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National Electrification Strategy For Uganda

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NATIONAL ELECTRIFICATION STRATEGY STUDY

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Acronyms

DFI	Development Finance Institution
ECP	Electricity Connection Policy 2018-2027
ERA	Electricity Regulatory Authority
ERT	Energy for Rural Transformation
GIS	Geographic Information System
GIZ	Gesellschaft für Internationale Zusammenarbeit
GoU	Government of Uganda
MEMD	Ministry of Energy and Mineral Development
NEP	National Energy Policy
NDP I	National Development Plan 2010/11-2014/15
NDPII	Second National Development Plan 2015/16-2019/20
NES	National Electrification Strategy
PV	Photovoltaic
PUE	Productive Use of Electricity
REA	Rural Electrification Agency
REB	Rural Electrification Board
REF	Rural Electrification Fund
RESP I	Rural Electrification Strategy and Plan 2001-2010
RESP II	Rural Electrification Strategy and Plan 2013-2022
SE4ALL	Sustainable Energy for All
SHS	Solar Home System
SPV	Special Purpose Vehicle
UEB	Uganda Electricity Board
UECCC	Uganda Energy Credit Capitalisation Company
UEDCL	Uganda Electricity Distribution Company Limited
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
USEA	Uganda Solar Energy Association

1 Executive summary

Context and purpose of the NES report

The objective of the study is to prepare a "National Electrification Strategy (NES)" and corresponding plans aimed at achieving universal electricity access (on-grid and off-grid), taking into consideration technical, institutional, policy, regulatory, legal, and financial aspects. The NES is a key element in MEMD's mandate to update and consolidate the multiple strategy papers related to access to electricity. The implementation period covers the 10 years from 2021 to 2030 and targets an overall access of 100% considering the minimum service level of Tier 1 as per the SE4ALL multi-tier access definition.

This NES final Study report is a key instrument to support the discussions among the national stakeholders during a presentation workshop to be organized following the submission of this report. The objective of the workshop will be appropriation of the approach, analysis, overall strategic orientations and recommendations for NES implementation.

Electrification context in Uganda

The definition of electricity access refers to the connectivity, i.e. the population being directly served by either grid-based electricity services or stand-alone systems, providing at least Tier 1 access.

The actual electrification pace has consistently fallen short of targets mainly because of high electricity tariffs, high connection costs, high energy losses, lack of investments, lack of coordination between generation, transmission, distribution, and poor power supply quality and reliability. The current electrification status differs according to sources and service level. For the NES, the UBOS ERT-III 2018 household survey serves as the current electrification baseline: 50% of households access to at least one source of electricity, broken down as follows: 24% are connected to the national grid; 23% own a solar lighting system / solar lantern (incl. tier 0); 3% own a SHS.

An overview of the electricity sector is provided in this document. It encompasses the overall framework, a focus on the off-grid situation, a recap of the mini-grid projects existing and under development, as well as an outline of the transmission and distribution sectors and the grid customer growth.

Analysis of the electricity institutional framework

The current institutional set up of the electricity sub-sector is drawn and assessed with key challenges and recommendations considering, for each key institution, the legal mandate, the capacity to execute its mandate and the gaps falling under its responsibility. The analysis covers the MEMD, ERA, REB and REA, UEDCL, UECCC, UMEME, other Distribution Companies, as well as other key stakeholders including USEA and the main Development Partners. The overall recommendation is that the informal working relationships between stakeholders need to be formalised in the law and MEMD should be given a clear responsibility to co-ordinate planning and implementation of key projects in the sector.

The Government of Uganda has just adopted recommendations to restructure and rationalise the operations of several Government Agencies that will have impact on the electricity sub-sector. Under this arrangement, UEGCL, UETCL and UEDCL shall be merged into one company. ERA shall be strengthened and retained while the Rural Electrification Board (REB) and REA has been retained as a department of MEMD. The time frame for the implementation of these reforms had not been ascertained by the consultant by the date of this report but is likely to take a while since it will involve the amendment of the Electricity Act, process transferring of assets and liabilities as well as human resource. The Consultant has not undertaken any in-depth analysis of these reforms since they are outside the scope of the TORs of this study. However, some of the proposed reforms are consistent with Consultant's recommendations in particular, the retention and strengthening of ERA capacity to execute its mandate. The Consultant's recommendations also support one government entity to own all Government and donor funded assets. However, the Consultants view is that retaining REA under MEMD may constrain REA's ability to make timely decisions that may impact on the rollout of electricity access.

Analysis of policies and electrification strategies

A review of the different strategies and policy papers is summarized considering the main issues, critical analysis and main recommendations for the NES. This is followed with boxes which provide further details including a comparative table of the two underpinning papers namely the REMP and the Distribution Sector Diagnostic Review Study which are put in perspective with the new baseline and orientations applied in the NES. These key documents bring important inputs for the sector such as a financial model geared to the performance evaluation of service providers, or recommendations for the institutional framework including a PPP scheme. However, they lack a holistic approach encompassing for example a clear definition of access, a consolidated overview of the electrification status of each settlement, overlaps in distribution network, omission of areas where the population is scattered, omission of the business viability issues of mini-grids, and omission of densification activities. Overall, while there is a rich basis of information and analysis from previous strategy papers and studies, the information and recommendations remain highly fragmented and are not supported by a robust action plan and investment scheme to assist with implementation. The NES addresses all the issues identified.

An international benchmark of successful electrification strategies is proposed. This covers the classification of electrification models, namely: centralized approach - integrated state model, public electrification agency or fund model, private financing models. The lessons learnt highlight the following factors of success: applying a reduced household connection fee that is proportionate to household monthly income, strong political commitment, fast-paced extension of the grid, potential role of mini-grids in sparsely populated areas, priority of targeting public facilities and productive uses, deployment of ready-to-use switchboards, introduction of appliance efficiency standards, deployment of prepaid meters. The section is concluded with a recap of the gaps of national strategies taking into account international experience.

Strategy for the incorporation of productive uses into the NES

The availability of electricity is most of the time a necessary but often not sufficient condition for socio-economic development. The potential demand for productive uses of Electricity (PUEs) with its main drivers are analysed. It encompasses microbusinesses, SMEs, industrial and agricultural sectors through processes of conversion to electricity by substitution or modernization of existing activities, but also innovation for setting up new activities. Standardized energy usages are characterized in the report with examples of value chain business cases. A special focus on PV for productive use is proposed in the report by assessing existing and new solar technologies. Among others, a comparative cost-benefit calculation detailed in this section shows that solar irrigation pumping costs c$6.7/m3 whereas gasoline irrigation motor pump costs c$10/m3. However, the market of PV Pumping still needs subsidies because of the very high upfront costs compared to motor pumps. Moreover, we summarize the characteristics of the main financial institutions active in Uganda and the credit facilities offered to support the productive use initiatives. Gaps and constraints for PUE are appraised with extensive recommendations of practical actions and accompanying measures useful to foster PUE.

Analysis of off-grid business models and options

Business models for investment and operations of mini-grids with their financing mechanisms are characterized in this section. These include Electricity co-operatives; the Community managed model, Electricity distribution franchise, Fee-for-service model, and Private sector model. A special focus on solar PV kits is given through SWOT analysis and by reviewing the specific business models and challenges. Finally, strategic recommendations to develop off-grid solutions are proposed taking into account key lessons learnt from previous initiatives in Africa. In addition, success factors and proposed actions to create an enabling environment for the PV sector in Uganda are set out in this section. The proposed actions encompass issues related to fiscal barriers, consumer protection and awareness, supply chain financing and consumer financing.

Analysis of the legal and regulatory framework

The current legal and regulatory environment is presented in this section. The impacts of the laws and policies and the constraints faced by the electricity sector are analysed by considering the key issues, current provisions, gaps and key recommendations, as summarized in the table below.

#	KEY ISSUE	RECOMMENDATION
1	Definition of key terms	Connection, Electrification, Coverage, Rural Electrification: these terms are defined in the proposed law to ensure the common understanding and uniform application of the terms.
2	Definition of minimum Access	Tier 1 level should be considered for distributed solutions or as a temporary solution pending graduating to a higher level. This is indeed too low to affect meaningful level of social and economic transformation, and is incompatible with upper middle income status Uganda aspires to (as set in the Vision 2040).
3.	Uncoordinated roles of sector players	Need to take holistic view of the sector: MEMD should take responsibility for sector planning and co-ordination of project implementation, in particular in the distribution sector among REA/Umeme/SSSP/Private sector[1]. This should be formalized in the law.
4.	Market Structure	- Proposed amendment to relax the role of UETCL to allow generators sell directly to some bulk consumers and distributors. But caution is needed not to undermine UETCL existing PPA obligations and there is need to study the wheeling infrastructure and wheeling charges frameworks before implementation. One efficient way of doing this and avoiding operational distortions is to create the distinctions through the tariff based on criteria that curve out the targeted industries of course with a provision to keep UETCL financially viable to meet its PPA obligations. - The issue of wheeling charges should be addressed when demarcating new distribution territories to avoid payment of wheeling charges.

[1] For example, KFW had to cancel 15% of villages in the latest programmes as they were already built.

		- A recommendation to have one operator, a Special Purpose Vehicle (SPV) under a PPP model to operate the national Distribution grid in the country with service obligation to communities in licensed territory is important to eliminate overlaps of service territories, duplication and tariff discrimination. - Existing small service providers should be phased out but can be retained as sub-contractors by the SPV. Where a licensee fails to provide a service within a reasonable time, other operators should be licensed to fill in the gaps and provide on or off grid solutions.
5.	Roles of ERA to attract investment in new services & technologies.	- ERA has adopted regulations for Isolated grid systems, Electricity (Isolated Grid Systems), 2020 which are more light handed, simplified and flexible than the regulations in the Grid codes for the national distribution grid which should attract private capital. The regulatory framework for small off-grid operators in rural electrification should be further enhanced by providing incentives to encourage PUE and targets for increasing access, introduction of new technologies and innovative ways of service delivery. - The important role played by small operators for off grid areas is imperative. The market for off-grids such as mini-grids and SHS should be open to competition so as to attract new technology and innovation. It should also be noted that renewable energy which is often adopted for these projects attract donor financing which can be lost to the country if the country does not adopt strategies to tap into these projects. In addition it would speed up electrification for those areas not covered by the national grid due to viability considerations or time to implement the national grid extension. It would therefore help developing local demand and in speeding up electrification. With respect to the necessity of small operators on the grid, their role should be confined to off-grids where the national operator is unable to serve within a reasonable time for whatever reasons. The diagnostic review study and others studies extensively studied the operation of the small service providers and established their lack of capacity to execute their mandate and a detailed analysis established that a single operator of the National grid would be more economical, produce better results using an SPV under a PPP model. This service vehicle will be responsible for covering all Uganda irrespective of any given area whether accessible or not. - ERA should delegate some of its regulatory functions especially in relation to standards for new technologies and off-grid solutions to local Authorities or other Government Agencies.
6.	Licensing procedures	Competition should be encouraged in Procurement of all big electricity projects which should follow an integrated system development plan. However, even small projects can be packaged and bidded out to encourage competition such as UNBS.

7.	Tariff setting for rural concessionaires	There is need to standardize tariffs using targeted subsidies allowing for financial viability for private investors both in off-grid and on-grid areas. There should be cross subsidization among customer categories.
8.	Distribution projects financing	The role of UECCC in mobilization of funds for electricity projects should be formalized in the law.
9.	Increasing demand for electricity to match generation	The productive use of electricity should be given priority over domestic use through tariff incentives and more subsidies as well as adopting a multi-sectoral approach to empower communities.
10.	Small distribution licensees capacity	The existence of smaller operators to operate off-grids is critical in extending power to isolated communities. There should be provisions for capacity building for them and addressing the operational constraints faced by small operators. Before providing TA, it should be checked that these are viable entities going forward, depending on cross-subsidization potential and efficient operations.
11.	Distribution assets ownership and replacement	The ownership and responsibility for government or donor funded distribution assets should be provided for under UEDCL or the successor entity, which is a Government distribution asset owning company to ensure sustainability of the sector.
12.	Land acquisition for project and way leaves.	The law needs to be amended to balance the right to compensation of private land owners and public interest to execute public projects in timely manner. This includes a mechanism to expedite the resolution of compensation disputes e.g. by setting up Special Tribunals.
13.	ERA powers to enforce sanctions	Proposed amendments in the Act to provide for fines and penalties are in right directions. The regulator should be allowed a range of other options to deal with errant licensees.
14.	Rampant vandalism of electricity installations	Proposed fines and penalties should be deterrent enough and paid into special Energy Fund to be utilized for electricity projects.

The GOU has initiated the process of amendment of the Electricity Act and an Electricity Bill, 2019 is before the Parliament for debate. While the proposed amendments address some of the pertinent issues affecting the sector, some important aspects have not been addressed adequately as highlighted above and should still be incorporated. These include the following: unclear definition of terms; the institutional capacity and functions of ERA; licensing of unsolicited project proposals; lack of conducive regulations geared to attracting innovative services and technologies; lack of market guarantee for investors in generation sector; unclear modalities of the Electricity Investment Fund and role of UECCC; unregulated royalties payable by IPP to local administrations and; lack of commensurate instruments against breach of license conditions.

Technological review and recommendations

A review of the current on grid and off grid technologies is provided and covers the MV and LV design data, the construction units, the types of structures according to their function, the list of current off-grid power plants operating in Uganda, etc. A specific outline on SWER concludes that this technology is not suitable in Uganda. An international benchmark of low-cost technology options is presented and pinpoints the technical implementation practices. This is illustrated through two short case studies. We also present the technical principles that will guide the implementation of the NES projects. We distinguish in particular the minimum requirements of the grid and off-grid PV technologies to be used, the lower cost alternatives to be applied on a case-by-case basis, unit cost assumptions, quality and security. We finally highlight the points of attention for each stage of the implementation of on-grid projects: selection and sequencing of localities to be electrified, demand forecast, financing arrangement, preliminary and detailed design studies, selection of suppliers, companies for works and social intermediation, carrying out and supervision of execution studies and works, registration and management of connection requests, case of a dedicated connection programme and finally commissioning and operation. The same applies to off-grid projects, with specific recommendations, in particular for the formulation and launching of off-grid Facilities and processing of project proposals submitted by private promoters, up to the signature of financing and concession agreements.

Analysis of capital investment strategies & control mechanisms

As a result of low consumption patterns, electrification programmes often require large subsidies or concessional loans, either directly from the State, DFIs or through additional fees on the existing grid-tied customers. Moreover, at the formulation stage, it is recommended to include accompanying measures such as promotion activities for productive use, marketing actions to increase the connection rate, social tariffs for connection and acquisition of ready-boards, etc.

The electricity sector financing ecosystem is comprised of the GoU (through UECCC, REF, State Budgetary Allocations, public debt), DFIs, foundations, commercial banks, Investment Funds and off-grid companies. To enable a risk allocation in line with various players' expectations, 3 key types of legal structures can be used: (i) government owned projects, (ii) private owned projects with commercial risk and minimal government risk-taking, and (iii) Public-Private Partnership (PPPs) with shared risks and ownership. The related advantages and disadvantages of the respective legal and financing schemes and a summary of the electrification methods linked to the financing sources available are pointed out in this section of the report.

In practice, the financing plans for on-going strategies and policies face the following challenges:

- Electrification policies formulated usually do not include clear financing plans
- Electrification of rural areas is not commercially viable and therefore requires heavy subsidies
- Current policies and strategies were not synchronised
- The ECP 2018-2027 tries to coordinate the plans, budgets and financing sources
- A clear financing plan is still needed to comprehensively match the needs with the sources

For grid extension, intensification and densification:

- The grid is usually managed by a single operator to ensure its stability
- Private players undertake heavy investment through PPPs
- Grid distribution can be split among several operators
- Grid investment needs are very large and a common bottleneck for electricity sectors
- Cost efficiency can be achieved through competitive tendering
- Privately funded grid requires a mature energy market

For mini-grids:

- Generation and distribution activities may be separated
- PPPs can foster investment in mini-grids

- The development of productive uses shall be supported through appliance financing
- Mini-grids in rural areas are creating a new energy market for energy, but commercial viability of mini-grids remains a challenge in areas where demand and household budgets are limited
- Mini-grids require cheap, long term financing to fund their large upfront costs
- Local communities should get involved in mini-grids financing and operations

For stand-alone Systems:

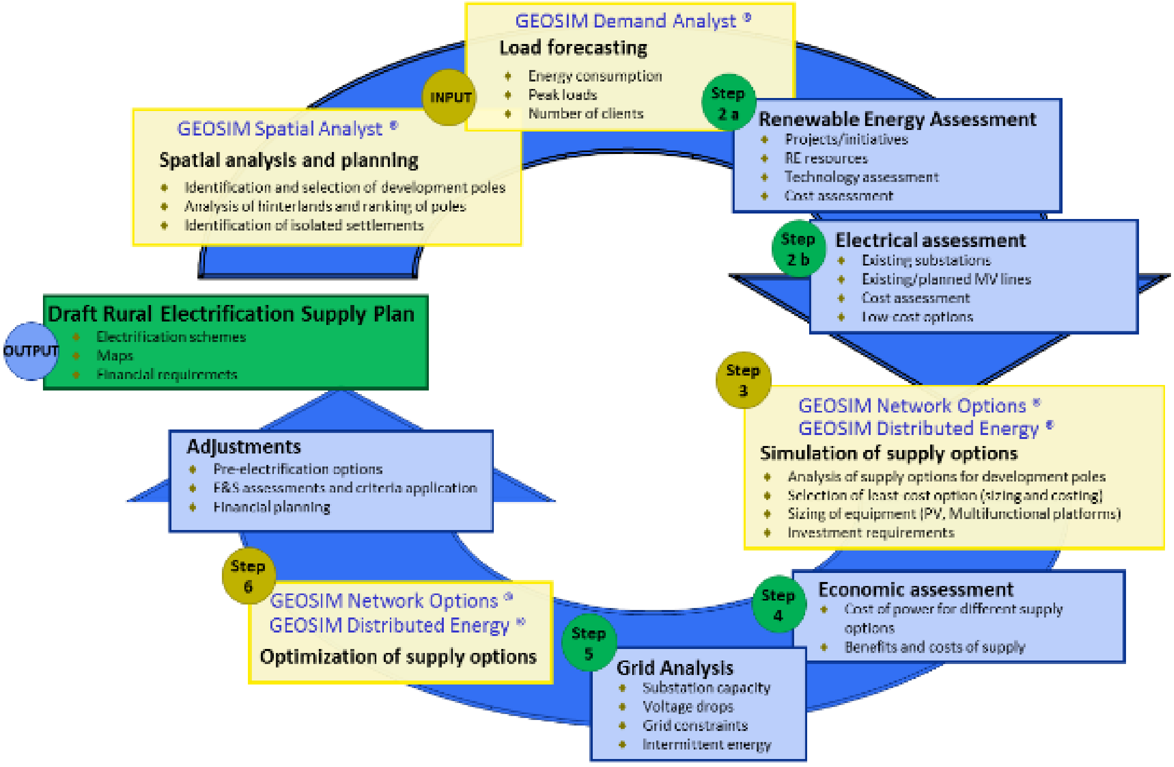
- Successful deployment of the technology hinges on consumers' trust
- The government should control the quality of products of stand-alone systems
- Micro-finance institutions or PAYG operators undertake the up-front investment of SHS
- Standalone Systems are commodities, and their financing therefore differs greatly from the project-based mini-grid or grid-tied transactions
- Successful African financing solutions are being leveraged upon and tailored to needs
- GoU can help finance standalone systems through dedicated financial instruments

Finally, a review of international benchmark and best practices is detailed in this report. Key takeaways include:

- A financially stable national utility company facilitates the subsidization of non-profitable electrification activities.
- Grid investment is critical for power absorption and a common bottleneck.
- Consumer financing programs leveraging on a strong pre-existing microfinance framework can be an effective instrument. UECCC could act as the central provider for credit support facilities.
- Cooperatives encourage a culture of collective responsibility through engagement and ownership by local populations in employment creation, financing and implementation of the initiatives.
- Strong consumer confidence in the new technologies is a pre-condition for microfinance institutions involvement. The absence of enforceable quality standards for the products sold in Uganda is deterrent for potential consumers and financers.
- Systematic prioritization of the electrification of productive sectors such as agriculture can provide supplementary financing.
- Stakeholder Associations (e.g. of solar developers) provide better risk pooling and diversification opportunities for investors hence leveraging on economies of scale when providing financing.

