Success in Rural Electrification
Framework Case Studies

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Ethiopia
Integrating Off-grid Technologies into Electrification Planning

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Success in Rural Electrification

GET.transform Case Study Series on Off-Grid Frameworks and Industrialisation

Achieving the energy transformation begins with the identification of realistic approaches. For this Case Study Series, GET.transform has worked with governments, companies and industry experts to find real-world examples of where renewable energy solutions are truly working viably, to create value for communities, boost employment, and achieve national objectives.

The identified case studies focus on the one hand on renewable energy industry solutions built on revenue-driven business models, as well as on best practice regulatory frameworks that have solved common challenges in the development of the rural electrification and off-grid market. With a focus on Africa, the case studies aim to present policymakers and stakeholders with encouraging evidence from the renewable energy world.

This case study features Ethiopia and draws on the experience of the Ministry of Water, Irrigation and Energy, its Directorate of Electrification, Regional Energy Bureaus and the Ethiopian Electric Utility, who have cooperated with development partners such as the World Bank's ESMAP, the AfDB and GIZ, with their support on the planning dimension and Ethiopia's off-grid electrification agenda.

1 Distinguishing Feature

1.1 Description

To bring Ethiopia's nationwide electrification from 30% in 2017 (20% on-grid and 10% off-grid) to 100% in 2025, the Ministry of Water, Irrigation and Energy (MOWIE) developed a highly evolved master plan under its National Electrification Program (NEP). The plan designates the most suitable access technology per community throughout the country – an approach many governments are trying to emulate.

In 2017, Ethiopia launched its first NEP, resulting in an improvement to 33% in on-grid and 11% in off-grid access to electricity by the end of 2019. Recognising the need to strengthen off-grid planning, an updated version of the NEP (NEP 2.0) was developed in 2019, including a target of 35% off-grid access by 2025. The strategy behind increasing the share of off-grid was twofold: First, for communities far from the grid and transport corridors, off-grid solutions provide the lowest costs long-term, while providing an appropriate service level. Second, for those areas which are to be electrified by the grid in the mid-term, the Ethiopian government views off-grid access technologies as an intermediate "pre-electrification" solution for quicker universal access.

The key ingredients and basis for a powerful digitalised master plan under the NEP 2.0 are:

1. **Creating a geospatial map with cross-referenced and digitised baseline data.** To prepare the necessary data for Ethiopia's electrification plan, geo-referenced building locations for over 14 million objects were collected through a visual inspection of satellite imagery. This dataset was then clustered into approximately 455,000 settlement locations based on a geospatial algorithm. Demographic information was added to this settlement layer by incorporating census data, household size statistics and population growth rate forecasts, thus making best use of complementary datasets from various sources. The existing medium voltage network infrastructure was digitised through physically tracking the location of grid lines using GPS trackers and uploading these to the geographic information system (GIS). While upfront costs of satellite imagery, aerial photography and geo-referencing are prohibitive for many planners, strong multi-sectoral commitment to infrastructure planning makes investments viable, particularly if data (and costs) are shared across institutions and used productively.

2. **Surveying household energy access, gathering additional needed data and tracking progress.** Additionally, an Energy Access Household Survey (on the so-called *Multi-Tier Framework*) based on differentiated power supply levels was established to create a clear baseline for electricity access, against which progress can be tracked through future surveys. The Survey provides details on the reliability and quality of grid services as well as the penetration of off-grid supply, while attempting to measure the willingness and ability to pay of rural off-grid communities. This ongoing flow of data into the master plan is a key element for ensuring that the instrument remains in use.

3. **Comparing and calculating optimal electrification solutions and timelines.** Based on the distance from the grid, the costs and effectiveness of different technologies, the size of communities and overall settlement patterns, the areas to be served by grid extension or off-grid technologies were distinguished and published in a detailed geospatial map through the NEP 2.0, accessible online. Short-term pre-electrification for communities up to 2.5km from the existing grid is to be carried out through solar home systems (SHS), with these areas expected to be grid connected by 2025. Medium-term pre-electrification for communities between 2.5 and 25km from the grid is to be done through a mix of SHS and mini-grids, with grid connection expected by 2030. For the deep rural areas further than 25km from the existing grid, a grid connection by 2030 is not considered feasible. 285 sites with more than 250 households each in the long-term deep rural areas have already been identified for mini-grid development through the initial geospatial planning.

