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MINISTRY OF WATER AND ENERGY

NEP 3.0
ELECTRIFYING ETHIOPIA

THE WORLD BANK

National Electrification Program

NEP 3.0

Final Report

Federal Democratic Republic of Ethiopia

NEP 3.0 - FINAL REPORT
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Abbreviations & Acronymous

Stakeholders & programmes

ADELE	Access to Distributed Electricity and Lighting in Ethiopia
AfDB	African Bank of Development
ASCENT	Accelerating Sustainable and Clean Energy Access Transformation
DBE	Development Bank of Ethiopia
DREAM	Distributed Renewable Energy–Agriculture Modalities
EEP	Ethiopian Electric Power
EEU	Ethiopian Electric Utility
ELEAP	Ethiopia Electrification Program
ESA	Ethiopian Standard Authority
ESEDA	Ethiopian Solar Energy Development Association
ESS	Ethiopian Statistical Service
EU	European Union
GIZ	German Cooperation Agency
GoE	Government of Ethiopia
GTP	Growth and Transformation Plans
MFI	Micro Finance Institution
MoWE	Ministry of Water and Energy
NDP	National Development Plan
NEP	National Electrification Plan
PEA	Petroleum & Energy Authority
SE4ALL	Sustainable Energy for All
UEAP	Universal Electricity Access Program
UNDP	United Nation Development Programme
WB	World Bank

Technical

AC	Alternative current
CAPEX	Capital Expenditure
CX	Connection
d	density
DC	Direct Current
DP	Development Pole
DPI	Development Potential Indicator (or IPD)
EA	Enumeration Area
ETB	Ethiopian Birr (=…US$ in … 2026)
G	Grid
GE	Google Earth
GHI	global irradiation on a horizontal plane
GTI	Global Tilted Irradiance
GIS	Geographic Information System
HAWT	Horizontal Axis wind turbine
HH	Household
HR	High Resolution
HV	High Voltage (> 33kV)
kW	Kilowatt
kWh	Kilowatt Hour
LCoE	Levelized Cost of Electricity
LV	Low voltage
µG	Micro-grid
MG	Mini-grid
MTF	Multi-tier framework
MV	Medium voltage (11-33 kV)

O&M	Operation & Maintenance
OG	Off-Grid
OPEX	Operating expenditure
PAYG	Pay as you go
PBG	performance-based grants
PJ	Peta Joule = 10^{15} Joule
Pop.	Population
PPP	Public-Private Partnerships
PSH	Peak Sun Hours
PUE	Productive Use of Electricity
PV	Photovoltaic
PVoC	Pre-export Verification of Conformity programme
QV	Quality Verified
RB	Rechargeable Battery
RE	Renewable Energy
SAS	Stand-Alone Solar system
SCS	Solar Community System
SHS	Solar Home System
SHP	Small Hydro Power
SL	Solar Lanterns
SLS	Solar Lighting System
SPS	Solar Pumping System
SWER	Single Wire Earth Return
US$	US Dollar (US$)
Wp	Watt peak
Y1	Year 1

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Foreword

Electricity is more than a utility, it is the foundation of modern life, a driver of economic growth, and a catalyst for social transformation. In Ethiopia, our vision of prosperity and inclusive development cannot be realized without universal access to reliable, affordable, and sustainable energy.

The National Electrification Program (NEP 3.0) represents a bold step forward in our journey to light every home, power every school, energize every health center, and enable every enterprise. It is not merely about extending wires and poles; it is about extending opportunity, dignity, and hope to millions of Ethiopians.

This program builds upon our nation's rich renewable energy potential, harnessing hydropower, wind, solar, and geothermal resources to create a resilient and green energy future. It is designed to be inclusive, ensuring that rural communities, urban centers, and marginalized groups all benefit from the transformative power of electrification.

The NEP is also a testament to Ethiopia's commitment to sustainable development and climate resilience. By prioritizing clean energy, we are not only meeting the needs of today but safeguarding the well-being of generations to come.

I call upon all stakeholders—government institutions, development partners, the private sector, and communities—to join hands in realizing this vision. Together, we can ensure that electricity becomes a universal right, a shared resource, and a cornerstone of Ethiopia's growth and transformation.

With determination and unity, we will illuminate the path toward a brighter, sustainable, more prosperous Ethiopia.

H.E. Minister Dr.-Inj. Habtamu Itefa Geleta
Minister of the Ministry of Water and Energy
Federal Democratic Republic of Ethiopia

EXECUTIVE SUMMARY

INTRODUCTION

The objective of the NEP 3.0 is to update the National Electrification Program (NEP 2.0) to reach universal access to electricity services by 2035 in Ethiopia as announced by the Government of Ethiopia. While a recent study from the World Bank pointed out that **65% of Ethiopians have access to electricity in 2025, and only 56% in rural areas, reinforcing access to electricity is indeed vital to improve people's living conditions and to foster economic development**. To achieve this goal, however, stakeholders of the energy sector in Ethiopia, like others in East Africa, face multiple challenges: lack of funding, affordability and population's ability to pay, technical and commercial losses, cost recovery failure, etc. Moreover, as a consequence of particular conditions in rural environments (low demand for energy, scattered population, etc.), electrification projects are often not profitable. This implies that investments subsidies are structurally mandatory. Since available public funds are limited, optimizing these subsidies is of utmost importance. For that, one of the answers lies in the ability of energy stake-holders to carry out realistic electrification planning in time and space, with the most appropriate supply options. A properly designed electrification plan helps to maximize the impacts of a program by accelerating its execution and widening its scope, while reducing on-site construction costs.

The update of the National Electrification Program is the fourth major plan to increase the access in Ethiopia. Ethiopia's push for electricity started with the Universal Electricity Access Program (UEAP), which, from 2005 to 2015, significantly increased the number of towns and villages connected to the grid – from only 667 to approximately 6,000. Following this achievement, access to electricity soared from 15% to almost 43% between 2005 and 2016. In 2017, the government then outlined a National Electrification Program to reach universal access by 2025, balancing grid connections (65%) with off-grid solutions (35%) as a strategy to accelerate access in rural areas where the national grid would not easily reach. Quickly after, this first program was reinforced by a second NEP (2019) providing a more detailed off-grid implementation framework based on smarter approaches gathering the use of a least-cost geospatial planning tool as well as strongest consultations with public and private sec-tor implementing agents. Despite significant achievements over the past twenty years, today 35% of Ethiopians remain without any access to electricity services: 9% in urban areas, 44% in rural areas1.

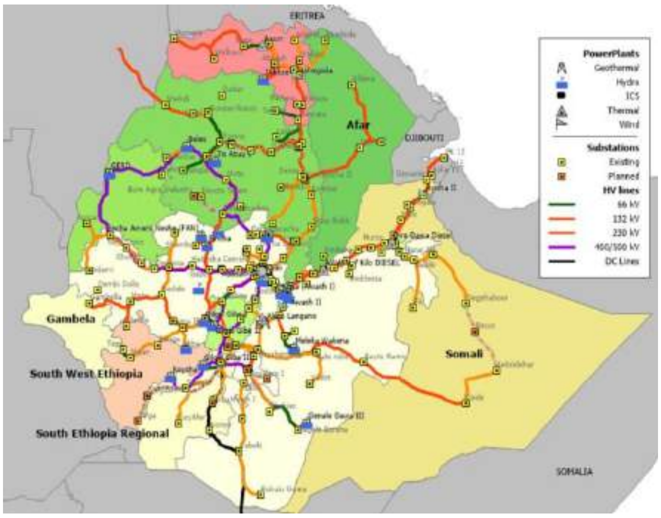
In this context, **MoWE has decided to update the National Electrification Program by developing a geospatial least-cost electrification analysis aimed at defining the pathway to achieve universal access to electricity ser-vices by 2035**. To achieve this objective, it was necessary

- to map electricity access across the country in order to understand how grid and off-grid distribution services and consolidate a **national GIS database** including electricity infrastructures, socio economic data, renewable energy resources assessment...
- to identify priority electrification projects based on socio-economic criteria defining which of the unserved localities should be electrified as a priority in order to increase the impact of electrification on the economy and public services while serving the greatest number of people
- to improve the quality of electricity services and optimize costs, conducting a demand forecast study for
- electricity over the planning horizon in order to tailor electrification options as closely as possible to future needs.
- to clearly define a **least coast pathway toward universal access in Ethiopia by 2035** based on various geographical and techno-economic criteria, to clearly understand where to electrify, with which supply option, for how many users, and with what levels of investment.

The NEP 3.0 covers the **Suitable options and arrangements for scaling up electrification** which aimed at defining mechanisms facilitating the NEP 3.0 implementation among national institutions. This key analysis included both financial planning and Institutional arrangement and setup. Many issues and challenges are, nowadays, slowing done the electrification process in the country. In order to favorize a **more efficient environment** and tackle various bottlenecks identified in Ethiopia, some recommendations were finally done.

1. POTENTIAL LEAST-COST TECHNOLOGY OPTIONS FOR ELECTRIFICATION

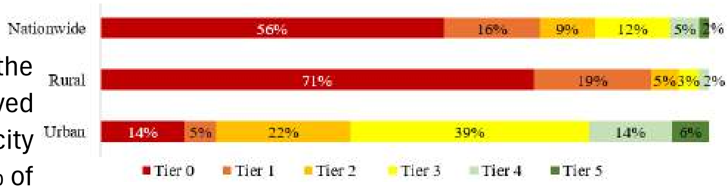
1. STATUS OF ELECTRIFICATION IN ETHIOPIA



♦ Infrastructures

Ethiopia's power generation and transmission network is extensive and quickly evolving. The country relies on a mix of **hydroelectric, geothermal, solar, wind, and thermal** energy sources. The transmission network spans **over 20,000 kilometers**, with voltage levels ranging from **66kV to 500kV**. Ethiopia has also established a 500kV DC trans-mission line connecting it to Kenya, fostering regional energy cooperation.
More than 230 substations are supplying energy from the interconnected grid to distribution networks reaching the main populated areas.

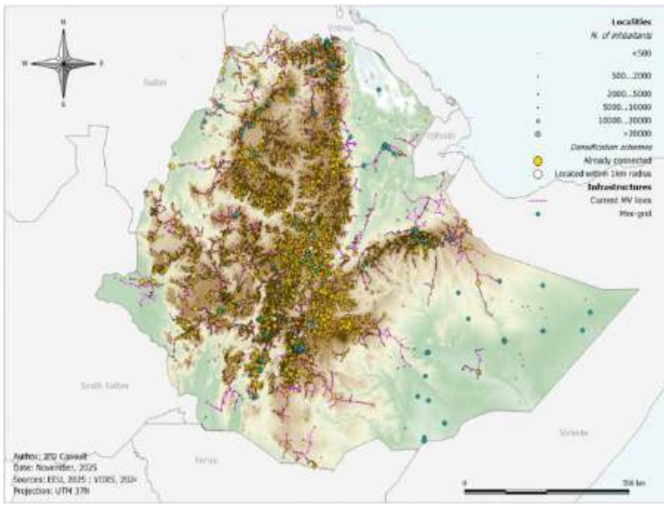
♦ Electricity Access



Regarding the electrification status, and according to the World Bank, nearly 94% of Ethiopians in urban areas enjoyed access to energy while only 43% had access to electricity in rural homes. The World Bank estimates that about 55% of the total population had access to electricity in 2022.

Based on the most recent Multi-Tier Framework (MTF) survey, 22% of households currently have a legal connection to the national grid, while only 2% of households have a Tier 5 connection (more than 23 h/day). Moreover, the latest census (Energy Access Survey in Ethiopia, 2025) pro-vides a more updated picture of the situation in Ethiopia and rather estimates the access rate around 44% with at least a Tier 1 connectivity

♦ Electricity coverage and connectivity



Out of **the 25,650 localities identified in the country national database, more than 9,597 (or 37%) are electrified**

According to the Energy Access Survey (WB, 2025) - **nationwide 65% of Ethiopians households have access to at least one source of electricity**. This includes access either from the national grid, mini-grids, generators, solar home systems, solar lanterns or rechargeable batteries. However there is some significant regional disparities et between urban and rural areas: **91% of households have access to electricity in urban areas compared to 56% in rural areas. About 28% of households are connected to the grid (8.2 million)**. EEU reports 4.3 million domestic connections around 47% of grid-connected households have an unformal connection (i.e. 3.8 million households). Considering that 65% of the population have access suggests that around 10.5 million Ethiopian households are also equipped with a SAS, while 10 million (35%) households have no source of electricity at all.

Type of access	Scenario 1 (133 M inhabitants)	
	N. of households	Share of households (%)
Grid, of which:	8,171,698	28 %
EEU domestic customers	*4,331,000*	*15 %*
Domestic consumers in need of regularization	*3,840,698*	*13 %*
Mini-grids	9,820	0 %
Standalone systems	10,546,180	37 %
Households without access	10,084,145	35 %
Number of households (2025)	**28,811,843**	**100** %
Households with electricity access	*18,727,698*	*65 %*

2. DIAGNOSTIC AND FINDINGS

1.Population gap

A strong discrepancy was observed during the database consolidation between ESS population projection and currently used figure. While ESS's projection is estimating the country's population around 111 million inhabitants in 2024, most international sources (UN, WB,...) estimate a higher figure around 133 million inhabitants. This gap will impact significantly electrification planning investment. The NEP 3.0 is therefore proposing 2 planning scenarios: the Baseline scenario 1 which considers a population of 133 million inhabitants and scenario 2 aligned on ESS population estimates.

2.Renewable resource assessment

Ethiopia has **significant untapped small-scale hydropower potential** (below 2 MW), especially in its highland regions where numerous perennial streams flow year round. The lack of a detailed assessment of mini hydropower resources currently prevents us from counting all the potential hydropower sites that could be developed into decentralized, low-impact energy solutions for rural communities far from the national electricity grid.

Ethiopia lacks also of a biomass resources assessment which should characterize agro-industries generating biomass residues that could be upcycled, such as wood processing units, plantations, mills, through gasifiers in order to energize mini-grids.

3.Off -grid solutions development

The national off-grid policy in Ethiopia mainly focusses on 2 technology solutions: mini-grids (MG) and stand-alone systems (SAS). Both Mini-Grid developers and SAS promoters are facing barriers and challenges, and also depending on their maturity level, the local context, etc. The main obstacles can be listed as follows:

- **Standalone system providers** (SAS): financial challenges like a lack of access to capital and stringent collateral requirements, difficulties with foreign currency exchange for imports, and a regulatory and administrative environment that can be unfavorable. Additionally, consumer-related issues such as low awareness, the prevalence of counterfeit products, and high costs for quality products also hinder growth.
- **Mini-grids developers** (MG): high upfront costs, a lack of access to finance and capital, weak and unclear regulatory frameworks, tariff uncertainty and limited technical and operational capacity. Other challenges are the cost of doing business, security concerns, and insufficient market information.

4.Decentralized Electrification planning barriers

One of the most significant barriers is the lack of standardized, decentralized planning tools and methodologies for regional authorities. Without these, regions cannot:

- Identify priority areas for grid expansion with high impact on population
- Conduct geospatial least cost analyses
- Integrate electrification with regional development plans
- Coordinate grid and off-grid solutions
- Engage effectively with private sector and development partners

This gap leads to **over-reliance** on regional/national plans, which may overlook local economic clusters, emerging towns, or underserved rural communities.

5.Productive uses and incentives

Electrification is most impactful when paired with productive use of energy. However:

- Credit access for SMEs is limited
- Agricultural value chains are under-electrified
- Industrial parks are prioritized over rural enterprises

This reduces the economic viability of grid expansion in rural areas and therefore the benefit for EEU

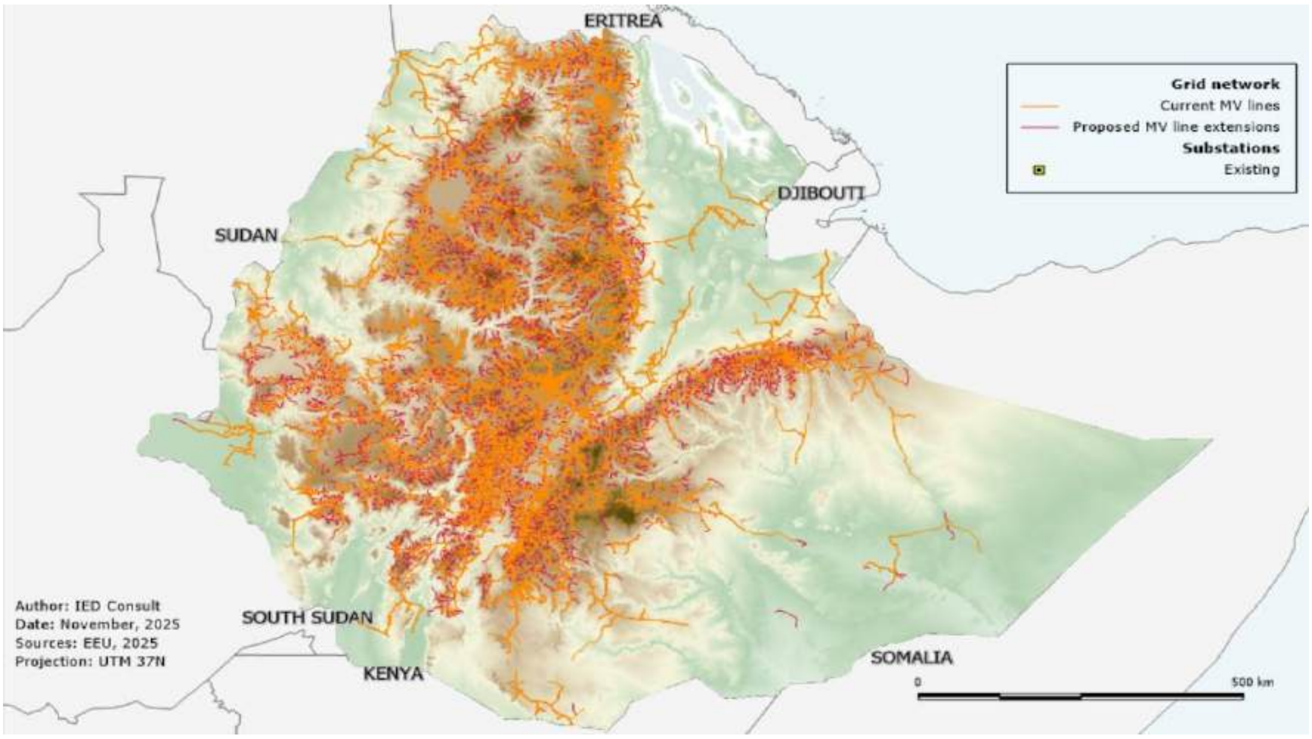
3. ELECTRIFICATION PATHWAY TO UNIVERSAL ACCESS

Due to the size of its population, Ethiopia will need to provide a very large number of connections to achieve universal access to electricity by 2035. According to the Baseline scenario, more than 32.5 million additional connections will be required to reach this objective.

Achieving universal access by 2035 involves massive deployment of connections through various packages of electrification including on-grid and off-grid electrification schemes.

- **Densification and grid expansions**

The proposed approach shall start with the least cost electrification component with will deal with the electrification of on-grid areas and particularly the densification of connections where the interconnected grid is already active. This component will also include the regularization of informal connections (Shared meters, unofficial connections...).

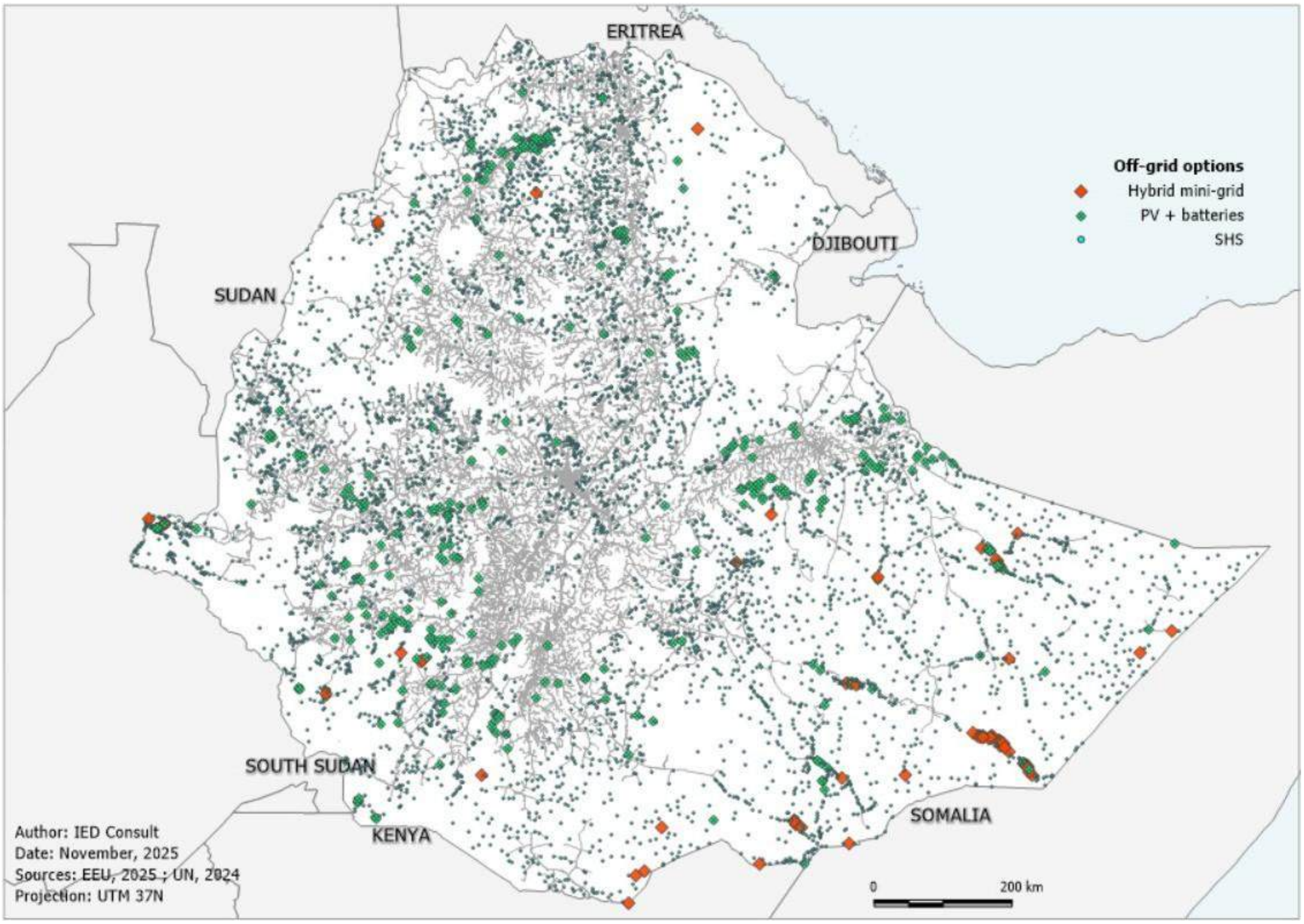


- **Mini-grids and standalone systems**

Regarding the Off-grid electrification component, universal access can only be reached by combining various technologies such as mini-grids, microgrids and standalone systems even though the proposed service level varies from Tiers 1 up to Tiers 3. While solar home systems (SHS) are common (estimate varies from 3 to 9 million of SHS sold since 2020), the sector is slowly moving from pre-electrification scheme with standalone systems (Tier 1 & 2) to-wards mini-grids (Tier 3 & 4) to also promote productive use of electricity (PUE), to increase income generation and to boost economic development in rural areas. Off-grid investment needs are listed below:

Off-Grid Scheme	Nb Connections	Investments (MUS$)	%	Cost/Cnx (US$)
Hydro projects	25,584	438.45	24%	17,138
Micro-grids	14,591	16.44	1%	1,127
Mini-grids	301,496	264.05	14%	876
SAS	4,051,776	1,145.85	61%	283
TOTAL	**4,393,447**	**1,864.79**	**100%**	**424**

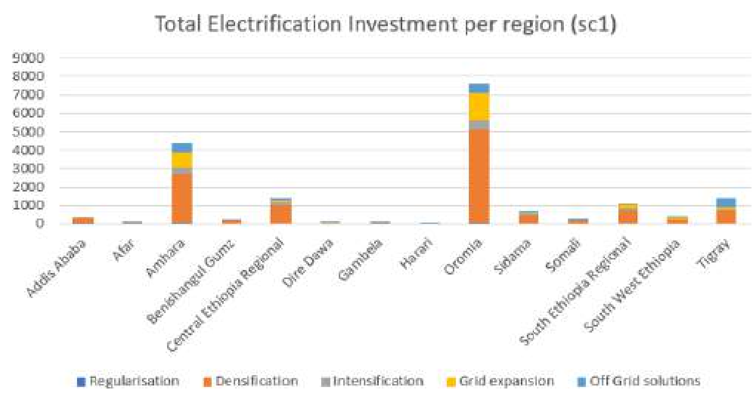
More than 1,86 million US$ shall be necessary to cover the off-grid areas with mini-grids and distributed energy solutions in scenario 1. Most of Ethiopian regions will be impacted except Addis Ababa and Harari urban regions.



The total capital investment requirement for achieving universal connectivity under a least cost rollout strategy is estimated at US$ 18 billion by 2035 for Baseline scenario 1. Of this total, grid connections account for US$ 16.2 billion corresponding to 32.5 million of the total new connections, while US$ 1.86 billion in off-grid investment is expected to provide connectivity to about 4.4 million households (including more than 5,786 localities).

Electrification schemes	N. of locali-	N. of connections target-	Investments needed (M	Average cost per connec-
Regularization	9,597	3,845,106	249.931	65
Densification	11,862	18,753,681	11,737.994	626
Intensification	2,734	1,790,776	1,312.955	733
Extension	5,268	3,754,893	2,922.007	778
Off-grid (mini-grids + SAS)	5,786	4,393,447	1,864.789	424
Total	**25,650**	**32,537,903**	**18,087.676**	**491**

Regional investment differs not only in terms of the total number of required connections, but also in the investment requirements and in the mix of investments re-quired to achieve those connections.



RECOMMENDATIONS

The NEP study concludes with few key recommendations to reinforce energy planning in Ethiopia thought an enhanced ambitious pathway including Institutional arrangements and financial analysis.

1.Improve and expand data and population knowledge

Ethiopia needs to take a strategic leap forward by strengthening how it identifies, maps, and understands its population. Accurately locating localities and producing more reliable population estimates is not just a technical exercise—it is the foundation for effective planning, equitable service delivery, and evidence-based policymaking. With-out a precise picture of where people live and how many they are, the country risks under-serving communities, misallocating resources, and slowing its own development trajectory. A modernized, data-driven population system is therefore essential for Ethiopia to plan confidently, govern efficiently, and invest where it matters most. In long term, ESS is obviously the most suitable institution to lead this activity through regional surveys and census.

2.Foster off-grid electrification through development of mini-grids

Together, solar mini- and micro-grids are expected to provide about 316,000 connections (representing about 7 percent of all off-grid connections); for a total investment requirement of US$ 280 million. The mini- and micro-grid technologies proposed in the Baseline rollout scenario are powered by solar PV, adding approximately 88 MWp of installed solar capacity. In addition, 25,500 new connections are targeted by 31 preidentified hydro schemes for a total investment requirement of US$ 438 million. Viability of those sites will only be ensured when interconnected to the mail grid. Additional investigation would still need to be performed for those opportunities.

3.Distributed energy systems, a key solution to reach scattered households and remote areas

Standalone solar home systems (SHS) designed to deliver a Tier-2 service standard (50 Wp) and a Tier-1 service (11Wp) represent the major share of off-grid connections; specifically, about 4 million connections out of 4.4 million total off-grid connections (92%).

The analysis suggests an opportunity segments for consideration by the GoE with respect to SHS policy, planning, and promotion, consistent with relevant lessons of good practice experience worldwide:

The Design and promotion of a private sector led market-based implementation of a “pre-electrification” program component, to provide basic electricity services to households that will otherwise not immediately benefit from grid or mini/micro grid connections in the near term.

Good practice lessons of relevant SAS experience elsewhere indicate that enabling policy support and establishing clear guidelines and standards for standalone solar systems can significantly contribute to (i) rapidly can go a long way to catalyse private sector- led and market- based rapid scale up deployment; (ii) developing a market for of certified products that meet meeting established service performance criteria; and (iii) to implement after-sales-service contracts consistent that comply with the guidelines for an appropriate code-of-conduct.

4.Government support and institutional framework

The success of the off-grid roll-out programme components of the National Electrification Program implementation and its sustainability in quality of services delivered in Ethiopia will depend among other factors on the government’s role in establishing a conducive and enabling environment (policy, institutional, financing, and regulatory frameworks) to develop, design and deploy scaled-up implementation programmes specifically in the off-grid space broadly identified in this report. In particular, the standalone and mini- & micro-grid solutions identified as least cost on a techno-economic basis for isolated locations – among the small and low-demanding rural settlements - will pose significant challenges as experience elsewhere has demonstrated.

2. INSTITUTIONAL ARRANGEMENTS AND SETUP

BACKGROUND

A key pre-requisite to the achievement of the ambitious National Electrification Program (NEP 3.0) grid and off-grid targets, is a well-coordinated and financially and technically capacitated institutional framework. As such, key stakeholders in Ethiopia's electrification sector ranging from Government Ministries, Regional Electrification Bureaus, utilities, the private sector, development partners, the regulator, and lobby groups, are expected to play a key distinct, but coordinated role within this framework to ensure seamless, cost-effective and rapid implementation of electrification in both rural and urban areas.

This strategy is informed by the review of prior strategies like NEP, NEP 2.0 as well as on reports on electrification programs undertaken prior, benchmarking analysis of regional peers (Kenya, Tanzania, Nigeria, Zambia, and consultative stakeholder discussions conducted in Ethiopia.

Contextually, the NEP 3.0 targets connecting 3.25 million households annually, a 6-fold increase from the current 500,000, with 4.4 million households to be connected in the off-grid sector by 2035. These targets are not only the most ambitious targets in the country, but in the entire African region, as such achieving this milestone will make Ethiopia a model country on electrification planning and implementation globally. As such efforts in financing, institutional planning have to be developed to match these ambitions. It is at the backdrop of this framework that the institutional strategy was developed.

IDENTIFIED GAPS AND CHALLENGES AFFECTING EFFECTIVE INSTITUTIONAL COORDINATION

The efficacy of the existing institutional arrangements was determined to be sufficient albeit with a few challenges on coordination, implementation capabilities, and procurement and contract administration constraints, and private sector participation.

On procurement of electrification equipment, while significant progress has been made by both MOWE and EEU, significant challenges still affect the timely implementation of electrification projects. The lack of a harmonized and singular procurement system for both EEU and MOWE remains a key area of concern. While the EEU is governed by its own procurement guidelines, the MOWE is governed by national procurement proclamation and directives. Other key challenges include; Inadequate procurement capacity at both MOWE and EEU; and inadequate contracts administration and the efficient resolution of contractual disputes.

On coordination, the lack of institutionalized coordination mechanisms across actors at various levels of government, have consistently led to delays and inefficiencies in project implementation. Improving coordination among MoWE, EEU, and the regional governments is thus essential to achieving universal access.

On private sector participation, it has been highly limited in the electrification spectrum, but they are expected to play a huge role in off-grid electrification which requires 4.4 million connections via mini-grids and Solar Home Systems installations.

On capacity, electrification programs by MoWE and EEU have had challenges in manpower, technical expertise, planning and design, with these institutions overstretched in the undertaking of their duties. As such, and cognizant of the fact the utilities and the ambitious NEP 3.0 has made significant efforts to address these challenges.

PROPOSED INSTITUTIONAL FRAMEWORK

♦ Ministry of Water and Energy

MoWE is the apex policy body for Ethiopia's energy sector, holding responsibility for national energy policy, sector strategy, target-setting, and oversight of the electrification program. MoWE also coordinates Ethiopia's international energy partnerships and is responsible for the legal and regulatory instruments governing the sector. Within MoWE's electrification framework, there will be two coordinated institutional set-ups:

- The High Level steering committee for NEP - The Committee, chaired by the Minister, is a cross sectoral body with representation from the Ministry of Finance, regional governments, and development partners. It meets quarterly to review progress against targets and authorize major fund allocations.

- The Directorate of Electrification- Compact Delivery and Monitoring Unit- Responsible for energy planning and NEP coordination and interfacing with development partners.

♦ Ministry of Finance and Economic Development

The ministry of Finance is expected to play a key role in financing coordination, fiscal oversight and engagement with development partners

♦ Ethiopia Investment Holdings

The firm, which owns both the EEU and EEP will be key in ensuring proper oversight of EEU and EEP in implementing NEP 3.0 targets by supporting their financial and operational reporting

♦ Ethiopia Electric Power (EEP)

EEP being responsible for electricity generation and high voltage transmission and provision of sufficient and reliable power supply to meet demand in the different regions of Ethiopia, will ensure:

- Expanding and reinforcing the transmission network to enable the households connection through grid extension.
- Supporting the increased load from grid densification, grid intensification and grid extension resulting in an additional peak demand of over 1,200 MW

♦ Ethiopia Electric Utility (EEU) and the Universal Electricity Access Program (UEAP)

EEU is the primary implementing agency for Ethiopia's grid electrification program — responsible for planning, procurement, construction, operation, and maintenance of distribution networks, and for the commercialization of electricity to end consumers.

Within EEU, the Universal Electricity Access Program (UEAP) is the designated execution arm for large-scale distribution system extension, and rural electrification, including isolated off-grid systems through its Off-grid Unit (OGU).. The elevation of UEAP to an **Executive Implementation Office** reporting directly to the CEO of EEU, with full administrative, financial, technical, and procurement autonomy. To be completed by end-2026 is a key pre-requisite to Ethiopia's access targets as it will allow UEAP to operate with the speed and accountability required. The Executive Implementation Office of the UEAP will be established with its own budget, a dedicated procurement unit, independent project management systems integrated with the national energy dashboard, and direct authority to engage contractors and certify project completion. There will be two directorates: one for grid-based expansion and the other for off-grid access provision (currently the OGU).

♦ Petroleum and Energy Authority

Under the NEP, the Petroleum and Energy Authority will be responsible for undertaking the following functions

- Tariff approval for private mini-grid developers
- Licensing private mini-grid operators under a streamlined framework with clear grid arrival protection instruments
- Establishment and enforcement of comprehensive Quality of Service Standards (SAIFI/SAIDI) applicable to EEU
- Ensuring quality standards for off-grid distribution systems and appliances are adhered to in collaboration with the Ethiopian Standards Agency (ESA)

♦ Re-Instated Rural Electrification Fund

The key objective of the REF will be capital mobilization in accordance with the Rural Electrification Establishment Proclamation No. 317/2003, which provides the following funding mechanisms:

- ✓ Budget Allocations from Local and Regional Governments
- ✓ Loans and Grants from Development Partners
- ✓ Grants from Non-Governmental Organizations
- ✓ Income from other sources
- ✓ 3%-5% of Electricity Sales by EEU

A competitively recruited central trust agent will be responsible for administration of the fund flow or loan facilities based on agreements made with MoWE, MoFED and EEU in the following manner:

- ✓ Financing UEAP Grid electrification projects
- ✓ Providing Results Based Financing Facilities to suppliers of off-grid appliances
- ✓ Providing CAPEX and OPEX subsidies to Private Mini-Grid Developers

♦ Regional Energy Bureaus

REBs provide the essential link between national planning and local realities. Under the NES, they have an expand-ed and formally defined role: providing "bottom-up" electrification priority data; coordinating land acquisition and community engagement and monitoring implementation quality of both grid and off-grid projects in their regions.

Development Partners

Development partners play a key role in financing access to electricity through concessional loans and grants, alongside governments, the private sector and customers. Ethiopia has benefited significantly from development partner support programs in the past. As such, development partners will be key in providing financing, technical assistance, capital mobilization, results-based financing and risk mitigation instruments for the country to achieve its targets on electrification, clean cooking, sustainable utilities, transmission and regional interconnection and private sector participation.

♦ The Private Sector

The private sector is a critical partner in implementing off-grid solutions in rural and underserved communities. This concept is adopted in NEP 3.0 where the private sector is envisioned to be a key financier and implementing agent of off-grid electrification consisting of mini-grids and standalone PV systems connecting over 4.4 million households. The government on the other hand focuses on promotion of off-grid solutions to connect isolated public facilities such as schools, health centers and improving access to essential services in rural areas.

♦ Ethiopian Solar Energy Development Association

Under the NEP 3.0 ESEDA will continue playing a key role as a lobby for driving the adoption of sustainable energy solutions, broadening rural electrification efforts and enhancing energy service delivery for underserved communities, fostering economic, social and environmental progress.

♦ Futuristic Consideration: The Rural Electrification Authority

Based on the consultants' analysis, it is certain that EEU has the capacity to undertake the function of implementing electrification efforts using its dedicated and improved UEAP unit with on-grid and off-grid departments and therefore for this specific NEP 3.0, the function should be undertaken by EEU.
However, the sustainability of the program in the long-run may require a dedicated Rural Electrification Authority, to specifically focus on the socioeconomic aspects of electrification in rural areas, leaving EEU the duty of focusing on commercial aspects of electricity distribution. A dedicated REA will be important in undertaking other functions like research and promotion of productive uses of electricity in rural areas.

RECOMMENDATIONS FOR THE INSTITUTIONAL FRAMEWORK

Prioritize the re-establishment of the rural electrification fund- To enhance capital mobilization and support to grid and off-grid electrification, and private sector participation in the off-grid market through RBF and other subsidy mechanisms (CAPEX, OPEX grants).

Approval and Operationalization of the Executive Implementation Office of UEAP- with full administrative, financial, technical, and procurement autonomy will enable UEAP to operate with the speed and accountability required.

Operationalization of the Compact Delivery and Monitoring Unit: To enhance electrification planning and NEP coordination and interfacing with development partners

Regulatory Aspects: Licensing private mini-grid operators under a streamlined framework with clear grid arrival protection instruments. Establishment and enforcement of comprehensive Quality of Service Standards (SAIFI/ SAIDI) applicable to EEU, ensuring quality standards for off-grid distribution systems and appliances are adhered to in collaboration with the Ethiopian Standards Agency (ESA).

Clear Grid Arrival Provisions to incentivize private sector participation pursuant to Mini-Grid Directive no.268/2020- Additional provisions on:

- ✓ Point of interconnection and documentation requirements
- ✓ Protection and Safety Requirements
- ✓ Power Quality Requirements at the Point of Interconnection
- ✓ Technical Conditions for supplying power to the National Grid
- ✓ Technical conditions for receiving supply from the National Grid
- ✓ Technical conditions for Asset Transfer and Inspection.

3. FINANCIAL ANALYSIS

FINANCIAL STRATEGY

The National Electrification Program (NEP 3.0) establishes an ambitious goal of universal access to electricity for Ethiopia by the year 2035 through a least-cost planning approach based on the GEOSIM geospatial model. To achieve this objective, gross financing requirements are estimated around US$ 17,239 million under a high-growth environment (Baseline Scenario 1).

The vast majority of these investments are concentrated in on-grid components, primarily for densification projects

that represent the largest number of projected connections. To sustain this capital requirement, the financing source structure contemplates a mixed scheme: on-grid investments will be financed mainly through concessional loans from International Financial Institutions (IFIs) at 61%, public budget allocations from the Government of Ethio-pia at 24%, and grants or climate financing at 15%; meanwhile, the off-grid segment will rely heavily on the private sector through tendered mini-grid concessions and the revitalization of the Solar Home Systems (SHS) market with Results-Based Financing (RBF) and Pay-As-You-Go (PAYG) models.

The financial viability of NEP 3.0 faces critical macroeconomic and regulatory challenges grouped into key financing considerations. Notable among these are the historic tariff lag of the public utilities (EEP and EEU) and the lack of effective tariff indexation against inflation and severe exchange rate depreciation, which erodes the real value of revenues and threatens the sustainability of the Regulated Asset Base (RAB). Likewise, foreign exchange scarcity hinders equipment importation and the repatriation of profits by foreign investors, making fundamental reforms in the off-grid market indispensable, including the flexibilization of business licenses, the authorization of alternative payment methods such as airtime, and the exemption of retail sale restrictions to promote joint ventures

FINANCING REQUIREMENTS AND EXPANSION SCENARIOS

To close the rural-urban access gap, NEP 3.0 projects universal access by 2035 under the criteria of the World Bank's Multi-Tier Framework (MTF). The program plans this expansion through a baseline scenario 1)requiring US$ 17,239 million, promoting social development and sustainable economic growth in the country.

In order to optimize resources, a hierarchy of on-grid interventions is prioritized, demanding between US$ 16,223 million (Baseline Scenario). This includes densification projects (MUS$ 11,738), regularization of informal connections (MUS$ 250), grid intensification (MUS$ 1,313), and the physical extension of medium and low-voltage lines (MUS$ 2,922).

In remote areas with low population density where grid expansion is not viable, decentralized off-grid solutions will be implemented with a constant investment of US$ 1,016 million for both scenarios. These technologies contemplate the deployment of micro and hydro renewable mini-grids (MUS$ 430), solar photovoltaic mini-grids (MUS$ 59.5), solar micro-grids (MUS$ 5.6), and the distribution of standalone solar home systems (MUS$ 521.4).

FINANCING SOURCES AND COVERAGE MECHANISMS

1.On-Grid Investments

The on-grid segment represents 94% (Scenario 1) of the plan's total investment. It is structured under 3 sources:

1. **Budget Allocations from the Government of Ethiopia (24% - ~US$ 3,928 million):** Direct transfers to EEU and the Rural Electrification Fund (REF) through mechanisms such as the Public Service Obligation (PSO) and the state debt management corporation LAMC (*Liability and Asset Management Corporation*). The LAMC absorbed historical debts of EEP and EEU caused by frozen tariffs to allow them to operate and expand without immediate financial burdens.
2. **Concessional Loans from IFIs (61% - ~US$ 9,831 million):** Financing provided by international development institutions, mainly the International Development Association (IDA/World Bank), the African Development Bank (AfDB), and the European Investment Bank (EIB).
3. **Grants from Development Partners and Climate Financing (15% - ~US$ 2,433 million):** Ethiopia leverages its electricity generation mix (90% of which is generated from renewable sources) to channel resources from the Climate Investment Funds (CIF), the Scaling-Up Renewable Energy Program (SREP), REDD+ programs, and the Biocarbon Fund.

2 .Off-Grid Investments

An approach centered on local and foreign private investment under two main streams:

Mini-Grid Concessions (~MUS$ 438): Projects awarded through competitive bidding. Private concessionaires con-struct, operate, maintain, and replace assets. To guarantee affordability for users without the operator incur-ring losses, the **Viability Gap Funding (VGF)** mechanism proposed under the NES will be applied to cover the gap between the real Levelized Cost of Electricity (LCOE) and the uniform national tariff.

Solar Home Systems (SHS) Market (~MUS$ 1,146): Developed in two phases:

- **Phase 1 (Short-Term):** Direct subsidy based on **Results-Based Financing (RBF)** of US$ 104 million administered by the MoWE and the REF to offset the "access premium" in remote regions. It applies only to quality-certified products.
- **Phase 2 (Medium to Long-Term):** Pay-As-You-Go (PAYG) models and competitive concessions under schemes such as **BOOT (Build-Own-Operate-Transfer)** for 15-20 years, requiring upfront capital subsidies of 40% to 60% (MUS$ 417) and a private investment commitment of around MUS$ 625.

KEY CONSIDERATIONS AND FINANCING BARRIERS

The Ministry of Water and Energy (MoWE) identified three historical gaps that constrained NEP 2.0: insufficient revenues from connection charges, external financing below anticipated levels, and limited private sector participation. On this basis, the following key considerations are defined:

Analysis of the Tariff Lag and Inflation

The tariff reviews of 2018 and 2024 sought a cost-recovery scheme with real quarterly increases. However, periodic indexation formulas to adjust for real devaluation and inflation were not implemented due to concerns about the potential socio-economic impact of such adjustments on low-income populations. This severely eroded the companies' revenues in real terms. The debt-absorbing LAMC mechanism represents a temporary fiscal relief that is un-sustainable over time and is not applicable to attracting the private investments that NEP 3.0 aims to attract.

Connection Charges and Affordability Barrier

Since requiring a connection fee of US$ 50 (a provision planned in NEP 2.0) represents an insurmountable economic barrier against average rural incomes of US$ 2 per day, NEP 3.0 discards its immediate collection. Although EEU's technical access fees are very low (ranging from US$ 0.57 to US$ 64), the program proposes **deferred payment** schemes and the gradual inclusion of these costs in the **Regulated Asset Base (RAB)** to safeguard the affordability of vulnerable families.

Regulatory Roadmap for the OGS-PAYG Market

To enable private participation in off-grid solutions, it is crucial to execute the Roadmap developed by the MoWE. This sectoral planning proposes urgent reforms to mitigate risks for investors through prioritizing foreign exchange allocation for importing key components, permitting joint ventures with foreign capital in retail activities, creating dedicated licenses for OGS providers, simplifying PAYG financing, and enabling alternative mobile payment methods.

RECOMMENDATIONS FOR FINANCIAL POLICY AND REGULATION

Efficient tariffs with indexation and social protection: It is fundamental to transition toward efficient, cost-reflective tariffs and periodically apply indexation formulas (against inflation and exchange rate depreciation) to prevent the erosion of real revenues for electric utilities (EEP and EEU). This policy must be complemented by social protection measures: a subsidized lifeline tariff for the first 50 kWh of residential consumption, cross-subsidies, and the use of standardized Ready Boards.

Establishment of a single-window mechanism for foreign exchange access: To mitigate macroeconomic risks for foreign investors and enable them to repatriate dividends, service external debt, and acquire imported equipment in a timely manner, it is recommended to establish a single-window mechanism that prioritizes foreign exchange allocation for activities associated with the National Electrification Program (NEP).

Promotion of local private investment: Establishment of specific financing policies and incentives aimed at strengthening and enabling the participation of local private developers and investors.

Regulatory reform for the off-grid segment: Swift implementation of the regulatory and institutional reforms out-lined in the MoWE OGS PAYG roadmap to optimally structure concessions and the SHS market.

Payment mechanisms and unified tariffs: Application of deferred payment schemes, inclusion of connection costs in the Regulated Asset Base (RAB) for the poorest rural households, and the design of subsidies that guarantee a fair and balanced tariff between on-grid and off-grid users

PRIORITY ACTIONS AND ACTION PLAN

Guarantee and execution of tariff investments: Enable and execute in a timely manner the investments recognized under the approved tariff framework for EEU, ensuring the flow of necessary capital planned for the regulatory period.

Activation of transparent subsidy mechanisms (VGF and RBF): Implement Viability Gap Funding (VGF) in mini-grid concessions to cover the gap between the actual cost (LCOE) and the uniform national tariff, guaranteeing the viability of the private investor. In parallel, activate Results-Based Financing (RBF) for Solar Home Systems (SHS) to offset the "access premium" in remote areas.

Application of efficient cost-reflective tariffs: Ensure that electricity tariffs reflect the actual costs of supply by applying periodic indexation formulas against macroeconomic fluctuations. This protects the integrity of the Regulated Asset Base (RAB) and incentivizes both private investment and multilateral financing by guaranteeing predictable revenues for debt service.

PHASE 1

Immediate Implementation and Delay Offsetting (Years 1-2 / Period 2026-2027)

Initial Investment and Regularization:

- ✓ Adopt and execute the investments already approved in the EEU Tariff Study for 2026 and 2027.
- ✓ Begin the physical and individual regularization of connections (targeting a total of 3.8 million connections), allocating equal annual investment amounts equivalent to one-fifth of the estimated US$ 250 million total for this mechanism.

Deployment of Renewable Technologies:

- ✓ For micro and hydro mini-grids (MHP-MG), execute the initial investment corresponding to 1% of the total in the first year and 5% in the second year.
- ✓ Maintain the constant annual investment allocation of US$ 52 million per year for Distributed Energy Solutions.

Short-Term Development of the Solar Home Systems (SHS) Market:

- ✓ Launch Phase 1 of the SHS market in areas where private solar companies currently operate, applying the Results-Based Financing (RBF) mechanism to offset the access premium.
- ✓ Condition disbursements strictly on independent verification of quality-certified connections, under the administration of the MoWE (and the REF once operational), requiring a subsidy of approximately US$ 104 million.

PHASE 2

Investment Scaling and Regulatory Integration (Year 3 and Onward / Period 2028 and Beyond)

Financial Scaling and Growth:

- ✓ Increase investments by 33% for the year 2028 under the Baseline Scenario.
- ✓ From 2029 onward, apply the projected annual growth rate of 10% in investments for densification, intensification, and grid extension for both scenarios (as detailed in the NEP annual investment breakdowns).

Leap Deployment of Off-Grid Solutions:

- ✓ For communities without grid viability, structure competitively awarded long-term concession contracts, utilizing Build-Own-Operate-Transfer (BOOT) structures lasting 15 to 20 years.
- ✓ Mobilize upfront capital subsidies of approximately MUS$ 417 (covering 40% to 60% of system costs) for this second SHS phase and attract around MUS$ 625 in private investment.

Key messages

The comprehensive geospatial electrification planning analysis results in this report shed light on eight strategic messages for decision makers and stakeholders in the Ethiopian power sector. These messages are summarized below and developed further in subsequent chapters of the report.

Message 1 – Ethiopia needs to take a **strategic leap forward** by strengthening how it identifies, maps, and understands its population. Accurately locating localities and producing more reliable population estimates is not just a technical exercise—it is the foundation for effective planning, equitable service delivery, and evidence-based policymaking. Without a precise picture of where people live and how many they are, the country risks under-serving communities, misallocating resources, and slowing its own development trajectory. A modernized, data-driven population system is therefore essential for Ethiopia to plan confidently, govern efficiently, and invest where it matters most.

While the ESS projects the country population to be around 110 million inhabitants in 2024, most international projections (UN, WB,…) estimate a higher figure of around 133 million inhabitants. This huge disparity significantly affected electrification planning investment. The NEP 3.0 is therefore proposing 2 planning scenarios: the Baseline scenario 1 which considers a population of 133 million inhabitants and scenario 2 aligned on ESS population estimates around 110 million inhabitants.

A key success factor for electrification planning and rural development also lies in the identification of **localities**, which are commonly used as the main electrification granularity. Localities can be named, characterized and localized in order to prepare future tenders and calls for proposal. Therefore, Ethiopia’s population was distributed using a National GIS database consolidating more than 25,560 localities identified across the country.

Message 2 – Overall, 55% of Ethiopian’s households have had access to electricity in 2022 (94% of Ethiopians in urban areas enjoyed access to energy while only 43% had access to electricity in rural homes). Around 22% of households currently have a legal connection to the national grid. Considering Tier 1 as the minimum service level, the number of households without real access (Tier 0) or without access to electricity at all, stood at 16.5 million in Scenario 1. Accounting for population growth, this implies that 32.5 million new household connections will be required in order to achieve universal connectivity nationwide by 2035 (scenario 1).

The overall connectivity[1] rate in Ethiopia stands at about 55% for 2022 (including informal connections). Achieving universal connectivity will require Ethiopia’s electricity sector to make 32.5 million new household connections by 2035. At the national level, this means more than multiplying by a factor 6, the average number of new connections made annually, from 500,000 per year currently to over 3,250,000 per year. This calls for a sustained and scaled-up physical implementation to be staged by EEU, and coordinated by national institutions such as MoWE.

Consistent with the spatial distribution of households and clustered settlements, the geospatial analysis has identified six primary electrification “segments” for households that are yet to be electrified (or “informally” electrified), broadly differentiated in the following table. It should be noted

[1] The connectivity rate measures the number of households possessing an electrical connection through either a grid connection, or a mini-grid or standalone connection meeting the MOWE’s minimum standard of service requirements, as a proportion of the total number of households.

that small, scattered pockets of households within each of the first three segments will be more effectively addressed by standalone systems or micro-grids.[2]

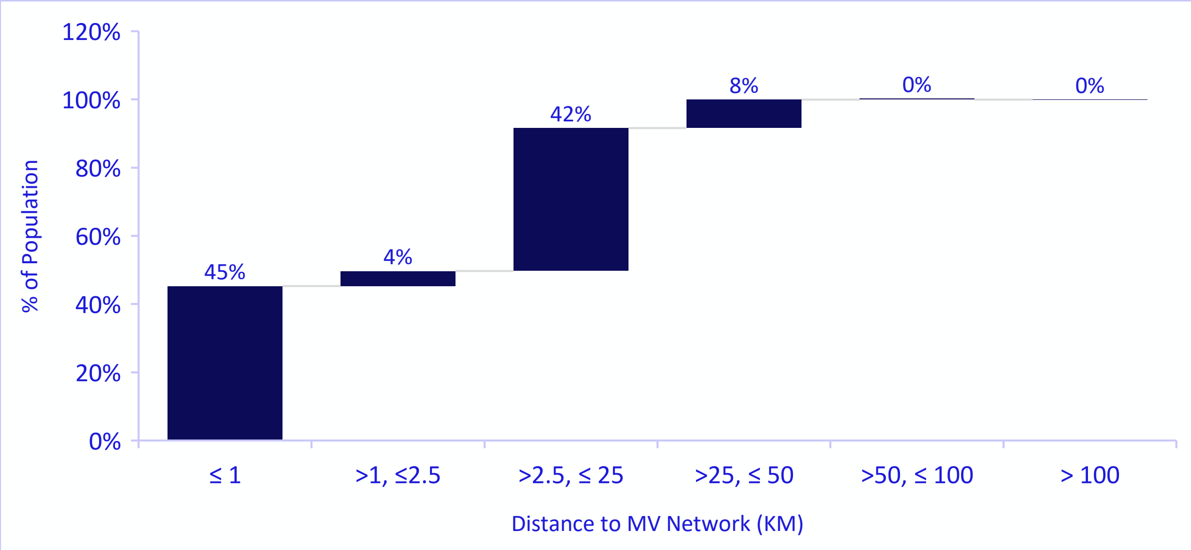
Table 1: Electrification segments studied in the GLCEP

Segment	Grid/off-grid	Level of service	Description	Unit costs
Grid densification	Grid	Tier 5	New customer connections or low-voltage network extensions between 0 and 1 kilometres from existing distribution infrastructure that require no, **or** very limited, investment in the medium-voltage distribution grid.	+
Meter regularization	Grid	Tier 5	Adding meters and droplines for households informally connected in localities already served by the grid.	+
Grid intensification	Grid	Tier 5	Short extensions of medium-voltage distribution network to connect unelectrified localities located between 1 and 2.5 kilometres from existing infrastructure	+ +
Grid extension	Grid	Tier 5	Medium-voltage distribution network extensions to connect unelectrified localities located between 2.5 and 25 kilometres from the existing distribution network.	+ + +
Isolated mini/micro-grids	Off-grid	Tier 3-4	Isolated distribution grids powered by renewable energies used to connect larger localities located in remote areas where grid-based connections are not the least cost alternative.	+ + +
Standalone solutions	Off-grid	Tier 2-3	Solar home systems or other individual generation systems used to connect households, public infrastructure, or productive loads whose location limits the technical or economic feasibility of a connection to the main grid or an isolated mini-grid. Individual isolated or highly dispersed households in grid-connected settlements may also have recourse to this solution.	+ + +

Around 49% of the Ethiopian population is located within 2.5 kilometre of existing grid infrastructures (see figure below). While some households may be most cost effectively addressed with standalone systems, the vast majority of connections in these areas fall into the grid densification segment, requiring very limited, low-cost extensions of the medium and low voltage distribution grids. An additional 42% of connections are located between 2.5 and 25 kilometres from existing infrastructure, while only 8% of total required connections are located beyond 25 kilometres from the existing grid, zones where mini and micro-grids are expected to be the primary least-cost delivery modality.

[2] Given the high level of household dispersion in Namibia, many households or pockets of households, even those close to the existing grid, may be too isolated to be affordably and feasibly connected to the grid.

Figure 1: Share of population living in non-electrified settlements by distance to MV network (km)



Message 3: The total capital investment requirement for achieving universal connectivity under a least cost rollout strategy is estimated at US$ 18 billion by 2035 for baseline scenario 1. Of this total, grid connections account for US$ 16.2 billion corresponding to 32.5 million of the total new connections, while US$ 1.86 billion in off-grid investment is expected to provide connectivity to about 4.4 million households (including more than 5,786 localities). **However, those investment figures doesn't include any transmission and distribution network reinforcement or the development of new generation capacities necessary to support the new on-grid electrification. The generation, transmission and distribution master plans may provide some estimates for those very important activities on which strongly depend the NEP 3.0 implementation.**

Achieving universal connectivity in Ethiopia is expected to require US$ 18 billion in capital investment across both grid and off-grid modalities in the Baseline Scenario (see below table). This represents an overall cost per household connection of US$ 491.

In scenario 2, investment requirement is much smaller at around US$ 12.8 billion due to a lower population target. Grid connection accounts for US$ 11.2 billion in this scenario with cost per connection decreasing to US$ 455. In both cases, more than 90% of the investments correspond to on-grid projects, primarily involving distribution network densification, regularization, intensification, and expansion activities.

Table 2: Investments by 2035 in Scenario 1 and 2

Electrification schemes	Investments by 2035 - Scenario 1 (MM US$)	Investments by 2035 - Scenario 2 (MM US$)
Regularization	249.93	249.93
Densification	11,737.99	7,641.10
Intensification	1,312.95	1,012.23
Extension	2,922.00	2,297.53
Off Grid Solutions	1,864.78	1,654.36
Total	**18,087.67**	**12,855.17**

On-grid investments amount to approximately US$ 16.22 billion under Scenario 1 and US$ 11.20 billion under Scenario 2. Within this category, densification projects represent the largest investment component, accounting for nearly 70% of the required resources. Off-grid investments total approximately US$ 1.86 billion and include hydro-powered mini-grids, solar mini-grids, microgrids, and standalone solar home systems.

The proposed financing framework is based on a combination of public resources, international concessional financing, climate finance, and private investment. For on-grid investments, it is envisaged that approximately 24% of the required funding will be provided by the Government of Ethiopia, 61% by international financial institutions, and 15% through grants and climate-finance mechanisms. Under this structure, the government contribution would amount to approximately US$ 3.9 billion, while financing from international financial institutions would exceed US$ 9.8 billion.

Off-grid investments (US$ 1,865 million) rely primarily on private sector participation through concession arrangements, Results-Based Financing (RBF) schemes, and Pay-As-You-Go (PAYG) business models. Private investors are expected to contribute approximately US$ 745 million to off-grid projects, complemented by public subsidies of around US$ 270 million aimed at ensuring the economic viability of investments and the affordability of electricity services. To address affordability concerns, the program contemplates the use of Viability Gap Funding (VGF) mechanisms, whereby direct subsidies bridge the gap between the actual cost of service and the uniform national tariff, allowing off-grid customers to pay tariffs comparable to those applicable to on-grid consumers.

The analysis identifies several major challenges to the mobilization of financial resources. These include the historical shortfall of external financing relative to electrification targets, limited private sector participation, foreign exchange constraints, high inflation and currency depreciation, and the financial condition of state-owned power utilities resulting from prolonged tariff levels below cost-recovery requirements.

NEP 3.0 concludes that the financial sustainability of the electrification program depends on the implementation of tariffs that reflect the efficient cost of service, tariff indexation mechanisms that preserve the real value of revenues against inflation and currency depreciation, and targeted subsidy schemes designed to protect vulnerable consumers. It also highlights the importance of ensuring access to foreign currency for the importation of equipment, debt servicing, and the repatriation of returns by private investors.

Finally, NEP 3.0 notes that mechanisms such as the Liability and Asset Management Corporation (LAMC), which has been used to absorb part of the indebtedness of Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU), may provide temporary financial relief. However, such measures do not constitute a structural solution to the long-term financial sustainability challenges of Ethiopia’s electricity sector.

Message 4: Off-grid delivery modalities will play a significant and complementary role in achieving universal connectivity at least cost, even in-grid proximate areas. Off-grid connections account for 12% of total connections in the Baseline Scenario.

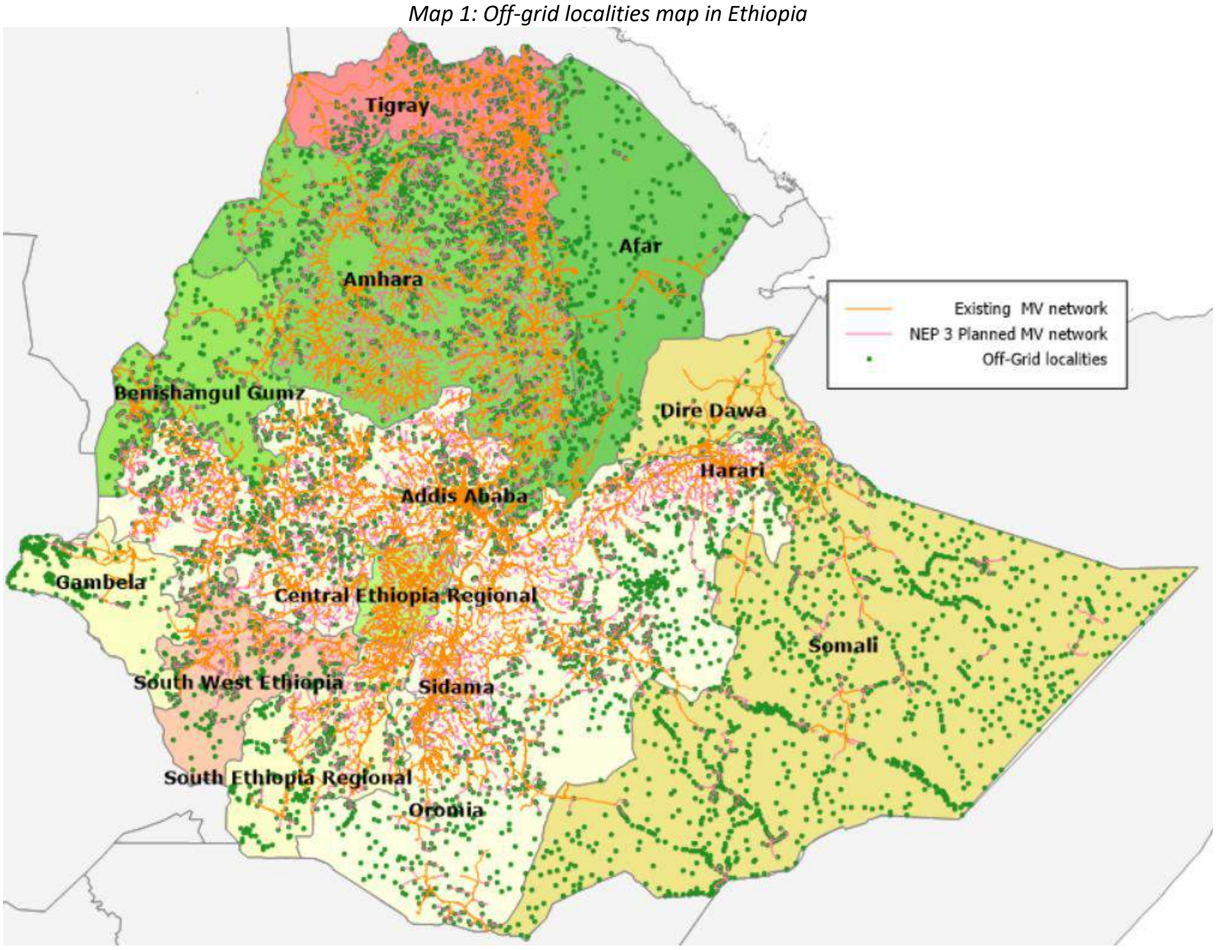
Off-grid connection modalities are expected to provide 4.4 million household connections in Ethiopia, or 12% of total connections. These households are typically located in sparsely-populated areas, and/or across scattered settlements with low demands, areas that are typically difficult and costly to reach with the interconnected grid. Deploying renewables-based mini- or micro-grids or standalone systems to these settlements can therefore drastically reduce the overall costs of the universal connectivity programme. The map below depicts the spatial patterns of the settlements selected for off-grid electrification in the Baseline Scenario (in green), compared with the projected grid footprint in 2035 (in orange).

