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The Electricity Access Index Methodology and Preliminary Findings

An Initiative of the MIT-Comillas Universal Energy Access Lab

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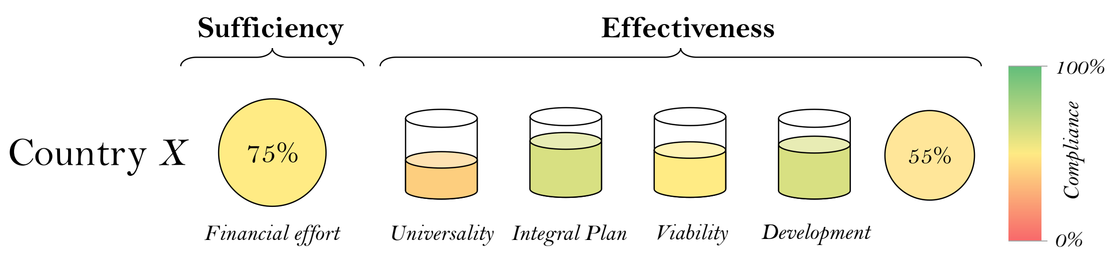
EXECUTIVE SUMMARY

In the world, 759 million people lacked electricity access in 2019, with Sub-Saharan Africa accounting for three-quarters of the global population without access. The annual rate of new connections slowed down during the pandemic, and with the current policies more than 670 million people may still lack access by 2030, completely missing the UN Sustainable Development Goal 7.1 (by 2030, universal access to affordable, reliable and modern energy services).[1] Adequate instruments are required to assess progress towards SDG7.1, signalling the main hurdles to electrification and the regions and countries that require an enhanced effort.

The Electricity Access Index, developed by the MIT-Comillas Universal Energy Access Lab for the Global Commission to End Energy Poverty[2], evaluates the electrification progress in a country by examining the current level of effort in the distribution segment of the electricity supply chain (both on- and off-grid) to achieve universal electricity access by 2030, from two perspectives:

- The *sufficiency* of the volume of effort, in economic terms, by comparing the volume of the current financial effort made by the country with that necessary to achieve universal electricity access in this decade (this determines the percentage in the sufficiency circle in the figure), while also verifying if such necessary effort would be financially viable (this determines the colour of the circle).
- The *effectiveness* in the allocation and utilisation of the current expenditure, by examining the compliance of the present effort to sound electrification principles: universality, conformity with an integral plan, economic viability, and focused on development.



[1] This target has two indicators. Indicator 7.1.1: Proportion of population with access to electricity. Indicator 7.1.2: Proportion of population with primary reliance on clean fuels and technology. The index described in this report only addresses access to electricity, although in principle it could be extended to clean cooking, heating and other energy uses.

[2] See https://universalaccess.mit.edu and https://www.endenergypoverty.org.

The main goal of the Electricity Access Index is not to provide a country ranking on universal access, but rather to stress which aspects of the electrification strategy must be improved in each country and to show the gap in the financial effort that should be filled, while also indicating how difficult will be to comply with SDG7.1 at individual country scale.

This working paper presents in detail the methodology to compute all the components of this multi-dimensional index. The methodology has already been tested on a number of countries that have not achieved full electrification yet. Although the results of this initial assessment are not shared in this document, some preliminary findings can be drawn:

- Without detailed and reliable data to track electrification efforts (both on- and off-grid) at country scale, it is not possible to follow progress, set achievable milestones, or identify areas where efforts must be urgently enhanced to achieve SDG7.1 globally. This aspect should be urgently improved, and focus must be placed on every country individually, making use of the expertise and information available.
- As underlined by other reports,[3] the current financial effort devoted to electrification is not sufficient to achieve universal access by 2030. Actually, with the financial instruments and current market and regulatory constraints, a significant number of countries simply cannot have a financially viable electrification plan compatible with SDG7.1.
- Regardless of the volume of effort currently being devoted to universal access, the electrification strategies of several countries fail to comply with sound principles. This may result in suboptimal electrification solutions and hamper the economic efficiency of the interventions that are being deployed.
- Aggregated assessments on universal electricity access, which condense information at a regional scale (e.g., Central America, East Africa), miss key aspects of the electrification effort that can be only identified at national scale. Countries belonging to the same region may face very different conditions.

These findings are just a preview of the picture – for each country and from an all-countries perspective – that can be obtained through the Electricity Access Index, which could represent a powerful tool to policymakers, development agencies, donors, NGOs and investors involved in universal access.

[3] See, https://www.seforall.org/events/high-level-dialogue-on-energy, for instance.

WHAT IS THE GOAL OF THE ELECTRICITY ACCESS INDEX?

As recognised by the United Nations through its inclusion as the seventh Sustainable Development Goal (or SDG7) of its 2030 Agenda, access to sustainable, reliable and affordable energy is a key element for the development of the economy and the society as a whole and an essential facilitator for all the rest of SDGs (UN, 2021). Between 2010 and 2019, 1.1 billion people gained access to electricity worldwide, bringing the global access rate from 83% to 90% (WB, 2021). The annual rate of growth reached 130 million people in the period 2017-2019, outpacing population growth globally, although not in every region. And preliminary data show that the global number of people without access was broadly stuck or increased in the period 2019-2021, mainly due to the impact of the Covid-19 pandemic, which hampered electrification efforts and amplified affordability issues (IEA, 2021).

In the world, 759 million people lacked electricity access in 2019, with Sub-Saharan Africa accounting for three-quarters of the global population without access. Worldwide, there is a significant urban-rural divide, with 84% of the global population without access living in rural areas. Accounting for population growth, 940 million people will have to gain access to electricity by 2030 in order to comply with SDG7.1.[4] According to all consulted studies, global investments are not on track to achieve this goal (RF, 2020) and, with the current and planned policies, more than 670 million people may still lack access by 2030 (IEA, 2021). New instruments are required to assess progress towards SDG7.1, signalling the main hurdles to electrification and the regions and countries that require an enhanced effort.

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[4] "Ensure universal access to affordable, reliable and modern energy services by 2030". This includes electricity and clean fuels. This document only addresses the target on electricity access.

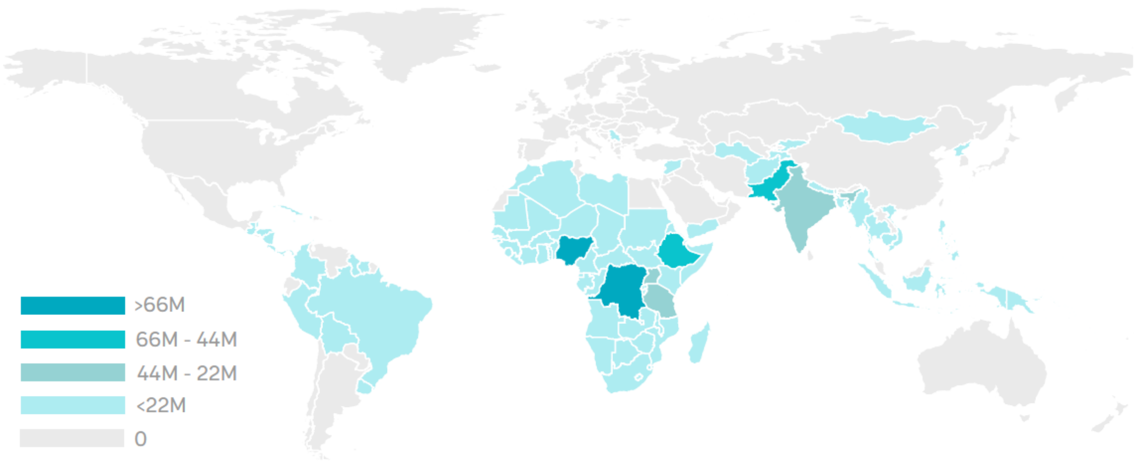

Figure 1. Population without access to electricity, millions of people (total); chart from WB (2021)

The Electricity Access Index, developed by the MIT-Comillas Universal Energy Access Lab for the Global Commission to End Energy Poverty, assesses at country level, whether the electrification effort is on track to reach universal access by 2030 from a quantitative perspective (the sufficiency component) and from its conformity to sound principles of electrification (the effectiveness component).

The Electricity Access Index is meant to detect the need to intensify electrification efforts, to warn about the insufficiency of the present financing instruments and institutions to attain universal electricity access in many countries, and to point out to possible deviations in the present electrification strategies in a country with respect to broadly accepted best international practices. The outcome of the Electricity Access Index is not a static description of the current degree of electricity access in a country, but rather a comparison between the trajectory of actual financial efforts towards universal access and the path that a country should follow to achieve SDG7.1, plus an objective assessment of the financial viability of the SDG7.1-compatible path.

WHAT IS THE SCOPE OF THE ELECTRICITY ACCESS INDEX?

The scope of the Electricity Access Index is defined based on the assumption, corroborated by many real-world experiences, that the distribution segment is the critical bottleneck to achieve universal access. In the context of this study, distribution is meant to encompass all those “last-mile” activities to supply electricity to end-users, including not only conventional on-grid distribution and retailing tasks, but also off-grid solutions (minigrids and stand-alone systems) that involve assets, as generation and storage, that commonly exceed the scope of distribution.

Distribution has historically attracted a very little share of private investments in the electricity sector of those countries that have not yet achieved universal access. This is especially true in Sub-Saharan Africa, where private capital flows into transmission and distribution sectors (T&D) are virtually zero (RES4Africa, 2021), as presented in Figure 2. Other reports (SEforALL, 2021) show how T&D receive a very minor share of electricity investments, and this minor share commonly targets large transmission projects.

