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Integrating Isolated Mini-Grids With An IDF-Compliant Regulated Distribution Sector: A Long-Term Perspective Towards Universal Electricity Access

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Abstract

Renewable energy mini-grids are playing an increasingly important role in advancing the electrification process in many developing countries. Significant steps have been taken by governments, regulators and development finance institutions to create conditions for the private sector to scale-up deployment of mini-grids in areas where grid is unlikely to expand (at least in the medium- to long-term) because it is not the least-cost option – sites too far from the main grid, with too low and disperse demand – or because of the dire financial conditions of the distribution company and the subsidized tariffs render grid extension an unviable proposition.

Under the present conditions, in most rural areas in low-access developing countries the three modes of electrification (on-grid, mini-grids and stand-alone systems) co-exist and are largely developed in silos. The current plans to roll-out stand-alone and mini-grid solutions will continue this trend. In particular, mini-grid focused initiatives based on the Results-Based Financing (RBF) approach[1], such as the Universal Energy Facility[2], can mitigate some of the administrative risk associated with accessing financing support and components procurement hurdles and inefficiencies presently plaguing private mini-grid companies in developing countries. Being subject to light-handed regulation or no regulation at all, the deployment of mini-grids under this kind of arrangement can be fast, with obvious advantages for the yet unserved population. However, with a limited track record, concerns may arise about the long-

[1] RBF typically involves payment of specified sums when mini-grid projects achieve a specific milestone most commonly verified connections. In some cases, where the viability gap may be too large, part of RBF support may also be provided to cover upfront capital cost. The level of support is usually capped at a specific point and is tied to specified requirements related to, for instance, quality of supply, tiers of service, etc. The application of the RBF to mini-grids is further discussed in SEforAll (2020), State of the Global Mini-grids Market Report 2020, https://www.seforall.org/system/files/2020-06/MGP-2020-SEforALL.pdf.

[2] The Universal Energy Facility is a multi-donor results-based financing facility which aspires to be a USD 500 million facility by 2023 (USD 100 million by 2021) and to deliver approximately 2 million electricity connections and 300,000 clean cooking solutions by 2023.

term inclusiveness (i.e., leaving no-one-behind) and permanence (i.e., financial sustainability, vocation) outcomes of such approaches once they are left to their own devices to meet demand growth over the project lifetime and to replace worn out components.

The Global Commission to End Energy Poverty (GCEEP) has deliberated, and widely supported, the adoption of the Integrated Distribution Framework (IDF)[3] as an ideal first solution to achieve universal access to electricity efficiently and sustainably. The IDF proposes that an "entity" (comprising one or more public and private actors) must be responsible for undertaking the distribution activity in a given area (under an investment-worthy contract like a concession) to ensure universal coverage through the optimum mix of the three electrification modes, which will dynamically evolve – as demand grows and the grid extension segment becomes financially viable – towards a higher proportion of the grid extension solution. It aligns with the view that over the long-term, the distribution sector in all low-access countries will need to converge to the well-tested regulatory principles of distribution business i.e., long-term remuneration schemes based on a cost-reflective revenue requirement for all electrification modes. However, the IDF requires a more complete regulatory support and a comprehensive business plan covering all electrification modes, compared to targeted approaches to scale-up mini-grid solutions (e.g., through the RBF) and its implementation will be necessarily slower. Would it be possible to take advantage of the strengths of both approaches, while minimizing their weaknesses?

This paper explores the point of convergence between measures to rapidly scale-up isolated mini-grid development in unelectrified areas, and steps taken towards an IDF-approach in the distribution sector broadly. Rather than viewing the two as conflicting approaches, given the longevity of electricity assets and distribution activities, the paper argues that the design of isolated mini-grid programs could integrate elements that provide the building blocks for the potential integration of isolated mini-grids into a regulated distribution business. Anticipating and planning for the transition will help address potential regulatory risks, internalize the transition in mini-grid business and financing models, and support a symbiotic co-evolution of the three electrification modes.

[3] I. Pérez-Arriaga, R. Stoner, D. Nagpal and G. Jacquot. "Global Commission to End Energy Poverty: Inception Report", September 2019. https://www.endenergypoverty.org/reports.