Least cost electrification planning approach and methodology

As illustrated in the figure below, the approach is based on the geospatial planning software called GEOSIM:

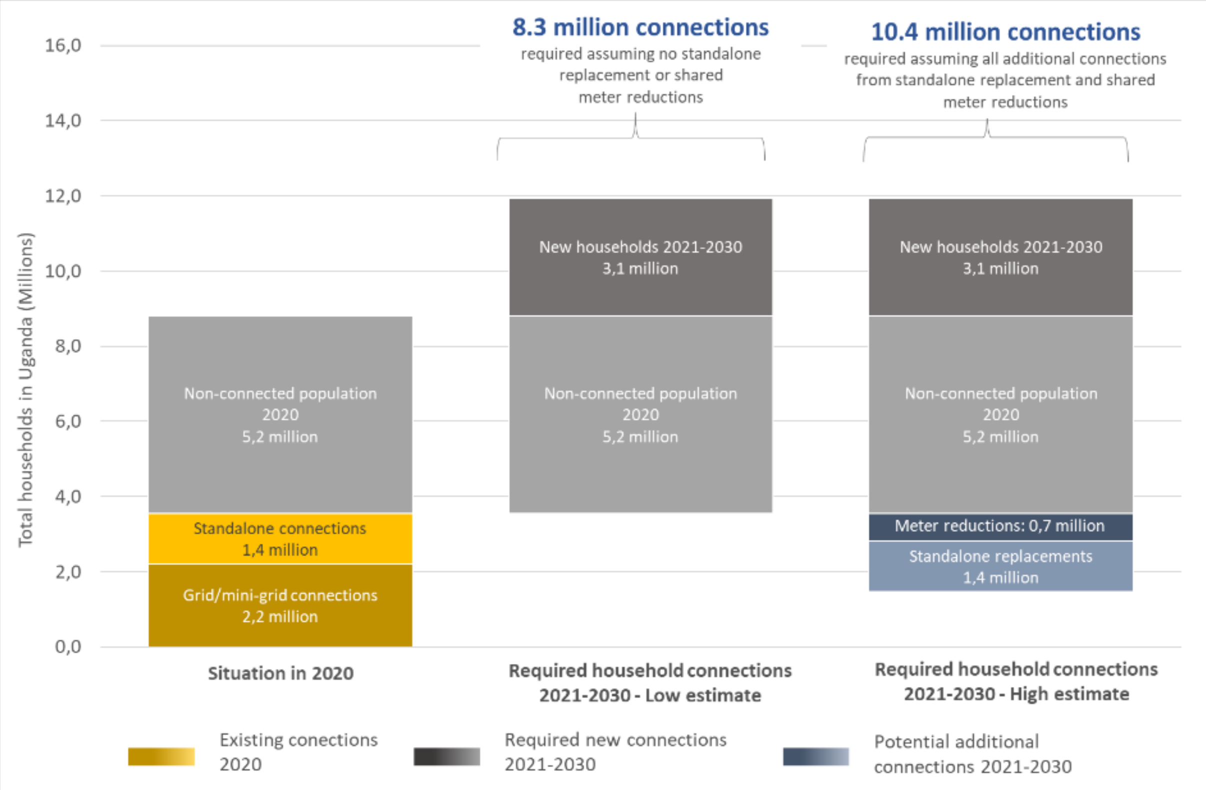


The least cost planning approach comprised four major steps:

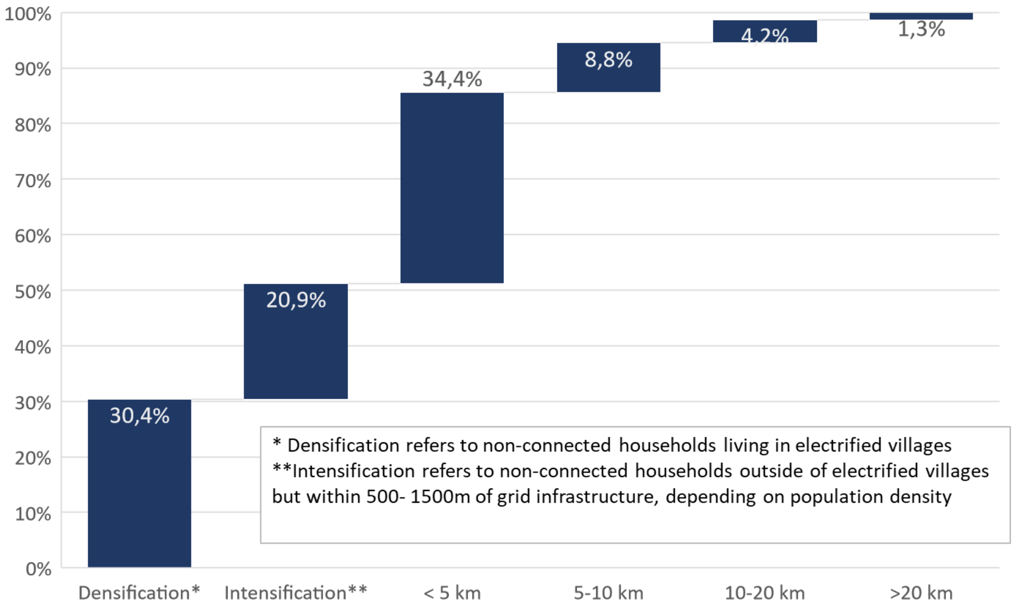
1. **Create a consolidated villages database**
   - Consolidation of administrative data, electrical infrastructures multi-sector data (education, health, admin, commercial, water access points, service stations…), demography, topography, renewable energy, infrastructure (road network, parks and reserves)
   - Reshuffle and reconsolidation of the GIS database based on the new administrative units of 64,369 villages (instead of 44,032 units processed for the NES Draft report). This database is not linked to the population or any census data at village level.
   - Estimation of the population in each of the 64,369 villages in Uganda using datasets that combine rooftop imagery with official demographic projections. No recent village-level census data was available from official sources.
   - Determination of the electrification status of each village: stakeholders in Uganda currently do not possess a consolidated dataset with the up-to-date electrification status of each village. This required a specific processing for building up, e.g. consolidation from the night satellite images, and geo-referenced connections and transformer data from distributors and REA.

2. **Conduct high level population analysis**
   - Locate electrified and non-electrified populations in 2021. IED estimates that of the 64,369 villages in the country, 16,449 – or 26 % – will be electrified via the interconnected grid, or an isolated or mini-grid by 2021.
   - Locate zones where electrification will have a high socio-economic impact (GEOSIM). This includes the calculation of indirect beneficiaries potentially impacted by the electrification of social services and public infrastructures.
   - Estimation of required connections over the period 2021-2030, based on the villages database connection statistics, policy goals, demographic projections, etc. 10.4 million connections are

expected to be required by 2030 in order to achieve universal tier-1 connectivity as shown in figure below.[2]



- Electricity demand potential analysis (GEOSIM): the figure below shows the percentage of required connections by distance from existing MV grid by Service Territory: the vast majority (i.e. 85%) are located in already electrified villages (densification) or in areas within 5 km of the existing grid. UMEME and UEDCL account for 3/4 of the total required connections.



[2] The figure accounts for customers who are currently sharing a meter and may choose to "regularize" their connection by obtaining their own meter and distributor contract, generating an increase in the required connections.

- Load forecast of domestic and non-domestic potential users taking into account specific assumptions for on-grid and off-grid areas, households categories of consumption, connections pace, unit consumption growth, etc.

3. Additional study on the electricity sector

- Small hydropower potentials identification using geospatial data. This is critical for potential mini-grid development or for injection in remote areas of the grid.
- Grid dimensioning studies on a selection of existing transformers. This is used to develop realistic assumptions for grid densification and extension to complement information received from stakeholders.
- Assessment of the suppressed demand due to among others load shedding, transmission or distribution capacities, poor quality and reliability of supply, strained network operating conditions, etc. The overall suppressed demand including from industrial parks is estimated at **2 420** MW. Specific recommendations are proposed according to the type of the suppressed demand.

4. Development and test of the selected base case scenario of electrification

The development of the NES is based on the criteria presented in the table below through geospatial optimization simulations carried out using the GEOSIM planning tool. The 3 modes of electrification are thus studied: densification and extension of the network, mini-grids and solar kits. These criteria were discussed and then approved by the stakeholders during different consultation rounds. They are the result of a consensus between the objectives of technoeconomic and socio-economic optimization, service levels according to electrification modes, a usual demographic threshold of 500 inhabitants applied by MG promoters to target off-grid villages, and realistic connection rates.

Criteria for the technology to be deployed for a particular village are based on average cost of making a connection for that particular village. The cost per connection is determined by proximity of the targeted village to the grid and the population size of the village. A model (computer software for optimized planning) is used to automatically select technology options and grid layout to be deployed in each particular village as follows:

a) Densification: for already electrified villages with connection targets of 70% to 100% depending on the initial access rate.

b) Grid extensions: Cost per connection is less than USD 1,999

c) Mini-grids: Cost per connection is USD 2,000 and above with a population of not less than 500homesteads

d) Solar Home Systems: For all non-connected household either in grid/mini-grid areas or in off-grid areas

Then, for each particular technology to be deployed, villages are prioritized on a calculation which integrates two criteria:

- first, the level of socio-economic infrastructures available in the settlement (significance of the educational, health or economic infrastructures that exist);
- second, the size of the population which can benefit from these services (inhabitants of the locality and inhabitants living in the surroundings: “population coverage”).

These 2 criteria are aggregated through the "covered population indicator". The higher is this indicator, the better the ranking of the localities. The planning criteria are further developed according to the consensual base case scenario in the table below.

#	Criteria	Base case final	Comments
1	**Budget**	No limit	– No specific constraint. The NES Final scenario presents the budgets required to achieve the selected optimum access
2	**Institution**	IED optimisation	– This is the techno-economic and social optimum grid footprint attained by using geospatial analysis and GEOSIM software.
3	**Connection rate in y10**	50% to 100%	– This criterion refers to connection rate within grid/MG connected villages. All non-connected HH = SHS Tier 1.
4	**Grid footprint in Y10**	no buffer	Threshold for technology selection – grid vs. off-grid zones: – 1: Grid-preferred – USD 1600 or less – 2: Mini-grids preferred – USD 2000 or more – 3: Mixed mode zones where MG projects were studied in competition with grid extension – USD 1601-USD 1999. – 4: Standalone Solar for all remaining non-connected HH
5	**Standard of service of household connections and others**	Tier 1 to 5	– For connected HH to grid or MG: service according to HH categorization (high, medium, low incomes) specific to on-grid and off-grid connection – For non-connected HH either in grid/MG areas (see criterion #3) or off-grid areas (see criterion #4): Tier 1 service and sensitivity analysis to a service level equivalent to MG option. – Infrastructures: Tier 3 to 5 depending on requirements
6	**Number of solar MG**	no limit.	– During the workshop of July 22, it was agreed to reduce the threshold from 1000 to 500 inhabitants allowing for micro-grids.

- Test scenario and assess results (GEOSIM):
  - Number of connections achieved
  - Additional demand from new customers
  - Total investment requirements
  - Economic value of investments (NPV)

Results of the NES simulations

- Grid densification: 3.44 million household connections to be achieved by 2030, or 344,000 connections per year on average. Total budget: $ 2.5 billion with a weighted average cost per connection of $ 730.

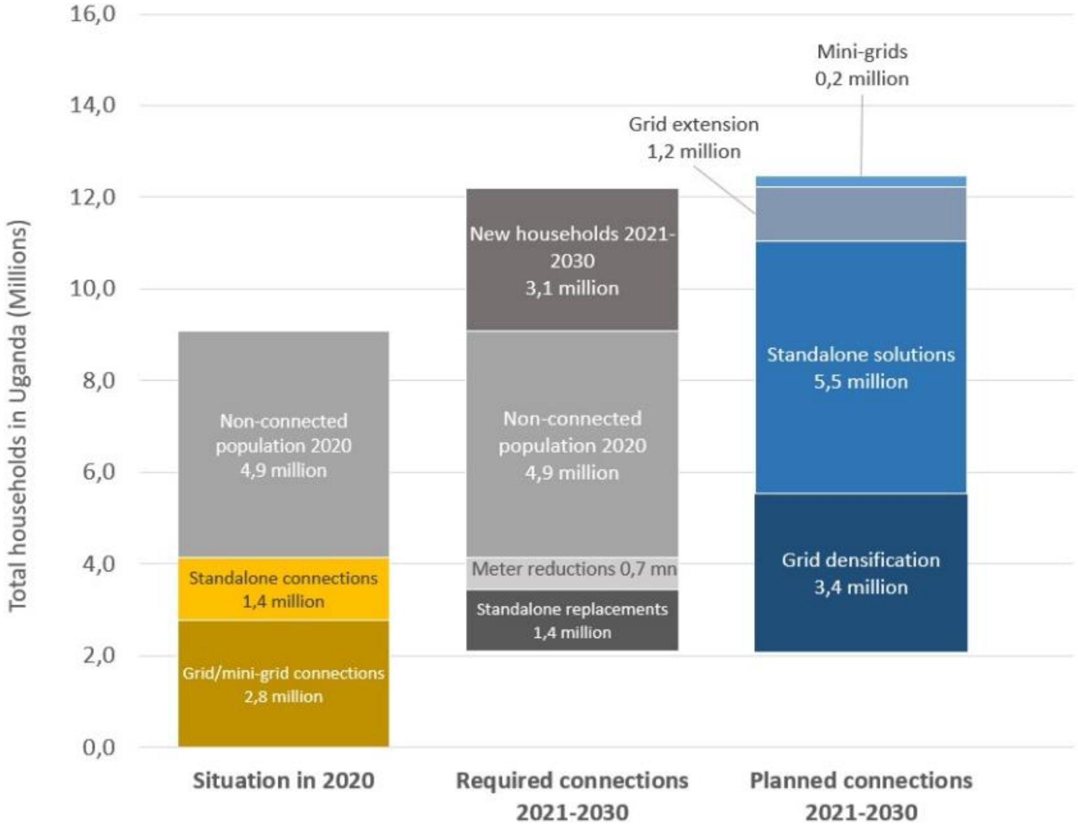
- Grid extension: 11,127 villages (1.19 million connections by 2030, connectivity increasing to 50% of households in Y10 after electrification) to be electrified by 2030 through almost 15,222 km new MV lines. This is in line with the current baseline. Total budget: $ 1.4 billion with an average cost per connection of $ 1,088.
- Hydro mini-grids: IED identified 4 potential hydro mini-grids with a combined nominal capacity of 1,7 MW. These grids could potentially supply 62 villages through 4 clusters, providing access to a population of approximately 40,000 people. But at over US$ 0.63 – 1.59 per kWh, the LCOE is too high to justify their inclusion in the NES planning scenario. However, these sites should undergo further study to identify potential anchor loads and/or cost savings measures that might improve economic viability.
- Solar mini-grids: As a result of the inconclusive hydropower developments, all mini-grid projects in the off-grid zone are planned as solar PV projects for villages with a 2021 population of greater than 500 inhabitants located in the off-grid zone. A total of 2,712 potential solar-diesel mini-grid projects serving about 234,280 connections are identified representing $ 356m total investment, i.e. about $ 1,519 per connection.
- SHS: In order to achieve universal Tier 1 connectivity by 2030, all remaining unconnected households are eligible to a 3W solar system (equivalent to 2 lights and phone charging), to provide access to a total of 5.5 million households for a $ 385 million budget. An additional $ 33 million budget would be required to electrify 3,065 public infrastructure points and productive uses. Besides, a sensitivity analysis is proposed on the service level in order to simulate the economic impact for mini grid-standards usages enabling microbusinesses for distributed solutions. The total cost would then amount to $ 17,066 million[3] (to be compared to US$ 418 million budget for SHS Tier 1 of base case scenario).
- Total estimated investment budget for this variant is $ 4.68 billion to connect 10.4 million households:
    - 84% dedicated to on-grid connections (54% densification, 30% grid extension)
    - 16% dedicated to off-grid solutions (7% solar mini-grids, 9% standalone solutions)
    - National weighted average cost per connection: $ 387
- The overall results are summarized in the table and figures below :

	Total	Densification	Grid extension	Solar mini-grids	Standalone solar systems*(*)*
Connections (million)	**10.4**	3.44	1.2	0.23	5.5
Investment ($ million) [sensitivity analysis on SHS service level: Tier 2+3]	**4,680** [21,328]	2,509	1,398	356	418 [17,066]
Costs per connection ($) [sensitivity analysis on SHS service level: Tier 2+3]	**387**	730	1,088	1,519	76 [3,104]

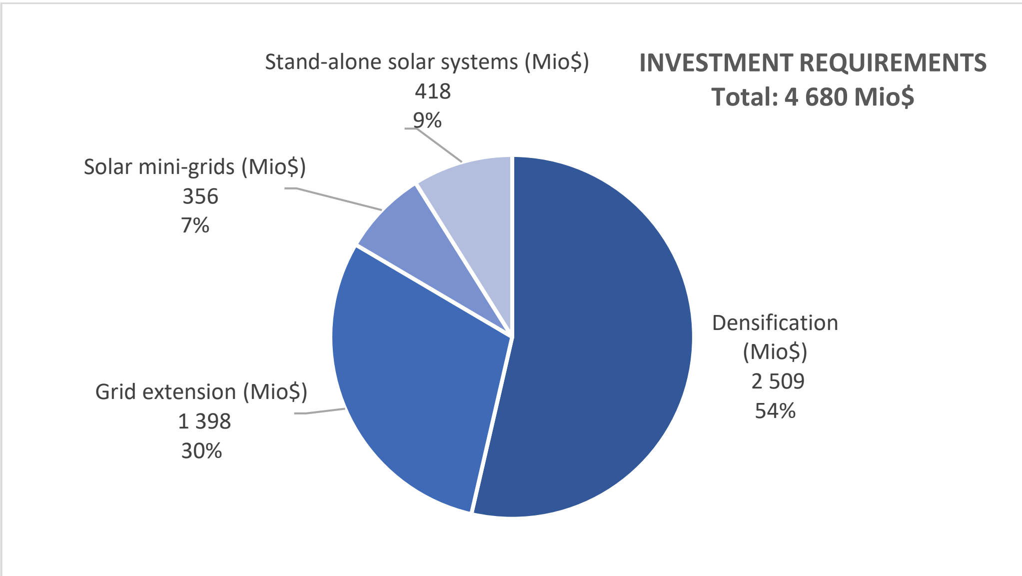
(*) including the replacement of the PV systems after 6 years of operation (life span of SHS).

[3] This amount includes the replacement of the PV systems after 6 years of operation (life span of SHS).

Consolidated results - number and type of connections



Consolidated results – investment requirements



Financing options and investment plan

The business models and risk profiles can vary significantly depending on the electrification methods, which directly dictates the type of financing instruments and players that can be engaged.

<u>Grid extension and reticulation</u> is usually **public owned through a national utility.** Grid investments are profitable only in the long-term, depending on the future economic development of the area, especially when connecting rural areas with a low economic output. Such long-term investments

combined with demand risk that is difficult to control make private-owned solutions expensive and complex to set up due to important risk-sharing mechanisms to put in place.

Utility grid electrification projects shall be financed through:

- **Rural electrification fees on power bills** to existing customers to support the investments that the transmission and distribution companies need to incur to extend the grid.
- **Long-term concessional loans from DFIs** supported by the State to give enough time for the utilities to make the new connections profitable as demand/customer base grows.
- **Subsidies from Government or DFIs** to further reduce the burden for the electricity sector and ensure the utility company remains bankable, which is essential to private investments in the sector.
- **Private financing for grid extension should remain limited** as the connected customers are not profitable on the short to mid-term. Private financing backed by State-guaranteed revenues through a PPP structure may be considered when projects are more profitable, or with a subsidy component.
- **Consumer financing programs to promote and fund productive uses** helps in building better credit profiles from revenues earned through productive uses.

<u>Mini-grid projects</u> can be private or public-owned with private EPC and O&M contractors. **Private projects seem more adapted** as public mini-grid projects have been slow to deploy. In addition, they are not always well built and operated as projects are very small, making it hard for the authorities to manage contractors who have no incentive to optimise projects performance.

Private investments could be financed through:

- **Investment grants facilities** to fund part of projects construction costs. Country-wide result-based facilities with pre-defined, standardized conditions should be privileged to give visibility to developers.
- **Long-term debt** through dedicated DFI funded initiatives managed by local banks or fund managers with mini-grid experience.
- **Equity funding** by impact investors, private equity or large energy companies with a long term vision.
- **Consumer financing programs to promote and fund productive uses** helps in building better credit profiles from revenues earned through productive uses.

Enabling by Government:

- **Scale is essential to decrease costs and reduce dependence to subsidies.** Projects should be attributed by large batches to a few promoters rather than distributed to numerous players with limited capacities.
- **Licensing processes need to be quick and simple** due to the small individual size of projects to enable rapid deployment and scale up.
- **Tax incentives** on solar panels and batteries with no duties and VAT during projects deployment phase. VAT exemption on off-grid energy (kWh) sold should also be considered in order to make the tariff more affordable.

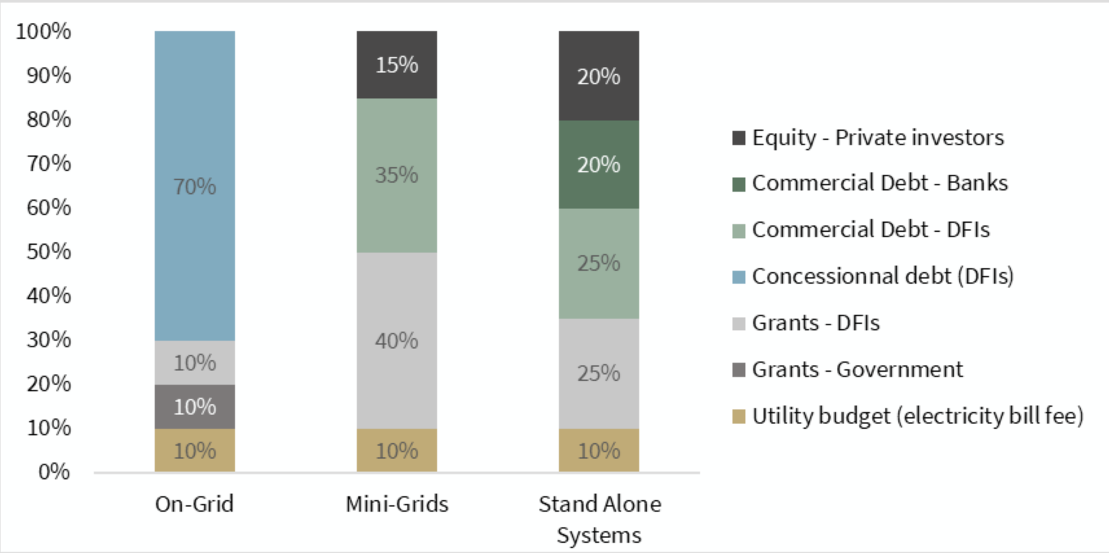
<u>Stand Alone Solar Systems</u> can be deployed by private companies as a viable commercial activity with Government intervention limited to regulation. Those companies should be funded through:

- **Working capital and inventory-finance** facilities through local banks with funding and technical assistance from DFIs.
- **Equity funding** by impact investors, private equity or large energy companies with a long-term vision.
- **Commercial risk guarantees** by DFIs covering part of the projects risk to make projects attractive to lenders.
- **Consumer financing programmes** leveraging on existing microfinance experience is instrumental to assess the solvency of customers and eventually strengthen their credit rating.