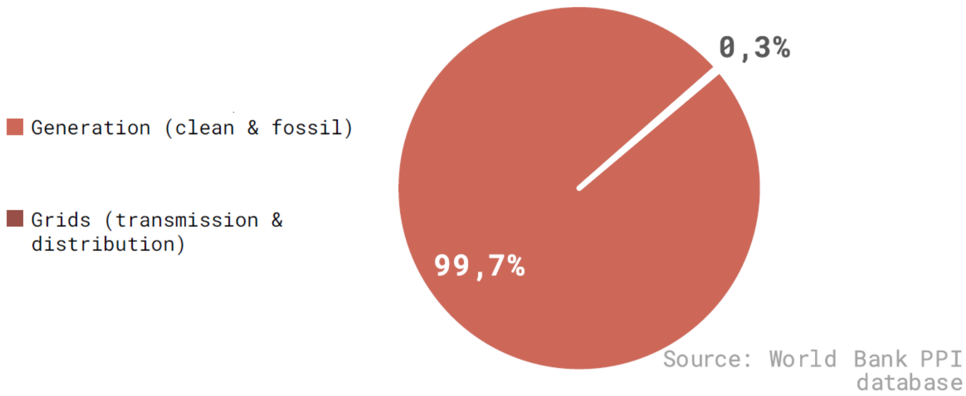

Figure 2. Private investments in the electricity sector of ten focus countries in Africa (Algeria, Ethiopia, Ghana, Kenya, Morocco, South Africa, Tanzania, Uganda, and Zambia) in the period 2010-2020. (RES4Africa, 2021)

Failures in the distribution segment of many low-access countries are dramatically hampering universal access to electricity. Distribution companies commonly face significant financial distress, and this provokes viability challenges that hinder the mobilisation of the substantial public and private investment needed to expand grid-based electricity access. The lack of a proper regulatory framework, encompassing the distribution activity, has a negative impact also on off-grid solutions, and recent growth of minigrids and stand-alone systems has occurred largely in silos. To reach universal access by 2030, new business models for distribution must be defined that leave no one behind, ensure permanence of supply, integrate the various electrification modes (on-grid and off-grid), and align with a vision for the long-term, sustainable development of the power sector and the economy.

The Electricity Access Index, therefore, focuses on the distribution activity. In its *sufficiency* component, it compares the financial effort that is presently dedicated to achieving universal electricity access in the distribution segment with the one required to reach SDG7.1. But sufficiency must also examine if the country would be able to financially sustain the level of effort compatible with full electrification by 2030. Here, effort is not defined only in terms of investments, but also of operational costs; the latter are usually ignored in most assessments on universal access, although they are of paramount importance to guarantee the permanence of the service. The financial effort must be defined in terms of TOTEX (total expenditures) in on- and off-grid distribution, as the summation of CAPEX (capital expenditures) and OPEX (operational expenditures). The *effectiveness* component of the index also focuses on the distribution activity, but now comparing the current practice of the electrification activities with the sound principles for universal access mentioned above and to be described in detail later (GCEEP, 2021).

WHY A NEW INDEX?

Electricity access cannot be assessed through simple quantitative metrics, such as the percentage of the population being provided with the service. Most of the experts nowadays agree that a multi-dimensional approach is necessary, and several institutions have made contributions in this direction. Excellent indexes have been developed in the last decades to measure energy access through this multi-dimensional perspective. The best example is probably the well-known Multi-Tier Framework, or MTF, developed by the Energy Sector Management Assistance Program (ESMAP) of the World Bank. As regards electricity, the MTF evaluates access in a country using the following attributes: i) capacity, ii) duration, iii) reliability, iv) quality, v) affordability, vi) legality, and vii) health and safety. Based on these attributes, tiers from zero to five are defined through the definition of thresholds (ESMAP, 2015) and they are studied in different contexts (e.g., urban vs. rural; households, business, and community facilities). This approach allows a more accurate characterisation of electricity access in a country, which goes well beyond the simple percentage of electrified households, as it can be observed in Figure 3 for Ethiopia.

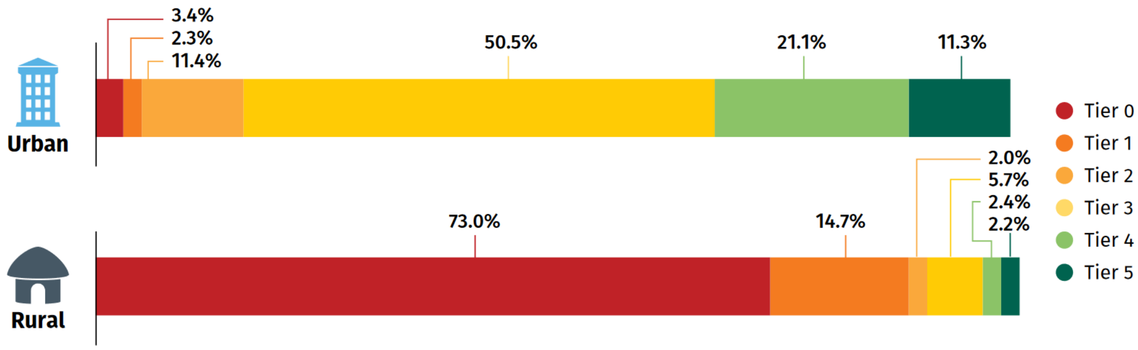

Figure 3. Electricity access in Ethiopia through the lens of the MTF approach (ESMAP, 2018)

Other reports[5] by several institutions working on this topic track investments in universal access and, in some cases, compare these expenditures with the ones required to achieve SDG7.1 (SEforALL, 2021; WB, 2021). Nonetheless, in these documents, data are commonly aggregated for very wide regions, without a country-by-country granularity, or across the different activities within the power sector (generation, transmission, and distribution). However, these activities have

[5] A comprehensive review of other indices related to universal access can be found in Annex I: Review of indexes relevant for universal access

a very diverse impact on granting access to new end-users and are subject to different conditions in terms of regulation and risk for the agents. Furthermore, as already mentioned, the vast majority of these studies focuses on capital expenditures, while electrification projects require large operational expenditures to provide the permanence of the service and a total-expenditure approach is necessary when analysing project financing.

With this background, and taking advantage of all these relevant studies, the Electricity Access Index follows a novel multi-dimensional approach to achieve the following objectives, which are not covered by any existing index on universal access.

- The index focuses on the distribution activity, both on- and off-grid, which has revealed to be the critical bottleneck to achieve universal access to electricity.
- The index has a country-level granularity, since countries, although located in the same region, may have very different conditions from the perspective of universal energy access, in terms of access gap, soundness of energy policy and regulation, financial viability of the distribution sector, or access to finance.
- The index is based on a TOTEX (CAPEX + OPEX) approach, considering all the costs that need to be covered to achieve full electrification and to maintain it over time.
- The index does not limit the analysis to the identification of the total costs required to achieve SDG7.1, but it also assesses how these costs should be financed, based on a financial plan tailored to the conditions in each country.
- The index goes beyond the current picture on the status of electricity access in a country and delves into the reasons behind such a status, assessing the major hurdles that are hindering a faster development of universal access and the elements of the electrification strategy that should be improved.

THE DESIGN OF THE ELECTRICITY ACCESS INDEX

In order to achieve the above-listed objectives, the Electricity Access Index has been structured around two main components:

- The *sufficiency* component measures the volume of financial effort currently being devoted in a country to universal access and compares it with the effort that would be required according to a sound and SDG7.1-compliant electrification strategy; furthermore, the sufficiency component also evaluates the viability of that SDG7.1-compliant plan from a financial perspective for the considered country.

- The *effectiveness* component assesses whether the present volume of financial effort devoted to electrification at distribution level is being deployed so that it can produce the desired results in the best possible way. This assessment is made by analysing the compliance of the national electrification strategy with sound electrification principles.

The two components depict very different but complementary aspects of the electrification process in a country. While the sufficiency ratio compares the present volume of effort with what would be necessary to attain universal access by 2030 – but also verifying if that necessary effort would be financially viable – the effectiveness evaluation indicates whether this current effort is well employed, with an implementation according to sound principles. Note that the sufficiency component not only evaluates if the present level of expenditure is enough to achieve the desired SDG7 target, it also examines the financial viability of a hypothetical electrification plan that would attain universal electricity access by 2030, assessing whether this plan would be financially easy, challenging, or impossible to accomplish.

The following subsections provide a more detailed description of each component. Further information, together with the detailed methodology, can be found in Annex II: Detailed Design of the Electricity Access Index.

4.1 The sufficiency component

As explained before, the sufficiency component examines the situation of the electrification process in a country from a double perspective. First, it is computed how much of the expenditure that would be needed to achieve universal access is actually covered by the present effort in the considered country (Figure 4). The comparison is made in annual terms, and it includes all the costs that must be incurred to meet SDG7.1.

The present financial effort devoted to universal access is obtained from data in publicly available sources[6] about existing projects of grid extension, minigrids, and stand-alone systems in each country (primarily from publicly available financial statements from relevant distribution companies and complemented with available reports on private investments deployed per country). The volume of annual expenditure goes to the numerator of the fraction in Figure 4. The amount in the denominator is obtained by developing the best possible financial

[6] These values are extracted from the OECD/DAC Creditor Reporting System. The OECD consolidates and categorizes the public financial support that donors (as the sum of official loans, grants, and equity investments) provide to developing countries for on- and off-grid projects. For details, see: https://stats.oecd.org/Index.aspx?DataSetCode=crs1

plan for a techno-economic electrification plan that achieves universal electricity access in 2030 in the country[7]. Therefore, for every country a detailed financial plan has been built, with a horizon of 20 years into the future, using the total cost annual values from the techno-economic electrification plan, the estimated income from regulated tariffs, and the best possible blended finance that would allow to meet common indicators for a business plan to be acceptable. The percentage x in Figure 4 can now be determined, but not the colour in the circle yet.

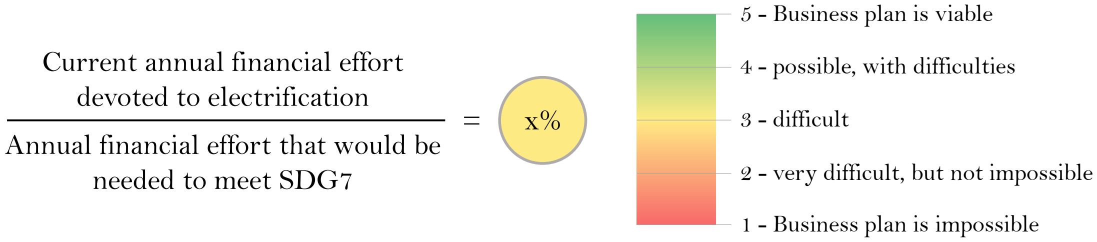

Figure 4. Graphical representation of the sufficiency component of the Electricity Access Index.