Introduction

Mini-grids are now recognized as an important pillar of an integrated approach to reach universal electricity access by 2030. Mini-grids based on diesel, hydro and biomass have been deployed for decades to meet electricity needs in unelectrified rural areas. Recently, with rapid advances in technologies, cost reductions and the participation of the private sector, the adoption of solar-hybrid solutions is growing rapidly in many low-access countries.

A number of steps are being taken to accelerate the pace of renewable energy mini-grid development. Regulators in several low-access countries have announced dedicated mini-grid regulations that address licensing and permitting requirements; tariff setting; main grid arrival implications; as well as public financing support for projects. Generally, mini-grid regulations are tailored by the size of installation and are meant to reduce the regulatory burden for smaller facilities (e.g., <100 kW requires no license and tariff is unregulated in Nigeria, Tanzania, etc.).

With utility-like structures and functions, mini-grid business models face several policy and regulatory risks although, unlike traditional distribution companies that usually cover a large territory allowing cross-subsidization between rural and urban consumers as well as between consumer groups, mini-grids cover areas that are much smaller, generally involving low demand, mainly from households. High capital costs, low consumption and limited ability/willingness-to-pay (and uniform national tariff regulations in some countries), mean that ensuring viability of mini-grids to cover capital and operational expenditures, including expectation of returns on investments (depending on ownership structures), requires a subsidy as has been the case with rural electrification globally.

Traditional support for mini-grids has involved upfront capital subsidies to cover part or entirety of the initial cost of the installations. The subsidy level may be administratively set or identified through tenders. Key shortcomings of an upfront subsidy-oriented approach have been the lack of incentive on the part of the operator to ensure permanence of supply, as well as the risk of insufficient resources to undertake maintenance and replacements due to under-recovery from tariffs. Further, upfront capital subsidies require substantial public financial outlay which is constrained. Results-based financing (RBF) approaches are increasingly advocated for to support mini-grid development. RBF shifts the risk of securing financing for upfront capital costs to the private developers, while providing regulatory clarity on financial support provided (e.g., for each verified connection[4]). The level of RBF could

[4] In certain cases, the verified connection grants have been linked to a specific quality of electricity service. For instance, in Tanzania, the RBF programme offered differentiated grants for Tiers 3, 4 and 5 services based on the Multi-Tier Framework.

be determined through an auction or guided by an electrification model based on cost-of-service delivery.

Indeed, the approach has been to create an "initial island of viability" in the distribution sector for mini-grids by offering tailored light-handed regulations, de-risking tools and concessional financing, including grants. It enables the rapid deployment of mini-grids with important gains in electricity access, complemented further by the roll-out of stand-alone solar solutions. The interaction between the isolated mini-grids and distribution companies is generally very limited – actually avoided, on purpose; typically reduced to ensuring that the area to be electrified is not in the immediate plans for grid extension; and when the grid does reach, to facilitate (but not mandate) the integration guided by a dedicated mini-grid regulation.

Notwithstanding the positive impact of isolated mini-grids and the possibility of a fast implementation of the approaches mentioned above, it is important to consider its implications on a longer-term view of the sustainability and viability of the distribution sector that ensures permanence and access to all. Under the present trajectory, it is very likely that in a given territory/region, the three modes of electrification (on-grid, mini-grids and stand-alone systems) co-exist in silos and each mode services customers most attractive for their business models. Guarantee of universal coverage or permanence of supply is unlikely. Further, it also results in a variety of tariff regimes (even if guided by the same methodology of determination as in Nigeria) and technologies (metering, billing and customer interaction, for instance), which do not allow the use of the benefits of broader cross-subsidization.

In the long-term, the distribution sector in all low-access countries will need to converge to the well-tested regulatory principles of distribution business i.e., long-term remuneration schemes based on a cost-reflective revenue requirement computed annually based on the actual needs and efficient management assumptions. These principles will need to be applied to all three electrification modes to ensure long-term viability of the distribution activity, attract investments at scale and ensure no-one-is-left behind. Building on these principles, the Integrated Distribution Framework (IDF) approach further advocates that an "entity" (comprising one or more actors) will need to be held responsible for undertaking distribution activity in a given area (under a contract like a concession) and ensure universal coverage. The entity could involve the existing disco or be a partnership with the private sector, or a combination of companies involved with various electrification modes.