Enabling by Government:

- **Quality control** and regulation by Government
- **Tax incentives on solar kits equipment and import**

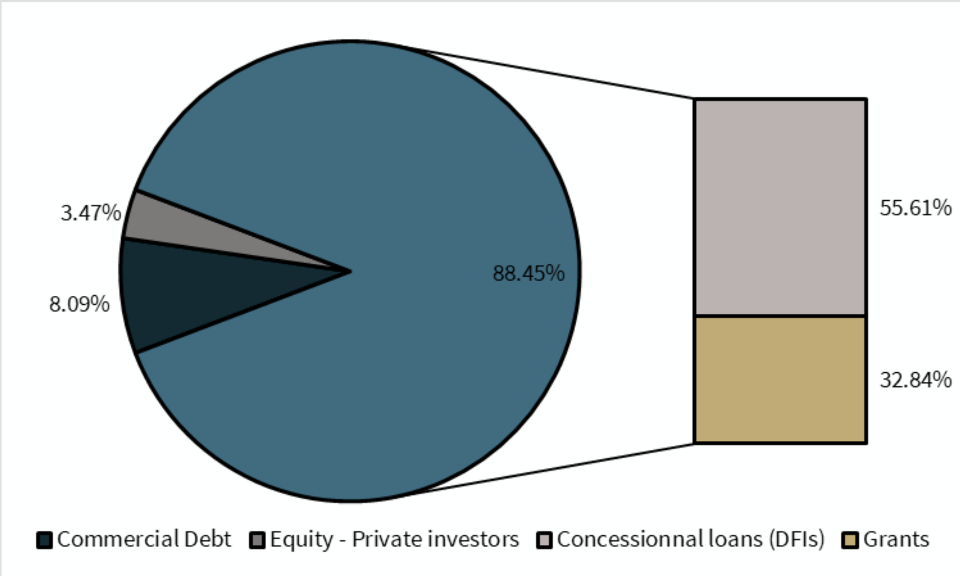
Based on the financing options analysis per segment, the following financing plan is recommended to cover the $4.68 Billion investment required to deploy the NES until 2030.



Based on the NES investment needs per subsector, the financing needs for each instrument are as follows on a yearly basis:

NES Yearly Financing plan ($ millions)	On-Grid	Mini-Grids	Stand Alone Systems	Total	%
Uses:					
Average 1 year needs	**391**	**36**	**42**	**468**	
Sources:					
Grants	**117**	**18**	**15**	**150**	**32%**
From electricity bills	39	4	4	47	10%
From State Budget	39	0	0	39	8%
From DFIs	39	14	10	64	14%
Concessional debt (DFIs)	**273**	**0**	**0**	**273**	**58%**
Commercial Debt	**0**	**12**	**19**	**31**	**7%**

From DFIs	0	12	10	23	5%
From Commercial banks	0	0	8	8	2%
Equity - Private investors	**0**	**5**	**8**	**14**	**3%**



Grants and concessional loans collectively account for about 88% of total financing. This is explained as grid electrification represents 80% of the total NES investment plan, and is expected to be financed through grants and concessional funding only. This large reliance on non-commercial financing sources to keep financing costs and ultimate costs to the consumers under control highlights the importance of proper planning and preparation on the State side to first dedicate sufficient budget and second work with DFIs to obtain their necessary contribution.

Strategic consolidation for decision-makers

This NES final Study report resulted in a NES Paper geared to decision-makers annexed to the report. It summarizes the key issues by highlighting the points of attention required for NES adoption, implementation and supervision. Strategic actions are proposed for NES implementation.

Conclusion

The final base case scenario is ambitious in terms of maximizing the quality of service for connections, but is also feasible, taking into account the various constraints faced by the sector from a capacity, financial and market perspective. All these constraints were identified and analysed with recommendations in this report. One of the future challenges will be to support stakeholders to enable them to take ownership of the elements of analysis, recommendations and improvement proposals contained in the NES final Study report with a view to operationalizing the strategy. A prerequisite is the effective involvement of decision-makers and managers of the institutions concerned, who should act in a spirit of continuous consultation, information sharing and proactivity. As mentioned above, in particular in the international benchmark of success stories, a strong political commitment that places electrification as a national priority is sine qua non of the ambition of universal access following in the footsteps of Kenya, Tunisia, or Morocco which have achieved or about to achieve such goals. Fundraising through transparent planning processes readable for all public, private and international stakeholders (without major changes along the way) is a key success factor.

The private sector is also called upon to play a leading role in the implementation of the NES. The off-grid regulatory framework is favourable to this but still needs to be implemented with flexibility and pragmatism, considering the pilot and risky nature of off-grid and MG projects (especially for the private sector who bears the main financial risks): these projects are essential for all actors (public, private, development partners, users) to gain know-how, experience and, ultimately, confidence in off-grid electrification solutions.

2 Introduction: context and purpose of the NES report

2.1 Reminder of objectives, results and activities of the Study

Objectives

The objective of the study is to prepare a "National Electrification Strategy (NES)" and corresponding plan aimed at sustainably and rapidly increasing national electricity access (on-grid and off-grid) to achieve the GoU's national electrification targets as stipulated in the NDP II and Vision 2040, taking into consideration technical, institutional, and financial aspects. The NES will also aim at increasing productive use of electricity and energy efficiency amongst consumers. The scope of work encompasses the preparation of a GIS database of relevant layers and a geospatial estimated least-cost electrification options analysis for use by the Ugandan government. The NES will be used as a tool based on GIS to rationalize investments and maximize the socio-economic impacts.

During the inception mission, it was agreed that **the implementation period of the NES covers 10 years from 2021 to 2030 and targets an overall access of 100% considering the minimum service level of Tier 1 as per SE4ALL multi-tier access definition.**

Results

The key results of the assignment are:

1. Database of technical and socio-economic layers of the GIS
2. GIS and online platform for geospatial visualization of electricity and socio-economic data
3. Potential least-cost options for achieving universal access: on-grid and off-grid
4. Investment and financing plans
5. Recommendations on regulatory, institutional and financing frameworks
6. O&M frameworks analysis
7. Capacity building to key institutional stakeholders and dissemination of relevant information
8. Database of the key institutional focal points for GIS updates and cross sector dialogue

Activities

The activities required to achieve the results are divided into 3 phases:

Phase 1: Inception phase

Deliverables: KoM, inception report and workshop
Completion by end November 2019

Phase 2: NES Preparation

Deliverables: NES draft report and workshop
Completion in September 2020 (date revised following the disruption caused by the viral pandemic)

Phase 3: NES Consolidation

Deliverables: NES Final report and workshop, Strategy and Tools Handover
Completion by May 2021 (date revised following the disruption caused by the virus pandemic)

The activities are specified below:

Phase 1: Inception phase

1. KoM & inception mission
2. Analysis of policies and electrification strategies
3. Analysis of regulatory & institutional framework
4. Stakeholder capacity analysis
5. Analysis of capital investment strategies & control mechanisms
6. Data compilation & GIS preparation
7. Inception report: Draft and final
8. Inception report workshop

Phase 2: NES Preparation

9. Criteria and planning parameters setup
10. Sensitivity analysis and scenario development
11. Spatial analysis with SPATIAL ANALYST ®
12. Load forecasting with DEMAND ANALYST ®
13. Least cost electrification options: on-grid
14. Least cost electrification options: off-grid
15. Recommendations on regulatory, institutional and financing frameworks
16. Draft NES Report and workshop
17. 1-day training GEOSIM

Phase 3: NES Consolidation

18. O&M frameworks analysis and performance indicators – tools such as the creation of an online platform for stakeholders[4], methodology for updating and sharing information between agencies
19. Estimation of suppressed demand due to non-served and under-served demand due to technical constraints on the distribution grid. This includes a quantitative and qualitative analysis of the demand generated by the new lines in each year of the planning horizon, and through 2040. This information can then directly feed into detailed planning studies for specific grid zones or a general Generation, Transmission, and Distribution master planning process.
20. Capacity assessment of contractors, technicians and wiremen to deliver NES
21. Analysis of global options of off-grid technologies/standards
22. Strategy for incorporation of productive uses into the NES
23. Socio-economic analysis and project prioritization- grid and off-grid extensions
24. Investment and financing plans
25. Final report & final workshop
26. Data transmission: software, 2-days training GEOSIM, online tool, ENERGYDATA.INFO portal

The activities defined in the “phase 3: NES consolidation” proceed from the “phase 2: NES Preparation”. In that way, the activities of phase 3 consisted in refining and detailing specific issues raised in the Draft report and the related MEMD comments.

2.2 Background related to this NES final Study report

This NES Study Final report is the third deliverable under the Assignment Consultancy for Preparation of the **National Electrification Strategy for Uganda**, commissioned by the Ministry of Energy and

[4] Which allows visualizing the latest data and planning simulations.

Mineral Development (MEMD) and being undertaken by Innovation Energie Développement (IED, France).

The work was launched on 15 October 2019 in a kick off meeting at MEMD's premises in Kampala, where representatives from the Ministry of Energy and Mineral Development (MEMD) and other key institutions involved in the electrification sector.

Then the consultant presented to the key stakeholders, the inception report for validation of the methodology and premises of the electricity sector. The workshop took place in Kampala on 17 December 2019.

Then, the NES draft report was submitted on 7 April 2020 and was followed with a set of several workshops with MEMD, WB, national and international stakeholders. The last version of the Draft report was submitted on 2 September 2020 for an approval which occurred at the end 2020. The whole process was highly disrupted by the COVID pandemic causing delays.

The development of the National Electrification Strategy for Uganda is a key element in MEMD's mandate to update and consolidate the multiple strategy papers related to access to electricity. In accordance with the Terms of Reference, the Electrification Strategy development is based on close cooperation and coordination with the MEMD as well as a continuous consultation and interaction with a wide range of stakeholders active in the national electrification development: they include ERA, REA, UECCC, UEDCL, UMEME, UETCL, UBOS, GIZ, USAID, USEA, and other institutions such as ministries of finance, health, education, agriculture, water & environment, NPA, NEMA, etc.

The work under the current Assignment will provide MEMD with an up-to-date tool for planning and implementation of national electrification provision meeting targets set in national policies and strategies as well as Sustainable Energy for All (SE4ALL) and for exploitation and utilisation of renewable energy sources. **This tool is the National Electrification Strategy which includes a consolidated GIS and specific planning software developed by the consultant**.

The resources and institutional capacities that are required to implement the National Electrification Strategy are important factors that have been assessed. Specific recommendations for policy and institutional priorities and actions are an integrated part of the project.

The assignment involves two main processes:

- **Development of a Least Cost Electrification Plan.** This includes the development of a *Geospatial Energy database, the implementation of specialized professional tool* followed by an analysis of policy and institutional implications, and completed with a 10-year period implementation strategy and programme. This also includes an indicative process of development of the financing plan of the NES.
- Elaboration of additional **tools and resources for decision making,** with emphasis on the capacity to further develop and implement this methodology, positioning MEMD and the other key stakeholders as main actors for monitoring and further reviewing the National Electrification Strategy. This includes the database which forms the base of the Electrification plan, required training of MEMD's staff to develop institutional capacities in the use of the tools was provided following the delivery of the NES draft report in December 2020, and a monitoring tool for the follow up of the process of providing energy access in Uganda.

This NES final Study report addresses most of the issues necessary to achieve universal access of electricity. The topics cover the current electrification situation, the analysis of the institutional framework, the analysis of electrification policies and strategies with international benchmark, the strategy for the incorporation of productive usages, the analysis of off-grid business models and options, the analysis of the legal and regulatory framework, a technological review including least cost options and focus on solar PV technologies, the analysis of the capital investment strategies and control mechanisms, the least cost electrification planning approach and methodology, the presentation of the new consolidated Geographic Information System (GIS) and the development of the NES with planning results of the simulations.

This NES final Study report is a key instrument to support the discussions among the national stakeholders during a presentation workshop to be organized following the submission of this report. The objective of the workshop will be appropriation of the approach, analysis, overall strategic orientations and recommendations for NES implementation.

3 Electrification context in Uganda

3.1 Definitions and premises

The definitions related to access to modern energy services to be applied in the National Electrification Strategy set the stage for ambitious levels. At the practical level, the definitions and associated targets will 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 to the Project take careful consideration of which definitions shall be applied.

In international and Ugandan 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 NES should provide 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 Uganda according to the NEP, explicitly addresses both grid-based electrification and distributed energy solutions. **The consultations with the key institutions held during the inception mission concluded that NES access targets refer to household Tier 1 as the minimum service level.**

Table 1: SE4ALL Multi-tier framework

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

Within the international and Ugandan 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 is compelled to develop a set of definitions to be applied for this Project. These definitions will continue to evolve during the preparation of the NES and as a result of input from stakeholders. They will have important implications in terms of eventual target setting, monitoring and communication. To the degree possible and reasonable, the team is committed to being consistent to existing usage of terms in Uganda.

Table 2: Central definitions

Terms	Definition and/or Description

Access to 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 reaping benefits from social services /Total Population).
Connectivity	Population being directly served by, and paying for, either grid-based electricity services or stand-alone systems, providing at least Tier 1 access.
National Grid	The transmission lines including 33kV, 11kV (sub-transmission lines) and low voltage network.
Isolated grid / off-grid	Off-grid electrification services comprising energy service technologies not dependent on the national grid.
Mini-grid	A mini grid consists of one or several power production units (for example hybrid PV + diesel or wind + diesel) of a capacity going from some kW to a few MWs. Power can be distributed via MV lines to a larger area than the micro grid. (Example: several villages, with MV transmission lines and LV distribution lines). Could be connected to the national grid from establishment or at a later point of time.
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).
Electrification	The 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.
Coverage	The proportion of the population in a given area with access to electricity
Rural Electrification	The process of extending electrical power to rural and remote areas through the extension of the grid, isolated grids or solar home systems

The definitions above are the ones applied to the NES and commonly used in strategies and policies. Indicatively, here are the definitions on access according to EAC and IEA:

- IEA definition in 2019:	*A household having reliable and affordable access to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average.* This definition is consistent with the sense defined above as “connectivity”.
- EAC definition:	There is no straight forward definition of access by EAC. However, with reference to the GoU Draft Energy Policy 2019 as read together with the EAC Energy Security Policy Framework 2018, the definition as provided in the UN Sustainable Energy for All (SE4ALL) initiative is enshrined in the policy for global electricity access by 2030.

3.2 Electrification status

Electrification Status to date according to sources

Comparative table of statistics according to sources (REA MP, UBOS, Diagnostic Review) and access definition regarding the electrification status and according to the Budget Monitoring and Accountability Unit (BMAU) of the Ministry of Finance, Planning and Economic Development of June 2019, it is stated that the overall rate of access to electricity in Uganda remains low (about 19% overall and about 8% in rural areas), while just over 3.2% of the total population has access to modern cooking fuels.

Table 3: Statistics according to sources (REA MP, UBOS, Diagnostic Review) and access definition

Source	Access (%)	Reference year
UBOS	19 (on-grid) and 38 (off-grid)	2020
Distribution Diagnostic Review	22.1	2019
ECP	20.4	2018
REMP	21.6	2017
UBOS	20.8	2016
NDP II	14.0	2015
SEE4ALL	14.9	2012

Link the statistics according to the service level

Though the definition of electricity access was not clearly stated, it is assumed that the figures presented above referred to at least Tier 2 as minimum service level according to SE4ALL definition. This corresponds to a connection to the main grid with an annual consumption above 365 kWh enough to feed lighting, phone charging, TV, fan.

Following the workshop presenting the inception phase, it was agreed that the UBOS household survey would serve as the current electrification baseline for the NES. This HH survey defines Tier 1 (lighting and phone charging) as electricity access and consequently results in the following statistics:

1. 50% of households in Uganda access to at least one source of electricity, broken down as follow:
    - 24% are connected to the national grid
    - 23% own a solar lighting system / solar lantern
    - 3% own a SHS
2. There are high regional disparities in terms of electricity access. For example: 52% of the population is connected to the main grid in the Central Region, as opposed to a rate of 3% only in the Northern Region.

According to the Background to the Budget, Financial Year 2019/2020, it is stated that in FY 2018/19, the national electrification rate reached 25% (BFP, FY 2019/20) of the total population, up from 22%

in FY2016/17. In the same period, rural electrification stood at 10.3% and is likely to increase once the new Electricity Connection Policy (ECP) is effectively implemented.

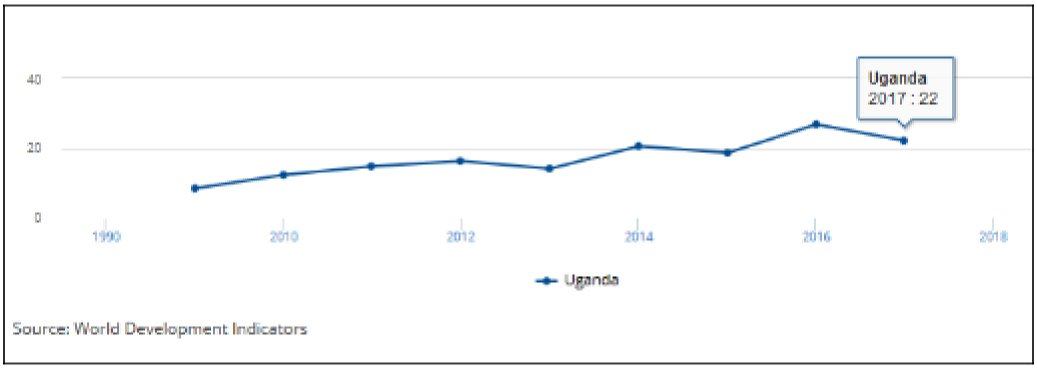
The policy aims to achieve 26% rural access to electricity by 2022 and then later increase to 60% in 2027. This is on account of the investment in rural electricity supported by the US$212 million loan approved by Parliament in the first quarter of FY 2018/19.

Table 4: Electrification pace according to source

Source	**Pace (No. of Annual Connection)**	**Target**
Uganda Vision 2040 (2010-2040)	--	80% by 2040
NDP II (2015-2020)	--	30% by 2020
Uganda SE4ALL	670,000	100% by 2030
ECP (2018-2027)	300,000	60% by 2027
RESP II (2013-2022)	105,000	1.3Million by 2027

The table below shows the evolution of electricity access in Uganda since 2000

Figure 1: Total electrification rate in %

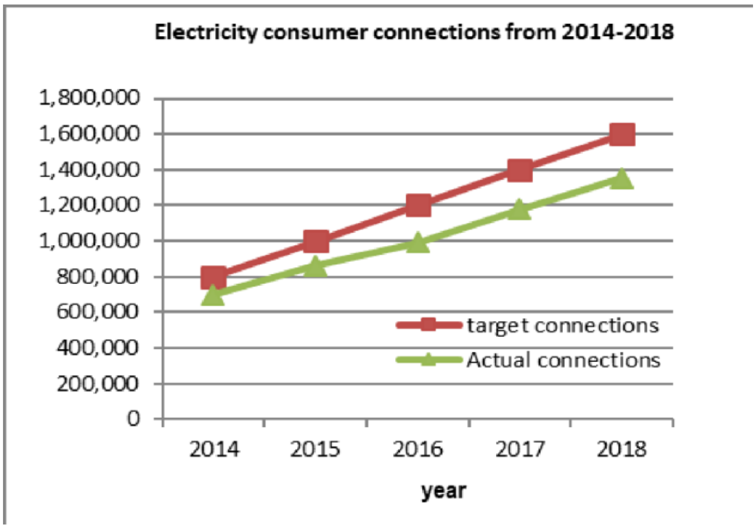


Source: World Bank

The graph above highlights the stagnation or very low electrification pace in the country. Despite the various interventions by Government, electricity access has not increased at a desirable rate to meet targets of the National access agenda and aspirations of GoU.

The graph below shows the gaps between the targeted connections to the grid and the actual number. In 2018, about 1.3m householders were connected.

Figure 2: Consumer electricity connections: targets vs actual connections



Conclusion: UBOS statistics as baseline for the NES

Different approaches and references which are not always aligned have been identified among the existing government policies and strategies on electricity access. Therefore, the NES baseline shall be the UBOS statistics on households' survey.

3.3 Overview of the Electricity Sector

Overall framework

While Uganda has modernized its regulatory framework in the energy sector, private sector investors still face constraints because the cost of doing business is perceived as high due to high cost of electricity and other fixed cost items, market risks, bureaucratic and procedural constraints. Indeed, Uganda ranks in the lower 50% of countries on the Doing Business 2019-surveys by the World Bank (116/190). It is expected that government initiatives, like the land tenure reform, reform of commercial laws, procedures of registering and licensing businesses, Rural Electrification Strategy and Plan (RESP), and the full implementation of the regional common market under EAC may continue to improve this perception and improve Uganda's rating in doing business performance and lower investment risks. Other measure to improve profitability of private investors in the sector could be optimally select transformers and not randomly install transformers where there are no consumers. The billing agency (UETCL) should be educated on billing requirements other than billing reactive power generated by low loaded lines as consumption.

