ASR WORKING PAPER

SUSTAINABLE AND SCALABLE BUSINESS MODELS FOR MINIGRIDS

AFRICAN SCHOOL OF REGULATION

SUSTAINABLE AND SCALABLE BUSINESS MODELS FOR MINIGRIDS

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Working Paper
DECEMBER 2022

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Summary

A very large number of minigrids must be deployed in Africa to achieve the goal of universal electricity access in the continent by 2030, according to estimates by the minigrid industry and well-known international organizations. Most of the large volume of capital that is needed must come from private investors, and this will only be possible if business models for minigrids can be defined that are financially viable and can maintain this condition permanently, i.e., if the business models are ***sustainable***. In addition, it is necessary that these business models ***can be scaled up*** to the necessary dimension, both in terms of the required financing and the technical and managerial capability of the minigrid developers to install all the minigrids identified in the electrification plan.

Despite the favourable projections, minigrids have failed resoundingly in Africa and everywhere else over many years to have a significant impact on electricity access. This paper explains that minigrids cannot attain the relevance they should unless the sustainability of their business model is resolved and implemented through necessary regulatory measures. The paper focuses on the specification of the fundamental regulatory conditions, business model designs, and financial approaches necessary to attain sustainability – a necessary but not sufficient condition for scalability – which is not examined here beyond the regulatory, business model and financial aspects that are common with achieving sustainability.

First, the paper presents the challenges involved in defining sustainable business models for minigrids, both from the viewpoint of the private investor and of the government of the country. Second, it highlights two fundamental conditions that are indispensable to attract the massive amounts of private capital needed to deploy all the minigrids that must be installed to achieve universal access to electricity: cost of service remuneration and adaptation to each particular situation of the universally accepted versions of cross-subsidisation. Finally, this technical note stresses the importance of addressing the electrification process with an integrated perspective in several dimensions: i) considering the three modes of electrification together – grid extension, minigrids, and standalone systems – at the planning stage; ii) defining regulatory and business models for each mode that are easily compatible among these modes; and iii) using a single comprehensive approach to finance the entire electrification plan.

2 International Energy Agency (IEA), "Africa Energy Outlook", 2022. https://www.iea.org/reports/africa-energy-outlook-2022, as well as Mattson, B., Sinha, M. and Brent, W. "Scaling solar hybrid minigrids: An industry roadmap", 2022. Husk Power. https://huskpowersystems.com/new-roadmap-says-minigrid-industry-needs-10-companies-with-10-times-current-scale-to-achieve-universal-energy-access-and-sdg7-2/

1. The role of minigrids in the electrification process.

The importance of electricity as a key enabler for economic and social development is indisputable. Electricity access that is reliable, sustainable, and affordable is critical to achieve most of the Sustainable Development Goals (SDG). However, at present in Africa, 600 million people, or 43% of the total population, lack access to electricity, most of them in sub-Saharan Africa, and many more only have access to unreliable power. More than 80% of Africans without electricity access live today in rural areas. It is widely acknowledged that the current electrification pace is woefully slow to achieve universal access by 2030, as stipulated in the SDG7. Without additional measures, 565 million people will still be without access to electricity in 2030,[3] with very different projections for individual countries.

Many countries, in Africa and elsewhere, have created rigorous techno-economic geospatial electrification plans, which show in great detail the least-cost path to universal electricity access for prespecified levels of demand and reliability of supply.[4] The majority of these plans show that the solution of minimum cost typically consists of a fraction of customers[5] to be supplied by extending the main grid, while others must be connected to minigrids or supplied with standalone systems.

For sub-Saharan Africa it has been estimated that more than 200,000 minigrids will be necessary to supply approximately 32% of the people that will be gaining access until 2030 assuming that universal access is achieved, with a cost of about 127 billion (10^9) US dollars.[6] In general, electricity supply with minigrids is the least expensive solution for clusters of population with the right combination of low aggregated potential demand and sufficient distance to the existing distribution grid. Even for population clusters close to the grid or already connected to it, minigrids are the only workable solution when the incumbent distribution company lacks the resources or the incentives to connect more customers and to provide a reliable supply. The added value of minigrids must not be underestimated. Minigrids can be deployed quickly, basically anywhere. If properly designed, minigrids can be integrated in the main grid if it happens to arrive to their location.