In the Baseline Scenario 1, the grid extension footprint is set at a maximum of 25 kilometres from the existing grid.[3] This means that for all settlements beyond 25 kilometres from the existing distribution

[3] The consultant considers that extensions beyond this distance are unlikely to be technically or economically feasible over the next ten years as part of the least cost electrification approach.

grid, off-grid connections through mini/micro grids or standalone solutions are the preferred, least-cost connection modality. However, even within the 1-25 kilometres grid intensification and grid extension footprint, many settlements are relatively scattered. In addition, a high level of household dispersion within individual settlements (i.e. large average distances between households) and low levels of electricity consumption may further limit the commercial viability of connecting all of these customers to the grid. Off-grid connection modalities are therefore expected to play an important role in these grid areas as well.

Map 1: Off-grid localities map in Ethiopia



Message 5: Together, mini- and micro-grids are expected to provide about 316,000 connections (representing about 7 percent of all off-grid connections); for a total investment requirement of US$ 280 million. The mini- and micro-grid technologies proposed in the Baseline rollout scenario are powered by solar PV, adding approximately 88 MWp of installed solar capacity. In addition, 25,500 new connections are targeted by 31 preidentified hydro schemes for a total investment requirement of US$ 438 million.

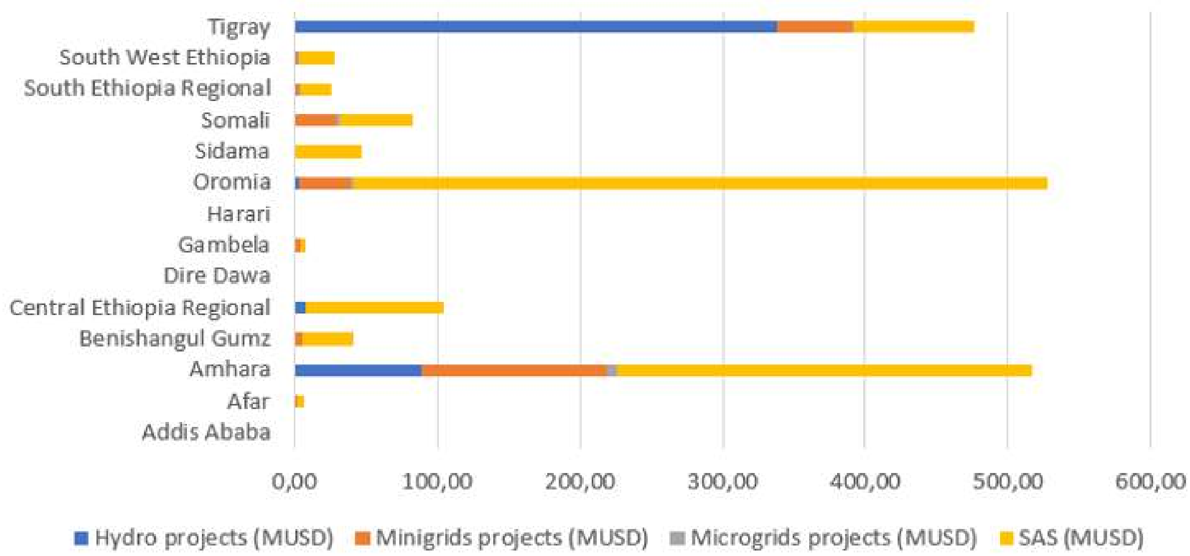
The analysis shows that mini- and micro- grid deployment in Ethiopia is cost competitive in investment terms with grid extension in off grid areas that have sufficient power demand and population density to support them. At a unit cost of US$ 876 - US$ 1,127, these solutions are competitive with unit costs in the grid extension segment, which average around US$ 815 per connection at a national level, and rise much higher in areas with very low population density and high settlement dispersion.

While Ethiopia has significant wind and biomass resources that can be deployed for grid injection, the analysis of renewable resources shows that both are not adequate for rural off-grid electrification development at a reasonable cost. Wind power is only exploitable in a few rare geographical areas far from localised demand and existing biomass technology is not yet appropriate to match rural low electricity demand.

Ethiopia has **significant untapped small-scale hydropower potential (below 2 MW)**, especially in its highland regions where numerous perennial streams flow year-round. The lack of a detailed assessment of hydropower resources currently prevents us from counting all the potential hydropower sites that could be developed into decentralized, low-impact energy solutions for rural communities far from the national electricity grid. Only 31 sites have been identified and are interconnectable with the existing grid. Small hydro offers reliable baseload power, minimal environmental footprint, and strong compatibility with local mini-grid systems, making it a practical pathway to expand energy access while supporting local economic development.

The mini and micro-grid technology proposed in the GLCEP is therefore mainly focusing on solar PV, corresponding to approximately 88 MWp of installed capacity, mostly in 3 regions (figure below).

Figure 2: Off grid investment per region (scenario 1 - NEP 3.0)



Message 6: Standalone solar home systems (SHS) designed to deliver a Tier-2 service standard (50 Wp) and a Tier-1 service (11Wp) represent the major share of off-grid connections; specifically, about 4 million connections out of 4.4 million total off-grid connections (92%).

The analysis suggests an opportunity segments for consideration by the GoE with respect to SHS policy, planning, and promotion, consistent with relevant lessons of good practice experience worldwide:

The Design and promotion of a private sector led market-based implementation of a "pre-electrification" program component, to provide basic electricity services to households that will otherwise not immediately benefit from grid or mini/micro grid connections in the near term.

Good practice lessons of relevant SAS experience elsewhere indicate that enabling policy support and establishing clear guidelines and standards for standalone solar systems can significantly contribute to (i) rapidly can go a long way to catalyse private sector- led and market- based rapid scale up deployment; (ii) developing a market for of certified products that meet meeting established service performance criteria; and (iii) to implement after-sales-service contracts consistent that comply with the guidelines for an appropriate code-of-conduct.

Standalone solar systems (SAS) are the most widely deployed off-grid technology in the Baseline Scenario 1, accounting for 12% of total connections and 92% of off-grid connections. For domestic use, the unit cost for solar home systems (SHS) is around US$ 300 per connection for a Tier 2 standard 50 Wp system with battery storage and US$ 66 for a Tier 1 standard 11 Wp kit (SLS). Given the low population density and high level of settlement dispersion in Ethiopia, these connections are deployed as the primary connectivity modality in approximately 4,929 localities but are also targeted to individual isolated households in grid and mini/micro-grid connected settlements. New SAS connections include the electrification of 6,762 social infrastructures (schools, health post/health center and water pumping) with community equipment (SPS and SCS).

In total, SAS are expected to serve over 4 million connections, and the total investment for SAS, including solar community systems, is about US$ 1.1 billion.

Figure 3: SHS investment per region (scenario 1)

Region	No. Connections	Investment (M US$)	%
Addis Ababa	0	0.00	0%
Afar	16,645	4.06	0%
Amhara	1,032,355	290.56	25%
Benishangul Gumz	137,668	35.75	3%
Central Ethiopia Regional	323,619	96.71	8%
Dire Dawa	1,061	0.30	0%
Gambela	12,122	2.98	0%
Harari	1,630	0.49	0%
Oromia	1,722,890	486.36	42%
Sidama	155,542	46.66	4%
Somali	172,574	50.34	4%
South Ethiopia Regional	79,817	21.18	2%
South West Ethiopia	89,063	25.82	2%
Tigray	306,791	84.65	7%
TOTAL	**4,051,776**	**1,145.85**	**100%**

In respect of the potential scale of a "pre-electrification program component", the NEP 3.0 analysis suggests that up to 4 million such household connections[4] targeted for pre-electrification schemes will likely be implemented progressively during the implementation period, between 2026 and 2035. National programs could focus on standalone community systems for key priority public services and productive uses.

Relevant good practice lessons of experiences indicate the pre-electrification segment can be almost entirely driven by the private sector and individual household demand and requires minimal public investment. However, development and expansion of the pre-electrification market in the start-up initial phase will require GoE's pro-active engagement by establishing the appropriate enabling policy environment and providing incentives for companies to serve rural markets in addition to easier-to-access urban and peri-urban markets.

Message 7: The scale and scope of challenges to achieving universal connectivity targets on a timely basis varies considerably across the regions. The analysis implies that targeted responses will need to be tailored to respond to the diversity of specific regional needs; in terms of capacity, detailed planning, ground-level rollout works programs, financing requirements, technology issues, market issues for SHS and pre-electrification.

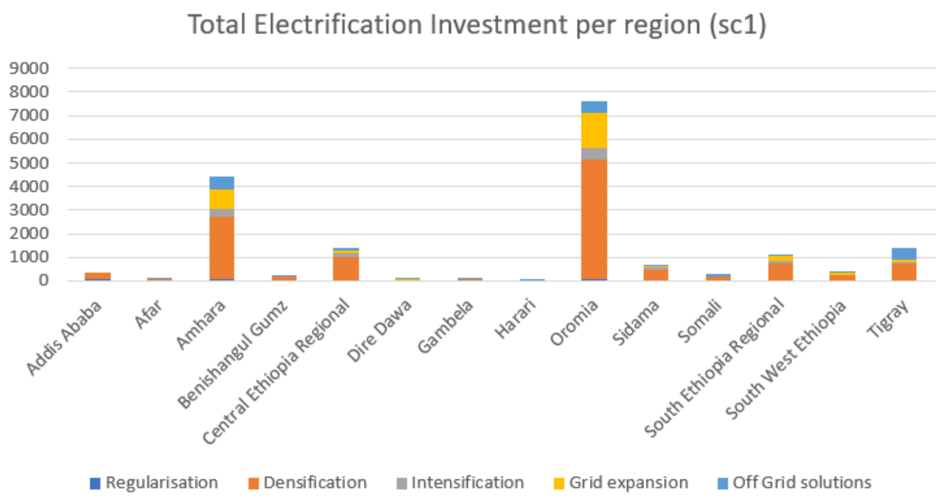
The spatial analysis of the NEP 3.0 presented in this report highlights the regional differences and disparities in the number of required connections between the various regions, driven largely by differences in the current level of grid coverage and population density. This is schematically depicted in the figure below.

Further, the regions investment differs not only in terms of the total number of required connections, but also in the investment requirements and in the mix of investments required to achieve those

[4] Grid and mini/micro grid connections.

connections. Regions with high population densities and/or major urban centres such as Oromia require both on grid-based densification and intensification connections, while others regions, which have a higher share of required connections in small, remote settlements more distant from the grid, will require a mixed effort on grid extensions and/or off-grid options such as mini-grids and standalone solar systems. These regional demographic and infrastructural differences are further compounded by differences in human settlement patterns and local environments, and underline the importance of an approach that targets funding and other electrification support to specific regional needs.

Figure 4: Total Investment per region (scenario 1 – NEP 3.0)



Message 8: The success of the **off-grid roll-out programme** components of the National Electrification Program implementation and its sustainability in quality of services delivered in Ethiopia will depend among other factors on the **government's role** in establishing a conducive and enabling environment (policy, institutional, financing, and regulatory frameworks) to develop, design and deploy scaled-up implementation programmes specifically in the off-grid space broadly identified in this report. In particular, the standalone and mini- & micro-grid solutions identified as least cost on a techno-economic basis for isolated locations – among the small and low-demanding rural settlements - will pose significant challenges as experience elsewhere has demonstrated.

Although the analysis of the strategic challenges for off-grid deployment is out of the scope of this study, the above message suggests that GoE, through its NES programme, should tackle these challenges as a condition for the successful large-scale deployment of off-grid solutions (last-mile connection programme) envisioned in the NEP Scenarios.

Message 9: The successful implementation of NEP 3.0, hinges upon a well-coordinated and financially enabled institutional arrangement and set-up from planning, financing, and procurement to on-grid and off-grid electrification. Empowering implementing agencies and securing sustainable financing are critical prerequisites for NEP 3.0.

A new set of institutions have been proposed to strengthen the current electrification framework, working either in parallel or within the existing institutions. The National Electrification Coordination Unit (NECU) within MoWE's Directorate of Electrification (DoE), the elevation of the Universal Electricity Access Program into an Executive Implementation office, and a reinstated Rural Electrification Fund (REF). A third institution, the Rural Electrification Authority has been proposed for future consideration to focus specifically on rural electrification and support for productive uses in areas of operation.

With the understanding that achieving national access will require concerted efforts from all market participants at federal and regional levels, a matrix of the roles of key stakeholders and enablers of electrification ranging from policy, oversight, implementation, regulation, and financing to technical assistance, advocacy and fiscal support has been developed. This ensures seamless coordination towards achievement of access targets.

1. Introduction – Planning electricity access in Ethiopia

The objective of the present study is to update the National Electrification Program (NEP 2.0) to reach universal access to electricity services by 2035 in Ethiopia as announced by the Government of Ethiopia. While a recent study from the World Bank[5] pointed out that **65% of Ethiopians have access to electricity in 2025, and only 56% in rural areas, reinforcing access to electricity is indeed vital to improve people's living conditions and to foster economic development**. To achieve this goal, however, stakeholders of the energy sector in Ethiopia, like others in East Africa, face multiple challenges: lack of funding, affordability and population's ability to pay, technical and commercial losses, cost recovery failure, etc. Moreover, as a consequence of particular conditions in rural environments (low demand for energy, scattered population, etc.), electrification projects are often not profitable. This implies that investments subsidies are structurally mandatory. Since available public funds are limited, optimizing these subsidies is of utmost importance. For that, one of the answers lies in the ability of energy stakeholders to carry out realistic electrification planning in time and space, with the most appropriate supply options. A properly designed electrification plan helps to maximize the impacts of a program by accelerating its execution and widening its scope, while reducing on-site construction costs.

The update of the National Electrification Program is the fourth major plan to increase the access in Ethiopia. Ethiopia's push for electricity started with the Universal Electricity Access Program (UEAP), which, from 2005 to 2015, significantly increased the number of towns and villages connected to the grid – from only 667 to approximately 6,000[6]. Following this achievement, access to electricity soared from 15% to almost 43% between 2005 and 2016. In 2017, the government then outlined a National Electrification Program to reach universal access by 2025, balancing grid connections (65%) with off-grid solutions (35%) as a strategy to accelerate access in rural areas where the national grid would not easily reach. Quickly after, this first program was reinforced by a second NEP (2019) providing a more detailed off-grid implementation framework based on smarter approaches gathering the use of a least-cost geospatial planning tool as well as strongest consultations with public and private sector implementing agents. Despite significant achievements over the past twenty years, today 35% of Ethiopians remain without any access to electricity services: 9% in urban areas, 44% in rural areas[1].

In this context, **the Ministry has decided to update the National Electrification Program by developing a geospatial least-cost electrification analysis aimed at defining the means to achieve universal access to electricity services by 2035**. To achieve this objective, it was necessary, first to map electricity access across the country in order to understand how grid and off-grid distribution services are organized in order to identify which localities and populations are covered and connected. Once the situation has been established across the country's regions, it become then possible to identify priority electrification projects based on socio-economic criteria so as to define which of the unserved localities should be electrified as a priority in order to increase the impact of electrification on the economy and public services while serving the greatest number of people? Furthermore, to improve the quality of electricity services and optimize costs, a demand forecast study for electricity over the planning horizon was conducted in order to tailor electrification options as closely as possible to future needs.
Finally, based on various geographical and techno-economic criteria, some scenarios were developed to clearly define a **least coast pathway toward universal access in Ethiopia by 2035**. All geospatial

[5] WORLD BANK, 2025, Ethiopia - Energy access survey. Insights Into energy access situation In Ethiopia on the Multi-Tier Framework, Unpublished, 64 p.

[6] ESMAP, 2019, Ethiopia's energy sector transformation, Issue 18, 4 p.

analyses were conducted using GIS database and the GEOSIM[7] electrification planning software presented in the Inception report. For clarification purposes, the following definitions are adopted for the main terms and concepts.

The next chapters of the NEP 3.0 cover the **suitable options and arrangements for scaling up electrification** which aimed at defining mechanisms facilitating the NEP 3.0 implementation across the country with a focus on national institutions and financing. This key analysis included both financial planning and Institutional arrangement and setup. Many issues and challenges are, nowadays, slowing done the electrification process in the country. In order to favorize a more **efficient environment** and tackle various bottlenecks identified in Ethiopia, some recommendations were finally done.

2. Definitions and premises

2.1 Key indicators

The definitions related to access to modern energy services applied in the Electrification Plan set the stage for ambitions levels. At the practical level, the definitions and associated targets set the framework for the analysis and implementation of the Electrification Plan and define communication and data collection efforts. **It is therefore of high importance that the key stakeholders of the Project careful consideration on the definitions applied**.

In international and Ethiopian contexts, there is a large variation in definitions related to access and availability of electricity solutions. Concepts of “access” and “connectivity/ electrification” are applied with varying degrees of consistency. **The Geospatial Least Cost Electrification Plan provides decisive guidance on access definitions, targets and monitoring of progress.**

The SE4ALL has developed a multi-tier access definition, incorporating a range of service levels, although its action plan for Ethiopia, according to the “NEP”, explicitly addresses both grid-based electrification and distributed energy solutions.

Multi-tier Matrix for Measuring Access to Household Electricity Services

	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Tier criteria		Task lighting AND Phone charging	General lighting AND Phone Charging AND Television AND Fan (if needed)	Tier 2 AND Any medium-power appliances	Tier 3 AND Any high-power appliances	Tier 2 AND Any very high-power appliances
	TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
Annual consumption levels, in kWhs		≥4.5	≥73	≥365	≥1,250	≥3,000
Daily consumption levels, in Whs		≥12	≥200	≥1,000	≥3,425	≥8,219

Figure 5: SE4ALL Multi-tier framework

MoWE directs that household service Tier 1 is to be regarded as the minimum specification for programmes initiated by GoE. However, Tiers 1 and 2 would be retained in the definition framework and could be offered to households requesting such tier services, assuming that all beneficiaries will pay usage fees corresponding to the service tier provided. While households having Tier 1 and 2 access should still be enumerated and reported as having such access, they should not be counted as part of the official access statistics in Ethiopia in future.

Within the international and Ethiopian energy access space, there are many examples of terms that overlap, are used interchangeably, have changing definitions, and even contradict one another. Thus, the team was compelled to develop a set of definitions, which evolved during the preparation of the NEP due to inputs from stakeholders. The definitions have important implications in terms of eventual target setting, monitoring and communication.

[7] More information on www.ied-sa.com

Table 3: Definitions of key indicators

Terms	Definition and/or Description
Access	Population being directly served by, and paying for, either grid-based electricity services, mini-grids or standalone systems, providing at least Tier 1 access.
Connectivity	Population being directly served by, and paying for, either grid-based electricity services or mini-grids, providing at least Tier 2 access.
Consumer	Any person consuming electrical energy.
Coverage rate by electricity services	Population living in/around localities served by electricity and thus reaping benefits from these services with an opportunity to gain connectivity. Also been referred to as "proximate access". *Access to electricity services = (Total Number of Benefiting Population/Total Population).*
Customer	Any person purchasing electrical energy to a legal operator or utility.
Distribution	Ownership, operation management or control of facilities for the movement or delivery of energy to enable supply to consumers.
Electrification	Process of using electricity as a primary source of energy and replacement of technologies that rely on fossil or biomass fuels as a source of energy.
Grid (1) **National grid (2)** **Isolated grid (3)**	- (1) The transmission lines including 33kV, 11kV (sub-transmission lines) and low voltage network. - (2) EEU operated main- and isolated-grids (provides Connectivity) - (3) An electricity grid that is operated by private, communities or EEU but is not inter-connected to the central national grid (i.e. is not in any way inter-connected with National Grid). (provides Connectivity)
Grid densification	Process of installing additional meters (and droplines), LV lines as well as transformers to connect unconnected households either in population clusters already served by the grid or a mini-grid, or in population clusters located within a 1,000 meters radius from an existing MV line.
Grid extension	Process of expanding of the grid to unserved localities within a radius of 2.5 to 25 km from the existing network.
Grid intensification	Process of expanding of the grid to unserved localities within a radius of 1 to 2.5 km from the existing network.
Locality (urban / rural)	Cluster of dwellings comprising a few to several thousand inhabitants which can be identified as a village, a quarter or a locality and therefore which can be named. Several localities can be located within the same kebeles, the smallest administrative unit in Ethiopia. Localities located in woredas with more than 2,000 inhabitants are considered as "urban". Localities located in woredas having less than 2,000 inhabitants are considered as "rural".
Modern energy	In the context of access to energy, modern energy is used to describe energy carriers that do not involve the burning of non-sustainable supplies of wood, the use of candles or paraffin, or the reliance on non-reusable batteries. (NEP definition)
Universal access to modern energy	Every household has the opportunity to use at least one type of modern energy. (NEP definition)

Standalone PV system	Automatic solar system that produces electrical power to charge banks of batteries and operating independently of the grid or mini-grid. Standalone PV system can include: • **Solar lanterns** power a single light bulb and could possibly power radio and/or phone charging. Under the MTF methodology, the capacity tier of a solar lantern is calculated based on the household size to capture the number of household members relying on the service and the ability to power radio and/or phone charging. • **Solar lighting systems (SLSs)** power two or more light bulbs and could possibly power radio and/or phone charging, but SLSs cannot power any other appliances. The capacity tier of a SLS is calculated based on the household size and the ability to power radio and/or phone charging. • **Solar home systems (SHSs)** power two or more light bulbs and appliances such as televisions, irons, microwaves, or refrigerators. (See Table 1 for the load level associated with each Capacity tier.)

2.2 Demographic situation in Ethiopia

Population figures for Ethiopia are subject to debate. On the one hand, the most recent **ESS projections (2016) estimated the country's population at 109.5 million for 2024**[8]. Considering an average annual growth rate of 1.73%[9], this figure can be revised to 111.4 million for 2025. On the other hand, international institutions, including the **United Nations Population Division and the World Bank, suggest a population of 133 million for 2025**[10]. This is close to the Copernicus estimates for 2024 (132.5 million inhabitants)[11]. Despite requests to ESS and the World Bank, it was not possible to distinguish between these estimates. Therefore, it was proposed by MoWE, to consider **two population scenarios**: Scenario 1, based on data from international institutions will be considered as the **baseline scenario**, and Scenario 2, based on data from ESS as a national scenario. Nationally, the Central Statistical Agency estimates the number of people per household at 4.7[12]. This represents 28.8 million in Scenario 1 and 23.8 million households in Scenario 2. Regarding population growth during the planning period, ESS estimates that the country will have 132 million inhabitants by 2035, compared to 170 million according to the United Nations Population Division. This will represent 37 million and 28 million households respectively in Scenarios 1 and 2.

In order to capture regional disparities ensuring results accuracy, all calculation were done using regional figures provided by ESS[13] in terms of population patterns (natural growth, households size…). Households and population projection as well as Load forecast are then specific per region.

[8] EES, 2016, Population size by sex, area and density by region: July 2024
[9] CENTRAL STATISTICAL AGENCY, 2013, Population Projections for Ethiopia 2007 - 2037, 173 p.
[10] THE WORLD BANK, 2025, https://databank.worldbank.org/source/population-estimates-and-projections
[11] COPERNICUS, 2025, Europe's eyes on earth, https://www.copernicus.eu
[12] CENTRAL STATISTICAL AGENCY, 2020, Ethiopia Socioeconomic Survey 2018/19, 90 p.
[13] EES, 2016, Population size by sex, area and density by region: July 2024

Table 4: Demographic situation and projections in Ethiopia (Scenario 1)

Region	N. of inhabitants (2025)	Annual population growth (%)	N. of inhabitants (2035)	N. of people per household	N. of households (2025)	N. of households (2035)
Addis Ababa	7,148,232	2.77	9,396,026	3.8	1,881,114	2,472,637
Afar	714,467	2.58	921,862	4.6	155,304	200,550
Amhara	31,420,257	1.81	37,596,719	4.2	7,480,944	8,951,548
Benishangul Gumz	1,472,545	3.25	2,026,788	4.5	327,223	450,434
Central Ethiopia Regional	10,399,374	2.76	13,649,836	5	2,079,874	2,729,946
Dire Dawa	690,600	3.56	979,606	4	172,649	244,903
Gambela	566,670	3.82	824,934	4.6	123,176	179,378
Harari	180,412	2.86	239,203	4	45,101	59,805
Oromia	52,878,446	2.74	69,306,334	4.9	10,791,439	14,143,932
Sidama	5,749,277	2.76	7,546,309	5	1,149,854	1,509,224
Somali	**2,681,639**	2.91	3,571,190	5.8	462,447	615,572
South Ethiopia Regional	7,881,584	2.76	10,345,186	5	1,576,318	2,068,948
South West Ethiopia	**2,731,368**	2.76	3,585,143	5	546,276	716,946
Tigray	8,484,637	2.14	10,481,216	4.2	2,020,124	2,495,498
Total	**132,999,508**	**2.5**	**170,470,352**	**4.7**	**28,811,843**	**36,839,321**

Table 5: Demographic situation and projections in Ethiopia (Scenario 2)

Region	N. of inhabitants (2025)	Annual population growth (%)	N. of inhabitants (2035)	N. of people per household	N. of households (2025)	N. of households (2035)
Addis Ababa	4,074,496	1.88	4,908,663	3.8	1,072,235	1,291,754
Afar	2,161,776	1.75	2,571,304	4.6	469,929	558,885
Amhara	23,879,703	1.23	26,985,029	4.2	5,685,604	6,424,908
Benishangul Gumz	1,310,834	2.22	1,629,511	4.5	291,282	362,099
Central Ethiopia Regional	8,839,533	1.87	10,638,786	5.0	1,767,893	2,127,754
Dire Dawa	580,102	2.41	736,089	4.0	145,027	184,025
Gambela	555,351	2.59	717,263	4.6	120,713	156,010
Harari	294,027	1.94	356,314	4.0	73,505	89,084
Oromia	42,831,962	1.86	51,499,670	4.9	8,741,248	10,509,975
Sidama	4,886,940	1.87	5,881,681	5.0	977,380	1,176,327
Somali	6,993,003	1.97	8,499,336	5.8	1,205,801	1,465,402
South Ethiopia Regional	6,699,566	1.87	8,063,244	5.0	1,339,914	1,612,606
South West Ethiopia	2,321,811	1.87	2,794,403	5.0	464,354	558,833
Tigray	6,024,234	1.45	6,957,023	4.2	1,434,343	1,656,399
TOTAL	**111,453,338**	**1.73**	**132,238,316**	**4.7**	**23,789,228**	**28,174,061**

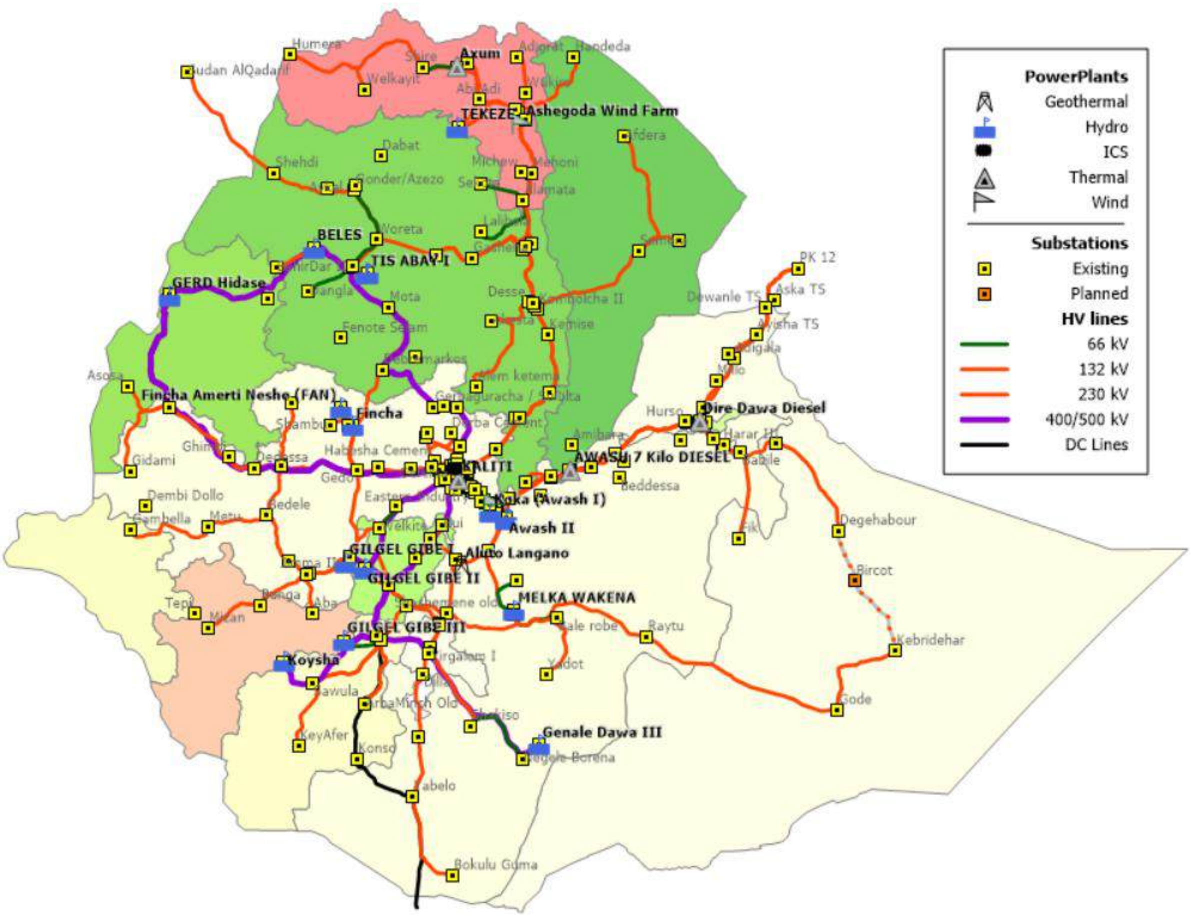
3. Current situation of electricity in Ethiopia

3.1 Existing electrical infrastructures

Tremendous efforts have been made in the past few years to extend the existing grid. However, the cost of electricity distribution has been increasing accordingly and now the Government of Ethiopia is looking for a more balanced electrification framework unevenly split between grid and off-grid areas, so as to optimize electrification costs while reaching each household within the country.

Ethiopia's power generation and transmission network is extensive and quickly evolving. The country relies on a mix of **hydroelectric, geothermal, solar, wind, and thermal** energy sources. The transmission network spans **over 20,000 kilometers**, with voltage levels ranging from **66kV to 500kV**. Ethiopia has also established a 500kV DC transmission line connecting it to Kenya, fostering regional energy cooperation.

More than 230 substations are supplying energy from the interconnected grid to distribution networks reaching the main populated areas.



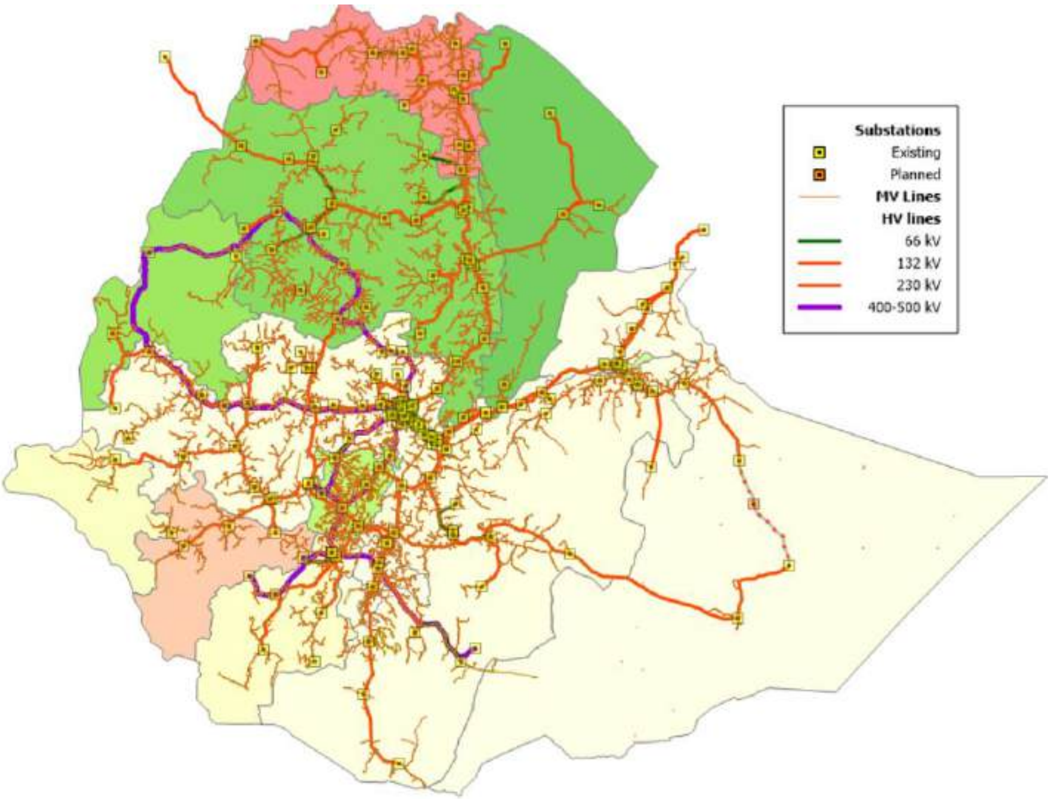
Map 2: Generation and transmission network – Ethiopia (sources EEP, EEU, IED)

Various projects shall be implemented in the next few years including the construction of new substations along the transmission lines:

- the South Ethiopia Power transmission project (Hawassa II-Shashemene II, 230kV; Bensa Daye 132kV; Durame 132kV and Bale Robe),
- the Eastern Ethiopia Electricity Grid Reinforcement Project (EEEGRP) including Degehabur – Kebridehar 132 kV Power Transmission Line Project

The country's electrification is mainly implemented by EEU, the distribution utility while EEP, is in charge of generation and transmission network.

The distribution network is therefore quite extended covering a big part of populated areas. However, the NEP acknowledges that grid electrification is not technically and economically feasible for all households in Ethiopia, on account of the large size of the country, coupled with an extremely low population density in some regions (Afar, Somali).



Map 3: Distribution Network in Ethiopia (source EEU, IED)

3.2 Electricity access in Ethiopia

Regarding the electrification status, and according to the World Bank, nearly 94% of Ethiopians in urban areas enjoyed access to energy while only 43% had access to electricity in rural homes. The World Bank estimates that about 55% of the total population had access to electricity in 2022.

Based on the most recent Multi-Tier Framework (MTF) survey, 22% of households currently have a legal connection to the national grid, while only 2% of households have a Tier 5 connection (more than 23 h/day). Moreover, the latest census (Energy Access Survey in Ethiopia, 2025) provides a more updated picture of the situation in Ethiopia and rather estimates the access rate around 44% with at least a Tier 1 connectivity.

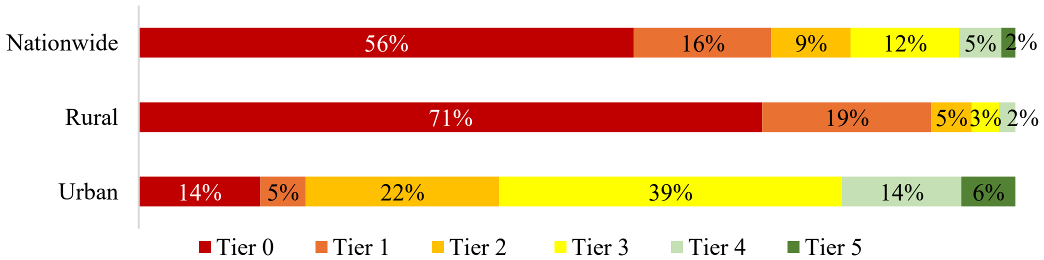


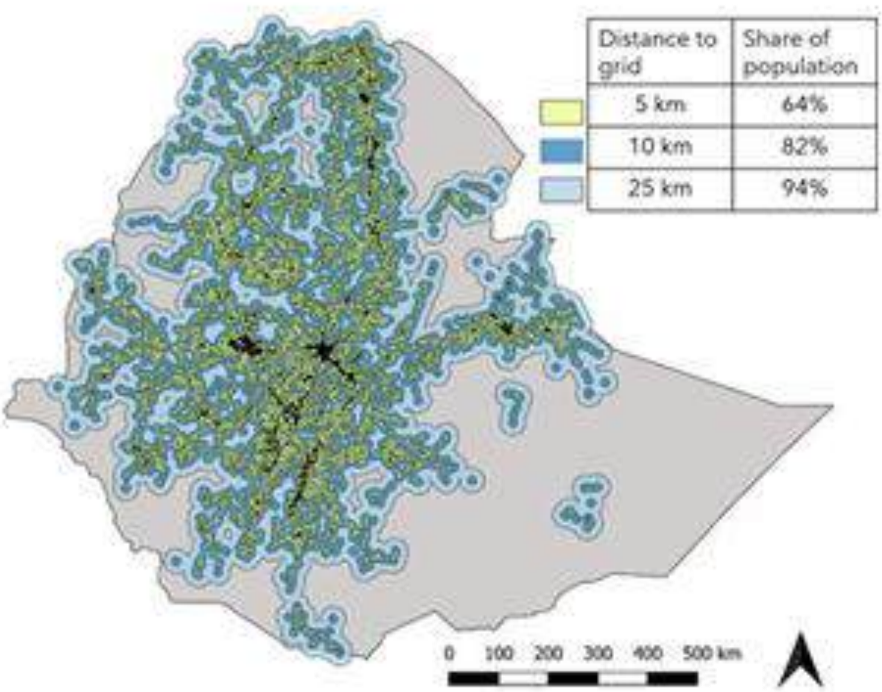
Figure 6: Access rate in Ethiopia (*Source: Energy Access Survey in Ethiopia, 2025)*

The above figure shows that rural areas are poorly electrified with only 29% of electrification ratio while urban areas are highly electrified with a ratio around 84%.

Since 2017, Ethiopia has made significant progress in energy access. Ethiopia's National Electrification Programs (NEP1 and NEP2 – 2017-2025) put efforts to reach universal energy access by 2025 (65% from the grid and 35% from off-grid solutions). From 2015 till now (2025), the overall electrification rate (grid & off-grid) has risen from 20% to 55%. For instance, ELEAP programme (2018-2026) provided meaningful support on connections with a target to connect about 6.3M people at the end of the program.

But, despite Government efforts and several ambitious programmes supported by WB, AfDB and other donors, such as UEAP, ELEAP, ADELE, the grid-connection rate (~250,000 new connections per year) is far below the projections and around 60 million Ethiopians remain without electricity access, mostly in rural areas. Ethiopia has the third largest energy access deficit in Sub-Saharan Africa with about half the population still without access to reliable electricity. Only a fourth of primary schools and a third of health clinics have access to electricity (EAES/ENDEV, 2025).
Some specific peripheral regions as Afar, Somali, Oromia (South part), Benishangul and Gambela have limited grid infrastructures and low coverage rates. And expanding further the national grid is expensive due to the high costs of transmission lines, substations, and ongoing maintenance.
As the NEP 2 targets have not been achieved yet from grid extensions (65% on-grid electrification in 2025), the share of the off-grid electrification, far from the existing grid, remains quite important, with a more pronounced role for mini-grids, particularly if the growth in demand (per-capita demand) is faster.

Beyond the proposed grid extension (>25km), and even within the grid perimeter (extensions & intensifications 1-25km), a significant number of settlements and population clusters (~6%) will remain still out of reach because of the low population density, scattered households, and low energy demand. According to Energy Outlook 2025 (map below), 64% of Ethiopia's population lives within 5 km of existing grid infrastructure, making grid extension more cost-effective for these households compared to off-grid alternatives. This can be also explained due to the low cost of energy from the grid in Ethiopia. More than 94% of the population live within 25 km from the existing grid. Only in the Somali, Afar and Gambela regions more than 10% live 25 km or further from the grid.



Map 4: Coverage of existing distribution grid (source Energy Outlook 2025)

3.3 Electricity coverage situation in Ethiopia

The geospatial analysis methods presented in this report help to understand the current situation to electricity access in Ethiopia. The **locality coverage rate, also called the geographic coverage rate**, represents the proportion of localities served by electricity (either through the national grid, isolated grids, or mini-grids) out of all localities in the country: The population coverage rate represents the proportion of inhabitants living in or around localities served by electricity and thus benefiting from these services with an opportunity to gain connectivity.

Thus, **of the 25,650 localities identified in the country database (see Annex), more than 9,597 (or 37%) are electrified**, while 16,053 do not yet have electricity[14]. As shown in the table below, the lowest coverage rates were in the regions of Somali (14%), Gambela (25%), and Afar (29%), and the highest coverage rates were in the regions of Addis Ababa (100%) and Harari (84%).

The population coverage rate is set at 67%. While this rate remains constant across scenarios, the numbers involved differ. In Scenario 1, out of 133 million inhabitants, **90 million have access to electricity in their locality**, while 43.6 million do not. In Scenario 2, more than **75 million of the country's 111 million inhabitants have access to electricity in their locality**. It is important to emphasize that this rate means that 67% of inhabitants are covered but not necessarily connected. Some households may be connected and others not, but the latter could be connected quickly, since their locality is served.

Table 6: Electricity coverage of Ethiopian localities

Regions	N. of localities	N. of localities served by electricity	N. of localities unserved by electricity	Localities Coverage rate (%)
Addis Ababa	14	14	-	100
Afar	563	161	402	29
Amhara	5,915	2,414	3,501	41
Benishangul Gumz	506	168	338	33
Central Ethiopia Regional	1,496	787	709	53
Dire Dawa	70	36	34	51
Gambela	277	68	209	25
Harari	50	42	8	84
Oromia	9,677	3,454	6,223	36
Sidama	711	367	344	52
Somali	1,805	249	1,556	14
South Ethiopia Regional	1,770	713	1,057	40
South West Ethiopia	995	346	649	35
Tigray	1,801	778	1,023	43
TOTAL	**25,650**	**9,597**	**16,053**	**37**

We can observe that while localities coverage rate is sometime low like in Afar where few localities electrified, if we consider the population, the ratio is much higher which can be explained by the heavy weight of few electrified localities in terms of population (regional capital and few key cities) compared to the high number of small rural non electrified localities.

[14] Among those 9,597 localities, 145 are in the process of being electrified.

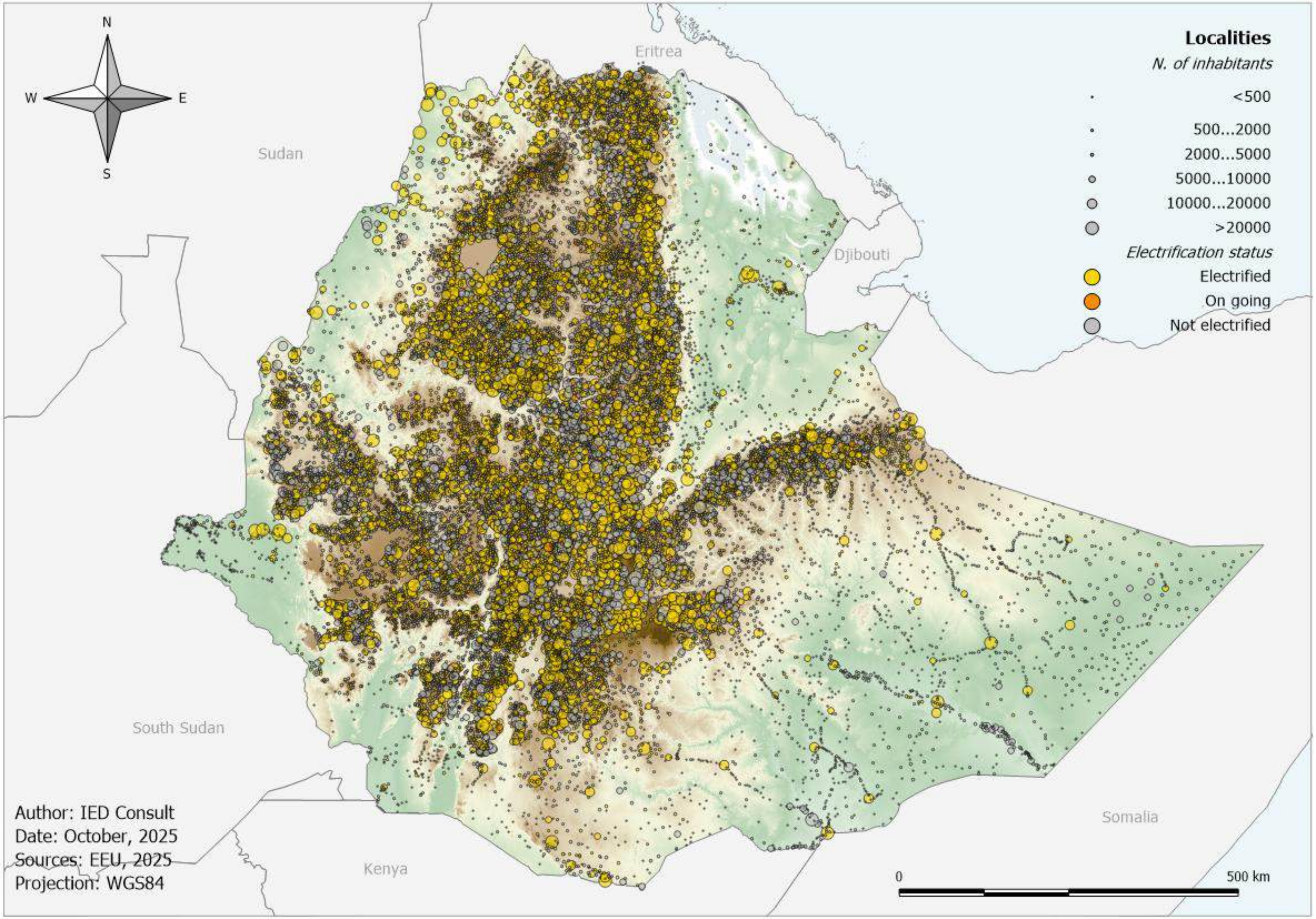
Table 7: Population coverage rates in Ethiopian regions – Scenario 1

Regions	N. of inhabitants (2025)	N. of inhabitants covered by electricity	N. of inhabitants uncovered by electricity	Population coverage rate (%)
Addis Ababa	7,148,232	7,148,232	-	100
Afar	714,467	609,983	104,484	85
Amhara	31,420,257	20,839,987	10,580,270	66
Benishangul Gumz	1,472,545	852,251	620,294	58
Central Ethiopia Regional	10,399,374	7,040,095	3,359,279	68
Dire Dawa	690,600	634,857	55,743	92
Gambela	566,670	491,021	75,649	87
Harari	180,412	154,570	25,842	86
Oromia	52,878,446	33,958,239	18,920,207	64
Sidama	5,749,277	4,084,935	1,664,342	71
Somali	2,681,639	1,630,413	1,051,226	61
South Ethiopia Regional	7,881,584	5,241,242	2,640,342	66
South West Ethiopia	2,731,368	1,775,825	955,543	65
Tigray	8,484,637	5,904,019	2,580,618	70
TOTAL	**132,999,508**	**90,365,669**	**42,633,839**	**67**

Table 8: Population coverage rates in Ethiopian regions – Scenario 2

Regions	N. of inhabitants (2025)	N. of inhabitants covered by electricity	N. of inhabitants uncovered by electricity	Population coverage rate (%)
Addis Ababa	4,074,496	4,074,496	-	100
Afar	2,161,776	1,847,901	313,875	85
Amhara	23,879,703	15,838,463	8,041,240	66
Benishangul Gumz	1,310,834	758,646	552,188	58
Central Ethiopia Regional	8,839,533	5,984,130	2,855,403	68
Dire Dawa	580,102	533,279	46,823	92
Gambela	555,351	481,200	74,151	87
Harari	294,027	251,902	42,125	86
Oromia	42,831,962	27,506,273	15,325,689	64
Sidama	4,886,940	3,472,232	1,414,708	71
Somali	6,993,003	4,255,142	2,737,861	61
South Ethiopia Regional	6,699,566	4,455,136	2,244,430	66
South West Ethiopia	2,321,811	1,509,487	812,324	65
Tigray	6,024,234	4,191,883	1,832,351	70
TOTAL	**111,453,338**	**75,160,170**	**36,293,168**	**67**

Map 5: Electricity coverage in Ethiopia (scenario1)



3.4 Connectivity in Ethiopia

According to the most recent study carried out to date - the Energy Access Survey released in 2025 by the World Bank - **nationwide 65% of Ethiopians households have access to at least one source of electricity**. This includes access either from the national grid, mini-grids, generators, solar home systems, solar lanterns or rechargeable batteries. Of course, access differs between urban and rural areas. According to the survey, **91% of households have access to electricity in urban areas compared to 56% in rural areas.**

These disparities between regions across Ethiopia in terms of connectivity remain important. Urban densified regions such as Addis Ababa, and Harari display high ratios while low density and desertic regions such as Afar and Somali offer low ratios.

Table 9: Current connectivity rate in electrified localities

Region	Current connectivity rate (%)
Addis Ababa	92
Afar	16
Amhara	40
Benishangul Gumz	22
Central Ethiopia Regional	35
Dire Dawa	82
Gambela	19
Harari	96
Oromia	30
Sidama	48
Somali	17
South Ethiopia Regional	35
South West Ethiopia	33
Tigray	52

Source: based on The World Bank, 2025

Among the 65% of households with an electricity access, it is also important to note that the level of service is also not the same. In the Multi-Tier Framework (MTF) that assesses electricity access on a range of five levels, households classified as Tier 0 lack electricity entirely or do not meet essential criteria, such as a capacity above 3W or an availability of power higher than 4 hours during the day and 1 hour at night. **Thus, according to the MTF standards, only 44% of Ethiopians households have an electricity access** equal or higher than Tier 1, which is according to the MoWE, the minimum level to consider a household as electrified.

Figure 7: The Multi-Tier Framework Electricity Tier Matrix

ATTRIBUTES		TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
			Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
	OR Services		Lighting of 1,000 lmhr/day	Electrical lighting, air circulation, television, and phone charging are possible			
2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
	Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
4. Quality						Voltage problems do not affect the use of desired appliances	
5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
7. Health & Safety						Absence of past accidents and perception of high risk in the future	

The distribution of households according to the types of access is presented below for each of the two scenarios. In Scenario 1, **households connected to the grid (8.2 million)** represent 28% of all households in the country. Indeed, EEU reports 4.3 million domestic connections and according to the study recently conducted by the World Bank[15], around 47% of grid-connected households have an illegal connection (i.e. 3.8 million households). For this scenario, the World Bank's estimated access rate (65%) suggests that **10.5 million Ethiopian households are also equipped with a SAS**, while **10 million (35%) households have no source of electricity at all**. The number of households connected to mini-grids - around 10,000[16] - is not significant out of the total number of households.

In Scenario 2, the number of households connected to the grid or a mini-grid remains the same (8.2 million) but the number of **households equipped with a SAS decreases to 7.3 million** (31% of households), and the **number of households without access at 8.3 million**. Taken together, the number of households with access to electricity is therefore 18.7 million in Scenario 1 and 15.5 million in Scenario 2.

[15] WORLD BANK, 2025, *Ethiopia - Energy access survey. Insights Into energy access situation In Ethiopia on the Multi-Tier Framework*, Unpublished, *64 p.*
[16] Ministry of Water and Energy, 2025.

Figure 8: Distribution of households based on type of access (Scenario 1 & Scenario 2)

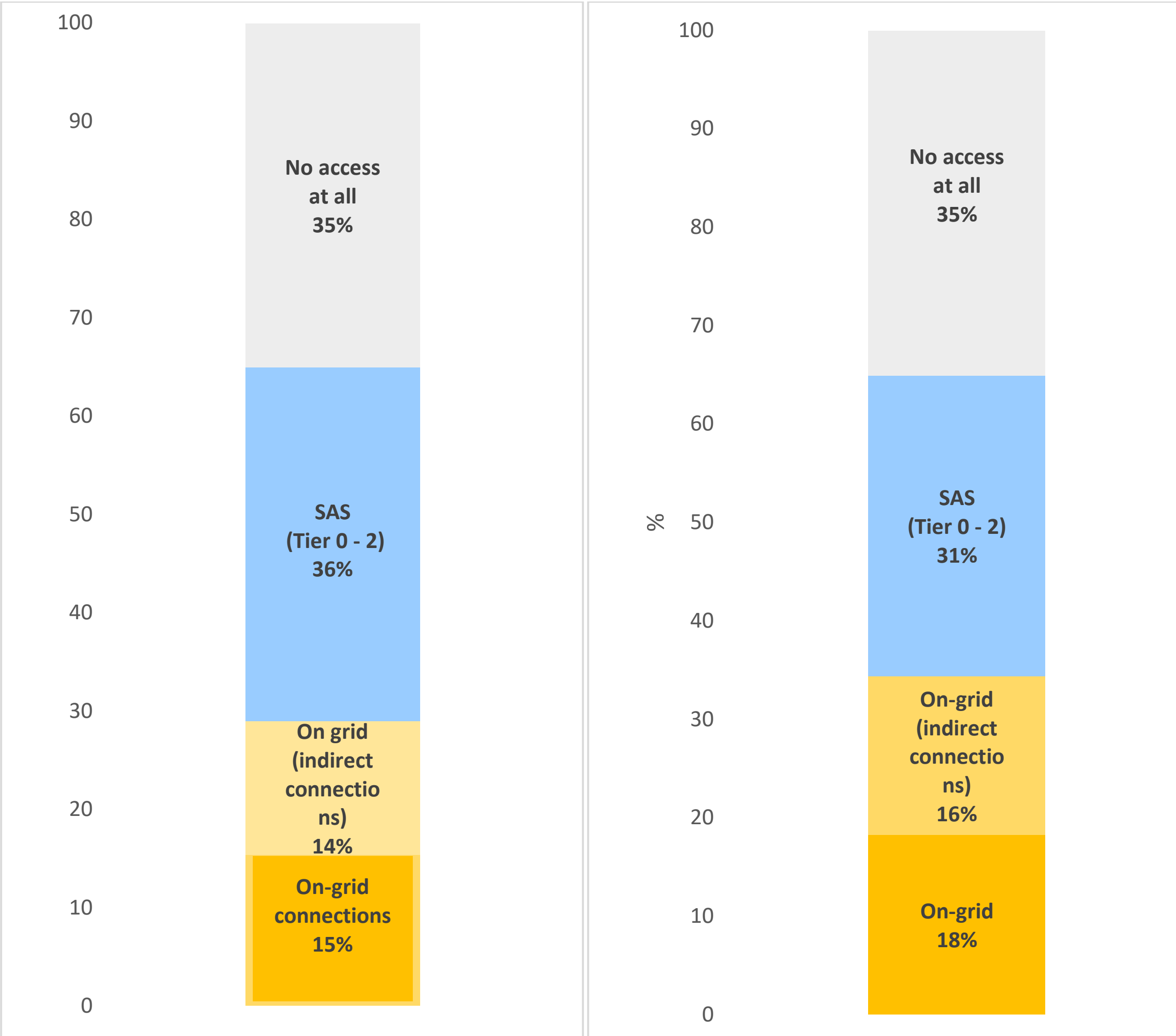


Table 10: Distribution of households based on type of access

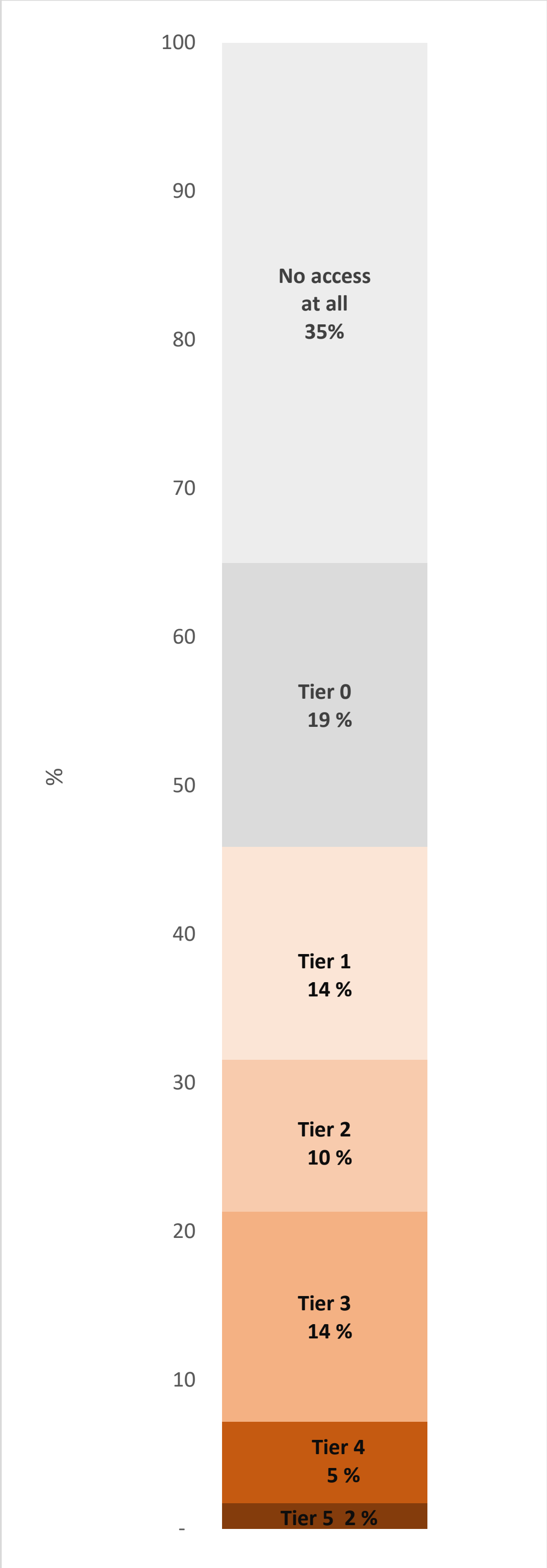
Type of access	Scenario 1 (133 M inhabitants)		Scenario 2 (111 M inhabitants)	
	N. of households	Share of households (%)	N. of households	Share of households (%)
Grid, of which:	8,171,698	28 %	8,171,698	34 %
EEU domestic customers	*4,331,000*	*15 %*	*4,331,000*	*18 %*
Domestic consumers in need of regularization	*3,840,698*	*13 %*	*3,840,698*	*16 %*
Mini-grids	9,820	0 %	9,820	0 %
Standalone systems	10,546,180	37 %	7,274,092	31 %
Households without access	10,084,145	35 %	8,342,456	35 %
Number of households (2025)	**28,811,843**	**100** %	**23,789,228**	**100** %
Households with electricity access	*18,727,698*	*65 %*	*15,455,610*	*65 %*

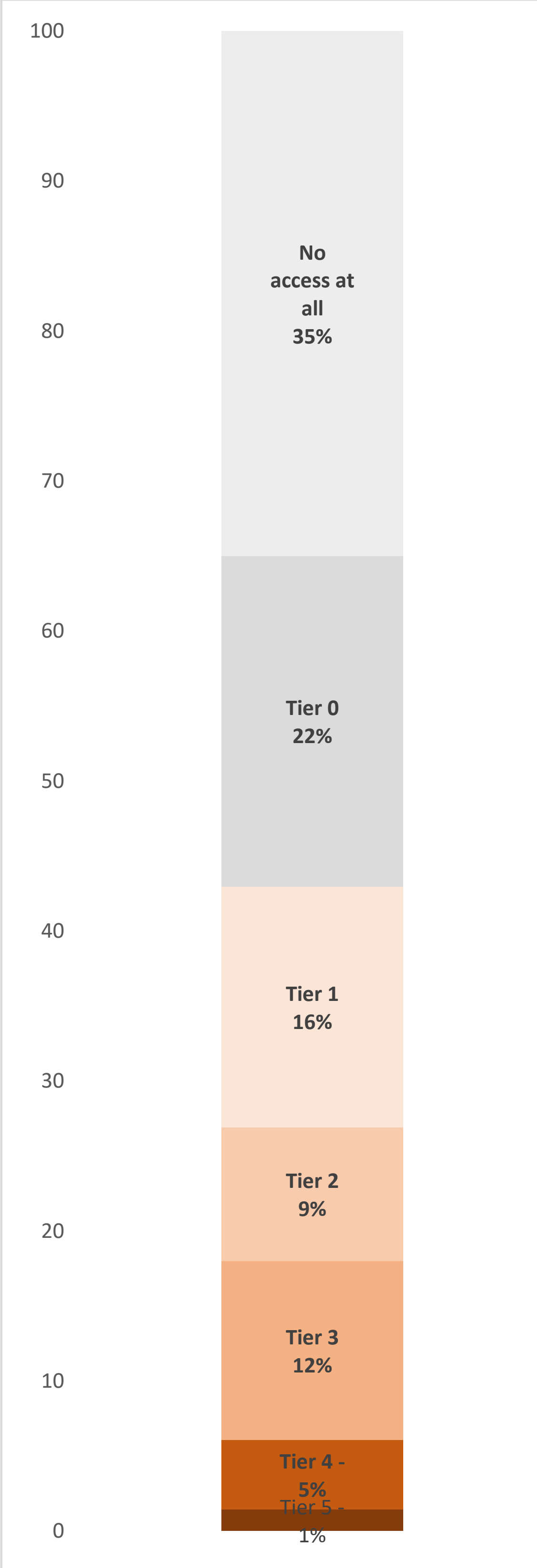
Considering Tier 1 as the minimum service level, the number of households with sufficient access to electricity becomes nevertheless 12.3 million in Scenario 1 and 10.9 million in Scenario 2. This brings the number of households without real access (Tier 0) or without access to electricity at all to **16.5 million in Scenario 1 (56%) and to 12.9 million in Scenario 2 (54%).**

Table 11: Distribution of households based on electricity Tier

Type of access	Scenario 1 (133 M inhabitants)		Scenario 2 (111 M inhabitants)	
	N. of households	Share of households	N. of households	Share of households
Grid, of which:	**8,171,698**	**28**	**8,171,698**	**34**
Tier 0	*326,868*	1	*326,868*	1
Tier 1	*572,019*	2	*572,019*	2
Tier 2	*2,206,358*	8	*2,206,358*	9
Tier 3	*3,350,396*	12	*3,350,396*	14
Tier 4	*1,307,472*	5	*1,307,472*	5
Tier 5	*408,585*	1	*408,585*	2
Standalone system, of which:	***10,546,180***	**37**	**7,274,092**	**31**
Tier 0	*6,116,784*	21	*4,218,973*	18
Tier 1	*4,113,010*	14	*2,836,896*	12
Tier 2	*316,385*	1	*218,223*	1
Mini-grid	***9,820***	**0**	***9,820***	**0**
Without access	**10,084,145**	**35**	**8,342,456**	**35**
Total	**28,811,843**	**100**	**23,789,228**	**100**
Without access	10,084,145	35	8,342,456	35
Total Tier 0	6,443,652	23	4,545,841	19
Total Tier 1-5	12,284,046	44	10,909,769	46
Total	**28,811,843**	**100**	**23,789,228**	**100**

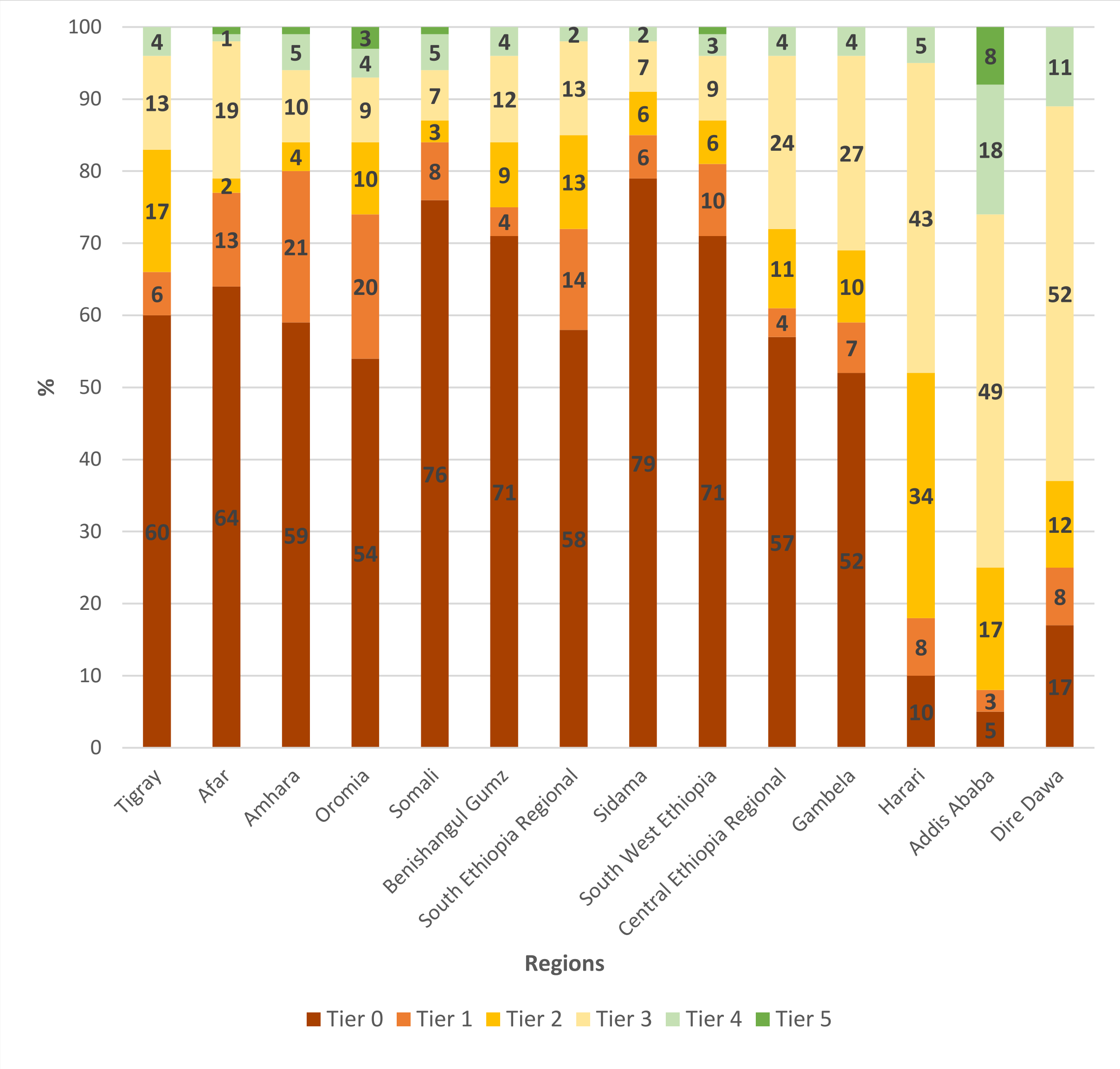
Figure 9: Distribution of households based on electricity Tier (Scenario 1 & 2)





Access to electricity is not homogeneous across the country. **Electricity services vary across Ethiopia's regions.** Harari, Addis Ababa, and Dire Dawa regions, which are small territories structured around large urban areas, have significantly higher access rates to Tiers 2, 3, and 4 than other regions, much more rural. In these three regions in particular, more than 75% of households have access above Tier 2, compared to just under a third in other regions. The below figure illustrates the disparities in terms of Tier Access among regions in Ethiopia.

