UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

GREEN MINI-GRID HELP DESK

Fast tracking rural electrification through accelerated and precise mini-grid policy formulation

CLEAN ENERGY MINI-GRID POLICY DEVELOPMENT GUIDE

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LIST OF ACRONYMS

BOOT	Build, own, operate, transfer
CAPEX	Capital expenditure
CRM	Customer relationship management
EPC	Engineering-Procurement-Construction
ERIL	Électrification rurale d'initiative locale
ESCO	Energy service company
FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic Information System
GIZ	German Corporation for International Cooperation
IMF	International Monetary Fund
IT	Information technology
KMM	KeyMaker Model
MG	Mini-grid
MYTO	Multi-year tariff order
O&M	Operation and maintenance
OPEX	Operating expenditure
PAYG	Pay-as-you-go
PPP	Public-private partnership
PV	Photovoltaic
REA	Rural Electrification Agency
REF	Rural Energy Fund
SDG	Sustainable Development Goals
TOU	Time of use
WACC	Weighted average cost of capital

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Authors:

FOREWORD

Mini-grids have been touted by experts as central to the rural electrification challenge for many years but remain poorly understood by decision-makers. Their energy services are high quality, their technologies are mature, but they are often constructed in remote, hard to reach areas, and their business models are quite different to many independent power producers.

It is therefore unsurprising that policies and regulations currently providing the framework for the mini-grid sector to work within are often not fit for purpose. A consequence of this is that while the World Bank estimates there is a need for over 140,000 mini-grids in Africa, in 2020 the average regulatory approval time across the continent for one mini-grid is over one year. [1]

This enormous gap between what is needed in terms of delivery and what is currently possible in terms of governance shows the extremely urgent need for new thinking and approaches to policy and regulation across the continent. This is particularly important given that only one decade remains to the 2030 deadline for achieving the globally agreed Sustainable Development Goals, around a dozen of which require universal energy access as a prerequisite for their success.

To speed up progress on this challenging front, this Clean Energy Mini-Grid Policy Development Guide takes a decision-makers perspective on the options, trade-offs and benefits of different approaches a country might take to designing the policies and regulations needed to radically speed up investment, deployment and progress on energy access using mini-grids.

This guide builds on the widely utilized Mini-Grid Policy Toolkit, released in 2014. This current guide has been a collaboration between INENSUS, the United Nations Industrial Development Organization (UNIDO), the Alliance for Rural Electrification (ARE), the Africa Minigrid Developers Association (AMDA), and the African Development Bank (AfDB). It highlights the challenges that governments and policymakers typically face, and presents customized approaches by means of decision guides, to facilitate smoother decision-making and to expedite mini-grid deployment.

It also provides a number of templates for contracts and agreements, which can be used as references by policymakers when seeking to tailor such documents for their respective markets. Lastly, the guide presents policymakers with a set of key recommendations on how to approach policies and regulations for a decentralized infrastructure market such as mini-grids – something that will require important and sometimes significant changes to how governments approach their energy sectors.

We now, however, need you – the reader – to help us take this guide to the places it is needed most, the hearts and minds of decision-makers and those who are supporting and working with them. We must take these guides, templates and ideas from paper, and put them into practice!

Signed
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1 AMDA, 2020. Benchmarking Africa's Minigrids. Africa Minigrid Developers Association (AMDA). http://africamda.org/wp-content/uploads/2020/09/AMDA-Benchmarking-2020-.pdf

EXECUTIVE SUMMARY

Mini-grids have been identified as a critical tool towards achieving universal electricity access by governments, donors and private sector actors alike. To enable the sustainable deployment of mini-grids, the public and private sector need to cooperate. Policies and regulations which support the most suitable mini-grid delivery models need to be developed to allow the sector to scale. The **Clean Energy Mini-Grid Policy Development Guide**, developed in partnership by ARE, AMDA, UNIDO, INENSUS and the AfDB Green Mini-Grid Help Desk, outlines the various forms and models that public-private cooperation could take and reflects on the outcomes of policy decisions on mini-grid deployment.

While the guide is not exhaustive, it provides an overview of the most important aspects of mini-grid policy, with the aim of supporting policy makers to accelerate mini-grid deployment and to help guide national debates and decision making on rural electrification policies and frameworks.

The guide incorporates lessons learnt from existing mini-grid policies and regulations and presents the key decisions that need to be taken by policymakers in designing the most appropriate mini-grid framework for their country. A decision tree designed for policymakers outlines which combination of key decisions leads to which outcome.

Five critical conclusions may be drawn from the guide:

1. **Sustainable mini-grid business/delivery models require scale.** In order to reach scale, all regulatory and administrative processes must be designed to be efficiently applied at large volume.

2. **The way in which mini-grids are ultimately deployed, including the degree of private sector involvement, depends on decisions taken by government.** In order to be sustainable, mini-grids require a comprehensive, long-term political commitment and a stable, reliable policy framework. The long-term sustainability of mini-grids is in the interests of both the operator and the government (if the government is not the operator). Sustainability in mini-grids means technically sound and reliable operation, high-quality customer service and financial profitability.

3. **Large government control over mini-grid deployment, minimum financial subsidies and low end consumer tariffs cannot all be achieved at the same time.** Policy makers need to balance out the level of government control over the mini-grid deployment with the financial contribution the government is willing to provide and the tariff applied to rural electricity customers. Different delivery models allow for specific combinations and degrees of achievement of the different objectives.

4. **The development of electricity demand in rural areas is difficult to predict, making it important to introduce demand risk mitigation instruments in the policy framework.** Demand growth is influenced by a number of factors beyond the control of the mini-grid operator, and may only be accurately predicted after a few years of mini-grid operation.

5. **The risk of a sudden end to the project, i.e. the termination risk, ought to be considered by policy makers and regulators.** Termination risk is not only related to the regulation of main-grid connection to the mini-grid, but also to concession contracts, lease agreements, usage rights agreements, PPP contracts, land right agreements etc.

A number of different instruments may be deployed to support the sustainable roll-out of mini-grids. **Templates which may be utilized for the practical development of mini-grid policy and regulation are linked to the guide.**

Among others, the following instruments are featured in detail in the guide:

- **Critical features of tariff tools and tariff regulation** applicable under the selected subsidy scheme (or vice versa) are presented, highlighting in particular the Cost of Service model. This model can be considered a scale that always needs to be in balance to allow mini-grids to operate sustainably. Government actions that lead to an imbalance of the Cost of Service model will automatically result in a failure of mini-grid electricity supply, with the regulatory authority considered as the guardian of the scale.
- **Appropriate licensing and permitting schemes** are discussed, including portfolio licensing and licensing based on system size. The granting of licences and permits is an administrative process that must be carried out quickly to enable accelerated rural electrification. Therefore, the documents and tools must be easy to handle for a large number of sites in a short period of time. Digital technologies with automatic data processing are highly recommended.
- **The diverse set of procurement processes for mini-grids** are analysed. Four competitive procedures (lowest service charge, lowest tariff, lowest weighted average cost of capital (WACC) and lowest grant) and one first-come-first-served procedure (fixed grant per connection, also known as RBF or PBG) are introduced.

Once a policy framework has been put in place, drastic and rapid changes to the framework must be avoided. Ultimately, the success of the deployed mini-grids will reflect the level of trust between all stakeholders, including electricity consumers, operators, donors, investors, government, authorities and the general public. Gradual changes must never unilaterally generate disadvantages without compensating the respective stakeholder.

When all aspects of a mini-grid framework have been carefully considered, deployed projects may fulfil a crucial role in achieving electricity access and fighting energy poverty, also enabling the development of rural industries and new industrial value chains. Successful collaboration between all stakeholders in the sector will result in significant progress and in helping to achieve energy access milestones.

You can access the templates here:

https://greenminigrid.afdb.org/afdb-mini-grid-training-and-templates

FIGURES

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1. INTRODUCTION TO THE GUIDE

The Clean Energy Mini-Grid Policy Development Guide is a tool that helps policymakers to tailor mini-grid policy to country-specific contexts. It guides policymakers through the relevant decision making processes and provides background information where required. The guide can be seen as an update to the widely used Mini-Grid Policy Toolkit 2014, incorporating lessons learned from developments in the mini-grid sector in the intervening years. Its rationale and messages are widely applicable, but are particularly suited to the Sub-Saharan African context.

Chapter 2 of this guide introduces a number of key decisions that need to be taken by policymakers as they move towards designing the mini-grid framework that is most appropriate for their country's context. At the same time, fundamental economic relationships and interdependencies between stakeholders in the mini-grid sector are presented, while the guide also suggests which constellations are feasible and lead to long-term sustainability in mini-grid operation and which do not. From this understanding, a decision tree for policymakers is derived, showing which combination of key decisions leads to which outcome, with regard to the following:

1. Government control over mini-grid operation and assets.
2. Required levels of public funding.
3. Resulting electricity retail tariffs.
4. Legal documents and tools to be prepared.

While the policy strategy is determined based on a process as described in *Chapter 2, Chapter 3* supports the policymaker in implementing the strategy in the form of tender documentation, tariff setting methodology and licensing approaches. Building on this, the chapter discusses the essential features that ensure a balanced policy environment in the mini-grid sector, and provides links for templates for some of the key tools and documents that already take these essential features into account.

Chapter 4 takes a nuanced look at national planning, with particular emphasis on the debate on national goal setting. This guide uses “delivery models” to explain the different options of policy strategies. The term “delivery model” describes the way in which mini-grids are implemented and operated, by whom and with which financing instruments. It should be noted that the delivery models presented in this guide are not exhaustive. The same applies to policies supporting these business models.

The guide shows that sustainable mini-grid business/ delivery models require scale, i.e. an entity that manages a large number of mini-grids and an even larger number of customers. As a result, delivery models such as the community model, which are unlikely to be scalable, are not considered in this guide.

While this document is not exhaustive, it provides an overview of the most important aspects of mini-grid policy. With this, the partners hope to support national policymakers accelerate mini-grid deployment and to help guide national debates and decision making on rural electrification policies and frameworks.

2. POLICY DEVELOPMENT GUIDE FOR DECISION-MAKERS

Mini-grids have become a viable option for providing reliable and high-quality electricity to rural populations and businesses. In total, 47 million people worldwide are already connected to 19 000 mini-grids, of which at least 2 577 are operational clean energy mini-grids (ESMAP, 2019). As economies of scale gradually take hold in the mini-grid sector, and the costs of photovoltaics and batteries decrease over time, overall system costs are falling. At the same time, the progressive use of information technology (IT)[2], together with mobile payment schemes and consumer protection measures, improve the reliability and offtake of power in mini-grids, thereby generating increased revenues. With falling costs and increased reliability, mini-grids have become more attractive to both the public and private sectors.

The positive experience of early adopters in countries such as Nigeria[3] has attracted more investors to the sector. This dynamic created a virtuous circle in which mini-grid companies are now ready to expand their operations. This is urgently needed, as a total of 180 000 additional mini-grids need to be built to supply electricity to 440 million people if the overarching objective of universal access to electricity by 2030 (ESMAP, 2019) is to be achieved.

Governments of countries such as Nigeria, Kenya, Uganda, Zambia, Sierra Leone and Senegal – among others – have recognized mini-grids as a cost-effective and quickly implementable solution for promoting the development and industrialization of rural areas, supplying reliable electricity to hospitals, schools, police stations, government offices and religious institutions, and connecting the surrounding households and businesses to decentralized distribution systems.

All the countries outlined above have either carried out or are in the process of carrying out a decision-making process aimed at developing their unique mini-grid delivery models and associated policy frameworks, which are tailored to their country-specific conditions.

This chapter aims to provide guidance to interested governments on the selection and development of appropriate mini-grid delivery models. The assistance should help the governments to achieve their countries' respective electrification and development goals within the specified time frames on the basis of accelerated rural electrification measures.

2 Examples: mobile money integration, remote monitoring and control, customer relationship management systems, digital call centres, Geographic Information Systems (GIS), ERP systems, etc. Examples: mobile money integration, remote monitoring and control, customer relationship management systems, digital call centres, Geographic Information Systems (GIS), ERP systems, etc.

3 In 2016, Nigeria was among the first countries to pass a specific mini-grid regulation

2.1 | CROSS-CUTTING DECISIONS

The following subchapters guide the reader through various fundamental decisions that policymakers may make when developing and implementing mini-grid policy. These decisions are based on mini-grid-specific economic mechanisms, legal dependencies between stakeholders and business opportunities that are briefly introduced for each topic on which a policymaker needs to take a decision.

2.1.1 | THE UTILITY OF MINI-GRIDS – WHERE AND HOW TO DEPLOY

Until the late 2010s, mini-grids were regarded as one of a number of technology options to supply as many rural citizens as possible with electricity at the lowest cost possible under the so-called "least cost electrification" approach. Mini-grids found their place in between solar home systems and main grid extension, depending on population density and distance from the main grid. The preferred operator of mini-grids was considered the entity that could best guarantee a reliable power supply at the lowest cost, be it the private sector, a government agency or the community itself.

In many cases, mini-grids remain the cheapest and fastest solution for the electrification of rural towns and villages; Further, knowledge of their potential impact on local and national economies has evolved. As a result, pure "least cost electrification" is now complemented by considerations of "maximum economic impact".

Geospatial analysis for integrated rural electrification planning begins by considering the geolocation of elements such as agricultural and mineral resources and the geolocation of critical government infrastructure.

Recent approaches have used mini-grids as a strategic tool to establish and actively promote specific rural industries based on locally available resources, in order to significantly advance the development of a particular community or district[4]. Mini-grids are therefore becoming an integral part of governments' rural industrialization strategies. The approach underlying this strategy will henceforth be called "fourth generation mini-grids" (see text box).

Fourth generation mini-grids

First generation mini-grids powered by diesel, steam or hydro were hybridized with renewable energy technologies in the second generation. The third generation introduced information technology to the sector, improving efficiency in tariff collection, remote monitoring, customer management and automatic operation. The fourth generation uses fully automated third generation mini-grids as a tool with which to tap into or establish new value chains outside of service or product sales to rural customers. The key drivers are those synergies between the business lines that lead to competitive advantages for the operator. Examples of fourth generation mini-grid business models include the multi-utility model, which uses mini-grid staff to also manage government infrastructure, the KeyMaker model, which pre-processes rural goods in mini-grids to establish logistical channels to trade hubs, the agri-hub model, which promotes the latest farming practices, such as drip irrigation in horticulture, and the anchor customer model.