Some additional special features in Ethiopia's approach to planning are also worth highlighting:

4. **Fine-tuned electrification planning considering required energy access levels.** While the above-outlined methodology enables planning from a purely least-cost perspective, the Government of Ethiopia plans to further utilise the Energy Access Survey to finetune planned supply to beneficiaries by location and service, moving away from the mere measurement of "access", to a more service-centric approach, identifying the necessary level of service to be provided in each area. This combination of GIS electrification planning and the Energy Access Survey creates the opportunity to assess:
    - Optimal techno-economic planning in the short, medium, and long term;
    - Progress in reaching the National Electrification Program's objectives;
    - Detailed energy demand patterns for optimised off-grid supply configurations.

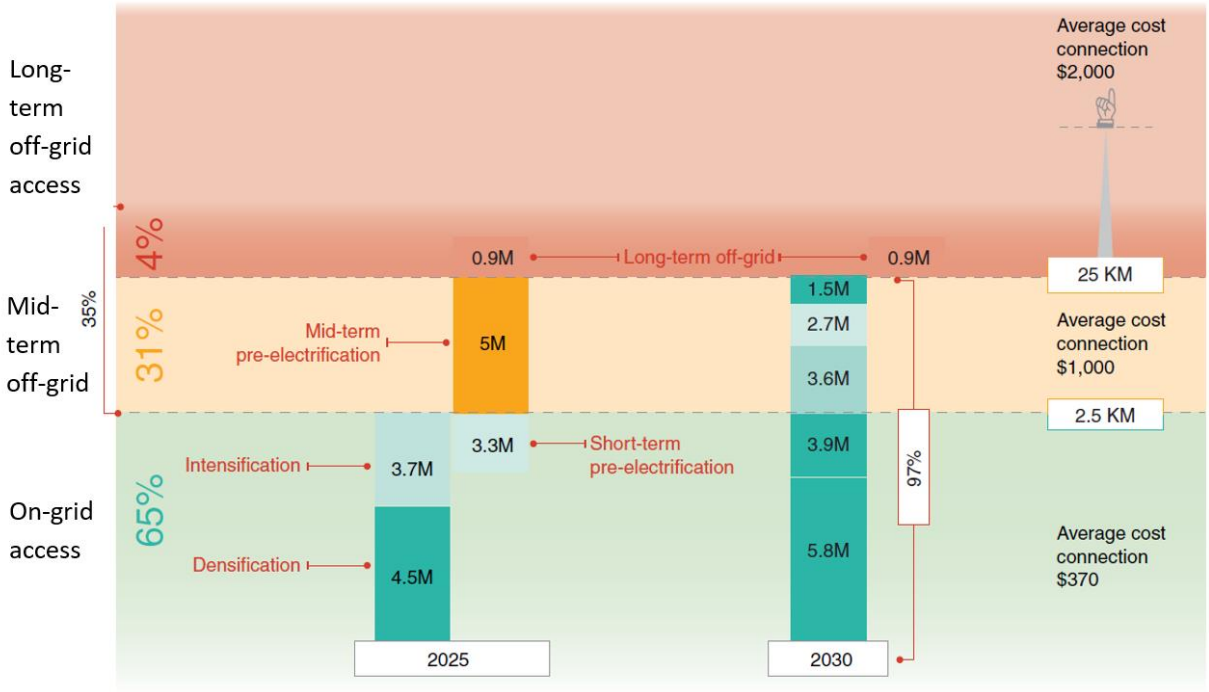

Figure 1. Households to be electrified by National Electrification Program 2.0 (Source: NEP 2.0)

5. **Utilisation, tracking and continuous updating through institutional cooperation.** The Government of Ethiopia intends to expand the platform for planning and tracking electrification allowing different institutions to effectively collaborate. While the integration of systems is currently ongoing, the government is already benefiting from this living plan, with updates to the geospatial map being made on an ongoing basis as new information becomes available from different sources and electrification projects are implemented. The plan is also able to incorporate new layers of useful data, with the latest updates focusing on areas with high agricultural potential or high agricultural activity, as well as government institutions with high demand for electricity.