Independent measures to support specific electrification modes are not necessarily at odds with a long-term vision to develop a viable distribution sector that provides universal, reliable and affordable services. Regarding mini-grids, given the longevity of electricity assets and distribution activities, what is necessary is that the building blocks are already in place for the potential integration of isolated mini-grids into a

regulated distribution business. Anticipating and planning for the transition will help address potential regulatory risks, internalize the transition in mini-grid business and financing models, and support a symbiotic co-evolution of the three electrification modes. This paper discusses various scenarios of transitions for isolated mini-grids and highlights building blocks that need to be established now to ensure the future smooth integration into an IDF-compliant distribution sector.

Pathways for isolated mini-grids transition to an IDF-compliant distribution approach

A large number of isolated mini-grids are already deployed and planned to be installed, facilitated by dedicated national programmes and funding facilities such as the Nigeria Electrification Project and the proposed Universal Energy Facility[5]. The regulatory contexts vary from country-to-country, as well as the ownership structures of mini-grids and their underlying business and financing plans. In this section, we shall analyze possible scenarios related to isolated mini-grids transitioning to becoming part of a regulated distribution sector (comprising all electrification modes) in a low-access country.

Scenario 1: Isolated mini-grid under willing-buyer/willing-seller tariff supported by connection-based RBF

Under this scenario, an isolated mini-grid under 100 kW is considered that is subject to dedicated mini-grid regulations (e.g., in Nigeria) governing licencing and tariff setting. It is assumed that the developer signs a performance-based grant from an RBF-facility to bridge its viability gap. The connection subsidy would be delivered after meeting well-established verification and reliability requirement guidelines. The connection grants may be expected to contribute to no more than ~50% of total capital expenditure[6][7], with the operational expenditure to be covered through revenues from tariff collection. For mini-grids under 100 kW, tariff may be determined based on a

[5] The Universal Energy Facility is a multi-donor results-based financing facility which aspires to be a USD 500 million facility by 2023 (USD 100 million by 2021) and to deliver approximately 2 million electricity connections and 300,000 clean cooking solutions by 2023.

[6] Assumption also followed with Endev RBF for mini-grids in Kenya and Rwanda. https://minigrids.org/wp-content/uploads/2019/07/RBF_Mini-grids_Implementation_Kenya-Rwanda.pdf

[7] Performance-based subsidies can significantly reduce the cost of mini grid electricity and allow mini grid services to be affordable to a larger group of end users. According to ESMAP analysis, a performance-based grant equivalent to 40% of CAPEX is estimated to reduce the LCOE from $0.55/kWh to $0.43/ kWh in a scenario with low productive uses of electricity (load factor ~22%). For high load factors (80%), the same 40% CAPEX grant reduces the LCOE from $0.42/kWh to $0.34/kWh. ESMAP (2019), Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers.

willing buyer/willing seller basis (e.g., in Tanzania) or be guided by a specific tariff-determination methodology (e.g., in Nigeria for mini-grids opting for permits).

The traditional distribution business plan is based on certain assumptions of financing, willingness to pay, number of connections (and associated subsidy), demand growth, capital and operational costs. In line with this traditional practice, one could expect a similar business plan for mini-grids to target a payback period of 5-8 years beyond which (and until the lifetime of the project) it may be assumed that no further financing costs will be incurred, as explained next. The revenue from tariff collection should sufficiently cover OPEX, plus the additional capital needs for replacement of specific worn out components (e.g. batteries) and for coping with demand growth, with majority of the connection-based subsidies being delivered within the first years of project operation[8].