4 This type of approach is currently being developed for roll-out in Ethiopia.

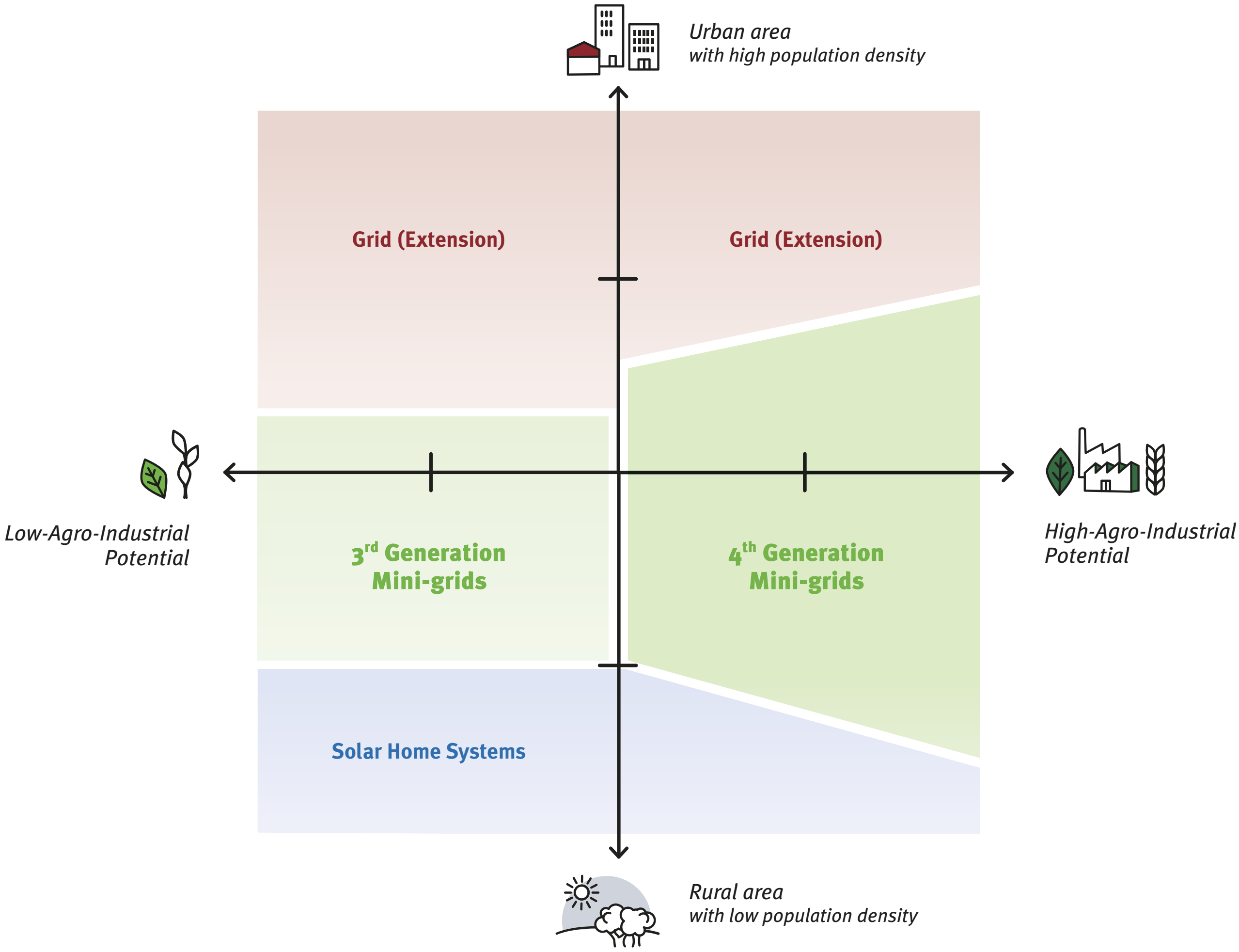


FIGURE 1. PRESENTATION OF THE MOST SUITABLE ELECTRIFICATION SOLUTION ACROSS THE RURAL-URBAN AND LOW TO HIGH AGRO-INDUSTRIAL DIVIDE

In this regard, it is of significant importance to understand which entity delivers the electricity and whether or not the entity is capable of making use of the opportunities of rural industrialization in the best interests of the respective government. A policy framework may be based on a variety of delivery models that are chosen with the aim of achieving different objectives (e.g. least cost electrification and rural industrialization), as shown in the following figure.

The choice made for each of the least cost electrification and rural industrialization planning branches, as outlined in *Figure 2*, in turn influences the set of policies and regulations to be put in place. As will be highlighted in the course of this guide, the mini-grid delivery model also determines the level of tariffs charged to rural customers, as well as the scope and type of financial support required for successful mini-grid deployment.

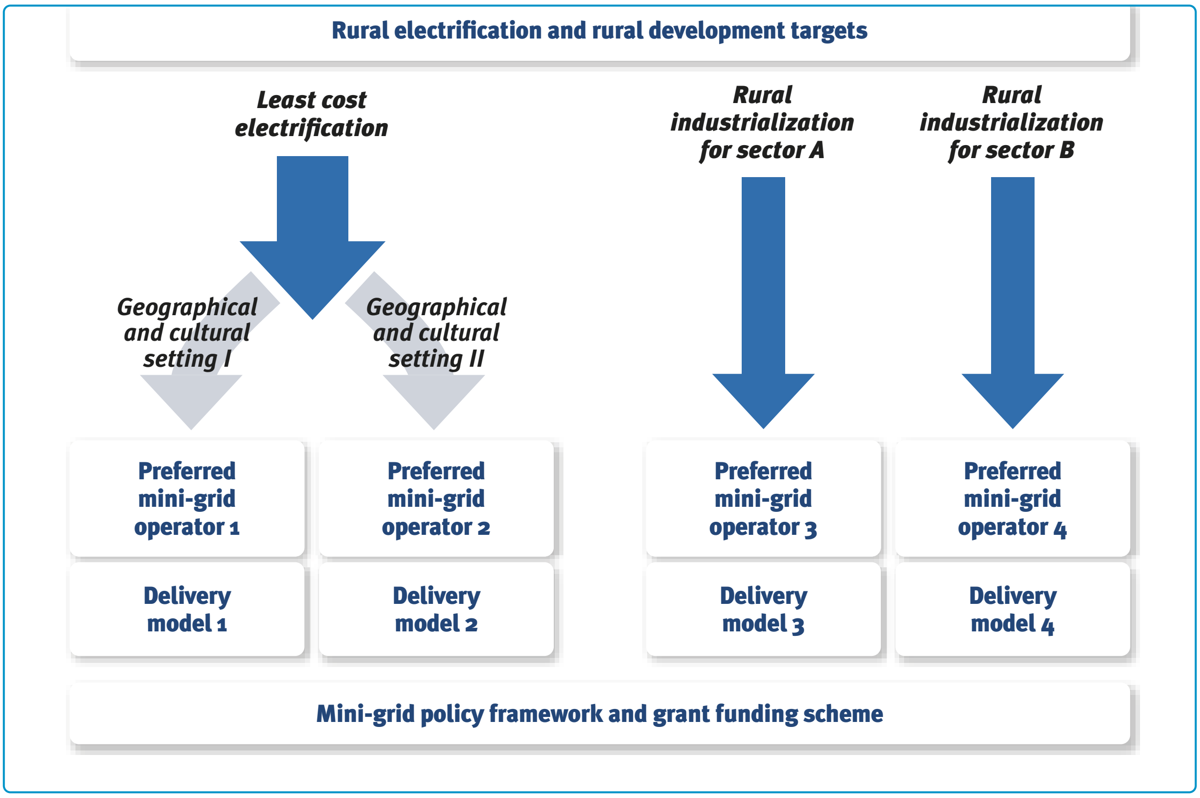


FIGURE 2. FROM RURAL ELECTRIFICATION AND DEVELOPMENT TARGETS TO POLICY FRAMEWORK AND GRANT FUNDING SCHEME. Source: INENSUS

A mini-grid delivery model is defined as the method by which mini-grids are rolled out (delivered). It answers the following questions: Who delivers and installs the mini-grid? Who pays for the mini-grid assets and by what means (grant vs. private investment or a mix of the two)? Who owns the assets and who is responsible for replacement or extension investments? Who operates the mini-grids and performs customer service?
The most popular and most scalable delivery models are considered to be the following:

- **EPC/utility** – A government or national utility contracts a private company to supply and install mini-grids. The national utility subsequently takes over the operation of the mini-grids.
- **ESCO – The government finances and owns the** mini-grid assets, which are installed and/or operated by a private company or cooperative. Tariffs charged to electricity customers (plus optional government operating expenditure (OPEX) grants) cover the private operator's costs of operation, including profit.
- **Split asset** – The distribution network is financed and owned by the government. The private sector or cooperative operator finances, builds and owns the generation assets and operates the entire mini-grid. In a slight variant of this model, the private sector receives a grant to partially finance the generation assets, which will be referred to as the "hybrid split asset/grant" model.
- **Private with capital expenditure (CAPEX) grant** – The private sector or cooperative mini-grid operator finances, installs, owns and operates the mini-grid assets and receives a CAPEX grant from the government.

In practical implementation, there are different versions of the above-listed delivery models, and combinations often occur. Community-driven models are not mentioned here, as they are not discussed in detail in this guide. For the sake of simplicity, cooperatives, which are managed like private companies, are listed below under the private sector models.

2.1.2 | DELIVERY MODELS – THE DEGREE OF PRIVATE SECTOR INVOLVEMENT

> The political decision-maker can decide either to support a pure least cost electrification approach or to use mini-grids purely as an instrument to achieve rural industrialization goals, or else to promote a combination of both approaches. Based on the decision outlined above, the preferred spectrum of mini-grid operators and associated business models may be determined.

As outlined in *Chapter 2.1.1*, all mini-grid delivery models involve the private sector, whether as a vendor and installer, as a partner in a public-private partnership (PPP) or in the fully private sector driven deployment of mini-grids. The involvement of the private sector in the selected mini-grid delivery model can increase the efficiency and quality of services and mobilize financial resources for mini-grid development. In general, the private sector is geared towards financial sustainability and profitability. In order to attract the private sector to mini-grids, it is therefore essential firstly to design an overall package for risk and return that is attractive to private companies. In this package, competition and regulation can be used to minimize cost, tariffs and required subsidy.

On the return side, the package may require private investment (equity and debt), provide capital grants and/or subsidies to finance the capital costs of building and operating mini-grids, while ensuring a tariff level that is both affordable for end users and financially viable for mini-grid operators. In order to maximize private sector investment and the rate of connections operational and investment risks need to be mitigated. This includes ensuring the long term stability of regulation and legislation, minimizing termination risk and ensuring that subsidies/grants are reflective of the demand profile of consumers, mitigating off-taker risk. A lower risk perception leads to lower return expectations and makes any competition and regulation more effective. See *Chapter 2.1.5* for further information on risk mitigation through policy design.

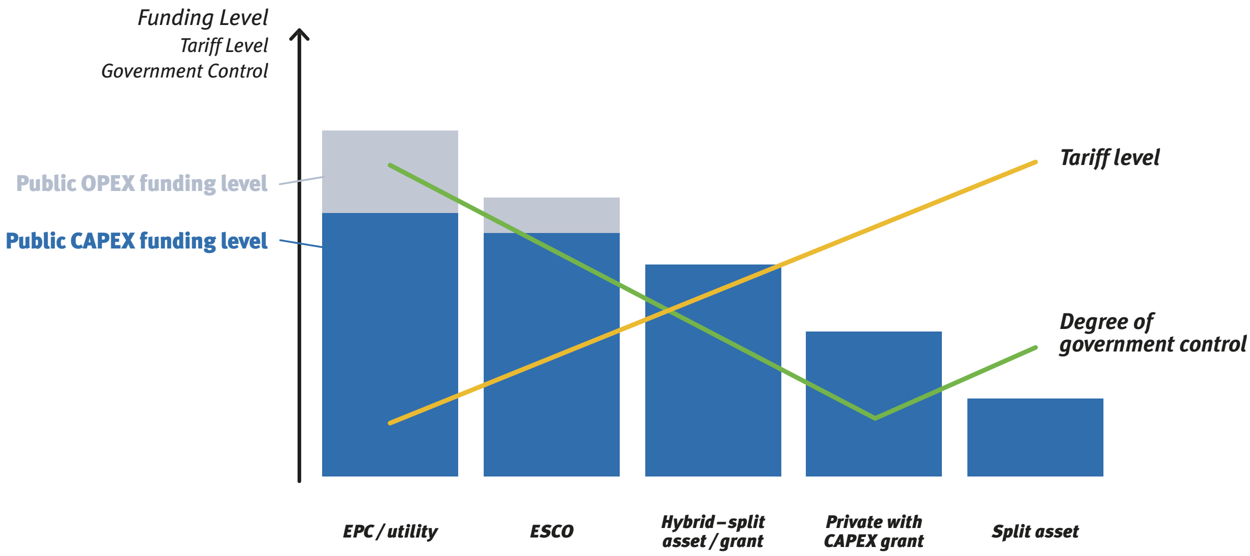
The identified mini-grid delivery models can be distinguished according to the following:

1. The degree of government control over key aspects of electricity supply, such as tariff levels vs. quality of service.
2. The operational and capital subsidies required for the successful implementation of these models.
3. The tariff levels to be charged to customers to make the respective delivery model financially viable.

The following figure describes the respective dependencies between public funding mechanisms for CAPEX and OPEX subsidies and the resulting tariff levels, based on the degree of government control as it would be either presumed or correspondingly required. Government contributions to the financing of mini-grids generally decrease as the private sector contribution increases. This applies to both CAPEX and OPEX. Higher CAPEX subsidies allow lower tariffs (see left side of *Figure 3*). Currently, OPEX is typically only subsidized in the EPC and ESCO model and only in rare cases in other models. As tariffs increase, the need for OPEX subsidies decreases. (see right side of *Figure 3*).

The total amount of government resources allocated to the development of mini-grids is also relatively consistent with the level of control that a government would (wish to) exert over the operation of the mini-grid. For delivery models with higher degrees of government control, the public sector needs to be prepared to invest more resources in mini-grids, including potential cross subsidization of electricity usage of rural customers if a national uniform tariff is to be charged.