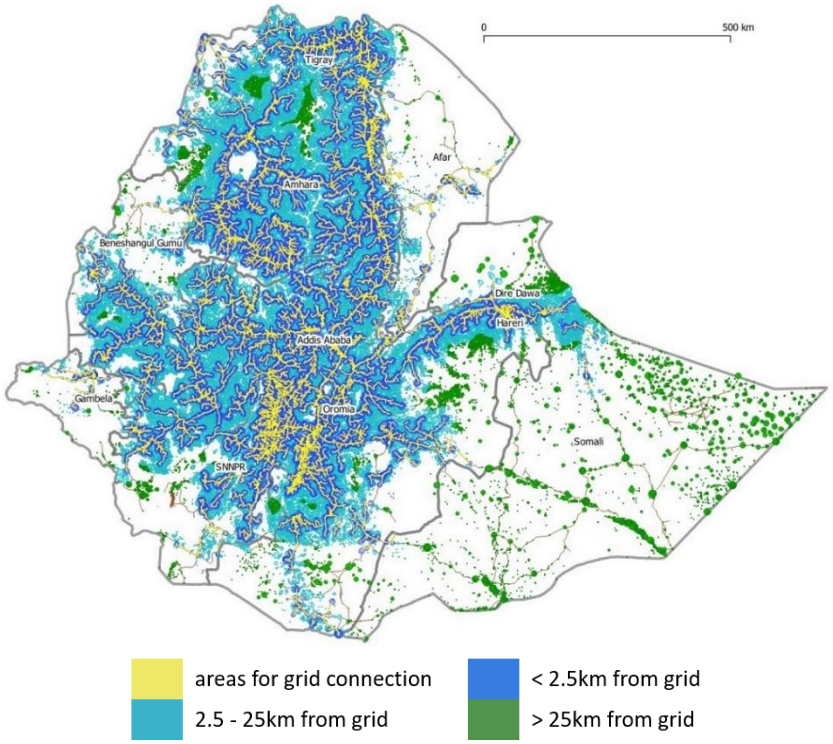

Figure 2. Settlements in Ethiopia based on distance from the electric grid (Source: NEP 2.0)

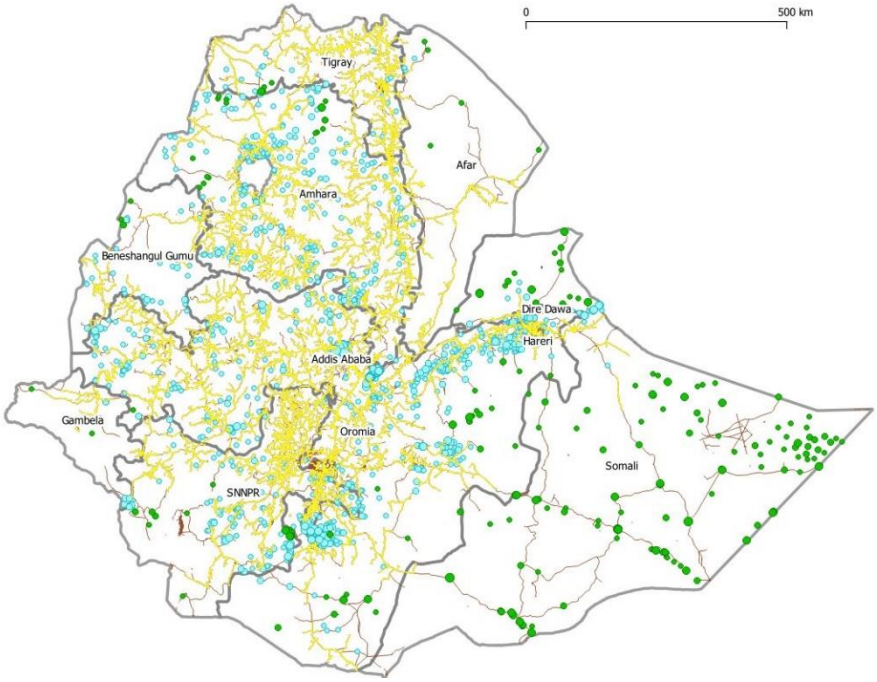

Figure 3. Potential mini-grid sites >25km from grid with >250 households (Source: NEP 2.0)