At a point in time in the future, it is presumed that the distribution companies' territory within which the isolated mini-grid operates transitions to an IDF-oriented approach. The distribution company (or a consortium led by the entity with concession) now has the mandate to ensure universal electricity access coverage within its territory, using an optimum mix of electrification modes. The implications of the transition could be seen as follows:

- A transition period will need to be defined for existing isolated mini-grids to be integrated into the regulated framework. The transition period will need to take into account the average payback period that exists for isolated mini-grids – a short transition period is likely to disrupt business models and lead to risk of capital investment loss. Transitioning mini-grids at a point when payback has been achieved will be preferable.
- Presuming that the concessionaire does not extend the grid to the area serviced by the isolated mini-grid, an option is that the mini-grid operator becomes a sub-licensee of the concessionaire. It may also be possible that the mini-grid operator becomes part of the consortium bidding for the concession, however this is presumed unlikely if multiple mini-grid operators are operating in a given concession area.
- Should the mini-grid operator choose to become a sub-licensee, regulated tariffs will apply to the customers attached to the isolated mini-grids, which are likely to be lower than what these customers were originally paying. The revenue generated by the isolated mini-grids from tariffs (and impact from the residual upfront CAPEX subsidy, if any) in the year prior to the transition (T_0) could serve as a benchmark for assessing the revenue requirement in the year

[8] The availability of RBF funds may also be limited by caps on the total support based on number of connections targeted, thus delivered on a first-come-first-serve basis.

of the transition (T_1). The actual revenue from tariffs in T_1 will be substantially lower owing to tariff regularization, which will need to be covered through a subsidy. Lessons from Cambodia may be relevant where after years of differentiated, cost-reflective tariffs for small power distributors, Cambodia introduced a subsidy that equalizes mini grid tariffs with those on the main grid while preserving a return on investment for the Small Power Distributor.[9]

Some open questions do emerge related to subsidy delivery and its impact on the mini-grid operator. For instance, mini-grid operator cash-flows would be impacted by reduced tariff revenues while transitioning to an annual cycle of subsidy provision. This does not account for the price elasticity of demand. Further, if the mini-grid operator is a sub-licensee, then the subsidy flows through the concessionaire. The concessionaire, in this case, would need to aggregate the revenue requirements of its own as well as of its sub-licensees to the regulator on an annual basis.

From the perspective of the private mini-grid operator, its business model continues to service the customers, although its revenue requirements are more closely regulated. By being within a regulated regime, its future capital costs associated with meeting growing demand or adding new connections will be remunerated under cost-of-service conditions, which is a major shortcoming of its original isolated business model. Should the concessionaire decide to extend the grid to the isolated mini-grid service area, it would further need to be clarified if the options available under the mini-grid regulation are still available to the now “sub-licensee”.

Summary for scenario 1

In summary, isolated mini-grids operating under willing-buyer/willing-seller tariff arrangements can potentially transition to an IDF-oriented regulated distribution framework as long as certain pre-conditions are met. These include: i) identifying the most appropriate point in the mini-grid project lifecycle for the transition to occur (with a view to reduce revenue uncertainty for the private sector and to reduce the asymmetry of information for the regulator); ii) effectively offsetting revenue reduction from aligning tariffs to regulated levels with guaranteed subsidies based on annually determined revenue requirements (backed by a legal agreement with the distribution licensee); iii) building capacity on the part of the regulator to benchmark and assess mini-grid economics; iv) ensuring that mini-grid financing programmes require annual regulatory accounting along the lines of distribution companies; and v) regulatory clarity for isolated mini-grids transitioning to a sub-licensee framework.

[9] ESMAP (2019), Investing in Mini Grids Now, Integrating with the Main Grid Later: A Menu of Good Policy and Regulatory Options, http://documents1.worldbank.org/curated/en/732841558714625815/pdf/Investing-in-Mini-Grids-Now-Integrating-with-the-Main-Grid-Later-A-Menu-of-Good-Policy-and-Regulatory-Option.pdf

Scenario 2: Isolated mini-grids with regulator-approved tariffs and supported by subsidies

Generally, mini-grids over a certain capacity threshold (usually 100 kW) are subject to some form of tariff regulation. In Uganda, these larger mini-grid developers propose tariffs to the regulator for review, while in Nigeria the regulator (NERC) has developed the mini-grid MYTO tariff calculator to guide developers in tariff determination; any deviations in tariffs proposed require a clear justification for approval by the regulator. While the approaches may vary, in a number of countries the regulators are already involved in guiding the tariff determination process for isolated mini-grids over a certain capacity. In this manner, the regulators exercise judgements on what constitutes cost-reflective rates for a given mini-grid based on a reference internal rate of return, as well as other benchmarks for capital and operational costs, and financing structures. The subsidy would be an exogenous input to the tariff determination process, having been secured by the developer in the form of grants, concessional equity or loans. Any subsidy received by the isolated mini-grid will result in some adjustment in the determination of its regulated revenue requirement by the regulator.