FIGURE 3. DELIVERY MODELS IN DEPENDENCY OF FUNDING LEVEL, TARIFF LEVEL AND DEGREE OF GOVERNMENT CONTROL. Source: INENSUS



In the *Private Sector with CAPEX Grant model,* the government will need to subsidize a lower proportion of the initial CAPEX than, for instance, in the EPC or ESCO model, but the overall level of funding can vary greatly depending on site-specific factors such as the size of the power plant, village layout and density and the economic status and potential of the community. **It is noteworthy, however, that in any scenario, a fully privately-funded mini-grid is difficult, if not impossible, to achieve without subsidies due to the challenges of powering rural communities.** These challenges include, among others, challenging logistics to install assets on site as well as maintain remote O&M and comparatively low ability and willingness to pay by consumers. Private developers can improve the economic viability by implementing fourth generation mini-grids, but it remains to be seen whether these will improve project finances sufficiently to enable fully private sector-funded mini-grids at scale.

In contrast, the “cost-reflective plus” retail tariffs that private operators need to charge to enable a business case are inversely proportional to the level of public funding for these projects. These tariffs cover both the operators’ costs and a profit margin.

The selection of delivery models therefore depends on the availability of public funding for the roll out of mini-grid projects, the willingness of customers in rural areas to pay for electricity and the envisaged degree of government control over the operation of mini-grids.

> The political decision-maker can choose one of the delivery models or a combination of models, based on the envisaged extent of government control, the planned degree of government funding and the desired levels of retail tariffs.

2.1.3 | TARIFF METHODOLOGIES AS A BALANCE BETWEEN COSTS AND REVENUES

Retail tariffs in mini-grid projects are determined by the CAPEX and OPEX of a system, the subsidy level and regulation. As shown above, tariffs can be reduced with increasing public funding contributions to mini-grid projects (see *Chapter 2.1.2*). Larger mini-grids with a high customer density, the existence of anchor customers and interesting productive use and rural industrialization potential are generally able to sell electricity at lower prices thanks to economies of scale. This effect can also be achieved if mini-grid operators are enabled to operate large mini-grid clusters under a single management unit, so that tariffs can be reduced to affordable levels. In addition, legislative, regulatory and contractual arrangements have a significant influence on tariffs, and a number of targeted measures could contribute to a reduction in tariffs in this context (refer to *Chapter 2.1.5*).

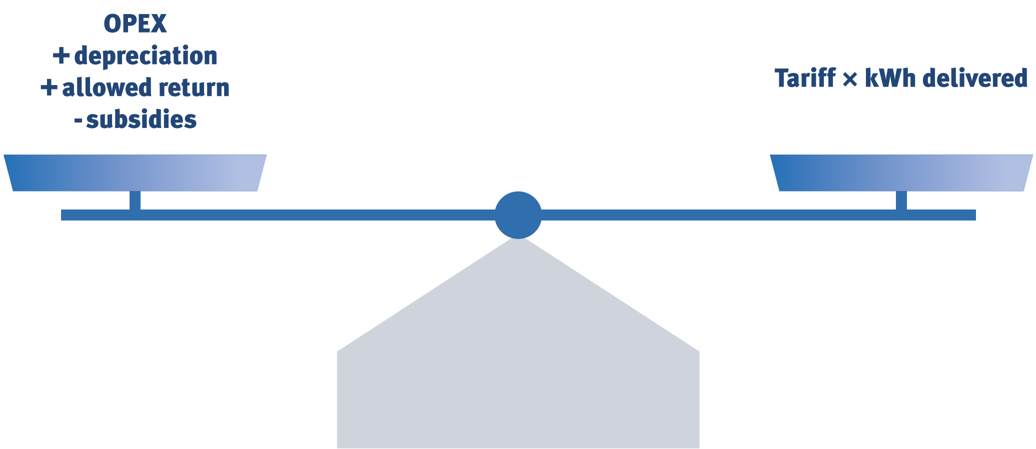
From the point of view of policymakers, the following aspects are therefore crucial levers for the design of electricity tariffs in mini-grid projects:

1. The provision of subsidies (the amount of the initial CAPEX and, if required, the OPEX of mini-grid operators that is covered by government subsidies).
2. The allocation of project sites to project developers and operators (how tendering procedures should be designed to allow clustering of sites and the selection of sites with potential for rural industrialization).

By making targeted use of these instruments, policymakers can steer the design of tariffs in the desired direction.

In contrast, tariff regulation cannot be considered and used as a policy instrument. Rather, the tariff calculation methodology applied should be understood as a scale that balances the costs and revenues in mini-grid power supply. In cost-reflective tariff methodologies, the tariff broadly equals the mini-grid's OPEX plus depreciation and allowable return of the assets minus any applied subsidies (see *Figure 4:* Tariff methodologies are a regulatory instrument that balances the costs and revenues of mini-grids. Source: INENSUS). Once calibrated, the scale should not be changed (e.g. by lowering tariffs without additional financial support to cover the costs), as this may lead to company losses that trigger a reduction in service or the bankruptcy of the companies and then the loss of consumer power.

FIGURE 4. TARIFF METHODOLOGIES ARE A REGULATORY INSTRUMENT THAT BALANCES THE COSTS AND REVENUES OF MINI-GRIDS. Source: INENSUS



Most rural households in previously unserved communities have a very constrained household income, which is usually insufficient for covering their basic electricity demand on a continuous basis. The available budget therefore determines the amount of energy consumed by the households, rather than the reverse. As a result, when tariffs are increased, the revenue of mini-grid operators from this type of domestic electricity consumption remains almost constant up to a saturation point, while the amount of electricity consumed changes.[5] Further research is required to determine the saturation points of basic electricity demand, which are likely to vary from region to region depending on climate and environmental conditions (e.g. demand for fan or no fan at night, demand for outdoor safety lights or no lights at night, etc.).

In contrast, for productive and rural industrial users, these budget constraints either do not exist or do so to a much lesser extent. They generally consume as much electricity as is needed to produce their goods or services as long as the electricity provided is cheaper, more reliable and more convenient than alternative power sources such as diesel motors.

Finally, from the perspective of policymakers, the above can be summarized as follows: the reduction in domestic retail tariffs primarily increases the demand for electricity, which in turn requires greater power generation and distribution capacities and, therefore, higher amounts of CAPEX subsidies.

Experience shows that high electricity tariffs lead to dissatisfaction on the customer side, especially when household customers are unable to cover their basic needs and when rural industrial customers are unable to compete with their products on regional or national markets. At the same time, customers appreciate the often high security of supply and high service quality in mini-grids. A tariff reduction, potentially a politically-motivated one, should not be enforced at the expense of lower supply security and lower service quality. Doing so could lead to an unsaturated basic demand and the dissatisfaction not only of low-income customers but of all customers within a community, on the one hand, and to income losses and thus reduced profitability of the operators, on the other.

When planning a large-scale deployment of mini-grids, political decision-makers ought to decide on the scale of this deployment and the location and quality of the sites reserved for it. A larger scale (a large number of mini-grids in large communities) with high rural industrialization potential leads to lower tariffs at constant subsidy levels, thanks to the good economic viability of the business models applied. On the other hand, governments run the risk of major political distortions if a large-scale deployment at very prominent locations fails to deliver the desired results.

Political decision-makers are often also opinion leaders in the tariff debate. Although, from a political point of view, national uniform tariffs in mini-grids can sometimes appear to be the easiest option, as they aim to create supposedly fair conditions for all citizens, very few delivery models actually meet this requirement. All delivery models involve high financial obligations on the part of the governments. Indeed, a governmental mini-grid deployment approach with tariffs well above the national uniform level, that covers the basic electricity demand of households based on their available household budgets and, at the same time, rapidly advances rural industrialization, may well be acceptable to rural populations.

Policymakers are advised not to influence the sensitive structure of a regulatory tariff methodology in such a way that they force lower tariffs on one side of the scale without keeping the balance by compensating for higher costs with additional subsidies on the other.

5 Test results supporting this conclusion can be found in Crossboundary, 2019.

2.1.4 | PUBLIC FUNDING PROGRAMMES FOR THE DEPLOYMENT OF MINI-GRIDS BASED ON PRIVATE OPERATOR MODELS

In most cases, public grants or subsidies are needed to put mini-grid projects on an economically sustainable footing. Public assistance may take the form of both direct fiscal support measures and complementary indirect incentives.

Direct fiscal support to mini-grids can be provided by a combination of the following mechanisms:

1. **Governments can make cash contributions to subsidize some or all of the initial investment.** The CAPEX grant can take various forms, including results-based financing (RBF) and performance-based grants (PBG). RBF or PBG can be paid out to mini-grid firms on the basis of verified customer connections. This requires the project developers to pre-finance all of the capital, including the grant, which often presents a cash flow challenge to smaller mini-grid companies, in particular domestic ones. With other types of grants, a certain portion of the cash flow is provided in advance against a bank guarantee and/or upon achievement of small milestones, which reduces the need for pre-financing, but increases the administrative burden and also, potentially, the implementation time.

2. **The amount of grant to be paid can either be a percentage of the total eligible costs,** which is usually equal to the initial CAPEX plus project development costs, or a certain amount per connection (as in RBF/PBG programmes, for instance). It can also be subject to a bidding process, as in the minimum subsidy tender (MST). Under the latter, the bidder with the lowest grant requirement for the electrification of a certain number of customers in a specific mini-grid with a specific tariff and certain technical and service quality requirements receives the subsidy and the exclusive right to electrify the sites. The MST process could also be structured as a reverse auction.[6]

   As an alternative to cash subsidies, governments sometimes grant free access to assets, especially to government-owned distribution networks. This can be done by the government making the assets available to a private mini-grid operator through free usage rights or a low cost lease.

   Governments can provide regular subsidies to the operating costs of a mini-grid if the set tariff is too low to generate revenues that cover the operator's costs (OPEX plus profits). These measures are usually applied after all options of CAPEX subsidies have been fully exploited, as CAPEX subsidies can usually be disbursed at a lower transaction cost than OPEX subsidies. To provide OPEX subsidies, governments need to create an independent rural electrification fund that is sustainably financed at minimum for the duration of a mini-grid project cycle (20 to 25 years) and has sufficient capacity to perform the clearing process. Additionally, a development bank can provide a payment guarantee to gain the confidence of private investors in the long-term payment of OPEX subsidies. In African countries, there is however limited experience with OPEX subsidies in the mini-grid sector to date.

3. Another way of supporting mini-grids financially with a one-off commitment are **partial risk guarantees,** under which central banks, for instance, provide a first loss coverage guarantee to commercial banks financing mini-grids. This reduces collateral requirements and interest rates.

4. Governments can stimulate market development by helping to increase the demand for electricity by **promoting appliances for productive use or facilities needed for rural industrialization processes.** Fostering productive use of electricity improves economies of scale and thus the economic viability of mini-grids. Supporting rural industrialization activities in addition to the above-mentioned measures gives the mini-grid

6 For further details on this process, please refer to section 3.1.1.

companies access to a second source of revenue and can thus increase the profitability of the mini-grid business.

5. For instances in which the developer is struggling to meet a community's particularly high demand for electricity, the government may consider the **distribution of energy-efficient appliances** (e.g. light bulbs) or other measures promoting energy efficiency, to avoid shortages of electricity supply.

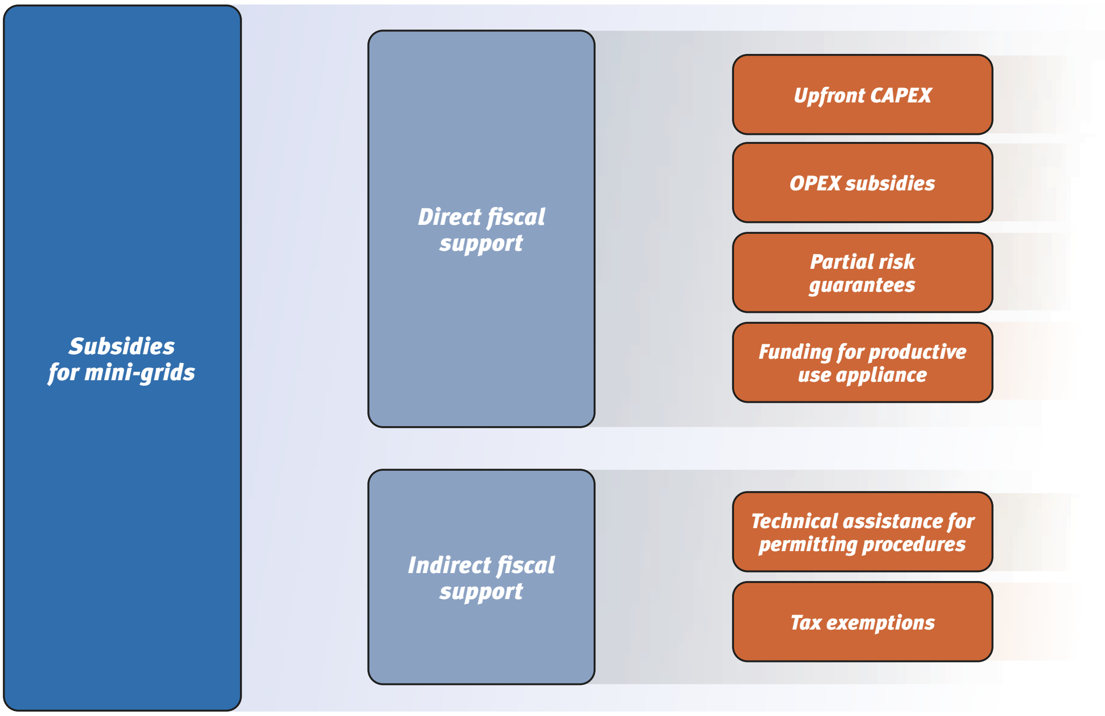
In addition to direct financial contributions, there are several indirect ways to provide government support to mini-grid projects.

Firstly, funding can be awarded to an entity that provides **technical assistance** to mini-grid developers. Private mini-grid firms report that technical assistance provides effective support, especially where it aims to simplify administrative processes between the governments and the private sector, rather than in actual site or electricity demand surveys, or similar.