Figure 10: Household aggregate electricity Tier distribution, by region



Source: The World Bank, 2025

4. Study approach and methodology

4.1 Methodology

The key purpose of the NEP 3.0 was to define and recommend the energy access options that are available, and their associated requirements in terms of budgets, institutional implementation capacity, and policy and regulatory priorities. This will ensure that the **National Electrification Programme appropriately reflects a holistic view of the Ethiopian physical, political and socio-economic reality.**

At the core of the process are technical and economic analyses and modelling of approaches to access provision. Other criteria, related to grid constraints for electricity, and non-quantifiable criteria and constraints will be applied to **optimize the Electrification Schemes and recommended action for implementation during the planning period.** The work methodologies presented in this chapter reflect this approach, with the process to establish the Electrification Schemes two main work streams.

To illustrate, the process of the analysis and optimization of electrification supply is shown in the following figure.

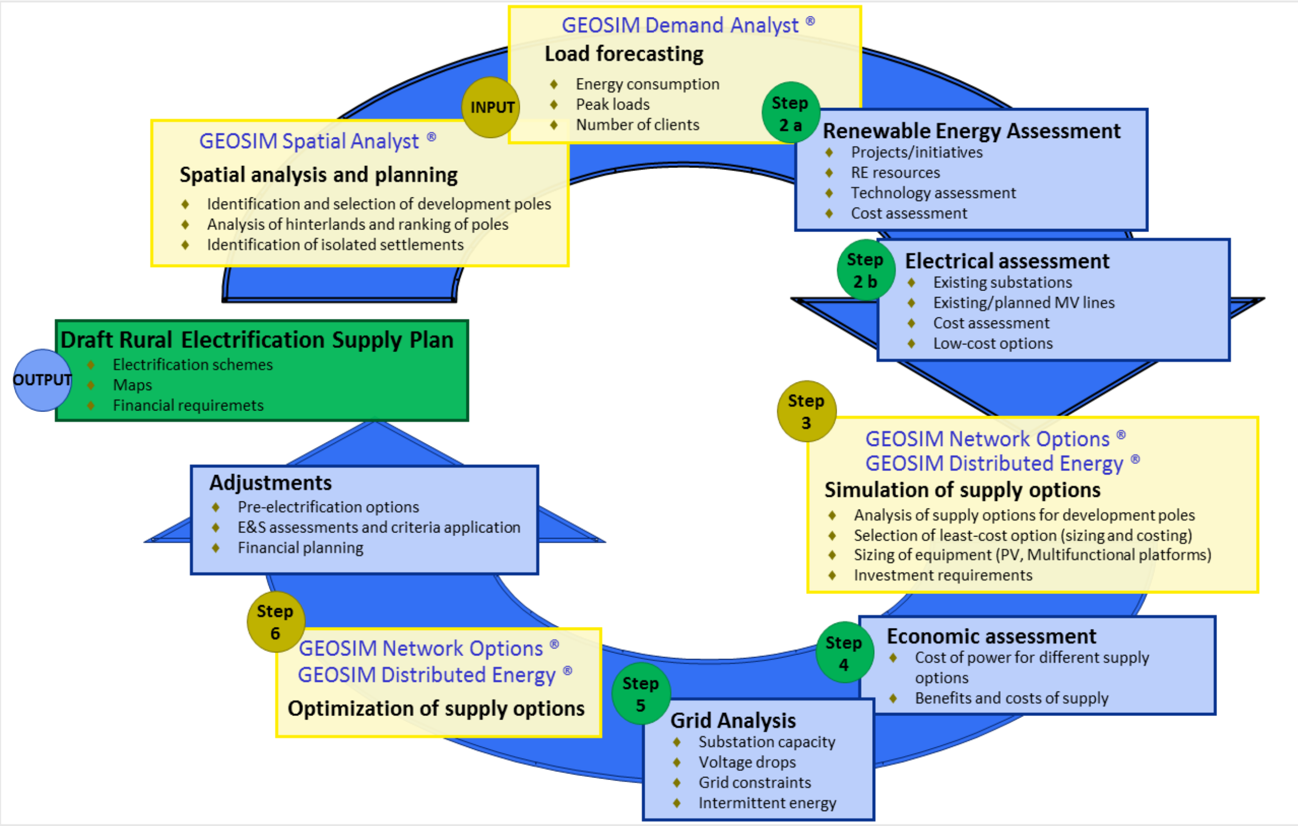


Figure 11: Analysis and Optimization for Electrification Schemes

4.1.1 Spatial analysis and load Forecast

The Spatial Analysis will select and rank areas where social and economic impact of electrification is the highest.

Data on health, education and economic facilities will be gathered for each locality and entered in the GIS database. These data are then processed through an analytical matrix, a la Human Development Index, measuring the potential of each locality for the development of their respective surrounding areas (hinterlands).

Potential benefits of electrification on these localities and their hinterlands are assessed, and the ones with the highest potential are considered “Development Poles” (the number of Development Poles to select will depend directly on the electrification targets set for the 12-years plan). These Development Poles will be given a higher priority in the rural electrification plan and will be ranked according to this rated potential.

Electricity load forecasting is undertaken for each individual locality using an aggregated approach (“bottom-up”) by GEOSIM (www.ied-sa.com). Main characteristics of demand are thus forecasted over the planning period using average load profiles of different types of end-users (different categories of households, businesses, small industries, public facilities etc.). In the case of the project, IED will make use of EEU data to estimate these profiles and build therefore a relevant national load forecast model valid for rural areas in Ethiopia.

As an output, the model will provide energy demand, peak and customers number for the planning period for each **village and settlements** in rural areas.

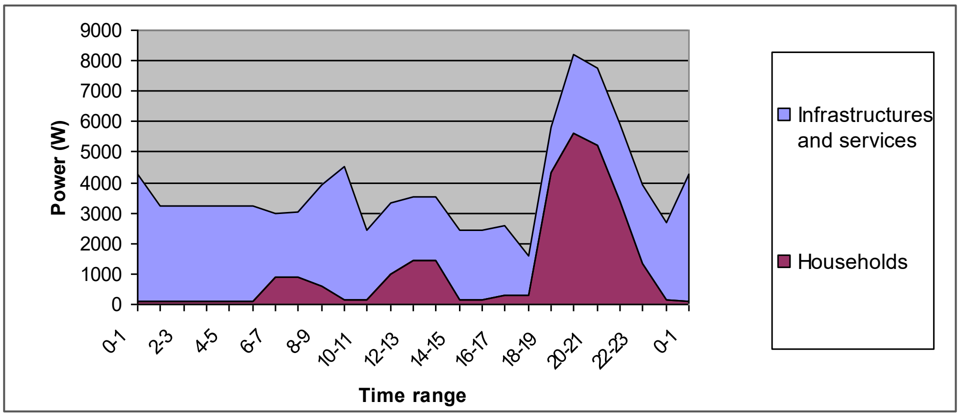


Figure 12: Sample average daily load curve (500p. village and 24h supply)

4.1.2 Electricity - Technical analysis, economic assessment and GEOSIM analysis

The Consultant's starting point is that **grid-based electrification (extensions and/or densification) normally is the cheapest way of providing electricity for areas located within a reasonable distance from an existing grid.** The potential role of mini-grids or micro-grids fed by local power generation is relevant in areas located at more remote distances, where local energy resources are available. Standalone solutions for basic energy services such as lighting (Pico PV products) will not be overlooked; as temporary options awaiting the electrification process to be completed, as well as more long-term options for particular rural people or communities.

The methodology to identify the optimal mix of these different access options in terms of electrification schemes/energy access packages follows the process above illustrated and is described in detail in the following sections.

STEP 1: Renewable energy assessment

The purpose of the assessment is to establish an overview over the technology options available **for rural energy access through mini-grids and/or off-grid alternatives based on Renewable energy resources**.

While Renewable energy sources represent a highly relevant generation option for the main grid, this concern is considered to be a part of a separate generation plan. However, going through the process, the Consultant will consider the potential role such local resources can play to support local power supply.

A review of existing assessments of Ethiopia´s renewable energy resources (wind, small hydro, solar, biomass) will be the starting point. Resource mapping is to a large extent already available, through various existing studies. Data from these studies will be reviewed and consolidated, and the relevant GEOSIM databases updated. The Consultant's assessment of the renewable energy resource situation, based on review of existing information, is presented later on the report.

The renewable energy assessment will include the following elements:

Technology overview:

- An assessment of potential mini-grids solutions based on the financially viable uses of local energy resources associated or not to diesel generation:
  - PV hybrid diesel mini-grids (wind may also be considered at this level)
  - Solar projects with battery storage
  - Biomass-based projects (mainly from bush encroachment)
- An assessment of benefits, challenges and potential restrictions for each of the renewable mini-grid technologies.

Brief assessment of local generation potential for grid power supply
Cost (CAPEX/OPEX)
Market development trends

The results from the renewable energy assessment will be serve as input to both the economic assessment and the GEOSIM simulation and optimization process.

Delimitations for the Renewable Energy Assessment

The Renewable Energy Assessment will thus not include an in-depth analysis of these resources, but rather look to briefly assess their status and potential. Recognizing that technology developments might ultimately dictate a changed approach; the Consultant will continue to consider whether technology developments could indicate that these energy fields become more relevant for rural energy supply.

A short rationale for not including an in-depth analysis assessment of these resources is provided in the report.

STEP 2: Electrical assessment

As there are several ongoing rural electrification projects in Ethiopia, the first step of the electrical assessment will be to establish an overview of the present status of rural electrification. This includes identifying status of all ongoing and planned projects for extensions of the MV grid, and densification (LV or MV).

Low-cost Technologies

The potential for and the opportunity to implement **low-cost rural electrification technologies** (i.e. SWER) in order to reduce the cost of electrification is an important aspect to address at an early stage of the analysis. Low-cost adaptions may be considered on all parts of the MV/ LV network including house and farms connections.

STEP 3: GEOSIM Simulation

Based on the results from the demand forecast combined with the input from Step 1 an assessment of state grid expansion will be conducted on the basis of an automated GIS cost-benefit algorithm.

A preliminary list of potential grid-extensions will also be identified through an initial GEOSIM simulation and based on village's NPV cost. This in order to develop a rough pattern for the overall grid extensions.

When the simulation is carried out, GEOSIM, can begin identify cluster of settlements or single localities where several supply options can be candidate to feed a mini-grid. A hierarchy of potential mini-grid options will be defined for each cluster according the LCOE carried out previously.

For each simulation GEOSIM will provide the following information:

- Demand (kVA and MWh) in localities for various supply options
- Investment for each solution and consolidated investments plans for the different items
- O&M costs and the resulting supplying cost for each locality in c$/kWh

Each option will be sized to achieve the lowest levelized cost, taking into account the technical, economic and financial parameters, adjusted to each provincial context.

The least-cost option will be selected for each identified Development Pole. This will result in a list of potential electrification schemes/energy access projects.

STEP 4: Economic assessment

The economic assessment nevertheless follows the same principle for both elements: The purpose of the assessment is to **identify and compare the economic benefits (for the society as a whole) on one side versus the costs for the beneficiaries on the other**. This process enables the Consultant to recommend the approach(es) to supply energy services that maximize(s) the net benefit.

Based on the design for grid extensions, investment cost and O&M cost, will be estimated. The resulting cost of power supply reflecting regional differences will be thus be established for each of the grid catalogue options.

Thus, the cost for grid-based connections will be compared with cost for connections through alternative solutions, such as mini-grids. In areas where grid connection costs exceed the alternatives, the Consultant will scrutinize the feasibility of such options.

STEP 5: GEOSIM Optimization

As a final step, a GEOSIM (www.ied-sa.com) optimization will adjust the results from the first simulations and adjusted LCOEs.

The results will also be reviewed to ensure that the final recommendations take due consideration of concerns that are not quantitative and that the GEOSIM simulation thus does not consider. This may relate to, for example, E&S concerns or particular political or other priorities.

4.1.3 National Electrification Programme

The grid extension and mini-grid electrification schemes will be presented as a list of projects for provision of electricity to the rural communities in Ethiopia, ranked according to their cost-benefit ratio based on a set of pre-defined criteria. Other outputs from the technical economic analyses that will be available to the Client include:

- Maps showing distribution of energy potential for each of the renewable energy resources (wind, solar and biomass)
- Detailed reports with budget and breakdown of costs (investments, O&M, fuels etc.) for each of the electrification schemes.

Electrifying Ethiopia by means of grid-extension and/or mini-grids will inevitably take time and money. Additionally, even in electrified areas household connections might, at least temporarily, remain outside some rural communities' payment capacity. This may be due to the remoteness of the settlement, its population characteristics, or other criteria.

In areas where conventional electrification options will not be provided at the end of the planning period (2035), off-grid solutions for lighting and basic power services can play an important role to fill the "access gaps".

The market for such technologies in Ethiopia already exists, driven by both local and international private sector actors but also by public programs (ADELE). The most relevant products which feet to the above access definition include:

- solar home systems
- PV kits for community health and education facilities

Although the market is in fast development, targeted support and facilitation could accelerate the process, allowing more local communities to be served.

Recognizing this potential role by off-grid solutions, the Consultant's analysis includes:

- Mapping the population targeted by Distributed energy solution
- Estimating investment required to reach the national objectives in terms of universal access
- Assessment of the technologies and market situation for current and future off-grid supply
- Review of international experience
- Identification and description of current barriers and opportunities, appropriate measures to facilitate market growth, and possible business models, building on local and international experience
- Assessment of ongoing supporting and facilitation initiatives and potential financing option

4.2 Least cost approach and electrification options

Various electrification schemes are proposed to reach universal access by 2035 and are classified according to their expected connection cost and level of services as part of the least cost approach:

- **On-grid densification:** this scheme consists of connecting households without grid connection in localities already served by electricity as well as all households living in unserved localities located less than 1 km from the existing network. This basically requires to add new meters and droplines for each household as well as transformers and short length of LV line.
- **Meters regularization:** this consists of adding meters and droplines for households informally connected in localities already served by the grid.
- **Grid intensification:** this consists of electrifying unserved localities located between 1 to 2.5 km from the existing grid, only in areas where the population density is higher than 100 inhabitants/km². This Involves to add meters and droplines, transformers, short lengths of LV and MV line.
- **Grid extensions:** this scheme consists of electrifying unserved localities located between 2.5 km to 25 km from the existing grid in areas where the population density is higher than 100 inhabitants/km². Grid extension requires to add meters and droplines, transformers, and certain lengths of LV and MV line.
- **Mini-grids:** in relation to the schemes proposed above, mini-grids aim to serve localities that are not covered yet by electricity and that are not targeted by the extension of the network. Like for the grid, mini-grids need to be implemented in areas where the population density is higher than 100 inhabitants/km².
- **Standalone PV systems**: this solution will be deployed for households that are not targeted by the schemes described above and will mostly target localities in low density areas.

5. Identification of priority projects for electrifying Ethiopia

Once the electrification situation has been defined at national level, **it is necessary to prioritize electrification projects based on their socio-economic impact on population** in order to set up a program which will optimize benefits for the Utility and from the point of view of local population.

NEP 3.0 use the GEOSIM Spatial Analyst algorithm (See ANNEXES) to identified such key places which will drive electrification programs.

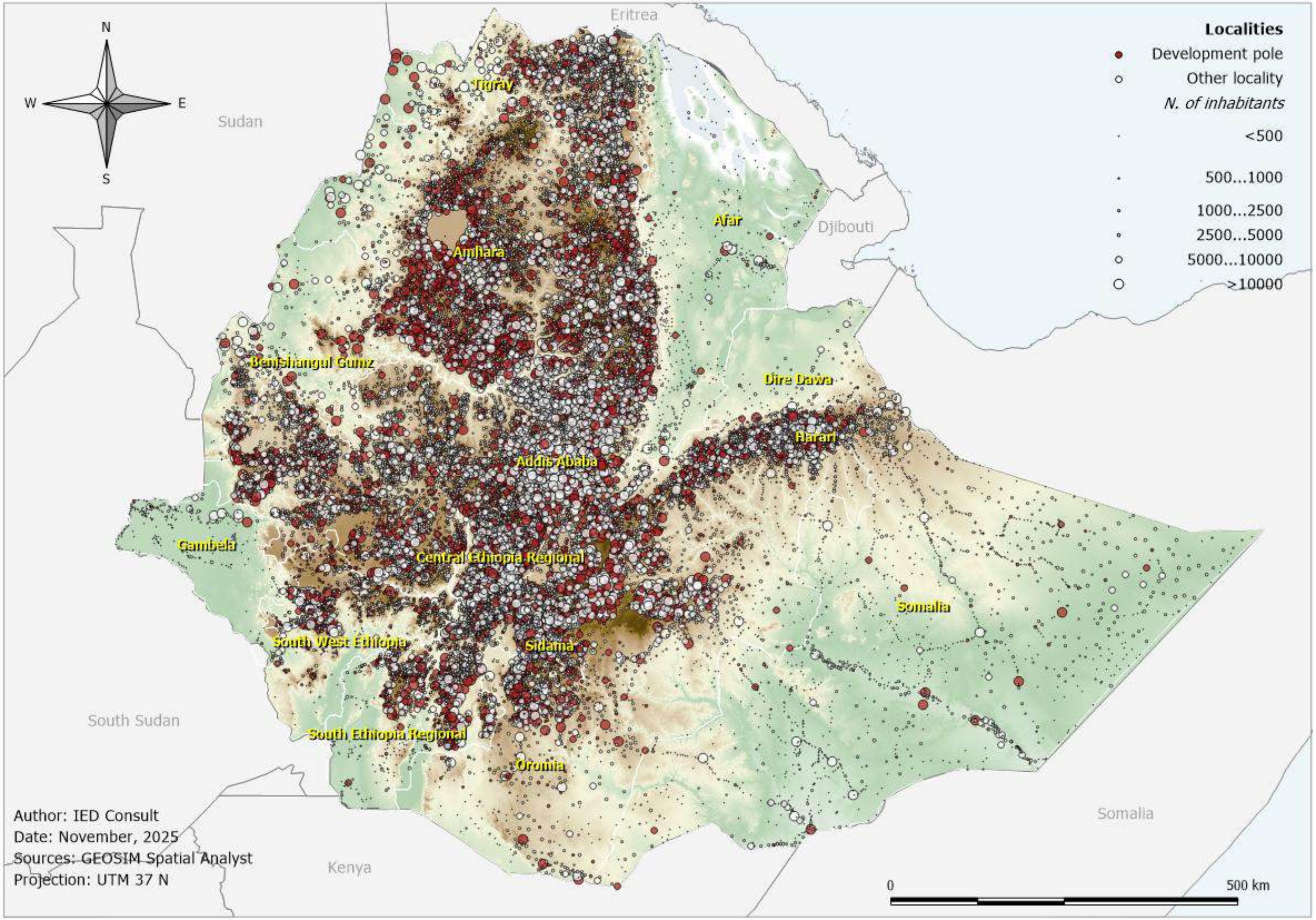
The following table provide an overview of the location of development hubs (or development poles) identified across the regions. The complete list of development poles by region is provided in the Annexes and in the GIS database delivered in the framework of the project.

Table 12: Development poles across the Country

Regions	N. of localities	N. of development poles identified	N. poles non electrified
Addis Ababa	14	3	0
Afar	563	113	27
Amhara	5,915	1,183	443
Benishangul Gumz	506	101	27
Central Ethiopia Regional	1,496	299	145
Dire Dawa	70	14	6
Gambela	277	55	11
Harari	50	10	0
Oromia	9,677	1,935	1,181
Sidama	711	142	87
Somali	1,805	361	56
South Ethiopia Regional	1,770	354	244
South West Ethiopia	995	199	193
Tigray	1,801	360	96
TOTAL	**25,650**	**5,130**	**2,516**

Among the identified development poles, half of them is logically already electrified. Electrification programs shall therefore target in priority development poles which are not yet electrified in order to maximize their socio-economic impact on the population. This electrification approach may then foster local economic opportunities and boost significantly rural development in short term.

Map 6: Position of the Development poles across the Country (scenario 1)



6. Demand Forecasting

6.1 General approach

Development of coherent electricity supply projects depends closely on the care taken to assess the load forecast whose conclusions will serve as a basis for sizing the systems**. Anticipating the behavior of potential consumers requires the planner to have a clear vision of current needs and expectations, but also of the changes brought by the arrival of electricity.**

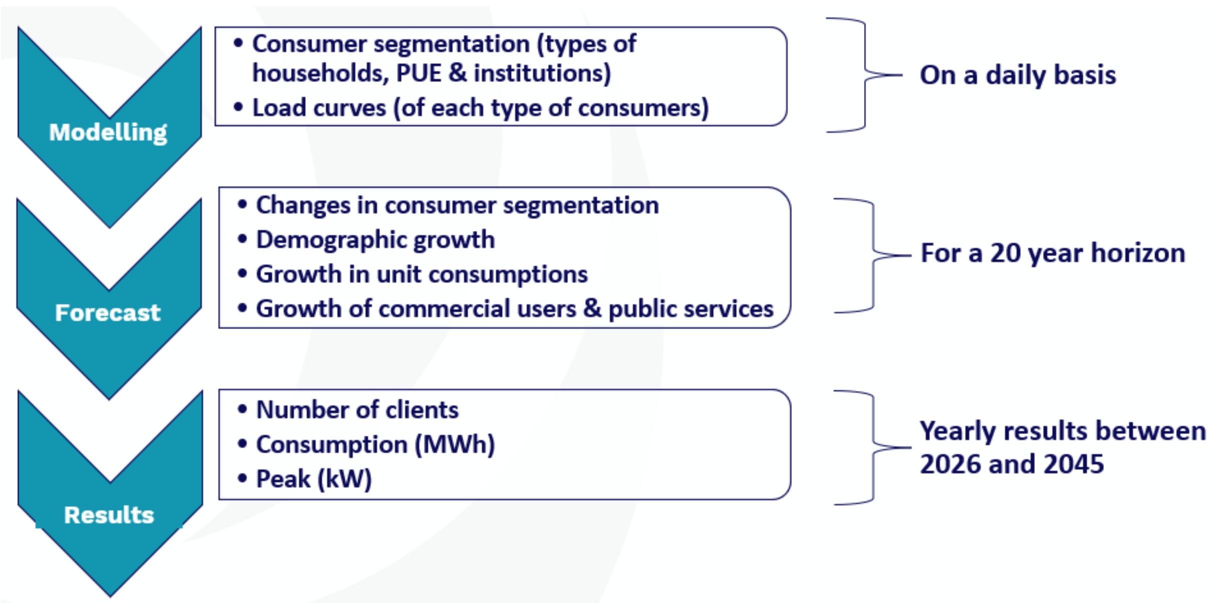
For this purpose, the load forecast is carried out using the GEOSIM Demand Analyst® which makes it possible to model and forecast the electricity demand at the level of each locality. Starting from the average consumption profiles of the different types of end users (categories of households on the one hand, public facilities and economic services on the other), GEOSIM aims to provide for each year of the planning (on a 20-year horizon) the following indicators:

- Number of consumers;
- Peak demand (kW);
- Annual consumption (kWh).

In order to be as close as possible to the socio-economic realities, a set of parameters and assumptions are required to tune the model. These different parameters and assumptions concern:

- The current level of household consumption and its growth in the future;
- The current level of consumption of infrastructure and services and its growth in the future;
- The growth of the population and of infrastructures and services;
- The evolution of socio-economic classes.

Figure 13: The bottom-up approach for the demand forecast



Source: IED

6.2 Household consumptions

Due to their income and size differences, Ethiopian households do not all consume the same amount of electricity. For planning purposes, it is therefore relevant to forecast demand based on three household categories defined as follows:

- "Low demand domestic consumers": represent households consuming less than 6 kWh per month;
- "Medium demand domestic consumers": households consuming between 6 and 30 kWh per month;
- "High demand consumers": represent households consuming more than 30 kWh per month.

These three categories are established on the basis of the consumption levels of the first three Tier (1-3) which are most frequent in the different regions of Ethiopia (cf. Chapter 1). According to consumption data obtained from EEU for 2.3 million customers, **households of the first category consume an average of 3 kWh per month. Households of the second category consume 18 kWh/month, and finally, households of the third category consume an average of 67 kWh per month.** The proportion of each category of consumers varies between regions but at the national level there are 59% of households with a consumption below 6 kWh/month, 19% with a consumption between 6 and 30 kWh/month and 22% with a consumption greater than 30 kWh/month.

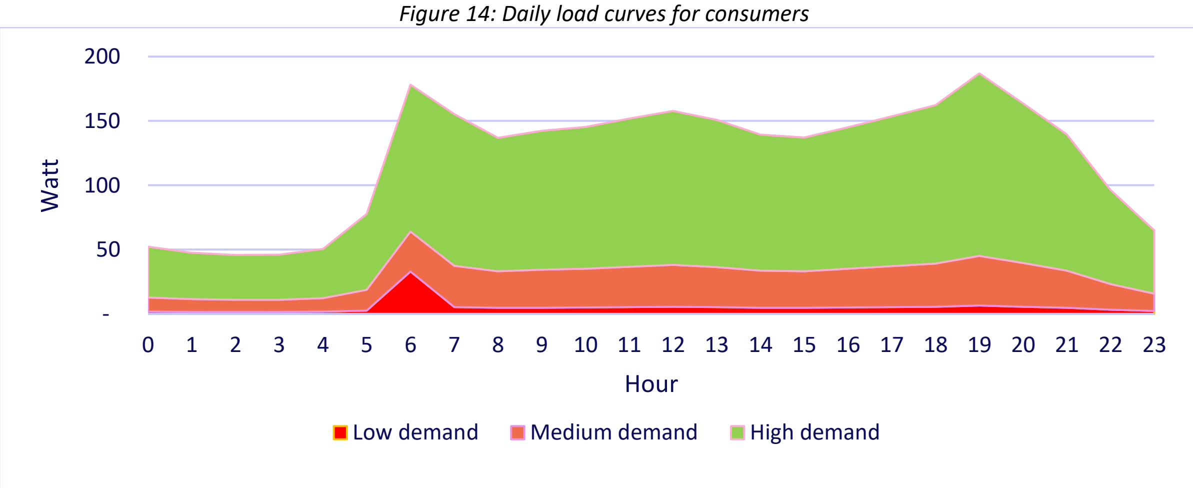
Table 13: Domestic categories according to current consumptions

Consumer category	Consumptions levels	Average yearly consumptions (kWh)	Average monthly consumptions (kWh)	Average daily consumptions (Wh)	Daily Peak (W)	Tier equivalence	Share of households
Low demand	<6 kWh/month	37	3	100	10	Tier 1	59%
Medium demand	6-30 kWh/month	220	18	600	39	Tier 2	19%
High demand	>30 kWh/month	805	67	2,200	142	Tier 3 and more	22%

Sources: SE4ALL, 2015; EEU, 2023

Consumption data collected from EEU also makes it possible to model typical load curves for each of the three consumer categories as presented below.

Figure 14: Daily load curves for consumers



Sources: SE4ALL, 2015; EEU, 2024

6.3 Demand forecast of commercial and public services

This step is fundamental for the least cost electrification approach developed in the framework of the NEP 3.0. In fine, this load forecast modeling will be systematically use:

- to size grid equipment (Transformers…)
- to evaluate energy needs required on the grid in long term to support the grid expansion
- to size mini-grid powerplant capacities and investment according to local energy needs

The load forecast of the localities to electrify must take into account the demand of commercial users and public services the most commonly present in localities. In Ethiopia, a locality electrified generally counts (i) public facilities like schools, places of worship, health centers or administrative offices, (ii) commercial services and productive uses such as cafes, tailors, workshops or mills. Thanks to the literature review, it is possible to define an average number of public facilities and services according to the size of the localities. This breakdown is visible in the table below.

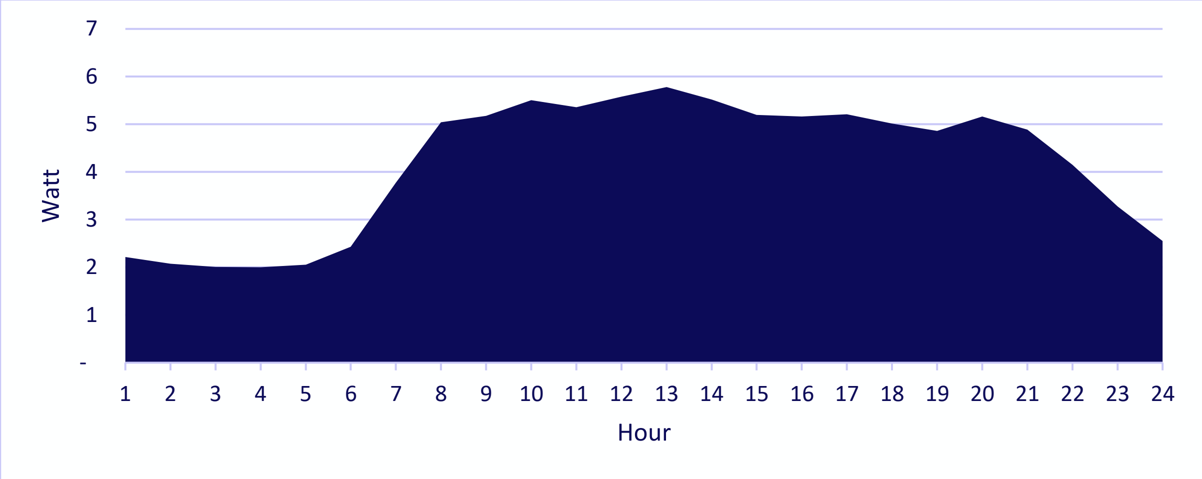
Table 14: Distribution of businesses and services by size of locality

Business & public services	N. of inhabitants					
	Less 500	500 – 1,000	1,000 – 2,500	2,500 – 5,000	5,000 – 10,000	>10,000
Cafes	0.12	0.37	0.87	1.87	3.74	7.49
Hotels	0.12	0.37	0.87	1.87	3.74	7.49
Barbers	0.12	0.37	0.87	1.87	3.74	7.49
Small shops	0.19	0.56	1.31	2.81	5.61	11.23
Tailors	0.12	0.37	0.87	1.87	3.74	7.49
Tea houses	0.09	0.28	0.66	1.40	2.81	5.61
Flour mills	0.12	0.37	0.87	1.87	3.74	7.49
Wood works	0.06	0.19	0.44	0.94	1.87	3.74
Iron Works	0.03	0.09	0.22	0.47	0.94	1.87
Financial institutions	0.06	0.19	0.44	0.94	1.87	3.74
Health institutions	0.10	0.29	0.67	1.43	2.85	5.70
Veterinarian clinics	0.03	0.09	0.22	0.47	0.94	1.87
Primary Schools	0.06	0.17	0.40	0.86	1.73	3.45
Secondary Schools	0.03	0.10	0.23	0.49	0.98	1.95
Government offices	0.12	0.37	0.87	1.87	3.74	7.49
Places of worship	0.09	0.28	0.66	1.40	2.81	5.61

Source: based on Wu and all., 2024, Advancing mini-grid clusters in Ethiopia.

The literature (Wu and all., 2024) also makes it possible to establish an average consumption level per day or per month for each business and service referenced, as well as to design a typical daily load curve (EEU, 2024). These consumption levels are presented in the chart and table below.

Figure 15: Typical commercial load curve



Source: EEU, 2024

Table 15: Average electricity consumption of businesses and public services

Business & public services	kWh/day	kWh/month	kWh/year
Cafe	2.9	87.8	1,051
Small shop	1.0	29.3	350
Barber shop	0.7	21.4	256
Flour mill	106.3	3,240.6	38,781
Local restaurant	9.6	293.1	3,507
Wood workshop	24.5	747.3	8,943
Iron workshop	35.0	1,067.5	12,775
Hotel	2.5	76.2	912
Tailor	2.0	61.0	730
Place of worship	1.8	55.2	661
Administrative office	0.4	12.4	148
Primary schools	2	62	740
Health post	27.0	823.5	9,855
Veterinarian service	10.8	329.4	3,942
Secondary school	6	183	2,190
Financial institution	0.6	18.3	219

Source: based on Wu and all., 2024, Advancing mini-grid clusters in Ethiopia.

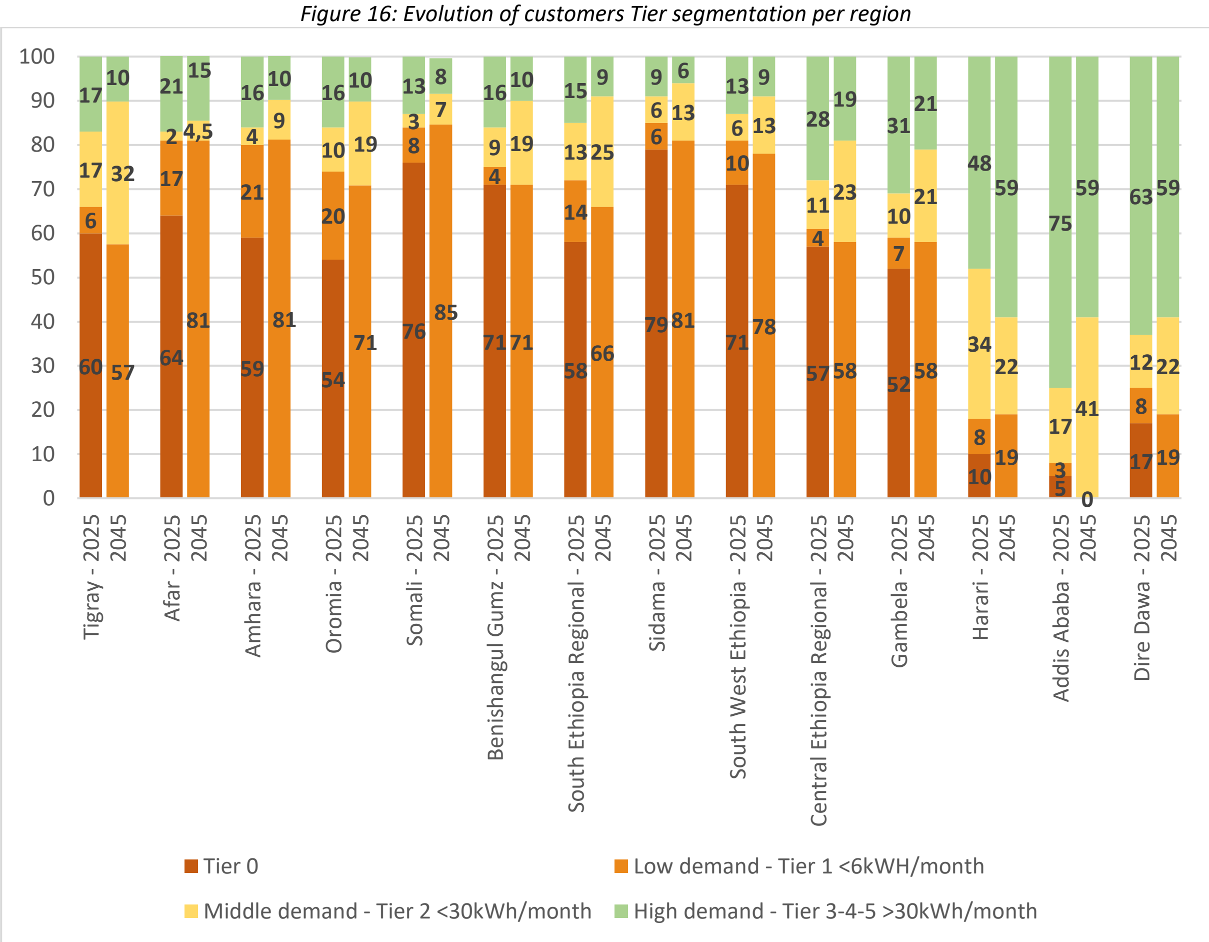
For street lighting, the Load Forecast model is considering a consumption ratio per 1,000 inhabitants for each locality, running between 6PM and 6AM. According to EEU (2024), **public street lighting was estimated on average of 33 GWh/year over the last ten years**. For a covered population of 75.16 million inhabitants (Scenario 2), this represents a consumption of 1,203Wh per day per 1000 inhabitants, or 100 Wh per hour over a period of 12 hours. As foreseen in the National Energy Compact (2025), the energy planned for irrigation will be generated by standalone solar pumps. Therefore, the demand forecast in the planning will not cover this specific need as most of villages are already equipped with some solutions (hand pump, gravity systems) which may not be converted to electricity in short terms.

6.4 Consumption growth

Once current consumption levels have been estimated, different growth assumptions must be taken into account.

- **Evolution of customer segmentation**: with the massive influx of new households into the grid, the segmentation of households based on their electricity consumption will change across different regions. The assumption is that the share of households with the highest consumption levels (Tier 3 and above) will decrease, while the share of households with Tier 2 and especially Tier 1 consumption levels will gain ground. Indeed, electrification programs implemented in the future will primarily target isolated, or at least, rural communities, thus increasing access for populations with lower income levels and therefore lower future consumption. The World Bank's Energy Access Survey showed that in Ethiopia, between 2018 and 2025, the share of households in Tier 3, Tier 4, and Tier 5 decreased by 2% per year, while the share of households at Tier 1 and Tier 2 increased by 1% and 4% per year, respectively. The share of households with a Tier 0 level of consumption had not changed between these two dates, but the objective of universal access should lead to consider that these households will shift towards a Tier 1 level of consumption, as presented in the table below.

Figure 16: Evolution of customers Tier segmentation per region



Source: based on The World Bank, 2025

- **Demographic growth**: to assess the growth of the demand in the coming years, a crucial parameter to take into account is of course the annual demographic growth. Nationwide, it is 2.5% per year in Scenario 1 and 1.73 %/year in Scenario 2, but of course, this varies according to the regions as presented in the table below.

Table 16: Annual population growth rate per region

Region	Annual population growth (%) - Scenario 1	Annual population growth (%) - Scenario 2
Addis Ababa	2.77	1.88
Afar	2.58	1.75
Amhara	1.81	1.23
Benishangul Gumz	3.25	2.22
Central Ethiopia Regional	2.76	1.87
Dire Dawa	3.56	2.41
Gambela	3.83	2.59
Harari	2.96	1.94
Oromia	2.74	1.86
Sidama	2.76	1.87
Somali	2.91	1.97
South Ethiopia Regional	2.76	1.87
South West Ethiopia	2.76	1.87
Tigray	2.14	1.45
TOTAL	**2.51**	**1.73**

Sources: ESS data (2013, 2016, 2020); UN, 2025

- **Growth in unit demand**: following data obtain from EEU on domestic consumptions between 2001 and 2022, an annual growth of household unit demand of 1.65% will be considered. For socio-economic infrastructures this rate is 2.2%.

- **Evolution of the consumer access rate**: according to the World Bank[17], the first year of electrification projects in Ethiopian communities, 30% of households are usually able to get a connection[18]. After five years, this rate reaches 54% with an average annual growth rate of 13%. At this pace, it is possible to consider that nearly 100% of households could be connected after 10 years, i.e. by 2035.

- In order to estimate **electricity universal access cost**, and because village electrification is a long and progressive process, the methodology will consider that all households will be connected by 2035 even though the villages electrification is done during the period 2026-2035.

[17] *The World Bank, 2016, Beyond electricity access: output-based aid and rural electrification in Ethiopia, 124 p.*
[18] *With funded instalment payments, like In GPOBA's project, it could even reach 55% the first year.*

7. Electrification plan for densification and grid expansion

Achieving universal access by 2035 involves massive deployment of connections through various packages of electrification including regularization, densification, Intensification and expansion schemes[19].

The proposed approach shall start with the least cost electrification component with will deal with the electrification of on-grid areas and particularly the densification of connections where the interconnected grid is already active. This part will also include the regularization of informal connections (Shared meters, unofficial connections…).

The next step will be the electrification of areas very close to the existing interconnected grid with the intensification component targeting villages located no more than the 2.5 km from the MV grid.

At last, the methodology will propose grid extensions to reach new areas not electrified yet, building new more expensive backbone feeders.

Results are aggregated by region in the report but data are also available at locality level within the National GIS database.

7.1 On-grid densification projects

A significant number of connections to be made in the context of the electrification planning will be located in the **9,597** localities already covered by electricity (*i.e.* benefitting from electrical infrastructure) or in the **2,265** localities situated in the immediate vicinity of the grid (less than 1000m from one MV line). Under this electrification scheme, the total number of **household connections to be achieved through densification by 2035 is 18.7 million in Scenario 1 and 12.2 million in Scenario 2.** On one hand this represents an investment of **US$11.7 billion** and on the other one, an investment of **US$7.6 billion**, with an **average cost per connection of US$ 625**.

Table 17: Densification connection targets per region – Scenario 1

Region	No. of localities	N. of households electrified (2025)	Total n. of households (2035)	N. of households to connect (2035)
Addis Ababa	14	1,730,624	2,472,637	742,013
Afar	191	20,764	175,800	155,036
Amhara	2,800	1,972,335	6,250,960	4,278,625
Benishangul Gumz	221	41,060	290,193	249,133
Central Ethiopia Regional	985	491,805	2,090,352	1,598,547
Dire Dawa	39	129,494	226,870	97,376
Gambela	79	20,567	157,993	137,426
Harari	43	36,985	53,286	16,301
Oromia	4,356	2,086,661	9,777,136	7,690,475
Sidama	463	393,591	1,198,146	804,555
Somali	394	47,384	384,216	336,832
South Ethiopia Regional	885	366,128	1,489,089	1,122,961
South West Ethiopia	432	115,483	490,881	375,398
Tigray	960	728,180	1,877,183	1,149,003
TOTAL	**11,862**	**8,181,061**	**26,934,742**	**18,753,681**

[19] Note that off-grid access through the development of mini-grids and the deployment of standalone PV systems will be presented during a second step, in a consolidated report.

Table 18: Densification connection targets per region – Scenario 2

Region	No. of localities	N. of households electrified (2025)	Total n. of households (2035)	N. of households to connect (2035)
Addis Ababa	14	986,459	1,291,754	305,295
Afar	191	174,209	490,888	316,679
Amhara	2,800	1,422,414	4,486,551	3,064,137
Benishangul Gumz	221	79,486	233,305	153,819
Central Ethiopia Regional	985	880,274	1,629,244	748,970
Dire Dawa	39	108,764	170,473	61,709
Gambela	79	80,886	137,374	56,488
Harari	43	60,272	79,371	19,099
Oromia	4,356	2,752,232	7,265,111	4,512,879
Sidama	463	196,444	933,868	737,424
Somali	394	221,338	915,137	693,799
South Ethiopia Regional	885	470,480	1,160,636	690,156
South West Ethiopia	432	108,154	382,619	274,465
Tigray	960	639,971	1,245,981	606,010
TOTAL	**11,862**	**8,181,383**	**20,422,312**	**12,240,929**

In Scenario 1, electrifying 100% of the targeted households would represent a **6,751 GWh** additional demand on the existing MV network as well as an additional **1,463 MW** generation capacity in **2035**. This result includes technical losses as well as demand of the new households and services related to the demographic growth. In Scenario 2, the demand would reach 4,407 GWh and the peak 955 MW by 2035.

Table 19: Densification connection targets per region – Scenario 1

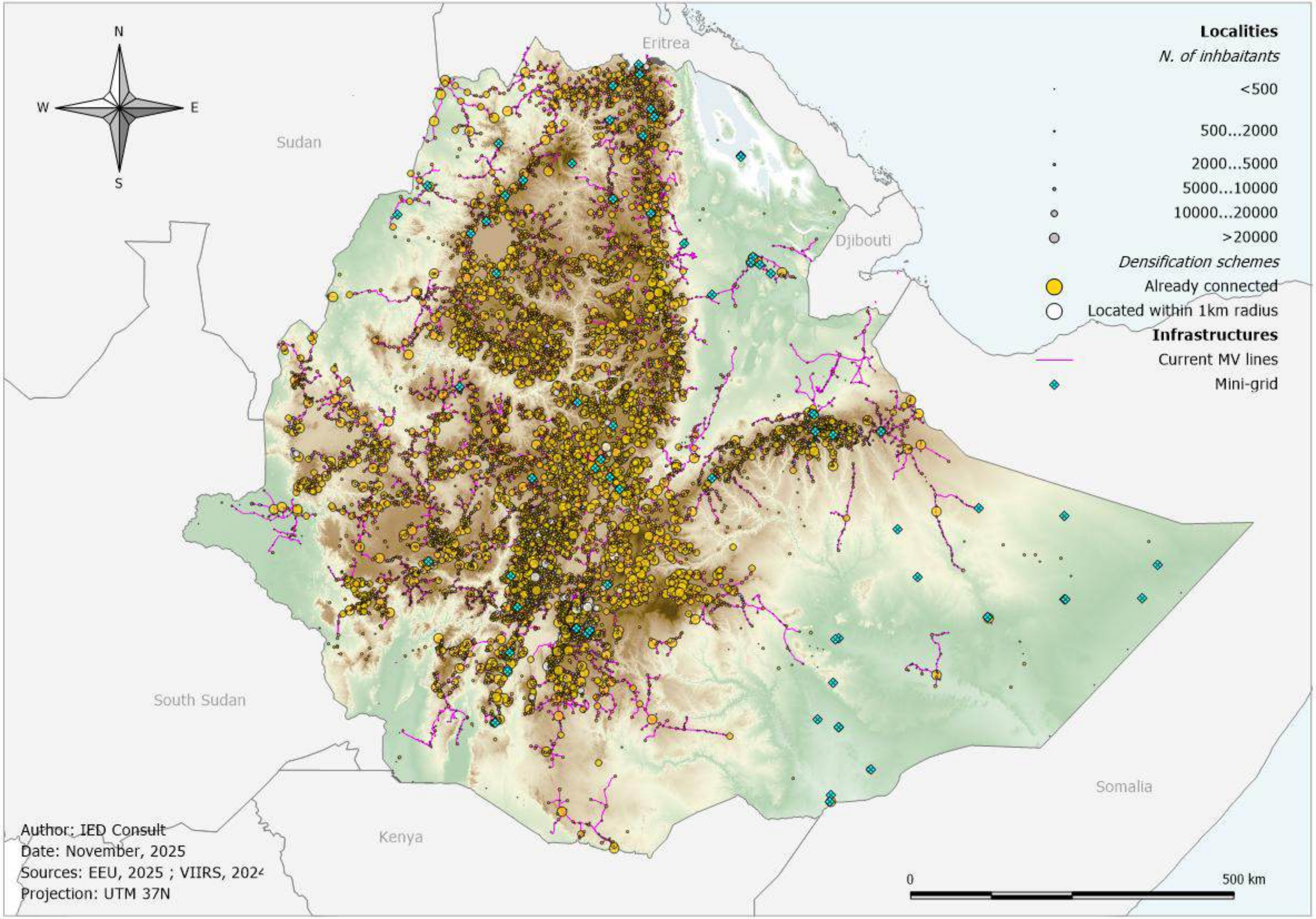
Region	N. of households targeted (2035)	Additional demand 2035 (GWh)	Additional peak 2035 (MW)	Investments (M US$)
Addis Ababa	742,013	267	58	280.480
Afar	155,036	56	12	91.133
Amhara	4,278,625	1,540	334	2,676.135
Benishangul Gumz	249,133	90	19	168.405
Central Ethiopia Regional	1,598,547	575	125	1,021.354
Dire Dawa	97,376	35	8	36.808
Gambela	137,426	49	11	97.943
Harari	16,301	6	1	11.638
Oromia	7,690,475	2,769	600	5,048.803
Sidama	804,555	290	63	477.550
Somali	336,832	121	26	177.565
South Ethiopia Regional	1,122,961	404	88	712.865
South West Ethiopia	375,398	135	29	240.169
Tigray	1,149,003	414	90	697.139
TOTAL	**18,753,681**	**6,751**	**1,463**	**11,737.994**

Densification effort is estimated around 11.7 B US$ for scenario 1 and 7.6 B US$ for scenario 2.

Table 20: Densification connection targets per region – Scenario 2

Region	N. of households targeted (2035)	Additional demand 2035 (MWh)	Additional peak 2035 (kW)	Investments (M US$)
Addis Ababa	305,295	110	24	115.401
Afar	316,679	114	25	186.590
Amhara	3,064,137	1,103	239	1,916.553
Benishangul Gumz	153,819	55	12	104.214
Central Ethiopia Regional	748,970	270	58	484.706
Dire Dawa	61,709	22	5	23.326
Gambela	56,488	20	4	40.260
Harari	19,099	7	1	13.636
Oromia	4,512,879	1,625	352	2,969.525
Sidama	737,424	265	58	435.241
Somali	693,799	250	54	366.274
South Ethiopia Regional	690,156	248	54	439.736
South West Ethiopia	274,465	99	21	175.690
Tigray	606,010	218	47	369.948
TOTAL	**12,240,929**	**4,407**	**955**	**7,641.107**

Map 7: Localities targeted by densification



7.2 On-grid connections regularization

In order to improve electricity access quality and optimize EEU's revenues, it is necessary to regularize household's electrification connections for those who share or use meters informally (about 47% of consumers). In total, only about 22% of households have a legal connection. This regularization activity will necessarily take place in already electrified areas. This activity will require to add new meters and drop lines targeting unformal connection at an average cost of US$65 per household. **In total, 3.8 million households would potentially be targeted by the electrification scheme, with a total investment of about US$ 250 million.**

Table 21: Number of households to regularize and related investments

Region	No. of localities	Total n. of households connected (2025)	N. of households officially connected (2025)	N. of households informally connected (2025)	Investments (M US$)
Addis Ababa	14	1,730,624	917,232	813,392	52.870
Afar	161	20,764	11,002	9,762	0.634
Amhara	2,414	1,972,335	1,045,325	927,010	60.255
Benishangul Gumz	168	41,060	21,761	19,299	1.254
Central Ethiopia Regional	787	491,805	260,654	231,151	15.024
Dire Dawa	36	129,494	68,633	60,861	3.955
Gambela	68	20,567	10,901	9,666	0.628
Harari	42	36,985	19,607	17,378	1.129
Oromia	3,454	2,086,661	1,105,922	980,739	63.748
Sidama	367	393,591	208,605	184,986	12.024
Somali	249	47,384	25,110	22,274	1.447
South Ethiopia Regional	713	366,128	194,036	172,092	11.185
South West Ethiopia	346	115,483	61,213	54,270	3.527
Tigray	778	728,180	385,954	342,226	22.244
TOTAL	**9,597**	**8,181,061**	**4,335,955**	**3,845,106**	**249.931**

7.3 On-grid intensification

Because electrification is quite costly, the least cost approach will then focus in electrification close the existing MV grid.

The intensification will target all remaining unelectrified localities located between 1 and 2.5 km from the existing grid. To reduce costs, localities in sparsely populated areas (less than 100 inhabitants per square kilometer) will be excluded from the list of candidates and targeted by pre-electrification programs using mainly solar home systems.

Nationally, the intensification component represents more than 2,734 localities including 1.8 million households by 2035 in Scenario 1 and 1.3 million in Scenario 2. The associated investments with this electrification scheme will reach US$ 1.3 billion in Scenario 1 and US$ 1 billion in Scenario 2. The difference in investment between the two scenarios is explained by a greater mileage of low-voltage lines in Scenario 1 (80,600 km versus 60,200 km) and logically by a number of meters that is almost twice as high in Scenario 2. **On average the connection cost will be $US 733 in Scenario 1 and $US 756 in Scenario 2.**

Table 22: Intensification targets and related load forecast – Scenario 1

Region	N. of localities	N. of households 2035	Demand 2035 (MWh)	Peak 2035 (kW)
Addis Ababa	-	-	-	-
Afar	2	435	138	28
Amhara	630	433,653	141,576	30,634
Benishangul Gumz	9	5,865	1,879	384
Central Ethiopia Regional	305	198,900	108,585	23,708
Dire Dawa	12	3,260	2,674	449
Gambela	1	2,246	959	168
Harari	6	4,495	3,625	636
Oromia	1,075	745,142	269,621	59,010
Sidama	123	88,926	30,445	7,663
Somali	20	3,225	1,020	237
South Ethiopia Regional	251	169,312	56,377	11,729
South West Ethiopia	103	25,651	8,537	1,945
Tigray	197	109,666	41,705	8,591
TOTAL	**2,734**	**1,790,776**	**667,141**	**145,182**

Table 23: Intensification targets and related load forecast – Scenario 2

Region	N. of localities	N. of households 2035	Demand 2035 (MWh)	Peak 2035 (kW)
Addis Ababa	-	-	-	-
Afar	2	1,213	402	77
Amhara	630	311,239	107,996	22,297
Benishangul Gumz	9	4,716	1,661	335
Central Ethiopia Regional	305	155,027	89,923	18,661
Dire Dawa	12	2,451	2,085	349
Gambela	1	1,953	853	149
Harari	6	6,697	5,423	920
Oromia	1,075	553,706	213,375	44,460
Sidama	123	69,321	26,892	6,348
Somali	20	7,694	2,419	513
South Ethiopia Regional	251	131,968	45,039	9,095
South West Ethiopia	103	19,995	7,358	1,618
Tigray	197	72,783	29,401	5,853
TOTAL	**2,734**	**1,338,763**	**532,827**	**110,675**

Table 24: Intensification investments – Scenario 1

Region	MV lines (MUS$)	LV line (MUS$)	Transformers ($US)	Meter + dropline ($US)	Total investment (MUS$)
Addis Ababa	-	-	-	-	-
Afar	79	260	9,440	28,275	0.377
Amhara	25.381	259.541	3,829,325	28,187,445	316.939
Benishangul Gumz	290	3.510	54,260	381,225	4.236
Central Ethiopia Regional	11.706	119.041	2,137,095	12,928,500	145.813
Dire Dawa	422	1.951	71,390	211,900	2.657
Gambela	8	1.344	8,530	145,990	1.507
Harari	185	2.690	47,545	292,175	3.215
Oromia	42.787	445.967	6,773,540	48,434,230	543.962

Sidama	4.736	53.222	834,810	5,780,190	64.573
Somali	823	1.930	95,240	209,625	3.058
South Ethiopia Regional	9.506	101.333	1,498,715	11,005,280	123.343
South West Ethiopia	3.881	15.352	541,560	1,667,315	21.442
Tigray	7.914	65.635	1,149,960	7,128,290	81.827
TOTAL	**107.723**	**1,071.779**	**17,051,410**	**116,400,440**	**1,312.955**

Table 25: Intensification investments – Scenario 2

Region	MV lines (MUS$)	LV line (MUS$)	Transformers ($US)	Meter + dropline ($US)	Total investment (MUS$)
Addis Ababa	-	-	-	-	-
Afar	79	725	12,585	78,845	0.896
Amhara	25.296	186.276	3,570,475	20,230,535	235.373
Benishangul Gumz	290	2.822	53,595	306,540	3.472
Central Ethiopia Regional	11.645	92.783	2,105,870	10,076,755	116.611
Dire Dawa	396	1.466	66,115	159,315	2.088
Gambela	8	1.168	8,530	126,945	1.313
Harari	185	4.008	50,515	435,305	4.679
Oromia	42.825	331.393	6,479,345	35,990,890	416.688
Sidama	4.705	41.488	815,620	4,505,865	51.516
Somali	844	4.604	114,990	500,110	6.064
South Ethiopia Regional	9.578	78.982	1,425,980	8,577,920	98.565
South West Ethiopia	3.879	11.967	529,820	1,299,675	17.676
Tigray	7.940	43.560	1,057,245	4,730,895	57.289
TOTAL	**107.676**	**801.249**	**16,290,685**	**87,019,595**	**1,012.236**

7.4 Grid expansion

According to the selection criteria defined previously[20], more than 5,268 or **33% percent of the 16,053 uncovered localities** have been identified as candidates for electrification through grid extension. As indicated in the below table, by 2035, around **3,755,000 households would have to be connected in these localities** in Scenario 1 and **2,816,000 in Scenario 2**.

Results from geospatial simulations show that extensions imply the construction of approximatively 19,600 kilometers of additional MV lines, 143,000 km of LV lines in Scenario 2 and 173,000 km in Scenario 1.

With meters and transformers, this will represent **an investment of nearly US$ 3 billion in Scenario 1 and $US 2.3 billion in Scenario 2**. This will result in an **average connection cost of $US 778 in Scenario 1 and $US 816 in Scenario 2**.

In Scenario 1, the additional demand of domestic and non-domestic users in 2035 would be around 1,350 GWh and the additional peak estimated around 295 MW. The annual demand would reach 1,069 GWh and the peak around 223 MW in the second scenario.

[20] For grid extensions, extensions target all uncovered localities located from 2.5km to 25km around the existing network with a population density below 100 inhabitants/km².