The second perspective focuses on the financial viability of the hypothetical business plan that has been used to compute the denominator in the fraction of Figure 4. The design of the business plan has been tested with some industry experts in infrastructures financing. These experts must assess whether the business plan for each considered individual country is financially viable or not, with the present institutions, criteria, and financial instruments. Financing an electrification plan that is technically viable may be impossible from a financial point of view for some countries, while it might be perfectly feasible for others. Experts must classify the financial viability of the business plan for each country into one the following categories: i) impossible; ii) very difficult, but not impossible; iii) difficult; iv) possible, with some difficulties; or v) viable. Such score is translated in a colour code (Figure 4) that, together with the percentage computed in the previous step, represents the sufficiency component of the index. Further details are presented in the Annex.

4.2 The effectiveness component

The effectiveness component is meant to qualitatively assess the compliance of the electrification strategy of a country with sound principles. These principles

[7] These values are obtained from National Electrification Strategies (when they exist and are SDG.7 compatible) or standard electrification plans such as the World Bank's Global Electrification Platform using the OnSSET model (https://electrifynow.energydata.info) – or our own analysis using the Reference Electrification model (REM) (https://universalaccess.mit.edu/#/main).

have been classified in four pillars[8], defined hereunder and presented graphically in Figure 5; they may look deceptively simple in theory, but they are very difficult to implement fully, and they are rarely applied in conjunction.

- A commitment to universal access that leaves no one behind. This requires permanence of supply and the existence of a utility-like entity with ultimate responsibility for providing access in a defined territory.
- Efficient and coordinated integration of on- and off-grid solutions (i.e., grid extensions, mini-grids and stand-alone systems). This requires integrated planning and appropriate business models to reach all types of consumers in the defined service territory.
- A financially viable business model for distribution. This will typically require some form of concession to provide legal security and ensure the participation of external and mostly private investors, as well as subsidies to cover the potential viability gap.
- A focus on development to ensure that electrification produces broad socio-economic benefits. This principle links expanded access to the delivery of critical public services (e.g. health, education) and productive uses and to the promotion of gender equality.

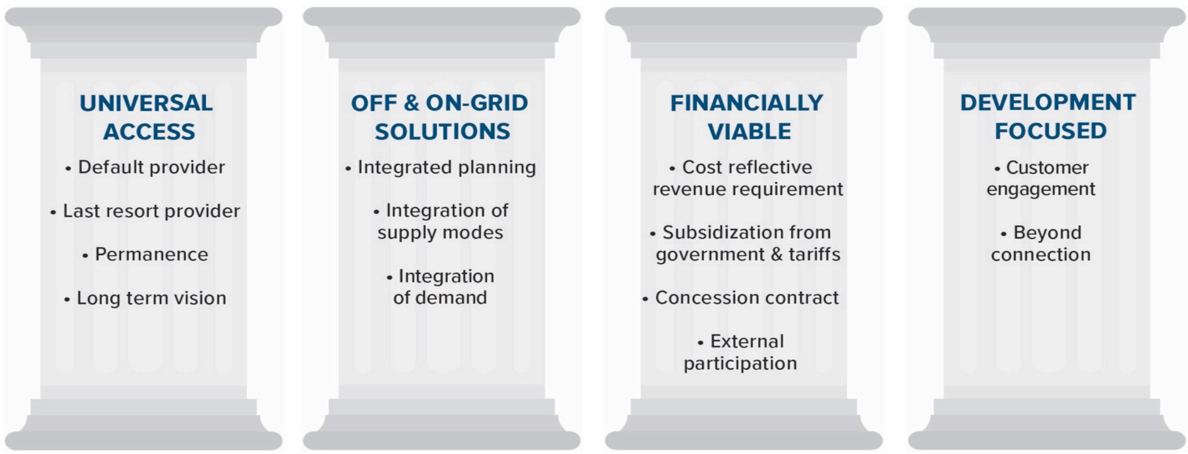

Figure 5. Graphical representation of IDF principles (GCEEP, 2021)

In the literature, it is possible to find renowned and reliable studies that aim to assess one or more of these aspects. The Regulatory Indicators for Sustainable Energy (RISE) computed by ESMAP (2020) encompass one pillar devoted to electrification planning, which assesses, through surveys with country experts, relevant topics as the framework for grid electrification, minigrids, and stand-

[8] These principles were condensed in the Integrated Distribution Framework (IDF), an approach to electrification proposed by the UEA Lab and applied in several projects in the context of the Global Commission to End Energy Poverty funded by the Rockefeller Foundations; for details, see https://www.endenergypoverty.org/.

alone systems, or utility transparency and creditworthiness. Other indexes and reports that do not focus on universal access, contain relevant information on the electrification strategy and the conditions that project developers have to face. The Electricity Regulatory Index (ERI) computed by the African Development Bank (AfDB, 2021) provides valuable information regarding the governance and the overall effectiveness of the regulatory frameworks of African countries. The well-known Doing Business report (WB, 2020) and the Global Competitiveness Report (WEF, 2020) present a clear picture of the private sector participation challenges.

However, none of the above-mentioned reports and surveys addresses the electrification strategy from the perspective required for the Electricity Access Index and the information they provide is not sufficient to evaluate all the principles outlined in Figure 5. Therefore, a specific 34-item questionnaire has been developed for the effectiveness component of the index. The questionnaire is sent to country experts, who are required to assign a score, from one to five, to each item. Items are divided among the four pillars presented above and this allows to compute, for each country being surveyed, a score for each pillar and the overall compliance with sound electrification principles. A colour code is also applied here to provide an intuitive graphical representation of the scores.

PRESENTATION OF THE OUTCOMES AND PRELIMINARY FINDINGS

5.1 Representative case studies

The sufficiency and the effectiveness components provide two different perspectives on the electrification process in every considered country, which are presented to the user without further aggregation. In fact, he main goal of the Electricity Access Index is not to provide a country ranking on universal access[9], but rather to stress which aspects of the electrification strategy are to be improved in each country and to show the gap in the financial effort that should be filled, while also indicating how difficult will be to comply with SDG7.1 at individual country scale. A possible presentation of the outcomes for three hypothetical countries is shown in Figure 6. These case studies do not reflect the reality of any specific country, but they represent a set of conditions that can be found in several jurisdictions that have not yet achieved full electrification.

[9] Given the multi-dimensional nature of the Electricity Access Index, it is not possible to generate a ranking, since a specific country may be well-positioned on a certain aspect, but it may perform poorly on another aspect of the electrification strategy.

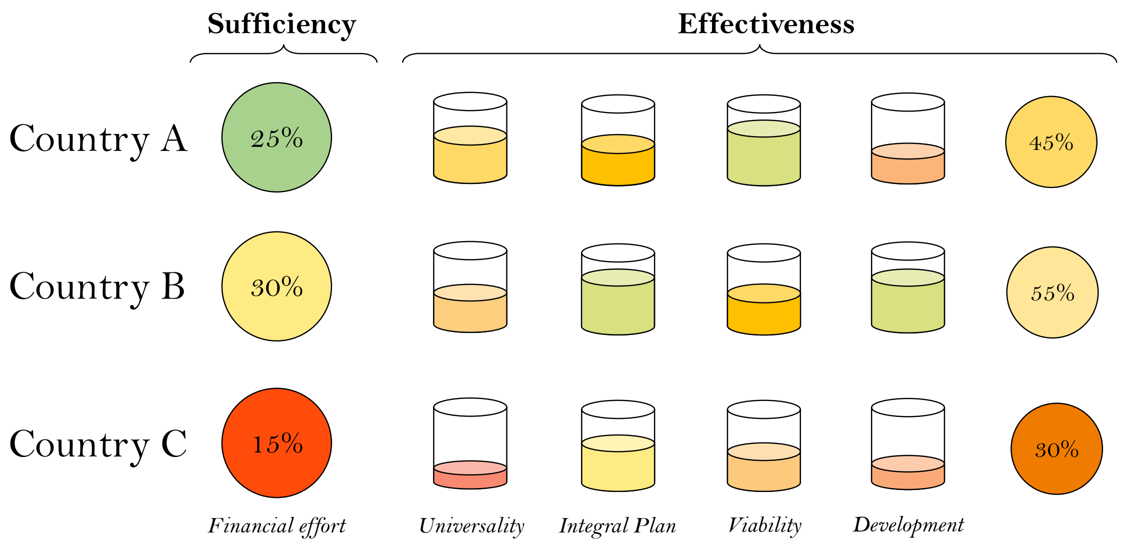

Figure 6. Possible presentation of the Electricity Access Index for three hypothetical countries

The information in Figure 6 on country A may portray some countries in Latin America or, more in general, some middle-income countries, which are only a few percent from reaching universal access, with the unelectrified population living in remote rural areas. The financial effort for this hypothetical country to achieve SDG7.1 is not large in absolute terms, and it could easily be covered, for instance, through a minor increase in the tariffs of connected end-users (green colour in the sufficiency component); however, the lack of political consensus to build and implement a viable financial plan results in a very slow-paced progress and therefore a low sufficiency percentage. The regulatory framework may assign clear responsibilities to the entities involved in electricity supply, but this role is not actually enforced, hampering the quest for universal access. Sound electrification plans, integrating different modes, have been developed and approved, but they are not being implemented. Electrification efforts are mainly driven by the intermittent or project-specific funding from development financial institutions or public funding. Electrification policies do not pay sufficient attention to productive and community uses.

The situation in country B may be typical of many developing countries that still have a significant electricity access gap and where substantial but largely insufficient electrification investments are taking place. Although the financial challenge is considerable, if sustained support from development finance institutions were provided and if a robust business model for private investors were defined, a sound business plan that achieves full electrification would be possible, with the financial costs of the plan being covered over a reasonable period of time after 2030 through demand growth and, perhaps, some moderate increase in electricity tariffs. However, presently the universality of electricity access is not strictly guaranteed, since the electrification plan from the government focuses on grid extension, while the deployment of minigrids and stand-alone systems is left to the private sector. Overall, the current plan may be financially viable, but the lack of support to off-grid electrification modes results in a slow overall progress in electrification at national level. On the other hand, the electrification strategy for the most part provides support for productive uses and incorporates a gender perspective.