3 International Energy Agency (IEA), "Africa Energy Outlook", 2022. https://www.iea.org/reports/africa-energy-outlook-2022
4 Ibid. See also the MIT/Comillas Universal Energy Access Lab https://universalaccess.mit.edu/#/main for the electrification planning approach.
5 The term "customers" is used instead of the more common "consumers", since a rapidly increasing number of agents that are connected to the grid can generate and store energy, in addition to consuming it.
6 See footnote 2.

Minigrids can provide reliable power 24 hours per day not only for residential demand, but also for productive and community uses. Minigrid developers are usually more inclined than the incumbent distributors to engage with end customers in promoting demand growth for productive and community uses, as their income critically depends on the volume of demand and the economic situation of their customers.

2.The barriers to the deployment of sustainable minigrids at scale.

Despite the need for a massive deployment of minigrids in Africa, only about 20,000 have been deployed so far, and the current pace is lower than 1000 minigrids per year.[7] With a few exceptions, these existing minigrids were built with the help of direct capital subsidies. Besides their number being hugely inadequate, in general these minigrids lack a viable business model that will give some guarantee of permanence when the developers must confront the costs of new investments in capacity and connections, as well as operation and maintenance in the absence of the initial subsidies that made the deployment of these minigrids initially possible. Clearly, this is not the path to raise 127 billion USD for the construction of the 200,000 minigrids that must be built by 2030 in Africa.

Minigrids count with several key favourable factors: they are needed in vast numbers, solar-based minigrids with batteries are expected to continue their remarkable path of cost reduction, the technology is available and proven, and there would not be scarcity of capital if business models with a reasonable risk level would exist, because there are powerful investors interested in this kind of business with positive impacts on human development and climate change mitigation. The problem is one of scale and financial and technical sustainability. The minigrid developing companies are presently too small for the task at hand, since for the most part they have depended on the supply of subsidies from donors and concessional loans; therefore, their contribution is limited, because the organizations whose

7 Ibid.

motivation is not an attractive return on their investments – philanthropic donors and development financial institutions – can only contribute a small fraction of total expenditure in minigrids that is needed. Moreover, in general these organisations are not interested in long-term commitments, and therefore they typically choose to provide initial capital subsidies, which result in business models that are only sustainable for a few years – until new investments are needed – and end up with high abandonment rates.

So far there is no consensus on what a viable business and regulatory model for minigrids could be. As indicated by one of the pioneering minigrid companies recently: "What is missing is a clearly defined pathway for minigrid developers to get to sustainability and scale."[8]

3. Sound traditional regulation for electricity distribution.

Sound regulation is the golden thread that must be followed to find solutions to the last-mile electricity distribution problems. There is a long and mostly successful experience in the regulation of electricity distribution by grid extension. Distribution by connection to the main national grid has been universally considered to be a regulated monopoly, i.e., the best solution is a single company with the responsibility to distribute electricity in a predefined territory with exclusivity and subject to meeting established minimum reliability targets.

The most important lesson that can be drawn from the universal practice of distribution regulation is that the annual remuneration of the distribution company – the "revenue requirement" – must be determined by the regulatory authority on the basis of the total cost of providing the service efficiently. The computation must be done following well-established regulatory practices and including reasonable remuneration for the invested capital that is consistent with the characteristics of the distribution business and the considered country. Ignoring this fundamental rule makes it impossible to attract substantial private capital for distribution.

8 Ibid.

In addition, regulators may establish penalties or credits associated with actual performance in specific areas, such as energy losses, reliability of supply, revenue collection, or a number of new connections. The end customer tariffs for every year must be set to produce sufficient revenues to pay the revenue requirement for that year.

Also, almost universally, all the customers in any given country (or sometimes all the customers supplied by the same distribution company) belonging to the same customer class (by the level of connected capacity, annual demand, or both) pay the same tariff, regardless of whether they are urban, semi-urban, or rural consumers. This urban/rural cross-subsidization among customers is universally accepted, despite the fact that distributing electricity in rural areas – especially in faraway places from the major urban centres – may be several times more expensive than distributing it in major urban agglomerations. Other common cross-subsidization among customers is established among those who consume more energy per month and those who consume less; typically, the former pay higher per-unit tariffs than the latter. In many developing countries industrial customers subsidise residential customers by paying higher-than-cost-reflective tariffs per unit of consumption. In countries with uniform tariffs but several distribution companies with different costs and customer mixes, transfers of funds among the companies are established so that each receives its cost of service. What can be learned from these successful experiences for the problem at hand?