The past two decades have witnessed major changes in Uganda's power sector, which redefined the role of the Government of Uganda (GoU) as enabler for private investments, and established new entities. In 1999, the GoU passed a comprehensive power sector reform strategy that sought to make the sector commercially viable, reduce dependence on government subsidies, improve access to electricity throughout the country, improve operational efficiency of the sector, strengthen reliability and quality of electricity supply, and attract private investment. To implement the reforms, the GoU passed the 1999 Electricity Act, which:

1. established an independent Electricity Regulatory Authority (ERA) to regulate all sector activities;
2. unbundled the vertically-integrated Uganda Electricity Board (UEB) into separate entities, namely the Uganda Electricity Generation Company Limited (UEGCL), Uganda

Electricity Transmission Company Limited (UETCL), and Uganda Electricity Distribution Company Limited (UEDCL);

3. established the Rural Electrification Fund and subsequently under a statutory instrument, SI no. 75 of 2001 (now repealed); the Rural Electrification Board (REB) to oversee the implementation of rural electrification activities with the Rural Electrification Agency (REA) serving as its secretariat. The Ministry of Energy and Mineral Development (MEMD) retained the responsibility for policy formulation in the sector and overall sector coordination and planning.

Uganda demonstrates a successful record of private sector participation in generation. Following the reforms, the UETCL became the sole operator of the transmission system and single buyer of electricity from government-owned power generation companies, and Independent Power Producers (IPPs). Currently, IPPs account for over 65% of Uganda's generation capacity and include Bujagali Energy Limited, Hydromax Limited, Electromaxx Limited, Jacobsen Limited and several others as detailed in tables 5 and 6 below, that generate electricity mainly from renewable energy resources. The UEGCL-owned Kiira and Nalubaale hydropower plants were leased to Eskom (Uganda) Limited in 2002 for operation and maintenance.

The key priorities for the power sector in Uganda are

1. To increase electricity generation capacity, the transmission and distribution networks,
2. To increase access to modern energy services through rural electrification and renewable energy development,
3. To promote the efficient utilization of energy and reduction of power losses.

However, in the current context, the Consultant recognizes that 15 years ago the sector was characterized by lack of energy supply (generation). As a result, the focus of many government plans and initiatives have been skewed to generation in the subsequent years. The greatest need now is how to optimally dispatch available capacity in the wake of surplus generation in the medium term. The NES specifically addresses this issue by recommending enlarging the grid footprint and creating clear pathways for productive use and innovations.

Focus on the off-grid situation

Off-grid solar energy systems represent a major alternative source of cleaner energy. The private sector can play an important role in providing quick access to reliable, affordable and modern lighting and energy services to households.

The Uganda Solar Energy Association (USEA) was formed to provide advocacy and other support to solar companies in advancing the uptake of solar energy solutions in the country. USEA carried out a Solar Market Data Collection (SMDC) to estimate the number and impact of off-grid solar systems sold across the four regions of Uganda.

According to the Uganda Solar Market Report by USEA, for the full year of 2018, a total of 313,424 off-grid solar products were sold, contributed a total of 8.18 Megawatt (MW) of newly installed electricity capacity, leading to improved energy access for almost 1.3 million people throughout the country.

Mini-grid projects: existing and under preparation

REA in association with other international funding agencies are undertaking some off-grid initiatives in many areas of Uganda where it is difficult to extend the grid easily. The vast majority of Uganda projects are solar/battery hybrid grids with some donors considering mini hydro grids. Mini grids which have been installed and those pending installation are listed below:

1. A 5kW PV mini grid installed by Remergy Energy in Kasese
2. Two 13.5 kW PV developed through a partnership between E4D and REA in Kyenjojo district
3. Six sites to be tendered by REA/WWF
4. Two 32 kW biomass gasification projects set up by Pamoja Energy.
5. There were studies that were done in Uganda by a company called Sesam which was intending to generate 40 MW from Kampala city Bagasse. They had also incorporated Wakiso. The project did not proceed because of failure to obtain Bagasse on competitive basis with other service providers in the city.
6. 25 sites of Solar currently being tendered by REA and GIZ in the Northern Part of Uganda.
7. 22.5 kW PV installed in Luwero by Krichno solar
8. 1.6 MW PV diesel hybrid installed by Kalangala infrastructure services (KIS) on Bugala island
9. 230 kW PV managed by Absolute Energy at Kitobo Island.
10. Under the "Get Access programme", KfW on behalf of Government of Germany and the EU is in the process of finalizing the concept and investment decision for the implementation approx 100 MG, in close cooperation with MEMD, REA and ERA.
11. GIZ is in the process jointly with MEMD of preparing a proposal to the Green Climate Fund with a potential of 600 MG sites under the initiative "De-risking private sector investments in low-emission rural industrialization in Uganda".

Other initiatives to electrify the country include cooperation between local people in a given area either through cooperatives, organized associations or through a consortium with the help of a consultant to develop a project suitable for their area. If they are willing to pay 30% of the cost, REA contributes 70%. For example, using this scheme, REA combined with Bujagali Energy Limited (BEL) to execute some rural electrification schemes as part of BEL's corporate social responsibility.

Mini Grids Implemented through Cost-sharing Funding between GoU & Partnerships are listed in the table below.

Table 5: List of PPP mini-grids

No	Scheme Name	District	Partnership
1	13.5kW Solar Mini grid at Kanyegaramire	Kyenjojo	Energy for Development Reasearch Project of the University of Southmpton
2	13.5kW Solar Mini grid at Kyamugarura	Kyenjojo	
3	32kW Biomass gasification mini grid at Tiribogo	Mpigi	Pamoja Energy Limited
4	11kW Biomass Solar Hybrid mini grid at Ssekanyonyi	Mityana	

Source: REA

Overview of the generation sector

The table below indicates the installed generation capacities by type of technologies versus the operational capacity:

Table 6: Installed generation capacities per technology vs operational

Generator	Installed Capacity (MW)	Actual Capacity in (MW)	Firm Capacity (MW)
Large Hydros	813	783	675
Mini-Hydros	119	115	90
Thermals	136	100	100
Co-generation/ Bagasse	96	96	70
Solar PV on-grid	50	50	50
Solar PV off-grid	7	7	7
GRAND TOTAL	**1,221**	**1,152**	**992**

The contribution of publicly owned generating plants, including both on-Grid and off-Grid Installation Capacity is 563 MW, around 46% of the total installed capacity. The table below provides an indication of the contribution of the public vs private sector in the generation sector:

Table 7: Power Plants Ownership by Public, Private and PPP

Ownership	No. of Plants	Type of Generation					
		Large Hydro	Small Hydro	Cogeneration	Thermal	Solar	Biomass
Public(GoU)	2	2					
IPPs	34		18	5	4	5	2
PPP	1	1					
Total	**37**	**3**	**18**	**5**	**4**	**5**	**2**

Source: ERA Electricity Supply Performance 2018

Overview of the transmission and distribution sectors

The transmission network in Uganda is operated by UETCL, who in addition having a license to construct, own and operate the high voltage transmission (above 33 kV) network in Uganda, has licenses for System Operator, Bulk Power supplier and Power export and import, from ERA. In addition, it is Public infrastructure provider with a license from Uganda Communications Commission to own, operate and lease out optic fibre cores.

Length of Transmission Lines of UETCL in 2019:

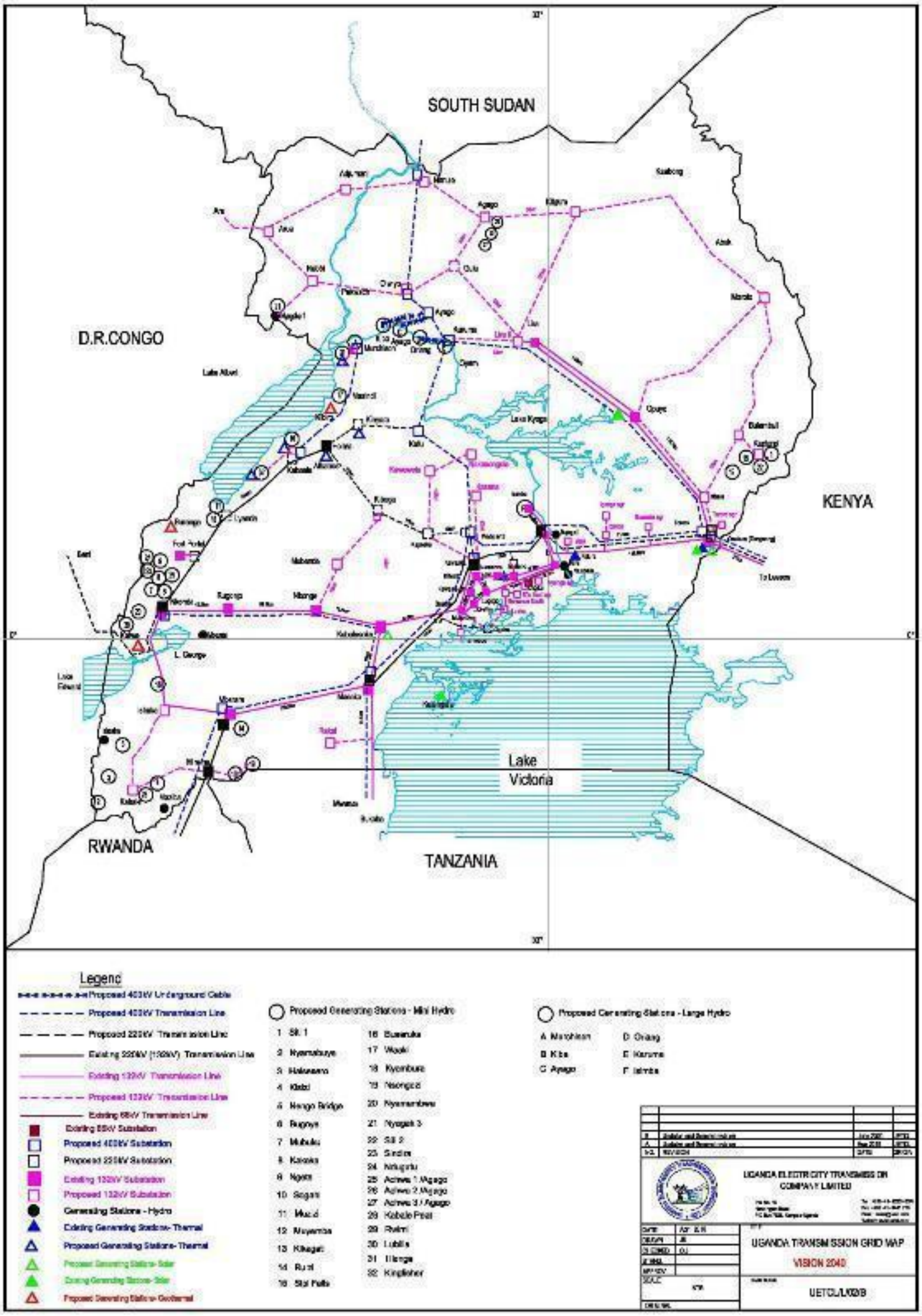
- 220 kV: 1,008 km
- 132 kV: 1,526 km
- 66 kV: 35 km

Number of substations:

- UETCL No. of Primary Substation: 18
- UETCL No. of Switching Stations: 2

Transmission Energy Losses: energy Losses are computed as the difference between the energy purchased and energy sold. During 2018, UETCL lost about 3.8% of the energy purchased. A map with existing and planned lines is presented below:

Map 1: Existing and planned transmission lines

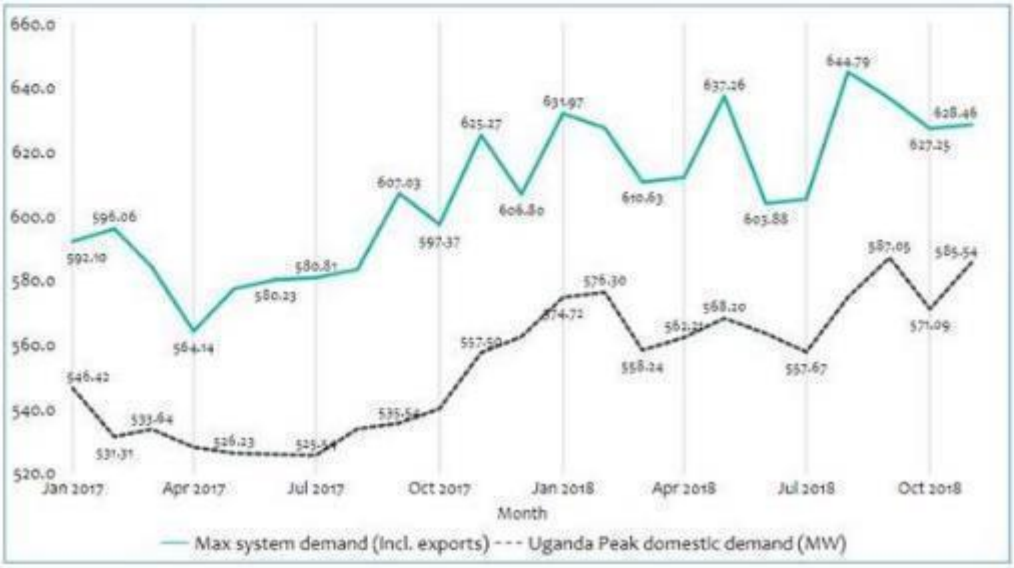


Source: Data received from UETCL updated in June 2020

Maximum Demand

The peak system demand (including exports to Kenya and Tanzania) during the year 2018 was registered as 645 MW (in August 2018), signifying a 3% increment, as compared to the 625 MW registered as the highest in 2017 (November 2017). This growth was mainly attributed to growth in domestic demand.

Figure 3: Monthly electric system peak demand in Uganda (Jan. 2017 to Oct. 2018)



Distribution Network

By the end of December 2018, the length of the distribution network was 45,423 kms, translating into an increase of 5,144 kms, compared to the 40,279 kms registered at the end of 2017. The network of Umeme Limited increased by about 512 Kms, while the network length of the mini-grids combined increased by about 4,632 kms. The increase in the network length of mini-grids was mainly attributed to the grid extensions made by the Rural Electrification Agency (REA).

Figure 4: Distribution network length: total, Umeme, MG (km)

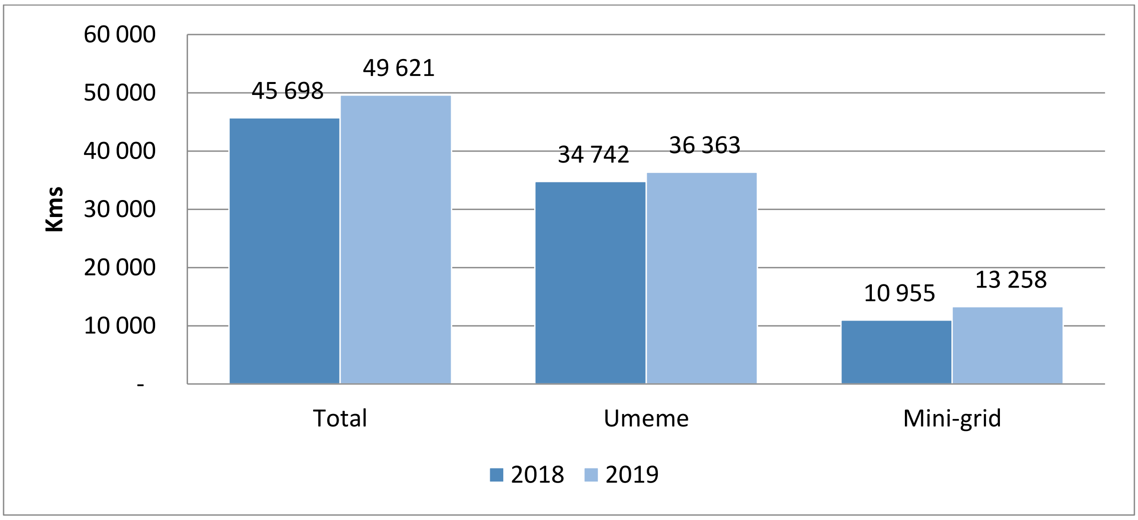
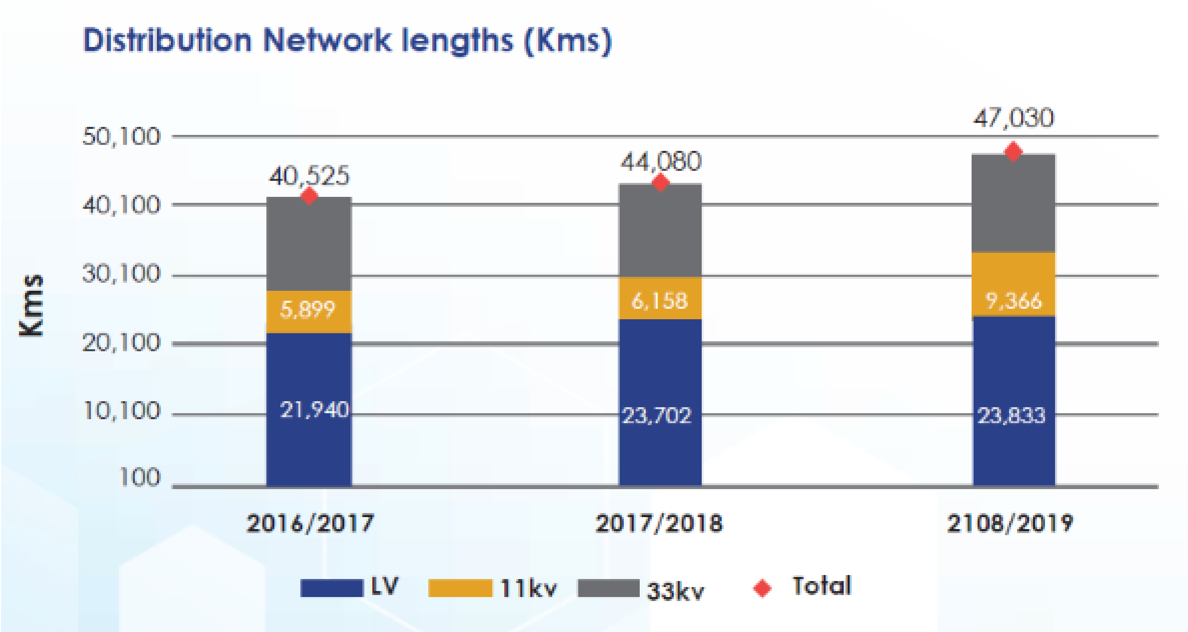


Figure 5: Distribution network length: LV, 11kV, 33kV (km)



Source: Performance of the Electricity Supply Industry FY 2018/2019 by ERA

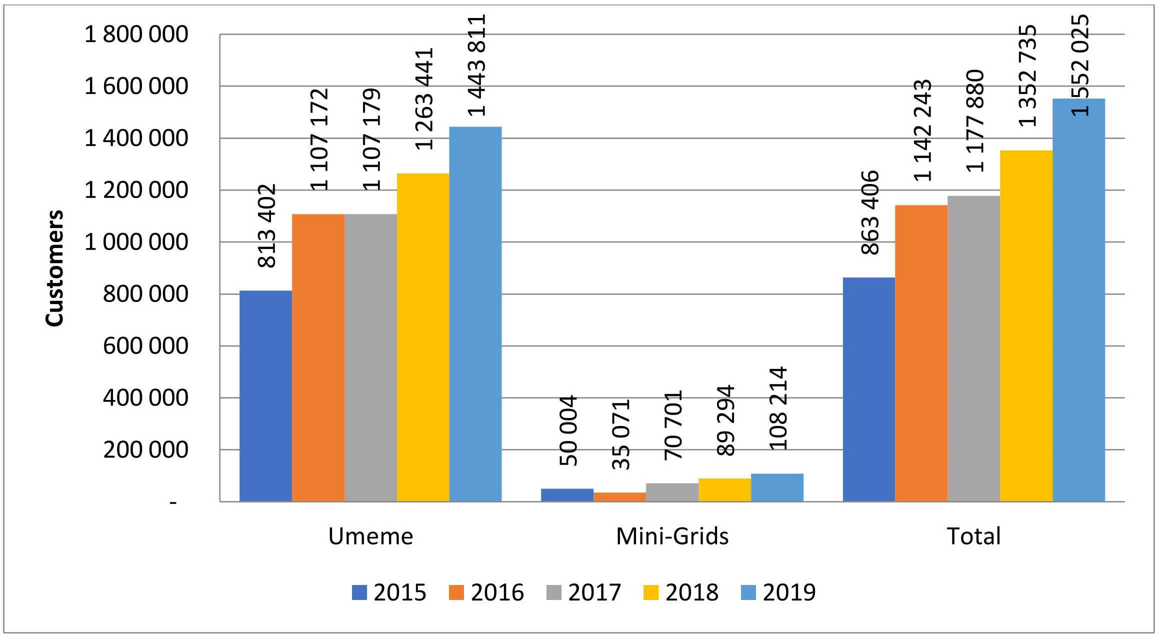
Number of substations:

- UEDCL 33/11 : 3,460
- UMEME 33/11 : 13,145

Customer growth

As at the end of 2019, there were 1,552,025 customers on the national grid, signifying an increase of 15%, from the 1,352,735 customers as at the end of 2018. About 93% of the customers on the network were served by Umeme Limited.

Figure 6: total customers on the network as at the end of December 2019



Customer Category	2015	2016	2017	2018	2019
Domestic	791,338	1,046,109	1,080,945	1,242,354	1,457,563
Commercial	68,710	92,761	93,412	106,824	90,761
Medium Industry	2,534	2,540	2,680	2,761	2,847
Large Industry	513	527	522	506	592
Extra Large	-	-	38	40	37
Street Lights	311	306	283	250	225
Total	863,406	1,142,243	1,177,880	1,352,735	1,552,025

Source: Electricity Distribution Statistics by ERA

4 Analysis of the electricity institutional framework

4.1 Presentation of the Current Institutional Framework

Under the Electricity Act, the Electricity Industry in Uganda is segmented into;

a) The Policy Level represented by the Ministry of Energy and Mineral Development (MEMD)
b) The Regulatory level represented by an Independent Regulator, the Electricity Regulatory Authority (ERA) and the Electricity Disputes Tribunal (EDT).
c) The Operational Level represented by the Licensees in the Generation, Transmission and Distribution and Sales sectors of the industry.