1.2 Strengths

Geospatial planning in Ethiopia was enabled through highly accurate datasets for buildings, population and medium voltage networks across the country following a massive data collection effort, which has often been inadequate in other attempts. The Ethiopian government also requested that geospatial maps be prepared by multiple vendors, allowing the government to compare approaches and recommendations, ultimately using the best inputs of each.

The integrated approach developed in Ethiopia, clearly defining electrification solutions by location and technology, is intended to maximise access to electricity within the shortest timeframe possible, while providing a long-term vision for on-grid access: In this vision, off-grid connectivity reduces from 35% in 2025 to 4% by 2030, whereby total electricity access will remain at 100%.

This approach provides transparency and clear targets not only for the public and private sector, but importantly for constituents, who are plainly informed about the intended type and timing of electricity access they are to be provided with. Combined with strong Ministry support, this measure also serves to reduce incidence of unplanned, disruptive projects and unsuitable use of a technology.

While providing actionable recommendations, the NEP and geospatial plan are considered living documents, being adjusted by the Ministry based on latest available information. Considering that several pilot projects are currently ongoing to test different mini-grid implementation models as well as costs and risks associated with those models, the results may ultimately be integrated into the electrification plan to improve granularity on access quality and use.

1.3 Weaknesses

Perhaps more of a challenge than a weakness, the great detail and breadth accomplished in the planning approach needs to be strengthened further by integrating the objectives and implications of the plan into the broader framework of electrification policy, to create harmony between various agendas and ensure more robust commitment from all agencies – efforts are underway but the task cannot be underestimated, and many master plans fail due to inadequate institutional and policy integration.

The timelines and targets set for the planning process and the overall National Electrification Program are very ambitious. Furthermore, the preference to drive implementation through the public sector compounds the difficulties of the ambitious programme, as staff capacities do not cover the volume or technical nature of all the work. Procurement processes and available financing for the multi-layered project are also stretched, resulting in a situation where some elements are initially approached with a pilot-type sensitivity, to be scaled when resources become available.

The Ethiopian planning vision could reduce the perceived investment security for private investors in mini-grids, considering the attitude around ‘pre-electrification’ for areas which will ultimately be covered through grid extension. Alleviating this issue, the majority of mini-grids will likely be implemented by the public sector, and the new mini-grid regulation in Ethiopia sets provisions for an eventual interconnection of the main-grid to mini-grids (see below in section 2.3).

Furthermore, the detailed implementation modalities for deep rural areas is not yet confirmed, and private investments will be difficult to attract into these deep rural areas. The tariff for rural households is intended to match the national grid tariff, but of course, these areas exhibit low economic potential, meaning there is limited potential for the desired cross-subsidisation by large productive users which are lacking in these areas.

The initial Energy Access Survey and geospatial analysis focused primarily on households, with institutions and productive use potential not prominently integrated. The density of settlements and their distance to the grid were still considered key factors for decision-making, with service levels and local loads only considered subsequently. Planners gradually realised that the determination of service level requirements and optimised electrification solutions calls for ongoing efforts in data collection on the productive use potential, including granular details such as cooperatives and small industries.