Table 26: Number of localities and households targeted by grid extensions - Scenario 1

Region	N. of localities	N. of households 2035	Demand 2035 (GWh)	Peak 2035 (MW)
Addis Ababa	-	-	-	-
Afar	13	5,295	2	0
Amhara	1,481	1,083,646	356	77
Benishangul Gumz	12	10,161	3	1
Central Ethiopia Regional	198	117,072	65	14
Dire Dawa	17	13,709	11	2
Gambela	4	2,436	1	0
Harari	1	394	0	0
Oromia	2,506	1,858,291	680	150
Sidama	122	66,605	25	7
Somali	78	18,634	6	1
South Ethiopia Regional	381	325,972	108	23
South West Ethiopia	234	108,826	36	8
Tigray	221	143,852	55	11
TOTAL	**5,268**	**3,754,893**	**1,350**	**295**

Table 27: Number of localities and households targeted by grid extensions - Scenario 2

Region	N. of localities	N. of households 2035	Demand 2035 (GWh)	Peak 2035 (MW)
Addis Ababa	-	-	-	-
Afar	13	14,792	5	1
Amhara	1,481	777,741	270	56
Benishangul Gumz	12	8,168	3	1
Central Ethiopia Regional	198	91,256	54	11
Dire Dawa	17	10,302	9	1
Gambela	4	2,119	1	0
Harari	1	588	0	0
Oromia	2,506	1,380,847	537	112
Sidama	122	51,901	21	5
Somali	78	44,389	15	3
South Ethiopia Regional	381	254,057	87	17
South West Ethiopia	234	84,817	30	6
Tigray	221	95,483	38	8
TOTAL	**5,268**	**2,816,460**	**1,069**	**223**

Table 28: Investment and demand breakdown for MV line expansion – Scenario 1

Region	MV lines (MUS$)	LV line (MUS$)	Transformers ($US)	Meter + dropline ($US)	Total investment (MUS$)
Addis Ababa	-	-	-	-	-
Afar	1.575	3.169	70,170	344,175	5.158
Amhara	112.565	648.562	9,132,550	70,436,990	840.697
Benishangul Gumz	1.099	6.081	73,910	660,465	7.915
Central Ethiopia Regional	12.264	70.067	1,362,405	7,609,680	91.304
Dire Dawa	1.050	8.204	124,845	891,085	10.271
Gambela	1.150	1.457	22,690	158,340	2.789

Harari	29	235	7,865	25,610	0.298
Oromia	190.397	1,112.187	16,224,035	120,788,915	1,439.597
Sidama	8.349	39.863	808,710	4,329,325	53.350
Somali	9.299	11.152	388,965	1,211,210	22.052
South Ethiopia Regional	26.921	195.094	2,371,090	21,188,180	245.574
South West Ethiopia	16.285	65.132	1,335,120	7,073,690	89.826
Tigray	16.386	86.095	1,338,395	9,350,380	113.170
TOTAL	**397.374**	**2,247.303**	**33,260,750**	**244,068,045**	**2,922.007**

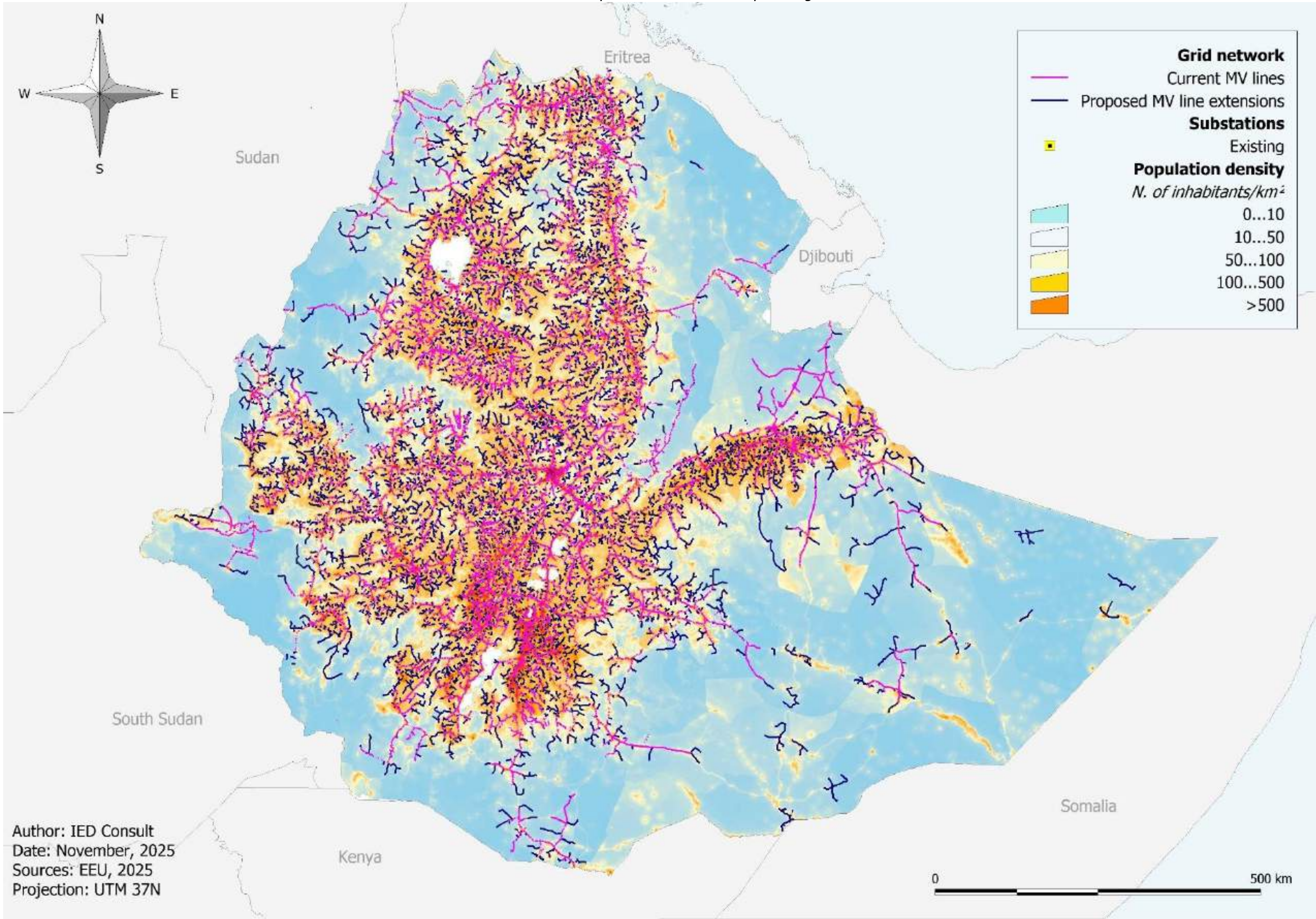
Table 29: Investment and demand breakdown for MV line expansion – Scenario 2

Region	**MV lines (MUS$)**	**LV line (MUS$)**	**Transformers ($US)**	**Meter + dropline ($US)**	**Total investment (MUS$)**
Addis Ababa	-	-	-	-	-
Afar	1.312	8.853	91,700	961,480	11.219
Amhara	111.713	465.477	8,539,295	50,553,165	636.283
Benishangul Gumz	1.105	4.888	73,245	530,920	6.598
Central Ethiopia Regional	11.992	54.616	1,343,450	5,931,640	73.884
Dire Dawa	1.049	6.165	121,345	669,630	8.006
Gambela	1.150	1.268	22,690	137,735	2.579
Harari	29	351	8,530	38,220	0.428
Oromia	190.099	826.436	15,520,545	89,755,055	1,121.812
Sidama	8.227	31.062	775,750	3,373,565	43.439
Somali	9.585	26.566	467,265	2,885,285	39.504
South Ethiopia Regional	27.259	152.053	2,283,150	16,513,705	198.109
South West Ethiopia	16.813	50.762	1,299,465	5,513,105	74.388
Tigray	16.678	57.146	1,244,875	6,206,395	81.276
TOTAL	**397.018**	**1,685.651**	**31,791,305**	**183,069,900**	**2,297.531**

Lists of localities targeted and **budget breakdown per village** for each electrification component are available on the database provided along with the report and separate reports.

The planned grid extensions can be visualized on the below map.

Map 8: MV line extension planning



8. Off-Grid electrification

8.1 Ethiopian off-grid environment

8.1.1 Off-grid sector

The off-grid sector in Ethiopia is now getting attention by Government, with support from the World Bank and development partners, to promote private sector and to focus on renewable energy-based mini-grids (MG) in addition to standalone systems (SAS). The development of the off-grid electrification sector is well addressed to be one of the main strategies for the electrification of the country. In addition, the government promotes off-grid solutions to connect isolated public facilities such as schools and health centers, improving access to essential services in rural areas. However, the utility & government are still focusing on grid-based activities and limited connections are made so far on mini-grids.

The off-grid electrification rate in Ethiopia increased significantly from 10% in 2017 to about 36% in 2025 (WB estimate) with a high majority of Tier 0, 1 & 2 customers using solar lanterns and SHS; very few mini-grids have been implemented.
While solar home systems (SHS) are common (estimate varies from 3 to 9 million of SHS sold since 2020), the sector is slowly moving from pre-electrification scheme with standalone systems (Tier 1 & 2) towards mini-grids (Tier 3 & 4) to also promote productive use of electricity (PUE), to increase income generation and to boost economic development in rural areas.
Based on MoWE & EEU data, about 40 solar mini-grids (28 ELEAP and 12 UEAP), 5-10 hydro-based mini-grids and 6 wind-based MG (as of August 2025) were implemented over the last decades and only part of them are still in operation.
The strong potential for developing off-grid solutions is closely linked to the significant renewable energy resources (solar, wind, hydro, biomass, and geothermal) available in Ethiopia.

8.1.2 Off-grid regulatory framework

Significant improvements in the **off-grid regulatory framework** were made over the last years under NEP 2, balancing grid extension with standalone solar and mini-grids and increasing involvement from both the public and private sector. The framework creates enabling ecosystem of policies, licensing, quality standards (e.g., for solar home systems), compensation mechanism, incentives and tariff guidelines, aims to advance the deployment of mini-grids.

- **Mini-grid and Standalone Directives**: Specific legislation and incentives exist to guide the development of mini-grids and standalone power systems, including connection codes for mini-grids to the national grid and provisions for selling electricity

- **Licensing Arrangements**: A clear licensing process allows private mini-grid operators to obtain approvals for generation, distribution, and sale of energy, enabling private sector participation and oversight.

- **Incentives**: Tax and duty exemptions are offered to support the development of standalone energy systems to encourage investment and uptake.

- **Local manufacturing:** Local assembly of solar kits (licensed from an international manufacturer and certified by Verasol) can be an advantage in terms of after-sales service guarantees, repair capabilities, and the "Made in Ethiopia" image for buyers. However, cost reductions are unlikely due to the lack of mass production and easy access to components and spare parts.

Until recently, the Government of Ethiopia has followed a public-sector driven approach with high government control, comparatively high subsidies and low tariffs. National tariffs at a level of approximately US$ 0.07 per kWh are to be applied for residential customers, with cross-subsidization through higher tariffs to commercial and industrial users (Get Transform, Inensus, 2021). For the benefit of private operators, tariffs will be increased. Ethiopia is implementing a progressive, four-year electricity tariff reform aimed at achieving full cost recovery by 2028.
For further off-grid development, private sector participation should be positioned as a core pillar of rural electrification. To unlock private investment, the regulatory framework should:

- Clearly define the role of private developers and establish predictable, streamlined licensing and permitting procedures.
- Clarify allowable ownership models (next §), actively promote PPP arrangements, and provide robust investment protection mechanisms.
- Establish transparent, cost-reflective tariff-setting principles

8.1.3 Off-grid delivery models

Since 2017, the Ethiopian government experimented with several off-grid electrification deployment models, depending on the technology chosen.

Mini-grids

Following a pilot phase of 12 solar mini-grids under UEAP, followed by 28 additional solar MG under ELEAP, the government now is promoting mini-grids according 2 delivery models under ADELE programme (Get Transform, Inensus, 2021):

(i) **EEU-driven**: new MG and hybridization of existing MG, deployed by EEU through EPC and short-term O&M contracts

(ii) **Private sector-led**: demo projects of different private sector-led approaches to leverage local and international private sector financing and local cooperatives for mini-grid scale-up, based on minimum-subsidy tenders or on performance-based grants (PBG).

Hybrid approach through PPP (Public-Private Partnership) is promising for MG development.
Presently, there are approximately 63 fuel-based MG owned by EEU and 50 hydro or solar powered MG owned by either EEU or private or cooperatives. About 24 solar mini-grids are supposed to be energized by 2025, according to MoWE, connecting more than 170,000 households.

Note that GEAPP has introduced successfully so-called "Interconnected Mini-Grids" (IMG) in Nigeria and is willing to support EEU and other developers on this in Ethiopia. These systems are designed to move beyond isolated, small-scale setups, with plans to strengthen and interconnect with the national grid, offering a scalable model for rural electrification. Those Interconnected Mini-Grids receive power from the main grid and from distributed renewable energy (DER) situated near consumption. This innovative model targets mainly peri urban settlements where the utility has limited financial, technical, commercial capacity to offer grid extension and reliable service. A DRE plant can also boost the low voltage of the weak grid.

Standalone Solar systems

In Ethiopia, the distribution of small solar products for standalone applications is a predominantly **cash market** and has been largely dominated by solar lanterns (SL <3 Wp). Over the period 2016-2021, according to Gogla/IFC, more than 3 million solar standalone products were sold.

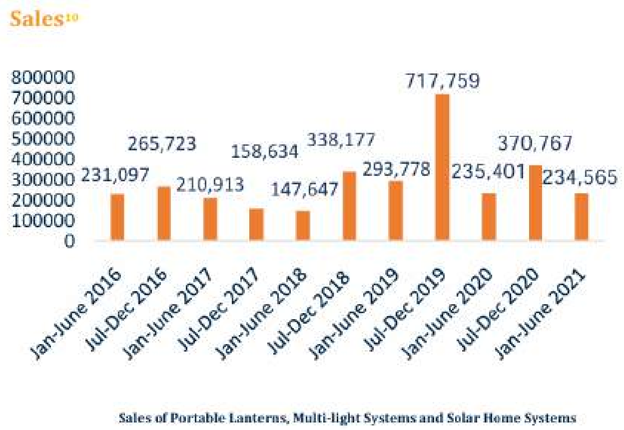


Figure 17: Solar lighting product Sales in 2016-2021

To control the quality of imported solar products, the Government first developed national standards for pico or solar lighting systems (SLS <15Wp) and for Solar Home Systems (SHS <350Wp) which were in application before 2021. Then, the Government of Ethiopia launched in September 2021 the Pre-export Verification of Conformity programme (PVoC) first to check that imported SAS products meet the required standards (quality label) before they leave their port of origin and secondly to carry out market surveillance activities. About 67% SAS sales in 2021 appeared to be QV (Quality Verified). In 2024, there were still issues with quality assurance as despite the PVoC being implemented; the majority of SHS on the market were still below standard. Ethiopian Solar Energy Development Association (ESEDA) has worked with Ethiopian Standard Authority (ESA) to promote certified quality products and even advocated for the implementation of PVoC but more work is needed on the implementation side.

Beside private sector-led market of small solar systems for households and small businesses, the government is actively supporting off-grid electrification of rural infrastructures through UEAP, ELEAP, ADELE programmes (cf. §7.1.6), with larger Solar Community Systems (SCS) for education, health and administration infrastructures, and also Solar Pumping Systems (SPS) for irrigation.
Presently in Ethiopia, there are approximatively more than 10 million SL, SLS, SHS sold/delivered to domestic/private consumers and about 2500 standalone solar systems for rural communities.
With 1.37 million units sold in 2024, sales of solar energy kits in Ethiopia have increased by 205% compared to 2023. However, it should be noted that a large share of sales for the first half of the year was attributed to humanitarian bulk procurement.

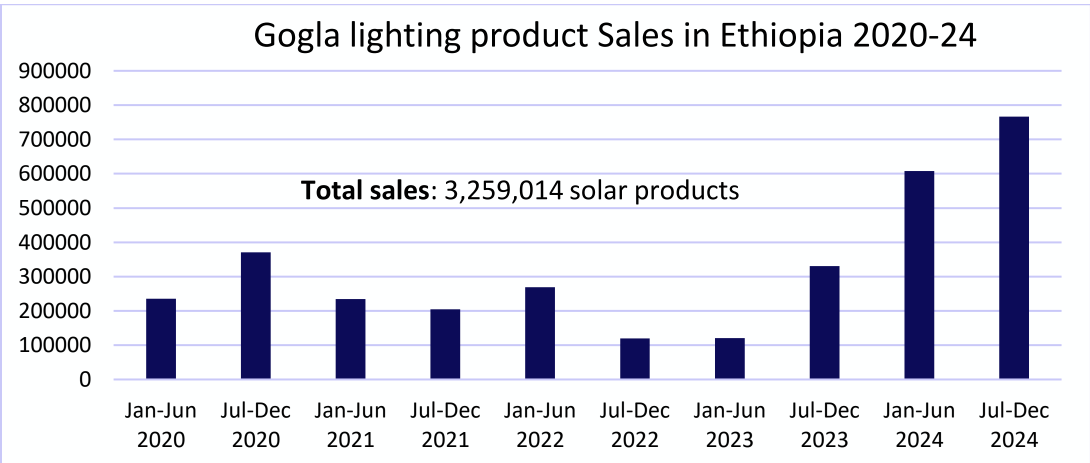


Figure 18: Solar lighting product Sales in 2020-24

Reported sales of appliances in Ethiopia are negligible. Due to too few companies reporting data, providing any other insights in this report is not possible. (Gogla 2024)

More details about solar standalone solutions are provided in next section.
The government and donor programs like the World Bank support direct sales and Pay-as-you-go (PAYGO) delivery models with incentives (tax breaks), aiming for private sector involvement and Public-Private Partnerships (PPPs) to scale up affordable & quality solutions.

The partnership between development banks (like the Development Bank of Ethiopia DBE) and private companies allowed to distribute millions of lanterns and home systems, replacing kerosene.
PAYGo sales shall allow users to pay for electricity in small, flexible instalments, making it more affordable and promoting digital financial inclusion. While the PAYG model for solar has been slow to gain traction (only 3% of sales volumes in 2021) due to a lack of a robust mobile payment ecosystem and a hampering regulation for financing and payments, the launch in 2021 of the mobile money platform Telebirr has created more potential for it. Recent policies allow non-financial institutions to issue digital payment instruments, which is key for products like PAYGO solar, and off-grid companies can also partner with registered financial institutions to manage consumer credit. Note that the PAYG model, still operating in a state of pilot mode, is also promoted to provide agricultural equipment (tractors…) to smallholder farmers (initiatives as Heifer International and HelloTractor).

Solar Water Pumps (SWPs) for drinking water supply

In Ethiopia, there are numerous isolated water utilities with off-grid diesel pumps (no single exact census figure available) which could be core in a larger mini-grid system development. There is a national potential to develop more than 20,000 new off-grid solar water supply systems and to convert over 10,000 existing diesel-powered rural pumps to solar by 2030. Under Phase II of the One WASH National Programme (UNICEF Water)), the government aims in 2023 to solarize 6,352 off-grid community water supply systems across Ethiopia.

Solar Water Pumps (SWPs) for Irrigation

Given the number of existing and potential motor pump users in Ethiopia (between 210,000 and 400,000, mostly off-grid), the scope for expanding the solar pump market for irrigation appears to be significant. Government offers duty/tax exemptions and financing access to boost the sector. So far, several business models (IWMI-CGIAR, 2018[21]) were considered to address this specific market:

(i) Individual farmers purchase solar pumps with potential support of MFIs, to increase their access to irrigation water throughout the cropping season
(ii) Agro-companies deliver solar pumps to farmers, sometimes directly or via cooperatives, often with buy-over-time or free-with-profit-sharing models.
(iii) Supplier model which facilitates access by farmers to financing from solar irrigation pump suppliers, manufacturers or importers (bundled financing using lease-to-own, PAYGo, Buy-as-you-use …).
(iv) Mini-grid model which provides electricity for both local irrigation, and domestic and commercial needs, allowing the use of standard electrical pumps and official electricity tariffs.

Between 2016 and 2025, Ethiopia successfully installed over 2,000 solar-powered irrigation systems across the Tigray, Amhara, Oromia, Central Ethiopia, and Sidama regions, with tangible gains. The IWMI Roadmap for Solar Irrigation (2018) describes how the country plans to scale these technologies and underlines that, when policies are coordinated and financial mechanisms are in place, solar irrigation could cost-effective and viable and could ensure a more resilient future (incomes & nutrition) for millions of farmers.

[21] *Business models for solar-powered irrigation in Ethiopia*

Solar solutions for other productive users

In the Demand Forecasting modeling, other high-value productive consumers are considered as grind mills, woods works, shops, or socio-economic infrastructures. Those loads are included in the typical load profile used in technical modeling (GEOSIM) for mini-grid design. For settlements with low household density, such productive consumers shall have their own standalone generators, also called Distributed Renewable Energy sources (DRE). The energy demand from MSMEs is not taken into account in off-grid modelling as most of them are located in urban or peri urban areas where the grid should be expended.

8.1.4 Off-grid gaps and barriers

Off-grid electrification for remote settlements remains, de facto, a challenge in Ethiopia due to remoteness, household dispersion, low demand, low income & low ability to pay for electricity, but also due to limited capacities of the public institutions and the private sector to implement large-scale programme. And those NEP 2.0 objectives (increasing grid-based electricity coverage from 33% to 96% by 2030 and providing electricity to the remaining population through standalone systems and mini/micro-grids) are not met so far due to several important gaps and barriers not yet overcome or fully addressed.

For instance, 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 (Get Transform, Inensus, 2021).

A specific report[22] was issued in October 2025 to analyze and to present the main gaps and barriers identified to grid and off-grid development and scale-up. The report also provides priority recommendations to address key barriers (institutional, regulatory, technical, financing) for off-grid development. (cf. “Gap and barriers" report)

The best strategy for off-grid connections is to offer flexible and sustainable technology solutions to match with specific local demand and skills; this includes mini-grids (MG) of various sizes where households are not too scattered and standalone systems (SAS) for more isolated customers. The profitability for the operator is strongly linked to the subsidy rate and the productive activities that can generate local incomes.

In NEP 2.0, it was suggested that mini-grids could be used as a bridging solution, where a mini-grid was constructed to give quick access to power, and after a few years (less than five years) the mini-grid should be connected to the national grid (Energy Outlook 2025).

Addressing grid encroachment risks is vital to improve the bankability of private off-grid investments. Private developers require legal and financial certainty and a suitable de-risking framework (asset transfer rules, interconnection procedures & arrangements, notice timelines, compensation mechanisms, Power Purchase Agreements (PPAs), …) regarding what happens when the main grid expands into their service territory.

Furthermore, given the high investment cost of mini-grids, it is crucial that, if connected to the national grid, the mini-grid network can be easily interconnected and that the expensive components of the power plant (photovoltaic panels, electronics, batteries), if not yet at the end of their lifespan, can be reused in other projects to avoid unnecessary overinvestment. This raises the critical question of design simplicity and component interchangeability.

8.1.5 Off-grid strategy and developments

[22] *“Update of the Ethiopia National Electrification Plan – Gaps and barriers”, IED/WB, 2025*

Previous and ongoing OG programmes

Since 2005 (under GTP I, II&III[23] and NEP 1 and 2), the Government of Ethiopia (GoE) has taken significant steps to expand electricity access through substantial investments in power generation, grid and off-grid solutions, and the launch of ambitious national programs. While these initiatives are noteworthy, further progress is needed to fully meet the country's growing needs. (Ascent program - WB 2025)

The development of off-grid electrification has been marked by the following major programs (also illustrated in the next table):

- **EEU**: Over the past few decades, EEU has implemented and operated around 63 isolated thermal power plants of varying capacities (100 to 500 kW) supplying isolated mini-grids. Most of them are still in operation, and half a dozen have been interconnected to the national grid.
- **UEAP** (Ethiopia Universal Electrification Program): launched in 2005 (2005-2015 – …M$) with specific objective to provide grid-based electrification to rural towns and villages and to ensure the sustainability of service delivery over time, moving away from a project-by-project approach. Implemented by EEP, then EEU, this was one of the largest and most ambitious Rural Electrification programs in Africa. Beside on-grid extensions, a thousand sites were geo-localized for mini-grids and 12 pilots were implemented.
- **ELEAP** (Ethiopia Electrification Program): supported by World Bank and launched in 2018 (2018-2026 – 645M$) with specific objective to facilitate over 1.6 million on-grid connections, 4,000 off-grid connections with 11 mini-grids, and more than 19,000 public facilities such as schools, healthcare centers, and administrative government buildings. Implemented by EEU and MoWE.
- **ADELE** (Access to Distributed Electricity and Lighting in Ethiopia Project): launched in 2021 (2021-2027 – 430M$) and built on the success & gaps of ELEAP, ADELE aims to provide electricity access to 2.7 million people (grid strengthening, hybrid mini-grids, SHS) and 1335 public institutions (SAS) by 2026 and to tackle the remaining barriers to off-grid development. Implemented by DBE, EEU and MoWE.
- **ASCENT** (Accelerating Sustainable and Clean Energy Access Transformation): launched in 2025 (2025-2030 – 424M$) and built on ELEAP & ADELE, the ASCENT programme focusses on both on-grid and off-grid electrification and aims to prioritize underserved and low-income communities and to connect nearly 6 million people with grid extension, isolated MG and SAS for Tier 1+. Implemented by EEU and MoWE. The ASCENT project activities include: (i) developing **guidelines** to ease rollout of solar home systems to poorer rural households battling affordability and liquidity issues, (ii) setting up **systems for monitoring rollout** of off-grid access, and (iii) developing and adopting **tariff guidelines** and methodology for mini-grids, which will ensure mini-grids are a more attractive investment for EEU and support the strengthening of regulatory framework for enabling **private sector participation** in mini-grid development. For remote areas where neither grid nor private sector are likely to reach in near term, ASCENT also aims to scale up public sector-led off-grid programs, including mini-grids and standalone systems.

[23] *Growth and Transformation Plans: GTP-I - 2010–2015, GTP-II - 2015-2020 (planned to reach eight (8) million customers mainly households for electricity connections by 2020), and GTP-III - 2020-2025*

- **ENDEV** (Energizing Development) – Ethiopia: since 2005, the ENDEV program, implemented by GIZ and co-financed by EU (4 periods between 2005-2025 – 52M€), has promoted solar systems and cooking stoves for various applications and beneficiaries: over 200.000 pico/SHS (with almost no subsidies), 540 SAS up to 2.4kWp for schools and health centers (100% subsidized) and 5 community-led solar mini-grids (648kWp) since 2024. In addition, ENDEV has also supported several pilot micro/mini hydro power (MHP) projects in the Sidama Zone/SNNPR. The MHP schemes use crossflow turbines with capacities from 5 to 55kW; for instance, 7 kW (Gobecho I), 30 kW (Gobecho II), 33 kW (Ererte), 55 kW (Hagara Sodicha), 10 kW (Kersa) and 20 kW (watermill upgraded in Leku - Jimma Zone/Oromia). In addition, there are several pico and micro hydro schemes (about 32 cross flow turbines) which power flower mills with output from 5 to 32 kW. But 30-40 % of the plants are not operational due to lack of water (in dry season), management as well as technical problems. (Source: Belay Kassa, A., 2019).
- **DREAM** (Distributed Renewable Energy–Agriculture Modalities): launched in 2022 (20,6M$), DREAM initiative is an innovative business model to pilot mini-grids with agricultural anchor loads. It targets smallholder farmers (over 2500 connections in its initial phase) and integrates MGs with agricultural infrastructures to power irrigation systems as an anchor load and Productive uses activities and Household connections. 9 MGs (over 4 MWp) in 4 regions (Amhara, Oromia, Sidama and Southern Ethiopia) will be implemented by 3 private mini grid developers (~10% equity) whereas the 40% grant from GEAPP and 50% from AfDB as concessional loan. The project envisions that by 2030, over 100 MGs will provide or expand access to electricity for more than 290,000 people and reduce greenhouse gas emissions by 200,000 tons. The project is jointly implemented by the Agricultural Transformation Institute (ATI) and SNV. ATI leads the development of irrigation infrastructure, while SNV is responsible for the power development component. The Ministry of Water and Energy (MoWE) serves as the sector lead, provides overall government oversight, including coordination of stakeholders.
- **EWAS (**Energizing Women in Agri-value chain Systems) was launched by **GEAPP** (Global Energy Alliance for People and Planet) in 2024 that includes an RBF Productive Use Financing Facility (**PUFF**) for equipment: an $11m program in Ethiopia with various implementation partner as well and $6m PUFF facility. The Agri-value chain focusses on coffee processing, cold storage, grain milling, apiculture, poultry, horticulture, and agro-processing hubs.
- **ENTER Energy Ethiopia** initiative: Launched in 2022 by Mercy Corps, the ENTER initiative is their flagship energy program pioneering an approach that is fostering public-private partnerships to provide access to sustainable energy in communities affected by displacement. In Ethiopia, Mercy Corps cofounded Humanitarian Energy PLC with Rensys Engineering and Trading, a private Ethiopian company that provides renewable energy solutions for underserved communities. Since 2024, Humanitarian Energy is operating the country's first commercially licensed private solar PV-powered mini-grid (254kWp) serving the refugee community of Sheder camp in Jijiga, Somali region (~1000 connected households and ~300 businesses). Electrification of 3 other refugee camps (Melkadida, Kobe, Hilaweyn) is also under investigation.

Note: more detailed descriptions of on-grid and off-grid electrification programmes in Ethiopia are provided in the "Gaps and Barriers" report, IED - 2025.

The below table summarizes the current status of off-grid infrastructures in Ethiopia electrified by REF or Ministries, including a hundred of mini-grids, around 10 million standalone solar systems and almost 2500 public infrastructures (health, education). EEU still operates a number of isolated diesel generation distribution systems, mostly in the Somali region. Only few have been connected to the grid; other are candidate for hydro or solar conversion.

Table 30: Current status of off-grid infrastructures in Ethiopia

OG infrastructure	Capacity range	Existing	Operational	Planned
Thermal plant	100-520 kW ?	63	?	-
Hydro plant	7-58 kW	7	2?	0?
Solar plant	75-2000 kWp	40	?	202? (240)
Solar MG & irrigation	?	0 116	0	200
Wind plant	1 kW	6	?	0?
Biomass gasifier	MW?	1?	-	-
Geothermal plant	-	-	-	-
SHS/SLS	0.02-0.2 kWp	10,550,000	?	750,000
SCS	1-10 kWp	2491 (2018)	?	1307

Key Off-Grid stakeholders

Some key stakeholders involved in off-grid electrification in Ethiopia include:

- **Government** (Ministry of Water & Energy MoWE, regional energy bureaus, PEA …),
- **Development Partners** (World Bank, UNDP, GIZ, EU, AfDB),
- **Private Sector** (OG solar companies, MSMEs, banks, investors),
- **Utilities** (Ethiopian Electric Utility - EEU),
- **Cooperatives** and **Industry Associations** (GOGLA, ESEDA).
- **Financial Institutions** (DBE, MFIs, commercial banks),
- **Communities** (households, farmers, schools, clinics),

These groups collaborate on policy, financing, implementation, and service delivery to expand clean energy access, especially in rural areas, focusing on households, businesses, and public services like health and education.

NES Off-Grid strategy

The 2024 off-grid sector reform focused on accelerating electricity access by addressing specific barriers through the NEP 2.0, which is being updated to NEP 3.0, and initiatives like the World Bank's ASCENT program. To reach universal access by 2035, the government shall continue implementing supportive policies, streamlined regulatory framework and broader economic reforms to attract private sector investment to complement public sector investment (dual approach).
On average, 3.1 million connections annually are required to reach universal access by 2035. Therefore, there is a need to further accelerate electricity expansion, particularly in off-grid rural areas where the

grid will not reach before 2030. New least-cost approaches are needed to accelerate the delivery of electricity access for Tier 1 and above consumers. (source: ASCENT PID 2025)

The updated strategy NEP 3.0 for off-grid electrification includes various technologies and resources available in rural areas and will rely mainly on:

1. Mini-grids and micro-grids powered by renewable resources such as PV, hydro, wind…
2. Standalone systems (for both domestic and non-domestic uses).

Financial modalities will also be reviewed in order to make off grid solutions more affordable and attractive for rural households. For instance, digital payments (mobile payments) are also a key enabler of PAYGo technology to leverage on electrification access.

The Off-Grid strategy must learn on past and on-going experiences and programmes in Ethiopia as listed on the below table.

Table 31: List of major off-grid programs implemented in Ethiopia

Programme name	Project period	OG Techno	Production source	Owner	Developer	Operator	# syst	Tot RE capacity	Business model	Status	Project CAPEX	Financing	Site names	Connexions	Details
		MG	Thermal OG	EEU	EEU	EEU	31			Existing					100-520kW
		MG	Thermal OG	EEU	EEU	EEU	62								62 in XL database + GIS ID
		MG	Thermal OG	EEU	EEU	EEU	5			Interco.					Now interconnected
UEAP	2005-2015	MG	Solar	MoWE	EEP/EEU	4 PSC?	12	3525 kWp	?	implemented / in operation?	ELEAP: 645M$	WB ...	Omorate, Qorile, Mino, Beltu, Ungoge, Kusrewad, Behima, Benbaho, Tumare (Tum), Wasel, Arae, Albasa), +Gulehamur? (Cf. list & details in XL database)	3977 CX achieved (11 MG)?	Hybrid (75-2000kWp + GE) awared to 4 PSC (pilot phase)
ELEAP	2018-2026	MG	Solar	MoWE	EEU	PSC ?	25+3 new		?	Tendering 2019 ?		WB ...	Cf. list & details in XL database		EEU & ADB; Hybrid
		SCS	Solar PV				19000								
ADELE - Comp. 2	2021 - 2027	MG	Solar hybrid	MoWE	EEU	EEU, PS, Coop, ...	240?		EEU-operated MG (EPC) PS-led MG (compet. Bidding)	Tendering?	265 M$	WB/IDA			MG Target=240.000CX + 11500 SMEs; GIS preidentified sites; 75-2000kWp/MG
ADELE - Comp. 3		SHS	Solar PV	MoWE	DBE/MoWE	?	750,000 HH		PS-led	Tendering?	65 M$	WB/IDA			> Tier 1; IEC/VeraSol certified
		SCS	Solar PV	MoWE	?	?	1307 SCS			Tendering?					PV systems for PS, SS, HC
ASCENT	2025-2030	MG	Solar hybrid	MoWE	EEU						424M$				
		SHS	Solar PV	MoWE											
DREAM	2022-2027	MG	Solar MG		3 PS	PS	9	4MWp	pilot minigrids with agricultural anchor loads	Construction phase	20,6	GEAPP, AfDB, EIB	Amhara, Oromia, Sidama and SNNP		Target smallholder farmers and power for irrigation, cold storage, and food processing
ENDEV (ACEA)	2005-2025	MG/µG	Solar	?	GIZ	Coop	5	648kWp	?	?	?	Multi-donors (EU ...)			GIZ mini-grid programme?
		MG	Hydro OG	?	GIZ	Coop	5	?		2 operational (2020)		Multi-donors (EU ...)	Ererte, Gobecho I & II, Hagere-Sodicha, Leku Migira		ENDEV/GIZ ; + GIS ID
		SHS/SL	Solar PV		GIZ		>200.000		pico & SHS + 0% subsidy			Multi-donors (EU ...)			
		SCS	Solar PV		GIZ		540		100% subsidy			Multi-donors (EU ...)			
ENTER Energy Initiative	2022-...	MG	Solar hybrid?	PEA?	Mercy Corp	PS (HumEn PLC)	1	254kWp	Commercial MG license	1 in operation (2022); 3 planned/tender?	2,6 M$	?	**Sheder** Refugee Camp (14600 people)	1000 HH + 300 SMEs	3 planned in Melkadida, Kobe, Hilaweyn
?	2017	MG	Hydro OG			?	2	?	?	Existing		Korean ICA?			UEAP & Korean ICA, 2017
?	?	MG	Wind OG	?	?	PSC (Ethio Resource Group)	6	6x 1kW	?	Licensed 2019		?			1kW each, Ethio Resource Group
?	?	MG	Biomass OG	?	?	?	?		?			?			
?	?	MG	Geothermal OG	?	?	?	?		?			?			

8.2 Ethiopian off-grid energy demand

8.2.1 Off-grid perimeter

According to the **National Energy GIS database**, about 16,000 localities, out of the total 25,650 settlements recorded in Ethiopia, are non-electrified yet, from which about 10,000 are targeted by grid extension/intensification/densification. Thus, the **off-grid perimeter** can be defined as the rural area covering the remaining **5,786 localities** (22% of the total) non-electrified and non-targeted by grid extensions by 2030.

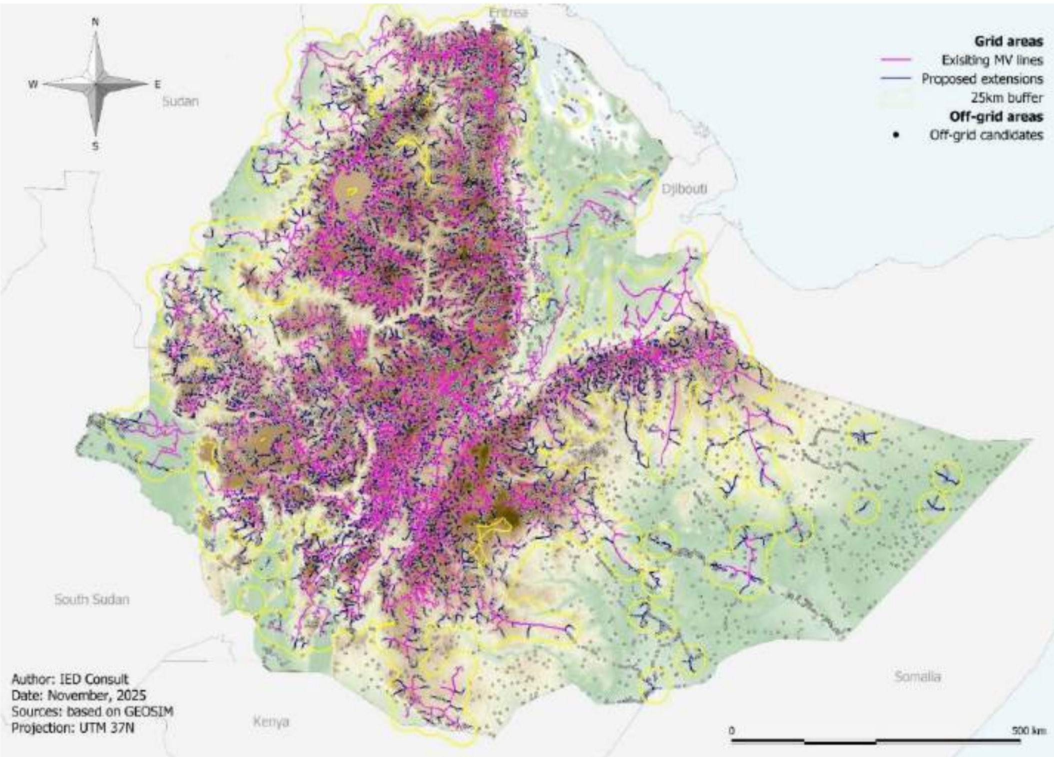
The below breakdown table highlights that 75% of those off-grid villages are located between 2.5 and 25km from the existing MV lines, and only 1,448 localities (25%) are located beyond the 25km buffer. The off-grid localities inside the 2.5-25 km buffer are actually characterized by a "low density" of households (less than 20 households per km²) where it is not cost-effective to extend the grid or even to plan mini-grids.

In terms of households, about 1.9 million households (18% of the total) are non-electrified and non-targeted by grid extensions. And most of them (89%) are located inside the 2.5-25 km buffer.

Table 32: Breakdown of grid and off-grid settlements In Ethiopia

<table>
<tr><td rowspan="5">Non-electrified localities: 16,053
>10,000,000 HH</td><td rowspan="2">Off-Grid localities: 5,786 (21.7%)
1,869,000 HH (18%)</td><td>2.5-25km (d<20): 4,338 (75%)
1,660,000 HH (89%)</td></tr>
<tr><td>>25km: 1,448 (25%)
209,000 HH (11%)</td></tr>
<tr><td rowspan="3">On-Grid localities: 10,267 (78.3%)</td><td>Densification: 2,265</td></tr>
<tr><td>Intensification: 2,734</td></tr>
<tr><td>Extension: 5,268</td></tr>
</table>

The below map illustrates candidate off-grid localities, either inside the 25km buffer (yellow line) or outside.



Map 9: Map with the candidate off-grid localities

8.2.2 Typology of rural settlements

Rural settlements in Ethiopia, as in many other sub-Saharan countries, are characterized by a wide range of typology and a wide variety of demand profiles, depending on various factors: economical, socio-cultural, geographical, climatical, environmental, political, etc. One traditionally finds:

Table 33: Typology of rural settlements

Agricultural practices	Geographical location	Settlement structure
Mix-farming (plow-cultivation, cattle rearing) areas	Northern highlands (Amhara, Tigray, Oromia)	Nucleated or dispersed rural villages
Enset-based (false banana) cultivation areas	Southern/Southwest (Central Ethiopia, SNNPR, Sidama)	Sedentary and dispersed settlements
Pastoral areas	Eastern/Northeast lowland	mobile or semi-mobile, temporary settlements
	Emerging Regions (Benishangul-Gumuz, Gambela)	High variability, lower population density, and, in some cases, rapidly changing settlement patterns

These settlements are further categorized by accessibility, with remote areas having lower access to services.

This section provides a geospatial analysis of non-electrified localities in 2025 in Ethiopia and not targeted by the grid extension under NEP 3.0.

The distance to the grid, the village sizes and the household density are the main parameters to categorize the rural settlements candidate to rural electrification.

The next table illustrates the breakdown of localities per village sizes (small-medium-large) and per household density (low-medium-high), based on **National Energy GIS database**. Out of **5,786** non-electrified localities:

- 85% have low density of households (< 20 households per km² or < 100 people per km²)
- 25% only have medium or high density (> 20 households/km²)

These thresholds of household density and village size can be used to define the adequate electrification solutions for each category. Green cells correspond to SHS ideally for localities with low households density, while pink and gold cells target µG and MG where households density are higher. In addition, the table highlights that 75% of the settlements are located at less than 25km from the existing MV network.

Table 34: Breakdown of off-grid settlements In Ethiopia

Non-electrified localities per size and density			Household density			
			Low	Medium	High	%
Size	Population	Households	<20 *<100*	20-100 *100-500*	>100 *>500*	hh/km² *pop/km²*
Small	<1000	<200	2,883	463	9	58.0%
Medium	1000-5000	200-1000	1,668	278	4	33.7%
Large	>5000	>1000	378	102	1	8.3%
			4,929	**843**	**14**	**5,786**
			85.2%	14.6%	0.2%	100 %
Distance from MV lines			**<20**	**20-100**	**>100**	**hh/km²**
< 2.5km			4,074	260	4	75.0%
> 25km			1,307	130	11	25.0%

8.2.3 Energy demand and MTF service levels

Based on the **Multi-Tier Framework (MTF)** definition already introduced above, the six energy access levels (Tier 0 to Tier 5) can be characterized by their load capacity, their daily consumption and the service availability/reliability, as summarized in the next table.
For instance, **Tier 1** usually concerns very low-income households with basic appliances (usually one light, one radio and one phone charger) and very low loads (3 to 49W). They can be supplied by all types of technology solutions: solar lanterns (SL) or rechargeable batteries (RB), solar lighting systems (SLS), mini-grid (MG) or grid (G) connections. On the opposite side, **Tier 5** refers to high-income households having large range of appliances with cumulated loads higher than 2kW and high availability/reliability service. They are typically grid or mini-grid customers. In addition, a **Tier 0** level groups together the households without any access (only candles and dry cells) or with less than 4 hours/day of power or less than 3 watts load capacity.

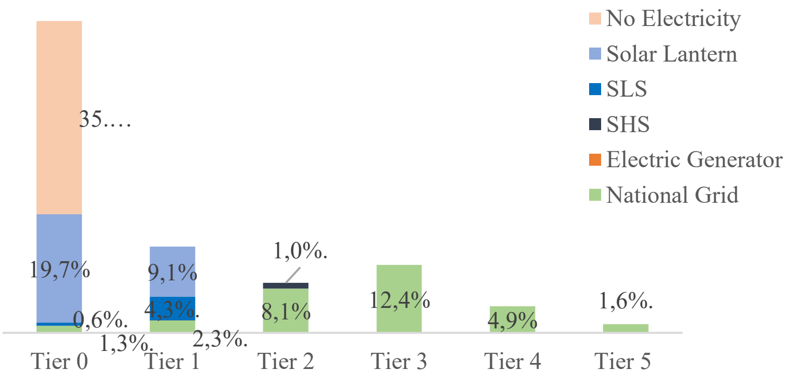
Table 35: Extract from MTF – Electricity Tier Matrix

Tier	1 to 5	1	2	3	4	5
Min HH power capacity	W	>3	>50	>200	>800	>2000
Min daily HH consumption	kWh/d	> 0.012	>0.2	>1	>3.4	>8.2
Min service (day availability)	h/d	>4	>4	>8	>16	>23
Reliability (disruptions/week)	#/week			>14	4-14	<3
Energy supply options		RB, SL, SLS	SHS, SCS	SCS, µG, MG	MG	G
Typical services		1LP (+ radio and/or phone charging)	> 2LP + televisions, irons, microwaves, or refrigerators		> 2LP + specific appliances	

Comparing the MTF survey conducted nationwide in 2018, and the survey updated in 2025, the aggregate electricity Tier distribution hasn't much changed.

- The Tier 0 fraction moved from 55.7% (2018) to 55.3% (2025) and the share of households with 'no electricity' reduced from 43% to 35%. Thus, about half of households are still in Tier 0 with very basic electricity sources (dry batteries or lanterns) or with no electricity.
- Only Tier 1 and Tier 2 fractions have increased, from 16% to 25%. Only 44.7% of households are still in "Tier 1 or above" for access to electricity, compared to 44.3% in 2018. Levels 3-4-5 have decreased.
- Only 1% of the households have an off-grid Tier 2 or above connection (by SHS).

Figure 19: MTF - Aggregate Electricity Tier distribution, by technology



Sources: MTF, Energy Access Survey report, Ethiopia, 2025

For access to electricity in 2025, most households that use standalone **off-grid solutions** (SHS, SL/SLS, RB) are in Tiers 0 and 1 (Tier 2 with SHS), while most grid-connected households are in Tiers 2–5, with the largest share in Tier 3. Most households in Tier 0 having access to electricity use a solar lantern and few a solar lighting system, that does not provide the minimum level of service needed for the household to reach Tier 1.

The new fact is that the total number of households using a SHS decreased from 4.5% to 1% in 2025 and this exclusively in Tier 2. Thus, all new SHS solutions offer more than 4 hours of supply a day. And the majority of SL/SLS users are able to power only very low–load appliances such as lighting and a radio and do not qualify for Tier 2 access.

About 14% of households with an off-grid solar solution as their primary source of electricity are considered to have 'access to electricity' (i.e. Tier 1 and above) under the MTF approach. As in 2018, the objective is to move off-grid households from level 0 to level 1 and above.

The distribution of households according to the types of national access was presented for each of the two scenarios developed under NEP 3.0.

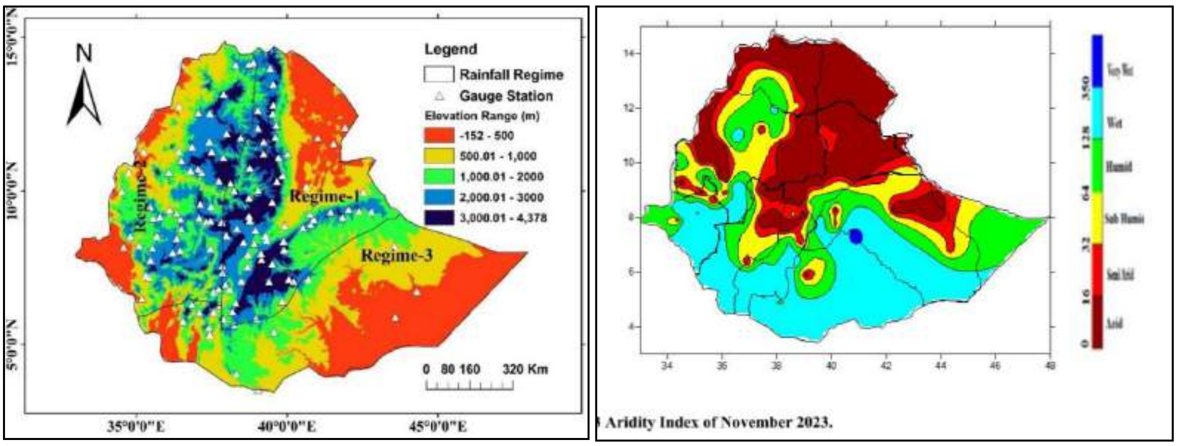
8.3 Renewable energy potential

Ethiopia is estimated to have a very largely untapped renewable energy potential (exploitable) of over 60,000 MW, with 45,000 MW from hydro, 10,000 MW wind, 5,000 MW geothermal, and high solar capacity (4,5-7,5kWh/m²/d), without accounting biomass potential (Aklilu, 2024). This offers enormous potential for the development of large-scale and grid-tied power plants. Today, Ethiopia generates most of its electricity from hydropower (>90%), supplemented by wind, geothermal, and solar energy.
The renewable potential for **off-grid applications** is also considerable, with a preference for **hydroelectric, solar and wind power** or a combination of several sources (hybrid). The use of biomass or geothermal energy for power generation is less suitable for off-grid applications due to the limited off-grid demand and the lack of small-scale energy production technologies (below 2 MW). This is particularly the case for geothermal energy, which is excluded from the potential assessment.
The challenge is to geographically match renewable energy resources with the needs of isolated rural settlements.

8.3.1 Hydro potential

Ethiopia, also known as "the water tower of East Africa", has rich water resource with many rivers and lakes. Ethiopia is also known for its massive use of hydroelectric resources for large power plants with more than 4 GW cumulated & installed since the 1950's.
In the center of the country, there are mountains and a plateau, with the altitude gradually decreasing around them. It is precisely this high terrain near the equator that explains the heavy rainfall in the region; this rainwater rises towards the lower-lying areas through surface runoff and underground infiltration. Hydrology is directly linked to rainfall patterns.

Ethiopia's rainfall regime is highly complex, largely shaped by topography and the seasonal migration of the Intertropical Convergence Zone (ITCZ). The major rainy season is **Kiremt** (June - September), the light rain is **Belg** (February/March - May), and the dry season is **Bega** (October - January/ February). The next left-handed map illustrates the three main regimes: **uni-modal** (one wet season, June-September) in the west, **bimodal** (two wet seasons: *Belg* in March-May, *Kiremt* in June-September) in the central/eastern highlands, and a different bimodal pattern in the south/southeast.
The right-handed map illustrates the aridity level in Ethiopia.



Map 10: Maps of rainfall regimes and aridity index

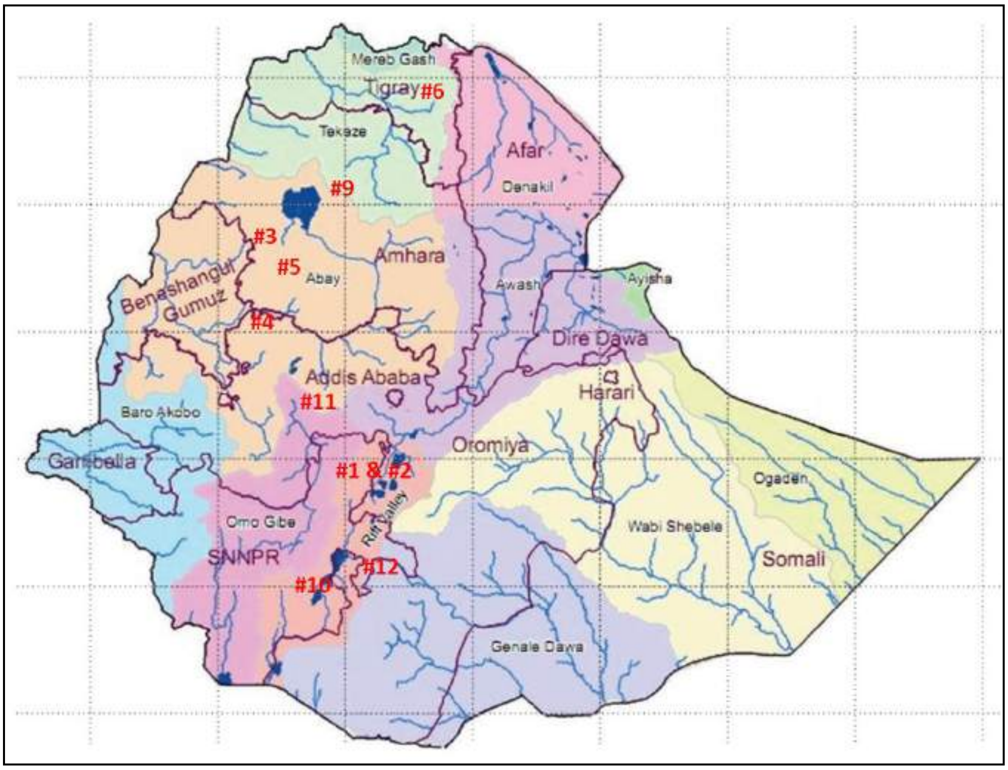
However, hydropower resource is less reliable as droughts to drought & floods intensify over the last decade. The global models predict more average rain in the wet areas, and also larger variation from year to year. To manage the vulnerability of hydropower to drought to drought & floods, Ethiopia is accelerating its transition to alternative sources, which complements existing hydro sources.

For off-grid use of hydro potential, we will limit our assessment to identifying waterfall heights and river flow rates close to demand centers that can produce between a few tens and a few hundred kW (max 5 MW). This **small hydro potential** is estimated at about 10% of its total hydropower capacity, with the most potential in western and southwestern regions.

Unfortunately, there isn't any **national atlas of the hydrological resource** in Ethiopia, nor a national database of potential sites for small, mini and micro hydropower (SHP) [24]. This assessment of the potential for small-scale hydropower is based on a number of previous studies (see Table 35) that have estimated the potential of specific rivers or catchment basins in Ethiopia. The review is therefore not exhaustive and may mainly cover the most suitable areas.

Note: This macro assessment of small hydro potential is a preliminary step and does not replace the need to conduct detailed field investigations to confirm the geological and hydrological characteristics of the sites, their accessibility and their suitability to the surrounding energy demand, bearing also in mind the severe droughts that have afflicted the country over the last decade.
The Consultant neither made use of a software generated hydro potentials assessment like for the NEP 2.0 because such approach could only be used to initiate a SHP atlas pre-identifying relevant aeras but cannot really be used for planning mini-grids which require much more details (Installed capacity, guaranteed power, annual energy…)

The map below shows the location of the main hydrological basins, and the reference number (#XX) of some key studies considered.



Map 11: Main hydrological basins in Ethiopia & study reference numbers

[24] The following terminology is used here in the report: Micro (5 -100kW); Mini (100 - 1000kW); Small (1 – 10 MW)

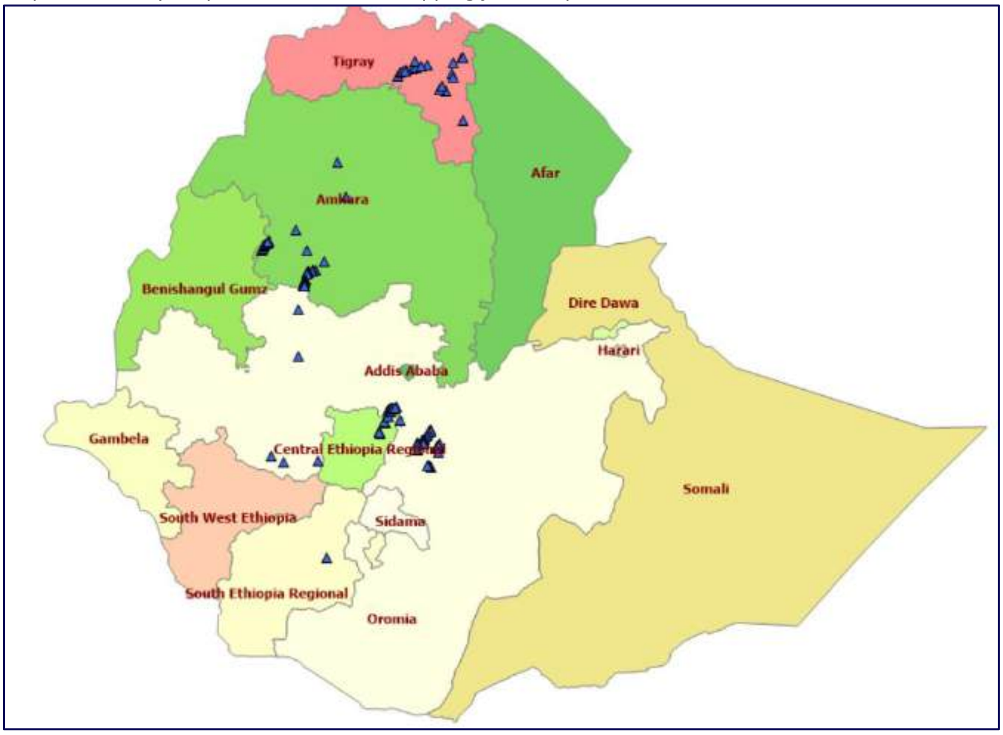
A list of 145 potential hydropower sites identified from 10 available studies (2014-2023) has been established with elementary data as geographical coordinates, design capacity (10kW to 10MW), annual production (in kWh/yr). This list could have been supplemented by other studies and other potential hydropower sites, but unfortunately, they lack essential data such as geolocation or installed capacity.

Table 36: List of some key studies considered for the hydro potential assessment

# ref.	Study sources	Year	River	Region	# sites	GIS data	Hydro data
#1	SHP sites in Ketar sub basin, Thesis, Wegene Talelign	2016	Ketar / Katar	SNNP/Oromia	30	Yes	Yes
#2	SHP sites in Meki sub basin, Thesis, Wegene Talelign	2016	Meki	SNNP/Oromia	19	Yes	Yes
#3	Assessment of SHP Site & GIS, Dura Watershed in Abay Basin, Thesis, A. Ali	2023	Dura	Ahmara	11	Yes	Yes
#4	Technical feasibility assessment of mini-hydropower development at selected sites in the Highlands, CGIAR/CIAT	2022	-	Ahmara & Oromia	15	Yes	Yes
#5	Hydropower potential, the case of Birr watershed, Abay bassin	2023	Birr watershed	Ahmara	19	Yes	Yes
#6	Feasibility study of SHP in Giba and Worie subbasins of Tekeze river	2014	Giba & Worie	Tigray & Ahmara	20	Yes	Yes
#9	Tindwat river_ Gunde Teklehaymanote Micro-hydropower	2020	Tindwat	Ahmara (C. Gondar)	1	Yes	Yes
#10	Techno-Economic Feasibility of Small Scale Hydropower, Kulfo river	2016	Kulfo	Southern (Gamo)	1	Yes	Yes
#11	Feasibility_Study_MHP-PV-Diesel_Indris river_Thesis by Bekele	2017	Indris	Oromia (W Shewa)	1	Yes	Yes
#12	Identification of small-scale hydropower potential sites using GIS and hydrologic modeling technique: Awata river, Genale Dawa basin, Ethiopia	2023	Awata	Oromia	28	Yes	Yes

From the above studies, sites' information were extracted so as to build a first database for SHP in Ethiopia. However, provided data were not detailed enough within few reports to characterize the potentials for few sites and they could not be integrated in the Hydro potential database for further investigation during the off-grid analysis. The below map shows the distribution of the 110 hydro potentials which will be studied as part of the NEP.

Map 12: Small hydro power assessment mapping for Ethiopia



In the end, mini-hydro potential is not yet fully mapped, leading to an over-reliance on solar even in areas where hydro could be more cost-effective.

8.3.2 Solar potential

Ethiopia has ample **solar energy** potential and is one of the African countries with the highest solar potential, with an average total daily solar radiation of 5.5-7 kWh/m²/day (2000-2500kWh/m²/year), largely untapped.

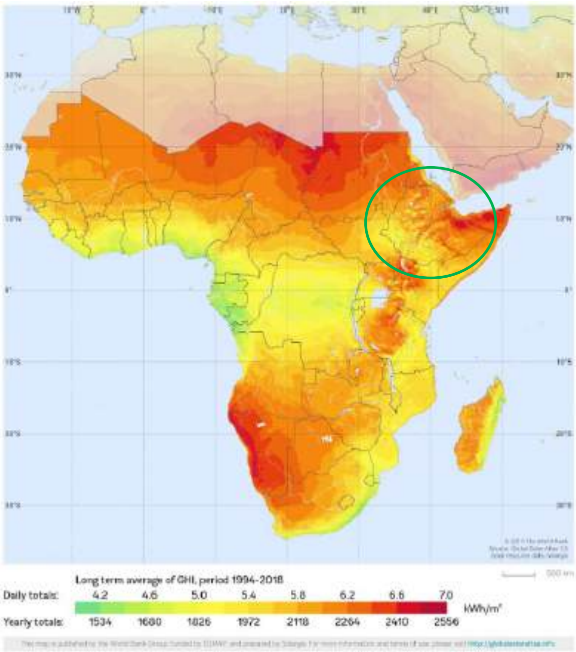
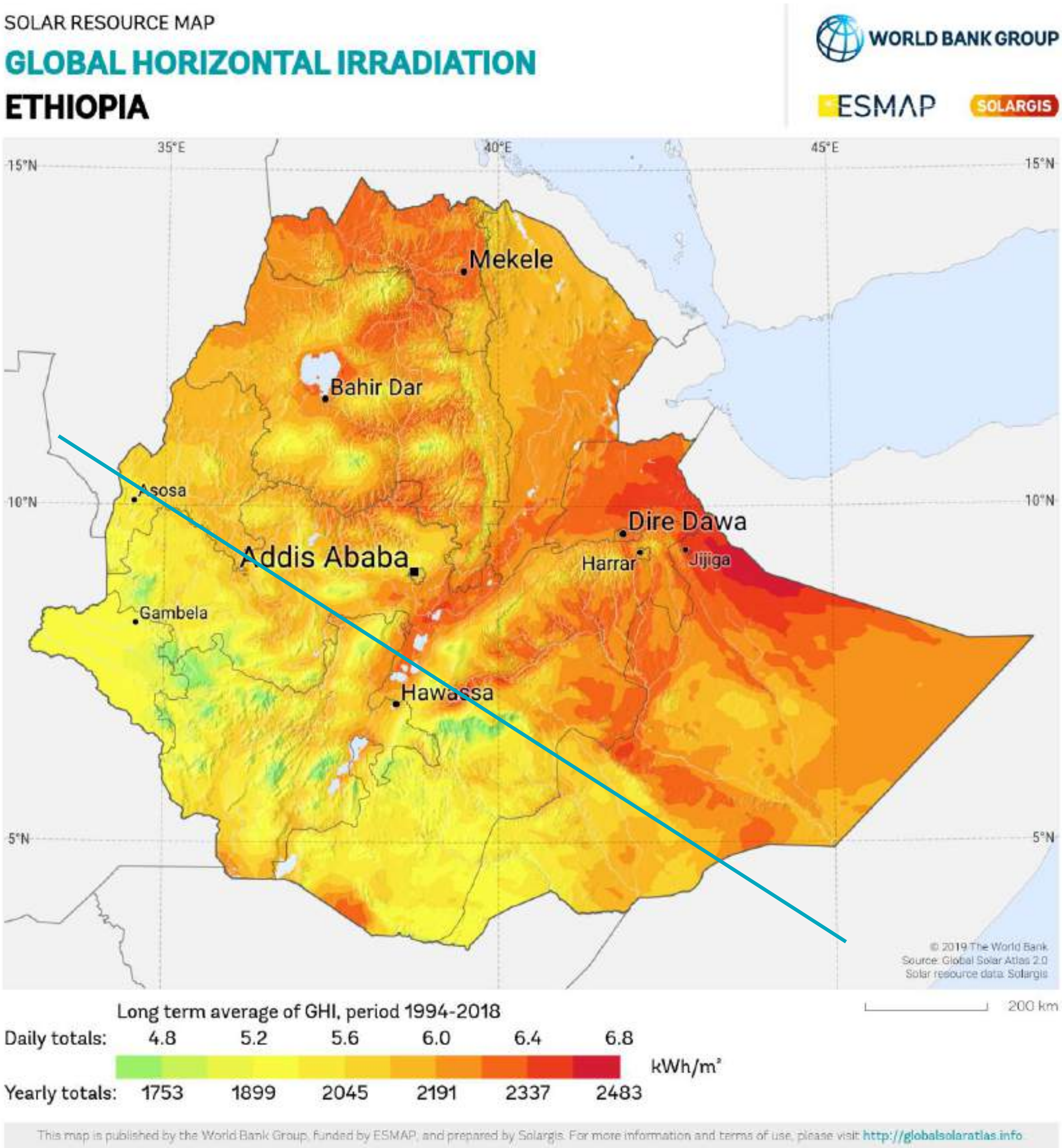


Figure 20: Solar potential in Africa (GHI 2019-2024, Global Solar Atlas)

To assess the solar potential for power generation in off-grid areas, the Consultant uses the Global Solar Atlas mapping, established by WB/IFC, ESMAP & Solargis (France). The below map illustrates the global irradiation on a horizontal plane (GHI) and shows that more than 2/3 of the country benefit of more than 2000kWh/m²/year (5.5 hours/day).