The law under SI no 75 of 2001 (now repealed) also establishes a special Rural Electrification Board (REB) and its secretariat, the Rural Electrification Agency (REA), which is responsible for the rural electrification of the country. REA has now been absorbed into MEMD and the functions hitherto performed by REA have reverted to MEMD under the SI no. 29 of 2021.

The reality on the ground however, is that there are a number of other significant key players and stakeholders, though not provided for under the law, who play a critical role in the electrification of the Country and in particular supporting of GOU effort in scaling up access under the rural electrification programmes as a critical factor to enhance the economic and social welfare of the population and poverty reduction.

These key players include:

a) Other Government arms, Ministries and Agencies;
    i) The Parliament of Uganda; the Committee on Natural Resources, which oversees the sector.
    ii) The Ministry of Finance, Planning and Economic Development (MoFPED) that co-ordinates funding and financial aid to the sector.
    iii) The National Planning Authority (NPA), responsible for overall national planning and co-ordination of sectoral plans.

b) Development Partners and Funding Agencies, mainly
    i) World Bank (IBRD/IDA, GEF & IFC)

ii) European Union (ACP-EU).
iii) German development cooperation (BMZ/KfW/GIZ).
iv) USAID – Power Africa Project.
v) Africa Development Bank (AfDB).
vi) Asian Development Bank (ADB)
vii) Other Funding Agencies including AFD, NORAD, SIDA, DFID, JICA, IDB, BADEA, OFID.
viii) UNDP, UNCDF, UNIDA
ix) The Shell Foundation, Philips Lighting Foundation
x) Multi-lateral partners including-Netherlands, Germany, Norway, UK, Switzerland and Sweden

These agencies and others have played and continue to play a critical role in the funding of the legal and institutional reforms of the sector, renewable energy projects such as GET FIT, rural electrification distribution networks and funding electricity connection and access under schemes such as Output Based Aid (OBA) to make connections affordable.

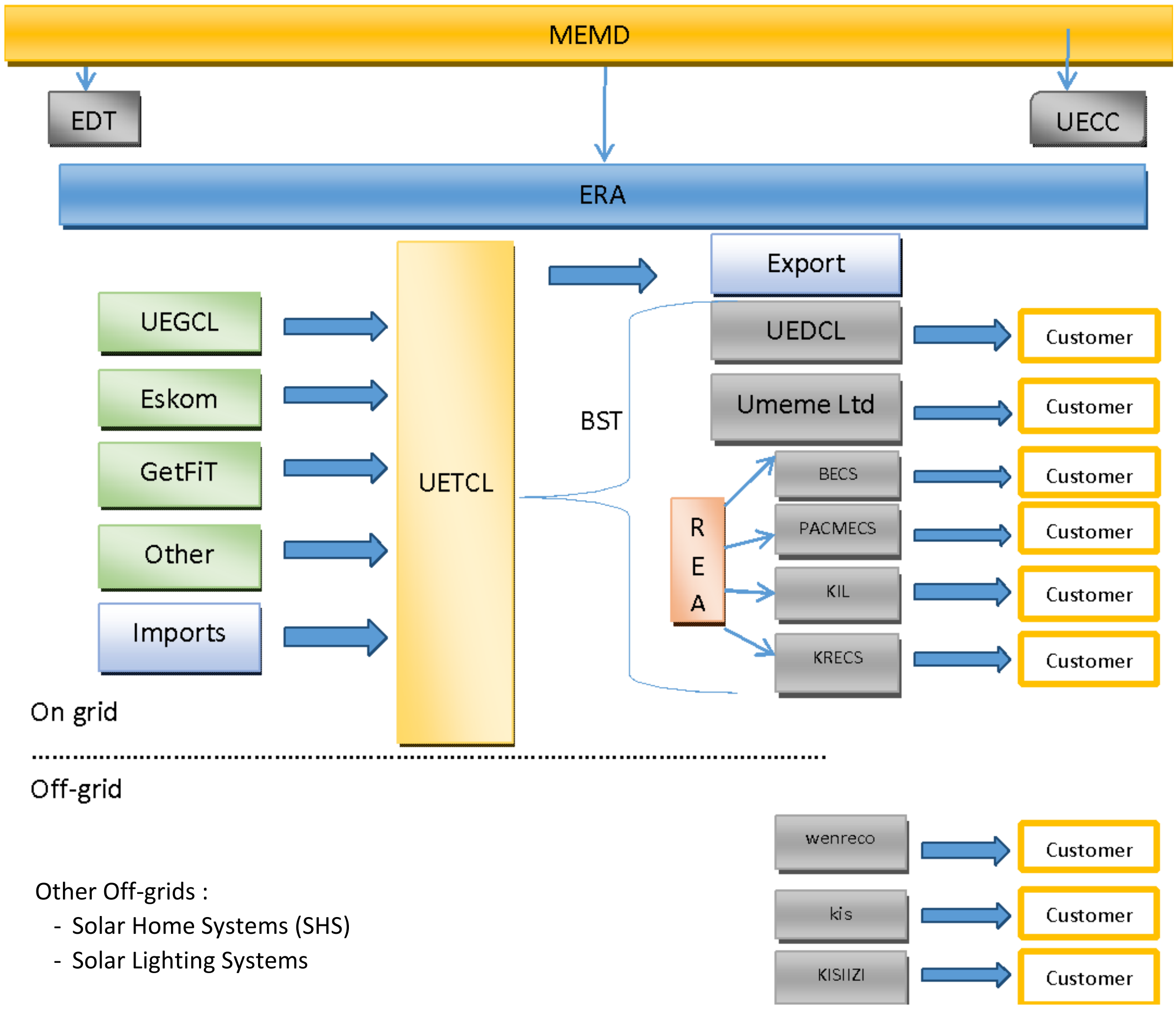
c) Associations and Alliances
   i) Uganda Solar Energy Association (USEA).
   ii) Bio-Mass Energy Efficient Technologies Association (BEETA).
   iii) Hydro Power Association of Uganda (HPAU).
   iv) Energy Efficiency Association of Uganda (EEAU).
   v) Uganda National Bio-mass Alliance (UNBA).
   vi) Wind Power Association of Uganda (WPAU)

These are associations that provide a platform and advocacy for various private sector players in the renewable energy sector and new off-grid technologies that have been critical in increasing access rates in rural electrification and the current reported high level of access the sub-sector boosts of, which is largely based on off grid renewable energy solutions.

d) Local and Foreign contractors in charge of electrification projects

The Diagram below illustrates the current key sector players and their inter-relationships.

Figure 7: Current Institutional set up of the Electricity Sub-Sector in Uganda



Adapted from Ricardo Energy & Environment and modified (Ref: Ricardo/ED11701)

Note: Under the Electricity (Establishment and Management of the Rural Electrification Fund) Instrument, No. 29 of 2021, REA has been disbanded and absorbed as a department under MEMD and the assets and obligations of REA will be undertaken by MEMD.

4.2 Institutional Assessment, Challenges and Recommendations

At the Policy Level, Uganda has adopted good balanced energy policies that should provide a clear strategic direction for the development of the Electricity Sub-sector. These include:

i) Energy Policy (2002) which is under review
ii) Draft Energy Policy, 2019, which is a review of the Energy Policy, 2002
iii) Renewable Energy Policy, 2007
iv) Electricity Connection Policy, 2018
v) Rural Electrification Strategy and Plan (RESP) 2013-2022
vi) Uganda Vision 2040
vii) SE4ALL, which Uganda subscribes to

Uganda has also a comprehensive Electricity Law and a well-developed regulatory system. However, despite this strength, government efforts and interventions to increase the level of electrifications in the country and in particular rural electrification, have not achieved the desired outcomes.

One of the key weaknesses in the development of the Electricity Supply Industry in Uganda to achieve the desired targets is the weaknesses in the institutional framework, the capacity of the individual institutions to execute their mandate and their interrelationships.

Some of the challenges include;

1. Lack of coordination in the planning and implementation of projects. The law does not clearly allocate responsibility for the overall planning and direction for the sector. Different sector players (UMEME, REA, UEDCL, and UETCL) undertake independent planning based on their specific mandate. The failure to take a holistic view of the whole country and sector results in inefficient and ineffective deployment of resources leading to sub-optimal results. The Draft Energy Policy of Uganda released in October 2019 highlights the need for integrated energy planning systems and supports integrated energy methods to be adopted.
2. Overlapping mandates over service territories or roles result in Institutional conflicts and rivalry.
3. Donor funding is sometimes targeted to specific areas and projects which may not be necessarily in accordance with the priority scheme of the relevant institution or the Country.
4. There is limited scope of co-ordination and information sharing through working groups which is not adequate to overcome the above problems.
5. Therefore, there is need to take a holistic view of the sector and the law should be amended to place over all sector planning and co-ordination under the direct control of MEMD to curb inter-institutional conflicts and rivalry.
6. Lack of capacity of the individual institutions, Government Agencies and licensees/operators to execute their mandate. This is attributable to:
   - Budgetary constraints.
   - Under staffing/Lack of skilled and experienced staff.
   - Lack of resources to execute mandate for example adequate financing to extend loans to sector players.
7. Existing Agreements which bind the GOU, for example the Umeme Ltd concessions, making it difficult to rationalize distribution service territories into viable units.
8. Lack of adequate resources devoted to research and development which limit the information available for decision making.
9. Sector wide issues beyond the control of the individual institutions such as:
   - Legal framework/mandate
   - Policy issues.
   - Inadequate public funding saddled with high cost of subsidies to power sector.
   - Demand side constraints.

Due to the above constraints, Uganda has persistently failed to achieve its electrification targets set under the various National Plans and Policies and thus, Uganda lags behind within the region in terms of the overall level of Electrification and the rural electrification programme.

Under the 2001 – 2010 plans, rural electrification increased from 1% to 5% as against the target of 10% and under the Second National Development Plan (NDP2) the rural electrification target is 26% by 2022. However, two years to the end of the period, rural electrification is at 22.6%. This level of poor performance is partly attributed to the weakness in the institutional framework.

The GoU commissioned a number of studies recently, which carried out in-depth studies *interalia,* on the Institutional Framework of the Electricity Industry and made a number of recommendations that were adopted by GoU but most of which have not been implemented.

These studies include:

i) The Review of the Power Sector Reforms in Uganda (2017) by AF-Mercardos.
ii) GET FIT Optimization Compliance (2018) by Azorom with Fichtner and Kaizen.
iii) The Uganda Distribution Sector Diagnostic Review and Directions for Future Reforms for Long-term Sector Development and Acceleration of Electricity Access Expansion.

The analysis of the Power Sector Value Chain and key institutions presented in the following pages give an insight into the problems underlying the institutional framework and poor performance of the sector. Our analysis of the performance and gaps of the key Institutions is presented here below;

1. Ministry of Energy and Mineral Development

Legal Mandate:
The mandate of the Ministry of Energy and Mineral Development (MEMD) is to establish, promote the development, strategically manage and safeguard the rational and sustainable exploitation and utilization of energy and mineral resources in Uganda for social and economic development. The mission is to ensure reliable, adequate and sustainable exploitation, management and utilisation of energy and mineral resources in Uganda.

Arising from the above mandate and mission, the functions and roles of MEMD with particular reference to the electricity sector include:

- To provide policy guidance in the development and exploitation of the Energy resources.
- To create an enabling environment in order to attract investment in the development, provision and utilisation of energy resources.
- To acquire, process and interpret technical data in order to establish the energy resource potential of the country.
- To inspect, regulate, monitor and evaluate activities of private companies in the energy sector so that the resources are developed, exploited and used on a rational and sustainable basis.

The main goal of MEMD is to meet the Energy needs of Uganda's population for social and economic development in an environmentally sustainable manner. Pursuant to the above goal, MEMD adopted major strategies to achieve this goal namely:

- To review and put in place modern policies and legislation that offers a conducive business environment.
- Increase the energy mix in power generation, promote and co-invest in the development of new power generation and transmission projects.
- To acquire and provide necessary information and data to attract and facilitate private sector participation and capital inflow.
- Promote and/or implement rural electrification through grid extension, development of decentralised power supply systems and use of renewable energy resources.

MEMD Capacity to execute its mandate:

- MEMD has both the legal mandate and the technical and human resources capacity to perform its role as the Policy organ and to formulate, direct and monitor the implementation of policy directives.
- The Government of Uganda has made infrastructure development and in particular, electricity, a key priority area which has made the sector benefit from comparatively high budgetary allocations.
- MEMD does not have the adequate capacity to handle technical matters such as planning for the electricity sector. In this connection, it may have to rely on the technical institutions under its supervision (such as UETCL, ERA, UEDCL, and Umeme) to achieve this.
- MEMD is in the process of strengthening the Directorate of Energy Resources to enhance its capacity to coordinate sector planning and monitoring and evaluation of the implementation of plans and projects.
- The absorption of the Rural Electrification Board and Agency in the main Ministry could provide an opportunity to MEMD to build its technical capacity by utilizing former staff of REA who were already involved in the planning, monitoring and evaluation of rural electrification schemes.
- The recommended Organization Structure of the MEMD's directorate of Energy Resources herein below is only a transitional and compromise arrangement pending full restructuring of the MEMD by Ministry of Public Service. The original recommended structure by the consultant was not acceptable by MEMD before approval by Public Service but is included in the report as Annex 15.4.
- Whatever structure is finally adopted by MEMD and whether the Planning Co-ordination, Monitoring and Evaluation functions are placed under the Directorate of Energy Resources or Planning Department of MEMD, the following positions should be provided for to ensure the implementation of the NES.

  a) Head, National Electrification Planning and Coordination Dept
  b) Principal Energy Officer – Planning
  c) Principal Energy Officer – M&E
  d) Senior Energy Officers – Planning
  e) Senior Energy Officers – M&E
  f) Senior Data Management Officer
  g) Senior GIS Officer
  h) Energy Officers – Planning
  i) Energy Officers – M&E
  j) GIS Officers
  k) Data Management Officers

Gaps falling under the responsibility of MEMD

MEMD performance of its role has produced mixed outcomes. MEMD has put in place a comprehensive law and policies to achieve rapid expansion of access to electricity in the country. Electricity generation capacity has almost increased tenfold since 2000 when Karuma Hydro-power Project is commissioned. However, the power sector in Uganda still faces the following challenges:

- Private sector participation in the Energy sector, in particular rural electrification is weak and, the funding of the sector is still dependant on public and development partners.
- The power sector in Uganda has not yet attained financial sustainability. The tariffs are not fully cost reflective because of affordability issues by domestic consumers who are the majority.

- Productive Use of electricity is still low which affects the uptake of existing generation capacity and hence revenues and financial sustainability of the operators and the sector.
- The power sector in Uganda is highly dependent on the hydro-power generation which poses a risk in this era of rapid global warming and climatic change.
- Procurement through unsolicited offers which limits competition, value for money and transparency is still apparent.
- Poor coordination in sector planning, overlap of roles and duplication of efforts, especially in the rural electrification segment is a big constraint to scaling up access.
- Poor implementation of plans resulting in persistent failure to achieve targets.
- Lack of policy regarding the ownership and responsibility for replacement of the distribution assets in the rural electrification.
- The absorption of REA by MEMD poses a number of challenges including:

  a) Risk of real or perceived conflict of interest by MEMD roles as policy organ and implementer. For Example ERA will find it difficult to regulate MEMD if there is poor implementation of projects or failure to meet standards.

  b) will be difficult to attract and retain competent staff under civil service terms and conditions of services.

  c) Decision making processes will be longer and more bureaucratic because of the nature of Government Ministries and Civil Service structures.

  d) MEMD does not have all the relevant technical staff under one roof and will have to depend on other ministries (e.g. Ministry of Justice and Attorney General, the Lands and Survey Ministry, etc.), which will result in slow implementation of projects.

  e) The staff who were transferred face uncertainty and job insecurity, which affects the morale of staff and efficiency.
- To this extent, it would appear that MEMD has not been able to ensure the implementation of its policies to achieve the policy objectives in full.

Recommendations to achieve the National Electrification Strategy

- MEMD should assume the role of co-ordinating sector planning and control of sector development to ensure well co-ordination and harmony in the implementation of the National Electrification Strategy (NES).
- The restructuring of MEMD to enhance its capacity to implement the NES should be accelerated.
- The MEMD Directorate of Energy Resources and /or the Planning Department technical unit should be strengthened and availed sufficient resources to build the necessary capacity to execute the planning function and co-ordination of the planning, monitoring and evaluation of the implementation of the NES and projects in the sector.
- The existing adhoc planning co-ordination committee under MEMD should be formalized by legislation under a statutory instrument and allocated budgetary resources to ensure proper co-ordination of sector planning, information sharing and implementation of projects under the electricity subsector.
- Promote private sector participation in the power sector by providing the necessary incentives to attract new technologies and innovative ways of service delivery.
- Clarify the policy on ownership and responsibility for the replacement of distribution assets acquired by REA in the Rural Electrification Program.
- Legislate for all distribution assets financed by GoU and Donor funds under REA to be transferred to UEDCL or the successor entity which is Government owned and the mandated entity to hold distribution assets on its behalf.
- Avoid political interference in technical matters.

- Quality standards should be established and enforced for the off-grid solar home systems sector in corroboration with UNBS.
- A clear definition of electricity access (based on achieving Tier 1 performance level of the ESMAP Multi-Tier framework), covering grid, mini-grid and off-grid access solutions, should be established with a clear framework on upgrading level of access as level of household income improves.
- Initiate programmes to promote productive use of electricity by promoting and providing incentives to SMEs which have potential for providing the majority of employment and productive use of electricity thereby ensuring a more sustainable electricity sector.
- The plan to set up a fund initiated by REA (in the form of a subsidy or loan) to support the connection for SMEs should be supported and taken up by MEMD.
- Currently SMEs are expected to pay over 6 to 7 million for a connection. Government and/or utilities may also support SMES and reduce connection time and initiate promotion activities through sensitization, supporting on wiring and gifting with appliances that utilize electricity thereby boosting the PUE.

2. The Electricity Regulatory Authority

Legal mandate:

The Electricity Regulatory Authority (ERA) mandate is to regulate the generation, transmission, distribution and sale of electricity in Uganda.

ERA is rated highly among its peers, the Regulatory Agencies in Africa. According to the Regulatory Index of 2018 and 2019 in Africa compiled by the African Development Bank, ERA is one of the two Regulatory Agencies rated as having attained high level of development.

The Electricity Act provides a comprehensive legal framework to regulate the power sector and the Regulator has made regulations to provide the detailed regulation of the different key aspects of the power sector including technical standards, quality, safety, license procedures, reporting requirements, among others.

Capacity to execute mandate:

ERA has a track record. It has a competent staff compliment in line with its role and functions. ERA has attained financial autonomy through license fees and levies and, this is set to be enhanced in the proposed amendment of the law to increase the license fees. The law allows the Regulator flexibility and discretion in the regulatory matters.

Gaps falling under the responsibility of ERA:

However, the regulator still faces a number of challenges:

- The number of Board members is limited and does not provide sufficient flexibility in appointment of Board committees to focus on different aspects of electricity regulation and attainment of quorum for meetings.
- ERA has no regional presence and control of the whole country from the Centre is inefficient and not effective given the growth of the industry and various operators in the countryside.
- ERA has failed to develop an effective delegation system of some of its regulatory roles and/or functions to local governments and other agencies close to operators as is provided for in the Act and to bring services closure to consumers outside of Kampala.
- ERA has focused on the Grid Power but has not developed appropriate regulations to promote and provide incentives for new technologies such as Solar/PV, Wind, Geothermal

and the new innovative way of service delivery using off-grid solutions. The recently adopted regulations for isolated grids is step in right direction but need to be further enhanced.

- There is perception of political interference in technical regulation decisions, such as tariff setting and licensing.
- Dealing with unsolicited proposals may lead to poor planning of projects and lack of transparency.
- High tariffs act as disincentives to grid connection due to affordability problems.
- Assets procured through grants and GoU funding is not included in the rate base leading to concerns about their future replacement.
- Tariff setting framework does not allow for full recovery of costs which may threaten the financial sustainability on the sector in the long run.
- ERA lacks adequate powers to impose sanctions, fines and penalties for breach of license conditions.
- Regulatory burden imposes high cost on small operator. A good example is the unnecessary reporting requirements.
- Existing market structure may restrict entry and investment in the sector and impose great financial burden on the bulk supplier. The bulk supplier (UETCL) is unwilling to take on more PPA obligations which make investment in the generation sector more uncertain and riskier.

Recommendations for ERA to achieve the NES:

The proposed amendments in the law (currently before the Parliament) have addressed some of the issues referred to above but do not go far enough as illustrated in the legal analysis here in below:

- ERA needs to increase its capacity to delegate some of its regulatory functions as provided for under the law.
- ERA needs to work very closely with local administration to build capacity of local governments to carry out some of the regulatory functions, delegated to them by ERA.
- The number of Board members of ERA should be increased to a minimum of seven (7) members to make it easier to set up board committees to focus on different aspects of electricity regulation.
- ERA needs to develop appropriate regulatory framework incentive system to attract new technologies and innovations in the rural electrification.
- ERA needs to strengthen its independence from vested interests.
- ERA needs to provide for ownership and responsibility for replacement of assets acquired by REA in the rural electrification
- ERA needs to adopt appropriate regulatory regime for light handed regulation and flexibility for small operators of isolated grids, mini-grids and other off-grid technologies.
- ERA should be provided with a range of sanctions with varying levels of severity that could be applied to Service Providers who fail to comply with licence requirements.
- ERA should continue to develop output-based incentive arrangements to encourage capital and operational expenditure efficiency, higher levels of quality of service, and increased electricity access to the grid,
- ERA needs to enhance a tariff structure that provides incentives for productive use of electricity to boost demand for electricity in particular targeting SMEs.
- Lifeline tariffs should be rolled-out throughout the country, wherever possible to avoid tariff discrimination.
- Tariffs in areas served by mini-grids should be permitted to differ from those charged in the main grids including allowing innovative tariff structures.