Adaptation to less than fully electrified countries.

In many developing countries where universal access has not yet been achieved, the distribution activity – i.e., the provision of electricity to the end customers – must be contemplated more broadly, since a combination of grid extension, minigrids, and standalone systems is necessary to attain full electrification. The minigrid and standalone components of this "extended distribution activity" can be performed by multiple agents in competition, which favours innovation, cost reduction, and customer engagement, although this competition should also be regulated in the interest of a sound long-term vision of the power sector in a given country (which must include universal electricity access), as discussed below.

This additional complexity must not be an excuse to abandon the two key lessons that have been learned from many years of experience worldwide in electricity distribution: i) the principle of remuneration based on the efficient cost of service with a reasonable return on investment (RoI),

and ii) the social acceptance that an essential commodity like electricity must have the same price for all customers receiving similar service over an entire country, or at least, if several distribution companies exist in a country, for all the customers of each one of them. Abandoning these two fundamental rules in non-fully electrified countries has undesirable consequences.

Cost of service remuneration.

If the principle of remuneration of the cost of service is not respected,

i) the service provided by the incumbent distribution company will deteriorate and it will refuse to extend the grid in rural areas, which has a higher per-unit cost than the average tariff for those already connected (typically including most of the urban customers that can be electrified at a low cost);
ii) only the minigrids whose cost can be paid by the communities – typically with some anchor load(s) willing to cross-subsidise the tariffs of residential customers or that can rely on a donor – will be deployed; if a cross-subsidization scheme cannot be organized and agreed, the minigrid will only supply productive users under willing-buyer / willing-seller agreements; and
iii) only the households and firms that are able to pay for a standalone solar system will have one.

Thus, without cost-of-service regulation universal electricity access will never be achieved. The incumbent distribution companies will not extend the grids in rural areas as required by the national electrification plan. Communities that cannot afford the cost of supply of minigrids will be left behind, as well as those customers separate enough from clusters – so that the least cost solution for them is not a minigrid but an individual system – who cannot pay the cost of that individual system. The principle of remuneration based on the cost of service must be the bedrock upon which to build viable business models for the incumbent disco, the minigrid developers, and the providers of solar home systems.[9]

Cross-subsidization mechanisms.

If the socially accepted principle of "same price of electricity for similar service" is abandoned, poor rural customers supplied by minigrids and solar home systems will end up paying much higher prices than the customers connected to the main grid.

9 For the viability of distribution companies see the documents on concessions for electricity distribution at the African School of Regulation website https://africanschoolregulation.org/2022/10/international-conference-on-concessions-in-the-power-sector-learning-from-practitioners/

Since the service provided by standalone systems may not be equivalent to that of the main grid or minigrids, and their business models are different in general, these two electrification modes must be examined separately, although under the same fundamental regulatory principles. In what follows we shall focus on the case of minigrids and leave the standalone systems for another paper.

Note that the classification of customers according to which of the three electrification modes they fall within will evolve with time as the level of demand will grow, and the main grid will gradually expand. Therefore, the natural thing to do, being consistent with the universal practice of cross-subsidisation among urban and rural customers, is to apply equal per unit tariffs for all customers in the same consumption category, regardless of whether they are supplied by the main grid or a minigrid, since in principle all of them receive a similar class of access. This provides a solution to the vexing problem of having poor rural customers connected to minigrids and being subject to much higher tariffs than those connected to the main grid, who typically are more affluent. However, this approach introduces the need for transfers of funds between distribution companies and between these and the minigrid developers.[10]

In addition to the by-and-large socially accepted uniform tariffs, the other common versions of cross-subsidisation that have been mentioned previously suggest ideas that can be used to design an integrated approach to financing the entire electrification plan of a country, to be presented later. Before that, it is necessary to examine how to achieve sustainable business models for minigrids.

4. Sustainable business models for minigrids.

Here, ***sustainability*** of the business model is understood in the strict meaning of permanence or being able to remain financially viable indefinitely. The broader sense of sustainability, which is being able to create value for all the stakeholders without depleting the natural, economic, and social capital the business activity relies on, must be also considered, but it is not the subject of this paper. It is impossible for the minigrid sector to attract the necessary volume of capital if its underlying business model is not financially sustainable.