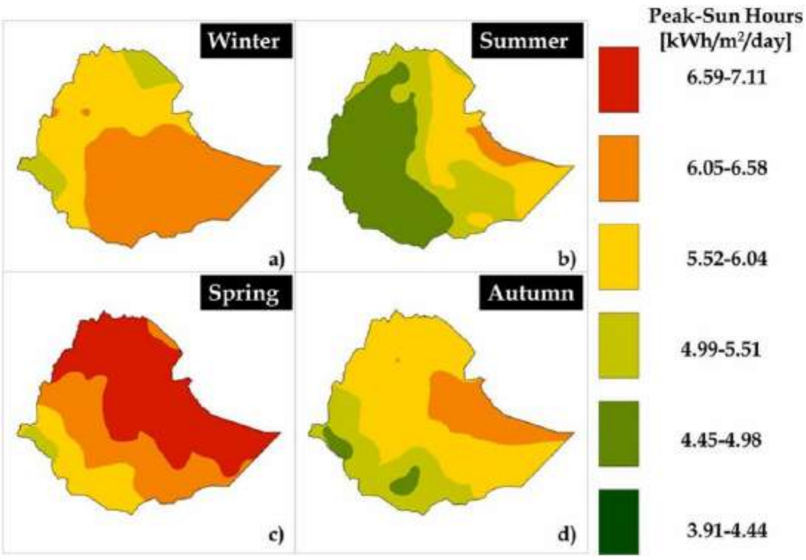
The Atlas also provides Global Irradiation for Optimally Tilted Surfaces (GTI) potential (kWh/kWp) which will be used in order to assess the solar resource for PV powerplants identified within the Ethiopian territory.



Map 13: Daily Solar Irradiation (SOLARGIS/ESMAP - http://globalsolaratlas.info/)

However, the solar irradiation varies seasonally due to cloud cover and rainfall patterns. Peak solar intensity occurs during the dry or light rain season, particularly from September to May, while the lowest radiation is recorded during "Summer", the rainy season from June to August, as illustrated by the 4 seasonal maps below.

Solar Powerplants sizing may therefore integrate energy storage to address this issue including diesel genset backup when relevant.



Map 14: Daily peak sun hours (PSH in kWh/m²/day) over the year (Assaye Gedifew, 2025)

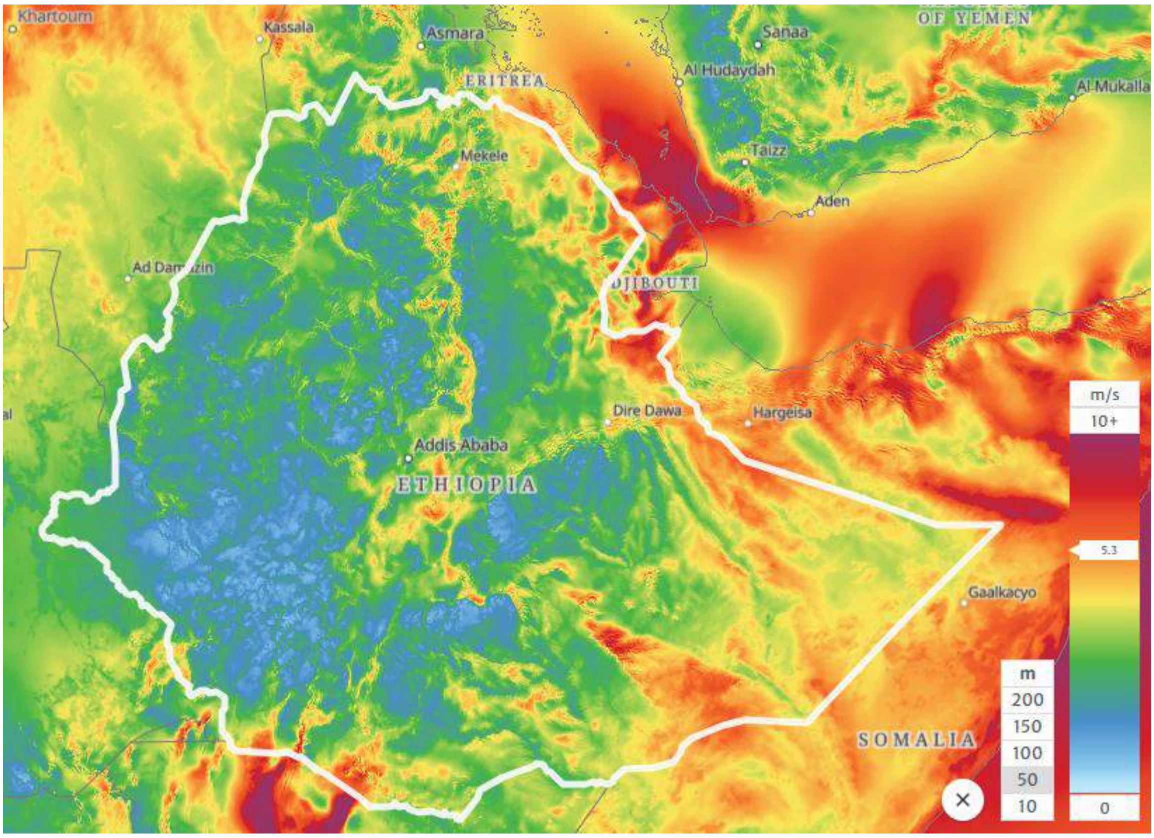
8.3.3 Wind potential

Despite being located along the Equator line and having limited wind potential, Ethiopia has some promising windy areas described later. The exploitable wind energy potential is highly variable depending on the sources, starting from 10GW (Aklilu, 2024).

Currently, 7 large wind farms (Ashegoda I+II, Adama I+II, Aysha I+II, Assela) have been completed and connected to the grid with 665 MW total installed capacities. This will make wind power a crucial ingredient of the grid energy mix by improving the reliability of the system even in dry seasons (seasonal complementarity between wind and hydro).
However, there are very few off-grid projects using mini or micro wind turbines. Only 6 micro-wind turbines (of 0.9-1kW each), licensed in 2019 to Ethio Resource Group, have been identified but no details could be found so far. In this off-grid section, we consider the following categories of wind turbines: Micro (5 -100kW), Mini (100 – 1000 kW) and Small (1 – 10 MW).

To assess the potential for wind power generation in **off-grid areas**, we will use the Global Wind Atlas, established by WB/IFC, ESMAP & DTU Wind (Denmark), and based initially on simulations done in 2016 @ 10m, 50m, 100m (Ethiopia Wind Mapping Mesoscale Modeling Report, WB/3E, 2016), further detailed and complemented by measurements from 17 wind stations. Micro and mini turbines for off-grid have usually a pole height of 30-50m.

The below map illustrates the main regions in reddish color where the wind speeds are higher than 5m/s @ 50m: (i) alongside the main East African rift valley, (ii) the North-Eastern escarpment of the country near Tigray regional state and (iii) the Eastern part of the country.



Map 15: Wind speed potential @ 50m (ESMAP - https://globalwindatlas.info/)

Regarding seasonal variation, wind power generation is typically lower from May to September, during the rainy season, compared to the other. From October to April (the "dry" months), there is a steady trend, with December typically having the highest peak in most years.
However, even with such variable resources, wind energy is seen as a promising addition to hydropower because they complement each other well. The power generation from wind is typically lower during the rainy season, while the hydropower potential is higher. For instance, the next chart illustrates this monthly variation of the production at Adama I wind farm.

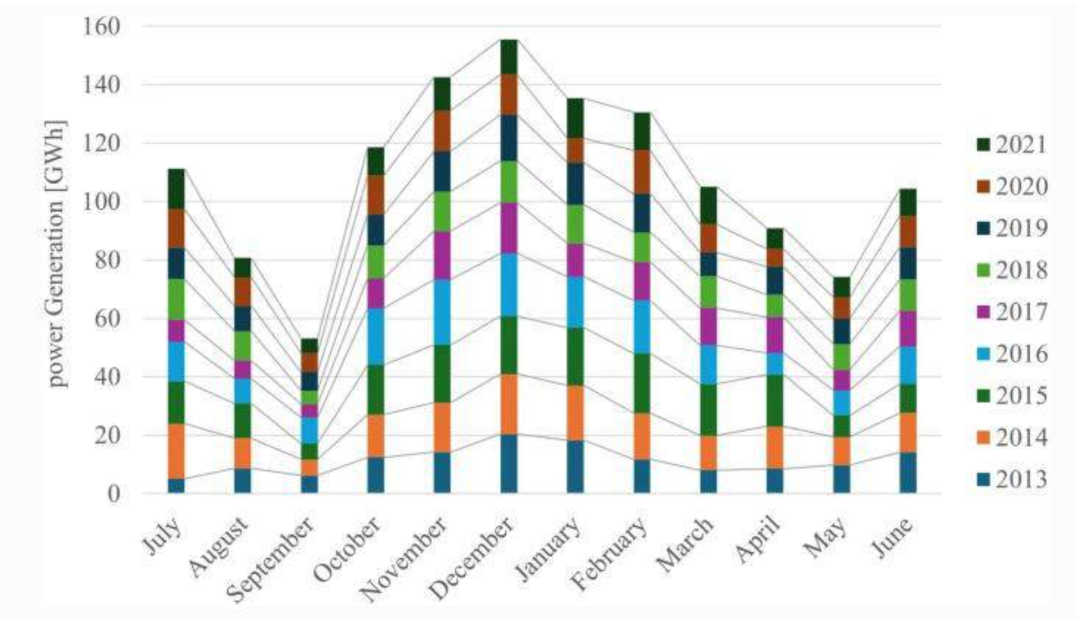


Figure 21: Monthly power generation from Adama I wind farm (source: EEP data)

In the case of rural electrification, the wind potential strongly depends on site's characteristics, and are particularly sensitive to local environment: relief, land cover (and its shear coefficient). This feature makes the identification of wind projects difficult to planned without any preliminary field visits. Consequently, this option will hardly be integrated for such high-level national planning.

8.3.4 Biomass potential

Ethiopia possesses a massive, largely untapped biomass energy potential estimated at 750 PJ[25] annually (210,000 GWh), with the capacity to generate up to 70,000 GWh of electricity yearly. Key sources include forest residues (46.5%), agricultural crop residues (34% - maize, sorghum, teff), and livestock manure/waste (18.8%), providing a major opportunity to bolster rural electrification and diversify the national energy mix.

Until now, the national efforts have focused on promoting in rural areas modern domestic digesters and alternative cooking solutions using biogas from livestock farming and substantial agricultural production, in order to replace the traditional, inefficient and unhealthy reliance on raw biomass. It is reported there are currently 46,000 biogas digesters.

Since 2013, biomass is also used in large-scale biomass power plants currently producing electricity from bagasse in sugar factory and from dry waste for municipality: about 10 plants are existing or under construction, cumulating 500MW capacity. More generating units are expected to be integrated into the energy mix. In addition, the production of ethanol is carried out in 2 sugar factories and mainly used for E5/E10 fuel blending to reduce imports and for clean household cooking stoves. (Hailu, 2020)
To produce **off-grid electricity** for small isolated sites using biomass, three technologies are possible depending on the available biomass resource (dry or wet) and the project scale:
(1) Gasification of wood or dry residues to produce syngas;
(2) Micro-cogeneration via a boiler equipped with a Stirling engine or a micro-turbine to produce heat and electricity;
(3) Anaerobic digestion of wet organic waste (manure, food scraps) to produce biogas.

The Gasification is the most efficient and suitable for small, isolated rural site electrification. A gasifier transforms solid biomass (wood, corn cobs, rice husks, sugar bagasse, etc.) into a combustible gas called syngas, which then powers a conventional thermal engine (modified genset type) coupled to an alternator. Those compact units generally cover needs ranging from 10 kW to 100 kW and ensure relatively stable and controllable production.
However, to our knowledge, no pilot experiments have been conducted on the use of biomass for off-grid electricity production in Ethiopia, and few specific assessments (e.g. Amsalu Tolessa, 2023) of the solid biomass potential (stalk, straw, husk, peelings, shell, pod, pruning, leaves, and so on) have been conducted for future gasification development.
The main challenges for this technology lie in the quality of the raw material (moisture content), its availability (seasonality), and logistics (storage and transport).

The lack of trained and experienced operators and the absence of any biomass resource assessment which could quantify and locate residues availability make the technology uncertain and difficult to analyze for the such planning exercise.

[25] PJ: Peta Joule = 10^{15} Joule

8.4 Off-grid technology solutions

This section provides a review of the existing RE-based solutions to match the specific rural off-grid demand in Ethiopia and to meet the objective of achieving universal provision of electricity services by 2030.

8.4.1 Technology approach

Off-grid Solution

To meet the energy demand from the wide range of Ethiopian off-grid settlements described in section 7.2, different technology solutions could be proposed. The challenge for off-grid electrification is the wide variety of demand profiles (from isolated & low-income thatched houses to large productive users and wealthy households) and the unknown density level of potential rural customers.

Only field visits or satellite image analysis combined with GIS data can help to assess the typology of settlements or how the rural buildings are scattered from one another (household density), and then to identify their demand profiles and to propose potential electrification solutions based on RE sources. For each settlement, there is either a single technology solution or a mix of different solutions to reach universal access, as illustrated by the below figure.

- **Mini-grids** (MG) or **micro-grids** (µG) will target clusters of households with enough household density to deploy cost-effective distribution network;
- **Standalone systems** (SAS) will target scattered households (or sometimes very low-income households).

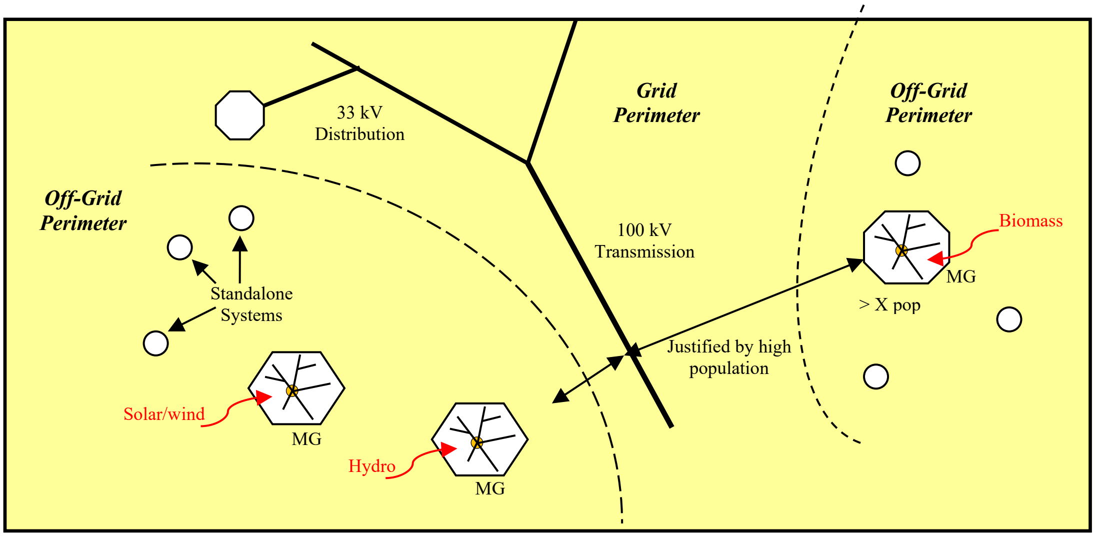


Figure 22: Illustrative view of Grid and Off-Grid perimeters (DFID-IED, 2013)

Solution selection criteria

In remote areas with a population density high enough to justify the construction of LV networks to connect multiple clients, off-grid connections can be done through the construction of renewables-powered **micro- or mini-grids**. Where populations are too small or too dispersed for a micro- or mini-grid to be technically or economically feasible, **solar home systems** or other standalone systems will provide household connectivity.

For this study, we use the following main criteria & thresholds for technology selection:

1. Distance to the grid (MV lines):	beyond 2.5km and beyond 25km
2. Household density (HH/km² or pop/km²):	below 20 HH/km² or above 100 HH/km²
3. RE resources:	priority to Hydro, then Solar or/and Wind
4. Demand level:	Tier 1 and above

Solution quantification

Based on the previous analysis, we can consider that out of **5,786** non-electrified localities:

- **4,929 localities** (85.2%) have a low density of households (< 20 households per km^2 or < 100 people per km^2) and are candidate for **Solar Home systems (SHS)**.
- **472 localities** (8.2%) are small size (< 200 households) with medium or high density (> 20 households per km^2 or > 100 people per km^2) and are candidate for **micro-grids (µG).**
- The remaining **385 localities** (6.7%) are potential candidates for **mini-grids (MG)**.[26]

Table 37: Breakdown of off-grid technology solutions In Ethiopia

Non-electrified localities per population and density		Households' density			
		Low	Medium	High	
Population	# households	<20	20-100	>100	hh/km^2
Small	<200	2,883 "SHS"	463 "µG"	9 "µG"	58.0%
Medium	200-1,000	1,668 "SHS"	278 "MG"	4 "MG"	33.7%
Large	>1,000	378 "SHS"	102 "MG"	1 "MG"	8.3%
		4,929	**1,284**	**14**	**5,786**
		85.2%	14.6%	0.2%	100%

Additionally, in the 511 localities targeted by MG or µG, some of the households will be dispersed and located too far from LV/MV distribution network (> 1km buffer) and are candidate for **Solar Home systems.** The following table proposes to quantify the proportion of buildings targeted by SHS for 3 different sizes of settlements: 30% SHS in a large locality (>100 HH) up to 60% SHS in a small locality (<200 HH).

Table 38: Indicative breakdown of building types vs. settlement sizes

Type of buildings	Size & dispersion level	>1000 HH	200-1000	<200 HH	Proposed solution
Small residential houses, very small businesses	Small and scattered	30%	50%	60%	Standalone Solar System
Concrete buildings (houses / businesses)	Medium and gathered	0%	0%	40%	Micro-grid
Concrete buildings (houses / businesses)	Large and gathered	70%	50%	0%	Mini-grid
TOTAL		**100%**	**100%**	**100%**	

And for specific cases, some public infrastructures (schools, health centers, administration…) and some productive users or businesses may also be located beyond the reach of the mini-grid and require specific **Standalone Systems** (SAS) with more power than a single SHS.

Usually far from the mini-grid buffer, the farmers practicing irrigation rely on manual or fuel-powered pumps and are excellent potential candidates for **Solar Pumping Systems** (SPS). Moreover, such system could also benefit from water access for many villages which mostly are equipped with hand pumps, springs or wells.

[26] Note that in NEP 2.0, more than 285 sites were potentially identified for MG beyond 25km from the existing MV lines but this number was overestimated because the household density wasn't considered.

8.4.2 RE-based mini-grid solutions

A **renewable energy-based mini-grid** is defined as a system where all or a portion of the produced electricity (10kW – 1 MW or more) by RE sources (solar, wind, biomass, hydro or mix) is fed into a small isolated distribution grid (low & medium voltage (LV/MV); single-/tri-phases) which provides several end-users with electricity. Mini-grid can also operate in both grid-connected or island-mode, with or without a backup diesel genset. Micro-grids are generally smaller and supplied by solar PV & battery generator only (no genset). This is also illustrated in the previous figure.

Hybrid Solar PV/diesel mini-grids (MG)

Wherever there is no hydropower potential to supply off-grid villages, a solar mini-grid solution will be proposed if the housing density is sufficient (> 20 HH/km²). When villages are large enough (>200 HH), a hybrid solution combining solar energy, batteries and a fuel-powered generator, has been chosen to ensure quality service to households as well as to the socio-economic activities of the locality.

Figure 23: Solar mini-grid in Tum village, Ethiopia. Photo: Binyam Teshome (WB website)

As highlighted earlier, there are very few medium and large non-electrified settlements in Ethiopia (> 200 pop.) where mini-grids can be deployed. Most of them are already targeted by the grid extension plan and actually only 141 localities out of 405 targeted by MG or µG are located outside the grid-footprint (25km from existing MV lines).

Solar mini-grids usually include a hybrid solar-battery generator coupled with a diesel genset, a LV/MV distribution network and a customer connection with meter, if possible, with monitoring and communication capabilities.

Solar plant is usually located within the vicinity of targeted villages. The distribution network will have MV lines only of the load dispersion can justify the extra-cost (cluster of several villages or for significant loads, located away from the power plant (more than 1km from the plant).

By assuming an average consumption of 1.2kWh/day/connection (year 1)[27], a **100kWp PV hybrid plant** could supply approximately 260 connections. With the minimum ratio of 1,500 kWh/kWp/year in Ethiopia, such solar plant will be able to produce 150 MWh/year, or 410 kWh/day.
Multi-source management adds a certain complexity to the power system and requires more attention and expertise for operation and maintenance.

A representative mini-grid system typical of these settlements would be a hybrid solar/diesel/battery mini-grid as described in the next figure and box.

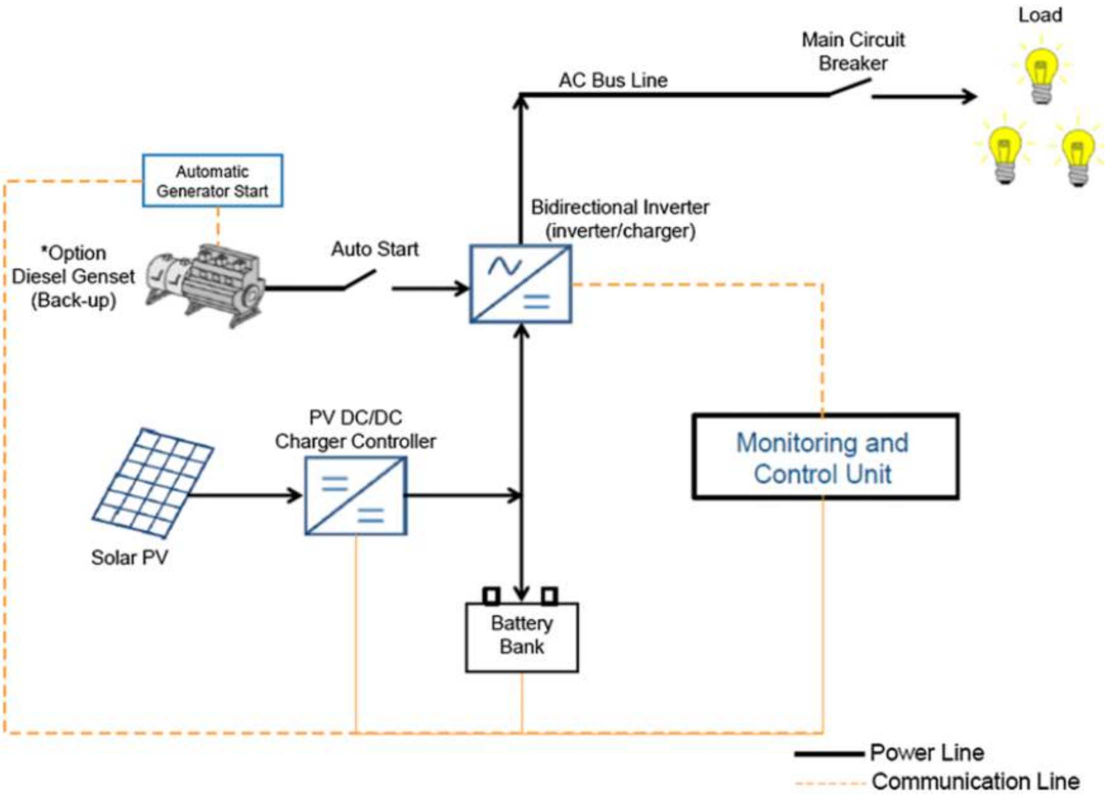


Figure 24: Solar Mini grid technical scheme

<u>Hybrid Solar PV/diesel mini-grids</u> **(assumptions based on ADELE sizing for Kara Gulu 500kWp – Package IIB)**

- **Target customers:** all rural infrastructures (domestic, public infrastructures, productive uses & businesses) with a min. load density = 20 household/km² or 30 households per LV km.
- **Service:** AC-power supply & 24h/7 access and all range of appliances including motors and thermal appliances. Individual restrictions by fuses & meters.
- **Technology:**
    - Hybrid system including solar PV generator (250Wp and 1.2kWh/day per customer), storage battery (>0.9kWh/customer) and fuel genset (<100W/customer). Eventually combined with a wind generator to reduce even further the fuel consumption.
    - LV distribution network (90% of total km); max. distance: 1200m from power plant in 400V - 3 phases network
    - MV distribution (10% of total km in 15 to 33kV) can be considered to reach clusters of settlements separated by more than 1km from the powerhouse, up to few tens of km.

[27] *Estimation from ADELE project*

- **Performances:** >4.1kWh/kWp/day **(≥ Tier 4)**
- **CAPEX:** US$ 2500$/kWp is used for solar/battery generator costing, including installation & commissioning, excluding VAT and import taxes. And similarly, 10,000$/km for mixed distribution network. This is in phase with Oborso East project (200kWp) by ENDEV and with regional benchmark.
- **OPEX:** ~5%/year of CAPEX (3% Gen. + 2% Distr.), without fuel/oil cost
- **Lifetime:** 25 years for PV modules, 10 years for Li-ion batteries, 10 years for electronic

Solar powered micro-grids (µG)

A **micro-grid** is defined as a system where the produced electricity from solar only (no genset) is fed into a small and simplified LV distribution grid which provides several end-users with electricity. Micro-grids usually operate in island-mode with a capacity between 1 - 10kW. They preferably operate with AC low voltage and single phase but can also operate with DC power system for instance in 48V for a very small network. Customer connections are also often simplified.
In Ethiopia, according to Table 4 above, the potential for deploying such micro-grids is higher than for mini-grids (~350 non-electrified localities). Those rural settlements (basically <200 households) are often isolated groups of buildings gathered around a community or business center.

By assuming an average consumption of 1.0kWh/day/connection, a **10kWp solar plant** could supply approximately 40 connections. With the minimum ratio of 1,500 kWh/kWp/year in Ethiopia, such solar plant will be able to produce 15 MWh/year, or 41 kWh/day.

Solar powered micro-grids

- **Target customers:** small settlements with less than 200 households (population below 1000) and with eventually some basic infrastructures & businesses. Min. load density = 20 household/km² or 30 households per LV km.
- **Service:** AC-power supply & 24h/7 access and limited number of appliances including motors and thermal appliances. Individual restrictions by fuses & meters.
- **Technology:**
  - Solar PV generator (250Wp and 1.0kWh/day per customer) with storage battery (>1.2kWh/customer) & DC/AC inverter.
  - LV distribution network (1-phase); max. distance: 600m from power plant.
  - Low-cost and smart metering or current limiter
  - No fuel genset backup; no MV line.
- **Performances:** >4.1kWh/kWp/day and ~200W for 12h or 500W for 5 hours (≥ Tier 3)
- **CAPEX:** US$ 2200$/kWp is used for solar/battery generator costing, including installation & commissioning, excluding VAT and import taxes. And similarly, 9,500$/km for LV distribution network.
- **OPEX:** ~5%/year of CAPEX (3% Gen. + 2% Distr.), without fuel/oil cost
- **Lifetime:** 25 years for PV modules, 10 years for Li-ion batteries, 10 years for electronic

Small wind power generation

In some specific regions with acceptable local wind condition as highlighted in previous section 7.3.3, a hybrid solution using wind generator as complement to diesel/solar/battery system can be relevant to significantly reduce the fuel consumption. But the CAPEX of such solution rises quickly.

In terms of wind technologies, all wind turbines used today fit within two broad classes Vertical and Horizontal Axis (VAWT and HAWT). The HAWTs are the most advanced, reliable, and economical. They

come in many sizes (from few kW to few MW) and shapes. They are all descendants of the old windmills used to grind grain or pump water and today these machines are proven. They are used throughout the world producing clean, affordable, and sustainable electricity.
Typically, a modern HAWT turbine of **100kW** have a tower of about 40m height with a rotor of 25m diameter and produce electricity 70-85% of the time, whenever the wind is over the cut-in speed of 3m/s.

However, only few suppliers are really active in the continent for such small turbines and particularly in Ethiopia where such options are still not implemented which makes the technology risky for such large-scale planning program. The option could only be studied for local opportunities.

8.4.3 Standalone solutions

Solar Home & Solar Lighting Systems (SHS/SLS)

For dispersed customers who are too far from the micro- or mini-grid infrastructure, two categories of standardized SAS (described below) are offered to meet two levels of household affordability, while ensuring a minimum Tier 1 service to achieve Universal access. The category of solar lanterns (SL) and rechargeable batteries (RB) is excluded here because it generally does not meet this minimum service level.

- Solar Lighting System (SLS): Ideally, a 25Wp system would be needed to produce 100Wh per day. However, the cost of such a system would be prohibitive for the poorest households, and experience in Ethiopia clearly shows that most rural households opt for much smaller solar lighting systems, or even just solar lanterns. Therefore, the decision was made to use the smallest possible SLS while still ensuring the minimum Tier 1 service. An 11Wp SLS is thus proposed for the Tier 1 category, producing an average of 42Wh/day (min. 2 lamps + 1 mobile charger + 1 radio).
- Solar Home System (SHS): For Tier 2 customers, the minimum peak power is 50Wp. It produces an average of 200Wh/day and provides a significantly higher level of comfort than SLS (min. 4 lamps + mobile chargers + radio + TV + PC/fan).

Based on previous recent experiences (ENDEV, ADELE), the average unit cost proposed for SHS/SLS investment is 8-10 $/Wp.

Solar Home System (SHS)

- **Target customers:** domestic houses, small businesses, small infrastructures, etc.
- **Service:** DC-power supply & 24h/7 access; basic appliances as lights, radio, TV, Video, fan. No motors or thermal appliances.
- **Technology:** 50 Wp system with a 0.3 kWh storage battery (+ DC/AC inverter in option)
- Performances: > 0.2 kWh/day (≥ Tier 2)
- **CAPEX:** 6.0 US$/Wp including installation & commissioning, excluding VAT and import taxes
- **OPEX:** ~4%/yr of CAPEX
- **Lifetime:** 25 years for PV modules, 10 years for Li-ion batteries, 10 years for electronic

Solar Community Systems (SCS)

In addition to households and small businesses, there are also sometimes public infrastructures that cannot be connected to mini-grids. A detailed examination of the needs for each category of infrastructure reveals significant variations depending on its type and level of equipment. Given the trend towards providing increasingly more electrical equipment when these infrastructures are electrified, it is crucial to size the Solar Community Systems (SCS) accordingly. The ADELE program has adopted relatively high solar capacities compared to previous Ethiopian experiences and to typical needs in rural Africa. To avoid placing an excessive burden on final national investments, we recommend slightly lower capacities, which are still more than sufficient to ensure the digitalization of services and the provision of modern, high-performance equipment.

- Primary school: A **3kWp** AC system is proposed which is double NEP 2.0 capacity but less than ADELE recommendation (5kWp). It will produce in average 9 kWh/day. This is also the capacity recommended by ENDEV/GIZ in Ethiopia.
- Secondary school: A **6kWp** AC system is proposed which represents more than double the NEP 2.0 capacity but less than ADELE & ENDEV recommendation (8kWp). It will produce in average 18 kWh/day.
- Health post: A **3kWp** AC system is proposed which is also double NEP 2.0 capacity. It will produce in average 9 kWh/day. This capacity is higher than the one recommended by ENDEV/GIZ in Ethiopia (0,6 kWp).
- Health center: A **8kWp** AC system is proposed, halfway between NEP 2 experience (5kWp) and ADELE recommendation (10kWp). It will produce in average 24 kWh/day.

Given the type and number of public institutions located within the off-grid perimeter, we can consider an average capacity of 4 kWp, all categories combined.
Based on previous experiences (ENDEV, ADELE), the average unit cost proposed for SCS investment is 12 $/Wp.

Solar Community System (SCS)

- **Target customers:** public infrastructures as rural school, health center, administration office.
- **Service:** AC-power supply & 24h/7 access; standard appliances as lights, radio, TV, computer, printer, fan, refrigerator, small tools … No motors or thermal appliances.
- **Technology:** 3-8kWp system per infrastructure with a 10-30kWh storage battery and 5-10kVA DC/AC inverter
- **Performances:** 9-24kWh/day (Tier 5)
- **CAPEX:** 10 US$/Wp including installation & commissioning, excluding VAT and import taxes
- **OPEX:** ~4%/yr of CAPEX
- **Lifetime:** 25 years for PV modules, 10 years for Li-ion batteries, 10 years for electronic

Solar pumping systems (SPS)

Finally, the standalone category also includes solar pumping systems (SPS) for irrigation-based agriculture. The potential for converting diesel-based motor pumps by solar pumps is huge in Ethiopia (around 6 million ha of land are suitable for irrigation mainly in the Abbay, Rift Valley, Omo Ghibe, and Awash river basins). Although water requirements for irrigation vary considerably depending on the area and type of crops grown, a standardized 1.5 kWp pumping system is proposed, which can provide approximately 40m³ per day at 40m and can irrigate 0.5-2 hectares of crop fields depending of the irrigation method (Drip vs Sprinkler/surface). The average unit cost proposed for SPS investment is 8 $/kWp, as proposed by ENDEV/GIZ.

Solar Pumping System (SPS)

- **Target customers:** small & medium farms. The proposed irrigation system is sized for 1 ha of garden (40m³/day at 40m).
- **Service:** AC- or DC-power supply during sunny hours (no battery storage); standard immersed pumps.

- **Technology:** 1500 Wp system without storage battery (+ DC/AC inverter in option)
- **Performances:** > 4kWh/day or 160m[4]/day
- **CAPEX:** ~8 US$/Wp including installation & commissioning, excluding VAT and import taxes
- **OPEX:** ~4%/yr of CAPEX
- **Lifetime:** 25 years for PV modules, 10 years for Li-ion batteries, 10 years for electronic

8.4.4 Comparison of RE-based solutions

As developed in previous sections, a wide range of renewable energy technology solutions available in Ethiopia can meet off-grid rural needs, in particular for electricity consumption.

The next table summarizes and compares the main indicative characteristics of each off-grid solution, either standalone or isolated mini-grids, and the service provided (Tier levels as defined MTF framework).
Each Off-Grid solution is selected based on specific criteria (village size, households density and grid distance) and on demand level.
The key outcomes from the table are:

- **Standalone systems** include solar lighting systems (SLS) and solar home systems (SHS) that provide respectively at least **Tier 1** and **Tier 2** service with respectively 1.0 and 1.5 kWh/day per customer and with a 24 hour-access to electricity. Solar community (SCS) and solar pumping systems (SPS) are also described.
- For instance, **SHS category** in the range of 20Wp to 200Wp provides usually enough DC power and energy to ensure at least a Tier 1 service (> 4hrs/day). For our simulations, a 50Wp SHS has been selected which can produce 200Wh/day (Tier 2).
- Solar hybrid **mini-grid category** (MG) covers a wider capacity range from 10 to 500kWp and can offer at least Tier 3 service (> 1kWh/day) for villages larger than 1000 inhabitants (200 households). For our simulations, a 100kWp solar MG has been selected which can produce 400kWh/day. If each connection consumes in average 1.2 kWh/day (Tier 3), such 100kWp solar MG can supply about 340 connections. In that case, the average PV capacity per connection is 300Wp/CX, i.e. 6 times higher than for the SHS.
- **Solar micro-grid** (µG) in the range of 1 to 10 kWp targets smaller communities (10-200 customers) than mini-grids but provides more energy per customer than a solar home system. For our simulations, a 10kWp solar µG has been selected which can produce 40kWh/day. If each connection consumes in average 1.0 kWh/day (Tier 2), such 10kWp solar µG can supply about 40 connections.
- **Hydropower** plant has potentially larger capacity than solar mini-grids and can also supply a cluster of villages interconnected through MV line. A 500kW plant can produce 4,2MWh/day to supply 1000 connections, or 3.4 kWh/day per connection (Tier 4).
- **Wind power** is considered in our simulations only for improving solar hybrid system performances when production curves are complementary.
- **Biomass-based mini-grids** are not considered in our simulations as the technology becomes mature and cost-effective only for larger loads, for instance for settlements above 5000 population.

Table 39: Main characteristics of the proposed off-grid RE-based solutions vs. potential demand

			Standalone Systems					Isolated Networks		
	Characteristics		**SL / RB**	**SLS (pico)**	**SHS**	**SCS**	**SPS**	**Solar µG**	**Solar (Wind) MG**	**Hydro (Biom) MG**
Criteria	Village size (HH)	# HH	<200	<200	<200			<200	200-1000	200-1000
	Village size (pop)	# pop.	<1000	<1000	<1000			<1000	1000-5000	1000-5000
	HH density	hh/km^2	<20	<20	<20			>20	>20	>20
	Distance to MV line	km	>0	>0	>0			>2.5	>2.5	>25
Design & costs	Design RE Capacity	kW(p)	-	**0.011**	**0.05**	**4**	**1.5**	**10**	**100**	**500**
	Theoretical output	kWh/yr		16.5	75	6000	2250	15000	150000	1533000
	Aver. daily production	kWh/d	-	0.044	0.2	12.0	4.5	40.3	403	4200
	Aver. daily consumption per CX	kWh/d/CX		**0.044**	**0.2**	**12**	**4.5**	**1.0**	**1.2**	**3.4**
	Targeted connections	CX	1	1	1	1	1	40.0	340	1240
	Average capacity per CX	Wp/CX		11	50	4000	1500	250	300	410
	Average CAPEX (generator)	$/W	-	6	6	10	8	2.2	2.5	5.0
	Average OPEX (Gen)	%/yr		4%	4%	4%	4%	3%	3%	4%
	Indicative Tier level	**0 to 5**	**0**	**0-1**	**1-2**			**2-3**	**3-4**	**3-4**
Equipment	RE capacity range	kW or kWp	0.001-0.005	0.005-0.02	0.02-0.2	0.1-10	0.5-5	1-10	10-500	10-1000
	Hybrid configuration		Batt.	Batt.	Batt.	Batt.	-	Batt.	Batt. + Gen	
	Distribution network		(DC)	(DC)	(DC)	(AC)	(AC/DC)	LV	MV-LV	MV-LV

8.4.5 Off-Grid technology costing

The investment costs for RE technologies for off-grid electrification are significantly variable according to project, system size, RE resource, national regulation, etc.

Hydro solution costing

The below table provides the basic assumptions for the hydro-powered mini-grids and our cost simulations for 3 sizes adapted to off-grid solutions.

GEOSIM - Hydro MG	Unit	Micro	Mini	Small
Capacity (kW)	kW	5-100	**100-1,000**	1,000-10,000
Lifetime of the Turbine	Year	25	**30**	30
Investment cost	$US/kW	10,000	**5,000**	3,000
O&M cost	%/yr	4%	**4%**	3%

The identified hydro potentials in Ethiopia range mainly in the mini hydro power category.

Solar solution costing

While the cost of solar PV and batteries has been reduced over the last decade, the total cost of mini-grids is still noticeably high, with the battery being the costliest element. Levelized cost of electricity (LCOE) from mini-grids is 33 US$ cent/kWh or more, as opposed to 10 US$ cent/kWh for electricity from the national grid. For rural mini-grids, demand at night requires more battery capacity and is often limited for each household. In this way, mini-grids may not always deliver the same quality as the grid (Energy Outlook 2025).

It is also important to note that solar system prices are affected by many factors including but not limited to system quality and sophistication level, geographical location and remoteness (urban vs. rural, transport logistics, last-mile delivery costs), regional market conditions and supplier availability, as well as macroeconomic conditions such as the notable devaluation of the ETB in 2024, which had an impact on imported solar component costs and consequently, end-user prices (GIZ, Etsub, 2026).

Off-grid electrification **CAPEX** cost assumptions and calculations in $/kWp and $/connection are described in the table below. These estimated costs (including installation & commissioning, excluding VAT and import taxes) result from international benchmark prices for renewable energy solutions (IRENA 2025; ENDEV/GIZ 2026) and are adjusted for the proposed off-grid solutions based on prices observed in the Ethiopian RE market.

The **OPEX** assumptions include O&M costs for solar systems but doesn't include fuel/lubricant costs. Standalone systems require a bit less maintenance (yearly 4% of the capex) than micro-/mini-grids (yearly 5-7% of the capex for generation & distribution).

Table 40: CAPEX & OPEX calculations (US$) for off-grid solar solutions

CAPEX & OPEX (per unit)	Unit	SLS	SHS	SCS	SPS	PV-µG	PV-MG
Solar generator CAPEX	US$/Wp	6	6	10	8	2.2	2.5
Distribution grid CAPEX	US$/Wp	-	-	-	-	1.0	1.3
Total System unit cost	US$/Wp	**6.0**	**6.0**	**10.0**	**8.0**	**3.2**	**3.8**
OPEX cost (no fuel/oil)	% of capex	4%	4%	4%	4%	3%+2%	3%+2%

For our simulations and LCoE calculation, 25 years lifetime for PV modules and 10 years lifetime for PV inverters /electronics and Li-ion batteries will be considered.

The below table summarizes the key data for the solar off-grid solutions and our cost simulations.

Table 41: Solar assumptions for NEP 3.0 simulations (GEOSIM)

GEOSIM – Solar solutions	Unit	SLS	SHS	µG	MG
Capacity (kW)	kW	11Wp	50Wp	10kWp	100kWp
Lifetime of PV module	Year	25	25	25	25
Investment cost	$US/kW	6,000	6,000	3,200	3,800
O&M cost	%/yr			3%	3%

Wind solution costing

The below table provides the basic assumptions for the wind component of our cost simulations for 3 size categories of wind turbines adapted for off-grid solutions.

GEOSIM - Wind MG	Unit	Micro	Mini	Small
Type of Wind turbine	%	HAWT	HAWT	HAWT
Height	m	>15	>30	>50m
Capacity (kW)	kW	5-100	100-1000	1000-10000
Lifetime of the Turbine	Year	25	25	25
Investment cost	$US/kW	6,000	5,000	4,000
O&M cost	%/yr	6%	4%	3%

8.4.4 Key renewable technology assumptions

In the next table, the key assumptions for the RE resource and generating technologies for off-grid development in Ethiopia are:

OG Assumptions	Hydro	Solar	Wind	Biomass
Resource avail.	> 6000 h/yr	> 1500 h/yr	> 4000 h/yr	> 7000 h/yr
Min. resource		> 5.5kWh/m²/d	>5m/s @ 50m	
Capacity range	5kW-10MW	10Wp-1MWp	5kW-1MW	50kW-10MW
CAPEX*	2000-10,000$/kW	2000-12,000$/kWp	4000-6000$/kW	3000-6000
OPEX*	3-4%/yr	3-4%/yr	3-6%/yr	3-6%/yr
Lifetime*	25-30 yr	10 / 25 yr	15-20yr	15-20yr

(*) for generator part only

8.5 Off-Grid electrification simulations

The off-grid electrification simulations were carried out using the geospatial planning software GEOSIM, developed by IED[28]. Once the initial grid extension simulation is done, GEOSIM then identifies single village or a cluster of settlements where local renewable energy supply options and demand profiles could potentially support the development of a mini-grid and simulates the dimensioning and operations of the potential mini-grid. For villages that do not meet the minimum demand/population criteria for a mini-grid, a standalone solar solution or micro-grid is simulated and budgeted.

[28] https://www.ied-sa.com/solutions/planification/geosim.html

For each simulation, GEOSIM provides the following information for mini-grids:

- Number of customers for village in each year in the simulation
- Demand (kVA and MWh) in each village in each year in the simulation
- Investment estimates for each off-grid project
- O&M costs and the resulting supply cost for each mini-grid project
- Levelized cost of electricity (LCOE)
- Energy produced, lost and consumed per year

The solar resource is estimated by GEOSIM using the Global Tilted Irradiance map provided by Global Solar Atlas for each locality based on its exact location.

For standalone solutions and micro-grids, the total number of connections and investment requirement is calculated based on the locality population. Micro-grid OPEX is calculated on the basis of a simplified $/Wp assumption (see previous section). Each option is sized to achieve the lowest levelized cost of electricity, taking into account the technical, economic and financial parameters.

Based on the potential customers and their demand profile, 3 different off-grid RE-based supply solutions (standalone, micro- and mini-grids) and design assumptions have been developed in this report.

8.5.1 Micro and Mini Hydro powered mini-grids (MHP-MG)

As described above, Ethiopia has significant hydro resource to supply national network and also to power some isolated and fortunate villages. Relatively limited hydropower capacities in the range of 100-1000kW are enough to supply those rural localities.
Since it was not possible to identify and to assess all potential hydro sites for off-grid applications, we used a number of sites already studied to potentially connect neighboring localities. The selected sites generally correspond to hydro sites with average flow rates between 0,05 and 5m^3/sec and variable drop heights between 5 and 50m, but sometimes up to 250m.
A CAPEX of US$ 5000$/kW will be used for hydropower generator in the range of 100-1000 kW, including installation & commissioning, excluding VAT and import taxes as a key investment parameter.

The approach adopted by the geospatial planning software GEOSIM was used to identify the least cost mini-grid option in term of LCoE (generation + distribution). The planning and prefeasibility study demonstrated that only few projects are really eligible for the following reasons:

- ✓ Located in on-grid areas where surrounding localities are already electrified
- ✓ Sites are located very close to each other's as the assessment was targeting some specific rivers. Only the best site was then studied.
- ✓ Surrounding demand is too low and the LCoE too high to present an economically viable opportunity for developers.

More than 31 projects could still potentially be studied for further analysis. The study clearly demonstrated that developing isolated Hydro mini-grids is clearly not viable in terms if LCoE. Due to the low demand to supply and their location near the MV grid network, the proposed optimized solution would be to interconnect the identified mini-grids to the main grid in order to inject excess of power and stabilize the energy consumption during peak loads (see table below).
The 31 projects may then target 62 localities, impacting 148,654 inhabitants and including 25,278 new customers the initial year for a total investment of 438.45 million US$.

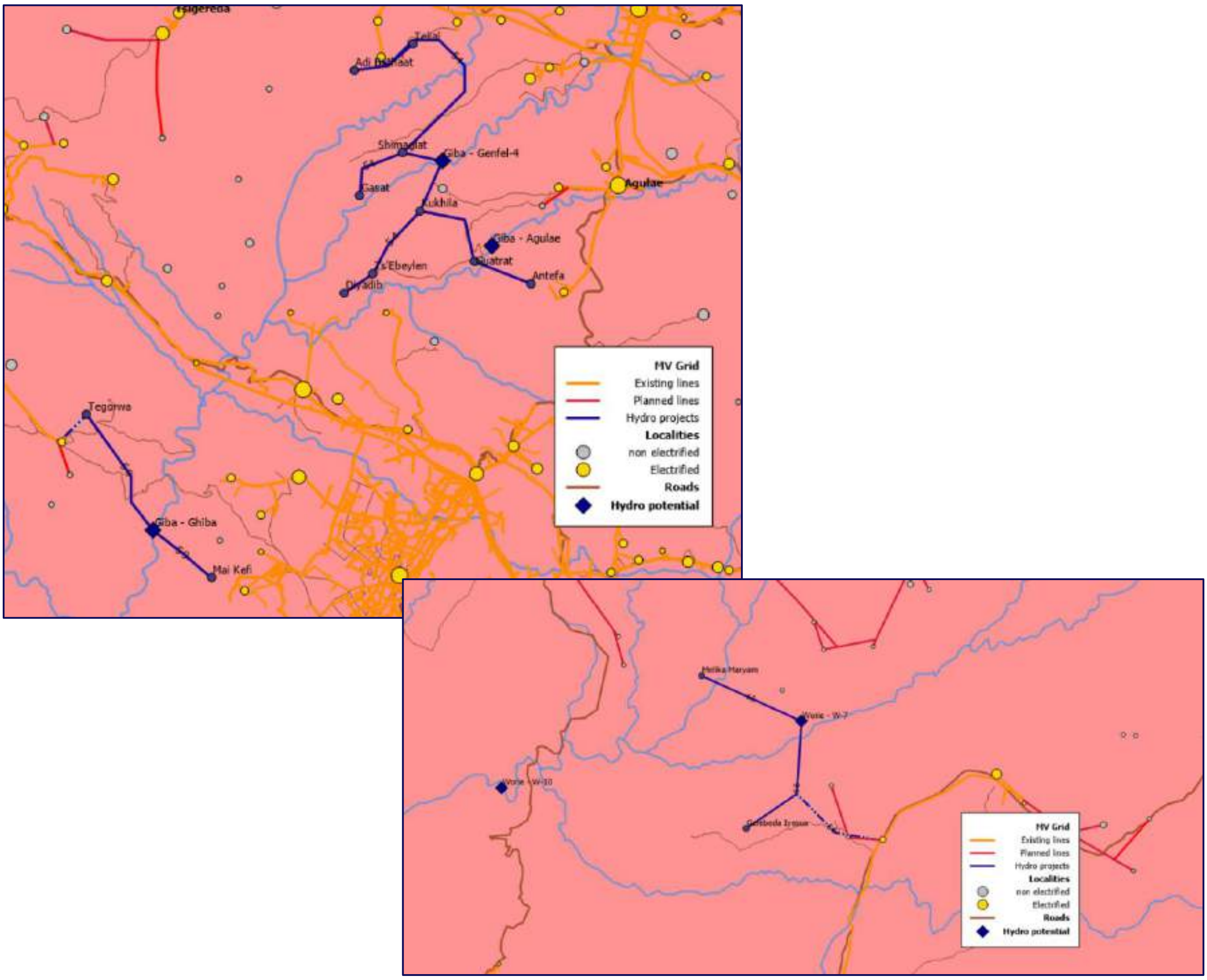
The projects' LCoE varies from 0.05 US$ to 0.30 US$, which is acceptable considering that the indicator includes both generation and distribution investments.

Even though the calculated results seem quite attractive for businesses, a deeper investigation shall be necessary to validate the hypothesis and site characteristics used for the study.
With a closer look at results, it seems that sites are more attractive for energy injection rather than for rural electrification - the share of energy sold is the majority in the balance - but the lack of accurate data can lead to bias for a relevant analysis. The nature of the terrain in some areas (deep valleys, steep gorges, mountains…) can also strongly influence the results.

<u>Recommendations:</u>
In general, the Consultant shall recommend the GoE to prepare a national atlas referencing MHP across the country particularly targeting in priority areas lacking of power. This resource assessments can be initiated by a computer pre-identification followed by field visit by mini hydropower specialists. A new locality database could also benefit to the mini-grid optimization locating new rural villages which could be supplied…

Few maps of hydro projects are detailed below on the GIS database:

Map 16: Typical hydro projects in Tigray region (source GEOSIM)



The investment distribution for Hydro mini-grid per region is given in the below table

Table 42: Hydro projects impact and Investments per region (scenario 1)

Region	Nb Villages	Population	Nb Customers	Investment (M US$)
Amhara	18	21,103	4,007	88.558
Central Ethiopia Regional	8	32,844	4,001	8.219
Oromia	8	5,250	852	3.520
Tigray	28	89,457	16,726	338.152
TOTAL	**62**	**148,654**	**25,584**	**438.450**

Table 43: Hydro projects impact and Investments per region (scenario 2)

Region	Nb Villages	Population	Nb Customers	Investment (US$)
Amhara	18	16,272	3,106	87.629
Central Ethiopia Regional	8	27,556	3,353	7.481
Oromia	8	4,253	692	3.344
Tigray	28	63,524	11,903	333.135
TOTAL	**62**	**111,605**	**19,054**	**431.591**

The budget gap between scenario 1 and scenario 2 can be explained by the number of connections to be implemented.

The table below provides key indicators results per project. However, GEOSIM provided more details for each project including energy balance, investments breakdown and operating and maintenance cost per year for a 20-year horizon. Detailed economic analysis per project is provided in a separate Annexe.

Table 44: Extract of the economic analysis for Melkabedi hydro project (5 first years)

Hydro Projects detailed report

Mode : Grid integrated

GeoSim

Currency : $US

Project # 28 | Source : Ketar - 28 - MelkaBedi | Area : Oromia

Total cluster population (Y1) : 234 | Cluster Settlements number : 1

MV length : 8 088 m | SHP Capacity : 163 kW

Levelized Cost : 0.05 $US/kWh

	Year 1	Year 2	Year 3	Year 4	Year 5
ENERGY					
Backup / from grid :	0 kWh 0%	0 kWh 0%	0 kWh 0%	-1 kWh 0%	1 kWh 0%
SHP :	0 kWh 0%	1 231 218 kWh 100%	1 231 218 kWh 100%	1 231 218 kWh 100%	1 231 218 kWh 100%
Total energy produced :	**0** kWh	**1 231 218** kWh	**1 231 218** kWh	**1 231 217** kWh	**1 231 219** kWh
Demand	0 kWh 0%	5 353 kWh 0%	6 352 kWh 1%	7 412 kWh 1%	8 535 kWh 1%
lost / sold / not satisfied :	0 kWh 0%	1 225 865 kWh 100%	1 224 866 kWh 99%	1 223 805 kWh 99%	1 222 684 kWh 99%
Investments					
SHP generator:	407 500	407 500	0	0	0
Genset :	0	0	0	0	0
MV lines :	82 902	82 902	0	0	0
MV internal lines :	3 914	3 914	0	0	0
LV lines in village :	8 464	8 464	0	0	0
Power house :	0	0	0	0	0
Meters MV :	0	0	0	0	0
Meters LV :	0	910	195	260	195
Transformers LV :	2 360	2 360	0	0	0
Transformers MV :	4 265	4 265	0	0	0
Grid connection :	0	0	0	0	0
Total Investment :	**509 404**	**510 314**	**195**	**260**	**195**
O&M					
Maintenance :	0	20 376	20 376	20 376	20 376
Personnel :	0	0	0	0	0
Operating :	0	0	0	0	0
Fuel/grid energy:	0	0	0	0	0
Total O&M :	**0**	**20 376**	**20 376**	**20 376**	**20 376**
Peak	1 kW	1 kW	1 kW	2 kW	2 kW
Nb Customers LV :	11	14	17	21	24
Nb Customers MV :	0	0	0	0	0

Table 45: Hydro projects characteristics (scenario 1)

Project#	Project name	Grid connected	Levelized cost ($US/kWh)	Investment ($US)	Investment / Customer ($US)	Population (year 1)	Impacted localities	LV Customers		Energy demand (kWh)	
								Start	End	Start	End
HYDRO PROJECTS				**438,450,546**		**148,654**	**62**	**25,278**	**38,478**	**358,502,636**	**361,082,344**
28	Ketar - 28 - MelkaBedi	X	0.05	1,035,554	24,083	234	1	39	63	1,231,218	1 231 218
32	Meki - 2 - Akamuja	X	0.18	2,076,065	1,740	9,972	1	1,038	1,754	1,029,288	1 263 311
34	Meki - 4 - Lebu	X	0.11	2,599,040	2,223	9,931	2	1,056	1,788	1,825,146	1 926 475
37	Meki - 7 - Weldia3	X	0.10	1,446,586	3,158	3,919	1	413	699	1,007,838	1 010 127
40	Meki - 10 - Rufael4	X	0.30	2,097,480	1,295	9,022	1	1,422	2,389	557,736	1 017 692
50	Giba - Suluh	X	0.09	2,888,635	8,861	1,625	1	301	444	2,076,996	2 076 996
51	Giba - Genfel-1	X	0.08	5,088,540	8,051	3,141	2	582	870	3,883,308	3 883 308
52	Giba - Genfel-2	X	0.07	1,596,640	399,160	5	1	4	4	1,290,348	1 290 348
53	Giba - Genfel-3	X	0.07	18,773,182	35,354	2,629	2	490	723	17,076,744	17 076 744
54	Giba - Genfel-4	X	0.10	19,530,448	3,384	28,669	10	5,307	7,915	12,511,398	13 038 228
55	Giba - Agulae	X	0.07	12,107,125	12,456	4,789	1	876	1,320	10,350,816	10 350 816
56	Giba - Meskila-1	X	0.28	2,088,638	1,427	7,319	1	1,348	2,036	652,330	1 070 188
57	Giba - Meskila-2	X	0.19	8,272,365	2,052	19,987	5	3,695	5,503	3,295,814	3 803 508
58	Giba - Meskila-3	X	0.07	7,128,681	26,501	1,332	1	248	366	6,244,128	6 244 128
59	Giba - Ghiba	X	0.06	89,949,552	105,823	4,236	3	782	1,167	83,955,840	83 955 840
60	Worie - W-1	X	0.07	76,055,300	55,313	6,845	4	1,267	1,903	70,001,160	70 001 160
61	Worie - W-2	X	0.06	51,534,352	195,948	1,304	2	243	364	47,944,356	47 944 356
62	Worie - W-3	X	0.07	38,556,412	33,911	5,649	4	1,046	1,568	34,682,592	34 682 592
66	Worie - W-7	X	0.08	4,582,497	11,514	1,927	3	357	538	3,702,852	3 702 852
70	Dura - D1 - Mentawuha	X	0.11	8,744,956	130,522	334	1	63	87	4,599,000	4 599 000
74	Dura - D5 - Yechereka	X	0.11	20,961,150	71,540	1,180	1	259	468	11,025,774	11 025 774
80	Dura - D11 - Tirigi	X	0.17	1,066,793	7,112	604	1	133	244	396,094	434 714
81	CGIAR - 1 - Gumera	X	0.23	2,474,771	1,603	7,828	2	1,440	2,028	875,012	993 811
86	CGIAR - 9 - Waro	X	0.26	1,027,251	2,345	2,443	1	384	646	321,802	357 500
88	CGIAR - 11 - Welege	X	0.12	662,309	3,763	989	2	159	266	379,083	386 823
89	CGIAR - 12 - Gibe	X	0.10	795,517	2,841	1,584	1	253	426	522,972	527 577
90	Birr - 1 - Shembed	X	0.09	7,029,801	36,614	946	1	174	248	4,679,592	4 681 752
91	Birr - 2 - Yeweredageorgis	X	0.09	11,292,229	50,412	1,113	1	209	290	7,827,936	7 827 936
95	Birr - 6 - Ferap	X	0.10	4,615,867	11,805	1,982	1	364	519	2,910,160	2 961 638
99	Birr - 10 - Warikma	X	0.09	7,547,474	33,694	1,113	1	209	290	4,958,343	4 976 083
100	Birr - 11 - Kengena kuandel	X	0.09	24,825,339	20,740	6,003	3	1,117	1,552	16,686,960	16 739 849

8.5.2 Solar powered mini-grids (PV-MG)

In total, developing the 385 PV mini-grids identified in Ethiopia (Scenario 1) would impact more than 1,770,000 people and generate about 356,000 new customers. The required investment budget is estimated around 264 million US$. Project details are given in a separate annexe. Projects' LCoE range from 0.31 US$/kWh to 0.42 US$/kWh (Generation and distribution included). Only 366 were identified in Scenario 2 as localities population is globally lower and some projects will be more suitable for microgrids. Total budget is around 248 million US$ for connecting 1,649,000 people.

As described in the above sections, the proposed technology should serve a larger population ensuring a good quality of service which may not depend on weather or climate conditions. The included backup genset shall be used either for satisfying the demand during the peak time but also to ensure energy supply when weather conditions don't allow energy generation from the PV panel.

Four regions (Amhara, Oromia, Tigray and Somali) concentrate most of the identified mini-grids projects.

Table 46: PV Mini-grids Investment per region (scenario 1)

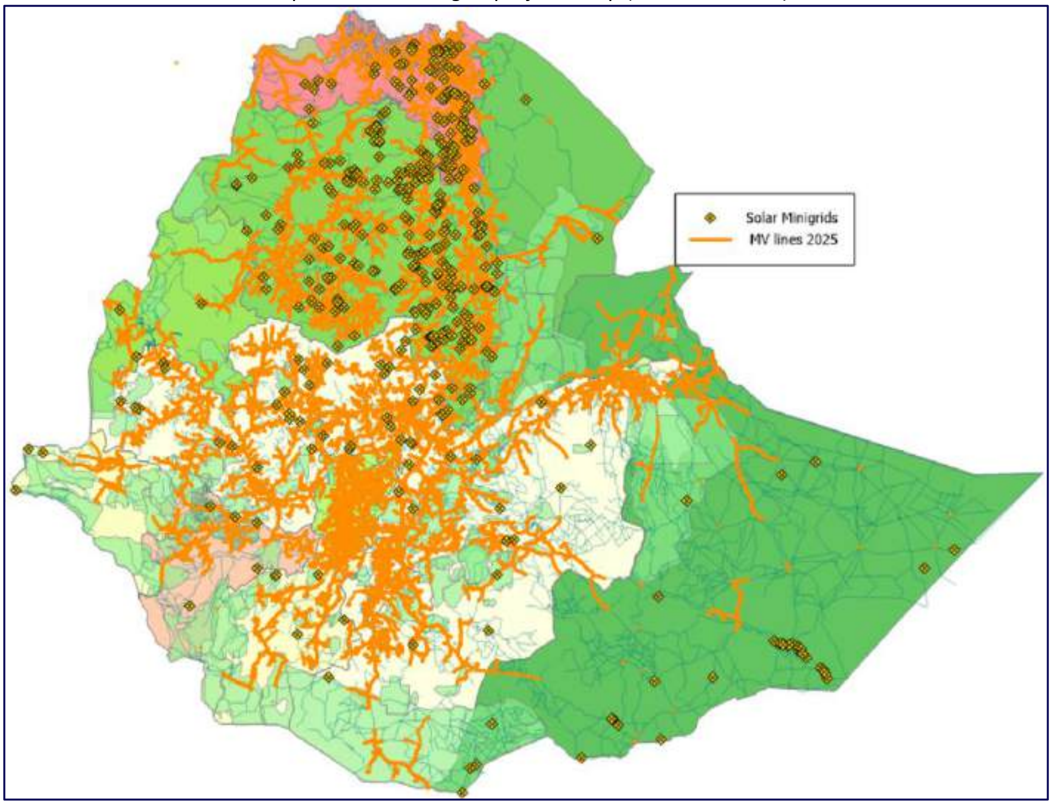
Region	Nb Projects	Population	Nb Customers	Investment (M US$)
Afar	3	9,921	2,050	1.686
Amhara	201	840,813	152,551	129.743
Benishangul Gumz	3	32,901	6,940	5.516
Gambela	3	20,942	4,532	4.076
Oromia	49	273,121	42,254	35.862
Somali	38	221,785	36,626	29.239
South Ethiopia Regional	5	22,353	4,465	3.693
South West Ethiopia	5	14,555	2,208	1.881
Tigray	78	334,544	60,513	52.349
TOTAL	**385**	**1,770,936**	**312,139**	**264.049**

Table 47: PV Mini-grids Investment per region (scenario 2)

Region	Nb Projects	Population	Nb Customers	Investment (M US$)
Afar	5	32,197	6,536	5.668
Amhara	185	585,806	103,367	93.492
Benishangul Gumz	3	26,229	5,418	4.706
Gambela	3	18,002	3,814	3.753
Oromia	42	193,909	29,085	26.562
Somali	48	550,839	88,317	74.728
South Ethiopia Regional	5	17,265	3,390	3.048
South West Ethiopia	5	11,242	1,656	1.488
Tigray	70	213,838	37,654	34.653
TOTAL	**366**	**1,649,327**	**279,237**	**248.101**

The map below locates all the PV mini-grids (scenario 1).

Map 17: Solar mini-grid projects map (source GEOSIM)



8.5.3 Solar powered micro-grids (PV-MG)

Regarding microgrids, the approach suggested that more than 472 smaller localities could potentially host solar microgrids (scenario 1) compared to scenario 2 which offers more opportunities with 491 projects due to localities' lower population. The microgrids development would reach about 83,500 inhabitants, adding 15,819 new off-grids customers. The total budget is estimated around 16,44 million US$. More details are given in the annexes.
For such projects located in remote areas with low density and small population, micro grids are more adapted even though the energy service may not be as reliable as for mini-grids and more sensitive to climate disturbances. Batteries can indeed spare energy for only few days when rains and cloudy weather do not allow solar energy generation.

Micro-grids are comparable to mini-grids in terms of LCoE and range from 0.18 US$/kWh to 0.45 US$/kWh.