Secondly, governments can grant exemptions from taxes and duties, including import taxes and duties, tax holidays for profit taxes, etc. For areas in which rural industrialisation is to be encouraged, an accelerated depreciation of mini-grid assets may be introduced to motivate already profitable domestic players active in the agro-industry to implement mini-grids and processing infrastructure in the rural communities located in their respective supply or catchment areas. The initial tax burden of these players would thus be reduced, stimulating rural industrialization, creating jobs and power supply infrastructure. However, without a strong and profitable core business of a domestic company, accelerated depreciation of mini-grid assets is likely not to yield any effects, considering that an investment in mini-grid projects as such does not usually generate any profits within the first years of operation. The same applies to tax holidays for mini-grid profits within the first years of operation. Both instruments can, however, be good incentives to promote rural industrialization approaches based on mini-grids, which may deliver early returns.

Figure 5 illustrates the different types of fiscal support that governments can provide to PPP mini-grid delivery models.

FIGURE 5. THE MAIN TYPES OF GOVERNMENT SUPPORT MECHANISMS FOR MINI-GRID DEPLOYMENT.
Source: INENSUS



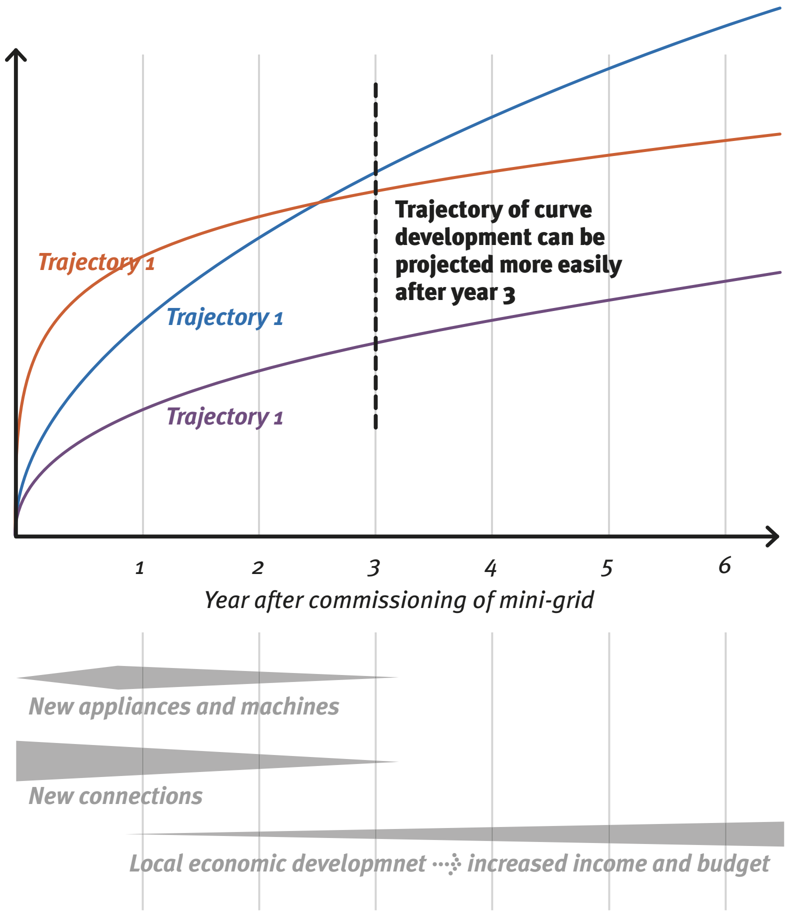
2.1.5 | SUSTAINABILITY OF MINI-GRIDS – MITIGATING RISK THROUGH POLICY DESIGN

The returns must outweigh the risks if private or public operators are to operate mini-grids sustainably. With regard to the degree of government influence and the level of risk for mini-grid operators, two risks, in particular, stand out, namely demand risk and termination risk.

Demand risk: Demand for electricity in mini-grids typically increases over time due to three factors: 1) new customer connections, usually within the first two years of operation, 2) a growing number of appliances and machines per customer up to a saturation point, usually within the first three years of operation and 3) improved local economic conditions, resulting in rising income levels and increasing budgets for electricity expenditure. As a result of these three factors, electricity demand typically increases in the form of a root function curve[7].

The generation and distribution systems in a mini-grid are optimized to meet a certain estimated electricity demand at minimum cost. If the demand deviates from this estimate, either the costs increase or the operation becomes technically unfeasible. Until now, no survey methodology has been able to project accurately the electricity demand with all its social and socio-economic influencing factors over several years. The demand risk is the risk that demand for electricity in a mini-grid does not correspond to the forecast level. Levels of electricity demand that are both too high and too low can be dangerous for the financial sustainability of a mini-grid. If demand is significantly higher than projected, demand cannot be saturated until the developer has invested in additional generation assets, which reduces satisfaction among customers, as well as their willingness to pay. In cases where demand is too low, break-even may never be achieved. *Figure 7* depicts the areas in which a mini-grid can be profitable. Demands that are beyond these boundaries might make the mini-grid project financially unviable, possibly leading to a sudden stop in power supply to the rural community with potentially devastating effects on the local economy. Demand side management strategies such as load shifting and valley filling exist, which the developer can exploit to a certain degree to address customer demand.[8]

FIGURE 6: Electricity demand development following root function shaped curves. Which trajectory the development takes can only be projected with high certainty after 3 years.



7 This curve, which takes the form of a root function, contradicts most financial models and policies, which, until a few years ago, erroneously assumed unlimited exponential growth based on a constant percentage increase in demand.
8 For further reading on demand side management activities, please refer to Green Mini-Grid Help Desk (2019): Demand Side Management for Mini-Grids.

However, policy makers are encouraged to help mini-grid operators mitigate these risks.

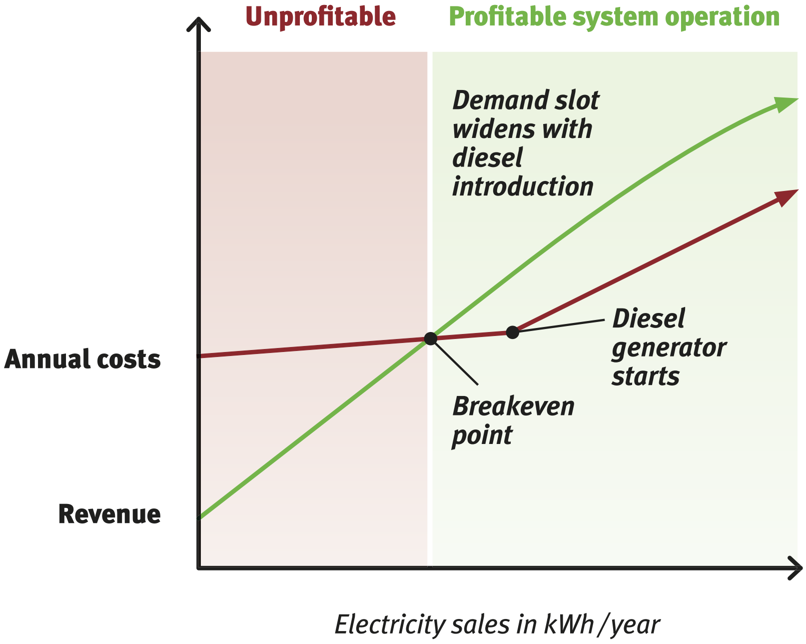
The following policy measures can assist in mitigating demand risks:

1. Enabling a phased mini-grid implementation. Approximately three years after the start of operation, the trajectory of demand development can be projected quite accurately. At this point, mini-grid operators should be able to adjust the system sizing with the same level of subsidization as in the first phase of system implementation.
2. Opportunities to adjust productive/commercial use tariffs and tariffs for high-income households, when the demand development trajectory becomes apparent, may reduce the demand risk to a certain extent.
3. Allowing a small percentage of generation technologies which can be activated on demand in systems that are otherwise designed for the highest possible renewable fraction.
4. OPEX subsidies may be considered.

Delivery models require appropriate financial support measures for the initial investment or operating costs, potentially supplemented by tax exemptions, as outlined in *Chapter 2.1.2*. In addition, governments can accelerate the implementation of mini-grid projects with technical assistance measures and promote the development of rural areas by fostering productive use and rural industrialization based on appropriate policy decisions.

Termination risk: The connection of the national grid to the mini-grid without adequate compensation to the mini-grid operator or a fixed end date to a concession or licence contract poses a termination risk to the mini-grid operator. In some cases, the demand for electricity in a mini-grid develops steadily but very slowly. For example, it may take a significantly longer time for all customers to be connected than initially anticipated, or the local economy requires much more time than expected to develop. In this case, the developer will aim to make the mini-grid sustainable through tariff adjustments and other demand stimulating measures as previously discussed. Once all measures have been exhausted, investors, financiers and operators, whether private or public, may however not allow for the extended time required to break even, also posing a termination risk for the mini-grid developer.

FIGURE 7: DEMAND RISK: Break-even of mini-grid projects depends on electricity demand. Demand that is too high or too low endangers the financial sustainability of mini-grids.



Governments can mitigate the termination risk by applying the following measures:

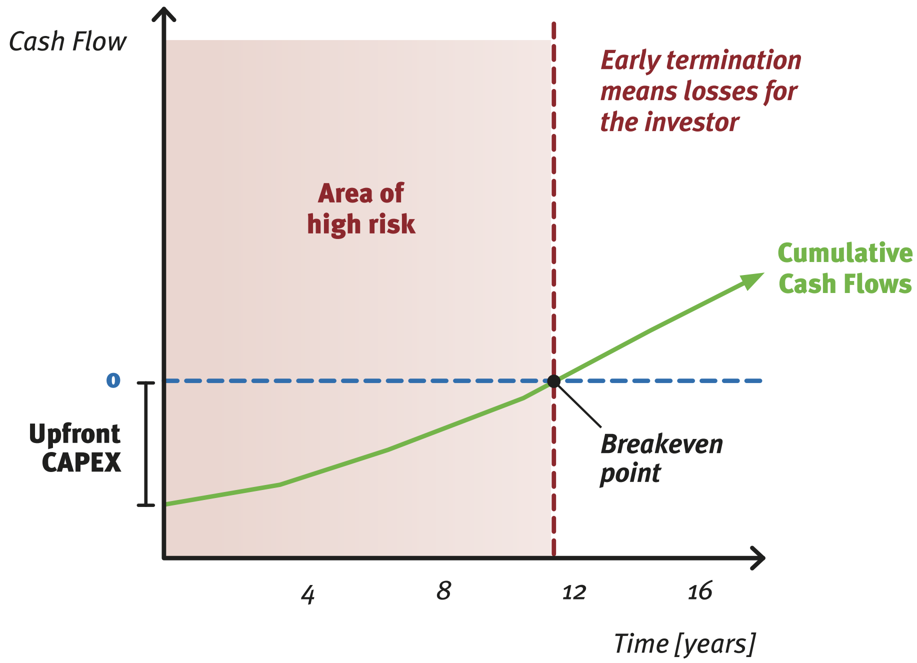
1. Integrating a clear methodology for calculating the compensation to be paid to the owner of the mini-grid in the event of connection to the national grid. This compensation must take into account the value of the assets and the business value created by the mini-grid operator. Other options, such as the mini-grid operator becoming a small power producer or small power distributor, ought to be firmly and clearly anchored in regulation.
2. Any lease contract, concession agreement, licence or permit should be either open-ended or include clauses for simple renewal/prolongation.

Governments generally lose some degree of control over mini-grids by reducing the termination and demand risks for the operator (especially if the operator is a private company or a cooperative). On the other hand, governments often save on the provision of subsidies by making the necessary contractual changes to mitigate termination and demand risks. A lower risk perception reduces the required return on investment of the private sector, resulting in lower subsidy requirements to achieve the desired tariffs.

Templates for contracts and other legal documents as linked in *Chapter 3* already take the above mentioned recommendations into account.

The policymaker may decide to go a step further in legislation, regulation and contract design by willingly reducing the government's influence on the mini-grid in order to mitigate the demand risk and the termination risk. In the end, this will also reduce retail tariffs or the need for subsidies. On the other hand, the policymaker may accept higher tariffs or higher subsidy requirements to keep the government's influence on mini-grids at a high level.

FIGURE 8: **TERMINATION RISK: If electricity demand develops slower than expected, contracts with fixed end dates or main-grid connection to the mini-grid without compensation may lead to a termination of the mini-grid project before break-even.**



2.2 | DECISION-MAKING PROCESS AND POLICY DEVELOPMENT

Policy development is a process that starts with the definition of objectives, as in national electrification or rural industrialization strategies, for instance. Thereafter, a ministry is often mandated to implement the policy and convert it into legislative proposals, which, once adopted, set the framework for the sector. Finally, government authorities and agencies are provided with a budget on the basis of this legislation and requested to implement all necessary regulations and procedures for the deployment of mini-grids, in close collaboration with higher levels of government.

FIGURE 9: SEQUENCE OF IMPLEMENTING POLICIES AND REGULATIONS

Over many iteration cycles, the political framework conditions are shaped at the various government levels. In all of these steps and cycles, the macroeconomic objective should always be considered.

Given the high correlation between electricity and economic development, electricity supply is the backbone of any economy. Without electricity, there can be no modern water supply and sanitation, while health care and education lag behind that of cities and more developed economies. The implementation of mini-grids offers a unique opportunity to directly impact rural areas at the macroeconomic level. By increasing productivity, employment and entrepreneurship opportunities in rural communities, rural-urban migration can be reduced, rural development goals can be achieved and other benefits, such as additional tax income, can be realized. Opening up the rural electricity sector can further increase foreign direct investment. At the microeconomic level, together with further development of local infrastructure (water, sanitation, education, etc.) and provided that electricity is used effectively, local economic growth can be successfully promoted.

In order to ensure a cost-efficient mini-grid roll-out, governments are therefore advised to take these macroeconomic effects into account from the outset of planning. If deployed properly, mini-grids can be a tool for accelerating rural economic inclusion, rural and cross-sectoral development and can consequently lead to nationwide development. However, the decision-making process for planning of mini-grids is iterative and composed of complex layers for which decisions require to be made prior to selecting a suitable mini-grid delivery model (see *Figures 10 and 12*).