10 This is not a fiction; these transfers already happen in those countries with uniform tariffs and more than one distribution company. If preferred, these multilateral transfers can be avoided by making use of a centralized automatic scheme for reception of the collected revenues and their distribution to the agents respecting the agreed transfers, as it is done, for instance, in Spain.

Sustainability of the business models for minigrids must be examined from two perspectives. On the one hand, the "investors" who will finance, install, operate and maintain the minigrids. On the other hand, the "governments" that must create appropriate conditions – via regulation, legal security, subsidies, and guarantees – for the investors to do their part.

As indicated above, some minigrids can be and have been deployed with support from development partners or rural electrification agencies (typically mostly funded by development partners too) via financing schemes that usually consist of subsidies to cover a part of the totality of the initial investment costs. In general, these business models are not sustainable in the mid and long terms. Other group of minigrids can take advantage of the existence of local anchor loads – industrial or commercial loads of enough size – to cross-subsidise residential tariffs; even other minigrids may find clusters of customers that are able to pay the true costs of service, but these two kinds of minigrids are presently in short supply. Here we are concerned about the regulation and the business models that will be necessary to deploy and operate sustainably all the remaining minigrids – which probably are the immense majority – that are necessary to achieve universal electricity access in any given country in a reasonable time horizon.

Here it is assumed that there is the willingness – shared by the government of the considered country, the development partners, and other stakeholders – to achieve universal electricity access in a reasonable time (hopefully on the SDG7 timeframe of 2030 or even earlier), following an integrated electrification plan that includes all three electrification modes, in a sustainable manner that is consistent with a sound long term vision for the power sector, and that is focused on the economic and human development of the affected communities.[11]

Sustainability from the viewpoint of the investor.

A sustainable business model for minigrids requires investors/operators to function in a "utility-like" mode, i.e., committed to permanence in the supply of electricity. Private investors can only be attracted and be expected to remain if they receive remuneration with a satisfactory RoI and the legal security that this situation will continue for a period of time sufficiently long to recover their initial investment, as well as further investments that will be necessary as the business develops.

11 A detailed discussion on the conditions that are required for a successful electrification process can be found in the working paper Perez-Arriaga, I., Nagpal, D., Jacquot, G. and Stoner, R. (2021), "Integrated Distribution Framework: Guiding principles for universal electricity access", Global Commission to End Energy Poverty, Working Paper Series. https://static1.squarespace.com/static/5d371cb401986300013881d3/t/5fc69ef13c6ccf69f34825fa/1606852340478/2020-integrated-distribution-framework-guiding-principles.pdf

Present uniform tariffs for main grid and minigrid customers that have been designed to cover the cost of supplying the existing already electrified customers cannot recover the total cost of supply of the new minigrids, since the per unit cost ($/kWh) of what remains to be electrified in rural areas is always higher than the average cost of what has been already electrified. Therefore, if uniform tariffs are applied, there will always be a "viability gap" between the total cost of supply with the new minigrids and the revenue collected with the uniform tariffs from the customers of these minigrids. The challenge is how to cover this viability gap, and this will be examined next.

Covering the viability gap.

If the already indicated business models with pitfalls that do not ensure sustainability are avoided, and the minigrids with anchor loads willing to subsidize residential demand are left aside, as well as those minigrids with customers able to pay the true total costs, the following approaches can be considered as candidates for sustainability of minigrid business models at scale, ordered from lower to higher level of sustainability:

A) Direct subsidies to minigrid developers obtained from some governmental electricity access program.

Governmental programs typically have a limited budget and duration and are linked to political priorities. Therefore, the risk that a governmental subsidy will disappear or be modified after some time is considered to be high.

To reduce the risk for private investors of a governmental minigrid program that includes direct subsidies to minigrid developers some sort of compensation fund would be needed that i) must be independently and professionally managed, ii) capitalized using a well-defined and transparent procedure, and iii) backed up to some limit with guarantees from some development financial institution(s). When possible, because of the country's situation, cross-subsidization schemes introduced in the tariffs provide a strong level of risk reduction for the payment of subsidies

B) Direct subsidies to minigrid developers from cross-subsidization embedded in the tariffs.

This approach significantly increases the legal security associated with the subsidy, once it is implemented, since the subsidy remains permanently embedded in a highly technical procedure managed by the regulatory authority, as it is the case with the diverse types of subsidies that were mentioned before.