The characterization of country C may reflect the situation of (mostly sub-Saharan African) countries that present a very small level of electricity access and would require a huge financial effort to achieve full electrification by 2030. Constraints on the sovereign debt impede the country to absorb the financial burden of achieving SDG7.1, donors can only cover a small portion of it, and private actors perceive a high risk due to the lack of a viable plan. The country will not be able to achieve SDG7.1 and the target should be moved forward. It is not possible to define a viable business model that allows to achieve the universality of the service. Some of the business models for the electrification activities being presently deployed are sound, but they can only be implemented on a small scale. Not enough attention is being paid to productive uses, which could foster demand and improve cost recovery.

These are only three examples of the different situations that could be revealed by the Electricity Access Index when applied to individual countries, as our research team is currently doing. These examples show the multi-dimensional nature of the Index, which may result in numerous different combinations of the sufficiency and effectiveness scores. The Index exposes the impossibility of ranking the countries by “progress made in electrification” using a single metric, as the situations are much more nuanced. The Index helps identifying the weak aspects in the electrification process of the countries and suggests corrective actions tailored to each individual situation.

5.2 Preliminary findings

Beyond defining the methodology to compute the Electricity Access Index as presented in this report, the MIT-Comillas Universal Energy Access Lab has also applied this methodology and calculated the multi-dimensional index for a small number of countries that are diverse enough to cover a wide spectrum of values for the index components. A future report will present the results of this analysis once a sufficient large number of countries have been evaluated. However, the assessment carried out so far permits to present some preliminary findings.

The first message is not a finding itself, but rather a warning bell for the community working on universal access. It is extremely hard to track electrification efforts in the distribution segment at the country level and to find reliable data to populate the model behind the Electricity Access Index. No global database is available and most of the relevant reports present these data at regional level. National institutions and private companies, when committed with transparency, may provide relevant information for on-grid electrification, but off-grid solutions may be implemented by other entities and go unrecorded. This data dispersion may look intrinsic to the complex and multi-actor framework of universal access. However, without a proper tracking of electrification efforts at the country level, it is not possible to follow progress, set achievable milestones, or identify areas where endeavours must be urgently enhanced to achieve SDG7.1.

Beyond this initial consideration, the following preliminary findings can be drawn from the assessment that is being carried out.

- As underlined by other reports, the current financial effort devoted to electrification, considering both capital and operational expenditures, is not sufficient to achieve universal access by 2030 in most of not-yet-fully-electrified countries. Actually, with the financial instruments and rules in place now, a significant number of countries simply cannot have a financially viable electrification plan compatible with SDG7.1. Not only is the current financial effort insufficient, but there is also no viable financial plan able to cover the required effort.
- Regardless of the volume of effort currently being devoted to universal access, the electrification strategies of several countries fail to comply with robust theoretical principles. This may result in suboptimal electrification solutions and hamper the economic efficiency of the interventions that are being deployed. Even if the volume of expenditure is aligned with the actual requirements of a country, this effort may fail if it is poorly implemented.
- Aggregated assessments on universal electricity access, which condense information at a regional scale, miss key aspects of the electrification effort. The starting point of any assessment should be represented by national techno-economic and financial plans developed at individual country level, reflecting all the peculiarities of the national context, in terms of electrification status, financial constraints, or regulatory environment. Countries belonging to the same region may face very different conditions; two neighbouring countries may have very similar electricity access gaps, but one of them may be unable to achieve universal access due to, for instance, constraints on the public debt or an inadequate regulatory environment.

These findings are just a preview of the overall picture that can be obtained through the Electricity Access Index. If computed for all the countries that have not yet achieved universal access, it is expected that more finding and insights will be attained and made available to policymakers, development agencies, donors, NGOs and investors.

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ANNEX I: REVIEW OF INDEXES RELEVANT FOR UNIVERSAL ACCESS

This annex reviews some indexes and metrics directly focusing on universal access and rural electrification or that can be relevant for the topic. The justification of why a new index is needed has been discussed in subsection 0; this section only provides an overview of existing indexes and metrics.

Tracking SDG7

The "Tracking SDG7: The Energy Progress Report" is a joint effort by the Custodian Agencies for Sustainable Development Goal 7 (SDG7) – IRENA, IEA, WB, UN, WHO – which provides the most comprehensive look available at the world's situation regarding global energy targets on access to electricity, clean cooking, renewable energy and energy efficiency.

The report gives the international community a global dashboard to register progress on three key targets:

- Ensuring universal energy access.
- Doubling progress on energy efficiency.
- Substantially increasing the share of renewable energy by 2030.

It assesses the progress made by each country on these targets and provides a snapshot of how far the world from achieving SDG7 is. Since the report is issued every year and the metrics used are consistent over time, it provides a measure of the progress being made. The same information is available per country and broken down into rural and urban populations. Figure 1 shows a world map based on the results of the Tracking SDG7 report.

The Multi-Tier Framework (MTF)

The ESMAP report "Beyond connections. Energy access redefined" proposes a multi-tier framework that can be used for measuring and goal-setting, investment prioritization, and tracking progress. This index captures the multiple modes of delivering energy access from grid to off-grid, including the wide range of cooking stoves and fuels. It also helps reflect the contributions of various programs, agencies, and national governments toward electrification. Energy use is divided among three so-called locales which are studied separately. ESMAP (2015) define locales of energy use as the broad locations of end use of energy for availing energy services; locales of energy use include households, community institutions, and productive enterprises.

For the household locale, the proposed multi-tier framework examines i) access to electricity, ii) access to energy for cooking solutions, and iii) access to energy for space-heating solutions as three separate sub-locales. Separate multi-tier frameworks are defined for each of these components. Separate indices of energy access are calculated for each of the components, defined as the average tier rating across households in the given area adjusted to a scale of 100. The overall index of household access to energy may be calculated as the average of the three sub-locale indices. A graphical representation of the outcomes of this assessment was presented in Figure 3.

For the productive engagement locale, the proposed multi-tier framework examines the energy supply vis-à-vis critical energy applications. Measuring energy needs for productive uses is a complex challenge. There are multiple types of productive enterprises, encompassing different scales of operation, varying degrees of mechanization, a multitude of energy applications, and a variety of energy supplies. Further, it is not possible to set norms of energy needs for different enterprises or applications to measure energy access deficits. Also, lack of adequate energy access may not be the only constraint to functioning and expansion of the productive enterprise, which may be constrained by raw materials, capital, land, skilled manpower, markets, transportation, government licenses, or other inputs. Specifying minimum energy needs of different types of enterprises would be a very cumbersome approach. Also, it is important to capture energy needs of small and micro enterprises and productive engagements in the informal sector, which are often not reflected in enterprise surveys that tend to focus on large enterprises. To address these challenges, an approach based on surveys of individuals for their key productive engagements and energy needs is proposed. Under this approach, energy access for productive engagements is aggregated across individuals, thus eliminating the need for reflecting the relative scale of operations of different enterprises. An index of access to energy for productive uses for any given geographical area can be calculated as the average tier level across all individual respondents in that area, adjusted to a scale of 100. In addition, sub-indices can also be calculated for various productive activities (e.g., small shops, artisans, or agriculture) by taking the average of tier levels across respondents engaged in those activities.

For the community facilities locale, five sub-locales need to be considered: i) health facilities, ii) educational facilities, iii) street lighting, iv) government buildings, and v) public buildings. Access to energy for each sub-locale can be determined based on surveys of either the users of the facility or the providers of the facility. The former requires a survey of households, whereas the latter requires a survey of the relevant community institutions. Whereas the former can only yield subjective and limited information, more detailed information can be obtained from the latter. Multi-tier frameworks are defined for each of the sub-locales, and separate indices are calculated based on the average tier rating for each sub-locale, adjusted to a scale of 100. The overall index of access to energy for community facilities is calculated as the average of indices across the five sub-locales.

For any geographical area, an overarching index of access to energy can be calculated as the average of the indices across the three locales—households, productive uses, and community facilities.

IIASA improved approach to measure energy access

According to IIASA (International Institute for Applied Systems Analysis), while the MTF is a significant enhancement to the earlier binary formulations of energy access, it is now too complex and conceptually muddled to track access at a global scale (Pachauri and Rao, 2020). A new framework is built based on the Multi-Tier Framework (Figure 7), which simplifies and advances the approach to identify the energy poor more accurately.

AF Measurement of Household Access to Electric Services

	Tier 0	Tier 1	Tier 2	Tier 3
Energy Supply Poverty				
Availability	None	<8hrs	8-16hrs	>16hrs
Cost of supply^	NA	NA	NA	NA
Energy Service Poverty				
Service level	None	*Minimal* (Lighting/ phone charging)	*Decent* + (TV | fridge| cooling)	*Affluent* + (other appliances)
Affordability (budget share)	NA	>10%	5-10%	<5%

Note: ^ The cost of supply is context specific

MTF Measurement of Household Access to Electric Services*

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Duration – Day Evening		≥ 4hrs	≥ 4hrs	≥ 8hrs	≥ 16 hrs ≥ 4hrs	≥ 23 hrs ≥ 4hrs
Quality					Voltage problems do not affect use of desired appliances	
Reliability Disruptions per week					≤ 14	≤ 3 of total duration < 2hrs
Capacity		≥ 3W	≥ 50W	≥ 200W	≥ 800W	≥ 2kW
Consumption levels, in Wh/day	<12	≥ 12	≥ 200	≥ 1,000	≥ 3,425	≥ 8,219
Affordability				Cost of standard consumption package of 365 kWh per annum is < than 5% of household income		

Note: * The MTF also includes dimensions - "Legality" & "Health and Safety"

Figure 7. A simplified alternative framework compared to the multi-tier framework for energy access measurement (Pachauri and Rao, 2020)

The framework distinguishes between two aspects of access: the quality of power supply and the circumstance of the end-user. This distinction is important to better direct policy efforts where they are most needed, i.e., to energy suppliers and/or to households. It also reduces the number of dimensions and tiers to simplify the MTF.

Instead of correlating energy consumption with energy access, a key advancement of the new framework is using ownership of different types of appliances as a proxy for measuring household amenities and services derived from the use of these appliances to improve wellbeing. Electricity consumption is a misleading measure of energy service, because for those who use inefficient appliances, more consumption does not translate into more service. For instance, a household using six inefficient light bulbs is not better off than one that uses three efficient high-luminosity light points and an efficient fan that provides comfort from the summer heat. The framework also improves on how affordability is measured to consider appliance purchase costs in addition to recurrent electricity expenditures in assessing the budget share spent on electric services.