Table 48: PV Micro-grids Investment per region (scenario 1)

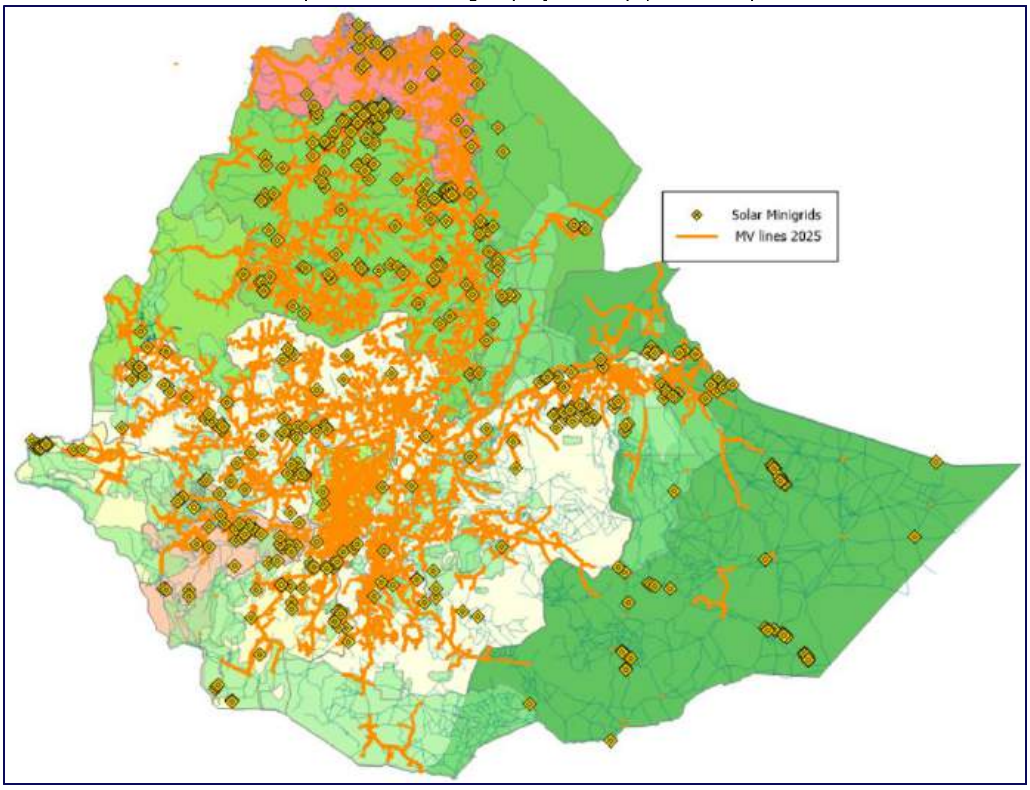
Region	Nb Projects	Population	Nb Customers	Investment (US$)
Afar	19	2,086	476	514,045
Amhara	141	40,827	7,664	7,596,238
Benishangul Gumz	2	255	58	59,110
Central Ethiopia Regional	2	13	8	17,115
Dire Dawa	1	7	5	9,497
Gambela	14	1,709	397	471,148
Oromia	103	8,265	1,563	1,912,400
Sidama	3	20	12	26,447
Somali	86	17,219	3,067	2,979,183
South Ethiopia Regional	39	2,812	658	786,784
South West Ethiopia	41	3,202	598	751,058
Tigray	21	7,080	1,313	1,318,863
TOTAL	**472**	**83,496**	**15,819**	**16,441,889**

Table 49: PV Micro-grids Investment per region (scenario 2)

Region	Nb Projects	Population	Nb Customers	Investment (US$)
Afar	17	889	205	299,008
Amhara	157	43,780	8,237	8,582,194
Benishangul Gumz	2	206	48	54,600
Central Ethiopia Regional	2	12	4	17,115
Dire Dawa	1	6	3	9,497
Gambela	14	1,490	359	464,355
Oromia	110	13,647	2,331	2,914,071
Sidama	3	18	6	26,447
Somali	76	12,576	2,257	2,525,179
South Ethiopia Regional	39	2,223	499	723,450
South West Ethiopia	41	2,524	442	702,611
Tigray	29	11,383	2,149	2,221,719
TOTAL	**491**	**88,753**	**16,540**	**18,540,245**

The map below locates all the proposed PV microgrids.

Map 18: Solar microgrid projects map (scenario 1)

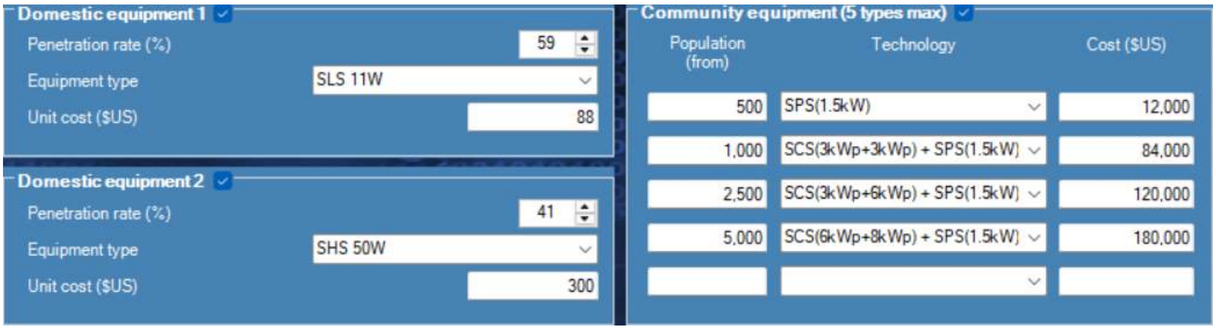


8.5.4 Standalone systems solutions

Modelling distributed energy solutions in Rural areas

Based on the demand analysis for domestic users and commercial and public services, distributed energy solutions were then modelized in GEOSIM so as to estimate standalone equipment to electrify the remaining villages not reach by either the interconnected grid or by mini-grids.
Two types of SHS (11 kW and 50 kW) are planned to be delivered to the population based on their consumption patterns while community equipment will be deployed based on the presence of health post/Health centers and schools as defined by population categories. SPS are also proposed for villages to improve their water access.

Figure 25: Distributed energy modelling parameters



Distributed Energy Solutions (standalone systems) Investment level per region

Electrifying the 4,929 remaining and most isolated villages with distributed energy solutions would cost approximately 522.89 million US$. Such program would provide domestic SHS for about 1,975,268 new customers including the electrification of 6,762 social infrastructures (schools, health post/health center and water pumping) with community equipment (SPS and SCS).

Besides new villages electrification, some scattered households can be identified within the on-grid area as electrification is only targeting the most densified core of localities in order to optimize LV grid investments. As described above, each region is defined by a scattered factor which models the housing pattern of average rural localities in terms of densification. Those scattered households are then temporarily electrified through 50 W SHS.

The table below resumes standalone systems requirement for each region. Scenario 1 would require 1,145 million US$ to connect up to 4 million households while scenario 2 targets 3.3 million households with a 956 million US£ budget.

Table 50: Distributed energy solutions distribution per region (scenario 1)

Region	Nb new localities	Nb SLS 11W	Nb SHS 50W	Nb SPS 1.5kW	Nb SCS 3kW	Nb SCS 6kW	Nb SCS 8kW	Investment (M US$)
Addis Ababa	0	0	0	0	0	0	0	0
Afar	335	9,537	7,108	38	28	0	0	4.057
Amhara	662	278,118	754,237	521	631	168	97	290.558
Benishangul Gumz	259	80,381	57,287	176	219	47	16	35.753
Central Ethiopia Regional	6	4,513	319,106	6	7	3	2	96.711
Dire Dawa	1	98	963	0	0	0	0	0.295
Gambela	176	7,052	5,070	19	16	3	1	2.984
Harari	0	0	1,630	0	0	0	0	0.489
Oromia	1,588	495,415	1,227,475	1,084	1,262	277	163	486.357
Sidama	0	0	155,542	0	0	0	0	46.662
Somali	1,189	99,311	73,262	388	399	57	16	50.339
South Ethiopia Regional	209	47,017	32,800	101	134	28	12	21.175
South West Ethiopia	180	25,560	63,503	89	93	13	4	25.816
Tigray	324	118,407	188,384	238	290	80	36	84.646
TOTAL	**4,929**	**1,165,408**	**2,886,368**	**2,660**	**3,079**	**676**	**347**	**1,145.847**

Table 51: Distributed energy solutions distribution per region (scenario 2)

Region	Nb new localities	Nb SLS 11W	Nb SHS 50W	Nb SPS 1.5kW	Nb SCS 3kW	Nb SCS 6kW	Nb SCS 8kW	Investment (M US$)
Addis Ababa	0	0	0	0	0	0	0	0
Afar	335	26,464	19,686	90	84	15	7	12.922
Amhara	662	202,074	541,758	498	624	141	49	214.122
Benishangul Gumz	259	66,164	47,064	171	215	39	14	30.784
Central Ethiopia Regional	6	3,583	248,750	6	7	3	2	75.035
Dire Dawa	1	76	723	0	0	0	0	0.221
Gambela	176	6,224	4,389	19	16	3	1	2.725
Harari	0	0	2,428	0	0	0	0	0.728
Oromia	1,588	374,997	916,317	1,020	1,151	235	110	372.307
Sidama	0	0	121,232	0	0	0	0	36.369
Somali	1,189	240,750	176,605	557	632	132	118	115.415
South Ethiopia Regional	209	37,338	25,955	97	127	23	10	17.704
South West Ethiopia	180	20,303	49,694	77	85	10	3	20.652
Tigray	324	79,743	125,322	223	281	55	14	57.147
TOTAL	**4,929**	**1,057,715**	**2,279,924**	**2,758**	**3,222**	**656**	**328**	**956.136**

Off Grid electrification Investment per region

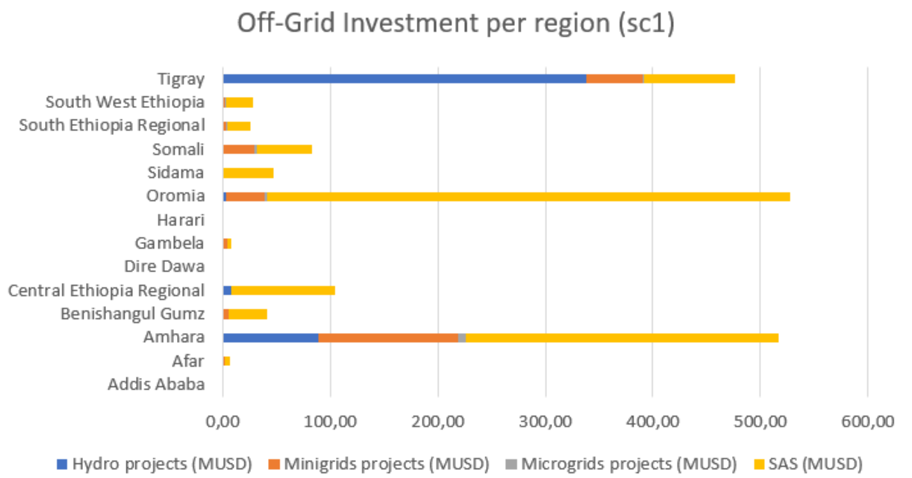
Finally, the total investment is resumed in the table below

Table 52: Off-grid electrification investment per region (scenario 1)

Region	Hydro projects (MUS$)	Minigrids projects (MUS$)	Microgrids projects (MUS$)	SAS (M US$)	Total Invest (M US$)	%
Addis Ababa	0.00	0.00	0.00	0.00	0.00	*0%*
Afar	0.00	1.69	0.51	4.06	6.26	*0%*
Amhara	88.56	129.74	7.60	290.56	516.46	*28%*
Benishangul Gumz	0.00	5.52	0.06	35.75	41.33	*2%*
Central Ethiopia Regional	8.22	0.00	0.02	96.71	104.95	*6%*
Dire Dawa	0.00	0.00	0.01	0.30	0.30	*0%*
Gambela	0.00	4.08	0.47	2.98	7.53	*0%*
Harari	0.00	0.00	0.00	0.49	0.49	*0%*
Oromia	3.52	35.86	1.91	486.36	527.65	*28%*
Sidama	0.00	0.00	0.03	46.66	46.69	*3%*
Somali	0.00	29.24	2.98	50.34	82.56	*4%*
South Ethiopia Regional	0.00	3.69	0.79	21.18	25.66	*1%*
South West Ethiopia	0.00	1.88	0.75	25.82	28.45	*2%*
Tigray	338.15	52.35	1.32	84.65	476.47	*26%*
TOTAL	**438.45**	**264.05**	**16.44**	**1,145.85**	**1,864.79**	*100%*

The Amhara, Tigray and Oromia regions would absorb most of the total investment (82%). Three others regions (Sidama, Somali and Central Ethiopia Regional) will also be particularly targeted (~13%).

Figure 26: Off grid electrification investment distribution per region

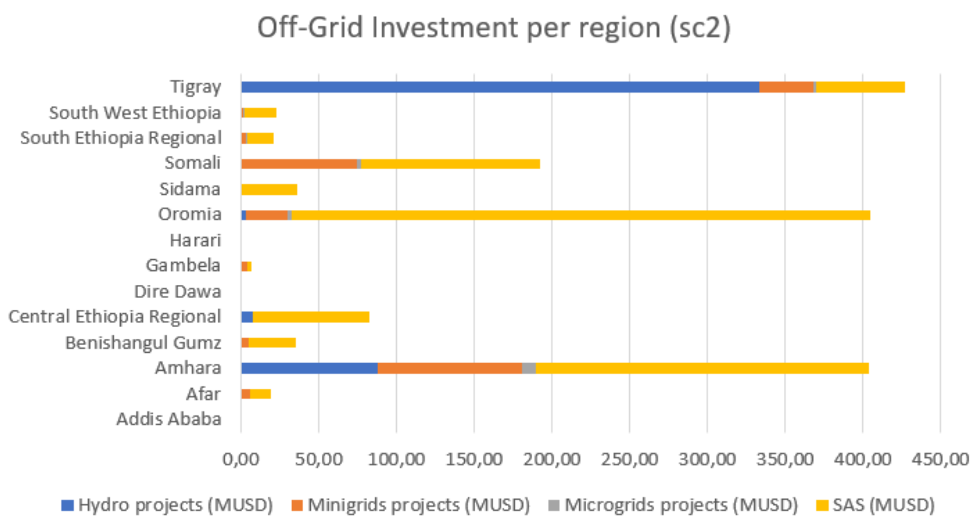


Regarding scenario 2, the results are presented in the below table.

Table 53: Off-grid electrification investment per region (scenario 2)

Region	Hydro projects (MUS$)	Minigrids projects (MUS$)	Micrgrids projects (MUS$)	SAS (M US$)	Total Invest (M US$)	%
Addis Ababa	0.00	0.00	0.00	0.00	0.00	*0%*
Afar	0.00	5.67	0.30	12.92	18.89	*1%*
Amhara	87.63	93.49	8.58	214.12	403.83	*24%*
Benishangul Gumz	0.00	4.71	0.05	30.78	35.55	*2%*
Central Ethiopia Regional	7.48	0.00	0.02	75.04	82.53	*5%*
Dire Dawa	0.00	0.00	0.01	0.22	0.23	*0%*
Gambela	0.00	3.75	0.46	2.73	6.94	*0%*
Harari	0.00	0.00	0.00	0.73	0.73	*0%*
Oromia	3.34	26.56	2.91	372.31	405.13	*24%*
Sidama	0.00	0.00	0.03	36.37	36.40	*2%*
Somali	0.00	74.73	2.53	115.42	192.67	*12%*
South Ethiopia Regional	0.00	3.05	0.72	17.70	21.48	*1%*
South West Ethiopia	0.00	1.49	0.70	20.65	22.84	*1%*
Tigray	333.14	34.65	2.22	57.15	427.16	*26%*
TOTAL	**431.59**	**248.10**	**18.54**	**956.14**	**1,654.37**	*100%*

Figure 27: Off grid electrification investment distribution per region



9. Institutional arrangement and setup

9.1 Institutional Framework

The achievement of NEP 3.0 targets will require a well-coordinated and capacitated institutional framework for the on-grid and off-grid market. Stakeholders in planning, financing, implementation and oversight will be required to have a seamless coordination framework over the timeframe of the NEP 3.0 avoiding duplication of roles and wastage of resources in an effort to cost-effectively attain electrification targets.

9.1.4 Ministry of Water and Energy (MoWE)

MoWE is the apex policy body for Ethiopia's energy sector, holding responsibility for national energy policy, sector strategy, target-setting, and oversight of the electrification program. MoWE also coordinates Ethiopia's international energy partnerships and is responsible for the legal and regulatory instruments governing the sector. Within MoWE's electrification framework, there are two key coordinated institutional arrangements in place as discussed below:

a. The High-Level Steering Committee for the NEP:
   The Committee, chaired by the Minister, is a cross-sectoral body with representation from the Ministry of Finance, regional governments, and development partners. It meets quarterly to review progress against targets and authorize major fund allocations.
   In the updated NEP 3.0 this Committee is envisioned to continue its work on project oversight and deliberations on electrification targets and progress on the following subject matters:
   - **Project Financing** – Concessional Loans (issuance and repayments), Grants, Government Disbursements.
   - **State of Implementation** of Grid and Off-Grid Electrification Projects, including progress to achieving national access targets
   - **Policy and Regulatory Support Instruments:** To solve challenges that hinder seamless electrification efforts. These include aspects like wayleave issues, compensation claims, procurement challenges and other government incentives.
   - **Authorization of Funding:** Authorize funding for agencies implementing electrification projects

b. The Directorate of Electrification (DoE)
   The Directorate of Electrification is the primary unit responsible for energy planning and NEP coordination as follows:
   - Planning and Stakeholder Coordination: Responsible for harmonizing technical, social and policy inputs for grid and off-grid connections rolled out under the NEP 3.0
   - Custodian of the national geospatial data platform,
   - Facilitates sector-wide monitoring through the National Energy Dashboard
   - Provides the secretariat for the High-Level Steering Committee.

   This Directorate is envisioned to be strengthened Under the NES through the establishment of a dedicated Compact Delivery and Monitoring Unit (CDMU), with and additional mandate of providing day-to-day coordination of NEP 3.0 implementation and interfacing with development partners.

9.1.5 Ethiopian Electric Power (EEP)

EEP is the state-owned enterprise responsible for electricity generation and high-voltage transmission. It owns and operates Ethiopia's hydropower plants, wind farms, and other generation assets, as well as the 20,390 km national transmission network. EEP also manages Ethiopia's growing cross-border power trade portfolio.

Under the NES, EEP has three priority mandates: expanding and reinforcing the transmission network from 20,390 km to 30,000 km by 2030; diversifying the generation mix — increasing non-hydro renewables from 5.6% to at least 15% of installed capacity by 2030; and developing and signing bankable Power Purchase Agreements (PPAs) with Independent Power Producers (IPPs), supported by partners with risk guarantee instruments to address currency convertibility and payment security concerns.

The NES is aligned to the NEP 3.0 with regard to the critical role of EEU in ensuring sufficient and reliable power supply to meet demand in the different regions of Ethiopia. Under the NEP the EEP's key roles will be:

a. Expanding and reinforcing the transmission network to enable the connection of 2.8 million households through grid extension.
b. Supporting the increased load from grid densification, grid intensification and grid extension resulting in an additional peak demand of over 1,200 MW.

9.1.6 Ethiopian Electric Utility (EEU) and the Universal Electricity Access Program (UEAP)

EEU is the primary implementing agency for Ethiopia's grid electrification program — responsible for planning, procurement, construction, operation, and maintenance of distribution networks, and for the commercialization of electricity to end consumers.

Within EEU, the Universal Electricity Access Program (UEAP) is the designated execution arm for large-scale distribution system extension, and rural electrification, including isolated off-grid systems through its Off-grid Unit (OGU). However, UEAP's current position as a third-level unit within EEU's hierarchy — preventing direct procurement, contract signing, or budget management without multiple layers of approval — leading to delays that result in gap between planned and achieved connections.

The elevation of UEAP to an Executive Implementation Office reporting directly to the CEO of EEU, with full administrative, financial, technical, and procurement autonomy. To be completed by end-2026 is a key pre-requisite to Ethiopia's access targets as it will allow UEAP to operate with the speed and accountability required. The Executive Office will have its own budget, a dedicated procurement unit, independent project management systems integrated with the national energy dashboard, and direct authority to engage contractors and certify project completion. There will be two directorates: one for grid-based expansion and the other for off-grid access provision (currently the OGU).

Under the NEP, the UEAP Executive Implementation Office will be responsible for:

a. Electrification Planning
b. Procurement and Construction of MV and LV lines
c. Development of Isolated Off-grid Systems through the Off-grid directorate
d. Connection of consumers to the national grid

9.1.7 Petroleum and Energy Authority (PEA)

PEA is the independent regulatory body for Ethiopia's energy sector, covering licensing, tariff review and approval, technical standard-setting, and consumer protection at both national and federal levels of government.

Under the National Electrification Strategy (NES), PEA's role is to be substantially strengthened with the following measures: establishing and enforcing comprehensive Quality of Service standards (SAIFI/SAIDI) with a penalty/incentive mechanism; deploying a smart monitoring system for outage data; licensing private mini-grid operators under a streamlined framework with clear grid arrival protection, elaborating the mini-grid directive; and advising MoWE on the phased tariff adjustment trajectory. PEA will also mandate independent third-party audits of EEU's outage logs and connection data, replacing self-reported statistics with verifiable certified performance data.

The role of PEA extends to the federal governments. REB's in sector regulation do not have regulatory powers/mandates that conflict with PEA. However, they participate in the development of policies or regulations during their initial drafting and implementation phases, ensuring that the needs of REB's on economic and social contexts are considered.

Under the NEP, the Petroleum and Energy Authority will be responsible for undertaking the following functions

a. Tariff approval for private mini-grid developers
b. Licensing private mini-grid operators under a streamlined framework with clear grid arrival protection instruments
c. Establishment and enforcement of comprehensive Quality of Service Standards (SAIFI/SAIDI) applicable to EEU.
d. Ensuring quality standards for off-grid distribution systems and appliances are adhered to in collaboration with the Ethiopian Standards Agency (ESA)

9.1.8 Reinstated Rural Electrification Fund (REF)

The REF was established under Ethiopian law to finance rural electrification and support off-grid energy access but is currently non-operational. Its reinstatement is an urgent priority to channel dedicated resources from the government and other sources to the Executive Implementation Office of the UEAP. The REF will be reconstituted as a permanent, ring-fenced financial mechanism governed by a Board drawn from MoWE, MoF and the EEU.

The key objective of the REF will be capital mobilization in accordance with the Rural Electrification Establishment Proclamation No. 317/2003, which provides the following funding mechanisms:

a. Budget Allocations from Local and Regional Governments
b. Loans and Grants from Development Partners
c. Grants from Non-Governmental Organizations
d. Income from other sources
e. 3%-5% of Electricity Sales by EEU

A competitively recruited central trust agent will be responsible for administration of the fund flow or loan facilities based on agreements made with MoWE, MoFED and EEU in the following manner:

a. Financing UEAP Grid electrification projects
b. Providing Results Based Financing Facilities to suppliers of off-grid appliances
c. Providing CAPEX and OPEX subsidies to Private Mini-Grid Developers

Based on key informant interviews undertaken by the consultants, only the World Bank and the Development Bank of Ethiopia actively funded the activities of the REF before its collapse after World Bank support ceased from in 2018[29]. It is therefore important for the REF to have a constant supply of funds that are predictable and sustainable. As such an addendum to the rural electrification

[29] Key Informant Interviews with former REF employee

establishment proclamation will be paramount to include a percentage of the electricity sales by the EEU to the scale of 3-5%, thereby creating a new source of sustainable revenue for the REF.

Based on a review of the successful experience of other countries, the sustainability of the REF highly depends on its financial and operational autonomy and as such it should be capitalized through a mandatory electricity sales levy of 3–5% on all EEU electricity sales (generating an estimated US$ 30–50 million per year), supplemented by government budget allocations, and concessional loans and grants from donors. The REF will operate with annual financial audits and public reporting of disbursements.

Table 54: Sources of Financing for rural electrification projects in selected countries

Country	Electricity Sales	Matching Fund	Development Partners	Other Sources
Ethiopia	Not Applicable	Budget allocations from local and regional governments	Active: World Bank and the Development Bank of Ethiopia	Grants from NGO's.
Kenya	5% levy on electricity sales	County and local government support on a shilling by shilling basis	Active: World Bank, AfDB, NorFund,JICA, EU, EIB, BADEA	Interest Income.
Zambia	3% excise duty paid by electricity customers	Annual national and local government disbursements	Active: World Bank	Interest Income
Nigeria	Not applicable	Budget Allocations from state governments, the federal government and local communities	Active: World Bank, AfDB ,JICA.	Surplus Appropriated, fines from the regulator, donations.
Tanzania	5% levies on commercial generation of electricity to the grid 5% levies on electricity sales on specified isolated systems	Annual Budgetary Allocations from the government	Active: World Bank, AfDB ,JICA.	Any fines obtained from the regulator, fees in respect of programs, publications, seminars etc.

Source: Consultant's Elaboration based on Benchmarking Studies.

9.1.9 Regional Energy Bureaus (REBs)

REBs provide the essential link between national planning and local realities. Under the NES, they have an expanded and formally defined role: providing "bottom-up" electrification priority data; coordinating land acquisition and community engagement (which have historically caused significant construction delays); and monitoring implementation quality of both grid and off-grid projects in their regions. To fulfil this expanded role, REBs will receive dedicated capacity building support and be formally integrated into the national energy data platform.

Under the NEP, the roles envisioned under NES for REB's will be adopted as follows:

a. Providing bottom-up electrification priority data
b. Coordinating land acquisition
c. Undertaking community engagement

9.1.10 Ministry of Finance and Economic Development (MoFED)

The ministry of Finance is expected to play a key role in financing coordination, fiscal oversight and engagement with development partners.

9.1.11 Development Partners

Development partners play a key role in financing access to electricity through concessional loans and grants, alongside governments, the private sector and customers. Ethiopia has benefited significantly from development partner support programs like the Universal Electricity Access Program (UEAP), Ethiopia Electricity Program (ELEAP), Access to Distributed Electricity and Lighting in Ethiopia (ADELE), Accelerating Sustainable and Clean Energy Access Transformation (ASCENT) and Distributed Renewable Energy-Agriculture Modalities (DREAM) among others.

The country's National Energy Compact (NEC) further recognizes the role of development partners in providing financing, technical assistance, capital mobilization, results-based financing and risk mitigation instruments for the country to achieve its targets on electrification, clean cooking, sustainable utilities, transmission and regional interconnection and private sector participation.

A harmonized framework for Development Partner coordination in financing and provision of technical assistance will be key to increasing electricity access cost effectively by eliminating fragmented approaches and duplication of efforts by stakeholders.

9.1.12 Ethiopia Investments Holdings

Ethiopian Investment Holdings (EIH) was established in December 2021, is dedicated to enhancing the performance and profitability of state-owned enterprises (SOEs) by strengthening their service delivery, safeguarding their legacy, and ensuring their success.

The firm, which owns both the EEU and EEP will be key in ensuring proper oversight of EEU and EEP in implementing NEP 3.0 targets by supporting their financial and operational reporting.

9.1.13 The Private Sector

The private sector is a critical partner in implementing off-grid solutions in rural and underserved communities. This concept is adopted in NEP 3.0 where the private sector is envisioned to be a key financier and implementing agent of off-grid electrification consisting of mini-grids and standalone PV systems connecting over 4.4 million households. The government on the other hand focuses on promotion of off-grid solutions to connect isolated public facilities such as schools, health centers and improving access to essential services in rural areas

Ethiopia has faced a series of constraints affecting private sector investments including, foreign exchange shortages, regulatory uncertainty and currency inconvertibility. A strict commitment to a comprehensive set of enabling measures — competitive procurement frameworks, de-risking instruments, and foreign exchange facilitation will therefore be a key pre-requisite to crowding-in private sector investments. Progress has however been made on a few of these aspects as described in the country's National Energy Compact. Macroeconomic reforms including foreign exchange liberalization, Investment climate improvements and better governance of state-owned enterprises have been undertaken and are collectively expected to enhance risk reduction for investors and open up new financing opportunities for energy infrastructure.

On regulatory uncertainty, despite significant progress made as discussed in section 7, identification of mini-grid sites for private sector development and the absence of grid arrival protection instruments remain a key obstacle. To crowd-in investments in the mini grid market, clear, transparent and enforceable regulations on technical and financial aspects of the mini grid framework should be in place. These include aspects on licensing procedures, tariffs and tariff build-up, incentives/subsidies and/or tax exemptions etc. This, however, must be complemented by stable macroeconomic and socio-political conditions in the country of operation.

Project developers typically require guarantees to enable the achievement of reasonable returns on their investments over the lifetime of their projects. Two such guarantees are the need for clear regulations on possible options available to developers due to early grid arrival, mitigating the huge risk of financial loss and clear taxes and incentives policies.

a. Taxes and Incentives

Tax incentives like waivers for certain categories of PV equipment and import duty exemptions play the role of indirect subsidies, reducing the financing burden of developers on capital costs therefore increasing their investment appetite. Such incentives can have a ripple down effect on the projects levelized cost of electricity is a key determinant of the resultant tariffs imposed to customers.

For Ethiopia, tax exemptions exist in the off-grid market, but only for standalone solar home systems (SHS). SHS with quality certificates are exempt from import duty but are subject to a 15% Value Added Tax and a 3% withholding tax. Extending this to mini-grid developers should be considered a key priority

Other key incentives are subsidy schemes to incentivize increased private sector participation while at the same time shield consumers from prohibitively high tariffs. Due to diseconomies of scale mini-grid developers charge higher tariffs in comparison to national utilities which also benefit from direct subsidies (government allocation) or indirect subsidies (cross-subsidization across different customer clusters). As such a certain level of incentives may be needed to make mini-grids affordable to rural customers. The government and development partners may support the private sector in the following manner:

Table 55: Incentives and Subsidy Mechanism

Instrument	Definition	Characteristics
CAPEX Grants	Refers to one-time grants awarded to developers to reduce their Capital Expenditures. Typically provided on a US $/Connection.	Mostly provided on a non-revolving basis
OPEX Grants	Refers to one-time or revolving grants awarded to developers to reduce their operating expenditures and are typically provided on a US $/Connection.	May or may not be on a revolving basis
Results Based Financing	An incentive structure in which payments are made to companies or directly to customers triggered ex-post by the delivery or installation of a given quota or an output	Increases liquidity to beneficiaries One of the Most adopted grants providing scheme in the off-grid sector
Reward Based Crowdfunding	A system in which entrepreneurs and early-stage companies raise funds to bring a product into the market	Mostly adopted for Productive Use Applications in the off-grid sector
Outcome based grants	Like RBF but mostly adopted for the implementation of PUE on operating mini-grids	

Source: own elaboration based on Funding the Sun: New Paradigms for financing off-grid solar companies.

b. Grid Arrival Regulations

Grid Arrival regulations are a key pre-requisite to crowding-in private sector investments. Provisions/Requirements on the following key aspects in the existing mini-grid directives should be added:

i. Point of interconnection and documentation requirements: A formerly defined Point of Interconnection (PoI) between EEU and the mini-grid.

ii. Protection and Safety Requirements: Requirements for anti-islanding and safety coordination
iii. Power Quality Requirements at the Point of Interconnection: Ensures that quality of electricity exported to or imported from the national grid complies with the power quality limits defined under the Ethiopia National Distribution Grid Code (ENDGC)
iv. Technical Conditions for supplying power to the National Grid (In the event the mini-grid is configured to supply power to the national distribution system): This considers synchronization capability, export operating parameters, protection and interface coordination and use of standard compliant equipment
v. Technical conditions for receiving supply from the National Grid (In the event the mini-grid continues operating as a local distribution network): This considers compatibility with LV voltage, coordinated protection between the parties' networks, adherence to grounding and earthing requirements and maintenance of internal voltage quality.
vi. Technical conditions for Asset Transfer and Inspection: Provides for the compensation framework in the event of EEU acquiring the mini-grids assets.

9.1.14 Ethiopian Solar Energy Development Association

The association was established to support the development of a conducive solar energy business environment, build industry capacity and promote widespread adoption of solar energy solutions across Ethiopia. Under the NEP 3.0 ESEDA will continue playing a key role as a lobby for driving the adoption of sustainable energy solutions, broadening rural electrification efforts and enhancing energy service delivery for underserved communities, fostering economic, social and environmental progress.

9.2 Roles and arrangements

9.2.1 Summary of Key Institutions and their Roles under NEP 3.0

The table below provides a detailed summary of the Institutions, key roles and high-level purpose as envisioned in NEP 3.0.

Table 56: Institutional key roles

Institution	Key Role	Purpose
Ministry of Water and Energy	a. High Level Steering Committee for NEP ○ Project Financing – Concessional Loans (issuance and repayments), Grants, Government Disbursements. ○ State of Implementation of Grid and Off-Grid Electrification Projects, including progress to achieving national access targets ○ Policy and Regulatory Support Instruments: To solve challenges that hinder seamless electrification efforts. These include aspects like wayleave issues, compensation claims, procurement challenges and other government incentives.	Oversight
	b. The Compact Delivery and Monitoring Unit (CDMU) under DOE ○ Development of the NEP based on least-cost geospatial analysis, ○ Custodian of the national geospatial data platform, ○ Facilitates sector-wide monitoring through the National Energy Dashboard, ○ Provides the secretariat for the High-Level Steering Committee. ○ Day-to-Day coordination of NEP 3.0 ○ Interface with development partners	Oversight, Monitoring and Evaluation

Institution	Key Role	Purpose
Ministry of Finance and Economic Development	Financing coordination, fiscal oversight and engagement with development partners.	Fiscal Support
Ethiopia Investment Holding	Key in ensuring proper oversight of EEU and EEP in implementing NEP 3.0 targets by supporting their financial and operational reporting	Support in Financial and Operational Reporting
Ethiopian Electric Power (EEP)	a. Expanding and reinforcing the transmission network to enhance grid expansion connecting 2.8 million households b. Supporting the increased load from grid densification, grid intensification and grid extension resulting in an additional peak demand of over 1,200 MW	Power Generation and Expansion of Transmission network
Ethiopian Electric Utility (EEU)	a. Universal Electricity Access Program (UEAP) Executive Implementation Office with two directorates: On-Grid and Off-Grid. Responsible for: ○ Electrification Planning ○ Procurement and Construction of MV and LV lines ○ Development of Isolated Off-grid Systems through the Off-grid directorate ○ Connection of consumers to the national grid	Implementing Agent of Grid Electrification and development of Isolated off-grid systems
Rural Electrification Fund (REF)	Provide capital mobilization in accordance with rural electrification establishment proclamation No. 317/2003. The following funding mechanisms adopted: ○ Budget Allocations from Local and Regional Governments ○ Loans and Grants from Development Partners ○ Grants from Non-Governmental Organizations ○ Income from other sources ○ 3% to 5% of Electricity Sales by EEU Note: An addendum to the rural electrification establishment proclamation will be paramount to include a percentage of the electricity sales by the EEU to the scale of 3-5%, thereby creating a new source of sustainable revenue for the REF. The Utilization of the REF: a. Financing UEAP Grid electrification projects b. Providing Results Based Financing Facilities to suppliers of off-grid appliances c. Providing CAPEX and OPEX subsidies to Private Mini-Grid Developers	Financing
Development Partners	Providing financing, technical assistance, capital mobilization, results-based financing and risk mitigation instruments for the country to achieve its targets on electrification	Financing and Technical Assistance
Private Sector	a. Responsible for Off-Grid Market Development connecting over 4.4 million households through: ○ Mini-Grids ○ Standalone PV Systems	Implementation of Off-grid Electrification
Regional Energy Bureaus	a. Providing bottom-up electrification priority data b. Coordinating land acquisition c. Undertaking community engagement	Community Engagement, Land Acquisition and data provision
Ethiopia Solar Energy Development Association (ESEDA)	Advocacy, collaboration facilitation, policy support, and capacity enhancement in driving electrification efforts in the off-grid market	Advocacy

Institution	Key Role	Purpose
Petroleum and Energy Authority (PEA)	a. Tariff approval for private mini-grid developers b. Licensing private mini-grid operators under a streamlined framework with clear grid arrival protection instruments c. Establishment and enforcement of comprehensive Quality of Service Standards (SAIFI/SAIDI) d. Ensure quality standards for off-grid distribution systems and appliances in collaboration with the Ethiopian Standards Agency (ESA)	Regulations and Standards Compliance

9.2.2 Future Considerations for the Development of an Independent Rural Electrification Authority

Note:
Based on the consultants' analysis, it is certain that EEU has the capacity to undertake the function of implementing electrification efforts using its dedicated and improved UEAP unit with on-grid and off-grid departments and therefore for this specific NEP 3.0, the function should be undertaken by EEU. However, the sustainability of the program in the long-run may require a dedicated Rural Electrification Authority, to specifically focus on the socioeconomic aspects of electrification in rural areas, leaving EEU the duty of focusing on commercial aspects of electricity distribution. A dedicated REA will be important in undertaking other functions like research and promotion of productive uses of electricity in rural areas.

The framework for the development of a Rural Electrification Authority is considered futuristic, i.e. To be implemented in the medium-to-long term period (5 to 10 years). A transition timeline will be required as it was for the case of Kenya. The availability of the rural electrification fund (REF) and its regulations provide a good transition starting point as the REF framework can be adapted to become a fully-fledged REA.

This section undertakes a benchmarking analysis of rural electrification authorities in selected Sub-Saharan African countries with an aim of understanding their main functions, sources of funding, their efficacy in implementing sub-economic rural electrification projects and collaborative frameworks with the private sector and utilities in both grid and off-grid electrification. It also reviews African countries which have achieved significant electricity access levels without the need of a dedicated REA, which is similar to Ethiopia's strategy. Afterwards, the consultant undertakes a Pros and Cons analysis of having a utility driven universal access to electricity program vis-à-vis having a dedicated rural electrification authority using benchmarks. Additionally, a comparative SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for Ethiopia in the event of adoption of a REA is undertaken.

a. Introduction

The need for a Rural Electrification Agency to support off-grid electrification and manage the rural electrification fund may be considered in the near future. While the existing mechanisms are deemed sufficient to enhance universal access to electrification, the sustainability of the mechanism should go beyond universal access to aspects of energy research and productive use applications.

In Sub-Saharan Africa, REAs have been widely established and have had varied mandates on electrification from grid expansion to provision of off-grid electrification through mini-grids and standalone PV systems. Some REAs have additional mandates on productive use, energy research and renewable energy development.

The table below provides a summary of the rural electrification agencies reviewed delineating their similarities, differences and unique features.

Table 57: Comparative Review of rural electrification agencies in Africa

Aspect	Kenya	Nigeria	Tanzania	Zambia
Legal Basis	Energy Act (1997, 2006, 2019); Energy Policy	Electric Power Sector Reform Act (2005); National Electric Power Policy (2001); Rural Electrification Policy (2009)	Rural Energy Act No. 8 (2005); Rural Energy Master Plan (2022/23–2029/30); RESP; National Energy Policy (2015)	Rural Electricity Act 2003
Rural Electrification Plans	Rural Electrification Master Plan, Kenya National Electrification Strategy	Rural Electrification Strategy and Implementation Plan	Rural Energy Master Plan, Rural Electrification Strategy and Plan	Rural Electrification Masterplan
Collaborative Framework	Works with Kenya Power (KPLC) via Service Level Agreement; counties provide land & funds; joint project identification	Coordinates with Ministry of Power, distribution companies, private developers; strong private sector role; REF subsidies	Works with TANESCO (national utility) for grid expansion; REA leads Beyond the Grid Access Program (BGAP) for remote areas	Collaborate with government, private sector, local authorities in rural electrification
Project Development	REREC develops assets, KPLC handles O&M, metering, billing; joint inspection & handover	REA invites bids, allocates REF subsidies competitively; technical directorate ensures compliance with standards	TANESCO implements NGAP (grid strengthening); REA implements RGAP (grid expansion) & BGAP (mini-grids, standalone PV)	Undertakes both grid and off-grid development
Funding Mechanisms	Rural Electrification Programme Fund (5% levy on electricity sales); Matching Fund Programme; development partner support; revenue from Garissa Solar (50MW)	Rural Electrification Fund (capital subsidies, grants); development partner support (World Bank, AfDB, JICA); private sector investment	Rural Energy Fund (levies up to 5% on generation, govt allocations, donor support); development partner loans & grants; private sector	Rural Electrification Fund, Local Constituency Development funds and development partners
Key Initiatives	LMCP, KEMP, KOSAP, Matching Fund Program	Nigeria Electrification Project (NEP), DARES Project	NGAP (grid alleviation), RGAP (grid expansion), BGAP (off-grid access)	ESAP (On-grid) OGESS (On-grid) PREP (On-grid) ORESS (Off-grid)
Impact / Electrification Rate	Rural electrification grew from 1% (1997) to 55% (2023); national access ~75%	Rural electrification grew from 15% (1993) to 32% (2023); supported millions of households & MSMEs	Targets: 100% access by 2030; 75% connectivity by 2030; currently expanding grid & off-grid	Targets 51% access by 2030
Unique Features	Matching Fund Programme with counties & constituencies; REREC owns rural grid assets; revenue from solar generation	Strong private sector participation: REF provides competitive subsidies; REA structured into specialized directorates	Integrated electrification & clean cooking strategy; levies on electricity generation fund REF; dual focus on grid & off-grid	Local Authority funding through CDF

Source: Consultant's elaboration based on benchmarking studies

It has been widely observed that Rural Electrification Authorities are key in ensuring equitable distribution of electricity in rural areas. Consequently, they are key enablers of, and drivers to the achievement of universal access targets in most economies. It's also important to note that a REA scheme is not the only model for rural electrification, countries like Morocco are perfect examples of the power of national utilities with dedicated rural electrification departments complimented by private solar concessionaires in achieving widespread rural electrification.

A particularly interesting case is Uganda whose REA transitioned from be autonomous to being a department within the parent ministry. Although the effects of this transition are yet to be felt, there are widespread concerns on the capacity of the ministry to undertake timely project approval and implementation and retaining a skilled rural electrification workforce.

b. Benchmark Countries

i. Kenya

Kenya's electrification scheme is distinctive, overseen by two companies: The Kenya Power and Lighting Company (KPLC) and the Rural Electrification and Renewable Energy Corporation (REREC). KPLC plans and develops the grid in economically viable zones (such as cities) and undertakes rural electrification in sub-economic electricity markets via a government-funded scheme commonly referred to as the Rural Electrification Scheme (RES). REREC, on the other hand, is mandated to undertake rural electrification albeit on a larger scale. Under both schemes, the task of operation and maintenance of rural electrification assets is undertaken by KPLC. Another key player is the administrative regions (county governments) in electricity reticulation. These regions have a partnership with REREC through provision of matching funds for electrification projects.

The REREC-KPLC collaborative scheme has been successful due to an existing legal framework established between the two utilities known as the supply level agreement (SLA). The agreement delineates the roles of each utility in rural electrification on the following aspects; identification of projects, project design, construction and commissioning of projects, operation and maintenance, asset ownership and development of off-grid power generation projects as delineated below:

a. Identification and Selection of Projects

Within this collaborative framework, the two utilities independently identify and select projects to be implemented, with the obligation to share information amongst each other to avoid duplication of efforts. While the system has not always been effective, rural electrification has grown tremendously with the involvement of the two firms from 1% in 1997 to 55% in 2023[30].

b. Project Design

REREC only undertakes asset development with KPLC undertaking functions of operation and maintenance as well as metering and billing for end use customers. As such the design process of the rural electrification scheme is highly collaborative, with some level of independence in the formative stages of project survey, obtaining wayleave, easements, consents, approvals and crop/property damage. The national utility (KPLC) reviews final design specifications for compliance with national standards prior to construction.

c. Construction and Commissioning of Projects

Both REREC and Kenya Power are responsible for construction of their selected projects. Once complete, a joint inspection of the projects is undertaken after which REREC hands over the project to KPLC with all relevant documents.

d. Operation and Maintenance of Commissioned Projects

KPLC is responsible for the operation and maintenance of all distribution assets after handover-the costs of which are recouped from the electricity tariff and via government annual budgetary allocations. This scheme has however proven to be unsustainable due to inconsistent and usually low government allocations year after year, making it hard for the utility to undertake its mandate optimally.

e. Asset Ownership

[30] Kenya National Electrification Strategy 2025

REREC owns the rural grid infrastructure on behalf of the Government of Kenya (GoK), implying that it takes charge of all assets related to rural electricity infrastructure. These assets are reflected in REREC's books of account as assets held in trust for the GoK.

REREC codes/marks all works, equipment and capital assets that are part of a project before handing it over to KPLC to differentiate them from works, assets and equipment belonging to KPLC.

f. Off-grid power generation projects

The cost of developing new off-grid power generation stations is provided by the GoK. REREC undertakes responsibility for their identification, design, construction and commissioning. The assets are then handed over to Kenya Power for O&M after joint inspection, testing and commissioning.
The table below delineates electrification initiatives implemented to date, with huge involvement by both REREC, Kenya Power and County governments.

Table 58: Sources and Impact of Electrification Projects in Kenya

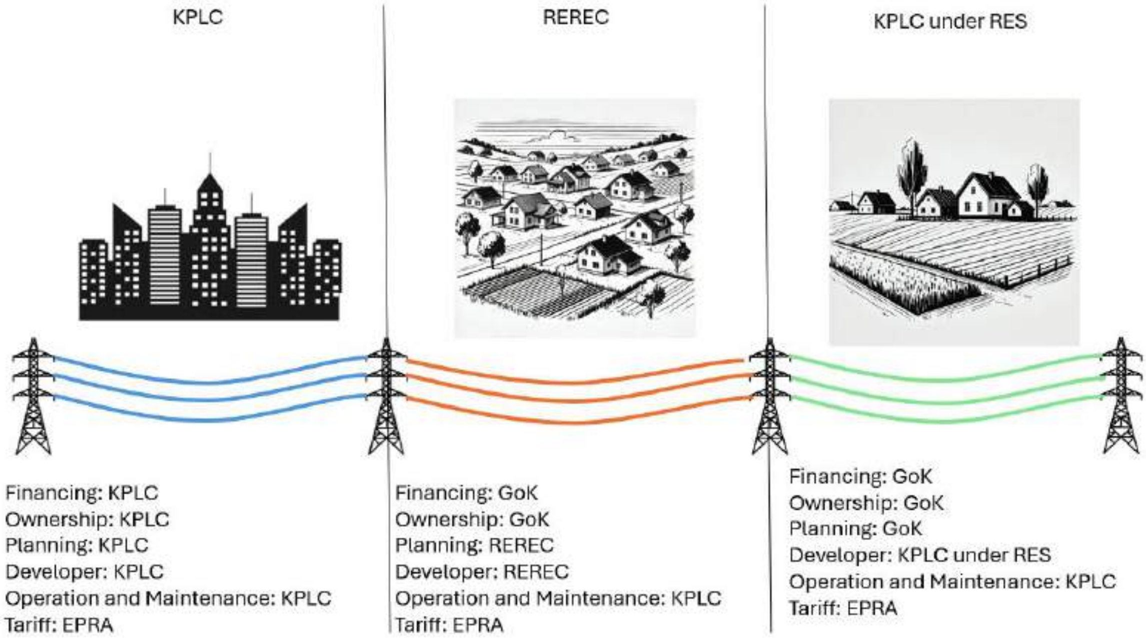
Initiative name	Start Year	Implementing Agency	Funders	Status	Households Connected
Last Mile Connectivity Program (LMCP)	2015	REREC,KPLC-RES	GoK, AfDB, WB, EIB, EU, JICA	Active	947,493
Kenya Electricity Modernization Project (KEMP)	2015	REREC,KPLC-RES	WB	Finished	816,531
Kenya Off-grid Solar Access Project (KOSAP)	2017	REREC,KPLC-RES	GoK, WB	Active	139,14331
Matching Fund Program (MFP)	2018	REREC/County Governments	REREC, County Governments, NG-CDF	Active	606 projects implemented

Source: Elaboration based on World Bank, Kenya Power, KOSAP and REREC

With regard to funding of projects, rural electrification projects benefit from a wide variety of funds and revenue sources enabling seamless development of projects in their pipeline. The Rural Electricity Program Fund (REPF) is the major source of financing legally provided through the Electricity Act. Other funding mechanisms include government disbursements, development partner programs and regional funds provided through a matching fund scheme. REREC also receives revenue from electricity sales as a power producer due to its 50MW solar power plant, which helps in financing its operations.

[31] As at 2022, 139,143 solar PV systems had been sold providing access to close to 700,000 people.

Figure 28: Kenya's Electrification Scheme



Source: own elaboration.

ii. Nigeria

The Rural Electrification Agency of Nigeria was established under the Electric Power Sector Reform Act of 2005 to promote and facilitate the provision of reliable, affordable and sustainable electric power to all rural and peri-urban communities in Nigeria, especially the unserved and underserved ones. The REA's vision is to empower these communities with electricity, lifting them out of energy poverty and fostering economic prosperity. The REA is the implementing agency of the country's National Electrification Project (NEP).

The REA plays more of a coordinator role, focusing on off-grid electrification providing financial and technical support to developers of decentralized energy systems like mini-grids and standalone systems. This is unlike Kenya, who's agency doubles up as a grid developer in addition to supporting off-grid projects.

The scheme adopted by REA has proven to be effective on project implementation, with huge private sector participation in decentralized power development, leading to electrification of households, medium and small sized enterprises and learning institutions as seen from the DARES and NEP projects.

Table 59: Status and Impact of Electrification Projects in Nigeria

Initiative	Year	Implementing Agency	Funders	Status	Impact on Electrification
Nigeria Electrification Project	2018	REA	World Bank, REA, AfDB, Private Partners	Active	a. 600,000 Households b. 4,795 MSMEs c. 7 universities d. 2 teaching hospitals
DARES Project	2022	REA	WB, JICA Private Partners, REA	Finished	a. 3,244,900 Households b. Additional Capacity 465 MW c. 236,986 MSMEs

Source: REA-Nigeria.

Funding schemes are largely provided through public finance with development partner support and the existence of a legally established fund like the Rural Electrification Fund (REF) providing capital subsidies and financing for project developers. This is similar to Kenya's own model, with one stark difference, in the former, the REF is not a levy provided as a percentage of electricity sales in the tariff mechanism.

iii. Tanzania

The Rural Energy Agency (REA) of Tanzania, was established vide the Rural Energy Act No. 8 of 2005 as an autonomous institution to promote and facilitate access to modern energy services in rural areas of Mainland Tanzania. The core function of the Agency is to provide grants, subsidies, technical assistance, training and capacity building to rural energy project developers.

Similar to Kenya and Nigeria, the agency partners with the private sector, non-governmental organizations (NGOs) and community-based organizations (CBOs) to mobilize the funds necessary to undertake its mandate.

Tanzania adopts a collaborative approach in rural electrification, largely spearheaded by the rural energy agency (REA) and the national power distribution utility, TANESCO. This electrification model is similar to that of Kenya with one major difference, the administrative regions don't play a significant role.
REA is however not only implementing grid connected projects but is also active in the off-grid space working hand in hand with private sector developers for establishment of mini-grids and standalone PV systems, providing subsidies via the rural electrification fund. This model is similar to Kenya's KOSAP projects as well as Nigeria's. DARES projects providing subsidies, results-based financing facilities and technical assistance to off-grid project developers.

Table 60: Status and Impact of Electrification Projects in Tanzania

Initiative	Implementing Agency	Funders	Status	Impact on Electrification
Rural Electrification Densification Project Round I, II and III	REA	World Bank, REA, AfDB, Private Partners	Active	a. REDP I: 33,102 Households b. REDP II: 3,924 villages c. REDP III: 37,610 villages (Ongoing)
REA 3 Round 1 and 2	REA	WB, JICA Private Partners, REA	Active	d. REA 3 Round 1: Completed e. REA 3 Round 2: Ongoing-Targets 3,748 villages
Turnkey III Phase 1 and 2	REA	World Bank, REA, AfDB, Private Partners	Active	f. Turnkey Ph. 1&2: 7,416 villages connected

Source: Adapted from World Bank32 and REA-Tanzania.

With regard to funding of projects, rural electrification projects benefit from a wide variety of funds and revenue sources enabling seamless development of projects in their pipeline. The rural electrification fund (REF) is the major source of financing legally provided through the Rural Energy Act of 2005. Other funding mechanisms include government disbursements, development partner programs and regional funds provided through a matching fund scheme.

iv. Zambia

The Rural Electrification Authority (REA) of Zambia was created in 2003 by an act of Parliament as a special purpose vehicle (SPV) to increase electricity access in rural areas. Similar to Kenya and Tanzania, the authority adopts both on-grid and off-grid electrification options including grid expansion and mini-grid development. The key functions of the Authority pursuant to section 5(1) of the REA Act are:

[32] Tanzania Rural Electrification Expansion Program (IDA Credit No. 72110-TZ P153781) and The TZ-Accelerating Sustainable and Clean Energy Transformation Program (ASCENT-TZ) (IDA Credit No. 7456-TZ P179631) Implementation Support Mission, December 2 - 6, 2024

- Promote the utilization of available rural electrification technological options.
- Develop mechanisms for the procurement of grid extension networks, on-grid and off-grid systems, for rural electrification
- Implement the rural electrification masterplan
- Administer and Manage the Rural Electrification Fund
- Mobilization of funds within and outside the country
- Designing and offering developers or operators, on a competitive basis, smart subsidies for capital costs on projects.
- Finance project preparation studies for rural electrification projects in accordance with guidelines developed by the Authority
- Coordinate rural electrification with the private sector, non-governmental organizations and any other party involved in rural electrification

Zambia adopts a collaborative approach to rural electrification, largely spearheaded by the Rural Electrification Authority (REA), private sector players and local authorities. This electrification model is similar to that of Kenya with one major difference, the national utility does not play a major role

Similar to Tanzania and Kenya, REA not only implements grid connected projects but is also active in the off-grid space working hand in hand with private sector developers for establishment of mini-grids and standalone PV systems, providing subsidies via the rural electrification fund.

Table 61: Status and Impact of Electrification Programs in Zambia

Initiative	Implementing Agency	Funders	Status	Impact on Electrification
Electricity Service Access Project	REA	World Bank,	Active	• 22,000 Households • 1,000: MSEs connected
On-Grid Electricity Access Expansion	REA	World Bank	Active	• 70,554 households connected
The Off-grid Rural Electrification Smart Subsidy Project	REA-Subsidies	World Bank,	Active	• 4 small mini-grids developed • 746 SHS distributed
Accelerating Sustainable and Clean Energy Access Transformation	REA	World Bank	Active	• 1,000,000 beneficiaries
Priority Rural Electrification Projects	REA & Local Authorities	REA and Local Authorities		• 142 MoU's signed • 155 priority areas submitted by local authorities • 1 Project completed

Source: REA-Zambia annual report 2024

With regard to funding of projects, rural electrification projects benefit from a wide variety of funds and revenue sources enabling seamless development of projects in their pipeline. The rural electrification fund (REF) is the major source of financing legally provided through the Rural Electrification Fund. Other funding mechanisms include government disbursements, development partner programs, and local funds provided via the constituency development fund (CDF) kitty.

v. Morocco

Rural electrification in Morocco rapidly increased from 18% in 1990 to almost 100% by 2020 with a combination of grid electrification (90%) and off-grid electrification by use of Solar Home systems covering the remaining 200,000 households (10% of the population) which resided in remote and sparsely populated rural areas.

The country has a unique model of electrification spearheaded by the national utility known as the Office National de l'Électricité- ONEE (National Electricity Company) and solar concessionaires. The electrification scheme focused on grid extension, complemented by solar driven electrification programs in grid-infeasible areas in the beginning of the 21st century.

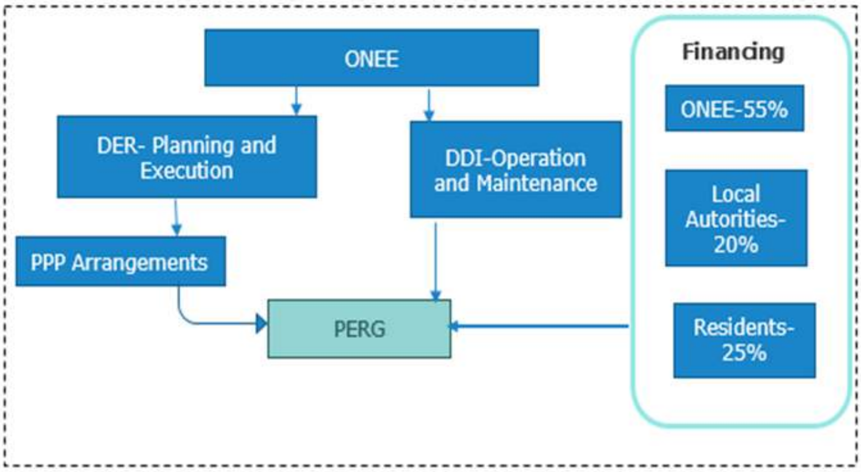
Morocco's success in rural electrification was bolstered by strong political support in favor of solar PV systems, leading to actionable policies and frameworks; availability of donor financing schemes, private funding support and government led incentives to the Office National de l'Électricité- ONEE (National Electricity Company) and solar concessionaires. Incentives like cross-subsidies and direct public subsidies adopted by the government eased connectivity costs creating greater connectivity among rural households.

Additionally, the development of national rural electrification strategies with ambitious targets and strict adherence by the implementing agencies complemented by strong government support initiatives were key to the successful attainment of 100% national electricity access in the country. One such program was the Global Rural Electrification Programme (PERG).

The PERG, which was to run for a period of 15 years, was expected to connect 100,000 households annually and achieve an overall connectivity of 90% by 2010. It was prepared in a least-cost spatially optimized manner that incorporated grid extension, mini-grids and solar home systems, wind plants and micro-power stations. The framework of the PERG was optimally developed, with a comprehensive engineering design based on surveys which enabled ONEE to have a detailed GIS database for all rural communities and villages in the country.

To enable proper coordination and implementation of the PERG, ONEE developed a dedicated rural electrification department (DER) and a department for Electrical Distribution (DDI). The DER was responsible for overseeing project planning and execution from bidding to full completion while DDI was responsible for operation and maintenance of the projects. Local councils and authorities played an important role in this system including co-financing projects, providing all permits and facilities required for implementation, mitigating and managing local conflicts and sensitizing villagers to electricity use and the related safety measures.

Figure 29: The PERG Framework and its key players



Source: own elaboration based on "JICA Morocco Rural Electrification Project Evaluator-2007" and IsDB Morocco-2013".

It is important to note that partial payments for the connection costs were allowed under the PERG system. This is one of the earliest representations of PAYGO mechanisms in electrification in Africa. Households were given an option of paying the costs over a period of 7 years through monthly instalments of not exceeding 5 dollars.

Each of the five stages of the PERG had its own model of application with ONEE connecting households with connection costs below 27,000 Dh (US$ 2,000), and solar concessionaires providing solar PVs to all remaining households. The maximum costs for grid connection were later revised to 50,000 Dh in stage 5 of the PERG in 2009.

In the above scheme, construction, management and operation of infrastructure for all grid-based projects were the responsibility of ONEE. Whereas for off-grid projects, the implementation, construction and management were left to private operators who had been granted 10-year territorial concessions upon winning internationally tendered bids under a Public Private Partnership (PPP) framework with ONEE. ONEE's role in the off-grid projects was largely minimized to organization, planning and monitoring.

The PPP contracts for rural electrification adopted a fee-for-service model under a build-operate-transfer system whose framework involved installation and maintenance of the infrastructure by the private concessionaire for 10 years and remunerated based on a PAYGO system. Under the PAYGO mechanism, consumers would commit to pay a one-off connection fee and a monthly fee depending on their installation's size. Families were given an option of paying off the charge for their initial connection over a period of seven years through monthly instalments of less than 5 dollars. A pre-paid card was issued to them to be credited through recharging networks in the area.

It is important to note that the electrification plan required customers to pay for 25% of the overall investment costs of electrification with the ONE catering for 55% and the local commune covering 20%.

Table 62: Key stakeholder responsibilities under the PPP-concession model

	ONEE	Developers	Consumers
Duties	• Oversight • Owner of all installations	• Marketing and Client Identification • Signing subscription contracts • Buying and installing all PV system components • After-sales service and renewals • Revenue Collection • Environmental Control	• Committed Connectivity and monthly payments

Source: own elaboration based on Reaching Universal Access in Morocco, 2020.

vi. Uganda

Similar to Kenya, Nigeria, Zambia and Tanzania, Uganda had a dedicated and autonomous rural electrification agency, legally constituted and with its own budget. It was later dissolved and its operations merged under the Ministry of Energy and Mineral Development (MEMD) to streamline operations, pursuant to the Electricity (Establishment and Management of the Rural Electrification Fund) Instrument, No. 29 of 2021

The decision to disband REA was part of a wider government program to undertake a comprehensive review and restructuring of the government Ministries, Departments and Agencies (MDA's). The government's goal was streamlining MDAs thereby eliminating overlapping mandates, duplication of roles, institutional rivalry and wastage of resources and harmonize the terms and conditions of services throughout the MDA's.

The REA had been established in 2003 to increase the pace of rural electrification by implementing the Rural Electrification Strategy and Plan (RESP) 1 and 2. By 2016, REA had extended over 10,000 km and 7,000 km of medium and low voltage electricity distribution lines increasing rural electrification from 3.3% to 12% in 2016, and later to 26% in 2021.

The effects of the policy decision on this restructuring are yet to be felt, but there are widespread concerns over whether the decision was well informed with proper background research on all agencies, especially the REA. This was well reiterated in the country's national electrification study (NES) of 2021. The key concerns are as follows:

- Operating REA as a department within MEMD may affect its efficiency and performance in that the turnaround time for decision making process will be longer due to the bureaucracy associated with government ministries and civil structures.
- Project implementation could also be slower because a semi-independent REA could set up technical project implementation teams with all relevant professionals (technical, legal, finance) under one roof which may be hard for MEMD.
- REA could attract and retain more qualified and skilled staff than MEMD due to better working conditions compared to those in the civil service.

c. Utility driven Electrification versus Electrification via a Dedicated REA

The choice of mode of electrification either via a utility or via a combination of the utility and a dedicated rural electrification authority is highly dependent on the utility's ability and capacity to objectively undertake the function, with backing from the government and development partners. It is also worth noting that the utility is usually faced with competing interests, with an incentive to connect economic over sub-economic areas due to economies of scale and as such, a dedicated rural electrification department that is well-funded and capacitated to cater for electrification in sub-economic schemes is important. This is the case for Morocco, Uganda and Ethiopia.

For utility driven electrification, development partners who fund a majority of the projects need to have an assurance that the funds are dedicated to their intended purpose. Otherwise, the development of a dedicated REA will be preferred. The REA plays an important role as an independent agency whose sole purpose is electrification and as such mobilizing resources for electrification and private sector support for off-grid activities through subsidies and results-based financing schemes is usually easier as seen in the assessments above for Kenya, Zambia, Nigeria and Tanzania.