The initial implementation can find social opposition since it will increase the tariffs for some segments of customers and electricity tariff increases are usually conflictive and may have political implications.

This approach is limited by the volume of subsidy that is tolerable, given the impact on the tariffs. In countries where the percentage of non-electrified demand is low – a few percent, for instance, in most Latin American countries still without universal access – cross-subsidization can pay for the total cost of the electrification plan. In countries where this percentage is higher, cross-subsidization can only partly contribute to the viability of the business model of minigrids.

Another implementation topic is the method of transferring the subsidy to the minigrid developers, since the funds for the subsidy are collected from the tariffs of grid connected customers, who belong to the incumbent distributor – usually a different company from the minigrid developers. This may require a centralized public agency that collects some levy from the distributors to be employed in the subsidies to the minigrids. The cross-subsidization between the urban and rural customers connected to the main grid happens automatically via the uniform tariff since all of them belong to the same company.

C) Direct subsidies to minigrid developers included in a concession contract.

A concession to develop minigrids is an agreement in which a firm – the concessionaire – obtains from the government of the host country the right to supply electricity under the conditions that are specified in a contract. These conditions include the period (20 years is a typical figure), the right to sell and distribute electricity in the concession area with specific exclusivity rights, termination of the agreement, and the right to be beneficiary of the viability gap funding. All these conditions are generally described in great detail in the contract, which, if properly written, provides strong legal security to the concessionaire.[12]

Further regulatory topics.

This is not the end of the regulatory analysis for sustainability. The economic viability of the minigrid business critically depends on the level of risk – actual or perceived – of the business model. Thus, regulation must try to eliminate or at least reduce substantially this risk.

12 Hosier, Richard; Bazilian, Morgan; Lemondzhava, Tatia; Malik, Kabir; Motohashi, Mitsunori; Vilar de Ferrenbach, David (2017). "Rural Electrification Concessions in Africa: What Does Experience Tell Us?" World Bank. https://openknowledge.worldbank.org/handle/10986/27476 provides an excellent general description of the types of concessions and the numerous experiences in the power sector. The International Finance Corporation (IFC) Scaling Mini-Grid Program, "Concession Agreement User Manual" (2022) is an excellent reference document for this topic. See
https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/infrastructure/priorities/power/scaling+mini-grid

Foreign exchange is an important source of risk, due to the fact that usually financing is made in hard currencies like USD or euros, while the revenues of the utility are obtained in the local money. This topic will not be covered in this paper, which focuses on the regulatory and business model design aspects. Development financial institutions can design mechanisms to mitigate this risk.

Probably the other major source of risk for a minigrid is the arrival of the main grid to the site of the minigrid. In the first place, this risk can be reduced if the incumbent distribution company makes its plans to expand the grid known, and/or guarantees a minimum period of time during which the grid will not arrive. In the second place, regulation must be ready well in advance, specifying the options open to the developer in case the grid arrives; several countries have already passed regulations for this specific situation, with options typically ranging from i) staying as an independent supplier, to ii) becoming an independent power producer selling power to the grid at a specified price and being compensated for the residual value of the network which becomes part of the main grid, or ii) other intermediate options.[13]

Other risks are the arbitrariness in setting the taxes that apply to imported goods necessary to build minigrids, changes in administrative procedures, or the regulatory delay in updating the revenue requirement of the minigrids in the presence of increments in the costs of equipment, labour, or other components of the total cost of supply with minigrids. Obviously, everything is facilitated if the investors manage to reduce the cost of the project.

Nothing has been said yet about how it is decided which developer has the right to deploy a minigrid in some particular place. This topic is examined in detail in the next section on the governmental perspective.

Sustainability from the viewpoint of the government.

When the regulation and the business models for minigrids are contemplated from the governmental perspective, several new topics must be considered: i) to make sure that the electrification plan is actually implemented, i.e., that nobody that should be supplied with minigrids is left behind;

See, for instance:
IRENA, "Policies and regulations for renewable energy minigrids", October 2018.
https://www.irena.org/publications/2018/Oct/Policies-and-regulations-for-renewable-energy-mini-grids
IRENA, "Policies and regulations for private sector renewable energy minigrids", September 2016.
https://www.irena.org/publications/2016/Sep/Policies-and-regulations-for-private-sector-renewable-energy-mini-grids
OKAPI, "Beyond Off-grid: Integrating Mini-grids with India's Evolving Electricity System", 2017.
https://shaktifoundation.in/wp-content/uploads/2022/01/Integrating-Mini-grids-with-Indias-Evolving-Electricity-System.pdf

ii) to contemplate a long term vision of the power sector, in particular from the point of view of the deployment of minigrids, avoiding balkanization of the power system and facilitating an orderly transition towards a mostly connected delivery of power throughout the country; iii) to ensure the overall financial viability of the electrification plan; iv) to implement carefully designed transitory measures to start making progress towards full electrification, without jeopardizing the more comprehensive long-term approach that is outlined in this paper and which make take longer to be adopted.