FIGURE 10: LOGIC TREE DEPICTING THE DECISION-MAKING PROCESS LEADING FROM THE DETERMINATION OF UNIVERSAL ELECTRICITY ACCESS TARGETS TO A DECISION ON MINI-GRID DELIVERY MODE

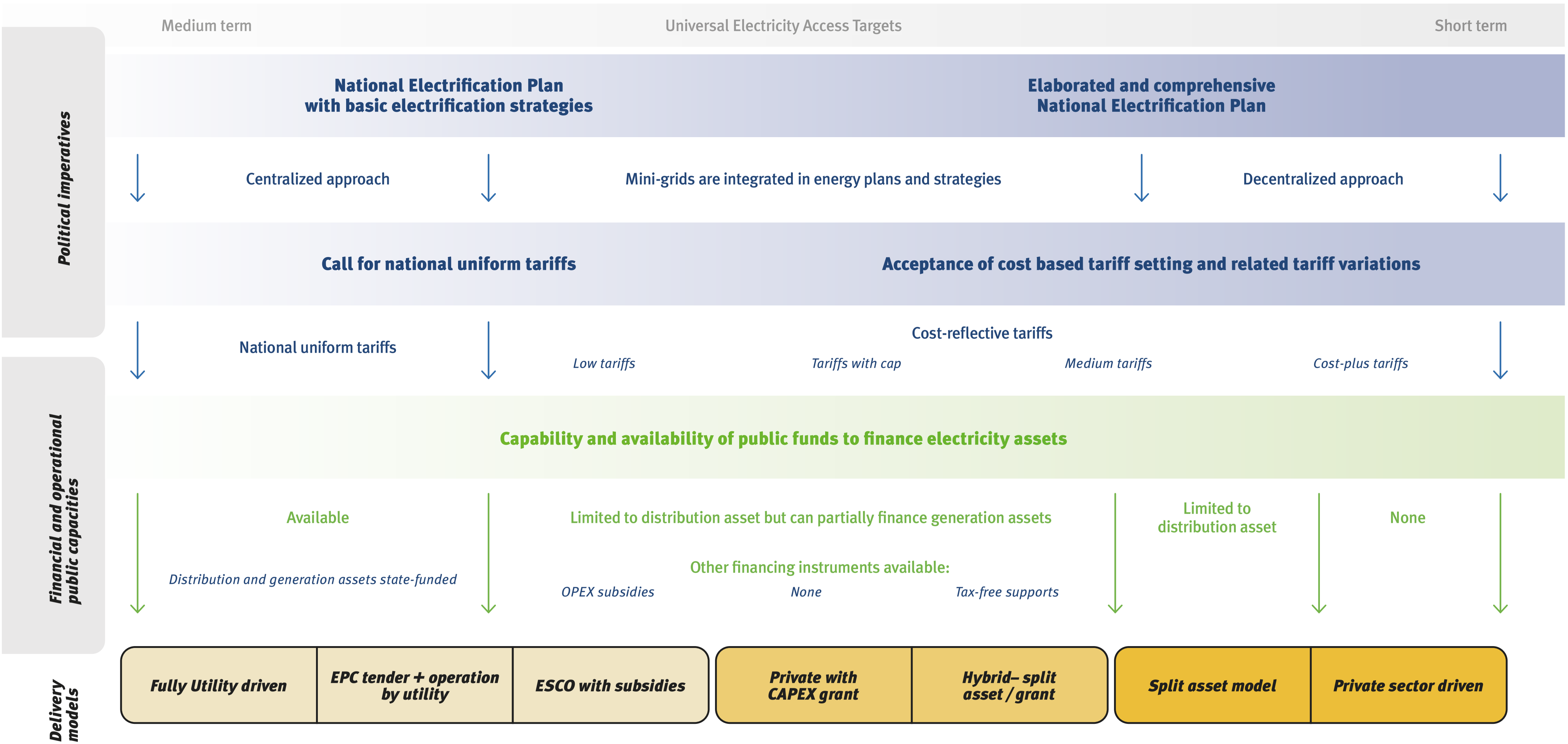
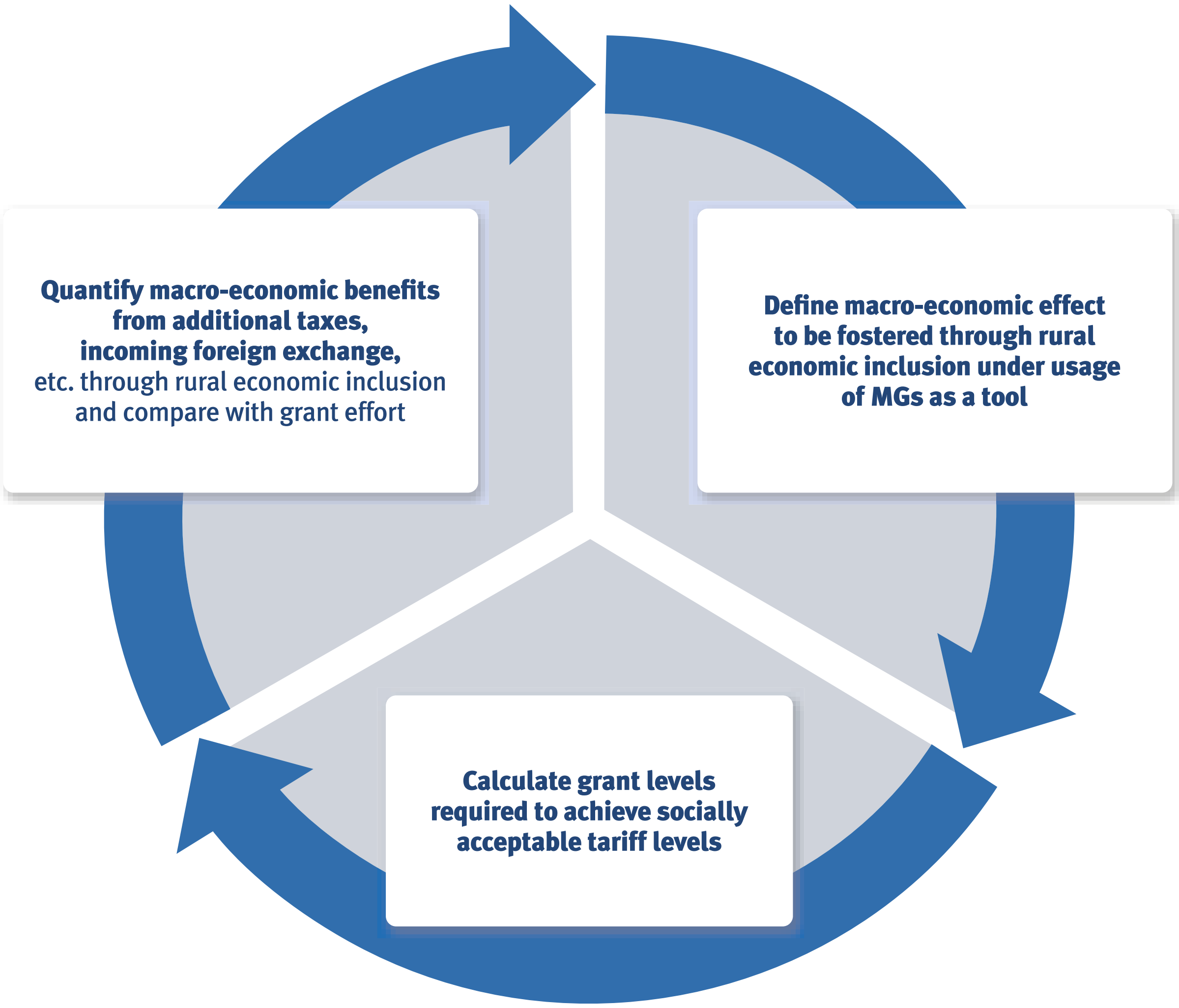


FIGURE 11: ITERATION CYCLE FOR PLANNING OF RURAL ECONOMIC INCLUSION USING MINI-GRIDS



2.3 | THE DECISION TREE

While the above chapters have introduced cross-cutting aspects that need to be decided upon individually, the following subchapter brings all these decisions into a single structure. The Decision Tree provides a tool that helps governments to ask the appropriate guiding questions, ultimately leading to the selection of the right delivery model for their respective country, including contractual agreements, tariff levels and types of subsidies. Each internal node represents a decision that needs to be made and each terminal node presents an outcome in the form of a mini-grid delivery model.

The guiding questions posed here may, in reality, be much more complex to answer than a binary "yes" or "no". Therefore, although the Decision Tree is useful for organizing parameters and trade-offs of different decisions, it does not exhaust the range of possibilities that determine choices of mini-grid delivery models in a given country. Nor does the Decision Tree prescribe the order in which decisions are to be made. It rather indicates which decision will lead to which consequences. It shall therefore not prevent the reader from considering other strategic aspects in order to reach a conclusion about the delivery model.

2.3.1 | DECISION TREE QUESTIONS EXPLAINED

Does the government aim to rapidly industrialize its rural sector and/or achieve SDG 7?

The provision of universal electricity access by 2030 in remote and rural areas of emerging markets with mainly renewable energy (SDG 7) stimulates local industrialization and agricultural production, as well as commercial and social services such as health care and education. In many cases, mini-grids are the fastest and cheapest option for bringing reliable electricity powerful enough to drive electric machines into rural areas.

Does the government have a national electrification planning strategy with mini-grid development?

When a government decides to promote rural electrification, policymakers tend firstly to engage in national electrification planning to identify the most cost-effective technology for populations of given locations and sizes, also taking into account the potential economic impact of mini-grids on rural industrialization. Specifically, this results in determining whether certain rural areas will be electrified through grid extension, mini-grids or solar home systems.

Does the government have the financial capacity to cover distribution assets for planned mini-grid roll-outs?

Access to financial resources and the capacity to manage them adequately are important factors influencing the selection of mini-grid delivery models. When assessing whether a government has the financial capacity (or sufficient donor support) to provide funding for mini-grid programmes, two distinct paths emerge: either a fully privately-driven mini-grid delivery model or a wide range of delivery models, ranging from fully publicly-driven to split asset models.

As described in *Chapter 2.1.2*, existing examples of a fully private sector-driven model without CAPEX grants are extremely rare. In view of the high risks involved in developing mini-grids, a 100 percent privately-funded investment is not economically viable in almost all scenarios. Where governments cannot pay for distribution assets and mini-grid developers are unable to charge viable tariffs, **no mini-grid projects, either public or private, are possible.**

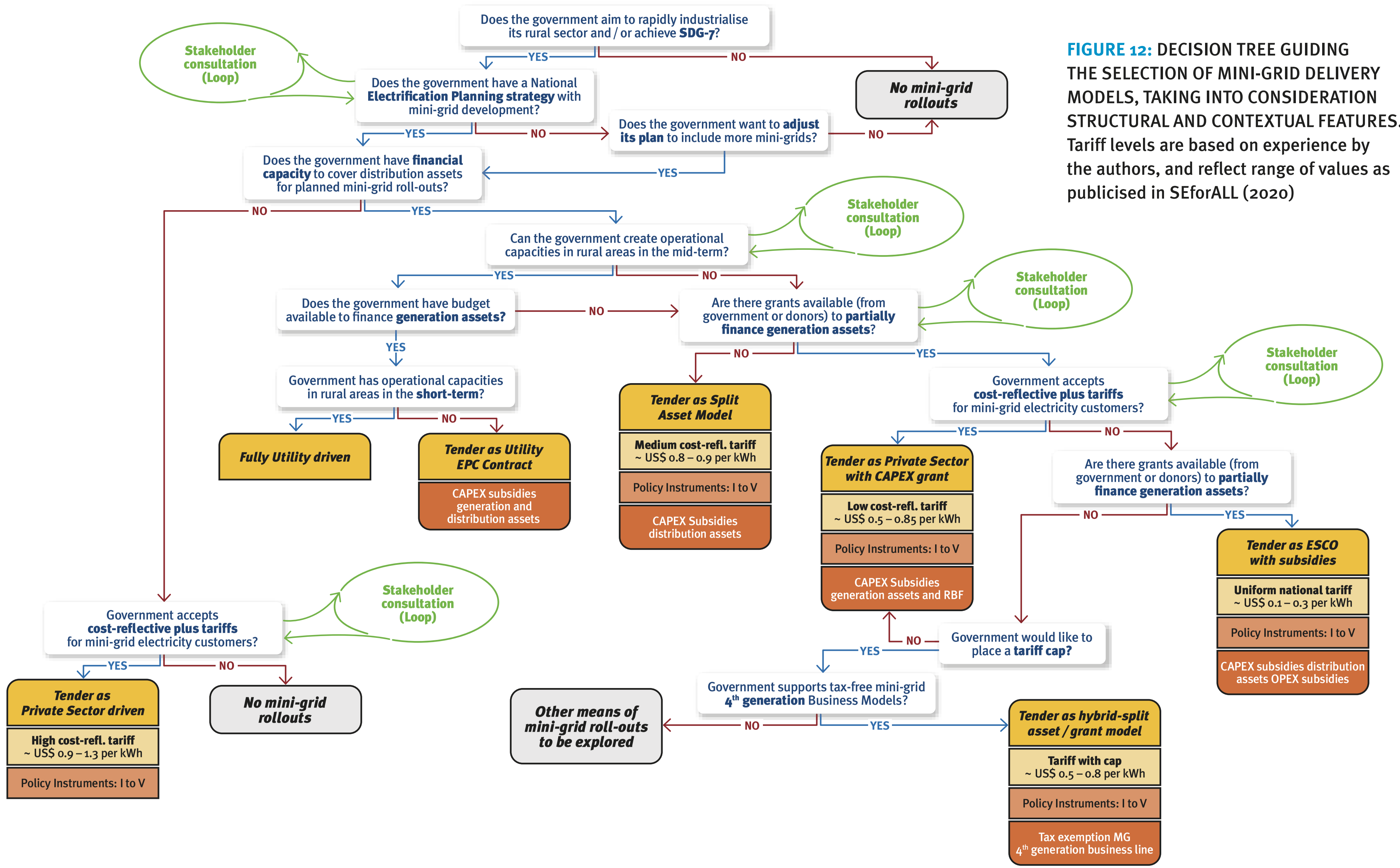


FIGURE 12: DECISION TREE GUIDING THE SELECTION OF MINI-GRID DELIVERY MODELS, TAKING INTO CONSIDERATION STRUCTURAL AND CONTEXTUAL FEATURES. Tariff levels are based on experience by the authors, and reflect range of values as publicised in SEforALL (2020)

Policy Instruments:
I: tariffs, **II:** interconnection, **III:** licencing and technical standards, **IV:** environmental permitting, **V:** land rights and building permits

Can the government create operational capacities in rural areas in the medium term?