2 Framework Elements

2.1 Mini-Grid Delivery Model and Decision on "tariffs vs. subsidy vs. govt control"

To achieve the ambitious targets laid out by the Ethiopian government, two main mini-grid delivery models have been developed:

1. The Ethiopia Electric Utility Company (EEU) is driving delivery of mini-grids in commercially attractive areas, typically through tendering out Engineering, Procurement & Construction (EPC) and short-term operations and maintenance (O&M) of three to six months to private sector entities, after which the EEU takes over O&M aspects. The EEU is the owner of mini-grids under this model.
2. Through minimum subsidy tenders for less attractive sites, a private company or cooperative becomes the owner and operator of a mini-grid, with the government entities merely acting in a supervisory role. Under this model, the EEU is the contracting authority and would operate the mini-grids in case of non-performance and subsequent loss of license by the operator.

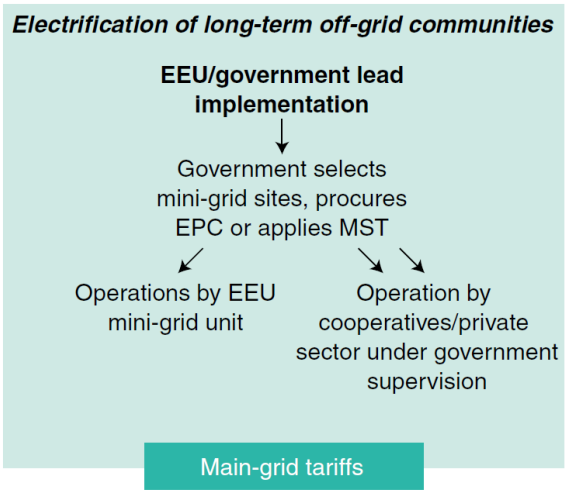

Figure 4. Method of electrification for long-term off-grid communities (Source: NEP 2.0)

National tariffs at a level of approximately US$ 0.07 per kWh are to be applied for residential customers, with cross-subsidisation through higher tariffs to commercial and industrial users. To enable cross-subsidisation within each cluster of mini-grids, large anchor customers are sought and where possible initiated through energy-agriculture sector coupling, especially drip irrigation. The Ethiopian government aims to pilot this approach on 10 mini-grids before implementing on a larger scale.

The Government of Ethiopia follows a very clear agenda of a public-sector driven approach with high government control, comparatively high subsidies and low tariffs.

2.2 Institutional Setup

The public sector-driven approach lends itself towards centralised decision-making and coordination, which is clearly displayed in Ethiopia's institutional setup.

The **Directorate of Electrification (DoE)** under MOWIE, provides day-to-day oversight and coordination of the NEP's implementation. It serves as the coordinator of geospatial data and electrification planning and facilitates a consultative process between the Ministry of Health, Ministry of Education, MOWIE, Regional Energy Bureaus (REBs), the EEU and Ethiopian Electric Power (EEP).

The **Ethiopian Electric Utility (EEU)** acts as the implementing agency for the public-sector driven mini-grids, organising procurement and EPC tenders as well as operating the public sector mini-grids. Because of the traditional focus of the EEU on grid extension, the NEP provides for capacity building to the EEU for the deployment and operation of off-grid solutions. The EEU is even supporting productive uses and access to basic education and health services.

The **Ethiopian Electric Authority (EEA)** has licensing and regulatory oversight and is responsible for establishing standards and regulations for the implementation of on-grid and off-grid programmes, including social, safety, and environmental safeguards, as well as ensuring operator compliance.

There are two further relevant directorates under MOWIE: The Energy Study and Development Follow-Up Directorate (ESD) and the Alternative Energy Technology Development and Promotion Directorate (AETDPD). The ESD is a directorate for strategy and coordination within the energy sector. The AETDPD was originally an implementing agent, coordinating the Rural Energy Fund, but is now transforming into a strategy and dissemination institution along with the ESD. Government is also interested in re-activating the Rural Energy Fund, especially to support and manage private sector-driven rural electrification, and is seeking suitable funding.

While decision-making is largely centralised, the role of Ethiopia's **Regional Energy Bureaus (REBs)** should not be discounted. The REBs provide MOWIE with key bottom-up information and data on electricity access while supporting implementation, among others in the form of education campaigns.