When applied to real data, the framework suggests that the energy poor are more segmented than what is reflected by existing binary or MTF indicators. The categorisation of households according to electricity consumption differs markedly from that according to energy services and using appliance ownership, revealing greater heterogeneity among the energy poor than what is reflected in the MTF consumption-based indicator.

In addition, the new framework shows that affordability is even more of a constraint to gaining access to modern electric services for households in Ethiopia, India, and Rwanda than reflected by the MTF. According to the MTF indicator of affordability, practically no one in Ethiopia or India would be considered unable to afford electricity access. However, if one includes the discounted cost of appliances needed to consume electricity in the indicator, about a third of the population in India and Ethiopia might be categorized as facing issues with affordability. In Rwanda, even without considering the discounted cost of appliances, most electricity consuming households are faced with affordability constraints to using basic electric services at home.

The Modern Energy Minimum

The Modern Energy Minimum is a new global electricity consumption threshold proposed by the Energy for Growth Hub. The analysis is performed at country level. In simplified terms, the reasoning is mostly based on two empirical relationships:

- A “quasi-linear” relationship between national GNI per capita and national average electricity consumption (kWh per capita).
- A frequent national ratio of 30% residential consumption vs 70% non-household consumption (industrial, commercial, agriculture and transport) consumption.

The conclusion is drawn that for a country to get to a low-middle income status ($2511 per capita) the annual per capita consumption level must be 1000 kWh and 300 kWh per capita should be the Modern Energy Minimum to be set as an objective of electrification (Figure 8).

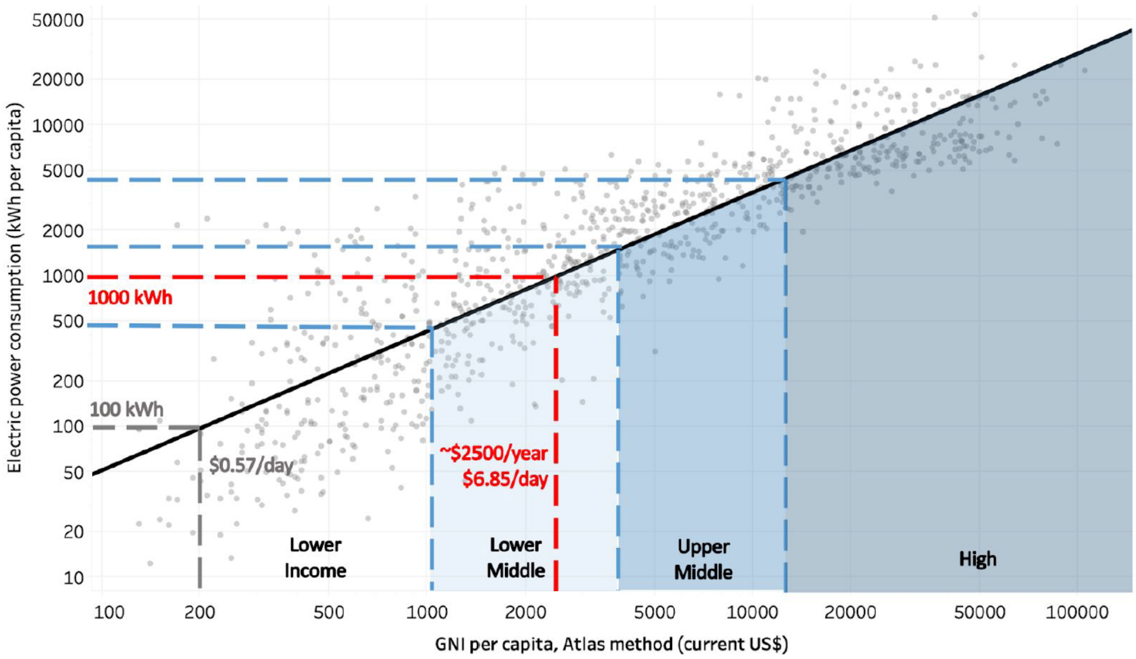


Figure 8. Electricity consumptions and income level through the lens of the Modern Energy Minimum (Energy for Growth Hub, 2020)

It is therefore suggested to count people that have achieved electricity access as those that: i) consume at least 300 kWh/year at home and ii) live and work in an economy with average non-residential consumption above 700 kWh per capita.

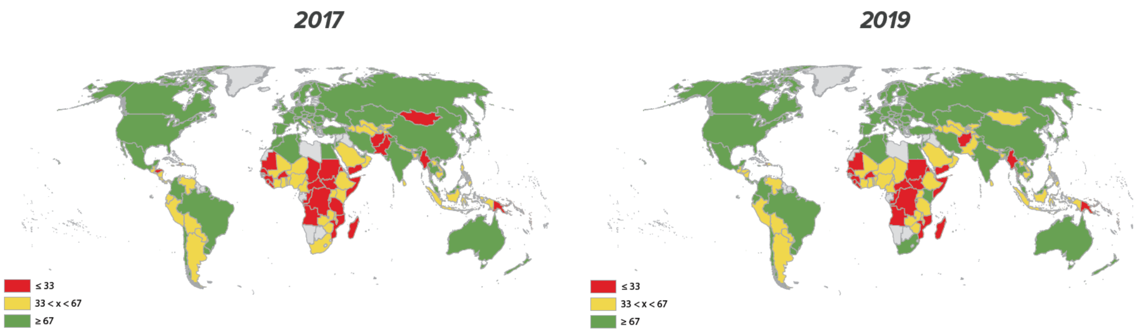
Regulatory Indicators for Sustainable Energy (RISE)

RISE is a set of indicators to help compare national policy and regulatory frameworks for sustainable energy. RISE assesses countries' policy and regulatory support for each of the four pillars of sustainable energy, i.e., i) access to electricity, ii) access to clean cooking (for 55 access-deficit countries), iii) energy efficiency, and iv) renewable energy. With over 30 indicators (Figure 9) covering 138 countries and representing over 98 percent of the world population, RISE provides a reference point to help policymakers benchmark their sector policy and regulatory framework against those of regional and global peers, and a powerful tool to help develop policies and regulations that advance sustainable energy goals. Each indicator targets an element of the policy or regulatory regime important to mobilising investment, such as establishing planning processes and institutions, introducing dedicated incentives or support programs, and ensuring financially sound utilities. Together, they provide a comprehensive picture of the strength and breadth of government support for sustainable energy and the actions they have taken to turn that support into reality.

ELECTRICITY ACCESS	• Electrification plan • Grid electrification framework	• Framework for standalone systems • Utility transparency and monitoring	• Scope of the electrification plan • Framework for mini grids	• Consumer affordability • Utility creditworthiness
CLEAN COOKING	• Planning	• Scope of planning	• Standards and labeling	• Incentives for clean cooking solutions
RENEWABLE ENERGY	• Legal framework for renewable energy • Incentives and regulatory support for renewable energy	• Network connection and use • Carbon pricing and monitoring	• Planning for renewable energy expansion • Attributes of financial and regulatory incentives	• Counterparty risk
ENERGY EFFICIENCY	• National energy efficiency plannin • Incentives and mandates: Public sector • Minimum energy performance standards	• Transport sector • Energy efficiency entities • Incentives and mandates: Utilities	• Energy labeling system • Carbon pricing and monitoring • Incentives and mandates: Industrial and commercial end users	• Financing mechanisms for energy efficiency • Building energy codes

Figure 9. RISE pillars and indicators (ESMAP, 2020)

RISE classifies countries into a green zone of strong performers in the top third of the 0-100 score range, a yellow zone of middle third performers, and a red zone of weaker performers in the bottom third (Figure 10).



Source: World Bank, RISE 2020.

Figure 10. Evolution of RISE scores worldwide (ESMAP, 2020)

The Electricity Regulatory Index (ERI)

The Electricity Regulatory Index measures the level of development of electricity sector regulatory frameworks in 43 African countries and the capacity of regulatory authorities to effectively carry out their relevant functions and duties. The ERI is made up of three pillars or sub-indices: the Regulatory Governance Index (RGI); the Regulatory Substance Index (RSI); and the Regulatory Outcome Index (ROI).

The ERI scores are calculated based on responses to comprehensive surveys distributed to electricity sector regulatory institutions, and utilities in African countries with confirmed regulatory authorities. Based on the responses to the surveys, each indicator in the sub-indices is assigned a score between 0 and 1. Figure 11 shows the result of such assessment for 2021, with the colour code specified in the legend.

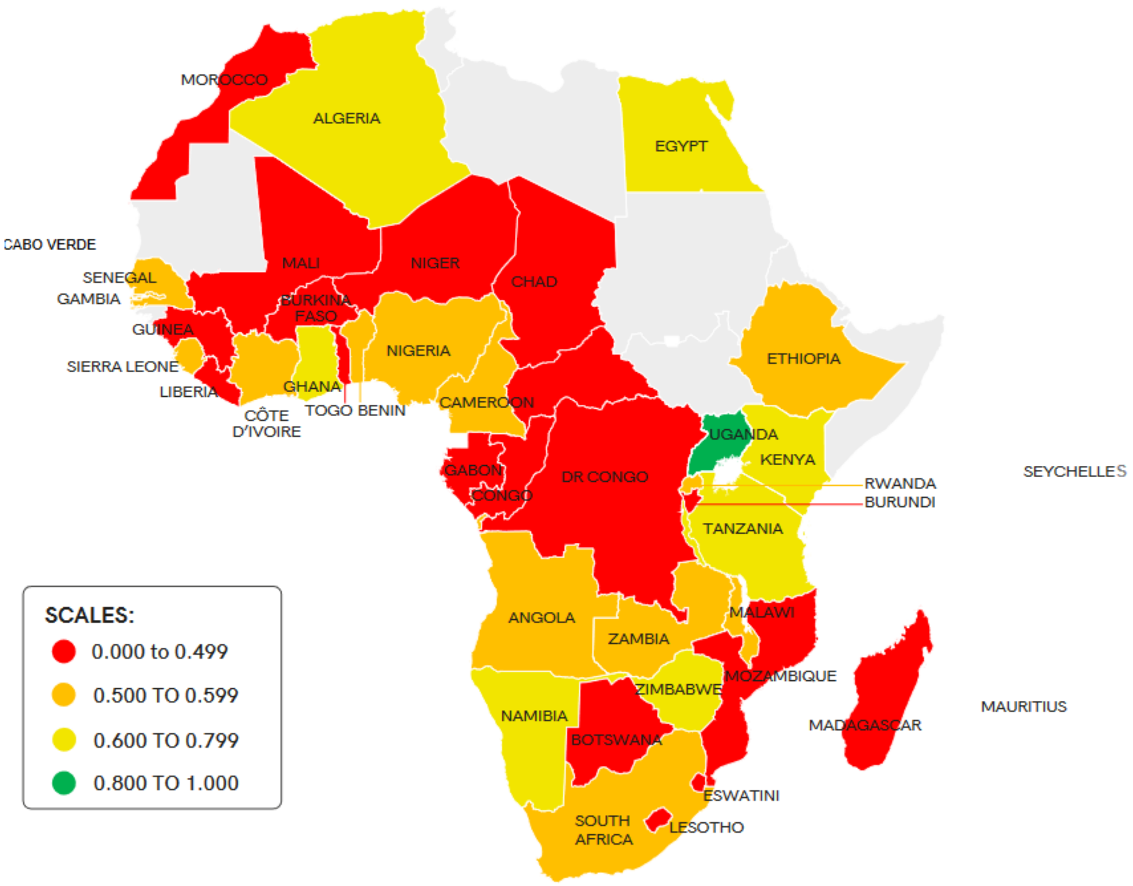


Figure 11. ERI index for African countries (AfDB, 2021)

ANNEX II: DETAILED DESIGN OF THE ELECTRICITY ACCESS INDEX

The body of this report only presents the main elements of the methodology used to compute the Electricity Access Index. This Annex provides all the details required to replicate or scale up this exercise.