Ensuring inclusivity.

Ideally, a cost-reflective remuneration with an attractive RoI should suffice to attract mini-grid developers to deploy all mini-grids included in the national electrification plans and to guarantee their sustainability. In practice, some intervention may be needed to make sure that some "default and last resort provider" will install and operate minigrids where others do not want to go and will take control of providing the service where others quit supplying.
Several solutions are possible, with the usual pros and cons. There are two extreme options with intermediate versions:

- One extreme option is total freedom of installation, with no other constraint from the government or the regulator than to abide by the national electrification plan (if it exists). In other words, only the minigrids that have resulted from a national electrification plan can be built. The annual "revenue requirement" – i.e., the annual remuneration – for each minigrid will be regulated, as well as the tariffs for the end customers, resulting in a viability gap to be covered by one of the methods previously described. This option maximizes the freedom of installation of the developers and the facilitation of entry; however, it may result in a balkanized power system with many different owners, technologies, and companies that might be too small to benefit from economies of scale. This option would probably fail to achieve complete electrification, despite the fact that cost of service remuneration would be mandatory, since some parts of the country might have low appeal for investors.

- At the other extreme, the only option to deploy a minigrid is to win one of the tenders for groups of minigrids organized by the government. If there is enough competition, tenders may reveal the efficient cost of installing, operating, and maintaining a minigrid. But tenders can be slow and add a substantial bureaucratic burden to the process, particularly for small developers.

Tenders lead naturally to contracts, which can adopt the format of long-term concessions and therefore can provide strong legal security, if properly drafted. Under equal conditions, the government may give priority to the bids coming from the distribution company that is geographically closest to where the minigrids will be located; this measure will reduce the balkanization of the power sector.

• Among the intermediate versions, one can think of acceptance of unsolicited offers to deploy, operate and maintain minigrids under a concession agreement, to be negotiated with the government or to be allocated under restricted competitive conditions.

An alternative to the use of tenders to guarantee inclusivity would be to agree with one of the minigrid developers to play the role of "default and last resort provider", being compensated for it with some regulated payment. The selected developer will be a normal off-grid solutions company for all purposes, with the exception that it must be ready to respond to requests by the government to build and operate the mini-grids in the national electrification plan that others do not build and to take charge of any mini-grid business that disappears.

Ensuring compatibility with a long-term vision of the power sector.

Balkanization of the power sector by allowing multiple minigrid developers supplying in the same territory – even if the sites are the ones defined in the national electrification plan – may create compatibility and organization problems in the future, when most customers finally become connected to the main grid and makes it difficult to exploit economies of scale. It seems preferable to let competition function in the allocation of concession contracts for specified territories that are sufficiently large and compatible with the specification of electrification modes in the national plan. Regulation must be ready to specify in detail how to deal with minigrids that are operating already in the concession area under "willing buyer – willing seller" conditions and the existing options for the minigrid developer "if the main grid arrives."[14]

Ensuring the financial viability of the electrification plan.

The regulatory and business model – in its different versions – that has been presented in the preceding section ensures sustainability from the viewpoint of the minigrid developers, and therefore must be able to attract private capital if the payment of the subsidies is guaranteed.

14 Ibid. The regulation in several countries deals already with this topic.

However, it remains to verify if this business model for minigrids is financially viable from the viewpoint of the government of the country. In other words, if the government will be able to pay the subsidies to the minigrids and for how long.

This question cannot be answered by looking only at the sustainability of the minigrids business model, since the government is responsible for the viability of the entire electrification plan. Each country must prepare a financial analysis for the adopted national electrification plan, considering the three electrification modes together, rather than in silos, as it is usually done. Financing an electrification plan must be contemplated in an integrated way, thus making it possible to pool together the contributions of the revenues from the regulated tariffs, the contributions from governmental agencies, plus the private equity and debt, and the concessional funds and guarantees provided by development partners – development financial institutions (DFI) and philanthropic donors. In addition, it is advisable to explore the utilization of the cross-subsidization mechanisms that are customarily used in electricity distribution worldwide, as described before.