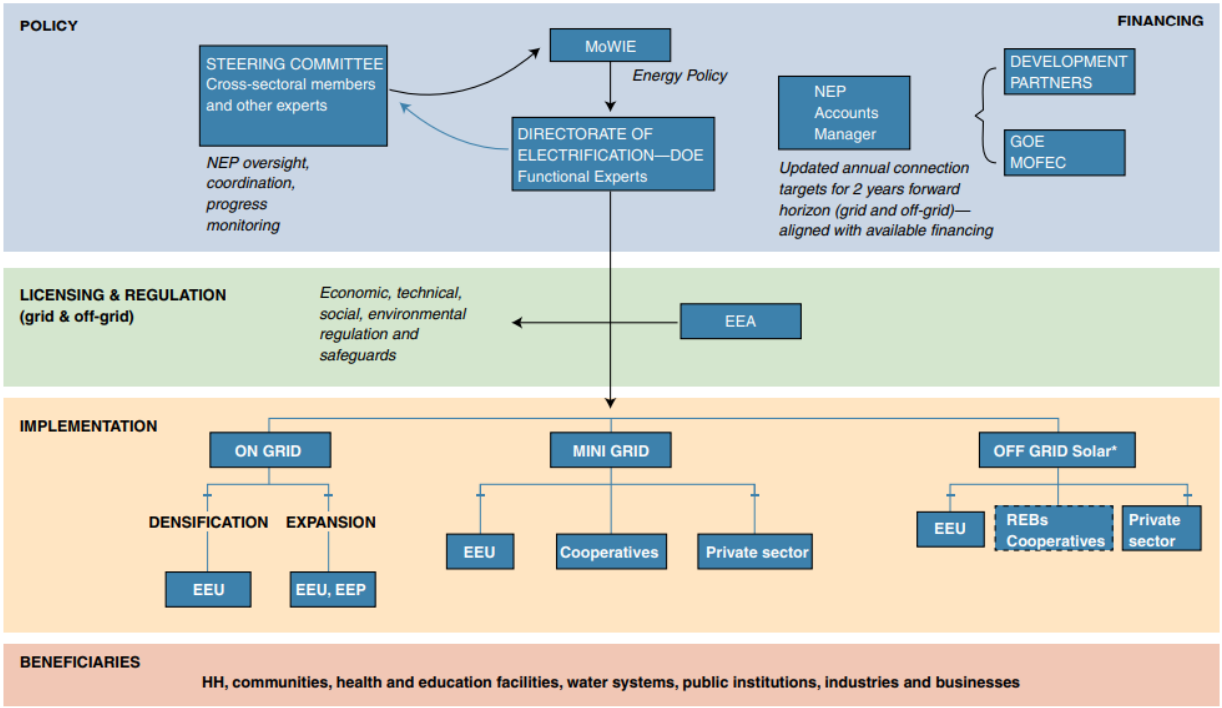

Figure 5. Institutional setup (Source: NEP 2.0)

2.3 Policies and Regulation

To support the NEP, an enabling ecosystem of policies, institutional buy-in, regulations and incentives advancing the roll-out of mini-grid delivery models is under development. Since the publication of the NEP 2.0, Ethiopia has published the Energy Regulations 2019, providing a foundation for the publication of mini-grid directives. A third draft of the directives has been published, incorporating aspects of tariffs, licensing and technical standards. The directives further define the approach for compensation upon

grid arrival, which is important considering that all areas earmarked for pre-electrification will ultimately be connected to the grid (see 2.6).

2.4 Financing Instrument

The newly established Directorate of Electrification (DoE) under MOWIE is the implementing vehicle for all off-grid initiatives, including mini-grid programmes. Ethiopia has been working with GIZ, the World Bank and the African Development Bank, which have each funded several mini-grids (see 2.7). Mini-grids implemented by the EEU are funded through the DoE, while those under the minimum subsidy tender scheme are part public-, part privately financed.

Access to hard currency for imports, the long-term stability of the local currency and access to loans are the main financial challenges for private sector investments into mini-grids, along with the investment security for mini-projects in pre-electrification areas.