The responsibility for mini-grid operation requires a constant connection to the mini-grid sites (e.g. by remote data retrieval and telephone communication), a regular presence on site and the provision of technical staff, tools and spare parts to be deployed on site at any time. If the government is capable of providing these capacities for every mini-grid in its portfolio, the answer to this question is "yes", otherwise it is "no".

Are there grants available (from government or donors) to partially finance generation assets?

In cases in which distribution assets can be partially financed by the government, the degree of public subsidy to cover generation assets, together with the operational capacity of the public utility, determines the extent of private participation in the rural electrification effort. **If the government is able to fully finance, procure and build the generation and distribution assets, has the financial operational capacity and the necessary knowledge and experience with clean mini-grids, rural electrification will be *fully driven by the public utility.*** As with the fully privately-driven delivery model, this case is very rare, given that public utilities generally do not have the capacities to undertake all engineering, procurement and construction activities for mini-grid projects. **In cases in which the government is able to fully finance all assets but has limited operational capacity, the public utility will be driving rural electrification with the help of the *private sector through EPC contracts.*** Outsourcing the design and construction to private companies specializing in mini-grid infrastructure will accelerate rural electrification efforts.

Government can provide an OPEX subsidy to cover the gap between uniform and cost-reflective tariffs?

In a situation in which political imperatives expect the introduction of uniform tariffs (or where a cap on tariffs is envisaged), the public sector ought to be willing to provide OPEX subsidies and, potentially, other financial instruments such as tax exemptions. Otherwise, there will be no viable mini-grid business models as a result. In the ***ESCO with subsidies model,*** mini-grids receive subsidies to cover operational expenses: the public sector needs to bridge the gap between cost recovery and uniform tariffs.

Government would like to place a tariff cap?

A tariff cap is an upper limit set by the government, which the tariff charged by the mini-grid operator must not exceed. In cases in which the delivery model is not viable with tariffs below the tariff cap, additional subsidies (usually OPEX subsidies) ought to be provided and/or specific tax exemptions granted to facilitate cross-subsidization between business units (see below). Alternatively, the mini-grid is not implemented.

Government supports tax-free mini-grid fourth generation business models?

In a situation in which the government puts a cap on tariffs, business models for fourth generation mini-grids offer an opportunity that may be seized. Under the ***hybrid split asset/grant model,*** revenues from complementary activities based on fourth generation mini-grids may overcome the absence of OPEX subsidies and allow mini-grids to be successfully deployed thanks to improved economics.

2.4 | KEY TAKEAWAYS

- Today, based on geospatial planning approaches, mini-grids are not only deployed as a least cost electrification solution, but also where the rapid implementation of a reliable power supply system is required to drive rural industrialization using fourth generation mini-grid models.

- In all of the delivery models evaluated, private sector/cooperatives play a role, either as technology suppliers and installers, as operators and/or as investors. Governments are therefore advised to clearly define the role of the private sector/cooperatives in their preferred delivery model.

- The long-term sustainability of mini-grids is in the interests of both the operator and the government (if the government is not the operator). Sustainability in mini-grids means technically sound and reliable operation, high-quality customer service and financial profitability. Without the latter, the other two sustainability criteria cannot be achieved.

- When designing the policy framework for a mini-grid deployment, policymakers will need to make a number of decisions regarding a) the envisaged degree of government control they wish to have over the mini-grid's assets and operation, b) the financial contribution that the government is willing to provide and c) the tariff level that the government is ready to justify to rural electricity customers. All three objectives – maximum government control, minimum government financial contribution and lowest end customer tariff – cannot be achieved at the same time. Different delivery models allow for specific combinations and degrees of achievement of the different objectives.

- The allocation of large villages/towns in large clusters of sites (economies of scale) for mini-grid electrification under one managing entity, together with high rural industrialization potential at these sites, provides an opportunity to achieve lower tariffs, together with lower subsidy provision and higher government control.

- Taking the demand risk and the termination risk into account in legislation, regulation and PPP contracts can reduce government control over mini-grid assets to some extent, while at the same time reducing tariffs and/or subsidy requirements thanks to a higher degree of security for the operator and, possibly, the investor, with correspondingly lower expected risk premiums.

3. ACCELERATING ELECTRIFICATION

THROUGH MODERN MINI-GRID REGULATIONS, PROCUREMENT AND CONTRACTUAL ARRANGEMENTS

Once a decision for a delivery model has been taken and integrated into the national electrification policy and strategy, related regulatory documents and tools, as well as procurement and PPP contract documents, must be prepared. For mini-grid delivery models to be sustainable in the long term, a fair and reliable regulatory and contractual relationship between the stakeholders must be established, which also mitigates the main operational risks.

This chapter summarizes the issues that need to be taken into account when translating the specific requirements of the individual stakeholders for the selected delivery model into procurement approaches, tariff determination and licensing procedures. These theoretical considerations should be seen in conjunction with their practical counterparts in the form of regulation and contract templates, which are referred to and interlinked in this chapter. The templates already incorporate all of the recommendations contained in this guide.

The mini-grid sector as a whole is moving towards fast deployment at scale. In general, therefore, any process, document and tool must be ready for large-scale deployment of mini-grids. For each of the three policy instruments discussed here – procurement, tariff determination and licensing procedures – design elements that cater for the respective scaling requirement will be introduced.

The "Decision Tree" in *Figure 12* assigns documents and tools to delivery models, while *Figure 13* depicts this assignment with further clarity. Many of the tools and documents mentioned here are also covered by the templates prepared.

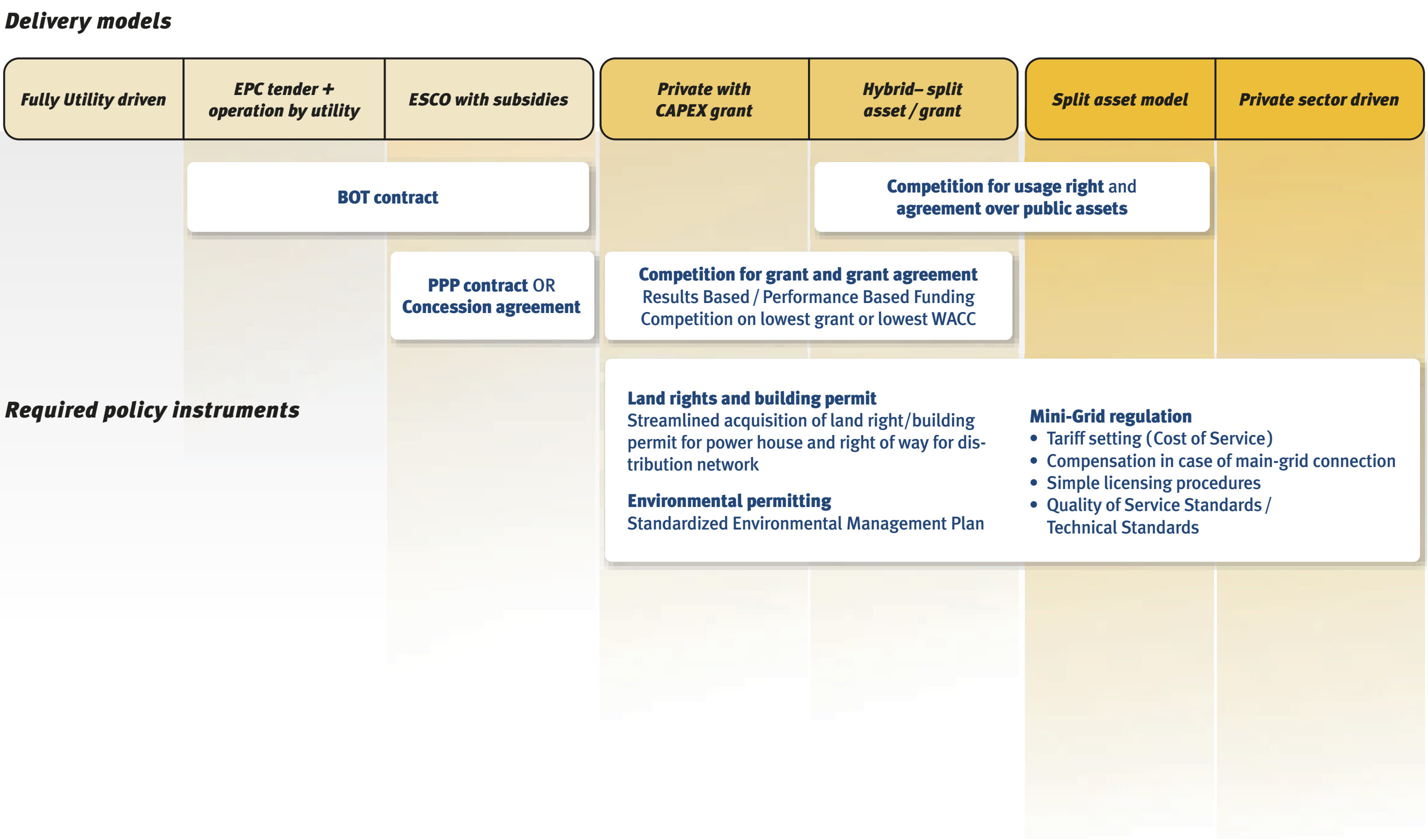
Each of the various policy instruments introduced in this chapter are applicable to a range of delivery models. The colour code as indicated at the bottom of each page is used to display which policy instrument is applicable to which mini-grid delivery model.

A	for EPC tender + operation by utility	D	for ESCO with tariff-based contract
B	for ESCO with service contract	E	for hybrid – split-asset/grant
C	for split asset model	F	for private with CAPEX grant

TABLE 1. LIST OF MINI-GRID REGULATION AND CONTRACTUAL TEMPLATES

https://greenminigrid.afdb.org/afdb-mini-grid-training-and-templates	Template available	
	Yes	No
EPC/BOT contract with option for BOOT	✓	
Competition for usage right agreement and agreement over public assets		✗
Concession agreement	✓	
RBF Grant Agreement	✓	
Land rights and building permits		✗
Environmental and Social Management	✓	
Mini-grid regulations, incl. licensing and tariffs	✓	

FIGURE 13. MINI-GRID POLICY INSTRUMENTS BASED ON DELIVERY MODELS



3.1 | PROCUREMENT, TENDERS AND GRANT ALLOCATION

Applicable for:

A	B	C	D	E	F

All delivery models have interfaces with the private sector, whether as a vendor and installer of assets, as a service provider or as an operator. Wherever the private sector and the public sector collaborate, some form of procurement procedures apply in order to guarantee a level playing field for all market participants. Four competitive procedures (lowest service charge, lowest tariff, lowest weighted average cost of capital (WACC) and lowest grant) and one first-come-first-served procedure (fixed grant per connection, also known as RBF or PBG) are introduced below. Idea competitions, in which the private sector can test new approaches in pilots, are not applicable to large-scale mini-grid roll-outs and are therefore not considered further here. *Table 2* indicates which procurement procedures are applicable under which delivery models.

A tender on **lowest service charge** is a well-known and widely used procedure, usually awarded to the technically compliant bidder who offers the lowest price, or using a rating and weighting procedure between technical quality and price to determine the winning bidder. This works best in sectors that are more mature with costs that are more stable, considering that particularly in new markets only a portion of the costs can be accurately predicted.

Tenders on **lowest tariff,** as practised in large-scale grid-connected solar or wind, are challenging in the context of mini-grids. In grid-connected solar and wind projects, all of the electricity generated can actually be sold. This is not the case in mini-grids, where supply must always exceed demand to ensure a satisfactory quality of supply. As the electricity demand of customers can only be projected with low accuracy and develops over time, the revenue of a mini-grid operator can only be projected with very low accuracy (demand risk). Productive and commercial use tariff adjustments over time are one of the mitigation instruments for demand risk (refer to *Chapter 2.1.5*). Thus, the long-term determination of the tariff in the bidding process can become a

TABLE 2: OVERVIEW OF PROCUREMENT PROCEDURES APPLICABLE IN VARIOUS DELIVERY MODELS

Tender on:	Applicable for					
Lowest service charge	**A**	**B**	C	D	E	F
Lowest tariff	A	B	**C**	**D**	**E**	F
Lowest WACC	A	B	C	**D**	**E**	F
Lowest grant	A	B	C	D	**E**	**F**
Fixed grant per connection	A	B	C	D	**E**	**F**

A	for EPC tender + operation by utility	D	for ESCO with tariff-based contract
B	for ESCO with service contract	E	for hybrid – split-asset/grant
C	for split asset model	F	for private with CAPEX grant

highly risky undertaking, unless tariff adjustment mechanisms applied during operation are considered in the tariff bidding approach. The government of Uganda is testing this approach in cooperation with the German Corporation for International Cooperation (GIZ).

Tendering mini-grids on **lowest WACC** is an alternative to the tender on lowest tariff, which leaves room to adjust the productive use and commercial use tariffs at a later stage. The WACC is the parameter in tariff regulation that determines the return of investors and financiers on their capital contributions. A high WACC indicates that a company spends a proportionally large amount of money on raising capital. The investment is therefore considered to be rather risky by the financiers and investors. A low WACC, in contrast, indicates that the respective company raises capital at comparatively low cost, resulting in lower tariffs or a lower grant requirement. Consequently, in a tendering procedure, the private developer with the lowest WACC would be awarded the grant. The advantage of tendering a project on the lowest WACC compared to the lowest tariffs is that the electricity tariff can be adjusted by the regulator at a later stage of the project, with changing economic conditions impacting the project's viability, while this is not possible in the case of bidding on the lowest tariff. There is not yet a real life example to illustrate this approach.

The tender on **lowest grant** approach is also widely used and is known as the Minimum Subsidy Tender. The government determines a starting tariff as an objective to be achieved together with a set of minimum technical requirements and minimum quality of service requirements. The grant is awarded to the bidder with the lowest grant requirement. Similar challenges as for the tender for lowest tariff could apply here, but may be mitigated by tariff adjustment under certain conditions. A Minimum Subsidy Tender is currently being implemented by the Rural Electrification Agency (REA) of Nigeria.