Sufficiency component

As explained in section 4.1 of the main document, the elaboration of the index requires the development of a business plan to finance the electrification plan that can achieve universal access in the country by 2030. In some countries the electrification plan corresponds to an existing national electrification strategy, in other cases it has been obtained from publicly available studies performed by development organizations – such as the World Bank's Global Electrification Platform using the OnSSET model – or our own analysis using the Reference Electrification model (REM).[10]

The critical importance of the business plan stems from the fact that, in an electrification process that aims to achieve full electrification in less than a decade starting from a large access gap, very substantial investments in assets with long economic lives are necessary during a relatively short period of time. On the other hand, regulated tariffs, even when designed according to orthodox regulatory principles of cost-reflective revenue requirements, recover the costs slowly, especially when the access rate is low and so is the customer base. This lack of synchronism or time offset between costs and revenues creates financial needs. When the tariffs are not cost reflective, or the revenue collection has significant gaps, the business model is stressed and becomes non-viable in some countries. This is a key indicator that the business plan can detect. On the other hand, the business plan for other countries can handle this time offset without much difficulty, returning to a balance situation a few years after 2030, with a cost-reflective revenue requirement and a progressive stabilization of the capital structure at sustainable leverage levels/ratios.

For the sake of homogeneity, so that the results could be comparable, some common criteria have been adopted for all the techno-economic plans and business plans:

- Adopt the viewpoint of the government, as the ultimate responsible entity in the electrification process.

[10] See the MIT/Comillas Universal Energy Access Lab E https://universalaccess.mit.edu

- Consider the entire distribution system, both on- and off-grid, existing and new. The techno-economic electrification plan should correspond as much as possible to the least cost mix of the three electrification modes.
- All residential customers are supplied at least tier 2, and all commercial and industrial customers receive reliable power.
- The business plan considers all costs (including the costs of maintenance and replacement of assets) and all revenues of the distribution activity.
- When the latest financial statements of the distribution utilities are available, this becomes a primary information source of the business plan.
- As the business plan expands over a long period of time (in principle until 2040), all assets must be replaced at the end of their economic lives.
- The current regulated tariff structure (i.e., breakdown into consumer types) of grid-connected customers is assumed to continue over the entire horizon of the business plan, although the numerical values can evolve over time. Mini-grid customers are charged the same tariff as grid consumers. Standalone-system users are charged the average Rural Household Energy Consumption equivalent.
- Grants from DFIs to governments are linked to the deployment of CAPEX and recognized in the profit and loss account as revenues, whereas subsidies from the Government can be used without restrictions.
- The time horizon of the business plan has been divided into two periods. The first one covers the interval from the present time to 2030, when universal access is assumed to be achieved. This is a period of heavy investment and with the revenues from the tariffs gradually growing, as more people are supplied with electricity. During the second period, from 2030 to 2040, investments are only needed to cope with the increment in demand due to population and demand growth, as well as to replace assets that reach the end of their economic lives.
- The design of the financial plan must carefully balance multiple factors, such as the distribution of the investments during the first period (until 2030), which customers to supply first, the evolution of the tariffs during the entire horizon of the plan, the limits that might be imposed by the sovereign debt of the country, the blend of financial resources and the parameters that define each financial instrument. The business plan must maintain acceptable values of the key financial ratios so that it is possible to raise the capital necessary for the electrification plan until 2030. Finally, the business plan must attain a stable financial condition by 2040 or earlier, whereby the annual expenditures, the

regulated revenue requirement from all the distribution activities and the revenues from the regulated tariffs tend to converge.

- The total amount to be financed must be calculated over the financial projections period. It includes the operating cash flow (until the business plan becomes cash flow positive and starts contributing to the electrification capex roll-out), the investment plan up to 2030 and the cash outflows (financial interest and taxes) associated to the suggested capital structure, computed as shown in Figure 12.

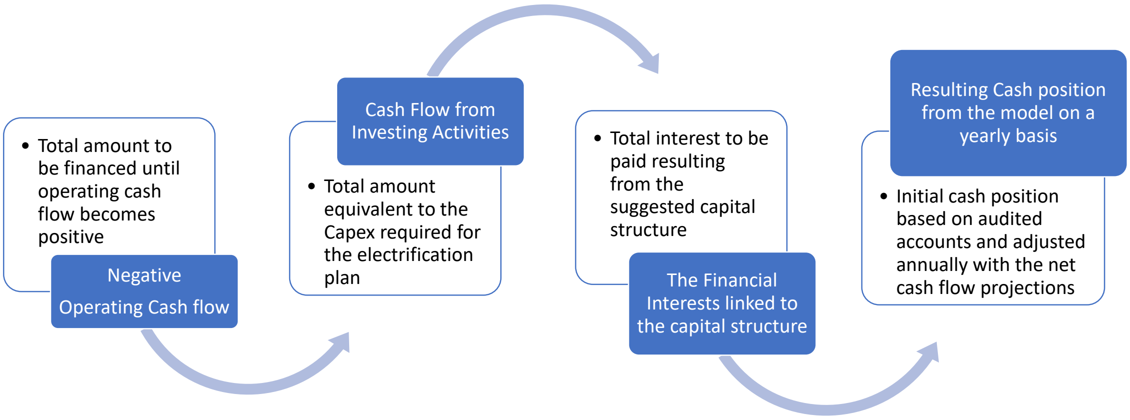


Figure 12. Term-by-term determination of the total amount to be financed.

Other more technical aspects in the elaboration of the financial plan are:

- The iterative adjustment of parameters in the financial plan must be carried out noticing that the different components (Debt/Equity/Grants) are interrelated and conditioned to each other. In each iteration, some key financial ratios are analyzed to make a first assessment of the optimal capital structure and maximum amount of debt (corporate/commercial) that the BP can tolerate.
- Government support is critical for several reasons – support and respect for the regulatory framework, subsidies if they exist, grants, and channeling DFIs financing – for both equity and debt, so the overall impact on and expected support from the Government is also analyzed.
- The most challenging component of the capital structure, both to structure and potentially to raise, is the equity (rate/governance/return and exit, if any). Additionally, both the dividend (as per market practice) and the overall return on equity are modeled and computed.

Once the business plan has been developed, it can provide two key pieces of information. In the first place, the plan shows how much annual expenditure is presently needed to be in the right path to meet the SDG7.1 target. This is the amount that goes into the denominator in Figure 4.

In the second place, the business plan can be presented to experts in evaluating large infrastructure projects in developing countries to get their assessment about the overall viability of the plan. After examining the plan and any additional information provided, each expert is asked to classify the financial viability of the business plan for the considered country into one the following categories: (1) impossible; (2) very difficult, but not impossible; (3) difficult; (4) possible, with some difficulties; or (5) the plan is viable.

It follows the enumeration of the information that must be provided to the experts for them to carry out the evaluation.

Information that is provided to the expert evaluators

For each considered country, the following information is provided in a separate file:

- Relevant general information on the country:
    - Total population, broken down into urban and rural. National electrification rate, and the individual rates for rural and urban populations.
    - Average electric consumption per household and per capita.
    - GDP present value and rate of growth, inflation rate, and sovereign credit ratings, as well as the World Bank's *Ease of Doing Business* ratio.
    - Total value of the assets of the power distribution segment.
- The ratio (in percentage) of the present electrification effort to the effort that would be needed.[11]
- Summary Table of Financing Sources and Uses
    - Internal sources of financing:
        - Collected revenue from the regulated tariffs, which may include cross subsidization among categories of consumers.
    - External sources of financing:
        - Grants based on DFIs funds to Government, typically linked to the deployment of the CAPEX of the electrification plan.

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[11] This is the first element that is needed to compute the sufficiency component of the index. For each country, the numerator is computed from actual data in the annual reports of the utilities, complemented with other data bases with information on off-grid solutions. The denominator is obtained from national electrification strategies (when they exist and are SDG.7 compatible) or standard electrification plans in the World Bank data bases.

- Concessional Debt from DFIs.
- Subsidies from the Government (bailouts to the distribution segment).
- Commercial debt.
- Equity.

The information provided must differentiate two periods: i) the first one covers the initial years, until the operating cash flow becomes positive; ii) the second one covers the subsequent period until 2030, when the heavy investments necessary to achieve the universal access goal stop and are followed by a period where the need for financing new investments is significantly reduced.

- Key financial ratios of the business plan

From a financial perspective, the evolution of the ratios has most interest until 2030, when the heavy investments associated to the electrification plan stop. However, the period 2030-2040 has also interest to understand how the financial situation evolves towards a state of equilibrium between the annual revenues from regulated tariffs and the annual incurred costs. The provided ratios are:

- EBITDA / (Interest + repayment)
- (EBITDA + CAPEX) / (Interest + repayment)
- Subsidized & concessional debt / EBITDA
- Commercial & corporate debt / EBITDA
- Total debt / EBITDA
- Net debt / EBITDA
- EBIT / Financial interest
- EBIT / (Equity + Net debt)
- Net Operating Profit After Tax / (Equity + Net debt)
- Net income / Equity
- Total debt / Property, Plant, and Equipment (in %)

- **Other information from the business plan**
  - Total CAPEX of the electrification plan over Property, Plant and Equipment (PP&E) at the Beginning of the considered period (2021). Same over Average Cash Flow during the 2021-2030 period.