Setting up a REA will however require regulatory, technical and financial arrangements and may take up resources (time and finances) that could otherwise be used on electrification itself. A cost-benefit analysis may be required by the policy makers in Ethiopia before resorting to developing a dedicated REA. The steps for a REA development in Ethiopia are delineated in the figure below:

Table 63: Required steps for the development of REA in Ethiopia

Aspect	Description
Clear legal and Institutional Framework	All reviewed countries had one thing in common, a legal and policy framework establishing their Rural Electrification Agency (REA). Such frameworks establish the mandate and scope, its board of directors, role of the Chief Executive Officer, staff and funding for REA
Clear Policy and Planning Framework	The development of national and rural electrification master plans is key to determining the direction of rural electrification in any country, regardless of whether or not a REA is in place. The plan should be GIS specific with clear targets for grid and off-grid electrification, costs per connection and timelines for their achievement. The plan should also have a financing mechanism for pooling resources for its achievement clearly delineating the role of the government, development partners, private players and local consumers.
Clear Transition Framework	A specific time-frame will be required for the establishment and operationalization of the rural electrification agency. A proper transition framework from the current model of rural electrification to an Agency led mechanism is therefore of extreme importance. For a start, members from the technical staff of the EEU in charge of rural electrification can be transferred to the REA to enable knowledge transfer and skills development in this new agency. Further, REA can commence collaborating with EEU in implementing rural electrification projects for a period of time until its deemed ready to fully take on project development and implementation. Such a scheme was implemented in Kenya when Kenya Power and REREC developed and signed a legally binding Service Level Agreement in 2010 with the aim of formalizing their relationship and clearly develop the roles of each party with

	respect to implementation, operations and maintenance of Rural Electrification project
Clear funding mechanism for rural electrification projects	The funding requirements for the operations of the REA should be well established from the legal texts establishing the REA. As seen from the review of the benchmarked countries, they may range from: i. Government through annual budgetary allocations; (All countries) ii. Contributions (loans and grants) from International Finance Organizations, Multilateral Bilateral Agencies and other Development Partners (All countries) iii. Levies on up-to a certain percentage on the commercial generation of electricity to the national grid; (Nigeria, 5%) iv. Levies of up to a certain percentage on the generation of electricity in specified isolated systems including systems for private consumption;(Nigeria, 5%) v. Levies of up-to a certain percentage on the excise duty charged on the electricity bills (Zambia, 3%) vi. Levies of up to a certain percentage on the electricity purchased by customers (Kenya, 5%) vii. Fees in respect of programs, publications, seminars, consultancy services and other services provided by the agency; (Kenya, Nigeria, Tanzania) viii. Any fines obtained by the Regulator (Kenya, Nigeria, Tanzania)

d. SWOT Analysis: Existing system vis-à-vis Development of a dedicated REA

The tables below provide an analysis of the strengths, weaknesses, opportunities and threats to the implementation and operationalization of a Rural Electrification Agency in relation to the current institutional arrangement of electrification by EEU. This provides further clarity to the key aspects that are currently working and those that need improvement or that may justify the development of a dedicated REA.

Table 64: SWOT Analysis for the development of a dedicated REA

Strengths-Case for Current System

Key Aspect	Description
Effective Planning	**Ethiopia Electric Utility** The EEU Developed the Program Management Office (PMO) to strengthen managerial level oversight of national electrification Adopted best practices in planning and electrification rollout with annual electrification plans detailing logistical, procurement and technical priorities in the delivery of grid connections **Ministry of Water and Energy** Has a dedicated Electrification and Energy Information Lead Executive Office responsible for electrification, rural electrification fund management and coordination of government and non-government electrification activities.
Strong Development Partner Support	The two institutions have demonstrated the ability to implement electrification projects and as such, Development Partners like the World Bank have confidence in their ability to undertake such projects.
Procurement Standards	Both institutions have well established procurement standards for all program related activities including contract management, complaint resolution and record keeping

Weaknesses-Case for REA

Key Aspect	Description
Weak Financial Management	**Ethiopia Electric Utility** Significant delays by the Board of EEU in budget approvals **Ministry of Water and Energy**

	Significant staffing constraints and lags in the utilization of the budget set aside for electrification programs. In this case, ELEAP.
Strained Institutional Capacity	Overstretched capacity for undertaking electrification at both MoWE and EEU. However, efforts have been made to increase the workforce in both institutions

Opportunities- Case for REA

Key Aspect	Description
Collaborative Approaches to Financing	Management of the Rural Electrification Fund, mobilizing resources from both the local, federal government, the private sector and development partners. The REA can even develop its own projects for sustainable revenue generation.
Efficiency in performance	A well developed and capacitated REA with adequate resources can be able to plan and implement electrification projects with ease without unnecessary bureaucratic hurdles as all activities relating to electrification are bundled in one firm. Just like Nigeria, several departments have to be developed in REA to enable effective management and efficient allocation of resources.
Faster Project Implementation	A well developed and capacitated REA with adequate resources can be able to implement electrification projects with speed as this is their only area of focus. The vision of a REA is always tied to equitable electricity access and community empowerment and its undeterred on issues of profit maximization

Threats- Case for REA

Key Aspect	Description
Overlapping Mandates with EEU	Without a proper service level agreement, like in the case of Kenya. EEU and the newly formed REA might find themselves having overlapping mandates and duplicating efforts. This is what led to the merging Uganda's REA with its parent ministry
Long Project Development Lead Time	There may be a long lead-time for the development and operationalization of a rural electrification agency. This involves legal processes, funding requirements and staff recruitment and capacity building trainings

10. Financial Analysis

10.1 Financing Requirements

Despite the progress achieved in recent years in electrification, Ethiopia continues to face significant challenges in terms of energy access. Approximately 65% of the population currently has access to electricity; however, substantial disparities persist between urban and rural areas. In rural areas, where the majority of the population resides, access levels are considerably lower, meaning that tens of millions of people still lack modern electricity services. This context highlights the need to significantly accelerate the expansion of the power system, both through grid extension and through decentralized technologies tailored to dispersed populations.

The primary objective of the NEP is to achieve universal access to electricity by 2035, ensuring that all households in the country have at least a basic level of electricity service in accordance with the criteria established by the World Bank's Multi-Tier Framework (MTF). This framework defines different levels of energy access based on capacity, quality, and reliability of electricity supply. The program aims to guarantee, at a minimum, access to initial service levels, with the broader goal of improving living conditions, supporting economic development, and strengthening the provision of social services such as education, healthcare, and water supply.

To achieve this target, the program estimates that the total number of electricity connections must increase substantially over the next decade. Under the high-growth and system expansion scenario (Scenario 1), the country is projected to reach approximately 36.8 million electricity connections by 2035, while under a more conservative scenario (Scenario 2), the figure would be approximately 28.1 million connections. These targets represent a significant increase compared to current levels and require the implementation of approximately 3.6 million connections per year in Scenario 1 and 2.8 million connections per year in Scenario 2 throughout the program period.
The program adopts a planning approach based on the principle of least-cost electrification. To this end, the GEOSIM geospatial model is used to identify, for each locality in the country, the most economically efficient technological alternative. The model analyzes variables such as distance to the existing electricity grid, population density, community size, estimated electricity demand, and the availability of local energy resources. Based on this analysis, it determines whether electrification in a given locality should be carried out through grid extension or decentralized solutions.
In general terms, the NEP electrification strategy is based on a hierarchy of interventions that prioritizes the use of existing infrastructure before resorting to more capital-intensive investments. In this regard, the plan first considers the regularization of existing connections that currently operate informally or without metering. It then promotes grid densification in areas that already have infrastructure but where unconnected households still exist. The third level involves grid intensification, consisting of extending infrastructure to communities located near the existing system. The fourth level includes grid extension to more remote localities. Finally, in areas where grid expansion is not economically viable, off-grid solutions—primarily based on solar technologies—are implemented.

The implementation of this strategy requires substantial investment. The program estimates that achieving universal electrification will require between US$ 12.9 billion and US$ 18 billion, depending on the demographic and electricity demand growth scenario considered (Scenarios 2 and 1, respectively).

A summary of investments by type and scenario is presented below:

Table 65: Investments Summary

Type of investment	Investments (M$US)		On-grid / off-grid
	Scenario 1	Scenario 2	
Densification projects	11,737.994	7,641.107	On-grid
Regularization	249.931	249.931	On-grid
Intensification	1,312.955	1,012.236	On-grid
Grid extensions	2,922.007	2,297.531	On-grid
Mini Hydro powered mini-grids (MHP-MG)	438.451	431.591	Off-grid
Solar powered mini-grids (PV-MG)	264.049	248.101	Off-grid
Solar powered micro-grids (PV-MG)	16.442	18.540	Off-grid
Distributed Energy Solutions	1,145.847	956.137	Off-grid
Total	**18,087.676**	**12,855.174**	

Source: GME-IED

The regularization of connections consists of formalizing electricity connections that physically exist but are not officially registered or lack individual metering. This intervention involves installing meters, formalizing users, and standardizing shared or informal connections. The program plans to regularize approximately 3.8 million connections through this mechanism, with a total estimated investment of around US$ 250 million. Since it leverages existing infrastructure, this modality has the lowest unit cost in the program, estimated at approximately US$ 65 per connection.

On the other hand, grid densification represents the largest share of connections within the program. Densification refers to connecting households located in areas that already have access to the electricity grid but where many potential users remain unconnected. This strategy makes use of existing infrastructure by installing new low-voltage lines, additional transformers, and metering equipment. The program estimates that, under Scenario 1, approximately 18.75 million new connections will be made through this mechanism, and 12.24 million under Scenario 2, with total investments of approximately US$ 11.7 billion and US$ 7.64 billion, respectively. The average cost is estimated at around US$ 625 per connection.

Grid intensification is also considered. This type of investment applies to communities located relatively close to the existing grid, typically at distances between one and two and a half kilometers. Intensification involves the construction of additional medium-voltage lines and local distribution networks to connect nearby communities that do not yet have electricity supply. The program foresees approximately 1.79 million connections under Scenario 1 and 1.34 million under Scenario 2 through this modality, with estimated investments of about US$ 1.31 billion and US$ 1.01 billion, respectively. The average cost of this type of connection ranges between US$ 733 (Scenario 1) and US$ 756 (Scenario 2) per user.

The next on-grid component corresponds to grid extension to more remote localities. This type of intervention applies to communities located approximately between 2.5 and 25 kilometers from the existing grid. Grid extension requires the construction of new medium-voltage lines, distribution substations, transformers, and low-voltage networks to supply new users. The program plans to connect approximately 3.75 million households under Scenario 1 and 2.82 million under Scenario 2 through this strategy, with total estimated investments of approximately US$ 2.9 billion and US$ 2.3 billion, respectively. The average cost per connection ranges between US$ 778 (Scenario 1) and US$ 816 (Scenario 2).

In addition to grid expansion, the program includes a significant component of electrification through decentralized or off-grid solutions. These solutions are particularly relevant in remote rural areas where low population density and long distances make grid expansion economically unfeasible. The geospatial analysis conducted under the program identified approximately 5,786 localities that cannot

be electrified through the national grid within the program horizon. In these communities, off-grid technologies adapted to local conditions will be implemented.
The off-grid solutions considered in the program include three main types of technologies: renewable mini-grids, micro-grids, and standalone solar systems.

The off-grid component of the program will require a total investment of approximately US$ 1.864 billion. Of this amount, around US$ 1,145 million will be allocated to standalone solar systems, US$ 438 million to mini hydro-powered mini-grids, approximately US$ 264 million to photovoltaic mini-grids, and about US$ 16.4 million to photovoltaic micro-grids. These investments will enable the electrification of approximately 4.39 million households through decentralized solutions.
The on-grid and off-grid investment figures are summarized in the table above.

Table 66: On-grid and Off-grid Investments per scenario

Type of investment	Investments (M US$)	
	Scenario 1	Scenario 2
On-grid	16,222.888	11,200.806
Off-grid	1,864.789	1,654.369
Total	**18,087.676**	**12,855.174**

Source: GME-IED

These figures, which were initially presented as aggregate amounts, have been disaggregated on an annual basis over the ten-year period covered by the National Electrification Plan (NEP), applying the following assumptions:

- For all investment categories, except Regularization, Micro and Mini Hydro Powered Mini-Grids (MHP-MG), and Distributed Energy Solutions, the investments approved for 2026 and 2027—corresponding to the final two years of the current tariff period for EEP and EEU—have been adopted. In addition, 40% of the investment amounts recognized through 2025 have been added, reflecting implementation delays reported by EEU during project meetings. For 2028, investment levels are assumed to increase by 33% under Scenario 1 and remain unchanged under Scenario 2 relative to 2027 levels. Thereafter, investments are assumed to grow by 10% in Baseline scenario 1 and 6% in scenario 2 annually.
- The Regularization component is assumed to be implemented during the first five years of the plan, with equal annual investment amounts allocated to each year.
- For Micro and Mini Hydro Powered Mini-Grids (MHP-MG), it is assumed that 1% of the total proposed investment will be implemented in the first year, 5% in the second year, and the remaining balance will be distributed evenly across the subsequent eight years.
- For Distributed Energy Solutions, annual investment levels are assumed to remain approximately constant at US$ 52 million for the two initial years and around US$ 130 million in scenario 1 and US$ 107 million in scenario 2 for the next years.

Table 67: Annual investments

Scenario 1	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
Densification projects	477,211	692,987	924,091	1,016,500	1,118,150	1,229,965	1,352,961	1,488,257	1,637,083	1,800,791	11,737,994
Regularization	49,986	49,986	49,986	49,986	49,986						249,932
Intensification	53,379	77,514	103,364	113,701	125,071	137,578	151,336	166,469	183,116	201,428	1,312,955
Grid extensions	118,795	172,509	230,039	253,043	278,347	306,182	336,800	370,480	407,529	448,281	2,922,007
Mini Hydro powered mini-grids (MHP-MG)	4,385	21,923	51,518	51,518	51,518	51,518	51,518	51,518	51,518	51,518	438,450
Solar powered mini-grids (PV-MG)	24,951	15,593	27,938	27,938	27,938	27,938	27,938	27,938	27,938	27,938	264,050
Solar powered micro-grids (PV-MG)	1,553	971	1,739	1,739	1,739	1,739	1,739	1,739	1,739	1,739	16,440
Distributed Energy Solutions	52,000	52,000	130,231	130,231	130,231	130,231	130,231	130,231	130,231	130,231	1,145,850
Total (000 USD$)	**782,260**	**1,083,482**	**1,518,907**	**1,644,657**	**1,782,981**	**1,885,152**	**2,052,524**	**2,236,634**	**2,439,154**	**2,661,927**	**18,087,678**

Scenario 2	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
Densification projects	453,116	657,997	657,997	697,968	740,368	785,343	833,050	883,656	937,335	994,276	7,641,107
Regularization	49,986	49,986	49,986	49,986	49,986						249,932
Intensification	60,025	87,166	87,166	92,462	98,078	104,036	110,356	117,060	124,171	131,714	1,012,236
Grid extensions	136,243	197,847	197,847	209,865	222,614	236,137	250,482	265,698	281,838	298,959	2,297,531
Micro and Mini Hydro powered mini-grids (MHP-MG)	4,316	21,580	50,712	50,712	50,712	50,712	50,712	50,712	50,712	50,712	431,590
Solar powered mini-grids (PV-MG)	27,346	17,090	25,458	25,458	25,458	25,458	25,458	25,458	25,458	25,458	248,100
Solar powered micro-grids (PV-MG)	2,044	1,277	1,902	1,902	1,902	1,902	1,902	1,902	1,902	1,902	18,540
Distributed Energy Solutions	52,000	52,000	106,518	106,518	106,518	106,518	106,518	106,518	106,518	106,518	956,140
Total (000 US$)	**785,077**	**1,084,943**	**1,177,586**	**1,234,871**	**1,295,637**	**1,310,107**	**1,378,478**	**1,451,004**	**1,527,935**	**1,609,539**	**12,855,176**

Source: GME-IED

10.2 Sources of Financing

The total investment will be financed through a blended model that combines user contributions, public sector resources, concessional international financing, and private investment.

10.2.1 On-Grid Investments

On-grid investments account for 90% under Scenario 1 and 87% under Scenario 2 of the total investment required for NEP 3.0. These investments are expected to be financed through budget allocations from the Government of Ethiopia in the form of direct transfers to EEU and the REF, concessional loans from International Financial Institutions (IFIs), grants from development partners, and climate finance mechanisms.
In line with the approach being developed under the National Electrification Strategy (NES) for Ethiopia, NEP 3.0 maintains the same proportional structure of financing sources for on-grid investments as defined in the NES. The main financing mechanisms are described below.

Budget Allocations from the Government of Ethiopia

The Government of Ethiopia participates through direct transfers to EEU and the REF. These transfers may take the form of targeted direct subsidies, such as those provided under the Public Service Obligation (PSO), as well as financial-accounting mechanisms such as the Liability and Asset Management Corporation (LAMC), which has already been used in the case of EEP and is currently helping to offset the effects of delays in tariff adjustments for both EEP and EEU.

The Liability and Asset Management Corporation (LAMC) was established by the Government of Ethiopia as part of a broader state-owned enterprise reform program, with the objective of absorbing a significant portion of the accumulated debt of strategic public enterprises, including Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU).

The need for this institution arose because electricity tariffs had remained below the actual costs of generation, transmission, and distribution for several years, resulting in recurring financial deficits. As a consequence, substantial debt was accumulated to finance investments and meet operational obligations, while revenues remained insufficient to adequately service these liabilities.

To address this situation, the Government transferred a significant share of the liabilities of various state-owned enterprises to LAMC, enabling EEP to reduce its financial burden and strengthen its balance sheet. This allowed the company to focus on the operation and expansion of the power system without the immediate constraints imposed by its accumulated debt.

LAMC assumed responsibility for managing and servicing these obligations through resources derived from government-owned assets, dividends from profitable public enterprises, privatization proceeds, and other government funding sources. Through this mechanism, the Government sought to improve the financial sustainability of key state-owned enterprises while facilitating continued investment in strategic sectors such as electricity infrastructure.

However, while these mechanisms may be effective in the short term, their long-term sustainability is analyzed in subsequent sections.

As noted previously, the financing structure maintains the proportions established in the NES currently under development in Ethiopia. In this context, the Government of Ethiopia's contribution is expected to account for 24% of total on-grid investment requirements, equivalent to approximately US$ 3.983 billion in scenario 1 and US$ 2.688 billion in scenario 2 over the ten-year period

Concessional Loans from IFIs

The investment levels envisaged under NEP 3.0 would be extremely difficult to achieve without financing from International Financial Institutions such as the World Bank (IDA), the African Development Bank, and the European Investment Bank, among others.
As highlighted in the Gap and Barriers Report, these IFIs have played a key role in supporting previous versions of the NEP, particularly the World Bank. However, NEP 3.0 requires a significantly larger volume of resources, implying a greater reliance on IFI financing.
Out of total on-grid investment requirements, 61% is expected to be financed through IFIs, representing approximately US$ 9.896 billion in scenario 1 and US$ 6.832 billion in scenario 2.

Grants from Development Partners and Climate Finance Mechanisms

Another important source of financing for the NEP consists of grants from development partners.
Ethiopia's position as a leader in clean energy generation in East Africa—where approximately 90% of electricity is generated from renewable sources—together with its strong commitment to green and sustainable growth, enhances its ability to attract climate finance, from which it has already benefited on multiple occasions.
In this regard, it is essential to leverage and expand existing partnerships to mobilize the resources required to achieve the objectives of NEP 3.0. Ethiopia participates in several climate finance mechanisms, such as the Climate Investment Funds (CIF), specifically through the Pilot Program for Climate Resilience (PPCR) and the Scaling-Up Renewable Energy Program (SREP). Through these initiatives, the country has received significant financing for geothermal development, electricity access expansion, and environmental protection.

The country has also benefited from programs such as REDD (Reducing Emissions from Deforestation and Forest Degradation) and the Biocarbon Fund Initiative, securing results-based financing. In addition, Ethiopia has signed agreements for the purchase of certified emission reductions, and the national Climate Resilient Green Economy (CRGE) mechanism has received technical and financial support from international institutions such as the World Bank and the United Nations Development Programme, as well as from partner governments.
Ethiopia is also registered with the Green Climate Fund (GCF). However, it has not received significant financing for electricity projects from this institution, as most of its funding has been directed toward water management and resilience-related initiatives.
In this context, financing from development partners and climate finance mechanisms for on-grid connections is expected to represent 15% of total requirements, amounting to approximately US$ 2.433 billion in scenario 1 and US$ 1.680 billion in scenario 2.

10.2.2 Off-Grid Investments

Consistent with the approach outlined in the NES under development by the Government of Ethiopia, the primary source of financing for off-grid investments is private investment. Given the scale of investment required, it is important to promote the participation of both domestic and foreign investors. Domestic investment plays a particularly important role and is explicitly encouraged under Ethiopia's current regulatory framework. At the same time, foreign investment will be essential to achieving the targets established under the National Electrification Plan (NEP), not only because of the financial resources it can mobilize, but also because of the technical expertise, operational experience, and international best practices that foreign investors can bring to Ethiopia's power sector.

The combination of domestic and foreign investment will therefore be critical to accelerating electrification, strengthening implementation capacity, and ensuring the successful achievement of the NEP's objectives.

In this regard, off-grid financing is structured around two main components: mini-grid concessions and the Solar Home Systems (SHS) market.

Mini-Grid Concessions

For solar mini- and micro-grids, as well as small hydropower plants, financing is provided through private sector participation under competitive bidding schemes in which domestic private companies may participate. Following the tendering process, a concession is granted for a defined period aligned with the investment recovery horizon. This concession is formalized through a contract under which the concessionaire commits to building all required infrastructure (generation, transmission, and distribution facilities), carrying out necessary operation and maintenance activities, and replacing assets as needed.

In return, the concessionaire is granted the right to apply a tariff sufficient to recover both investment and operation and maintenance costs. However, since these tariffs may reach levels that are unaffordable for consumers, the Viability Gap Funding (VGF) mechanism proposed under the National Electrification Strategy (NES) will be applied to bridge the gap between the actual Levelized Cost of Electricity (LCOE) and the uniform national tariff. This approach will result in a transparent, quantifiable, and independently auditable subsidy mechanism that ensures the financial viability of electrification projects while maintaining affordability for end users.

Under this scheme, private sector investments are expected to reach approximately US$ 438 million in scenario 1 and US$ 432 million in scenario 2.

Solar Home Systems (SHS) Market

Based on the framework defined in the NES (currently in a pre-approval stage), the development of the SHS market is structured in two phases: a short-term phase covering the first two years of NEP 3.0, and a medium- to long-term phase covering the remainder of the program period.

Phase 1: Short-Term

In areas where private solar companies are already operating, or where market entry is expected, financing will be based on verified results. This approach is known as Results-Based Financing (RBF).

Under this mechanism, subsidies are designed to compensate for the “access premium,” i.e., the additional cost of serving remote and low-income customers. These subsidies are structured in declining tranches to avoid market distortions and promote cost efficiency.

Disbursements are made only after independent verification of a functional, quality-certified connection. All eligible SHS products must meet quality certification standards; non-certified products are excluded. The subsidy fund will be managed by the Ministry of Water and Energy (MoWE) and the REF once operational.

This phase requires a government subsidy of approximately US$ 104 million.

Phase 2: Medium and Long Term

In more remote communities where private markets are not expected to operate commercially—even with the support of subsidies—SHS services will be delivered through competitively awarded concession contracts to private companies responsible for supply and maintenance.

Under this scheme, commonly known internationally as Pay-As-You-Go (PAYG), contracts may follow a Build-Own-Operate-Transfer (BOOT)-type structure (similar to those used in power generation projects). These arrangements involve the construction of the required infrastructure, operation of the systems, and eventual transfer to the Government of Ethiopia or end users at the end of the concession period, typically ranging from 15 to 20 years.

This financing model includes upfront capital subsidies (covering 40–60% of system costs) and long-term service obligations. Concessionaires are required to provide maintenance, spare parts, battery replacement, and customer service throughout the concession period.

Investments under this second phase are expected to include a government subsidy of approximately US$ 417 million and private investment of around US$ 625 million under scenario 1 and a government subsidy of approximately US$ 341 million and private investment of around US$ 511 million under scenario 2.

10.3 Key Considerations Regarding the Financing of NEP 3.0

The Gaps and Barriers Report presents the assessment conducted by the MoWE, which identifies three critical challenges:

1. Insufficient revenue from connection charges to cover the costs defined in NEP 2.0. These revenues are constrained by ineffective collection systems and, even when collected, are insufficient due to inflation and exchange rate depreciation.
2. External financing from international organizations has fallen short of the levels anticipated under NEP 2.0.
3. Limited private sector participation, particularly in off-grid solutions.

To these three challenges, it is necessary to add the issue of tariff lag affecting EEP and EEU.
In this context, an analysis of each of these issues is presented below.

10.3.1 Fiscal Affordability, Annual Budgetary Implications, and Fiscal Risks

Real Affordability and State Co-financing Viability NEP 3.0 represents a significant financial burden for the Government of Ethiopia (GoE), the viability of which must consider the following macroeconomic conditions and milestones for Ethiopia in 2024–2026:

- Fiscal Space Created by Debt Restructuring: In July 2025, under the program backed by the International Monetary Fund (IMF), Ethiopia reached an agreement to restructure USD 8.4 billion of its external debt with official creditors. This will provide debt service relief of approximately USD 2.5 billion between 2025 and 2028 (and over USD 3,500 million in total). This cash flow directly alleviates the federal budget, thereby enabling the allocation of resources toward critical infrastructure such as NEP 3.0.
- Share of the Federal Budget and GDP: Considering an average annual federal budget for Ethiopia of approximately 1 trillion ETB (equivalent to around USD 8,000–10,000 million based on the unified exchange rate), the GoE's annual contribution to NEP 3.0 will represent between 2.5% and 4% of the national expenditure budget. While this is a high fiscal effort, it is realistic given the priority status of the energy sector within the national development plan.

Other important thing is the Annual Budgetary Implications and Disbursement Schedule To avoid compromising macroeconomic stability, the flow of GoE contributions must be synchronized with disbursements from multilateral organizations—which will finance around 61% of the required investments—and structured progressively. According to the projected annual investments, the years of highest fiscal pressure for the GoE will be from 2030 onward, when annual spending on densification and expansion increases.

Finally, Program Fiscal Risk Matrix the GoE faces explicit fiscal risks that could cause cost estimates to deviate:

- Exchange Rate and Public Debt Risk: Since 61% of on-grid financing will come from concessional loans from International Financial Institutions (IFIs) denominated in foreign currency, the continuous depreciation of the Birr (ETB) will drastically increase debt service costs measured in local currency, exerting pressure on the fiscal deficit.

- Contingent Liabilities from Tariff Lags: If the Petroleum and Energy Authority (PEA) continues to delay tariff indexation to inflation (due to social impacts), EEU and EEP will operate under structural losses. This will force the GoE to undertake direct financial bailouts or repeatedly resort to the Liability and Asset Management Corporation (LAMC), transferring the commercial debt of State-Owned Enterprises (SOEs) to the Federal Government's balance sheet, which violates the borrowing limits of the IMF program.

- Prohibition of Central Bank Financing: Under the NBE modernization monetary reforms initiated in 2024, direct central bank financing (money printing) to cover the fiscal deficit has been prohibited. Therefore, the GoE will not be able to finance its 24% share through NBE advances, relying strictly on effective tax revenue collection and the issuance of treasury bonds in the local market.

10.3.2 Connection Fees

Currently, EEU charges inspection and estimation fees for different types of customers, as shown below:

Table 68: EEU Inspection and Estimation Fee

Consumption Type	Inspection and Estimation Fee (Birr)	Inspection and Estimation Fee (US$)
Single phase	90.00	0.57
Three-phase meter	300.00	1.91
From 24 kW to 120 kW	500.00	3.19
From 121 kilowatts to 1 megawatt	5,000.00	31.88
For more than 1 MW	10,000.00	63.76

Source: EEU (https://www.eeu.gov.et/contents/getting-electricity?lang=en)

Additionally, NEP 2.0 established a minimum user contribution of US$ 50, increasing progressively according to tariff brackets, with the lowest income quintile (bottom 20% of the population) exempt from this contribution. However, as observed, there is a significant gap between the charges currently applied for single-phase, three-phase, and medium-demand connections (24–120 kW).
In an economy where many individuals earn approximately US$ 2 per day, establishing a connection fee of US$ 50 or more is challenging and may represent a significant disincentive for households to connect to the public electricity service. In this context, although connection fees can represent an important source of financing, their adjustment should be gradual, starting from the levels currently charged by EEU. For this reason, no revenues from this concept are considered in the financing structure of NEP 3.0, this approach is consistent with the provisions of the National Electrification Strategy (NES), which identifies two mechanisms for financing connection costs: the deferred payment of connection charges, and the inclusion of connection costs in the Regulatory Asset Base (RAB) for the poorest rural households. These mechanisms are intended to improve affordability and expand access to electricity while ensuring the financial sustainability of electrification programs.

10.3.3 External Financing from IFIs

While IFIs have provided substantial support for previous iterations of the NEP, the financing received has not been sufficient to meet the established targets.

It is important to note that, according to the MoWE assessment, any financing institution evaluates two key aspects: (i) the implementation capacity of the project or program being financed, and (ii) the sources of repayment.

In this regard, the tariff framework becomes critically important, as one of the main sources of repayment is the revenue generated from tariffs paid by users once they are connected to the electricity service. This issue is further developed in subsequent sections.

10.3.4 Limited Private Sector Participation

Private sector participation is largely determined by investors' risk assessments. The financing schemes described in this chapter—such as concessions, Results-Based Financing (RBF), and Pay-As-You-Go (PAYG)—help reduce risks for both contracting authorities and private operators in the implementation of NEP 3.0.

However, private investments are also exposed to broader macroeconomic risks present in Ethiopia.

In this regard, Ethiopia's economy is characterized by high inflation rates and significant exchange rate depreciation, as well as restrictions on access to foreign currency, all of which directly affect investors.

Regarding inflation and exchange rate depreciation, it is important to note that companies investing in Ethiopia under concession or PAYG schemes will recover their investments through tariffs paid by end users. While these tariffs reflect efficient costs derived from competitive processes, there are external, non-manageable factors—such as inflation and exchange rate fluctuations—that impact cost structures.

Therefore, it is essential to ensure that tariffs offered and awarded through competitive bidding processes are indexed to inflation and exchange rate variations, so as to preserve their real value and enable investors to effectively recover their investments.

It is also important to consider that the NES under development by the Government of Ethiopia establishes that tariffs for off-grid services should not exceed those charged by EEU. Consequently, indexation mechanisms must also apply to EEU tariffs.

Furthermore, investors—whether EEU, local private companies, or international firms—require access to foreign currency to import the equipment and materials needed to develop electricity infrastructure. Additionally, international investors must be able to repatriate returns to their parent companies, which also requires access to foreign exchange. In this context, ensuring access to foreign currency is a critical condition for attracting private investment to finance NEP 3.0.

Another important aspect related to mini-grids concerns the regulatory treatment of situations in which the main grid expands and reaches an area already served by a mini-grid. In this regard, the Mini-Grid Directive No. 268/2020 establishes the criteria to be applied for the integration of a mini-grid into the main electricity network, including both technical requirements and compensation mechanisms.

By providing clear rules for the treatment of existing mini-grid assets and the compensation of investors when grid encroachment occurs, the Directive helps reduce regulatory uncertainty and investment risk. This framework enhances investor confidence by ensuring that private investments in mini-grid infrastructure are protected and fairly compensated in the event of subsequent grid expansion.

The tariff-related issues and foreign exchange availability constraints are discussed in the following sections.

Tariff Considerations

Tariff calculations for electricity services, as well as tariff bids resulting from competitive processes, generally share two key characteristics. First, they reflect efficient costs, as they are either derived from regulatory methodologies that ensure efficiency or from competitive market processes. Second, they are determined in real terms and therefore require the application of indexation formulas to periodically adjust their value and preserve purchasing power.

These formulas typically incorporate variables beyond the control of electricity companies, such as inflation, exchange rates, and, in the case of generation, fuel prices (where applicable).

Such indexation mechanisms are defined in regulation and it was proposed a formula to apply in tariffs approved in the most recent tariff studies conducted for EEP and EEU. However, they have not been implemented due to the significant tariff increases that would result from high inflation and exchange rate depreciation, and the potential socio-economic impact of such adjustments.

The most recent tariff reviews were approved in 2018 and 2024. Both aimed to gradually achieve cost-reflective tariffs by the end of the tariff period. In the latest review, the regulator approved quarterly increasing tariffs expressed in real terms, intended to reach cost-reflective levels by the end of the period. However, since these tariffs are defined in real terms, periodic indexation is essential to maintain their real value.

Unfortunately, indexation mechanisms were not implemented in either tariff period—neither during 2018–2024 nor in the 2024 review. As a result, within the described macroeconomic context, tariffs have experienced significant real value erosion, reducing revenues needed to cover increasing costs.

Currently, the government is intervening to address the financial situation of utilities by assuming part of their external debt and converting it into equity through the LAMC mechanism.

While this mechanism may provide temporary relief, it does not enable the achievement of cost-reflective tariffs and may therefore become unsustainable over time. Moreover, it is not applicable to private investments that NEP 3.0 aims to attract.

From both a financial and tariff perspective, the sustainability of NEP 3.0 depends on two fundamental conditions:

- The implementation of efficient cost-reflective tariffs
- The indexation of tariffs to account for non-controllable variables (inflation and exchange rate depreciation)

The analysis must also consider the affordability of tariff levels. Given the widespread poverty affecting a significant portion of the population, electricity services may become un-affordable for many households. Therefore, tariff policy must be complemented by a well-targeted subsidy framework that clearly identifies vulnerable groups and provides focused support.

In this sense, it is important to consider that the NES includes a range of social protection measures to ensure that low-income households remain able to access electricity during the transition to cost-reflective tariffs. Key measures include a subsidized lifeline tariff for the first 50 kWh of residential consumption, cross-subsidies from higher-consumption and commercial customers, full connection subsidies for the poorest households through a Public Service Obligation (PSO), and deferred payment schemes for connection charges. The strategy also reduces connection costs through standardized Ready Boards, incorporates connection costs for the poorest rural households into the Regulatory Asset Base (RAB), and provides Viability Gap Funding (VGF) to support off-grid solutions such as mini-grids and solar home systems. These mechanisms help maintain affordability while ensuring cost recovery and sector sustainability.

It is important to note that licensing, tariff determination, subsidy design and other important issues related to mini grids are governed by the Mini-Grid Directive No. 268/2020.

Access to foreign currency and other important considerations

For access to foreign currency and other considerations like the requirements for import equipment and materials the MoWE had developed a Roadmap to scale OGS PAYG in Ethiopia. This document concludes that scaling PAYG-enabled OGS in Ethiopia requires reforms in four key areas: access to capital and foreign exchange, market-entry and competition rules, business and regulatory classification, and financial and payment regulations. By implementing these reforms, Ethiopia can reduce costs, attract private investment, improve affordability, and accelerate progress toward universal electrification.

The following is a summary of the roadmap; however, it is important to note that regarding the challenges related to the exchange rate and the importation of materials and equipment, the NBE has issued directives liberalizing the foreign exchange policy, which is explained further below.

Limited Access to Foreign Exchange and Financing

OGS providers rely heavily on imported equipment, but Ethiopia's foreign exchange shortages and restrictive allocation policies make it difficult to obtain the forex required to import products and attract investment. Access to local financing is also limited. To address this, the roadmap recommends prioritizing the OGS sector in national forex allocation and local credit programs. This would allow OGS companies to access foreign currency and domestic lending more easily, supporting market expansion and helping achieve national electrification targets.

Import and Retail Restrictions

The regulations prevented importers from acting as retailers and prohibit foreign participation in retail activities. As a result, OGS providers depended on third parties for importing components, creating a fragmented value chain, increasing supply-chain risks, and raising costs for end-users. The roadmap proposes allowing joint ventures (JVs) between Ethiopian and foreign OGS companies, enabling greater vertical integration, improved access to capital and forex, and lower consumer prices.

Lack of a Clear Industry Classification for OGS Companies

OGS providers are currently classified as importers, retailers, and distributors rather than energy service providers. This creates regulatory uncertainty, requires upfront tax payments that do not align with PAYG business models, and prevents access to sector-specific incentives. The proposed solution is to establish a dedicated business licensing category for OGS companies, clarifying applicable regulations, improving tax treatment, and enabling access to incentives available to energy-access providers.

Restrictions on PAYG Financing

Ethiopian regulations currently treat PAYG financing as traditional credit, meaning only licensed financial institutions can legally provide financing. Consequently, OGS companies must partner with microfinance institutions or other lenders, increasing financing costs and raising the final price paid by consumers. The roadmap recommends creating a distinct regulatory treatment for PAYG financing, potentially under the leasing framework being reviewed by the National Bank of Ethiopia (NBE), or allowing OGS providers to offer financing directly under a simplified regulatory regime. This would reduce costs and improve affordability.

Limitations on Payment Methods

PAYG models depend on accessible payment channels, yet financial inclusion remains limited in rural Ethiopia. Although mobile phone penetration is high, existing regulations prohibit the use of airtime as a payment instrument. The roadmap proposes that the NBE provide regulatory exemptions or issue no-objection letters to permit airtime and other alternative digital payment methods for PAYG transactions. This would expand payment options for rural customers and facilitate wider adoption of off-grid energy solutions.

New regulations related to the Exchange Rate Policy

However, regarding Foreign Exchange (FX) Management and the Supply of Imported Equipment, the National Bank of Ethiopia's new FX Directive No. FXD/01/2024, issued on July 29, 2024, and its amendment NBE Directive No. FXD/04/2026, effective since February 12, 2026, fully liberalized the foreign exchange market. This eliminated the commercial banks' waiting list system and prohibited any priority or discretionary allocation of foreign exchange by the central bank or financial institutions. Consequently, any proposal for priority allocation, state quotas, or single-window foreign exchange systems controlled by the NBE for NEP 3.0 was eliminated. Instead, FX procurement for importing transformers, conductors, solar panels, and batteries will be managed through market-driven mechanisms authorized by NBE Directives FXD/01/2024 and FXD/04/2026. These directives also establish the following:

1. Currency Risk Hedging via Forward Exchange Rates Under the amendment section of Directive FXD/04/2026, the NBE explicitly authorizes commercial banks and their clients to negotiate and agree upon forward exchange rates for future transactions. For NEP 3.0, this provision implies that grid infrastructure contractors and private mini-grid developers can utilize forward contracts with authorized commercial banks to lock in the Birr-to-USD exchange rate for importing capital goods with long manufacturing periods (e.g., substations or mini-hydro turbines). This eliminates foreign exchange uncertainty during the project bidding and execution phases.
2. FX Financing via Supplier Credit and Decentralized External Loans Previously, external loans or private supplier credits required direct, individual approval and registration with the NBE, creating a logistical bottleneck. Directive FXD/04/2026 has decentralized this function. Regarding NEP 3.0, this provision implies that authorized commercial banks are now fully empowered to autonomously approve and process external loans (both in cash and in-kind) and supplier credits for private companies and energy sector developers, provided they comply with the required debt-to-equity ratio (60-40). This will streamline the direct import of Solar Home Systems (SHS) and mini-grid components by the private sector without government bureaucratic delays.
3. Guarantees for the Repatriation of Dividends and Profits for the Private Sector (FDI) The historical apprehension of international mini-grid and SHS investors regarding the inability to convert their Birr earnings into foreign currency for repatriation is resolved under the new framework: Directive FXD/04/2026 directly empowers commercial banks to approve and remit dividends and net profits abroad for registered Foreign Direct Investments (FDI), eliminating the need to request case-by-case approval letters from the NBE. The sole requirement is the initial registration of the foreign investment in foreign currency with the NBE upon entering the country. This drastically reduces Ethiopia's country risk profile for mini-grid investors and SHS distributors under the PAYGO model.
4. Use of Foreign Exchange Retention Accounts (FX Retention Accounts) For developers operating in Ethiopia, the FXD/04/2026 amendment establishes that service exporters can retain 100% of their FX earnings indefinitely in local bank accounts. Additionally, for-profit institutions receiving foreign transfers (such as international donations or grants) can open and maintain FX current and savings accounts directly with local commercial banks without requiring NBE authorization. These retained funds can be used directly to pay for NEP 3.0 technology imports or to settle external debt commitments.

Final considerations

Most of these issues remain unresolved and continue to represent significant barriers to attracting private investment and achieving the proposed electrification and connection targets. Therefore, the implementation of this roadmap is essential.

In addition, it is important to recognize that, for foreign investors, ensuring the availability of foreign exchange is a critical requirement. Adequate access to foreign currency is necessary to enable investors to repatriate dividends, service external debt obligations, and recover their investments. Consequently, foreign exchange availability should be considered a key element of the overall investment framework for the power sector.

In this regard, consideration should be given to establishing a dedicated one-stop mechanism that prioritizes foreign exchange allocation for activities associated with the National Electrification Plan (NEP). Such a mechanism could play a critical role in reducing investment risks, facilitating project implementation, and enhancing investor confidence by ensuring timely access to foreign currency for the procurement of equipment, debt servicing, and the repatriation of returns.

10.3.5 Strategic Mobilization of Climate Finance

To achieve the grant-based financing target, it is recommended to implement the following climate mobilization pathways:

- Energy Transition and Clean Cooking Pathway (Article 6 of the Paris Agreement): Given that over 90% of Ethiopia’s grid energy is of renewable origin (hydroelectric and wind), on-grid connections and mini-grids directly displace emissions by offsetting the use of kerosene and traditional biomass. The GoE can mobilize funds under Article 6 of the Paris Agreement by issuing Internationally Transferred Mitigation Outcomes (ITMOs) linked to rural electrification programs and the deployment of electric cooking (e-cooking) appliances in households benefiting from NEP 3.0.

- Portfolio Pivot within the Green Climate Fund (GCF): Historically, Ethiopia's approved portfolio with the GCF has been heavily concentrated on agricultural adaptation and water resource management. The GoE can submit a national framework program proposal to the GCF's Private Sector Facility (PSF) focused on providing guarantees and viability gap funding (VGF) for private solar mini-grid operators and distributors of high-quality, VeraSol-certified Solar Home Systems (SHS).

Integrated Multilateral Co-financing Mechanisms. It is proposed to maximize the utilization of global platforms such as the Mission 300 initiative (co-led by the World Bank Group and the Rockefeller Foundation) and the DREAM (Distributed Renewable Energy-Agriculture Modalities) program to structure Results-Based Financing (RBF) schemes that subsidize the procurement of Productive Use of Energy (PUE) equipment.

10.3.6 Other Considerations

In addition to the specific considerations of NEP 3.0, it is essential to account for external factors that, while technically outside the scope of the program, are crucial for achieving the established universal access and coverage targets.
Two key strategic considerations are outlined below:

- Grid Infrastructure and Power Generation Upgrades: The sheer magnitude of the connection expansion will require a substantial strengthening of power generation, the transmission backbone network, and substation capacity. This is vital to reliably secure and meet the growing electricity demand resulting from the roll-out of NEP 3.0.

- Development of Local Manufacturing Capacity: From the perspective of reducing installation and grid development costs—and considering that a significant portion of materials and equipment is currently imported, thereby heavily draining foreign exchange (FX) reserves—it is critical to support and strengthen local manufacturing capacity for electrical components and equipment.

10.4 Accounting treatment of new assets

10.4.1 International Standards

The accounting treatment of Property, Plant and Equipment (PPE) is primarily governed by IAS 16, which establishes the principles for recognition, measurement, depreciation, and derecognition of tangible fixed assets. However, IAS 16 does not operate in isolation; rather, it must be applied in conjunction with other standards that address specific aspects of asset accounting. Among the most relevant are IAS 23, IAS 20, IAS 36, IAS 37, IFRS 13, and, in certain cases, IFRS 15.

Under IAS 16, PPE assets are recognized when it is probable that future economic benefits will flow to the entity and the cost of the asset can be measured reliably. The standard requires that assets be initially measured at cost, which includes the purchase price and all costs directly attributable to bringing the asset to the location and condition necessary for it to operate as intended by management. Importantly, this principle applies regardless of how the asset is financed. Whether the asset is purchased, self-constructed, or funded through third-party contributions, the entity must recognize the full cost of the asset if it controls it and expects to derive economic benefits from its use. This principle is particularly relevant in industries such as electricity distribution, where assets are frequently financed through customer contributions, government grants, or funding from international organizations. In such cases, while the asset is recognized at full cost under IAS 16, the corresponding funding is not recognized as immediate income. Instead, it is treated in accordance with IAS 20, giving rise to deferred income.

IAS 20 (Accounting for Government Grants and Disclosure of Government Assistance) establishes the accounting treatment for grants and similar forms of assistance. Although the standard explicitly refers to government grants, its principles are widely applied by analogy to contributions from other third parties, including customers and international institutions, provided that such contributions are not in exchange for distinct goods or services.

According to IAS 20, grants related to assets must be recognized in the statement of financial position as deferred income (a liability), rather than as immediate income. This treatment is based on the matching principle, which requires that income be recognized in the same periods as the related expenses. In the context of PPE, this means that the benefit of the grant or contribution should be recognized over the useful life of the asset, in line with its depreciation.

Upon initial recognition, the deferred income is measured at the fair value of the consideration received or receivable. If the asset itself is received free of charge or at a nominal amount, both the asset and the deferred income are recognized at fair value, as determined under IFRS 13 (Fair Value Measurement). The deferred income is then systematically amortized to profit or loss over the useful life of the asset, typically on the same basis as depreciation. This results in a periodic recognition of income that offsets, fully or partially, the depreciation expense.

IAS 20 permits two alternative presentation methods for grants related to assets. The first method, which is generally preferred for transparency, consists of recognizing deferred income as a liability and amortizing it to profit or loss over time. The second method allows the grant to be deducted directly from the carrying amount of the asset, thereby reducing the depreciable base. While both methods are acceptable, the deferred income approach provides clearer information about the gross investment in assets and the extent of external financing.

A particularly important application of these principles arises in the case of customer contributions. In many regulated industries, customers may be required to finance infrastructure extensions, such as network expansions or service connections. From an IFRS perspective, it is necessary to assess whether such contributions fall within the scope of IFRS 15 (Revenue from Contracts with Customers) or should be treated as grants under IAS 20.

If the contribution is made in exchange for a distinct good or service, such as a clearly identifiable connection service, and the entity has a performance obligation, the transaction may fall under IFRS 15, requiring revenue recognition based on the satisfaction of that obligation. However, in many cases, customer contributions do not give rise to ongoing performance obligations beyond the initial connection, and the infrastructure remains under the control of the entity. In such circumstances, the contribution is more appropriately accounted for as a grant-like transaction under IAS 20, resulting in deferred income.

In the case of government grants or funding from international organizations, additional considerations may arise. Such funding is often subject to conditions, such as requirements to operate the asset for a minimum period, maintain certain service levels, or use the asset for specific purposes. According to IAS 20, a grant should only be recognized when there is reasonable assurance that the entity will comply with these conditions and that the grant will be received. These conditions do not prevent recognition but may affect the timing and pattern of income recognition.

When an entity constructs an asset using funds received from grants or contributions, the accounting treatment combines IAS 16 and IAS 20. The asset is recognized at its full construction cost, including directly attributable costs and, where applicable, borrowing costs capitalized in accordance with IAS 23 (Borrowing Costs). Borrowing costs—often referred to as intercalary interest—are capitalized when they are directly attributable to the construction of a qualifying asset, meaning one that takes a substantial period of time to get ready for its intended use. Capitalization begins when expenditures are incurred, borrowing costs are incurred, and activities necessary to prepare the asset are in progress, and it ceases when the asset is ready for use.

Simultaneously, the funds received through grants or contributions are recognized as deferred income. This ensures that the financing structure does not affect the measurement of the asset but is instead reflected separately in the financial statements. Over time, the deferred income is recognized in profit or loss in a manner consistent with the depreciation of the asset, thereby achieving an appropriate matching of income and expense.

This approach avoids significant distortions in financial performance. If grants or contributions were recognized as immediate income, entities would report artificially high profits in the period of receipt, followed by depreciation expenses in subsequent periods without corresponding income. The deferred income model ensures a more accurate representation of economic reality by spreading the benefit over the asset's useful life.

It is also important to note that all PPE assets, regardless of how they are financed, are subject to impairment testing under IAS 36 (Impairment of Assets). If there are indications that an asset's carrying amount exceeds its recoverable amount, an impairment loss must be recognized. Additionally, obligations related to dismantling or site restoration must be recognized in accordance with IAS 37 (Provisions, Contingent Liabilities and Contingent Assets), with the present value of such obligations capitalized as part of the asset's cost.

In conclusion, the accounting treatment of PPE under IFRS requires a comprehensive approach that integrates multiple standards. The combination of IAS 16 and IAS 20 is particularly critical in situations involving third-party financing. Proper recognition and systematic amortization of deferred income ensure that financial statements faithfully represent both the value of the assets and the economic effects of external funding. This is especially important in capital-intensive and regulated industries, where customer contributions, government grants, and international funding play a significant role in infrastructure development.

10.4.2 Directive on Uniform System of Accounts (USoA) No. 1/2019

Online with the international standards the document "Directive on Uniform System of Accounts (USoA) No. 1/2019", issued by the Ethiopian Energy Authority (EEA), establishes a uniform regulatory accounting system for electricity generation, transmission, and distribution companies. Its primary objective is to ensure consistency, transparency, and comparability of the financial information used for tariff regulation. The system is based on International Financial Reporting Standards (IFRS), while incorporating specific requirements for regulatory purposes.

One of the central aspects of the USoA is the definition of criteria for the recognition of electric utility assets, the capitalization of investments, the treatment of construction work in progress, depreciation, and capital contributions. These elements determine the composition of the Regulatory Asset Base (RAB).

Electric Plant

The Uniform System of Accounts (USoA) establishes that Electric Plant assets constitute the infrastructure used to provide electricity generation, transmission, and distribution services. These assets must be recorded at historical cost, including both acquired assets and assets constructed by the utility itself. Initial cost includes the purchase or construction cost, direct and indirect project costs, interest during construction, engineering costs, supervision, technical studies, permits, insurance, legal expenses, and any other expenditure necessary to place the asset into service.

Assets are classified according to their function within the power system, distinguishing among generation, transmission, and distribution assets. Furthermore, when an asset changes category or is transferred between accounts, records of both the original cost and the associated accumulated depreciation must be maintained. The regulatory objective of this treatment is to ensure adequate traceability of investments that will subsequently form part of the Regulatory Asset Base (RAB).

Capital Work-in-Progress (CWIP)

Investments that are still under construction and have not yet commenced commercial operations are recorded as Capital Work-in-Progress (CWIP). This account accumulates all costs associated with the development of a project until the asset is ready to provide the regulated service.

CWIP includes direct construction costs, project-related indirect costs, general overheads attributable to project execution, and interest during construction. The Directive specifies that interest capitalization applies only to projects with a construction period of six months or longer.

From a regulatory perspective, CWIP is not immediately included in the Regulatory Asset Base. It is incorporated into the RAB only when construction is completed and the asset enters service. At that point, the accumulated costs are transferred from CWIP to Electric Plant in Service accounts, and regulatory depreciation begins. The USoA also provides that CWIP may, during the construction phase, be valued using the regulator-approved rate of return for purposes of its subsequent inclusion in the asset base.

Depreciation

Depreciation is the mechanism through which the economic consumption of assets is recognized over their useful lives. The USoA mandates the use of the Straight-Line Method, under which the depreciable value of an asset is allocated evenly over its economic life.

Depreciation must reflect the expected pattern of asset utilization and be calculated using useful lives approved by the regulatory authority. These useful lives may be reviewed periodically; however, any modification requires regulatory approval and is applied prospectively.

When an asset has been revalued, depreciation must be calculated based on the revalued amount. Similarly, where significant future obligations related to asset retirement or decommissioning exist, such costs must be reflected either through adjustments to the residual value or through their gradual recognition over the asset's useful life.

Depreciation also plays a fundamental role in determining the Regulatory Asset Base, since accumulated depreciation is deducted from the gross value of assets in service to determine the net RAB. Consequently, as assets depreciate, the asset base on which the utility earns a regulated return also declines.

General Capitalization

The USoA establishes uniform criteria for determining which expenditures should be recorded as capital investments and which should be recognized as operating expenses. As a general rule, assets with a useful life exceeding one year and a value greater than 1,000 Ethiopian birrs must be capitalized.

Capitalization includes not only the physical cost of assets but also all expenditures reasonably attributable to their construction, installation, and commissioning. These include technical studies, engineering costs, project-related administrative expenses, easements, rights-of-way, insurance, taxes, and interest during construction.

Costs associated with easements and rights-of-way are capitalized when the related infrastructure enters service. These costs are subsequently depreciated over the economic life of either the acquired right itself or the asset to which they relate.

Once a project is completed and placed into service, all accumulated costs cease to be recorded as CWIP and become part of the utility's operational assets. From that point onward, they are subject to depreciation and may be included in the Regulatory Asset Base, provided that they effectively contribute to the provision of regulated services.

Renewal Expenditure

The accounting treatment of renewal expenditures depends on the nature and economic effect of the intervention performed on existing assets. The fundamental principle established by the USoA is to distinguish between expenditures that increase the economic value of an asset and those that merely restore it to its original condition.

When a renewal increases asset capacity, significantly extends its useful life, improves performance, or generates additional future economic benefits, the expenditure must be treated as a capital investment (CAPEX). In such cases, the costs are added to the asset value and become part of the base on which depreciation and regulatory returns are calculated.

Conversely, when a renewal merely restores the asset to its original operating condition without increasing capacity, substantially extending useful life, or generating additional economic benefits, the expenditure must be recognized as an operating expense (OPEX). This treatment typically applies to major repairs, corrective maintenance, and the replacement of components with equivalent items.

The proper distinction between CAPEX and OPEX is particularly important from a regulatory perspective, as it determines whether the expenditure will be recovered through asset remuneration within the RAB or through tariff mechanisms associated with operating costs.

Capital Contributions

Capital contributions represent funds provided by third parties, typically customers or users, to finance all or part of the construction of electrical facilities. The regulatory principle adopted by the USoA is that assets financed through such contributions should not generate additional remuneration for the utility.

Accordingly, capital contributions are recorded as a contra-account associated with the financed asset. Although the physical asset forms part of the utility's infrastructure, the portion financed by third parties is excluded from the Regulatory Asset Base.

These contributions must be amortized or depreciated over the economic life of the related asset. However, the depreciation associated with such contributions does not constitute a recoverable regulatory expense and therefore cannot be recovered through tariffs.

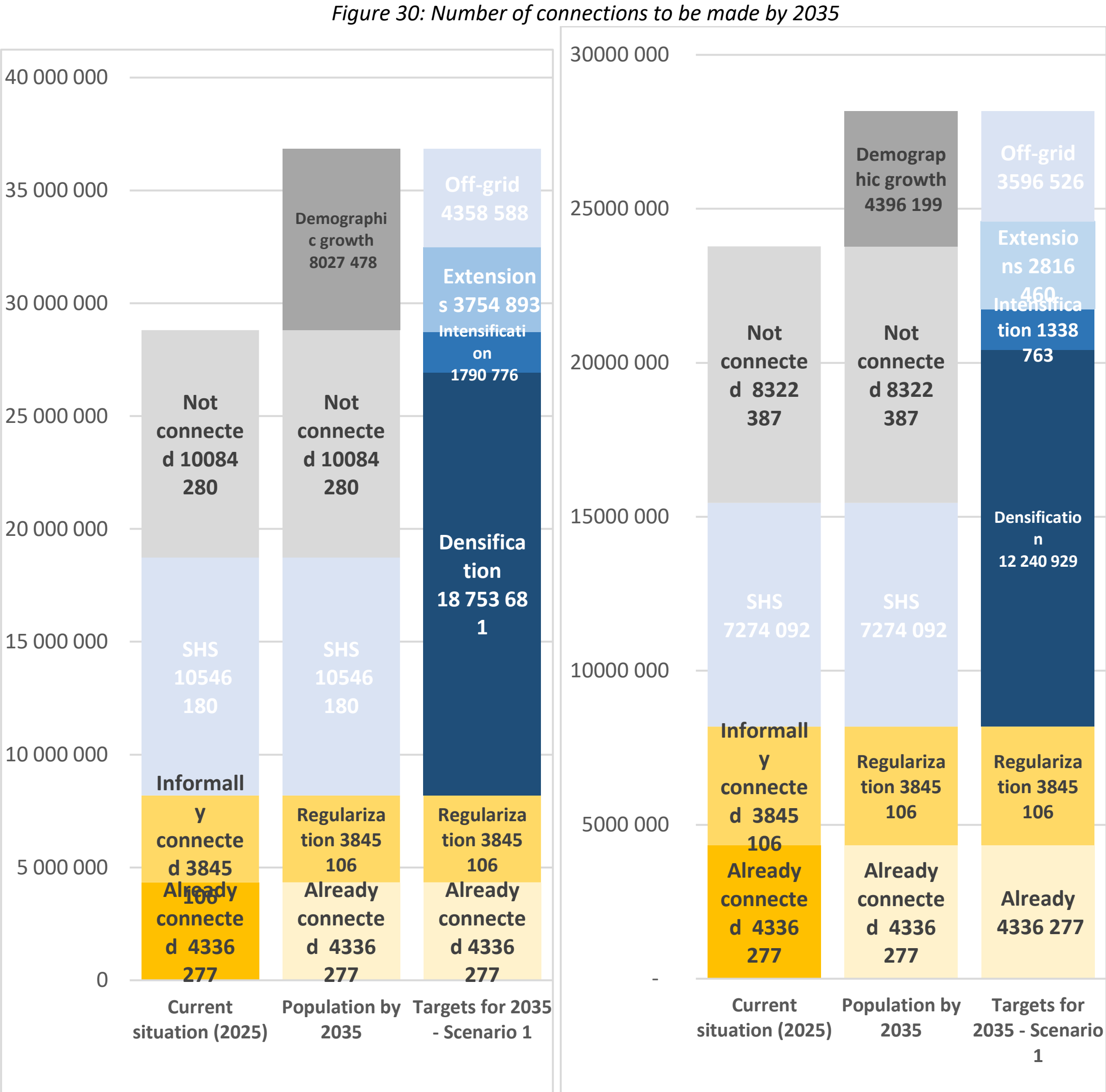
This treatment is intended to prevent the double remuneration of assets financed by customers, ensuring that utilities earn returns only on investments financed through their own resources or through financing sources that bear commercial risk.

11. Conclusions and recommendations

Reaching Universal access….

By 2025, 44% of Ethiopian households (more than 11 million) have a direct connection to a meter or a standalone system allowing a consumption level greater than or equal to Tier 1. This rate is relatively aligned with other Sub-Saharan countries where the connectivity rate stands on average at 54%[33]. Due to the size of its population, Ethiopia will nevertheless need to provide a very large number of connections to achieve universal access to electricity by 2035. **In Scenario 1, 32.5 million additional connections will be required against 23.8 million under Scenario 2.** In Scenario 1, this figure includes 3.8 million connections through regularization, 10.5 million connections to replace the current solar home systems, 10 million connections for households not yet connected, and 8 million additional connections for new households resulting from population growth. In this scenario, regularization and densification processes will account for 69% of the required connections, representing an investment of US$12 billion. Grid intensification and extensions will represent 17% of new connections, representing an investment of US$4.2 billion. The investment required for the remaining 14% of off-grid connections is yet to be determined.

Figure 30: Number of connections to be made by 2035



[33] The World Bank, 2025, *Access to electricity – Sub-Saharan Africa,* online: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZG

The three regions of Oromia, Tigray and Amhara would mobilize most of the investment (82%) in the Baseline scenario. The budget sharing is similar in scenario 2. This can be explain as those populated b regions concentrate the most unelectrified population both in urban and rural areas.

It should be noted that the above estimated budgets doesn't include any transmission and distribution network reinforcement although the NEP3.0 implementation couldn't be effective without any such strategic investment. New generation capacities would also be necessary to supply new connections. The Generation and Transmission master plan and the Distribution master plan (EEU) are then complementary to the NEP3.0 when considering the universal access required global investment.

Comparing with NEP 2

Despite some differences described below, **the number of connections and the overall investment presented in Scenario 2 appear relatively consistent with those of the previous NEP**. Although the total population is never mentioned, NEP 2.0 was developed based on ESS demographic data and aimed for 22.3 million new connections by 2030 (compared to 23.8 million in Scenario 2 and 32.5 million in Scenario 1) for a total investment of US$13 billion (compared to US$12.8 billion in Scenario 2 and US$18 billion in Scenario 1).

Table 71: Number of connections by 2035 in Scenario 1, 2 and in the NEP 2.0

Electrification schemes	Nb. of connections by 2035 - Scenario 1	Nb. of connections by 2035 - Scenario 2	Nb. of connections by 2035 - NEP 2.0
Already connected	4,336,277	4,336,277	3,100,000
Regularization	3,845,106	3,845,106	3,800,000
Densification	18,753,681	12,240,929	5,800,000
Intensification	1,790,776	1,338,763	3,900,000
Extension	3,754,893	2,816,460	7,800,000
Off-grid	4,393,447	3,652,472	1,000,000
Total Not electrified	**32,537,903**	**23,893,730**	**22,300,000**
Total	**36,874,180**	**28,230,007**	**25,400,000**

The notable differences between the NEP 2 and the Scenario 2 lie in in the number of households targeted by densification and intensification/expansion schemes. In Scenario 2, 12.2 million connections are planned for densification, compared to 5.8 million in NEP 2. Conversely, 11.7 million connections are expected for intensification/expansion, compared to only 4.2 million in Scenario 2. Two main explanations can be offered. First, electrification programs carried out in recent years have brought electricity to new, previously unelectrified localities, but connectivity rates within these localities have not reached very high levels (the number of connected households has only increased from 6.9 million to 8.2 million between NEP 2.0 and NEP 3.0). The number of connections identified for densification in Scenario 2 is therefore significantly higher. On the other hand, in NEP 3.0, it was proposed that localities in areas of very low population density (below 100 inhabitants, or 20 households per square kilometer) not be targeted for grid intensification and expansion, which was not the case in NEP 2.0. While 12,340 localities are located within a radius of 1 to 25 km from the existing grid, only 8,002 localities are situated in areas dense enough to be targeted by the grid. The remaining 4,338 will therefore be candidates for off-grid electrification, along with all 2,448 unelectrified localities located beyond 25 km from the existing grid. This also explains why the number of off-grid connections is higher in the Scenario than in NEP 2 (3.6 million versus 1 million in NEP 2).

Also one of the major difference lie into the used methodology. While NEP 2.0 is mostly using population density or building clusters for planning investments, NEP 3.0 brings new improvements and make use for the first time of a localities database which render the planning more concrete and relevant when considering electrification programs planning.