3. Rural Electrification Board and Rural Electrification Agency

Towards the conclusion of the NES study, GoU decided to absorb REA under MEMD. Under the Electricity (Establishment and Management of the Rural Electrification Fund) Instrument, No. 29 of 2021 which took effect on 10th May 2021, REA was effectively disbanded, and all assets and liabilities and staff of REA was taken over by MEMD. REA will henceforth work as a department of MEMD.
The mandate hitherto vested in REA and detailed below will now be executed by MEMD. The challenges that may be engendered by this policy decision is highlighted above in the Gaps under MEMD.
The decision to disband REA and absorb it under MEMD is part of the wider Government program to undertake a comprehensive review and restructuring of the Government Ministries, Departments and Agencies (MDA's). Under this program the former UEB Successor Companies will again be merged into one Company and REA absorbed into MEMD as a department. Only the Electricity Regulatory Authority (ERA) will be retained and strengthened.
The above decision is the outcome of recommendations made by a study commissioned by the Ministry of Public Service dated 2017. The Report on comprehensive Review and Restructuring of Government Ministries, Departments and Agencies.

The objectives of the Government decision to review, restructure and nationalize MDAs is generally intended to achieve the streamlining of MDAs to eliminate overlapping mandates, duplication of roles, institutional rivalry and wastage of resources and harmonize the terms and conditions of services throughout the MDAs.
However, the review of the Report clearly indicates that the study did not carry out an in-depth survey to address the specific and peculiar issues of the different sectors. With respect to the Energy sector the focus was on the functions of the MEMD and there was no in-depth review of the impact of the recommendations on the wider sector issues and in particular the electricity sub-sector reforms undertaken by the Government of Uganda since the late 1990's which culminated into the Energy Policy of 2002 and the Electricity Act of 1999, which preceded it.

In 2019, the Government of Uganda undertook a study to review the Energy Policy of 2002 and has also commissioned other studies to review the Electricity sector such as Draft Energy Policy 2019, the Distribution Diagnostic study 2020, the Review of the Electricity Act before Parliament etc. The thrust of the findings of all those studies are that the reforms of the Electricity sector implemented by Government of Uganda since the late 1990's have achieved tremendous results and these gains should be consolidated and built upon to achieve the NES. These reforms are underpinned by some of the following key policy objectives and principles:

a) The role of Government as an enabler focusing on policy frameworks to create conducive policy, legal and regulatory frameworks to facilitate private sector participation in the Electricity sector.
b) The Government focus on rural electrification to facilitate electrification of areas that would otherwise not be economically attractive to private investment by providing smart and targeted subsidies to buy down tariffs and connection charges, finance support for isolated grids and off grid solutions to achieve universal access by 2030.
c) Creation of an independent regulator thereby fostering transparency, competition and accountability in the energy sector and financial sustainability by putting in place tariff structures and methodologies that provide for cost reflecting tariffs and targeted subsidies.
d) The unbundling of UEB to create focus on the individual segments in the Electricity supply value chain (Generation, Transmission and Distribution) and establishing of UETCL as a single

buyer and system operator to allow private sector participation and investment in the Generation and Distribution segments etc.

While a lot remains to be achieved, there is no doubt that these reforms spurred substantial growth in the Electricity subsector and verifiable achievements. Uganda has a successful track record of private sector participation in the generation and distribution segments which resulted in tenfold increase in generation capacity and increase in access to electricity. The current rates of electrification 24% on grid and 26% by off grid solutions respectively has been a result of the above reforms.

Some of the key issues that require further examination is the need to harmonize new roles of MEMD as a policy organ, supervisor of the sector but also as the implementer of Rural Electrification programs through its REA Department to ensure there will be no conflict of interest (real or perceived).
The other issue is the role of the new vertically integrated entity formed by the merging of UEGCL, UETCL and UEDCL vis-a-vis the private sector players to ensure that it does not become an impediment to private capital investment and participation in the electricity sub-sector since the role of the private sector is still critical to achieve the NES.
The amalgamation of entities and departments in an effort to avoid overlapping mandates and roles is a positive development but there is a need to ensure that the amalgamated entitles will have the capacity to execute their mandates and some activities are not neglected as both human and budgetary resources will be realigned.

Going forward therefore, the consultant would recommend that Government undertakes a detailed study to access the impact of the proposed institutional landscape adopted by Government to ensure that the benefits of the sector reforms over the last two decades are not lost.

Legal mandate:
The Rural Electrification Board (REB) and its secretariat, the Rural Electrification Agency (REA) are established by the Statutory Instrument No. 75 of 2001 under MEMD now revoked. The main functions of REB and REA which will now be undertaken by MEMD are to:

- Promote equitable rural electrification access in particular, communities in the marginalised areas.
- Undertake planning of Rural Electrification Projects
- Implement Government priority rural electrification projects
- To maintain a national rural electrification database to monitor progress and establish targets for rural electrification.
- Enhance the available financial resources base for rural electrification through strategic fundraising.
- Promote institutional sustainability of the Rural Electrification Fund.

MEMD Capacity to execute the above mandate will until restructuring depend on the staff and structures inherited from REA:

- REA had a competent compliment of staff that had accumulated experience in Rural Electrification, however it lacked the regional reach to effectively supervise projects all over the country.
- Efforts had been made by REA to ensure geographical (Regional) presence to execute its mandate. Under the Exim Bank Funding for the sub-counties’ projects, land has been secured in four regions of the country, on which offices and stores are being constructed. These will be the first regional offices for rural electrification field-based staff including

engineers, clerks of works and social safeguards officers have been taken over by MEMD, but will not be sufficient to execute the NES.
- The demand for rural electrification projects is huge and GoU will have to scale up the financial resources substantially to enhance its financial capacity to meet the demand.

Gaps falling under the responsibility of the institution:
The Distribution Diagnostic study by Ricardo recommended that REA be made a legal (corporate) entity. The consultant's assumption was that the GOU adopted the recommendations of this report.

The consultant's view is that operating REA as a department of MEMD will affect its efficiency and performance in that the turnaround time for decision making process will be longer because of the bureaucracy associated with government ministries and Civil Service 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 etc.) under one roof which may not be possible under MEMD which may rely on other government MDs.

REA could attract and retain more qualified and skilled staff than MEMD because of better working terms and conditions which do not obtain in the civil service. Notwithstanding the above, MEMD could establish REA as a special unit under MEMD and provide conducive working arrangements to address the above perceived risks.

There is also uncertainty because the Statutory Instrument transferring REA to MEMD will expire after two years. It is not clear what happens after that.

However, the absorption of REA by MEMD will enhance the technical capacity of MEMD and will improve the coordination of planning and implementation of NES because of the MEMD ability to take a bird eye view of the whole sector provided that MEMD takes the necessary actions to mitigate the perceived risks highlighted above.

In addition, the Rural Electrification Program has not achieved its targets because of the following challenges which MEMD should address:

- Long and bureaucracy in procurement causes delays in implementing projects.
- Lack of sufficient funds to finance all rural electrification projects as demanded.
- High end user tariffs leading to affordability issues
- The rural population not able to pay for electricity connections.
- Lack of provision for rural electrification assets financed by public or donors in the rate base may make the sector unsustainable as these assets may not be well maintained and replaced in a timely manner as they get worn out.
- Low demand for electricity in the rural areas due to affordability issues of tariffs and charges.
- Low uptake of electricity for Productive Use due to poor incentives to SMEs.
- Licensing concessionaires that lack capacity to properly manage rural electrification projects.
- Fragmented distributed territories which are sometimes not viable and unattractive to private sector players.
- Lack of opportunity for stakeholders involvement and to hold implementing Agencies to account.

Recommendations for MEMD in respect of rural electrification to achieve the NES

- MEMD should change the strategic focus of its rural electrification strategies by pulling out of operational issues and focus on the Planning, mobilizing financial resources, monitoring and evaluation of rural electrification projects. Projects which have been completed should be handed over for operation by national or other licenced operators and assets should be handed over to UEDCL or its successor to hold on behalf of GoU. This will necessitate the enhancement of UEDCL capacity and funding to perform this role successfully.
- MEMD's role on the main grid sector should be focused on funding or partially funding projects brought to them by Service Providers which would otherwise not be undertaken.
- Capacity to execute rural electrification projects needs to be strengthened: the existing Human Resource is skilled but more staffing is required especially for field-based staff to ensure geographical presence. The current annual budget of about USD 100 million which REA operated will need to be enhanced significantly and availed timely and regularly in line with the required funding recommended under this NES report in order to achieve the target of 100% access to electricity by 2030.
- Streamline the planning, procurement and implementation of projects to improve co-ordination with other key sector players, promote the participation of local contractors, service providers to build and strengthen local capacity.
- Create more viable distribution territories as recommended by the Diagnostic Study of the Electricity Distribution Sector in Uganda taking into account the need to ensure equitable distribution and access to electricity.
- Creation of an SPV: It is recommended that all grid connected distribution network should be managed by one national operator (SPV) under a Public Private Partnership to avoid the current fragmentation of the distribution territories and the inefficient operations of small operators. In the Uganda Distribution Sector Diagnostic Review report, it was recommended that with "one national service provider for the whole country" would deliver the best financial and economic results for Uganda. This service provider (SPV) shall be under PPP (Public Private Partnership) Model. The SPV shall be selected by public procurement procedures. UEDCL will be responsible for selection of the SPV. The mandate of the SPV shall identify, plan, develop, operate and maintenance of all the distribution grid facilities with the Government retaining majority share ownership of the resulting vehicle and to electricity all Uganda to the goal of 100% access to electricity. The service provider will also liaise with REA who will study, research and develop, identify areas to be electrified, propose what to be done, source for funds and construct the network putting in place the electricity infrastructure, commissioning and handover to UEDCL. UEDCL shall then hand over the facilities to SPV for operation. When the SPV will not be operating well, UEDCL and ERA should be given the mandate with approval of GoU to terminate its services.

- Assist licensees and local contractors and service providers in capacity building.
- In order to enhance capacity of local contractors and service providers, Government need to put in place and be committed to a policy to promote local capacity by increasing the threshold reserved for local contractors and put a demand on foreign contractors to commit to higher percent of local content. This will necessitate review of the current procurement law and to negotiate future loan terms that favour local contractors.
- Promote productive use of electricity by providing incentives to remove or reduce the current impediments and high connection charges faced by SMEs for example by establishing a fund for that purpose.
- Encourage deployment of alternative technical and cost-effective solutions to increase access.

- Promote private sector participation in rural electrification.

4. Uganda Electricity Distribution Company Limited (UEDCL)

Legal mandate:
UEDCL is one of the successor companies of the former U.E.B which owned and operated the electricity distribution network of up to 33kV. It is a company limited by shares established under the Companies Act. Its shareholders are MEMD and MoFPED. It has legal mandate to execute its role.

Its assets were leased to Umeme Ltd for a concession period of 20 years effective from 2005 but it retained the ownership of distribution assets of former UEB.

The leasing of the assets to a private investor was mainly to; attract foreign direct investment; improve the quality of service, rehabilitate; upgrade and expand the distribution network, and; increase electricity access to other consumers in the country. These objectives are still relevant but there is need to tap into the experience of the last 20 years or so with a private operator, Umeme and design a better arrangement that would maximize the above benefits but avoiding the pitfalls that has been identified over the years with the private operator.

With concessioning of the distribution business to Umeme, the role of UEDCL changed to:

- Administering the lease and assignment agreement,
- A distributor operator of last resort, operating isolated thermal powered grids and REA projects that have not attracted private sector operators or where the private sector failed
- Operating the pole treatment plant.

Capacity to execute mandate:
UEDCL has legal capacity to execute its mandate and owns its home (office block). Following the leasing of its assets to Umeme, UEDCL retained only a skeleton staff to manage the concession with Umeme and a few isolated grids. However, UEDCL is increasingly getting involved in the electricity distribution business and hence will need to rebuild its human resource capacity if this trend will continue.

Gaps falling under the responsibility of the institution:
UEDCL operating in the sector is critical though there are some significant Challenges including:

- UEDCL lacks the capacity to undertake large scale distribution of electricity.
- UEDCL operations are largely not profitable, a few just break even.
- ERA has disallowed UEDCL recovering from tariffs depreciation costs and return on investment on projects financed by grant to maintain affordable tariffs. This poses risk on the long-term sustainability of the sector.
- UEDCL is burdened by debt obligations arising from acquisition of way leavers in the past as well as pension obligations for staff inherited from UEB which undermine its financial sustainability.

Recommendations to achieve the NES:

- UEDCL should hold all distributions assets financed by the GoU or donors on behalf of the Government. This will make it easier to lease to one National operator under an PPP arrangement or for UEDCL to participate in the PPP as shareholder on behalf of GoU.
- UEDCL operational capacity should be strengthened to perform the role of the distribution network owner, in particular capacity to monitor operations of the concessionaire in the maintenance, refurbishment and replacement of distribution assets.

- From the evidence collected by the majority of studies commissioned by GoU, it is recommended that the most adequate, efficient and effective way to deliver the best financial and economic results for Uganda whilst ensuring stakeholders' acceptance at all levels is to implement a PPP (Public Private Partnership) model for the ownership and operation of all distribution assets where the Government (through UEDCL) should retain the ownership of the distribution assets but lease them to a national operator under a PPP model through a Special Purpose Vehicle (SPV).
- The GoU should leverage its experience from previous privatization models such as Uganda Telecom Ltd which have not been successful.

5. Uganda Energy Credit Capitalisation Company

Legal mandate:
The Uganda Energy Credit Capitalization Company (UECCC), is a Government institution set up under the Companies Act as a Company Limited by Guarantee. It was created to facilitate investments in Uganda's Renewable Energy and, its main objective is to provide financial, technical and other support for Renewable Energy Projects and Programs. UECCC also carries out administration of the Uganda Energy Capitalization Trust, a framework for pooling resources from Government and Development Partners for the development of Renewable Energy Projects.

The mission of UECCC is to provide innovative financing initiatives and technical assistance that enables participation of the private sector and other stakeholders so as to enhance development and access to renewable energy. Its objectives include:

- To serve as a Credit Support Institution and to promote Private Sector led renewable energy Infrastructure Development.
- To provide financial, technical and other support to Renewable Energy Projects in Uganda.
- To introduce into the Ugandan Financial Market new and innovative financing modalities including Credit Enhancement Instruments directed at reducing real or perceived risks faced by primary lenders and other Financial Intermediaries.

UECCC Capacity to execute its mandate:
UECCC has a legal capacity to execute its Mandate but its role is not provided for under the Electricity Act. Its capacity is still limited in terms of Financial Capacity and Human Resources to undertake big and multiple transactions. Its operational capacity has hitherto been limited to financing small projects under the sector.

Gaps falling under the responsibility of the institution:

- Limited finance resources to meet the demand for financing of electrification projects
- Its role is not provided for in the Electricity Act.
- It lacks the Human resource capacity to undertake big projects.

Recommendations:

- The role of UECCC should be strengthened provided for in the law.
- UECCC should be availed more funding to lend to private sector projects
- UECCC should be considered for a role in the administration of the Energy fund.

6. Umeme Limited

Legal mandate:

Umeme is a Public Limited Liability Company listed on the Uganda Stock Exchange. It operates under a 20-year concession (with effect from 2005) to operate the electricity distribution network, previously owned and operated by UEB and subsequently UEDCL. Umeme is a significant player in the Electricity Supply Industry (ESI) in Uganda:

- Largest Electricity Distribution Company in Uganda and a symbol of Uganda's liberalised electricity industry and private sector participation in the Electricity Supply Industry (ESI).
- Accounts for over 96% of all connections and 98% of distributed/consumed electricity.
- Operates under a 20-year concession and license from 2005.
- Its mandate was to operate and maintain distribution network owned by UEDCL as at 2005 and had exclusivity to distribute electricity within 1 km radius of the then existing network.
- It had obligation to rehabilitate, strengthen and upgrade existing distribution network and reduce distribution losses based on 7-year targets in the license and thereafter annual targets set by the Regulator.
- Umeme had only modest connection targets in the initial 5 years under the License (60,000 new connections) and thereafter 15,000 new connection targets per annum due to low generation capacity prevailing at the time.

Umeme capacity to execute its mandate

Umeme has Legal capacity and relevant licenses to operate. Umeme is well resourced and has capacity to mobilise resources from the international equity and credit markets. As a listed company, it has capacity to raise money from the local capital market too. Umeme has a well-qualified and skilled management team, and well-trained technical staff to implement projects.

Achievements

Umeme has made significant achievements the period of its concession including:

- Distribution loss reduction from 35% in 2005 to 16.5% in 2019.
- Increase collection rate from 75% in 2005 to 98.0% in 2019
- Invested approximately USD 600 million in the distribution network since 2005.
- Taken on new distribution territory from REA.
- Increased customer base from about 240,000 in 2005 to over 1,500,000 by the end of 2020.

Gaps

- High level of return on equity required by Umeme Limited is blamed for the high electricity tariffs in the ESI.
- The existence of Umeme exclusive distribution territory has made it difficult to create viable distribution territories for other distributors.
- Lack of proper co-ordination in planning and project implementation between Umeme and REA resulted in lack of proper integrated national electrification plan and prioritization of resource deployment though this is improving.
- Umeme's reluctance to connect areas deemed to be non-economically viable and customers who may not afford to pay for consumption is a constraint in achieving universal access.
- Umeme's capacity to meet demand for connections is overstretched and there is increasing backlog.
- The expiry of Umeme concession in next five years creates uncertainty in the sector and mobilization of much needed financial resources to strengthen the distribution system is now a challenge.

Recommendations

- Implementation of recommendations in the diagnostic study of the distribution sector in Uganda will eliminate the problem of distribution territories that are not economically viable and have failed to attract serious operators.
- Recent planning co-ordination between Umeme and MEMD should be strengthened in order to further involve UMEME in achieving the electrification agenda of the government.
- GOU should start the process of preparing for the post Umeme concession period to remove uncertainty.
- The whole electricity distribution network should be operated by one national operator (SPV), under a PPP arrangement.
- Given that Umeme Ltd's concession does not expire until 2025 well into the implementation of NES, Umeme should be brought on board to ensure that its plans for the remaining period of the concession is in line with the recommendations of NES.

7. **Other Distribution Companies**

Legal mandate:

There are eight other distribution companies in the ESI in Uganda, six of which are connected to the main grid. Those connected to the grid include; Bundibugyo Electricity Cooperative Society (BECS) – BECS concession was taken over by UEDCL since 1st April 2021; Kyegegwa Rural Energy Cooperative Society (KRECS); Pader-Abim Community Multi-Purpose Electric Cooperative Society (PACMECS); Kilembe Investments Limited (KIL); Kisiizi Hospital Power Limited and Hydromax Limited. The electricity distributors operating off/isolated grids include; West Nile Rural Electrification Company (WENRECo) and Kalangala Infrastructure Services Limited (KIS).

Five of the operators are companies formed under the Companies Act, while three are registered as cooperative societies. These distributors are operating in various regions of the country, which has increased access to electricity.

Other Distributors' capacity to execute its mandate

Both Azorom and Ricardo carried out detailed capacity assessment of the above distributors and established that most of these operators lack capacity to operate efficiently, and are struggling to meet their license obligations. Some of the key findings were:

- Lack of sufficient technical capacity in terms of qualified technical personnel and equipment.
- Low staff levels
- Lack of Managerial capacity
- Poor corporate governance
- Lack of adequate financial resources
- Low level of business volumes
- Poor quality of service
- Inability to make long-term plans.
- Low quality controls on materials and an ineffective spares system
- High losses because of theft and inaccurate metering.
- With regard to Safety issues, hazards are posed to staff and the public.

Recommendations to achieve the NES:

It is recommended that all the operators on the grid connected distribution network should be phased out and give way to a single national operator (SPV) under a PPP model to improve the operational efficiency and resolve the problem of fragmented distribution territories and divergent conditions of electricity supply in different territories.

It is also recommended that Grid Power should extended West Nile Region to ensure reliability of supply and the region should be operated as part of the national grid.

It is proposed that SSPs can be phased out as follows:

a) They can be retained up to the expiry of their licenses. The time required to procure the One National Operator and transit from current set up is in the medium term, given that the UMEME concession will only expire in 2025.
b) When the current licenses expire, they should not be renewed. UEDCL or Umeme should take up and operate in the service territories till the procurement of the One National Operator.
c) They can be compensated for the un-expired period of their licenses by paying the unrecovered (undepreciated) CAPEX (assets) and the NPV of the net cash flows for the remaining period of the licenses or such agreed valuation method.
d) They can be given priority as sub-contractors of the national operator in the provision of customer services in their current or expanded territories. e.g.
    - Customer connections
    - Maintenance services/Fault clearance
    - Bills delivery
e) They can be given priority to operate identified off grids in their service territories in the proximity.

8. Roles and Responsibilities of other Key Stake holders of the Electricity Distribution Industry to achieve the NES

Although the bodies and institutions below are formerly not part of the Electricity Distribution Industry in Uganda, in practice they play important roles and exert a lot of influence on the direction of the industry. Some of the key players are:

4) Uganda Solar Energy Association

Legal mandate:

Uganda Solar Energy Association (USEA), is a non-profit business member organization, registered as a company limited by guarantee. USEA is one of the most active associations and was formed to facilitate the growth and development of private companies operating in the solar sector in Uganda and the East African region and, to provide advocacy and other support to solar companies in advancing the uptake of solar energy solutions in the country. It represents a major alternative source of cleaner energy to households that is quick to access, reliable and affordable modern form of energy for lighting and other energy services.