Under these conditions, transitioning to an IDF-compliant distribution regime would essentially require that the entity responsible for distribution in the area of the mini-grid integrates the isolated mini-grid within its distribution business model. This entails mini-grid consumers seeing tariffs transition to a different regulated regime – one dictated by the revenue requirements determined at the level of the distribution concession area rather than at the mini-grid level, potentially resulting in reductions in tariffs. The emerging viability gap for the mini-grid operators will need to be bridged by subsidies channelled through the distribution licensee. The adherence to tariff determination methodologies and regulatory approvals pre-transition phase may result in better availability of information on the isolated mini-grid costs, revenues and other financial indicators that will be critical to ensure that the subsidy levels are set right to deliver a mutually acceptable return on investment. Indeed, the transition has to be transparent and planned for to ensure transparency in the process to reduce risks for private sector participation and investment.

Summary for scenario 2

In summary, isolated mini-grids with some form of regulator-approved tariffs are likely to transition to an IDF-oriented distribution framework with lower hurdles compared to the first scenario. On a case-by-case basis, particular attention has to be paid on the regulatory approval processes for isolated mini-grid tariffs and the additional steps (if any) needed to align with traditional regulatory principles of distribution (i.e., long-term remuneration schemes based on a cost-reflective revenue requirement computed

annually). As with the previous scenario, any viability gap emerging from reductions in revenues due to tariff adjustments need to be guaranteed with subsidies.

Scenario 3: Isolated mini-grids under uniform national tariff supported by subsidies

Tariffs are a major policy issue and, in some countries, such as Ghana, there continues to be a preference for uniform national tariffs to be imposed on isolated mini-grids. Uniform national tariffs are only viable for mini-grids if significant subsidies are available, which requires commitment from the government (or donors) to ensure that the support is available in a transparent and predictable manner[10]. For instance, in Ghana, it is estimated that for a 140 kW solar mini-grid with a 100 kVA diesel backup generator to provide electricity at the uniform national tariff, ongoing operational cost subsidies would be needed in addition to a 100% capital cost subsidy[11].

The large subsidy requirements for mini-grids, potentially covering both capital and a fraction of the operational costs, can be too much to be borne by the government or donor. It may also negatively affect the permanence of projects with limited incentives on the part of the operator to ensure quality service delivery. In developed electricity systems, portions of population in isolated areas are connected to mini-grids and participate of the uniform national tariff, since the higher costs are cross-subsidized by the population connected to the main grid (ESMAP, 2017)[12]. Such models may be explored if uniform national tariffs are imposed on mini-grids, however replicability may be limited given large shares of rural, unelectrified populations in many low-access countries.

Isolated mini-grids developed under a uniform national tariff regime are well-positioned to transition to an IDF-oriented distribution system. Mini-grid consumers will be exposed to the same tariff regime, while subsidies can be integrated into the broader consumer base of the distribution licensee (utility) which may allow for cross-subsidization. For mini-grid operators, the subsidy delivery will now be channeled through the distribution licensee based on an annual review of revenue requirements. It is likely to introduce greater certainty for subsidy delivery compared to an earlier approached dependent on availability of public (usually donor) funds. A key limitation of this approach may, however, be the attractiveness of the model to attract private

[10] ESMAP (2019), Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers.

[11] ESMAP (2017), Mini Grids for Timely and Low-cost Electrification in Ghana, https://openknowledge.worldbank.org/bitstream/handle/10986/29017/121824-ESM-GhanaESMAPGhanaTechnicalReportDECclean-PUBLIC.pdf?sequence=1&isAllowed=y

[12] This is just part of a generalized cross-subsidization scheme at national level, since distribution costs are different in rural, peri-urban and rural areas,

sector investments given the large role of ongoing subsidies in the viability of the business model.

Summary for scenario 3

In summary, while isolated mini-grids under a uniform tariff regime usually face tremendous viability challenges owing to large upfront (and even operational) subsidy requirements, these are likely to transition to an IDF-oriented distribution system relatively easily. With limited impacts on tariff revenues for operators, the shift in subsidy regime to one based on annually computed revenue requirements is likely to provide greater security to operators as well as incentivize them to undertake further capital investments to improve quality of supply.