The **fixed grant per connection** approach, also known as RBF or PBG, works as the name indicates. The government pays any pre-qualified mini-grid operator a fixed amount per electricity connection confirmed by an independent entity, until the budget of the respective fund is depleted. While this approach leads to fast mini-grid deployment, it often results in the most underprivileged or less attractive communities being electrified last. It is also important that developers are not simply incentivised to connect as many customers in as little time as possible to receive the grants, with little regard for the long-term quality of supply. In many cases, fixed grant per connection approaches are combined with additional financial support for productive use of electricity and rural industrialization. The countries in which this approach is being implemented are Tanzania and Nigeria.

The list of procurement procedures above is not exhaustive. Hybrid versions of the approaches introduced above are often applied. Creative new approaches may be developed as long as these respect the following criteria:

1. do not limit the creativity and implementation of innovative ideas of private companies by imposing too heavy technical and procedural requirements and leave room for efficiency gains;
2. incorporate mitigation approaches addressing the demand risk and termination risk;
3. ensure that the country is ready for large-scale mini-grid deployment with highly efficient and fast-tracked administrative processes.

3.1.1 | SELECTING A PROCUREMENT PROCEDURE

All procurement procedures have their respective advantages and disadvantages. Various aspects of the procurement procedures already introduced are discussed below.

Table 3 compares the advantages and disadvantages of competitive approaches with those of first-come-first-served approaches. In competitive approaches, the project sites are usually pre-selected by the government, while in first-come-first-served approaches the private sector is in charge of compiling the clusters of sites. Generally, the first-come-first-served approaches lead to faster roll outs, while competitive procedures are more likely to trigger higher efficiency and greater innovation.

TABLE 3. PROS AND CONS OF COMPETITIVE PROCUREMENT VS. FIRST-COME-FIRST-SERVED APPROACHES FROM A GOVERNMENT'S PERSPECTIVE

	Pros from the government's point of view	**Cons** from the government's point of view
Competitive procedures (such as tender on lowest service charge/ tariff/WACC/ grant)	• Government has control over site selection and where/in which sector rural industrialization takes place. • The competition is more likely to lead to **higher efficiency,** lower costs and potentially new, innovative approaches on the private sector side, if the tender requirements do not limit the private sector's creativity. • Financing structure may easily incorporate rural industrialization support with the mini-grid support.	• The level of **effort is high and procedures may be lengthy.** For the electrification of one village, many proposals must be prepared and evaluated. Digitalization of this process using platforms such as Odyssey[9] can make this process more efficient. • Putting together concession areas and therefore a biddable package may be difficult for some governments.
First-come-first-served procedures (such as RBF/ PBG)	• The private sector is allowed to select the sites best suited to its (e.g. rural industrialization-related) business model, which makes the business more viable, as more uniform sites can be clustered without having sites in the cluster that do not fit the business model. • First-come-first-served means that the private sector will move fast to secure the best sites. • The administrative procurement effort is comparatively lower. Thus, deployment of funds is fast. This is the **fastest option** to roll out mini-grids.	• Individual sites usually suitable for mini-grid electrification may be left untapped just because they are located between clusters. • Government has **limited control over the geographic focus of mini-grid electrification.** The private sector will electrify the most commercially attractive sites first.

A	for EPC tender + operation by utility	D	for ESCO with tariff-based contract
B	for ESCO with service contract	E	for hybrid – split-asset/grant
C	for split asset model	F	for private with CAPEX grant

For all procurement procedures in which a tendering approach is used, **reverse auctioning** procedures are discussed as an alternative. If properly implemented, reverse auctioning can lead to better results for the public sector compared to tendering, where one parameter needs to be minimized. In tendering, bidders can only submit one bid, whereas in auctions, bidders can learn about their competitors' bids and can improve their own bids until the lowest possible service price, tariff, WACC or grant is determined. At the end of the auction, the contract is awarded to the lowest bidder. Reverse auctions have not yet been extensively tested in the mini-grid sector.

There are two options for the provision of **public contributions** to private mini-grid operators, **in kind or in cash.** Contributions in kind can, for example, be distribution assets that are procured and installed in bulk by the government and provided to the private operator as a grant or under a usage rights agreement[10]. Cash contributions are typically grants that are paid out to the private operator. In the first case, the government may retain ownership over fixed assets and reduce the overall cost through bulk procurement. This reduces issues and compensation discussions when the mini-grid is integrated into the main grid at a later stage. On the other hand, mixed ownership in the same system increases complexity on the contractual side. In the case of cash provision, the cost of asset procurement may be higher, but the control of the government over assets decreases, while the contractual complexity during the operational phase is also reduced.

Mini-grid **cash grants** can be provided either as an **advance payment or as post-payment**, or else as a mixture of both (e.g. milestone-based). Post-payment involves the least administrative effort and thus supports fast mini-grid deployment best. A verification of the satisfactory completion of the contracted service is performed and the grant is disbursed. At the same time, post-payments entail the least risk for the government, as grants cannot be misused if they are paid out after results have been verified. On the other hand, this system requires considerable interim financing by the private sector. However, this capital may not be available, especially to smaller domestic companies. It can therefore be concluded that post-payments accelerate electrification with a high degree of security for the government, but favour financially strong, usually international mini-grid companies with easy access to interim financing over smaller or domestic companies.

The degree of **required collaboration between authorities** varies according to the procurement model selected. While approaches with fixed grant per connection or tenders on lowest grant require little coordination, tenders on tariff or WACC need intensive collaboration between the authority granting the subsidy (usually a REA) and the electricity regulatory authority. In both cases – tariff and WACC tender – the regulator must use the tender results of the tendering authority when regulating tariffs. This need for collaboration could be the main reason why some of the theoretically beneficial procurement models mentioned have not yet been tested.

Wherever the **private sector** is expected to provide **long-term co-financing** to a mini-grid project, another issue arises. Access to long-term financing for mini-grid companies is mostly still challenging. In all competitive procedures, it is expected that the acquisition of financing is already at an advanced stage when bidding, even though the bidder does not know if the project can be realized as quoted. This increases the burden on the private sector in terms of bid preparation. Moreover, this requirement gives financially strong, usually international companies with access to the international capital market an advantage over smaller domestic companies with less access to financial services. This can be overcome, for instance, by tendering the grant component together with a predefined project-based financing package in collaboration with a bank. However, it may still take several years and a track record in the mini-grid sector before banks are ready to enter into this type of arrangement.

9 https://www.odysseyenergysolutions.com
10 Refer to template: Usage Right Agreement.

3.2 | TARIFF REGULATION

Applicable for:

B	C	D	E	F

Retail tariffs are the most politically sensitive element of mini-grids. The key question is: "How shall the higher relative cost (in currency per kWh) of supplying electricity to low-income rural customers be distributed among urban and rural society?". In fact, the answer to this question would be relatively simple in a main grid scenario. As everyone is connected to the same infrastructure, everyone pays the same tariff, which often results in the urban customer automatically and naturally paying parts of the cost to supply the rural customer with electricity. As soon as the infrastructure for supplying rural customers is separate to that supplying urban customers (as in mini-grids) and even when the entity supplying electricity is not the national utility, cross-subsidies do not flow naturally. Instead, subsidies would need to be provided by the taxpayers or by transfers from the electricity revenues of the main grid utility. This makes subsidies more visible and, thus, the focus of debate.

3.2.1 | TARIFF VS. SUBSIDY SETTING METHODOLOGY

Regardless of which subsidy scheme and associated delivery model is selected, the mini-grid operators must ultimately be able to generate total revenues (subsidy + tariff collection) that enable their organizations to operate the mini-grid in a sustainable manner. This minimum revenue requirement is independent of whether the mini-grid is operated by a government entity, a private sector company or a cooperative. The methodology used by regulatory authorities to calculate this revenue requirement and the resulting tariff is the **Cost of Service model.**

The Cost of Service model [11] was originally developed to regulate urban main grid electricity tariffs following the below formula:

$$\text{Tariff level required} = \frac{\text{Total revenue required}}{\text{Expected kWh sales}}$$

where the Total revenue required equals OPEX + fees and taxes + depreciation of privately-financed assets + the current value of privately-financed assets multiplied by the WACC.

All grants awarded for a project usually reduce the CAPEX level and thus the depreciation and the portion related to the WACC. Ongoing subsidies provided to the mini-grid operator are subtracted from the OPEX. In Nigeria, Sierra Leone and Tanzania, for instance, regulations and cost-reflective plus tariff tools for mini-grids have been introduced.

So-called **Multi-year tariff orders** (MYTO) project the costs for the upcoming four to six years and calculate the tariff accordingly. This approach, combined with an indexation of the tariff to inflation and diesel fuel price changes, reduces the administrative effort of regularly revising the tariff. Governments in some countries, such as Nigeria, have moved away from reviewing tariffs periodically and decided for a tariff revision on demand, which can be triggered by a group of electricity customers or by the mini-grid operator.

In some countries, **to adjust the original Cost of Service model to mini-grid sector-specific requirements,** some of the following new features have been added in recent years:

A	for EPC tender + operation by utility	D	for ESCO with tariff-based contract
B	for ESCO with service contract	E	for hybrid – split-asset/grant
C	for split asset model	F	for private with CAPEX grant

- An annuity-based depreciation methodology, together with the option to activate/capitalize the OPEX within the first two years after commissioning. This will avoid the tariff spike in the first years after commissioning when the "expected sales of kWh" are still low but growing rapidly (following the typical root function-shaped demand development curve (see *Figure 6*).
- The option to activate/capitalize OPEX in the first years after commissioning as part of the project development cost, as well as to reduce the initial tariff spike.
- An operational performance-related profit margin, in the form of a small amount per kWh sold, which is subsequently accounted for as the mini-grid operator's profit. This will attract the private sector to also electrify small villages, which require a high grant portion and thus have a lack of privately financed assets, resulting in low profit potential.

Finally, there is another effect to be considered. The **Cost of Service** calculation methodology, as developed for urban electricity customers, **assumes a saturated basic electricity demand** and, thus, a constant "Expected kWh sales" independent of tariff levels. It therefore assumes that the revenue of the mini-grid operator will increase and decrease with the tariff in a linear fashion. As shown in *Chapter 2.1.5*, this does not apply for low-income rural household customers, who buy electricity with a fixed weekly budget and tend to reduce consumption with increasing tariffs to keep the expenditure constant, rather than increasing their expenditure to keep consumption constant, even when purchasing electricity on a pre-paid basis. Therefore, given the high percentage of household customers in a regular mini-grid for village power supply, tariff changes have a smaller impact on the revenue of a mini-grid operator than previously considered. Instead, they change the amount of electricity consumed, and thus the size of the power station, together with the amount of CAPEX grant required.

The Cost of Service calculation methodology applies to all mini-grid settings, regardless of whether the tariff is nationally uniform, defined by a tender or calculated as cost-reflective plus. The government may decide to first set the tariff and then calculate the grant level through the Cost of Service formula (in national uniform tariffs), use the formula to calculate whether tariff bids are sustainable (fixing of tariffs through tenders) or fix the grant and subsidy amount first, before calculating the required tariff level (cost-reflective plus tariff). Any combination of the above options is also possible (such as bidding on WACC, application of tariff caps, etc.). *Table 4* indicates which tariff determination approach is typically used in which delivery model.

TABLE 4: TARIFF DETERMINATION APPLICABLE IN VARIOUS DELIVERY MODELS

Tariff level	Applicable for					
(Usually) National uniform	**A**	**B**	C	D	E	F
Tariff as bid during tender	A	B	**C**	D	E	F
Cost-reflective plus	A	B	C	**D**	**E**	**F**

11 Other names for this method (although potentially slightly varying in detail) include "Cost+ model", "Building Block model" or "Revenue Requirement model".

Besides subsidies and grants, there are **further methods to minimize tariffs.** Tariffs can be reduced by scaling to a large number of connected customers, thereby dividing fixed overhead costs by a larger number of kWhs delivered; by applying innovative business models, such as fourth generation mini-grids, which share fixed OPEX with other business lines and increase electricity demand; and by simplifying administrative processes to minimize the cost of project development. The following paragraphs will introduce options for the minimization of administrative efforts and costs with the objective of reducing tariffs and, at the same time, avoiding an administrative overload of the electricity regulatory authority.

Small mini-grids are especially sensitive to administrative costs and requirements, as these often apply per site. Some countries therefore exempt small mini-grids (for instance those below 100 kW of distributed power, as in Nigeria) from licensing and tariff approval requirements, though developers may in some instances choose to voluntarily go through the licensing process as it provides protection from grid encroachment. Although the tariffs in this case may be set according to the **"willing buyer willing seller"** approach, according to which the tariffs are freely negotiated between the community and the mini-grid operator, the mini-grid developer has the greater negotiation power in the process of approaching and selecting the unelectrified community. After commissioning, the negotiation power usually shifts from the developer to the community, which often leads to conflicts. The regulators are therefore advised to offer voluntary tariff approval and mini-grid developers are encouraged to use the Cost of Service formula to justify their willing buyer willing seller tariff to the regulator, in case a tariff regulation is applied to resolve such conflict.

Administrative burdens and costs for the mini-grid developers may be reduced by applying the **same tariff to all mini-grids under the same management** (same developer), or at least for all mini-grids of the same developer in a particular region. This also reduces the risk of tariff conflicts between the operator and the community.

Automation of tariff calculation and approval using information and internet technology is another method of minimizing costs and effort. This should be applied especially in countries that promote private sector-oriented delivery models.

3.2.2 | RETAIL TARIFF STRUCTURE

Applicable for:

A	B	C	D	E	F

The previous chapter discussed aspects related to the determination of mini-grid retail tariffs. The retail tariff determined is in fact an average tariff across all customer groups and all tariff components. In this chapter, we demonstrate the issues that need to be considered when breaking down this average tariff into customer groups and tariff components.