Table 72: Investments by 2035 in Scenario 1, 2 and in the NEP 2.0

Electrification schemes	Investments by 2035 - Scenario 1 (M US$)	Investments by 2035 - Scenario 2 (M US$)	Investments by 2035 - NEP 2.0 (M US$)
Regularization	249.931	249.931	380.000
Densification	11,737.994	7,641.107	2,300.000
Intensification	1,312.955	1,012.236	2,300.000
Extension	2,922.007	2,297.531	8,000.000
Total	**16,222.888**	**11,200.806**	**12,980.000**

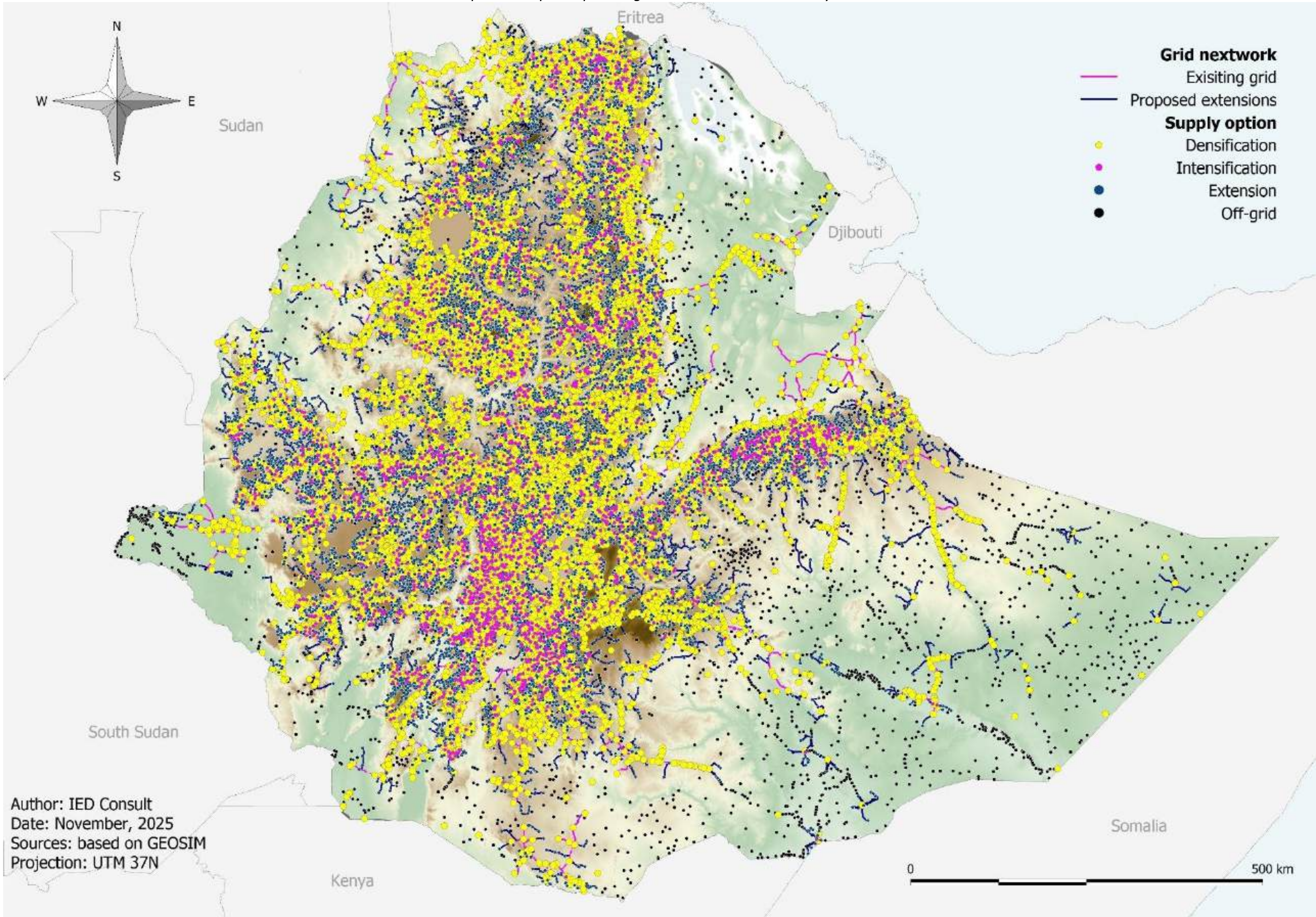
For these various reasons, to ensure consistency of investments between NEP 2.0 and the preliminary results of NEP 3.0, it is preferable to refer to the average connection costs per scheme rather than overall investments.
On this point, some differences still remain. In NEP 2.0, the connection cost for regularization is set at US$100, compared to US$65 in NEP 3.0. The Consultant proposes maintaining the cost of US$65, as it was recently validated by the Client. The method used to calculate the average densification cost in NEP 2.0 is not very detailed (meter + dropline + a short length of LV line). While this cost seems consistent for urban environment, it seems quite low in peri-urban or rural areas where housing is more scattered. The proposed cost in this NEP 3.0 is higher but seems more appropriate since it also includes a cost for transformer optimization. This last point also explains the slightly higher connection cost in NEP 3 compared to NEP 2 with regard to intensification. Finally, the average connection cost for expansion may seem somewhat low in NEP 3 compared to NEP 2 and international standards, which generally range between US $900 and US$ 1300. This is largely due to the short extension lengths of the MV lines in the NEP 3.0. Indeed, although MV extensions are possible up to a 25 km distance, the average length of medium-voltage (MV) line extensions to connect unelectrified communities Is around 3.7 km.

As the map 19 below shows, the extension process appears to be encountering a geographical limitation. The Ethiopian highlands, which concentrate most of the communities and population, have seen significant progress in the intensification and extension process over the past decade, leaving few communities truly isolated from the existing grid. In the lowlands, many population clusters remain to be electrified, so to avoid expensive extensions and connection costs, the deployment of off-grid solutions seems more appropriate.

Table 73: Average costs per connection in Scenario 1, 2 and in the NEP 2.0

Electrification schemes	Average cost per connection ($US) - Scenario 1	Average cost per connection ($US) - Scenario 2	Average cost per connection ($US) - NEP 2.0.
Regularization	65	65	100
Densification	625	625	397
Intensification	733	756	590
Extension	778	816	1 026
Off-Grid solutions	424	453	NA

Map 19 - Proposed planning to reach universal access by 2035



Financial policy and regulation

The achievement of Ethiopia's NEP 3.0 targets hinges upon a well-coordinated institutional framework that effectively balances centralized grid expansion with decentralized off-grid solutions. At the core of this strategy is the restructuring of the Universal Electricity Access Program (UEAP) into an Executive Implementation Office possessing full administrative, financial, and procurement autonomy. By reducing bureaucratic delays, this elevated unit will act as the primary engine for electrification, supported by the critical reinstatement of the Rural Electrification Fund (REF). Capitalizing the REF through a mandatory 3% to 5% levy on electricity sales, alongside development partner loans, will ensure a predictable and sustainable flow of funds to both grid and off-grid initiatives.

Furthermore, meeting the ambitious target of connecting over 4.4 million rural households requires immense participation from the private sector, which must be supported by a highly enabling regulatory environment. The Petroleum and Energy Authority (PEA) will play a vital role in this by streamlining licensing and enforcing quality standards. To overcome historical barriers and crowd-in private capital, Ethiopia must implement competitive procurement frameworks, de-risking instruments, and indirect subsidies such as tax exemptions. Crucially, the implementation of clear grid-arrival protection instruments is necessary to mitigate risks for private mini-grid developers, ensuring they are compensated or protected if the national grid arrives earlier than expected.

Additionally, and for purposes of future sustainability, while the current utility-driven model is deemed capable of handling NEP 3.0 objectives, the long-term sustainability of rural electrification may necessitate the creation of an independent Rural Electrification Authority (REA) within the next five to ten years. Drawing on benchmarking analysis from countries like Kenya, Nigeria, and Zambia, an autonomous REA would allow for a dedicated focus on the socioeconomic nuances of sub-economic rural markets, equitable electricity distribution, and the promotion of productive uses of electricity.
Transitioning the reinstated REF into a fully-fledged REA would streamline resource mobilization and effectively partner with the private sector without the conflicting commercial interests typically faced by national utilities.

Regarding the financial analysis conducted, the following conclusions can be resumed:

1. NEP 3.0 requires an unprecedented financial effort for Ethiopia, with investment requirements ranging from US$ 12.9 billion to US$ 18 billion over the period 2026–2035.
2. Grid expansion represents the primary use of financial resources, accounting for more than 90% in scenario 1 and 87% in scenario 2 of the total investments required to achieve universal access to electricity.
3. The program's financing strategy relies heavily on concessional funding from multilateral institutions, which are expected to provide approximately 61% of the financing required for on-grid investments. Consequently, the success of the program is closely linked to Ethiopia's ability to mobilize external resources on favorable terms.
4. The Government of Ethiopia will continue to play a critical role, both through direct budgetary contributions and through financial support mechanisms, subsidies, and risk-mitigation instruments designed to encourage investment.
5. Private investment is the cornerstone of the off-grid electrification strategy. However, attracting private capital requires stable regulatory frameworks, transparent subsidy mechanisms, and adequate conditions to ensure investment recovery and reasonable returns.
6. Inflation, currency depreciation, and foreign exchange constraints represent the principal financial risks facing the program, as they directly affect investment profitability and the ability of sector entities to recover costs.
7. The long-term financial sustainability of the electricity sector requires the effective implementation of cost-reflective and indexed tariffs, capable of covering operating costs,

capital investments, and financial obligations without permanent reliance on extraordinary government support.

8. The LAMC mechanism has provided temporary financial relief to Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU) through the absorption of accumulated liabilities. However, its continued use does not eliminate the need to address the structural causes of the sector's financial deficits.
9. Subsidies should be targeted toward protecting vulnerable consumers and supporting economically efficient projects, while avoiding distortions that could undermine the long-term financial sustainability of the electricity sector.
10. The successful implementation of NEP 3.0 will require more than the planned investments alone. It will depend on the continued implementation of the regulatory reforms already initiated through instruments such as the Mini-Grid Directive, the new exchange rate Directives (**NBE Directive No. FXD/01/2024**, and its amended **NBE Directive No. FXD/04/2026**, and related initiatives; strengthened institutional capacity; ; and a tariff policy capable of ensuring both financial sustainability and affordability for consumers.

Key recommendations

The NEP 3.0 study concludes with few key recommendations to reinforce energy planning in Ethiopia thought an enhanced ambitious pathway including Institutional arrangements and financial analysis.

On planning

- **Improve and expand data and population knowledge**

Ethiopia needs to take a **strategic leap forward** by strengthening how it identifies, maps, and understands its population. Accurately **locating localities and producing more reliable population estimates** is not just a technical exercise—it is the foundation for effective planning, equitable service delivery, and evidence-based policymaking. Without a precise picture of where people live and how many they are, the country risks under-serving communities, misallocating resources, and slowing its own development trajectory. A modernized, data-driven population system is therefore essential for Ethiopia to plan confidently, govern efficiently, and invest where it matters most. In long term, ESS is obviously the most suitable institution to lead this activity through regional surveys and census.

- **Foster off-grid electrification through development of mini-grids**

Together, solar mini- and micro-grids are expected to provide about 316,000 connections (representing about 7 percent of all off-grid connections); for a total investment requirement of US$ 280 million. The mini- and micro-grid technologies proposed in the Baseline rollout scenario are powered by solar PV, adding approximately 88 MWp of installed solar capacity. In addition, 25,500 new connections are targeted by 31 preidentified hydro schemes for a total investment requirement of US$ 438 million. Viability of those sites will only be ensured when interconnected to the main grid. Additional investigations would still need to be performed for those opportunities.
To effectively identify new off-grid electrification opportunities through sustainable mini-grids, it will be essential to undertake a comprehensive **resource assessment of both mini-hydro potential and biomass** availability. Such an exhaustive evaluation will provide the necessary data to determine viable sites, optimize investment decisions, and ensure that future projects are grounded in reliable resource information. By systematically mapping these resources, stakeholders can better prioritize areas with the greatest potential for sustainable and cost-effective energy access.

- <u>**Distributed energy systems, a key solution to reach scattered households and remote areas**</u>

Standalone solar home systems (SHS) designed to deliver a Tier-2 service standard (50 Wp) and a Tier-1 service (11Wp) represent the major share of off-grid connections; specifically, about 4 million connections out of 4.4 million total off-grid connections (92%).
The analysis suggests an opportunity segments for consideration by the GoE with respect to SHS policy, planning, and promotion, consistent with relevant lessons of good practice experience worldwide:
The Design and promotion of a private sector led market-based implementation of a "pre-electrification" program component, to provide basic electricity services to households that will otherwise not immediately benefit from grid or mini/micro grid connections in the near term.
Good practice lessons of relevant SAS experience elsewhere indicate that enabling policy support and establishing clear guidelines and standards for standalone solar systems can significantly contribute to (i) rapidly can go a long way to catalyze private sector- led and market- based rapid scale up deployment; (ii) developing a market for of certified products that meet meeting established service performance criteria; and (iii) to implement after-sales-service contracts consistent that comply with the guidelines for an appropriate code-of-conduct.

- <u>**Institutionalize Electrification follow-up, Strategic data and Planning activities at MOWE**</u>

It is the mandate of MoWE to follow-up electrification progress across the country. This can be done only by a dedicated team responsible for strategic data at MoWE level. A more specific service or directorate shall then be in charge of collecting, updating energy data (using the NEP3.0 database), evaluating key electrification indictors and potentially also supporting electrification planning activities in coordination with REBs. Such responsibility for updating the National Energy database would require new prerogatives in terms of data access. Developing **partnership** or data exchange protocol to update regularly the database with data providers EEU, EEP, ESS…
Also the involvement of REBs and EEU regional offices would clearly be beneficial as they often have access to more detailed, up-to-date and accurate data at regional level.
Some additional capacity building would then greatly enhanced the national and regional planning and electrification follow-up.

On institutional arrangements

The success of the **off-grid roll-out programme** components of the National Electrification Program implementation and its sustainability in quality of services delivered in Ethiopia will depend among other factors on the **government's role** in establishing a conducive and enabling environment (policy, institutional, financing, and regulatory frameworks) to develop, design and deploy scaled-up implementation programmes specifically in the off-grid space broadly identified in this report. In particular, the standalone and mini- & micro-grid solutions identified as least cost on a techno-economic basis for isolated locations – among the small and low-demanding rural settlements - will pose significant challenges as experience elsewhere has demonstrated.

- **Prioritize the re-establishment of the rural electrification fund** to enhance capital mobilization and support to grid and off-grid electrification, and private sector participation in the off-grid market through RBF and other subsidy mechanisms (CAPEX, OPEX grants).
- **Approval and Operationalization of the Executive Implementation Office of UEAP** with full administrative, financial, technical, and procurement autonomy will enable UEAP to operate with the speed and accountability required.
- **Operationalization of the Compact Delivery and Monitoring Unit:** To enhance electrification planning and NEP coordination and interfacing with development partners

- **Regulatory Aspects:** Licensing private mini-grid operators under a streamlined framework with clear grid arrival protection instruments. Establishment and enforcement of comprehensive Quality of Service Standards (SAIFI/SAIDI) applicable to EEU, ensuring quality standards for off-grid distribution systems and appliances are adhered to in collaboration with the Ethiopian Standards Agency (ESA).

- **Clear Grid Arrival Provisions to incentivize private sector participation pursuant to Mini-Grid Directive no. 268/2020- Additional provisions on:**
  - ✓ Point of interconnection and documentation requirements
  - ✓ Protection and Safety Requirements
  - ✓ Power Quality Requirements at the Point of Interconnection
  - ✓ Technical Conditions for supplying power to the National Grid
  - ✓ Technical conditions for receiving supply from the National Grid
  - ✓ Technical conditions for Asset Transfer and Inspection.
- **Empowering REBs** in planning activities and promotion of mini-grids would provide a more pragmatic approach of mobilizing regional developers. REBs 'missions should probably need to be redefined in accordance to the new challenges the electrification is facing. Capacity building at regional level is then strategic

On financial policy and regulation

- **Efficient tariffs with indexation and social protection:** It is fundamental to transition toward efficient, cost-reflective tariffs and periodically apply indexation formulas (against inflation and exchange rate depreciation) to prevent the erosion of real revenues for electric utilities (EEP and EEU). This policy must be complemented by social protection measures: a subsidized lifeline tariff for the first 50 kWh of residential consumption, cross-subsidies, and the use of standardized Ready Boards.
- **Applying NBE Directive No. FXD/01/2024 and NBE Directive No. FXD/04/2026 to guarantee the availability of foreign exchange.:** To mitigate macroeconomic risks for foreign investors and enable them to repatriate dividends, service external debt, and acquire imported equipment in a timely manner.
- **Promotion of local private investment:** Establishment of specific financing policies and incentives aimed at strengthening and enabling the participation of local private developers and investors.
- **Regulatory reform for the off-grid segment:** Swift implementation of the regulatory and institutional reforms outlined in the MoWE OGS PAYG roadmap, except of exchange rate regulations, to optimally structure concessions and the SHS market.
- **Payment mechanisms and unified tariffs:** Application of deferred payment schemes, inclusion of connection costs in the Regulated Asset Base (RAB) for the poorest rural households, and the design of subsidies that guarantee a fair and balanced tariff between on-grid and off-grid users.

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ANNEXES

ANNEX 1: Building localities database, a key step toward effective electrification planning

A. Localizing villages

The adopted electrification approach is based on settlements/villages electrification so as to insure the effectiveness and relevancy of electrification planning. Because any relevant on-grid/off-grid electrification programs (feasibility studies, tenders...) are usually prepared using localities which can be **identified** on the field, **named and listed**, and because electrification works are always implemented at villages level, it remains a key factor for success to target **villages & localities electrification** rather than buildings electrification. Grid sizing is indeed highly dependent of its environment and shall consider the whole area (a.k.a locality footprint) and not only small clusters of buildings independently.

Data collection demonstrated that there isn’t any "villages or localities" database available for the country which was confirmed by ESS.
As part of the its improved electrification path, NEP 3.0 which proposes an enhanced methodology at locality level, required therefore the consolidation of a database on localities that was as accurate as possible, the first and most detailed database available at that stage.

In the case of Ethiopia, the Consultant made use of several databases which locates either settlements, and localities or through socio-economic infrastructures which mentioned such information. The settlements and localities database consolidated data from EthioGIS, EMA, EEU (Transformers database), Education infrastructures, Health infrastructures, Google Earth, VIDA… The GIS consolidation succeeded to identify more than 25,650 localities including names and coordinates. However, such work may not be as accurate as an official census and may have some bias particularly in off-grid areas which lacked of data This first approach remains nevertheless relevant at planning level.

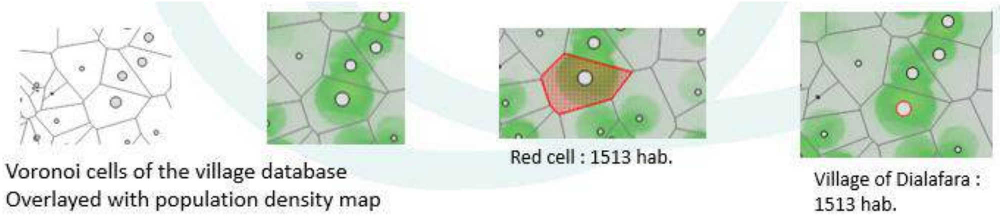
B. Estimating localities population

From past geospatial planning experiences in Ethiopia, IED already collected a “localities and settlements” database but IED has been working intensively to improve the accuracy of the database using the latest data available.
From the consultant experience, data sources often use alternative naming for a given locality name especially in the case of Ethiopia where localities name were translated from Amharic to Latin characters. The consultant used a fuzzy logic algorithm in order to reconciliate “extended name” of localities.

Fuzzy logic algorithm
This technic was successfully used for a recent project enclosing Mali, Guinea Bissau and Gambia, Congo and Namibia where the population of each village was known from the last censuses (without location data), and their location of villages were retrieved from OCHA (United Nation Office for the Coordination of Humanitarian Affair). The match between the two data sources could reach from 60% up to 90%. The population of the remaining 10% settlements will be analyzed manually thanks to their location within the GIS software. Finally, location of remaining villages will be checked using Google Earth.

Voronoi algorithm
To locate the population of Ethiopia, IED made use of the world referential Copernicus[2] latest database from Jan 2025 which produced population density map for Ethiopia but also the VIDA database which georeferenced buildings across the country to map population density.

If village's population and/or location are not available or not reliable, an alternative methodology could be implemented using the high-resolution global map of population density available from the internet (Worldpop, Copernicus) or Buildings footprint (VIDA). Then the Voronoi algorithm is used to generate clusters around each identified settlement or locality, these clusters define the "influence area" of each village, then the population inside each cluster is associated to the villages point. This Algorithm ensures that the total population of the country is spread among the localities of the country.



It appears that Ethiopia population was estimated around 132 M. inhabitants which is in line with common estimates by international organizations (UN, OCHA, WB…) and medias.

However, ESS estimates the population applying a national growth rate calculated from the latest census in 2009. The official results from ESS are then providing a population around 111 M. inhabitants. The villages population was then adjusted at regional level for 2025 to make sure that the population per region is in line with ESS estimates.

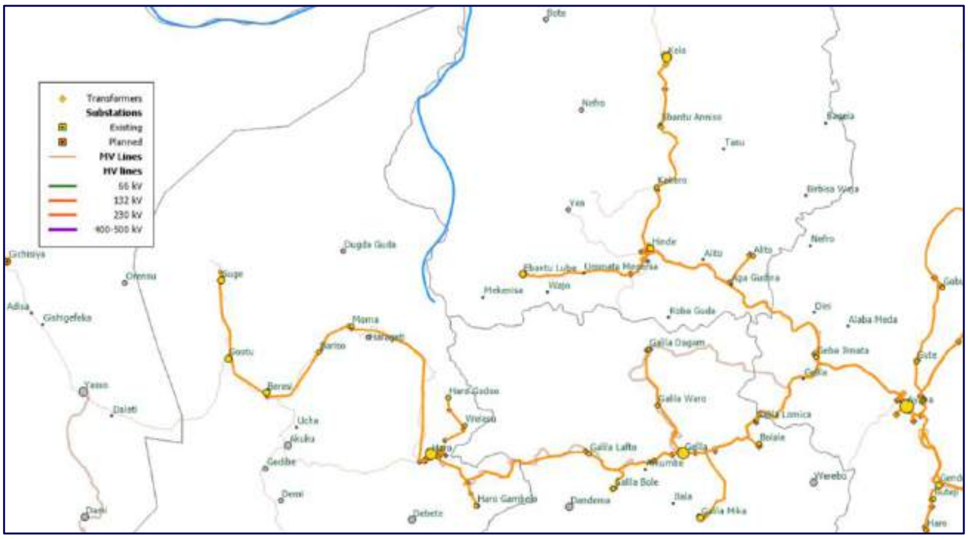
Two population figures are than calculated per village for 2025 which will cause the creation of 2 different scenarios. One scenario using the ESS (Ethiopia with 111 M hab.) population and the second scenario which will use the VIDA population (Ethiopia with 133 M hab.)

C. Estimating villages electrification status

The status of electrification of localities was done cross-checking various GIS layers including:

- Transformers location
- Night light imagery
- MoWE list of mini-grids

Any localities close to existing transformers or electrified through mini-grids, or where lights can be visualized during night are considered as electrified.



Map 20: Ethiopia electrification GIS map extract

ANNEX 2: Spatial analysis for maximizing socio-economic impact of electrification projects

The Spatial Analysis process identifies localities where the social and economic impact of electrification should be the highest, be prioritized and therefore, which should require special attention from planners. To conduct Spatial Analysis, data on health, education and economic infrastructures is processed at locality level through a multi-criteria analytical matrix.

Table 75: Multicriteria matrix to assess the DPI per locality

THEME	THEME WEIGHT	CRITERIA	CRITERIA WEIGHT	INDICATOR	VALUE
ECONOMY	1/3	Population	1/3	< 500 inhabitants	0
				< 1,000 inhabitants	0.2
				< 2,500 inhabitants	0.4
				< 5,000 inhabitants	0.6
				< 10,000 inhabitants	0.8
				> 10,000 inhabitants	1
		Distance to road	1/3	> 20km from a road	0
				< 10km from a road	0.1
				< 5km from a road	0.4
				< 2km from a road	0.7
				< 1km from a road	1
		Agriculture (US$/hectare/year)	1/3	< 100	0.2
				< 500	0.4
				< 1,000	0.6
				< 2,000	0.8
				> 2,000	1
EDUCATION	1/3	Schools	3/4	None	0
				Pre-primary school	0.2
				Primary school	0.4
				Elementary school	0.6
				Secondary school	0.8
				University	1
		VTC	1/4	Vocational training center	1
HEALTH	1/3	Medical facilities	3/4	None	0
				Health post	0.2
				Health center	0.4
				Specialty center	0.6
				Clinic & specialty clinic	0.8
				Hospital	1
		Pharmacy	1/4	Pharmacy	1

Source: IED

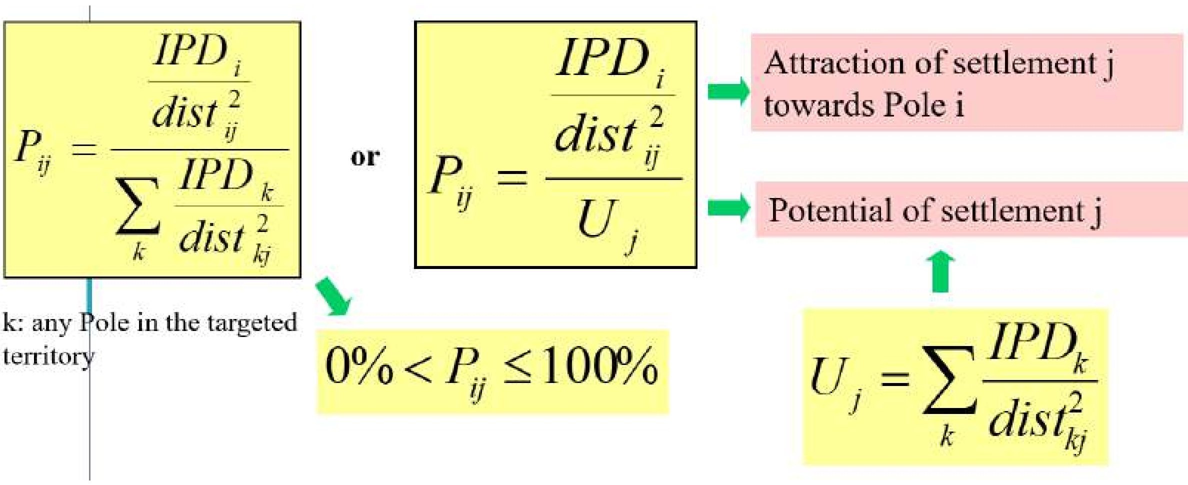
This matrix approach is based on a similar principle used at country level and know as the Human Development Index (HDI). It measures the locality potential to provide crucial basic services (education, healthcare) as well as economic opportunities to its own population and its surrounding areas. The matrix scores each locality on the basis of several weighted characteristics in each of three thematic components – Health, Education and Local economy. The weighted scores are then combined into a consolidated score, called the Development Potential Indicator (DPI), with a minimum value of 0 and a maximum value of 1. The above table shows the analytical matrix used to calculate the DPI for Ethiopian localities.

Once the DPI is calculated for all localities, the 20% of localities with the best score at the level of each region are considered as "development poles" (DP), *i.e.*, the localities with the highest level of socio-economic services. A ranking is then made between the development poles with the highest covered population. The ranking of the other localities is done thanks to the DPI score.

Strengthen electrification or electrifying a given locality will, of course, benefit the population directly living within its administrative boundaries. However, electrification is also likely to provide benefits to populations in other nearby areas, who will be able to access improved basic services or economic opportunities resulting directly or indirectly from electrification. In assessing the socio-economic potential for electrification of various candidates, it is therefore important to take into account the overall size of the covered population that would benefit both directly and indirectly from electrification.

After identifying the development poles, GEOSIM therefore automatically calculates their covered population using an adaptation of the Huff Gravitational Model. The model functions on the basic principle of gravitational attraction in physics, where attraction is a function of mass and distance. In the case of covered population, physical mass is replaced by the "mass" of services and development, represented by the DPI (a.k.a IDP). The Huff Gravitational Model builds on this principle by using a probabilistic approach to take into account the potential for populations to choose between multiple locations to access services, which at the end of the day represents the covered population.

Figure 31: Basic Huff gravitational model



Source: IED

Figure 32: Calculation of covered population used in GEOSIM

$$POP_{cov_i} = \sum_j P_{ij} \times POP_j = \sum_j \frac{IPD_i}{dist_{ij}^2 \sum_k \frac{IPD_k}{dist_{kj}^2}} POP_j$$

Source: IED

ANNEX 3: Key parameters for grid extensions

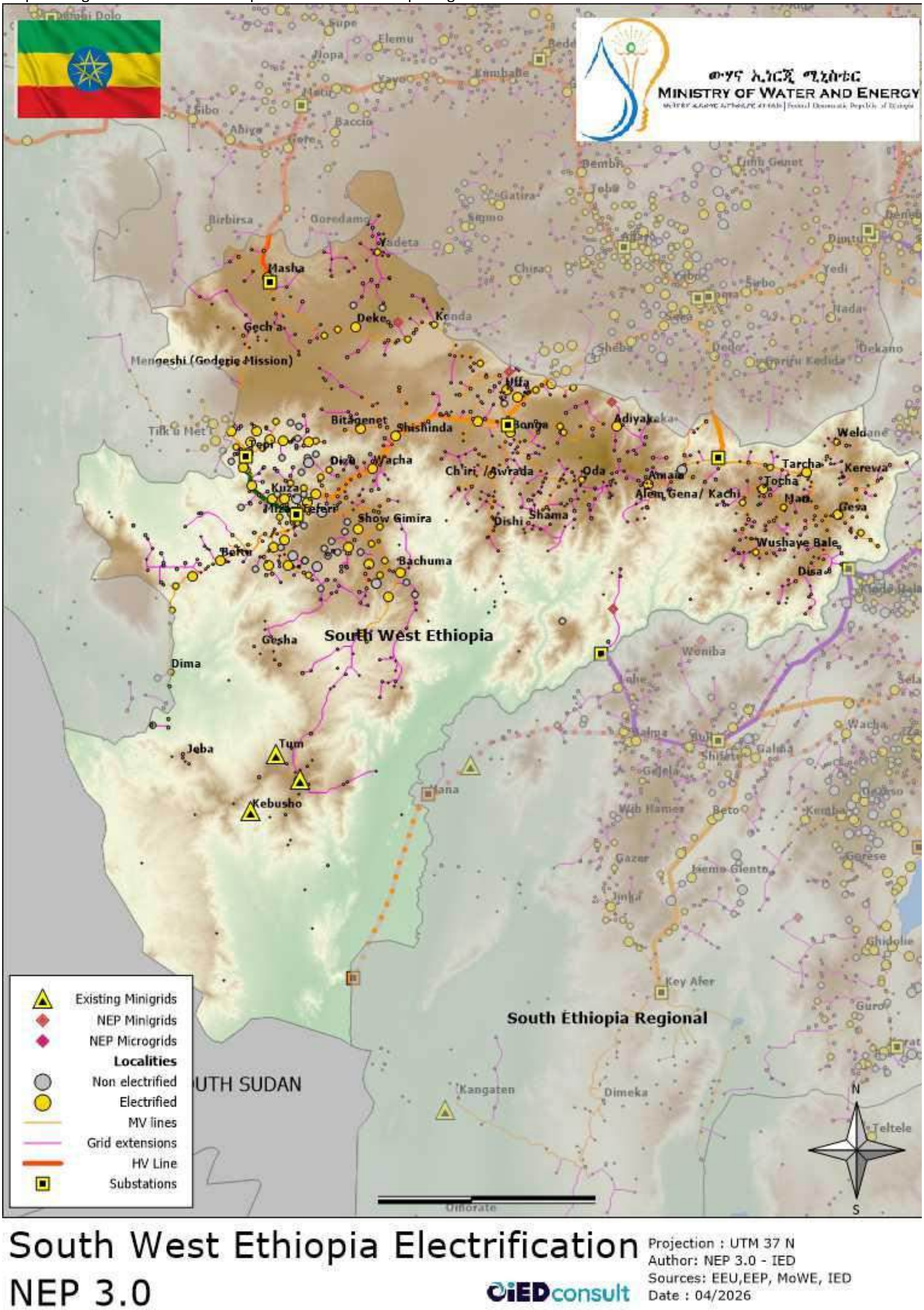
Technical parameters and costs used to assess the investment costs of electrification through grid extensions are listed on the table below.

Table 76: Key parameters and referential modeling costs

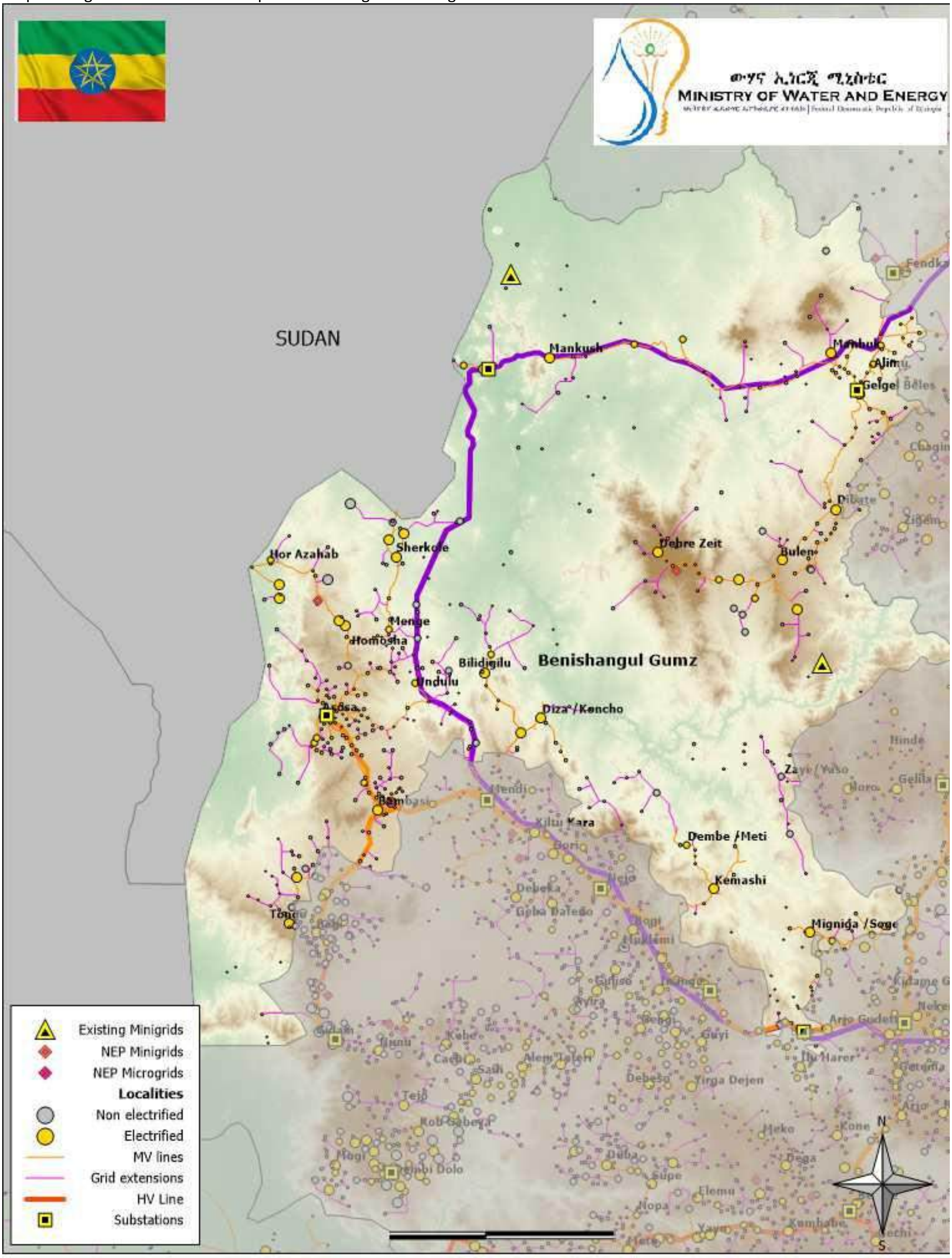
Dataset	Data type	Value	Source
No. of households / LV line km (Rural / Urban)	Integer	22 / 49	EEU, 2025
N. of consumers per 200 kVA transformer (Rural / Urban)	Integer	250 / 190	EEU, 2025
Average MV line cost (/km) - pole, work, cable, insulator…	US$/km	20,500	Benchmark for Eastern Africa, 2025
Average LV line cost (/km) - pole, work, cable, insulator…	US$/km	13,300	Benchmark for Eastern Africa, 2025
Transformers cost:			
50 kVA	US$	4,720	EEU, 2025
100 kVA	US$	5,560	EEU, 2025
200 kVA	US$	7,865	EEU, 2025
315 kVA	US$	8,530	EEU, 2025
LV meter cost + dropline	US$/unit	65	EEU, 2025
Lifespan of LV line	Year	30	International standards
Lifespan of MV line	Year	30	International standards
Lifespan of transformer	Year	30	International standards
LV lines O&M annual cost	%	2	International standards
MV line O&M annual cost	%	2	International standards
Transformers O&M cost	%	2	International standards
Discount rate	%	10.5	EPRA, 2024
Technical losses	%	14%	EEU, 2025

ANNEX 4: Regional electrification planning maps

Map 21: Regional Electrification map for South West Ethiopia region



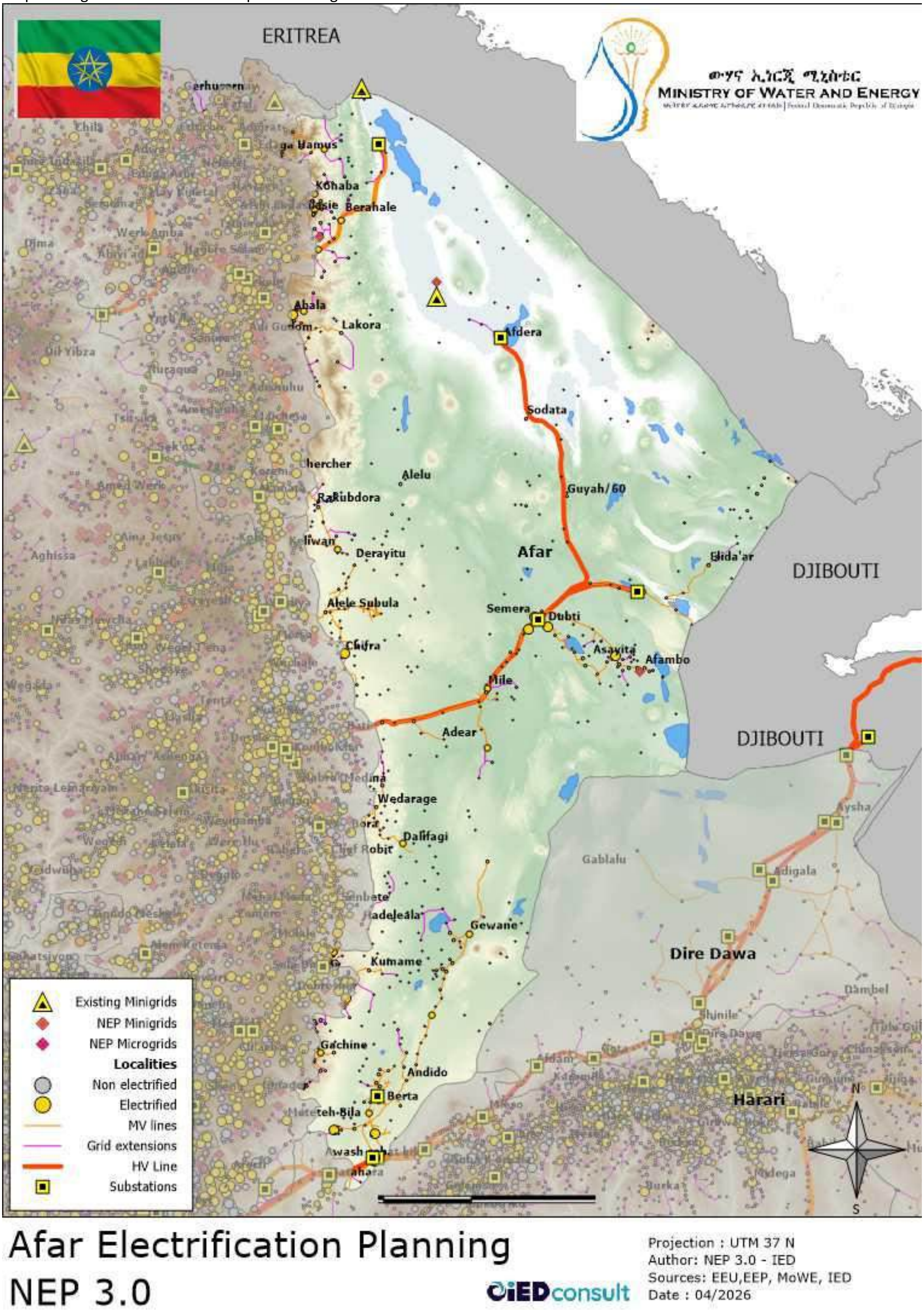
Map 22: Regional Electrification map for Benishangul Gumz region



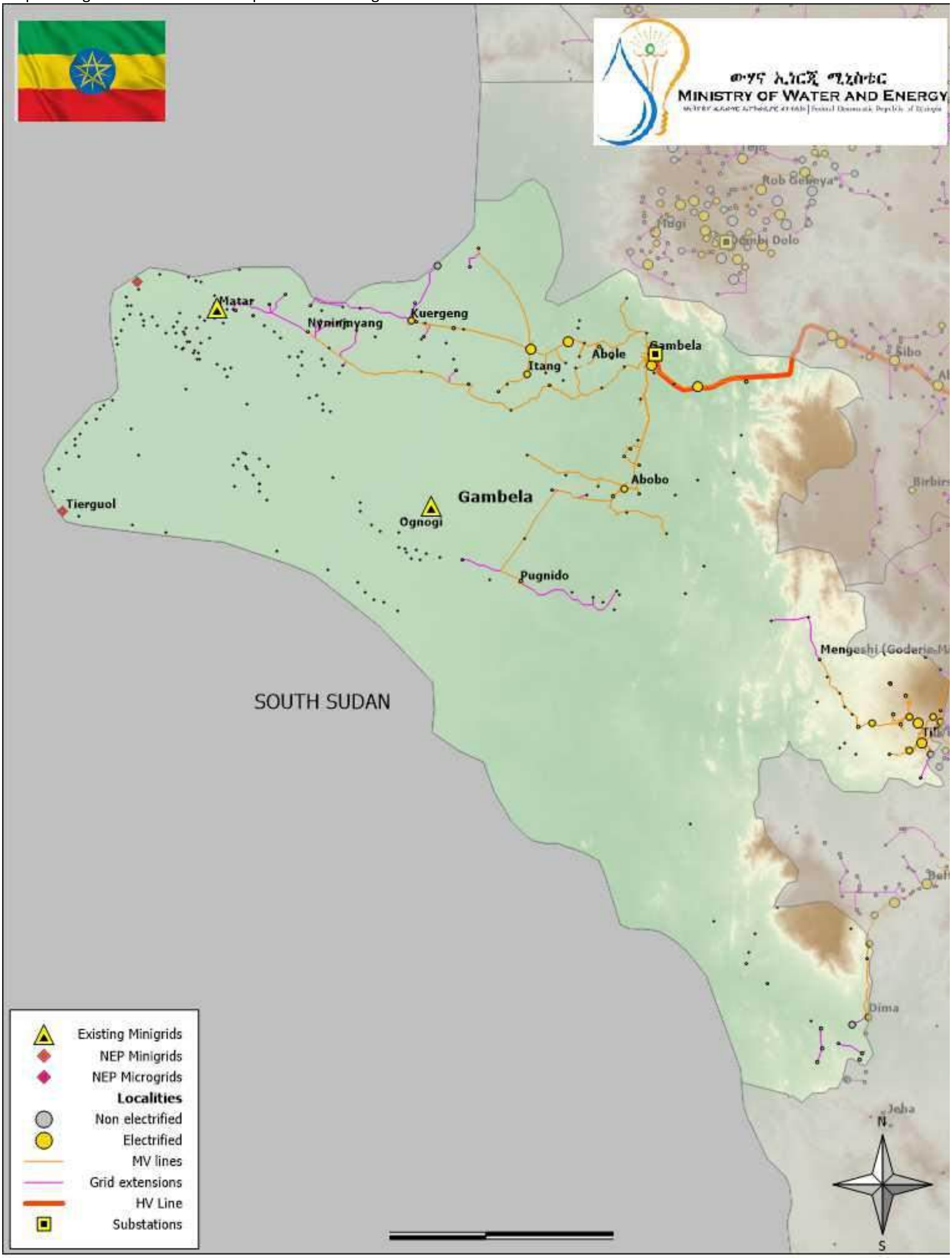
Benishangul Gumz Electrification Planning
NEP 3.0

Projection : UTM 37 N
Author: NEP 3.0 - IED
Sources: EEU,EEP, MoWE, IED
Date : 04/2026

Map 23: Regional Electrification map for Afar region



Map 24: Regional Electrification map for Gambela region

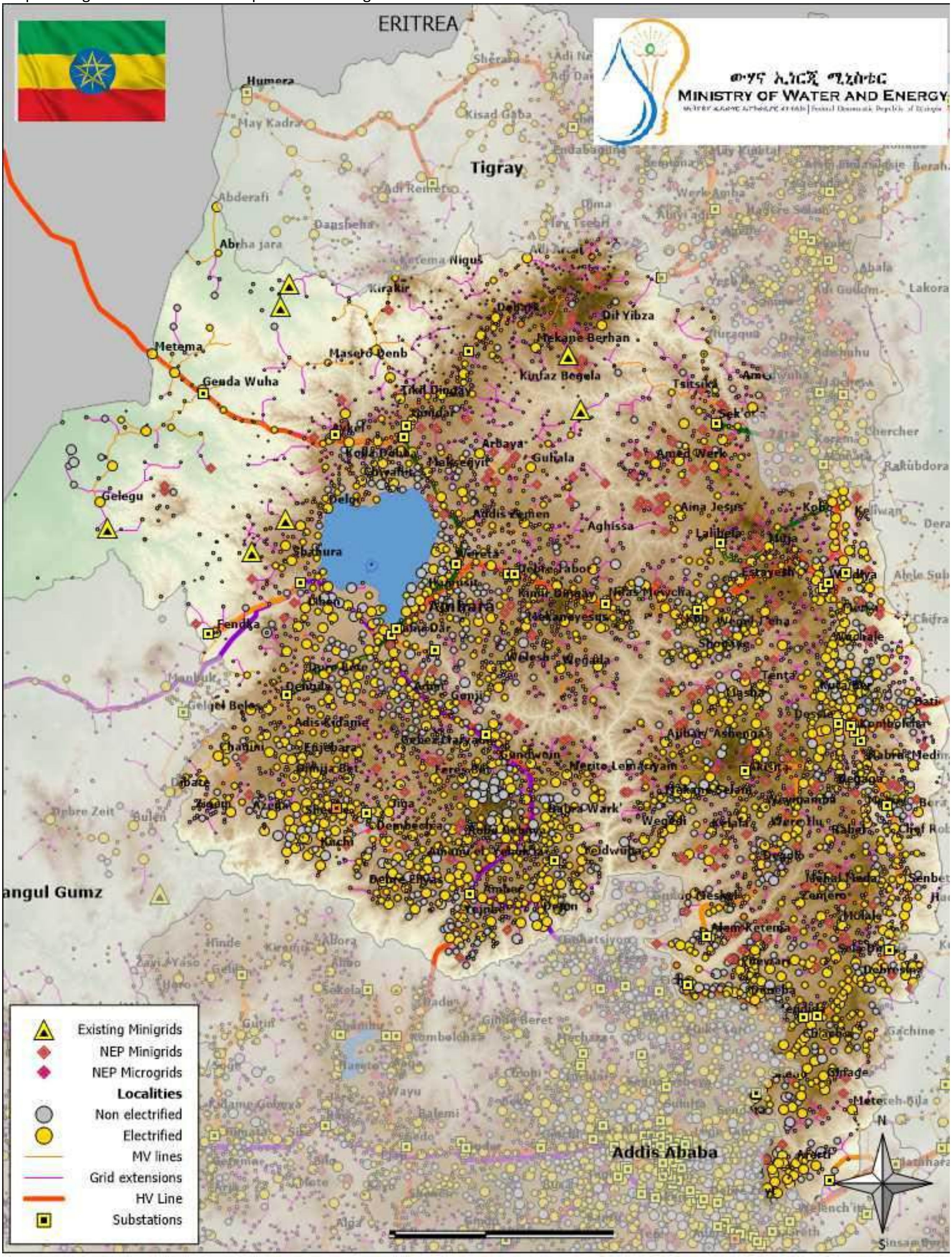


Gambela Electrification Planning NEP 3.0

IEDconsult

Projection : UTM 37 N
Author: NEP 3.0 - IED
Sources: EEU,EEP, MoWE, IED
Date : 04/2026

Map 26: Regional Electrification map for Amhara region

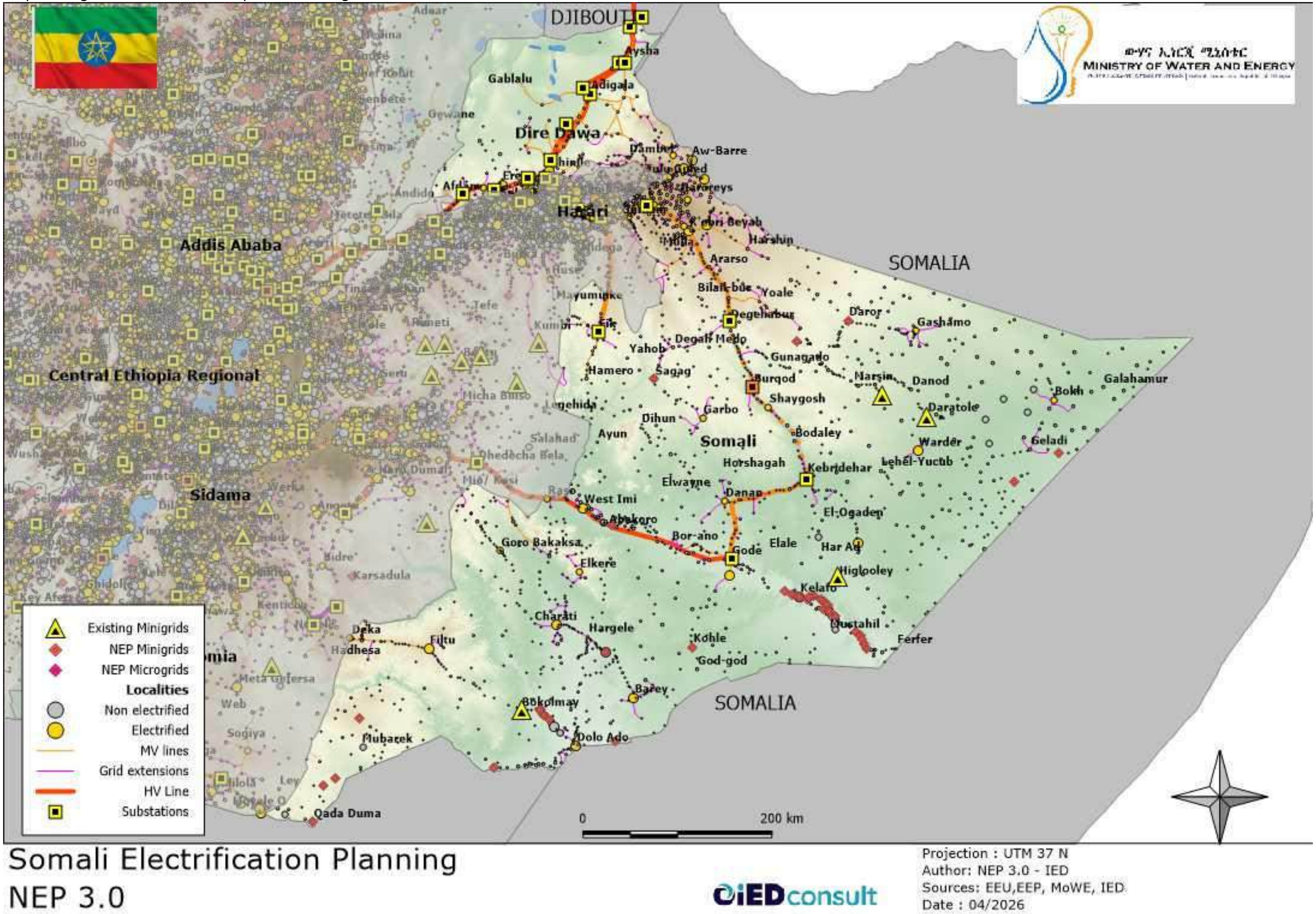


Amhara Electrification Planning NEP 3.0

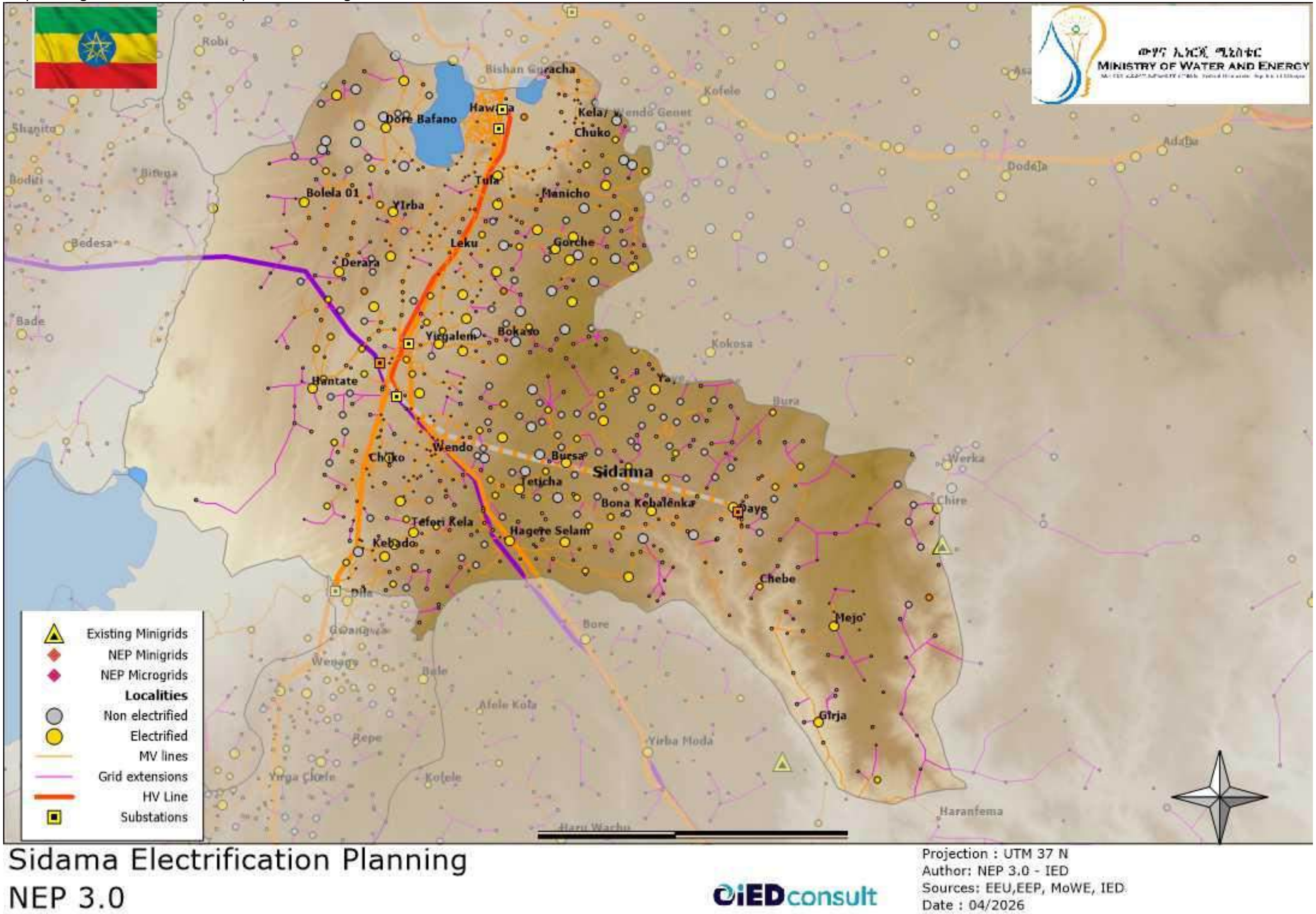
IEDconsult

Projection : UTM 37 N
Author: NEP 3.0 - IED
Sources: EEU,EEP, MoWE, IED
Date : 04/2026

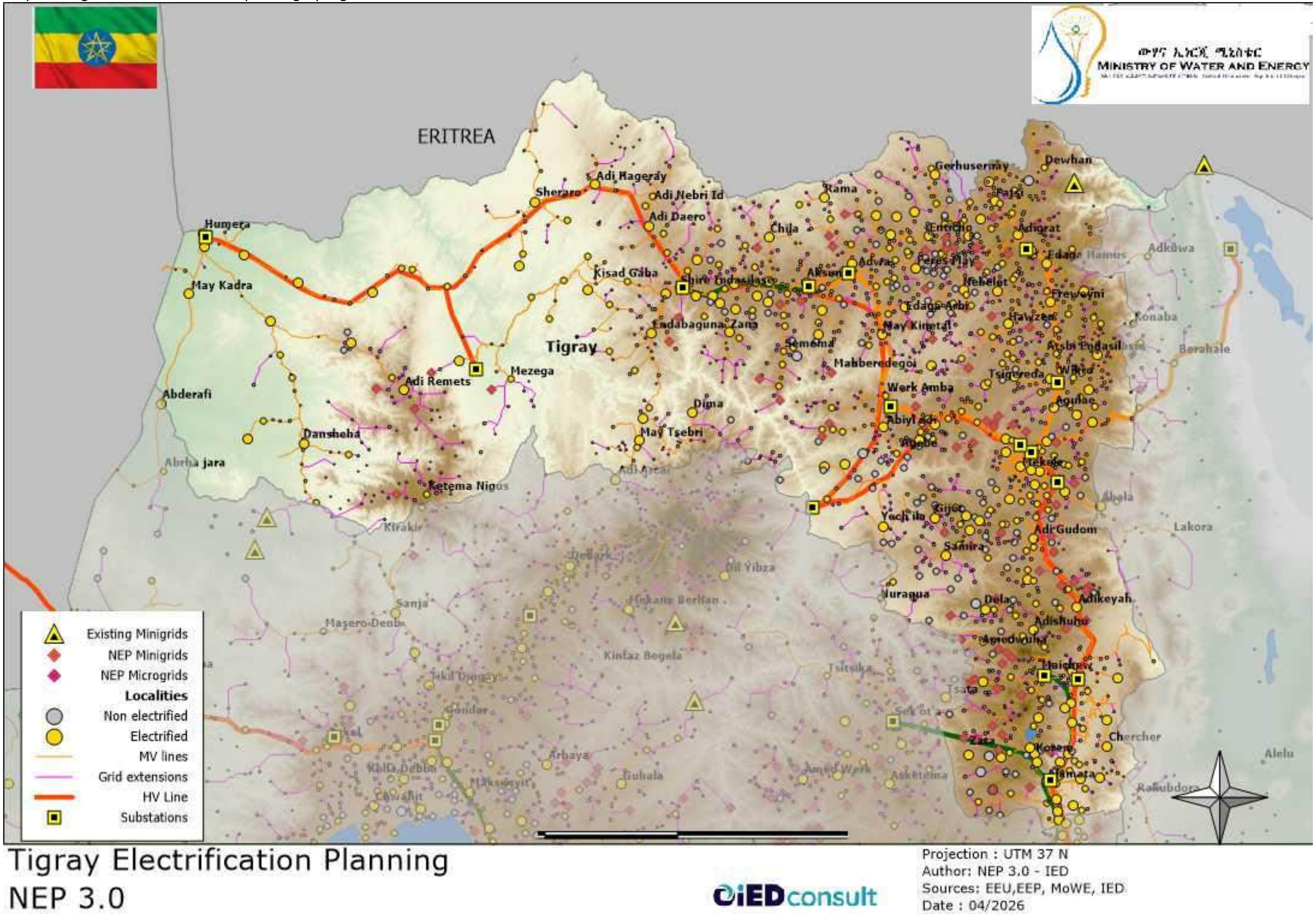
Map 27: Regional Electrification map for Somali region



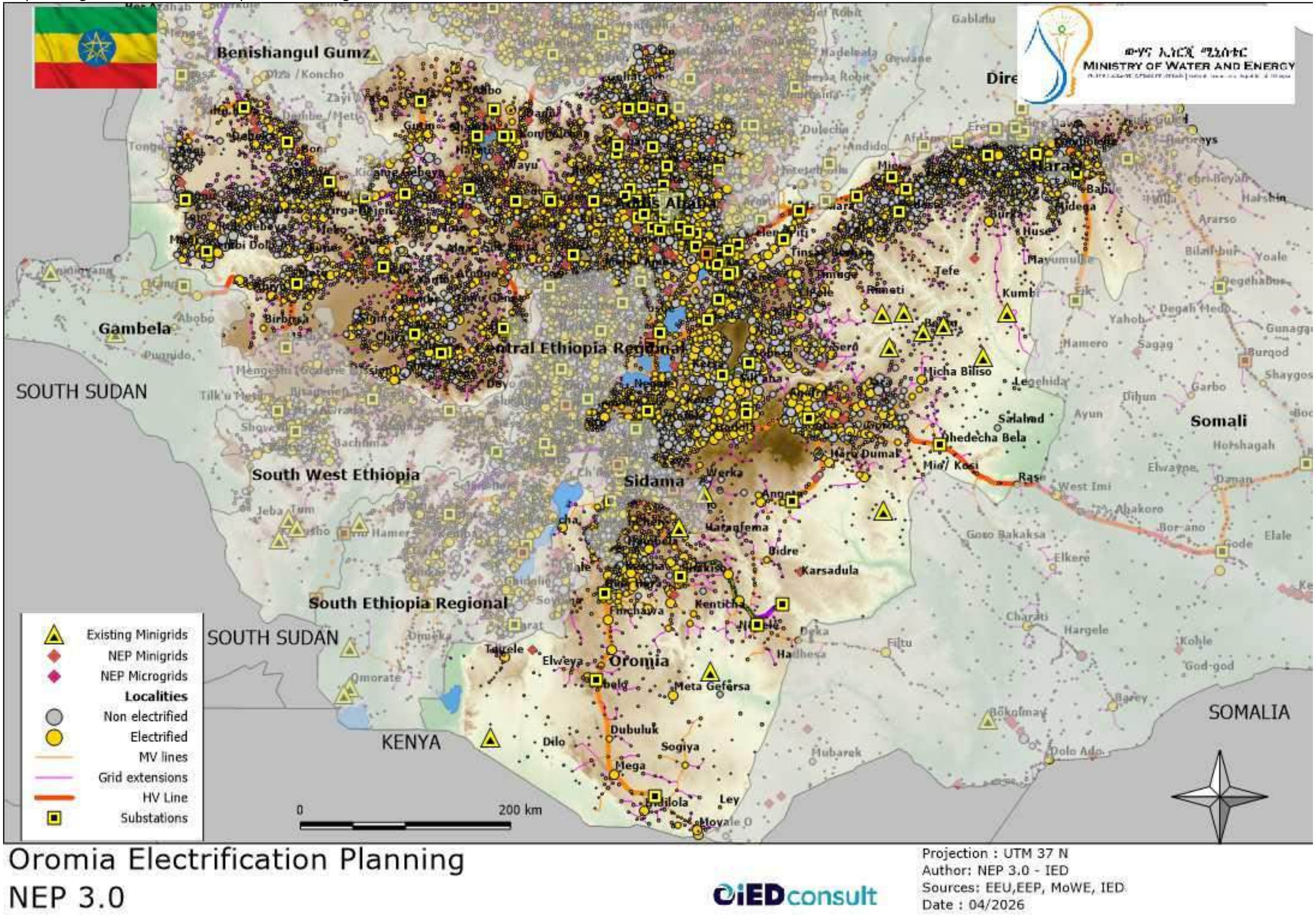
Map 28: Regional Electrification map for Sidama region



Map 29: Regional Electrification map for Tigray region



Map 30: Regional Electrification map for Oromia region



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