Considerations for existing and upcoming isolated mini-grid programs

While scaling-up isolated mini-grids can provide immediate gains in electricity access, existing and upcoming programs to support their adoption can provide the building blocks for a future transition of the mini-grids to a regulated distribution system – where distribution is understood in a broad sense, encompassing the three modes of electrification. It entails an "entity" to be responsible for distribution activities in a given concession area and with a mandate to reach universal access applying the principles of cost-of-service across all three electrification modes. The transition is crucial to ensure that no-one-is-left-behind, permanence of supply is guaranteed and an optimum electrification approach covering all three modes is maintained.

Existing isolated mini-grids could, therefore, be transitioned to the new paradigm and the implications of this will vary depending on the local contexts and regulations as discussed under the selected three scenarios earlier. The following considerations can be identified to be important for mini-grid progams, as well as regulators and other stakeholders, to consider:

1. **Stress test mini-grid business and financing model for regulatory transitions:** With varying conditions at the national-level, the business and financing models of isolated mini-grids needs to be better understood for their capacity to transition to a differing regulated regime at various stages of project lifetime.
2. **Anticipate and address information asymmetry:** A key impact point on mini-grid business models of a regulatory regime transition is that of tariffs and revenue generation. Alignment with the broader regulated tariff regime is likely to see a decrease in retail tariffs for mini-grid consumers. The decrease in revenue needs to be compensated by an equivalent subsidy computed as part of the aggregated revenue requirement for distribution activity conducted across the entire territory (through a mix of electrification modes). For regulators

to evaluate revenue requirements of mini-grid operators, internal accounting of mini-grid projects and information on business plans need to be available over a period of time. Existing mini-grid financing programs and regulatory requirements need to ensure this information asymmetry is addressed by establishing requirements for standardized reporting[13]. The extent of information asymmetry may vary depending on the existing regulatory exposure of isolated mini-grids – where tariffs are required to be approved by regulator or are required to follow a determined methodology, the asymmetry is likely to be lower compared to those mini-grids developed under a willing buyer/willing seller arrangement.

3. **Provide clarity for mini-grids subject to multiple regulatory regimes through project lifetime:** With a growing number of countries introducing dedicated mini-grid regulations to facilitate deployment, overlapping regulations may be applicable to mini-grid operators over the project lifetime. For instance, transitioning to an IDF-compliant distribution approach will likely require mini-grid operators to become sub-concessionaires/franchisees whose revenue requirements will be within the purview of the regulator guided by the distribution concession agreement. How this transition will impact specific protections offered to isolated mini-grids under the mini-grid regulation (e.g., main grid arrival implications) needs to be managed to ensure smooth transition.
4. **Compatible mini-grid infrastructure with grid to facilitate transition:** As already required with many mini-grid regulations, grid-compatible mini-grid infrastructure should be deployed to facilitate the transition. In the case of main grid arrival, mini-grid generation and distribution assets can be utilized in an integrated system with the operator picking from a menu of post-integration options (e.g., small power producer, small power distributor, asset buyout) as prescribed by mini-grid regulations.
5. **Building regulator capacity to assess mini-grid business and financing models:** Under a regulated regime, traditional annual tariff reviews based on aggregated revenue requirements of distribution licensee will also need to include inputs (e.g., O&M costs, capital expenditure, cost of capital, subsidies) from isolated mini-grids and other off-grid installations (e.g., solar home

[13] Nigeria's mini-grid regulation already provides a starting point for addressing this asymmetry with the requirement for mini-grids over 100 kW of utilizing MYTO methodology for tariff determination (which captures elements of revenue requirements) and, where a direct agreement exists between the mini-grid operator and the community, the regulator still retains the right to intervene and adjust tariffs if the rate of return of the operator exceeds a usual non-recourse commercial debt interest rate in local currency and with adequate tenure for such projects +6%.

systems). Adequate capacity will need to be built within the regulatory bodies for the determination of the Regulated Asset Base for distribution licensees with different electrification modes, and ensuring adequate returns to investors.