The role of the government is to finance with grants, equity, or debt the viability gaps of the three modes of electrification and – in some cases – also a fraction of the cost of new investments, more frequently those of grid extension. Part or all of this contribution usually comes from development financial institutions (DFI) under concessional conditions. Except for the grants, all other contributions of the government must be repaid with interest via the revenues collected by the application of regulated tariffs. Note that this intervention of the governments as funders and also as intermediaries with the banks may be limited, if the country reaches the limit of its sovereign debt that is dictated by the present borrowing criteria of the DFI and the commercial banks.

The financial analysis from the perspective of the governments will result in different diagnostics, depending on the situation of each country. In some countries the electrification plan will be financially viable, meaning that the capital costs of the equity and debt that must be raised by the government of a country to pay subsidies to the developers of minigrids and standalone systems and to shoulder the costs of grid extension to achieve full electrification by 2030 can be paid every year with the revenues from the tariffs, and perhaps also recurring to grants from the government and development partners, until a sustainable regime is reached in a reasonable period of time (2040, for instance).

Other countries will have to struggle to come up with a financially viable electrification plan. Limits to the amount of sovereign debt may impose hard constraints on the level of borrowing and financial guarantees that some countries can incur. Finally, other countries will have to postpone the date beyond 2030 to achieve full electrification, so that their plans can be financially viable.

Achieving sustainability from the perspective of the governments requires creating confidence in the development partners and private investors that the plan is financially viable. $127 billions for minigrids (only investment cost, i.e., not including administration, operation and management costs) will not be raised without a solid techno-economic electrification plan, a credible business and regulatory model, and a viable financial plan. And given that in the end the credibility resides in the governments – who are ultimately responsible for both grid extension and standalone systems – an integrated financial plan for the complete electrification plan will be necessary.

Adoption of transitory measures

Most minigrids, as well as standalone systems, will be a transitory solution for electrification, because in the medium and long term "the main grid will arrive" to most off-grid population clusters and all or most off-grid solutions will become connected to a national power grid, as it is the case in most countries where full electrification has been achieved. As it was indicated in the section on "further regulatory topics" specific minigrid regulations must be developed to provide guarantees and reasonable measures to terminate the minigrid business model with an adequate compensation or to continue it under different conditions.

Accepting non-viable minigrid business models transitorily, under the condition to turn them into viable ones in a prescribed period of time is a risky "quick-and-dirty" approach to accelerate electrification or to compromise with organisations that do not want to "waste time" negotiating a better business model with the regulatory authorities. In this case, transitory measures can be adopted to finance some fraction of the necessary expenditures of the total amount of minigrids that are necessary, while the three stages in the process of electrification planning – tecno-economic analysis, business and regulatory model, and integrated financial plan – are defined, agreed with all the stakeholders, approved by the regulators, and carried out. These transitory measures can save some time, which is becoming very scarce, although compatibility of these partial projects with the comprehensive sustainability perspective outlined in this paper is of the essence.

And it is critically important because, for building the investors' trust for the entire minigrid development plan that is needed, there is no way to avoid the complete painstaking analysis – technical, economic, regulatory, and financial – of the integrated electrification plan, which cannot be replaced by wishful thinking, as it frequently happens. Every so often, well-meaning relevant organizations pledge large volumes of funding devoted to minigrid programs, without any indication about the regulatory and business models that necessarily must be adopted, so that the effort is not wasted because of lack of sustainability and scalability.

The advice that can be given regarding these transitory measures is to accept that the initial phase will start from the "dark side of the Force" – i.e., those unsustainable and non-scalable business models that can be implemented quickly – and then move in a second phase to the "bright side" as soon as the sustainable and scalable approach is ready. To minimize irreversible damage, it is important that the decision and the procedure to change the business model from the dark side to the bright one is made clear from the outset.[15]

During the initial transitory phase, it can also be tried to extend the number of minigrids that can be economically viable without subsidies or with the minimum amount of subsidies, to maximize what can be done with the funding made available by the financing organisations. The following ideas can be useful in this respect:

- Estimate the affordability level of the residents in any communities that are considered of potential interest, for instance learning how much the households are presently spending on energy services (lighting, phone, entertainment, domestic appliances).
- Analyse the design of low cost minigrids to identify opportunities of reducing the total cost of supply (reduced time of service, less expensive components, make use of volunteer community support, use the available funding from donors) and find out if some customers can pay the resulting cost of service.
- Gradually expand the service to more members of the rural communities as the economic situation improves and the costs of supply become lower.