- Period until EBITDAs become positive (both timing and quantum). Same for the cash flow.

Effectiveness component

The effectiveness component is computed via the results of a questionnaire, based on 34 items, which are divided among the four pillars of the Integrated Distribution Framework: universality, integral plan, viability, and focus on development. For each country, the questionnaire is sent to several country experts, looking for a balance of the different perspectives that may be present in the country by engaging experts from public institutions, utilities and the private sector. Experts are asked to evaluate the institutional and regulatory framework in the country, assigning a score from one to five to each item.

The scores from different experts are averaged to define a final score for each item. Items are all given the same weight, thus the score for each pillar is obtained by simply averaging the scores of the items corresponding to that pillar. Finally, the overall compliance with sound electrification principles is obtained by averaging the scores of the four pillars and translating the score from one to five into a percentage, as shown in Figure 13.

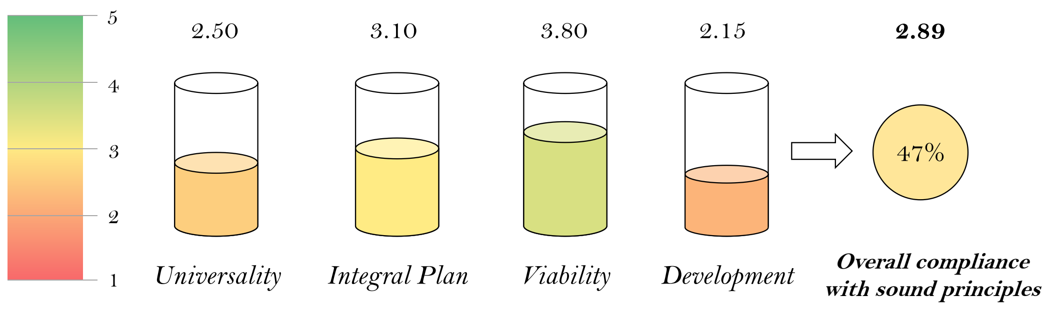

Figure 13. Example of the results of the effectiveness component of the Electricity Access Index

This annex starts with a presentation and justification of the importance and comprehensiveness of the principles of the Integrated Distribution Framework (IDF). Then it presents the 34-item questionnaire that country experts must fill in. Each item of the questionnaire has an introductory statement defining the topic, and a set of sub-questions. The experts can also provide comments for any of the topics.

Universal access

The principle of universal access requires that some entity, or combination of entities, makes sure that all customers in a considered territory will be supplied with at least a minimum level of service[12] and reliability through a combination of on- and off-grid solutions. Some entity must accept the role of default supplier (that is, being responsible for ensuring that nobody is left without service) and last-resort supplier (being responsible for providing the service in the event some previously existing supplier fails to do so). If these roles and responsibilities are not clearly defined, as it often happens, the electrification initiative may become inactive after a few years because of the absence of proper maintenance, funding, or management, or when demand grows and equipment needs to be repaired, replaced, or upgraded.

In practical terms, guaranteeing the universality conditions laid out above will require some kind of long-term agreement, as a concession, that ensures the permanence of supply. These long-term contracts can be established though a tender or via direct negotiation between the government and the potential project developers. The selected company (or companies) would commit to supply some prescribed level of electricity access to all customers and should also accept the role of last resort provider in the assigned area, being paid the corresponding cost for this service.

These agreements should encompass all areas where population without electricity access live and this requires a strong commitment from the government, who should also pursue the engagement of local communities to properly define the service level and characteristics. This commitment must be further backed by key development partners and embedded in a lead ministry or public agency that can guide the efforts of the many stakeholders and participants who will be involved.

Integration of on- and off-grid solutions

Within the population lacking electricity access in a certain country, very different conditions can be found, in terms of distance from the network, geography of the territory, or economic development. Therefore, a sound electrification plan must consider different electrification modes (grid extension, minigrids, and standalone systems) that could best fit each one of these conditions. The most efficient equilibrium of these electrification modes should be determined with a GIS-based optimisation tool, which should be able to internalise preferences or constraints that go beyond economic aspects, as those that could be raised by local communities or public institutions.

[12] There are different methodologies to define service level in electrification programmes (ESMAP, 2015). In any case, the level of electricity demand should reflect a basket of basic services (which are context-dependent), but it should also consider affordability issues.

The outcome of this exercise should be a techno-economic plan providing: i) a roadmap for investments and project implementation that meets electrification targets at least cost and ii) estimates of the cost of supply (including both capital and operational expenditures), which are needed as an input of the financial plan, in order to calculate regulated tariffs and assess the need for subsidies. These costs should be expressed with a yearly granularity.

An efficient integration of different integration modes also requires a certain degree of coordination among them, especially at the regulatory level. Decisions should be taken on the boundaries of each electrification mode and what happen when two modes meet, as when the main grid eventually reaches an area covered by a minigrid (ESMAP, 2018). A lack of clarity on these aspects may increase the risk perceived by the actors involved and hamper investments.

Turning a geospatial plan into reality requires addressing additional challenges with respect to the design of mode-specific regulations for remuneration, the management of interfaces between modes, provisions for default and last-resort service, and the dynamic integration of different supply modes with changing demand over time.

Financial viability

A sound electrification plan should be able to attract private partners who can mobilise investment capital, take advantage of advanced technologies, and bring technical and managerial expertise. These actors will show interest only if the financial viability is ensured for all the electrification modes considered by the plan. This requires the signature of long-term agreements based on regulated revenue requirement that encompasses all the costs faced by these companies. The revenue requirement should be computed through the cost-of-service method commonly used in monopoly regulation, with the application of some performance incentives[13]. Deviating from this basic regulatory approach increases the cost of capital, deters investment, and compromises the quality of service.

While the regulated revenue requirement should include all costs, the same is not true for end-user tariffs, which could internalise any sort of consumption subsidy. For instance, in some contexts, the regulation imposes the application of uniform tariffs in the entire national territory, and this would apply also to the new connections resulting from the electrification plan, regardless of the costs actually incurred. While the application of consumption subsidies is totally legitimate and, in many cases, essential to overcome affordability issues, it is of utmost

[13] These performance incentives may focus on service quality, customer services, or billing efficiency.

importance that any difference between the revenue requirement and the amount to be collected through tariffs is covered through a specific subsidy budget and paid to the company in charge of electrification. This budget may come from the government or international institutions, or it can be raised through cross-subsidies.

Focus on development

The ultimate goal of universal access is not to connect consumers, but rather to provide electricity as a facilitator of social and economic development. For the electrification plan to bring socio-economic benefits, a top-down approach has to be complemented by the bottom-up participation of electricity end-users. Entities such as non-governmental organisations (NGOs), foundations, and cross-sector agencies have important roles to play in the definition of the electrification plan (Batidzirai et al., 2021), which should reflect the priorities of local communities. Public institutions should promote these customer-engagement activities through specific participation processes or including dedicated clauses in the long-term agreements.

There are several aspects that could help align the electrification plan with the social development of the newly-connected territory. The mere access to electricity does not unlock by itself the potential of productive end-uses in rural communities (IIED, 2019; WB, 2021). The electrification strategy should include specific initiatives to facilitate the purchase of efficient appliances, foster the creation of small enterprises, or promote capacity building. The electrification plan should also include community services, as providing electricity to schools, hospitals, or water treatment facilities. Finally, the electrification strategy must consider a gender perspective. Beyond the common narrative according to which women are disproportionately affected by a lack of access to electricity or energy poverty, there is a growing awareness that women can also play an essential role in the effectiveness of the electrification plan, maximising its social impact (ESMAP, 2017; Winther et al., 2020). This could be reflected in the electrification strategy through specific assessments or initiatives targeting, for instance, female-led households.

Full questionnaire sent to country experts

The questionnaire is displayed in the following pages. Each item of the questionnaire has an introductory statement defining the topic, and a set of sub-questions. Experts can also provide further comments beyond raw scores.

Universal access

Do the existing policy, regulation, institutions, and business models make sure that everyone will have an adequate electricity supply on a sustainable basis?

nº	Question	Score (1 to 5)
1	*Priority from a political perspective*. Is universal electricity access a **political priority**, as compared with other important needs of the power sector and other economic sectors? Other needs of the power sector may include electricity supply for industrialization, improvement of the quality of service in urban centers, transmission interconnections, and the development of large generation plants for exports."	
2	*A sufficient level of access, which may be context dependent, will be guaranteed for all*. Is there a **national electrification strategy** with a **minimum access target** that at least: meets some reliability and quality requirements, is being followed or at least somehow enforced, used as a guide, and updated as needed? These targets may be context-adapted (e.g., tailored for urban, rural, and isolated communities, etc.).	
3	*Attention paid to specific categories of consumers*. Does the national electrification strategy include special provisions for informal settlements, vulnerable households, and female-headed families?	
4	*Existence of a competent local entity in charge of achieving universal access, i.e., nobody is left behind.* Is there a **national champion** institution that has been given the responsibility to **achieve universal access**, with executive power and the technical competency to accomplish this mission, and the technological, human, and financial resources to do it?	