2.5 Risk Mitigation

Risk mitigation has been considered in the draft mini-grid directives as follows:

1. There are currently no restrictions as to the minimum generation power required for each customer, and no limitation exists vis-à-vis renewable fraction, thereby minimising demand risks by allowing the developer to dimension systems for low risk.
2. Termination risks for mini-grids owned and operated privately are minimised through the clear definition of a compensation mechanism in case of grid arrival, with the entities first being given an opportunity to negotiate compensation levels. Should that negotiation fail, the compensation for mini-grid developers is defined as the remaining book value of the assets to be handed over based on the latest tariff tool and/or financial reports submitted, plus the last 12 months of revenue from the mini-grid site. Potential compensation under EPC and O&M contracts is regulated by contract.

2.6 Rural Industrialisation

While the NEP recognises cross-sectoral linkages with the productive sector as “critical”, no specific programmes have yet been initiated to drive rural industrialisation under NEP 2.0, and the published electrification plan currently does not consider the productive use potential of different sites. However, the Government of Ethiopia understands that the household tariff level as envisioned can only be achieved if strong anchor loads from industries such as decentralised processing of agricultural products can cross-subsidise the low payments from households. Therefore, government activities are focusing on the coupling of the agricultural sector with the energy sector, resulting in a pipeline of mini-grids in rural areas with particularly high agricultural/productive use potential. For example, the Agricultural Transformation Agency (ATA) is supporting irrigation pilots at mini-grid sites. Data on the potential for productive use and industrialisation is now being collected and will then be integrated into the electrification plans.

2.7 Degree of Success and Prevailing Barriers

Quite a substantial number of mini-grids have been launched and developed in Ethiopia:

- The EEU operates 31 isolated diesel-powered mini-grids with sizes between 100 and 520kW, with an additional five mini-grids that have now been connected to the national grid.
- The EPC and O&M for an additional 12 solar-hybrid mini-grids with high renewable fraction has been awarded to four private sector companies. These are pilots to test the technical, financial and operational feasibility of solar mini-grids in various locations with different geographic, demographic and social conditions.
- A tender for an additional 25 solar-hybrid mini-grids funded by the African Development Bank was launched in late 2019 by the EEU, with the EPC and three months of O&M to be carried out by the private sector.
- GIZ had built five hydro mini-grids between 2010 and 2016, testing the viability of operation by cooperatives, but only two were still operational in 2020, with efforts underway to rehabilitate the three dormant mini-grids.
- A further project for 10 cooperative-operated solar-hybrid mini-grids is to be launched by mid-2021.
- The NGO Mercy Corps is running a tender for the installation of 3 mini-grids in refugee camps.
- Ethio Resource Group was the first private company to be granted a license for six wind-powered mini-grids in 2019 (after commissioning in 2017) of 1kW each.
- Rensys Engineering & Trading has become the second company to install a privately operated mini-grid, with solar generation of 12kWp and a license provided in 2020.
- In collaboration with the Korean International Cooperation Agency, the former Universal Electrification Access Program (UEAP) also launched two hydro mini-grids in 2017.

Current challenges in the implementation of mini-grids include:

- The adoption of mini-grid directives is vital for the further involvement of the private sector, with delays here also impacting the roll-out of the minimum subsidy tenders.
- Many rural areas in Ethiopia are lagging behind on digital inclusion and mobile networks. The mini-grid rollout will have to be accompanied by an increase in mobile phone coverage and educational campaigns.

3 List of Key Documents, Regulations, and Policies

National Electrification Program 2.0 - https://www.powermag.com/wp-content/uploads/2020/08/ethiopia-national-electrification-program.pdf

Multi-Tier Framework Survey on Household Energy Access - https://datacatalog.worldbank.org/dataset/ethiopia-multi-tier-framework-mtf-survey-2018

Energy Regulations 2019 - http://www.eea.gov.et/index.php?option=com_content&view=article&id=192:energy-regulation-no-447-2019&catid=46&Itemid=225&lang=en

Draft Directives for Mini-Grids (Third Draft) - https://eea.gov.et/index.php?option=com_content&view=article&id=338:mini-grid-directive-third-draft-to-attorny-office-version-august-20-2020&catid=70&Itemid=181&lang=en

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