The objectives of USEA are:

- To strengthen the local solar industry, enhance business opportunities and facilitate the growth for the sector through networks, research and knowledge sharing.
- Coordinate, seek and utilise funding and training opportunities for the growth of the sector and member businesses.
- To strengthen the position of solar energy as an important source of power in Uganda's energy mix
- Promote the use of solar energy at all levels i.e. from the small and medium enterprises, through to commercial and public bodies and up to large parastatal and industrial establishments

- To provide a forum for information and knowledge exchange on matters relating to solar energy development and utilization.
- To create and promote a self-regulating environment that facilitates the offering of high-quality solar energy solutions and services to customers.

The key roles of USEA include;

- To act as a channel for development of the solar energy sector, improvement of solar energy standards.
- Attract new entrants to the solar energy sub sector in Uganda.
- Promote the interests of members of the solar energy sub sector among government, public sector, the general public and any other organizations that may impact on the development of the solar energy subsector.
- Create a forum for the dissemination and exchange of information and ideas on matters relating to solar energy development both locally and internationally.

USEA's Capacity to execute mandate:
USEA is a member association to provide a platform for its members to articulate their interests and lobby on their behalf. It has a lean organisation suit for this limited role.

Gaps falling under the responsibility of USEA:
A number of challenges faced by the off-grid sector actors as enumerated in Uganda Solar Energy Report include:

- Unfavourable government policies such as the mobile money tax,
- Inconsistent tax treatment of solar products,
- Unfair competition from low quality and cheaper counterfeit products and,
- Limited funding in the sector leading to slow adoption of technological and operational system innovations.

Recommendations:
USEA should undertake stakeholder education and sensitization to fight against substandard solar equipment and should lobby GOU to undertake the following:

- The Government should enhance the incentives to new technologies including solar given the important role in increasing access.
- The government should develop and enforce standards for solar equipment.
- The government should establish consumer protection mechanisms given the unregulated solar market.

4) Local contractors

Capacity of local contractors in electricity supply industry (ESI) is low and requires support to meet quantities and quality of contractors that meets the required specifications in the industry. Through government funded projects, REA and other executing agencies can give support to local contractors but this may be difficult with donor funded projects who dictate on international competitive bidding. In line with this, the PPDA policy needs to be reviewed to increase the limits for restricted bidding for works, that way the local contractors can be taken on board and projects can be ring fenced for local contractors. Additionally, government can negotiate better terms in the loan agreements to ensure that the Buy Uganda, Build Uganda (BUBU) policy is taken into consideration. This will provide impetus for local contractors and service providers to invest in capacity building.

4) Development Partners (EU, USAID, GERMAN DEVELOPMENT COOPERATION, WORLD BANK, AFRICAN DEVELOPMENT BANK, Export Import (EXIM) Bank of China, kFW and JICA)

Presentation of the main ones

Development partners (DPs) have played a very critical role in the rural electrification and increasing access to electricity. The main players include:

i. The European Union

The EU chairs the Energy Group in Uganda which co-ordinates aid to the sector to streamline aid follow and avoid duplication of effort. The EU through the Increasing Green Economy Project has supported a number of energy related projects including:

- Support of legal and regulatory reforms.
- Financial support to generation, transmission and distribution projects e.g KFW Grid extension and off grid solutions in Northern Uganda, GET FIT project and others.
- Support of West Nile Rural Electrification Company Limited (WENRECo) projects.
- Grants to supports OBA project through distribution companies.
- EU grants provide comfort to lenders and equity companies to participate and this has resulted in mobilization of about Euro 1 Billion for investment in the sector.

ii. GIZ

During the bilateral negotiations the Ugandan and German governments agreed that the cooperation should focus on three main priority areas including Renewable energies and energy efficiency.

iii. The World Bank

The World Bank is a source of financial and technical assistance to developing countries around the world, aimed at reducing poverty and supporting development. It provides low-interest loans, zero to low-interest credits, and grants to developing countries. The Bank provides or facilitates financing through trust fund partnerships with bilateral and multilateral donors in addition to supporting to developing countries through policy advice, research and analysis, and technical assistance. The World Bank is formed by two organizations namely; International Bank of Reconstruction and Development (IBRD) and the International Development Association (IDA).

iv. The African Development Bank

The objective of the African Development Bank (AfDB) Group, a multinational financial institution, is to spur sustainable economic development and social progress in its regional member countries (RMCs), thus contributing to poverty reduction. It achieves this objective by mobilizing and allocating resources for investment in RMCs and providing policy advice and technical assistance to support development efforts.

v. The *Export Import* (*EXIM*) *Bank of China*

The Export-Import Bank of China, the world’s third largest export credit agency, is a state-funded and state-owned policy bank and dedicated to supporting China’s foreign trade, investment and international economic cooperation.

EXIM Bank of China is financing the government of Uganda, through the Rural Electrification Agency (REA), the implementation of a Uganda electrification project at a cost of USD 212 million to light up 580 sub-counties and 52 town councils, through a concessional loan. Other major project financed by the Bank include the two hydro power stations.

vi. USAID; Power Africa

Power Africa focuses on support of three critical areas;

- Developing new generation.
- Access to power both on and off grid solutions.
- Create enabling environs and to attract investment.
- Preparation of Master Plans.

vii. kfW

Since 2007, KfW Development Bank on behalf of the German federal government has been committed to the Ugandan energy sector. KfW is contributing to the expansion of renewable energies by co-financing a 250-megawatt hydroelectric power plant in Bujagali. Furthermore, it is supporting the construction of high-voltage and medium-voltage transmission lines and is promoting new power connections in rural areas. By financing feed-in tariffs, KfW encourages private investments in small-scale sustainable energy projects. With its commitment in the sector, KfW is supporting the efforts of the Ugandan government to lay the foundations for enhanced economic and social development building on a sustainable electricity supply.

viii. JICA

JICA is supporting four main projects which include:

- Bujagali Interconnection Project
- Interconnection of Electric Grids of Nile Equatorial Lake Countries (NELSAP)
- Improvement of Queensway Substation
- Rural Electrification Projects

Capacity to Execute Mandate of DPs

Development partners in general operate under bilateral agreements with the Host Countries and are well resourced in terms of financial and human resource capacity and technical ability to execute their mandate.

Weaknesses

- Development partners dictate projects and areas where their aid is to be applied.
- Donor aid does not necessarily go to priority areas determined by the Country.

Recommendation

Development partners should work closely with partnering Country and provide aid to areas established by host Country as the priority area.

4.3 Strategic recommendations on institutional framework to achieve NES

To recap, the improvement in the institutional framework and in particular the interrelationships between the key players is a critical factor in achieving the objectives and targets set by the GoU. Despite the different players and their different mandates, there is need to take a holistic view of the whole electricity sub-sector and this study, the National Electrification Strategy is a useful starting point.

There are already initiatives underway in the sector to co-ordinate the Project planning and implementation of key electrification projects between REA, Umeme and UEDCL and at the sub-sector level, there are some working groups established for sharing information and coordinating the procurement and implementation of key projects between UETCL, UEGCL, Umeme Limited and others. However, these informal working relationships need to be formalised in the Law and MEMD given a clear responsibility to co-ordinate the sector planning, monitoring and evaluation of the implementation of key projects.

Our specific recommendations consist in the following actions:

1. **Sector Planning**
   a. Mandate MEMD to undertake central planning and development of Sector Plans while sector Agencies implement plans.
   b. Enhance measures to recruit, train and retain planning engineers within MEMD.
   c. Establish a sector skills development centre to enhance implementation capabilities of electrification projects both in GoU and Private Sector.
   d. There is need to take a holistic view of the sector and the law should be amended to place overall sector planning and co-ordination under the direct control of MEMD to curb inter-institutional conflicts and rivalry. MEMD should assume the role of co-ordinating sector planning and control of sector development to ensure well co-ordination and harmony in the NES.
   e. The Energy Resources Directorate should be strengthened in terms of its capacity to undertake Sector planning and Co-ordination as well as monitoring and evaluation of implementation of electrification programs in the whole country. In the alternative, this role could be shared out by the newly upgraded Planning Department in MEMD which has a technical unit but lacks the capacity to undertake any sector planning or monitoring and evaluation (M&E). Key roles and positions are presented below. They should be reflected in whatever organization Structure adopted by MEMD to ensure that MEMD has capacity to execute this mandate:
      - Head, National Electrification Planning and Coordination Dept
      - Principal Energy Officer – Planning
      - Principal Energy Officer – M&E
      - Senior Energy Officers – Planning
      - Senior Energy Officers – M&E
      - Senior Data Management Officer
      - Senior GIS Officer
      - Energy Officers – Planning
      - Energy Officers – M&E
      - GIS Officers
      - Data Management Officers
   f. MEMD should be availed sufficient resources to build necessary capacity to execute the planning function and co-ordination of the planning, monitoring and evaluation of the implementation of the projects in the sector. Under the current set up, the planning function of MEMD was not given any priority in resource allocation and capacity building.
   g. The existing ad-hoc planning co-ordination committee under MEMD should be strengthened and formalized by legislation under a statutory Instrument and allocated budgetary resources. The Committee should be chaired by MEMD with members from all

significant sector players and should be used as main mechanism to coordinate and harmonize sector planning and information sharing.

h. Under the law, MEMD is required to maintain a national electrification database and hence the MEMD should house the GIS and data Unit to maintain necessary data to facilitate the planning, co-ordination, monitoring and evaluation of the national electrification program (see also section 13. Monitoring and key indicators).
i. Sector planning committee convert the existing Adhoc Sector Planning Committee into a permanent sector planning committee by Statutory Instrument with representatives from all key sector players/operators. The committee should be chaired by MEMD. MEMD should provide a secretary (Secretariate). The committee should have a formal advisory role to the Minister. The committee should also have budgetary provision to enable it perform its role.
j. The Energy Resources Directorate (ERD) shall take direct responsibility for the implementation of NES in MEMD. It shall execute the planning and coordination role, undertake Monitoring and Evaluation (M&E) to monitor progress. Host the Sector Planning Committee, GIS office and Data Office. It should generate and disseminate progress reports on regular intervals for example twice a year for information of all stakeholders.
k. The Department of Rural Electrification Program (REP) shall be directly responsible for the implementation of planned and approved Rural Electrification Projects. It shall have responsibility for supervising contractors implementing Rural Electrification Projects. Completed Projects should be handed over to the National Operator, if on the national grid and to other operators if off-grid. The assets should be transferred to the Asset holding company on behalf of GoU.
l. The three MEMD Departments directly involved in the implementation of NES namely, Energy Resources Department (ERD), Rural Electrification Program (REP) and Procurement Department, shall be strengthened through capacity building and adequately resourced to ensure they have the capacity to implement the NES.
m. Sustainability arrangements: MEMD will ensure the sustainability of the NES through capacity building of the key implementing Departments and agencies in particular for the Planning Co-ordination, Procurement Functions and M&E. NES will utilize and optimize existing capacity to lower the cost of new connections. The bulk of the new connections (85%) will be within already electrified villages' densification or close by less than 5 km (intensification). Currently around 7% of domestic customers are on lifeline tariff putting pressure on the tariffs and pushing up the average tariff, the MEMD will aggressively promote PUE and efficient use of electricity which will have the effect of lowering the tariff, spur demand growth for electricity, tariff and sector sustainability and financial viability of the electricity utilities.

2. Restructuring the Distribution Sector

The distribution sector should retain a single National Operator (SPV) under a Public Private Partnership arrangement (One Territory + Operator Model) this is the model that will deliver the most efficiency gains and financial returns because under this model:

a. Economies of scale are maximized
b. Operational efficiency is improved by streamlining operation territories and restricting small operators to off-grids, SHS and as sub-contractors of the National Operator.

c. Financial sustainability is greatly improved, there is minimum requirements for subsidies from external support
d. Ability to implement life-line tariffs over the whole country is easier
e. Ability to implement cross-subsidies across customer groups and regions will reduce the need for external subsidies for tariffs.
f. Relieve UEDCL obligations as operator of last resort
g. The advantages of the PPA model are to mitigate the challenges of a pure Private Sector Operator because:
    i. Government can source Grants and low-cost finance for investment in access for non-commercial viable areas (Capital Subsidies) resulting in affordable tariffs.
    ii. The lease fees can be invested in a revolving Infrastructure Fund to finance new infrastructure or major refurbishments of existing network.
    iii. Tap into the advantages of private sector operator to improve operational efficiencies and tap private sector capital.
    iv. Eradicate territorial service limitations and conflicts.

Advantages of the SPV (Single National Operator)

a. Professional governance by Independent Professional Board
b. Operations based on sound business principles
c. Regulated on performance parameters may accelerate grid connections
d. Well-structured concession contract based on the PPP Legal Framework
e. Flexibility to outsource contracts and service providers while maintaining responsibility for targets and service quality.

A purely private operator would pose the following challenges and Risks:

a. Lack of competition and benchmarking comparative costs for same market/environment
b. May stifle local participation in the electricity sector.
c. Little support from stakeholders
d. Need for robust contractual arrangements that take time, effort and cost of set-up.
e. Perceptions of existing and potential investor especially IPPs working with government due to complex stakeholders buy-in (Parliament, Public, Laws, Existing contract buy-out amounts etc.)
f. Poor Government Track records on Joint Ventures
g. Political Interference

The PPP model would mitigation risks of a purely private operator in that:

a. National operator under PPP Model may be more sensitive to national interests.
b. Encourage public participation e.g. to buy shares in operators.
c. National Operator should engage current small operators as sub-contractors in provision of services.

3. Review and streamline the roles of the key Implementing Agencies

a. The Rural Electrification Agency (REA) has now been absorbed by MEMD as a Department.
    - The role of this Department should be reviewed and streamlined to improve its strategic focus on Rural Electrification Planning, Financing and Monitoring implementations of Rural Electrification Projects.

- The Department should not be involved in direct construction of projects or operational matters such as sourcing and supply of construction materials. This may lead to loss of strategic focus, conflict of interest and duplication of roles.
- MEMD should not own separate distribution assets. All distribution assets should be under one entity of GoU to make it easier to concession, maintain and manage.

b. UEDCL
- Should be an asset owner of distribution asset on behalf of Government of Uganda
- Should lease distribution assets to the national operator
- Develop capacity in procurement of concessions, monitoring use of the assets and terms of concession.

c. Small Distribution Operators;
- They face a lot of operational challenges e.g. lack of capacity, inefficiency and unviable relying on subsidies which is unsustainable.
- Small distributors should be restricted to off-grids and SHS.
- Small operators should be retained until the expiry of their licences or be compensated in accordance with the formula stated herein above.
- The main operator should be encouraged to sub-contract the small distributors as resellers, provision of services such as maintenance, construction of lines and connection of new customers.

Last minute event

The Government of Uganda has just adopted recommendations to restructure and rationalise the operations of several Government Agencies that will have impact on the electricity sub-sector. Under this arrangement, the Uganda Electricity Generation Company Limited (UEGCL), the Uganda Electricity Transmission Company Limited (UETCL) and, the Uganda Electricity Distribution Company Limited (UEDCL) shall be merged into one company. The Electricity Regulatory Authority shall be strengthened and retained while the Rural Electrification Board (REB) and Rural Electrification Agency (REA) shall be retained as a department of MEMD.

The time frame for the implementation of these reforms had not been ascertained by the consultant by the date of this report but is likely to take a while since it will involve the amendment of the Electricity Act, process transferring of assets and liabilities as well as human resource. The Consultant has not undertaken any in-depth analysis of these reforms since they are outside the scope of the TORs of this study. However under section 4.2.3 above, the Consultant noted that the Study on which the institutional reforms were based did not undertake an in-depth analysis of the electricity sub-sector specific issues and has recommended a further study on the new institutional framework to ensure that specific sector issues are addressed before implementing of the proposed institutional changes.

Notwithstanding the above observation, some of the proposed reforms are consistent with Consultant’s recommendations in particular, the retention and strengthening of ERA capacity to execute its mandate. The Consultant’s recommendations also support one government entity to own all Government and donor funded assets. However, the Consultants view is that retaining REA under MEMD may constrain REA’s ability to make timely decisions that may impact on the rollout of electricity access.

5 Analysis of policies and electrification strategies

5.1 Review of the different strategies and policy papers

The table below lists the key documents related to the national electrification strategies and summarizes the main issues with recommendations for the NES. This is followed with boxes which provide further details on these reference documents. In addition, we propose a comparative table of the two underpinning papers namely the REMP and the Distribution Sector Diagnostic Review Study. We put them in perspective with the new baseline and orientations applied in the NES.

Table 8: Summary review of the main national strategy and policy papers

Main Documents	Main issues	Critical Analysis	Recommendations for the NES
REA: Uganda Master Plan period 2018 – 2027	13 rural electric Service Territories (ST) were created by the Rural Electrification Agency (REA) in the framework of the RESP II (see below). Business plans were developed for each of the 13 ST which resulted in: - Annual investment requirements for grid and off expansion - Growth of the utility on internal investments requirements and operating Costs - Overall organizational structure including capacity building needs - Financial model to evaluate tariffs required to result in long-term	- The 13 ST experience face overlaps in distribution network, which cause challenges in terms of accurate monitoring of connections and energy losses. - Initial customer connection assumptions and projections seem too optimistic in light of recent WTP surveys undertaken in Uganda. - The connection rate assumptions do not reflect geographical disparities of income levels in Uganda - Whilst a threshold on customer numbers is indeed relevant, international experience shows that the financial viability of mini-grid projects is often correlated with the potential for productive use of electricity within the community rather than the number of customers or even household density. - The impact of master plans on the wider grid covers reinforcements on REA and UEDCL networks only without considering UMEME.	The master plans on the wider grid should cover reinforcements on UMEME network, in addition to UEDCL, REA and UETCL networks.

	sustainability for each service provider		
MEMD: Uganda Diagnostic Review of the Distribution Sector 2019	a. Socio-economic considerations b. Institutional setup c. Policy framework d. Legal and regulatory framework	- provides various options of organisational structures of the distribution sector for accelerated electricity access, which however require good planning and management at implementation - The study does not propose how the capital costs incurred financed from different sources can be captured as part of the full range of costs involved with the supply of power to customers. - The report highlights that ERA lacks a broad range of sanctions anchored in primary legislation to issue fines or other penalties to Service Providers but does not proposed alternative sanctions.	- The distribution sub-sector should be restructured so that there should be no more than three Service Providers covering the whole country. - Option 2 with "one national service provider for the whole country" is preferred it would deliver the best financial and economic results for Uganda. - A clear definition of electricity access is required based on achieving Tier 1 service level
Rural Electrification Strategy and Plan (RESP) 2013-2022 – Phase 2	The strategy is to achieve a rural electrification access of 26% by 2022 from the level of about 7% in 2013. Projects access to be at 51% by 2030 and 100% by 2040.	- The centralized rural electrification planning and program management underpins this new strategy, in order to reduce complexity and eliminate overlapping roles. - the Government shall proactively plan and enable the program's implementation, while mitigating commercial risks and related inhibiting barriers that prevented the private sector from fulfilling its responsibilities under the previous strategy - The beneficiary population, as the most motivated stakeholder group in rural electrification development,	- A modified approach for rural electrification development based on a coherent scheme to aggregate the market for rural electricity service expansion. - The beneficiary population should be involved during the implementation of the NES in setting local priorities, managing demand aggregation and consumer outreach and, wherever possible, managing and operating the schemes as cooperatives

		should be given a more robust role in achieving the aims of this new RESP - Capital expenditures should be provided under a system of capital recovery wherein the resources are recaptured by the Rural Electrification Fund (REF) for reinvestment in the future	
GoU National Development Plan II – NDP 2013-2020	- Increase power generation capacity from 850MW in 2013 to 2,500MW in 2020. - Access to electricity from 14% to 30% in 2020 - Expand the electricity transmission grid network. - Improve Energy Efficiency. - Promote use of alternative sources of energy. - Improve the policy, legal and institutional framework. - Build capacity in the energy sector.	- No geothermal power sources have been developed to improve generating capacity as indicated in the document. - Challenges in securing land for public infrastructure projects coupled with high compensation costs led to delays in the start of some of the major energy and in particular the transmission grid network - Poor / inefficient Project management of infrastructure & project timing leading to the unreliable and inefficient supply.	The document is now outdated. The objectives were unrealistic and are far of being achieved. Further, it fell partially outside the Vision 2040.
GoU Vision 2040	- targets to increase generation capacities up to 41,738 MW and electricity access from 10% in 2010 to 80%.	Vision 2040 Targets have been benchmarked with selected Upper Middle Income (UMI) countries that have achieved similar level of development status. This assumes similar conditions of development.	Overall, the targets set in Vision 40 are not supported through a robust action plan and investment scheme.
Energy Policy 2002	- Long term policy guidelines to encourage project development and harmonise sector activities. - The necessity that Energy for rural areas be brought into the	- The policy had limited consideration for off-grid energy solutions - Provisions for financing, communication and Monitoring and Evaluation were missing in the Policy.	The document is outdated. The revised policy will prevail and offset the weaknesses of the Policy 2002.

	realm of national Energy planning. - In addition to being a Constitutional requirement, it is to support and facilitate Government's programme		
The Revised Energy Policy (Draft)	- A need to consolidate these achievements, align the policy framework with recent international, regional and national developments and commitments - Government needs to be in positioned to address the new and emerging socio-economic challenges of the energy sector in the coming decade. -	- The policy does not give clear definition of electricity access. - The policy does not set targets and provide assumptions with regard to electricity access.	NES needs to provide the definitions and set targets and assumptions for electricity access. The revised Policy highlights the need for integrated energy planning systems and supports integrated energy methods to be adopted.
Electricity Connection Policy 2018	The ECP 2018 aims at tackling the causes of low electricity access: - high connection charges - high house wiring costs - lack of incentives for service providers to make timely and cost affordable connection - Surplus Energy - Sustainability of tariffs	- Under NDP II, GoU desires to accelerate electricity access and demand. ECP depends on the electricity infrastructure development by the service territory operators. - Focus on new connections is on households. - New household connections are of marginal consumers on life-line tariffs, which increases the tariff burden and financial sustainability of the sector. - There is surplus electricity supply. - Productive use of electricity focuses on industrial parks which take too long to establish fully to boost consumption.	- The Policy is complementary to the NES and will support its implementation. - The consultant will seek to explore an enabling environment for the operators in policy, regulatory and institutional frameworks. - There is need to focus on productive use of electricity to increase consumption - Focus should also be on SMEs, which provide the bulk of employment and a significant contribution to GDP.
Energy for Rural	- It consists of increasing on-grid &	The project focuses on grid densification rather than MV lines backbones. Cost of wiring	ERT III and NES are complementary: NES will propose new MV and LV

