusion of the rural population (IRENA, 2014). Also, the inclusion of local community members in project planning is key to ensuring that projects adapt to meet communities' specific needs.

Cross-subsidy tools and tariff guarantees can support private sector engagement, since they minimise risk and ensure the economical sustainability of projects. A further elaboration of the role of renewable energy mini-grids in national electrification plans and measures to scale-up deployment would encourage investment in generation capacity beyond basic electrification.

RESOURCES

- Ministerio de Energia y Minas. (October de 2009). Plan Nacional de Electrificacion Rural (PNER) 2009 - 2018. Recuperado el 31 de July de 2018, de *http://spij.minjus.gob.pe/graficos/Peru/2009/diciembre/24/RM-540-2009-MEM-DM.pdf*

- Republica del Peru Ministerio de Energia y Minas. (December de 2015). Plan Nacional de Electrificacion Rural (PNER) 2016 - 2025 . Recuperado el 23 de July de 2018, de *http://extwprlegs1.fao.org/docs/pdf/per153304anx1.pdf*

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