15 This working paper defines the conditions to transit from the initial unsustainable business model to the sustainable one: Nagpal, D., Perez-Arriaga, I. (2021), "Integrating isolated mini-grids with an IDF-compliant regulated distribution sector: A long-term perspective towards universal electricity access", Global Commission to End Energy Poverty, Working Paper Series. https://static1.squarespace.com/static/5d371cb401986300013881d3/t/5fc69fc52dd96f5918d626d6/1606852550226/2020-integrating-isolated-mini-grids.pdf

5. Achieving scale

Sustainable and scalable business models for minigrids are indispensable to achieve full electrification by 2030. But sustainability alone does not guarantee the required level of industrial scale, i.e., that the minigrid developers can deliver minigrids at a sufficient rate to meet the established SDG7 target. Sustainability is a necessary but not sufficient condition for scalability.

The average installation rate today by the top 10 companies is less than 100 minigrids per year each. Since the objective is to deploy 200,000 minigrids in Africa by 2030, and assuming that these 10 companies will install 90% of the total amount, each company might be able to install more than 2000 minigrids per year. Therefore, reaching the established target would require each company to attain an installation rate 20 times faster than today's.[16] This implies a radical change in how most minigrid companies organize and operate their businesses: logistics, operations, and supply chain management. The analysis of this transformation of the minigrid industry falls beyond the scope of this paper, which is the analysis of the regulatory, business model and financial aspects of electrification with minigrids.

16 Estimates provided by Mattson, B., Sinha, M. and Brent, W. "Scaling solar hybrid minigrids: An industry roadmap", 2022. Husk Power. https://huskpowersystems.com/new-roadmap-says-minigrid-industry-needs-10-companies-with-10-times-current-scale-to-achieve-universal-energy-access-and-sdg7-2/

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An excellent taxonomy of regulatory and business approaches for minigrids, with recommendations very much aligned with this technical note.
UNIDO (2020). "The Clean Energy Mini-Grid Policy Development Guide"
https://www.unido.org/sites/default/files/files/2021-03/CEMG_Development_Guide_EN.pdf

A comprehensive program for scalable deployment of minigrids that develops in detail the conceptual approach proposed in this technical note.

The International Finance Corporation (IFC) Scaling Mini-Grid Program (2022).
https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/infrastructure/priorities/power/scaling+mini-grid

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https://www.esmap.org/Mini_Grids_for_Half_a_Billion_People_The_Report

Jonathan Phillips, Benjamin Attia, and Victoria Plutshack (2020). "Lessons for Modernizing Energy Access Finance – Balancing Competition and Subsidy: Assessing Mini-Grid Incentive Programs in sub-Saharan Africa", Duke University, Energy Access Project.
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OKAPI, "Beyond Off-grid: Integrating Mini-grids with India's Evolving Electricity System", 2017.
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An excellent taxonomy and review of experiences of distribution concessions in Africa:

Hosier, Richard; Bazilian, Morgan; Lemondzhava, Tatia; Malik, Kabir; Motohashi, Mitsunori; Vilar de Ferrenbach, David (2017). "Rural Electrification Concessions in Africa: What Does Experience Tell Us?" World Bank.
https://openknowledge.worldbank.org/handle/10986/27476

The African School of Regulation organised a Conference on distribution concessions in March 2022. A summary and auxiliary documents can be found in:
https://africanschoolregulation.org/tag/conference/

A detailed manual of minigrid concessions:

The International Finance Corporation (IFC) Scaling Mini-Grid Program, "Concession Agreement User Manual" (2022).
https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/infrastructure/priorities/power/scaling+mini-grid

Recent initiatives on ambitious programs of minigrid development.

The World Bank Distributed Access through Renewable Energy Scale-Up Platform (DARES)
https://bit.ly/3iplOaE

The Africa Minigrids Program ("AMP") of UNDP, GEF, and RMI.
https://sdgfinance.undp.org/products-and-country-experiences/africa-minigrids-programme-amp

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