5	*The business model for grid extension is adequate for discos to do their part of the electrification plan.* Is the existing regulatory and **business model *for grid extension* adequate to supply demand for everyone** according to an electrification strategy as defined previously, on a permanent basis (i.e., in a financially sustainable regime)?	
6	*The business model for mini-grids is adequate for mini-grids to do their part of the electrification plan.* Is the existing regulatory and **business model *for mini-grids*** adequate to supply demand for everyone according to an electrification strategy as defined previously, on a permanent basis (i.e., in an economically sustainable regime)?	
7	*The business model for stand-alone systems is adequate to do their part of the electrification plan*. Is the existing regulatory and **business model *for stand-alone systems*** adequate to supply demand for everyone according to an electrification strategy as defined previously, on a permanent basis (i.e., in an economically sustainable regime)?	
8	*Full electrification needs a default provider: one that must supply where others would not – and a last resort provider: one that will take over supply where others have failed or quit.* Does the regulation explicitly include the roles of **default provider** and **last resort provider**?	
9	*The adopted regulation and business models must avoid resulting in a disorganized multiplicity of suppliers, technical standards, and contractual arrangements that will be difficult to coordinate in the future.* Are the present power sector structure and regulation and the national electrification strategy consistent with a **sound long-term vision** of the power sector in the considered country? Is electricity supply in the hands of "utility-like" entities?	
Comments:		

Integration of on- and off-grid solutions

Is there a national electrification strategy to be followed by an actionable plan that integrates all electrification models in an efficient manner, is supported by adequate regulation and business models, and is accepted by decision-makers?

nº	Question	Score (1 to 5)
1	*Existence of a competent local entity in charge of taking responsibility for the development and implementation of the national electrification plan.* Is there one or more institutions responsible for the **development and the implementation of a national electrification plan**? Is this institution technically able to manage the implementation of the plan, with executive power to accomplish this mission, and with the technical, human, and financial resources to do it? It is permissible that this institution consults third parties when developing the national electrification plan.	
2	*The plan must be based on least-cost principles and therefore must integrate the three modes of electrification.* Has the electrification plan been established following a **least-cost criterion**, employing GIS-based approaches, **considering all electrification modes** and the future transitions among them, subject to clearly specified objectives and constraints?	
3	*The development of the distribution segment must be consistent with other actions in the other segments of the power sector to achieve an efficient and reliable electrification target.* Is the electrification plan aligned with a **comprehensive power system development strategy** including generation, transmission, distribution, and off-grid development?	
4	*The electrification strategy and/or plan must be followed to be effective.* Is there a formal procedure of **monitoring and enforcing** targets concerning the **mix of electrification modes** that results from the electrification plan or strategy? Are these targets legally binding? Are electrification development partners' endeavours coordinated under the guidance of the national electrification strategy and/or plan?	

5	*The regulatory and financial environment should be able to attract mini-grid developers*. Are private developers of mini-grids **allowed to install, charge for, and operate** their facilities? Are there national programs which aim to develop mini-grids or support the development of mini-grids? Are there **licensing or authorization procedures for mini-grid operators**? Is there any regulation establishing the tariffs – or limits to the tariffs – for customers of mini-grids? Does the regulation consider any capacity thresholds or simplified procedures (e.g., depending on the technology or size of the mini-grid, etc.)? Are the procedures streamlined to facilitate the deployment of off-grid solutions, reduce administrative waiting times, and facilitate the procurement process?	
6	*The regulatory and financial environment should be able to attract stand-alone system developers*. Is there regulation requiring minimum quality standards for stand-alone systems? Are there national programs which aim to deploy stand-alone systems or **support the development of stand-alone systems**?	
7	*Regulation should exist that facilitates transfers between electrification modes.* Is there regulation ensuring that **future transitions among electrification modes happen smoothly** for customers and for the electricity suppliers? Specifically: Are there technical standards (i.e., a section of the distribution grid code) detailing the requirements for installing and operating mini-grids? Does regulation exist establishing when and what will occur if the main grid reaches a mini-grid or an area with a concession to deploy solar kits? Is the interaction between interconnected mini-grids and the main grid regulated? Is there any requirement to facilitate common access (or transfer of access) of consumer data?	
Comments:		

Financial viability

Are the present institutional, political, social, policy, legal, and regulatory conditions adequate to do business in the country, attracting substantial private investment in the distribution segment of the power sector?

nº	Question	Score (1 to 5)
1	*Substantial private investment in a country will only happen if some fundamental conditions exist.* How **easy is it to do business** in the country? Categories that can be considered are: starting a business, getting credit, protecting minority investors, paying taxes, and enforcing contracts.	
2	*One of the critical conditions to attract private investment into the power sector of a country is legal security, which must be based on a solid record of sound regulation, both the content of the regulation itself as well as the quality of the regulatory institutions*. How sound is the **regulatory framework** in the country? Categories that can be considered are: existence of a legal mandate, clarity of roles and objectives, independency of the regulator, transparency of decisions, and predictability of the regulatory framework.	
3	*The appetite for private investment in the distribution segment should be comparable with that for other power sector investment opportunities in the country.* Is the distribution segment obtaining a **share of the total amount of funding** that the power sector presently receives that can be considered adequate, given the typical distribution of investment expenditures into generation, transmission, and distribution, as well as the lack of access to electricity in the country?	

4	*Not only the volume of investment matters; how the funds are utilized is also important.* Are current expenditures on electrification within the distribution segment of the power sector **well-employed?** The answer to this question must consider whether funds have been employed in some electrification mode when they could had been used better in a different mode, the efficiency of procurement and operation activities, the choice of minimum levels of access, the adopted minimum reliability requirements, and the incurred level of public indebtedness, among other criteria.	
5	*Private investment in the distribution segment of the power sector can only happen if it is facilitated by the country's energy policy and regulation*. Is the distribution segment **unbundled** (at least on an accounting basis) from other segments of the power supply chain? **Is some form of PSP** (private sector participation, in property, management, or outsourcing of activities) **allowed in the distribution segment**?	
6	*A distribution concession model can be a plausible approach to attracting private investment and improving overall distribution performance in a country. Are conditions in the country suitable for the implementation of a distribution concession model?.* Can the adoption of a **distribution concession model** come in the form of a PPP (public private partnership) in the considered country? Do laws governing PPP exist? Are there clear processes and institutional responsibilities for selecting PPPs? Are defined PPP models available for distribution? Are unsolicited proposals, solicited proposals, or competitive tenders for power sector infrastructure investments possible?	
7	*A SDG7.1 compliant techno-economic business plan may be wishful thinking and fail to attract investment in the absence of a business plan specifying how the electrification process can be financed in a credible way.* **Does a business plan (financial plan) exist** that makes sure that the techno-economic electrification plan of any national electrification strategy can be viable? Are the present or envisioned funding mechanisms sufficient to cover the activities specified in the electrification plan?	

8	*Many developing countries are seriously indebted, and this may pose serious limitations to procuring loans necessary for executing electrification plans.* Could issues related to **sovereign debt** constrain the amount of financing that the country can get for its electrification plan? Are financial instruments available to distribution companies that could mitigate these financial constraints, such as DFI guarantees, escrow agreements for private distribution investors, or concessional lending not limited to government-owned companies?	
9	*Private investor confidence is possible only if cost recovery is expected, either through cost-reflective tariffs or through grants and subsidies.* Is the present business model for the **grid-connected distribution** segment financially viable? Is the annual revenue collected from end customer tariffs (reduced by the amount of theft and non-paid bills) able to recover the annual total cost of supply as determined by the cost-reflective regulatory revenue requirement? Are there publicly funded mechanisms to secure viability gap funding for grid extension in rural areas (i.e., the difference between the cost reflective annual revenue requirement and the estimated actual revenue collection from end customer tariffs)?	
10	*Private investor confidence in the mini-grid activity is possible only if cost recovery is expected, either through cost-reflective tariffs or through grants and subsidies.* Is the present business model for mini-grids financially viable? Is there an established revenue requirement calculation method for mini-grids? Are mini-grid tariffs regulated under a national uniform tariff approach? In case a viability gap exists, are there publicly funded mechanisms to secure viability gap funding for operators of mini-grids everywhere they are needed?	
11	*Private investor confidence in stand-alone systems is possible only if cost recovery is expected, either through cost-reflective tariffs or through grants and subsidies.* Is the present business model for stand-alone systems financially viable? Is there an established procedure to determine the revenue requirement for electricity supply with stand-alone systems? In case a viability gap exists, are there publicly funded mechanisms to secure viability gap funding for operators of stand-alone systems everywhere they are needed? Are there regulated tariffs under a national uniform tariff approach for subsidized customers supplied by stand-alone systems?	

12	*Is there sound regulation for expanding distribution through grid extension?* Do rules exist that mandate providing connection by the DSO (distribution system operator) where it has a concession or a license to operate? Are there rules imposing penalties or the removal of distribution licenses in case of noncompliance? Is there a grid code defining system operation rules for distribution? Regarding transparency and availability of data: are the balance sheets of public utilities publicly available? Is data regarding distribution grid operations and quality publicly available? Is there a clear and publicly available procedure to get the distribution authorization/license?	
Comments:		

Focus on development

Do the electrification plans contemplate "beyond electric supply" dimensions that facilitate human development?

nº	Question	Score (1 to 5)
1	*The economic and human development of non-electrified communities can only be achieved with electrification strategies that go beyond the supply of residential demand.* Does the plan include **productive uses** (e.g., agricultural, commercial, industrial activities, etc.)? Are the resources devoted to productive uses included in the national electrification plan sufficient in volume and tailored to the economic activity in the country/area?	
2	*The economic and human development of non-electrified communities can only be achieved with electrification strategies that go beyond the supply of residential demand.* Does the plan include **community facilities** (e.g., health centers, schools, administrative buildings, etc.)? Are the resources devoted to community uses included in the national electrification plan sufficient in volume and are they properly addressing the needs of the communities?	
3	*Most economic and community activities that are enabled by electricity access are only possible if the electricity supply meets acceptable standards of reliability and quality of service.* Does the business model for each electrification mode include incentives to provide an adequate level of reliability so that productive and community uses can happen?	
4	*Residential, commercial, and industrial customers may need some commercial and financial support and capacity building to make use of the opportunities that electricity access can provide.* Does the business model for each electrification mode include incentives to promote demand growth or to support the acquisition of appliances for residential, commercial, and industrial utilization (e.g., through microfinancing schemes, etc.)?	

5	*Careful regulatory design is needed for companies in charge of each electrification mode to experience the right incentives to perform well in terms of the elimination of "commercial" losses and other aspects related to customer engagement, even if these aspects are not directly related to electricity supply (e.g., participation of women in revenue collection activities, literacy or handicraft schools, financing social activities, etc.).* Does the business model for each electrification mode include incentives to promote best practices in billing, revenue collection, and customer engagement regarding complaints and any other issues?	
6	*Universal access should promote the development of the entire society and it should pursue gender equality and the empowerment of women*. Does the electrification plan or strategy include a gender perspective? Does it consider specific instruments to provide access to female-headed households?	
Comments:		