Customer groups of a mini-grid are usually low, medium and high-income households, commercial users such as shops, hairdressers and cafeterias, productive users such as mills, wood workshops, welding workshops, irrigation pumps, public and religious institutions, such as schools, health centres, local government offices, mosques and churches, and anchor customers such as telecom towers, large-scale irrigation schemes, small factories for processing of local goods etc. Not all customer groups within the same mini-grid pay the same tariff. An economically reasonable allocation of tariffs to customer groups follows the distribution of cost. Customers with low consumption whose connection costs the same and who require the same amount of customer service as customers with higher consumption pay more per kWh. This means that lowest-income customers would pay the highest prices per kWh, which is not

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B	for ESCO with service contract	E	for hybrid – split-asset/grant
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justifiable politically. As a result, some governments, through their regulators, require mini-grid operators to cross-subsidize household customer tariffs (and sometimes tariffs for public institutions) from the income of other customer groups.

This cross-subsidization has its limits where the commercial, productive and anchor customers either abandon their business due to high electricity expenditure or where diesel motors or generators become cheaper than electricity from the mini-grid. In addition, where rural industrialization is fostered, high prices for productive electricity usage must be avoided in order to make irrigation and rural processing a financially viable business.

Tariff components can be used to guide the user towards a certain electricity consumption behaviour or to better align the cost structure or a mini-grid company with the revenue structure, thus reducing the impact of customers' consumptions behaviour on the profitability/sustainability of mini-grid supply. The most widely used tariff components are outlined below:

- Energy-based tariffs are based on the amount of energy consumed (measured in kilowatt-hours [kWh]), sometimes referred to as pay-as-you-go (PAYG) if a recharge of electricity is possible via mobile phones at any time. Energy-based tariffs can be time of use (TOU) dependent. In a solar photovoltaic mini-grid, for instance, electricity consumed at night-time can be more expensive than electricity consumed during daytime, as per the cost structure of generating the electricity (battery cycling during night-time is costly).
- Fixed payments per week or month to provide access to a premium service may be part of a tariff design applied to limit the number of high-consumption appliances in a mini-grid. This may be necessary if the power generation capacity is significantly lower than the sum of power of appliances and machines connected to the same system. A weekly or monthly fixed charge motivates customers to connect only those machines that are used on a regular basis and motivates customers not to connect machines that are rarely used (e.g. a large milling machine which is only used for own consumption). Renewable energy-based mini-grids usually have a high portion of depreciation of CAPEX and fixed costs that can be suitably covered with fixed incomes from fixed weekly/monthly payments. In contrast, most families and businesses in rural areas resent the obligation to cover fixed expenditure with their variable income.
- An energy block or a daily/weekly energy allowance is a specified amount of energy to be consumed within a predefined period of time (e.g. a day or a week) and up to a predefined power (in kW). Energy that has been ordered but not consumed by the customer still needs to be paid for. This is a method of levelling the consumption pattern over days, weeks and seasons and stabilizing income, assuming that electricity customers are always able to pay.
- Flat tariffs are fixed payments per month (or other payment period), regardless of consumption level.

The above-mentioned components allow a regulator and mini-grid operator to introduce highly complex retail tariffs, which are presumably most effective in minimizing the financial risk and levelizing electricity consumption. However, a highly complex tariff poses a challenge for the customer relationship management. The higher the complexity of the tariff structure, the greater the time and effort usually required to answer customers' questions and complaints about the tariff, up to a level at which the trust relationship between the electricity customer and the mini-grid operator is at risk.

3.3 | LICENSING

Applicable for:

B	C	D	E	F

The granting of licences and permits is an administrative process that must be carried out quickly to enable accelerated rural electrification. Therefore, the documents and tools must be easy to handle for a large number of sites in a short period of time. Digital technologies with automatic data processing are highly recommended. One of the forerunners in this regard is the Nigerian Electricity Regulatory Commission, which has introduced a tailor-made management tool for licence application for mini-grid companies.

In the early stages of mini-grid regulatory development, several countries, including Tanzania, Uganda, Kenya, Nigeria and Zambia, developed mini-grid licensing processes based on system size. The intention was to create simplified licensing or licence exemptions for small systems, generally under 100 kW. However, the implementation of size-based licensing alone has not been sufficient to achieve the ambitious objectives in reducing cost and increasing speed of deployment of the licensing process. As countries have moved from pilot mini-grid deployment to scale, it has become clear that a size-based approach alone is not scalable.

Portfolio-based licence applications, such as those in Uganda, Sierra Leone and Zambia, ensure regulatory compliance and consumer safety and are better suited to large-scale mini-grid deployment. **Portfolio licences can significantly reduce bureaucratic burdens** and associated costs for both private developers and regulators, and are a more effective tool with which to leverage private developers to maximize electrification rates. Portfolio-level applications for tariff approval also support scale, with the added benefit that mini-grid developers are able to cross-subsidize their entire portfolio and reduce tariff prices for the most difficult-to-reach consumers.

A	for EPC tender + operation by utility	D	for ESCO with tariff-based contract
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4. MAKING A DECISION ON MINI-GRID DELIVERY

MODELS BASED ON A COMPLEX HOLISTIC ASSESSMENT

In the previous chapters, an attempt was made to structure the decision-making procedure into a streamlined process. In reality, finding a consensus among policymakers on subjects as politically sensitive as mini-grid retail tariffs, grant/subsidy levels and the targeted degree of government control is by no means an easy task. Mini-grids involve issues that go beyond the decision-making scope of an energy ministry, with its electrification authority and a regulatory commission. They include aspects that are under an environment ministry, aspects related to health and safety, concerning education and vocational training to build skills and capacities (e.g. for the management of the mini-grid), aspects that are under a finance ministry with respect to grant and subsidy schemes or tax and duty exemptions, as well as aspects related to planning and land allocation, fair competition, rural development, local governments and poverty alleviation. This list could be continued. Where public infrastructure is to be connected to mini-grids, aspects subject to a health ministry (hospitals and health centres, and those subject to an interior ministry (police, government offices) are addressed.

All related government entities ought to be integrated in some way into the decision-making process. Parliamentarians need to be provided with information (as with this guide) to enable debates. This is not only the case at national level, as regional and local decision-makers ought to be also involved in the decision-making process. Anyone who is **not** involved may end up sowing mistrust, which in turn may result in a failure of the mini-grid scheme. The general public needs to be informed about the options and limitations of mini-grids. Complex subjects such as the cost structures of mini-grids, the role of tariff regulation, demand risk and termination risk must be communicated in a way that is understandable to all. The public media plays a central role in this communication task. The unattainable goal is a national consensus on a delivery model with appropriate tariffs, grant/subsidy levels and government control over the mini-grid operations/assets and the role of the private sector. This consensus must be realistic and follow the “mechanics” of the mini-grid sector, as well as the minimum requirements of the individual mini-grid stakeholders, as outlined in this guide. Finding this consensus requires comprehensive debate.

The debate usually uses buzzwords such as “least cost option”, “most appropriate technology”, “power quality" and "national equity" in tariff and grant allocation, whose meanings must be defined. In the end, the debate will be guided by questions around these buzzwords, such as:

- Is the question of the "least cost" the least cost for the consumer today or for the government in the long run? In fact, from a macroeconomic perspective, mini-grids are often the least cost option for electricity supply, although the cost to the electricity customer may be higher than in the main grid due to limited government contributions.
- Is the search for the "most appropriate technology" also about the speed of introduction or only relevant to the costs? In some cases in which mini-grids are not the least cost solution, it may still make sense to deploy mini-grids, as they can usually be implemented faster than a high or medium-voltage line, with all its environment and construction-related aspects. On the one hand, this speed discussion may relate to the goals of universal electricity access. On the other hand, when a rural industrialization opportunity arises, speed may be economically more beneficial than cost efficiency.
- When discussing power quality, do we only discuss power bandwidth and voltage stability or also reliability of supply? In view of the fragility of long medium-voltage feeders, clean energy mini-grids in many cases supply more reliable power. At the same time, mini-grids can indeed be very powerful and drive large machines while maintaining a high level of voltage stability.
- If we compare the mini-grid tariffs with main-grid tariffs, do we compare the mini-grid subsidies with the subsidies for the main grid? Main-grid subsidies are often not clearly visible and can take the form of subordinated long-term loans, debt cancellations, tax alleviations or similar. These subsidies often create an uneven playing field compared to mini-grid subsidies, thus distorting the discussion about how expensive mini-grids really are. If one compares "apples with apples", mini-grids can be the "least cost" option in many cases. Once a level playing field has been created between the main grid and the mini-grid, the tariffs payed by mini-grid customers for electricity no longer seem "too high".

Although the task of involving all stakeholders in the discussion seems to require an enormous effort, some countries are very advanced in their respective consensus-building and framework development processes, and have already been rewarded with accelerated rural electrification (and partly industrialization) based on mini-grid roll-outs. Governments approaching this debate on rural electrification could learn from the experiences of these countries and drastically shorten the debating process from the six to ten years that have already passed in Nigeria and Senegal respectively.

Although regulations should preferably be developed after a decision for a delivery model has been taken, in practise, the debate often develops and culminates in parallel with the development of the policy and implementation instruments. Sites for mini-grid electrification only become visible once a geospatial analysis has been conducted. Mini-grid cost structures only become visible once tariff tools and financial models for demonstration sites have been prepared. Some policymakers are only prepared to inform themselves about the topic once drafts of policy documents are on the table. Pilot projects, which require a first run-through of all processes and trigger the drafting of respective tools and documents, are therefore indispensable for the progress of the debate on the framework. International organizations offer technical assistance for pilot projects, grant funding and related policy development. These pilots must be used to close the debate and maximise longevity of regulations. Longevity also means that regulations shall only be reviewed at certain trigger points with specific protections for existing projects.

The aim of the debate ought be to agree on a framework for mini-grids that all stakeholders can rely upon in the long term – one that provides mini-grid operators with reliable cash flows that enable sustainable operation, which then guarantees customers a reliable supply of electricity at affordable and acceptable tariffs, thus unlocking the potential for rural industrialization and job creation, resulting in rural development.

5. CONCLUSION AND RECOMMENDATIONS

Rural electrification with clean energy mini-grids is a fast way to supply highly reliable electricity to rural towns and villages. In combination with fourth generation business models, mini-grids not only provide electricity at a quality superior to the main grid, but advance rural industrialization and development. The entrepreneurial spirit of the private sector is key to unlocking the rapid rural electrification brought forth by mini-grids.

The degree of private sector involvement depends on decisions to be taken by government. In order to be sustainable, mini-grids require a comprehensive, long-term political commitment and a stable, reliable policy framework. Governments are therefore advised to select and adapt the delivery models from a suitable combination of the following:

a) government control over mini-grids;
b) electricity tariff levels; and
c) subsidy levels.

Balancing these aspects could be achieved using the Decision Tree as presented in *Chapter 2*, and by designing the policy framework accordingly. Once a decision on how to electrify rural areas has been made and, importantly, long term political support for the selected model secured (often the most difficult task), the mini-grid policy can be integrated into the rural electrification policy and plan. Thereafter, regulatory and contractual documents for the implementation of the policy and plan must be developed.

When deciding on a delivery model and when designing the "rules of the game", the following mechanics of mini-grid power supply to rural areas ought to be considered:

1. **Mini-grids in any delivery model, even if financed with a high grant component, require a certain level of revenue, i.e. a combination of tariffs and subsidies, to operate sustainably.** The long-term availability of ongoing subsidies should be guaranteed before, for instance, private investment is attracted. The instrument used to calculate the tariffs applicable under the selected subsidy scheme (or vice versa) ought to be a Cost of Service model. This model can be considered a scale that always needs to be in balance to allow mini-grids to operate sustainably. Government

actions that lead to an imbalance of the Cost of Service model will automatically result in a failure of mini-grid electricity supply, with the regulatory authority considered as the guardian of the scale.

2. **The development of electricity demand in rural areas is difficult to predict and influenced by a number of factors beyond the control of the mini-grid operator, making it important to introduce demand risk mitigation instruments in the policy framework.** Usually, the demand development follows a curve with a root function shape. However, the exact shape can only be projected with adequate accuracy approximately three years into the mini-grid operation. As the electricity demand has a very high impact on the sustainability of any delivery model, some demand risk mitigation instruments must be foreseen in the related policy framework. Such instruments may include phased implementation, the adjustment of productive use tariffs over time or a flexible subsidy scheme.

3. **The risk of a sudden end to the project due to contractual or legal arrangements, i.e. the termination risk, further ought to be considered by policy makers and regulators.** Mini-grid projects usually take around ten years to break even. Only after this time do investors begin to generate profits. An early end to the operating phase therefore leads to losses, which is why investors only commit large-scale financing if the termination risk is mitigated. Termination risk is not only related to the regulation of main-grid connection to the mini-grid, but also to concession contracts, lease agreements, usage rights agreements, PPP contracts, land right agreements etc. All of these legal and contractual documents should preferably be designed without a predetermined end date for mini-grid operation (or with a duration exceeding 20 years and that can be extended) and with reasonable and mandatory compensation to the operator in case of early termination.

4. **Mini-grid roll-out schemes must be designed for large-scale deployment.** One of the largest cost components in clean energy mini-grid tariffs is usually fixed overheads, which are often spread over far too few kWhs sold. To keep this tariff cost component low, as a rule of thumb, over 15 000 connections should be targeted under the same management. All regulatory and administrative processes must be prepared to efficiently handle the large volume of applications involved, both for the applicants and the authority concerned. This involves the approval of the same tariff for all sites under single management, application processing using internet technology, seamless collaboration between various authorities involved and/or a one-stop shop approach.

Once these four aspects are fully taken into account in the policy framework, the foundation for a sustainable operation of mini-grids in the respective country is laid. From here, depending on the implementation model chosen, governments can provide further support with additional measures. In some delivery models, import duty, tax exemptions and tax holidays are helpful, while others require a geospatial rural electrification plan that clearly indicates villages earmarked for mini-grid electrification. Other models benefit from repatriation rules that encourage foreign direct investments or additional financial support for productive use of electricity and rural industrialization, or require some form of partial risk guarantee by the government.

The success of the deployed mini-grids will reflect the level of trust that can be built between all stakeholders, including electricity consumers, mini-grid operators, donors/development banks, investors/financiers, government representatives at all levels, authorities and the general public. Therefore, drastic and rapid changes in frameworks must be avoided. Gradual changes must never unilaterally generate disadvantages without compensation for the respective stakeholder.

With this paper, **policymakers have a tool at their disposal with which they can finally disrupt trajectories in the development of rural communities with almost immediate effect by deploying mini-grids in a rapid and sustainable manner.**

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