Transformation (ERT III)	off-grid energy access, Institutional strengthening and impacts monitoring.	the premises to be borne by the customers. It only addresses existing electricity infrastructure focusing on grid densification and not MV lines backbones. The project is weak in support of the NES.	lines considering the technical and socio-economic optimum for the whole country
Renewable Energy Policy 2007	- establish the availability, potential and demand of various energy resources; - increase access to modern affordable and reliable energy services;	- The Policy is silent on access to the grid due to the low generation capacity at the time of its formation. - The aspect of Per Capita energy consumption was left out which is a fundamental indicator of development - The energy policy does not capture the fundamental	The policy is now outdated and lacks adequate legal, regulatory and institutional frameworks.
	- improve energy governance and administration; - stimulate economic development; - manage energy-related environmental impacts	- aspects of production, value addition and industrialization. - The policy also had limited consideration for off-grid energy solutions, climate change mitigation actions and emergency thermal power generation during the energy crisis - The Policy did not look at provisions for financing, communication and Monitoring and Evaluation	
Productive Uses of Electricity Program Initiative, 2018 – REA/NRECA	The initiative is based on three pillars 1-Market analysis of potential agricultural activities 2-Defining financial mechanisms to support the initiative 3-Technical/Business support towards economic activities	-The initiative is pegged to RESP2 (2013-2022) and is therefore obsolete to the baseline of the NES. -The policy is narrowed down to agricultural sector and omits other critical sectors that promote economic development in goods or services such as rural enterprise, health and education -It is silent on UMEME and UEDCL distribution corridors	-Involvement of all stakeholders is key especially the beneficiary population towards realisation of economic development. A strong communication and marketing support should be embedded within the operational structure for REA. -The initial capital outlay for the mini-grids is enormous and PUE

		beneficiaries of electricity access -PUE for the MG connected population was considered. The MG concept was embedded in the REA MP (2018-2027) after this REA/NRECA initiative -There are gaps demonstrated in the financing/technical pillar	should always be put in perspective where MG is an option -Financing is critical towards successful results of PUE. A special unit should be established in the GoU for sourcing and allocation of funds at the end use customers.
Electricity Regulation 2020 (Isolated Grid systems) SI No. 138	This policy document is an instrument that guides development, construction and operation of isolated grid systems categorised into two: *-Generation stations for commercial purposes with a capacity not exceeding 0.5MW* -*Isolated grid systems where generation capacity does not exceed 2.0MW* The specific provisions include: -Registration of isolated grid operators -Technical framework on design, installation, operation and maintenance, safety, metering, power quality and availability, consumer management	-This regulation will encourage private investors to come in and play a major role in accelerating electricity access in rural areas. -The SI focuses on generation and distribution but does not set targets in relation to electricity access. -PUE has a great impact on socio-economic affairs of the beneficiary communities. The SI is silent on PUE - No technical requirements specific to off-grid systems is provided. Technical framework only refers to overall regulation such as Distribution Line construction guidelines (2017). - -There are timelines allocated for application of Licence (appraisal and approval) procedure upon receipt of application but some steps are not specified such as Receive response from applicant, objections received from communities	-The huge investment that goes along with development of MG should have PUE in perspective during the licensing of MG operators - Minimum national technical requirements of quality and performance could be introduced for specific off-grid projects development and operation. - A review of the appraisal and approval period is recommended to reduce application-processing time.

	-Tariff computation and structure based on "cost plus" principle -Interconnection with main grid -Governance issues of respective enterprises.		

Box 1: Focus on REMP / REA / NRECA

NRECA International partnered with Uganda's Rural Electrification Agency (REA) to define the country's electrification strategy through the Uganda Accelerated Rural Electrification Program developed a master electrification plan for one new electric service territory in Uganda, with funding from the World Bank. Furthermore, NRECA developed master electrification plans for all 13 of the country's electric service territories under the REA Master Plans project funded by the USAID/Power Africa program in Uganda.

- **Summary of the objectives**

- Develop plans for densification of 11kv and 33kv distribution networks
- Estimated costing for associated capital investment
- Identification of sites and estimated costing for isolated grid supply
- Analysis to evaluate technical impact for grid densification.
- Financial model to evaluate tariffs required to result in long-term sustainability for each service provider

2. Summary of the main issues

- The grid expansion projects in each masterplan of the 13 STs were based on identified large clusters of the population close to the grid and omitted areas where the population is scattered. Satellite data is partly from 2013 and outdated.
- The masterplans do not portray a clear distinction between on-grid and off-grid technologies from least cost perspective
- Some of the identified mini-grid sites with negative NPV have not been captured in the MP, a clear indication of getting short of desired global access.
- Identification of mini-grid sites was more biased towards villages with large population clusters but omitted the aspect of business viability potential and would discourage investment.
- The densification activities of other agencies such as UMEME, UEDCL and small distribution operators in the STs was not put into consideration in the masterplans. There is a likelihood of clashing or duplication of efforts to penetration of electrification.
- Some feeders are shared among the districts. The STs as currently constituted are already experiencing a conflict in terms of business performance and system loss reduction while the customer experience is also compromised.
- The masterplan is misaligned to other plans such as SEA4ALL action plan and Vision 2040

- During implementation of RESP I, non-affordability to meet internal wiring and connection costs was a major barrier to success towards access. The MP has not addressed this barrier.

3. <u>Summary of the outputs in terms of access</u>

- Construct about 19,000km MV Lines
- Identified 418 Mini-grids to be developed
- Increase customer base to about 1.3 Million up from 105,000
- Development of USD 927 Million Investment Plan
- Estimated access rate shall raise from 2.1% in 2018 up to 60% in 2027
- The Master Plan defines Tier 3 as minimum service level for both on-grid and off-grid electricity access according to SE4ALL categorization.

4. **<u>Summary of the main recommendations for NES</u>**

- The coverage of the REA masterplans is for the period 2017-2027 and therefore creates a realisation gap to anticipated 100% universal access to electricity by 2030 according to SE4ALL. NES will provide a strategic direction to cover the gap.
- The extension of transmission infrastructure should be considered in tandem with the REA MP to address the long distribution lines leading to system losses.
- The MP has based the identification of the mini-grids on cost of investment and the number of omitted potential sites is undeclared. NES should harness identification of the potential mini-grids.
- As an incentive to customers in the very poor population areas, the cost of ready boards should be factored in as an incentive to those customers who cannot afford internal wiring and connection charges. The portion of customer cost could be recovered after connection as they buy consumption units.

Box 2: Focus on The Distribution Sector Diagnostic Review Study

The Distribution Sector Diagnostic Review and Directions for Future Reforms for Long-term Sector Development and Acceleration of Electricity Access Expansion for Uganda whose overall objective was to support the Government of Uganda (GoU) to accelerate electricity access and enhance distribution sector efficiency and financial sustainability through recommending appropriate institutional reforms, was carried out by by the World Bank Group in September 2018.

1. <u>The overall objectives of the study was to support GoU to;</u>
   - Accelerate electricity access
   - Enhance distribution sector efficiency and financial sustainability through recommending appropriate institutional reforms.

2. <u>Summary of the main issues highlighted in the document</u>
   a. Socio-economic considerations: Many households in rural areas cannot afford to pay for grid electricity –this is mainly imputable to prohibitive wiring fees (this will

be mitigated, to some degree, by the implementation of the Electricity Connection Policy)

b. Institutional setup
    i. Poor technical and financial performance of some Service Providers.
    ii. Capacity issues with some stakeholders.
    iii. Overlapping Service Providers is problematic.
    iv. Approaching the end of the Umeme Limited's concession period
c. Policy framework
    i. "Electricity access" definition is unclear.
    ii. Current strategies and plans may not meet objectives
    iii. Preferred electricity access solutions sometimes not the most appropriate.
    iv. Risk of stranded generation costs.
d. Legal and regulatory framework
    i. Overlapping stakeholders' mandates is impeding efficiency.
    ii. REA not established in primary legislation causes confusion: REA carries an active asset ownership role but does not fall under the scope of regulation of ERA
    iii. Improvements required to the off-grid market.
    iv. Incentives in the regulatory framework not sufficiently focused on increasing access.

3. <u>Summary of the outputs in terms of access</u>
    a. Access to electricity from the grid would grow from 11% in 2010 (NDPII) to no more than 40% by 2030, and would fall back to 30% by 2040 (unless there was continuing investment) as the current pace of efforts would soon be offset by demographic growth
    b. Total access to electricity of reasonable quality (including off-grid) would increase from around 36% in 2019 (Ricardo Study) to no more than 60% by 2030 and would fall to 50% by 2040 (again driven by demographic changes and unless balanced by continuing investment)

4. <u>Summary of the main recommendations for the NES</u>
    a. The distribution sub-sector should be restructured so that there should be no more than three Service Providers covering the whole country.
    b. Option 2 with "one national service provider for the whole country" would deliver the best financial and economic results for Uganda.
    c. The service provider(s) should operate all of the main grid within its (their) service areas
    d. Should be private sector utility(ies) selected by competitive process(es).
    e. If the PPP model is not adopted then ownership of all of the main distribution grid should be held by UEDCL–but UEDCL should not remain an operator of distribution assets
    f. Existing mini-grids not connected to the main grid should carry on as at present
    g. Quality standards should be established and enforced for the off-grid solar home systems sector

h. The solar home systems industry should be encouraged to develop customer confidence building measures.
i. A clear definition of electricity access (based on achieving Tier 1 performance level of the ESMAP Multi-Tier framework), covering grid, mini-grid and off-grid access solutions, should be established. However, Household Tier 3 should be regarded as minimum specification for grid access in order to affect meaningful level of social and economic wellbeing
j. A fully integrated strategy for access including all of these solutions should be developed
k. The Electricity Connections Policy should be continued including ensuring that there are free ready-boards or low-rate financing available for those who cannot afford internal wiring costs and/or live in precarious dwellings (e.g. without concrete wall) where internal wiring is impractical
l. REA's role in the main grid sector should be focused on funding or partially funding projects brought to them by Service Providers which would otherwise not be undertaken. In the mini-grid sector the role would be similar to that currently undertaken.

Box 3: Focus on the Electricity Connections Policy 2018

The GoU has established a connection Policy for electricity customers for the period 2018-2027. Previous policies and strategies have largely focused on strengthening grid infrastructure. The main objective of the ECP is to increase connection rate.

1. Summary of Objectives
   - Increase annual connections rate from 70,000 to 300,000
   - Increase electricity demand in the main grid by 500MW

2. Summary of the main issues affecting access
   - Subsidised connection charges for eligible customers existing within the LV distribution network. Connection materials have been costed at USD160 inclusive of taxes. Cost of internal wiring to be met by customers.
   - For grid densification and intensification, the ECP seeks to focus on densely populated areas within proximity of distribution network.
   - Make use of ready boards for customers who are unable to wire their houses.
   - Establish mini-grids and standalone solutions for customers where extension of the main grid is not financially viable.
   - Establishment of credit facilities for customers who are unable to pay connection charges upfront.
   - Enhanced capacity for distribution Service Providers

3. Summary of Output in terms of Access
   - Additional connections under existing GoU Plans as follows
     a) 11,256,721 under Vision 2040, 2013-2040 (Targeting 80% National)

b) 1,199,705 under NDP2, 2015-2020(Targeting 30% National)
c) 1,531,779 under RESP2, 2013-2022(Targeting 26% Rural)

- To support the target annual connections of 300,000 a total funding of USD55,845,000 broken down as follows
    a) Connection charges –USD48,000,000
    b) Verification of Connections –USD3,000,000
    c) Publicity –USD645,000
    d) Ready boards –USD4,200,000

4. Summary of the Main Recommendations for the NES
    - The coverage of the ECP is for the period 2018-2027 and hence will form a gap for the universal electricity access by 2030 which NES seeks to address
    - Definition of 'access' is not based on at least Tier1 as per SE4ALL of which it will clearly be embraced in the NES.
    - The ECP is biased towards customers along existing LV distribution network with direct service connection. On the other hand it encourages densification and intensification of distribution network in densely populated areas leaving out part of the population .
    - The policy appears to favour connections within the main grid but does not address connection charges for mini-grids and standalone connections of which the NES will offer a strategic direction.
    - The ECP supports for productive use of electricity through publicity and mobilization does not give a strategic enabler with the meagre annual budget of USD645,000. Recommendations for productive use promotion will be included in the NES.

5. Challenges, impacts, highlights of ECP

The Electricity Connection Policy (ECP) was passed in January 2018 but the implementation was rolled out in November 2018. The ECP is expected to be reviewed every three years. It is therefore too early to evaluate the impact of the ECP.

However, there is a need to realign the targets in the ECP in line with the NES roadmap. The ECP connection target is 60% by 2027 and at this rate, the NES connection target of 100% universal access by 2030 in line with SE4ALL which has been adopted by GoU cannot be achieved.

Hence the need to scale up the ECP targets to align with the NES targets.

The ECP correctly identifies the key bottlenecks that constrain increased connection rates namely;

a) High cost of connection charges of US$ 160 per household
b) Inability of most households to pay for standard wiring costs
c) Lack of incentives to service providers to make timely and affordable connections

The proposed solutions in the ECP have not achieved their full potential due to a number of limitations including:

1) Limited resource envelope available to REA which is inadequate to meet the desired accelerated connection rates. REA recommended the doubling of its budgetary provisions from the current approximately US$ 100 million to US$ 200 million

2) A related factor is the timing of the release of funds which is irregular and negatively impacts on the implementation of the ECP thereby creating backlog and lengthy waiting lists for connections. The Output Based Aid (OBA) has resulted in significant increase in connection rates but is constrained by delays and untimely release of funds which should be addressed.
3) Construction contracts embedded with connections is a good idea; however, the challenge in its implementation has been the mismatch in the timing of household wiring and project completion. Many potential consumers miss out on free connections because they are not ready with the wiring of the premises by the time the project has closed.

A related factor is the lack of spare capacity to accommodate new customers especially SMEs, which are attracted by the extension of the grid but find the network fully loaded and REA has no funds to provide extra capacity.

Table 9: Differences between REMP and Diagnostic Study with new orientation for the NES

Issue	REMP	Diagnostic Review	NES
Baseline assumptions in terms of access	21.6% in 2017 considering only tier 2 service (grid connected)	Quotes NDPII access rate 11% in 2010	50% in 2020 considering Tier 1 minimum (UBOS)
Targets in terms of access	26% by 2026	60% by 2030 of which 40% on-grid	100% by 2030 considering Tier 1
Main enhancements provided in the doc	- There are investments in MV and LV infrastructure in the CST - About 3,141 households were connected to the grid within the Umeme service territory - A financial model was developed to evaluate the financial performance of the CST service provider for the period 2018-2027 - REA divided Uganda into thirteen manageable rural electric service territories	Assess the optimal framework for electricity operation: max 3 Service Providers for the whole country Propose specific strategy for off-grid areas electrification Recommendations for the institutional framework including PPP scheme.	Consolidated GIS incl. electrification status of each settlements Consistent definition of electricity access definition and figures Least cost options and electrification scenario Optimize socio-economic impacts Concrete recommendations for the institutional and regulatory frameworks Consolidation of the other strategy papers
Main weaknesses	Lack of clear definition of access. Not consistent with	Lack of clear definition of access. Not consistent	Tier 1 definition of access is too low to support

	other assumption and strategies. Baseline and projections of connections too optimistic	with other assumption and strategies. No clear strategy to implement and finance the recommendations	efficiently socioeconomic development

Box 4: Focus on The Rural Electrification Strategy and Plan (RESP) 2013-2022 – Phase 2

The RESP was developed in a consultative process with the rural electrification program's principal stakeholders to identify corrective measures for improving the performance of the sector, focusing on measures to accelerate electricity access while ensuring program efficiency and sustainability. The aim of the RESP for the ten-year period 2013-2022 was to identify corrective measures to improve the acceleration of electricity access to meet national development goals.

1. The overall objectives of the strategy is to;
   a. The Primary objective was to achieve an accelerated pace of electricity access and service penetration to meet national development goals during the planning period and beyond.
   b. A secondary objective is to ensure that, progressively, the program facilitates access to all forms of modern energy services to replace kerosene for lighting and other forms of traditional cooking and heating.

2. Summary of the main issues
   a. lack of education of the rural communities regarding the benefits of electricity,
   b. inadequate marketing by Service Providers,
   c. a high cost for service connections,
   d. a lot of time lost in testing the original concept of the Rural Electrification Fund (REF) to support private initiatives
   e. organize the rural energy services market in order to achieve scale and commercial viability as rapidly as possible;
   f. facilitating the sustainable flow of capital financing to rural electrification and rural energy service infrastructure, as well as to overcome economic barriers to rural consumers in accessing such infrastructure;
   g. empowering rural electrification planning and implementing entities with appropriate authority and accountability to conduct their roles under adequately understood and transparent mechanisms;
   h. ensuring that sufficient capacity-building support for all stakeholders is provided in order to quickly adapt to the roles that they must play in a business-like fashion;
   i. reducing barriers inhibiting widespread electricity service provision in rural areas.

3. Summary of the outputs in terms of access

   a. The Investment targets are derived from 10-year business plan of the service territory concessions for the number of new consumer services is estimated 1,276,500 connections, including the rural areas of Umeme's service territory.
   b. The total number of service connections including solar PV installations for the 10-year RESP period is 138,500 from solar PV home systems (SHS) and mini-grids, and
   c. The access targets estimated above are equivalent to an overall access level of 26% of the rural population in 2022. There is no clear definition of access related to service level. It is assumed that the target refers to Tier 3 as a minimum.

4. Summary of the main recommendations for the NES
   a. Government should modify or enact legislation and policy to enable the RESP.
   b. The strategy's implementing structures and reforms shall be undertaken in a timely fashion and program stakeholders adapt successfully to their roles with adequate organizational and competency development.
   c. There will be a robust response from the private and cooperative sectors in offering proposals for service territory concessions.
   d. The planned power supply expansion program, including power generation and transmission infrastructure, shall be expanded in coordination with RESP needs in such a fashion so as to meet growing rural electricity demand.
   e. Donor agencies commit to the new strategy and help to provide the needed capital expenditure funding and capacity-building support to implement the strategy successfully

Box 5: Focus on Government of Uganda Vision 2040

Uganda Vision 2040 aims at transforming Uganda from a predominantly peasant and low income country to a competitive upper middle income country. It provides development paths and strategies to make operational the Uganda's Vision statement which is "A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years" as approved by Cabinet in 2007.

1. The overall objectives of the Vision is to;
   a. increase generation capacities
   b. Increase electricity access from 10% in 2010 to 80% in 2040
   c. Encouraging use of renewable energy due to climate change.
   d. Reduction energy deficit
   e. Support the human resources development especially in areas of nuclear energy and other energy sources

2. Summary of the main issues
   a. Preconditions to reach the targets are not clearly confirmed

3. Summary of the outputs in terms of access
   a. increase generation capacities up to 41,738 MW in 2040
   b. Increase electricity access to the national grid from 10% in 2010 to 80% in 2040

c. increase electricity per capita consumption from 75 kWh in 2011, to 3,668 kWh

4. Summary of the main recommendations for the NES
   a. The required capacity to be generated from different energy sources, and the main emphasis will be on use of energy source that will provide a competitive tariff compared to other countries.
   b. Government to invest in R&D and provide incentives to encourage use of renewable energy to deal with climate change
   c. Government to provide incentives to lower the cost of electricity infrastructure, facilities and equipment to improve access and availability of electricity to the rural and urban areas
   d. In an effort to improve energy efficiency, Government to support upgrading of industrial technologies to less energy consuming technologies.
   e. Importation of power from neighbouring countries under the Power Trade arrangement, and development of nuclear power and other renewable energy sources to be pursued to reduce energy footprint.

Box 6: focus on Energy for Rural Transformation (ERT III)

Currently REA is undertaking ERT III where electrical intensification is being carried out throughout Uganda under World Bank Funding and to connect free of charge all customers who are 100 m and below from the existing pole. The programme mainly focuses on grid densification.

1. The overall objectives of the Programme is to;
   a. increase on-grid & off-grid energy access,
   b. Institutional strengthening and impacts monitoring

2. Summary of the main issues
   a. The unclear roles and responsibilities of the different agencies involved in expanding access;
   b. The limitation in expanding the service network under the initial concessions;
   c. Insufficient incentives for the private SPs to increase access particularly amongst the rural poor;
   d. Weak capitalization of some SPs and their inadequate managerial and operating expertise;
   e. Affordability constraints relating to internal house wiring costs and service connections charge (on average US$200 per connection);
   f. Inadequate efforts to sensitize rural households about the benefits of electricity usage and to mobilize them to prepare and apply for service connections; and
   g. Ineffectual delivery mechanisms for the off-grid solar photovoltaic (PV) program

3. Summary of the outputs in terms of access
   a. Under its on-grid energy access component, the proposed project will finance a total of about 150,000 on-grid connections

b. Under the off-grid energy access component, solar energy systems will be installed in about 100 schools, 276 health centers, and 15 water pumping stations, all in rural area

4. <u>Summary of the main recommendations for the NES</u>
    a. Incentives targeting the end-users to increase the connection rate under the LV lines: the project aims to connect customers falling within 100m of existing LV network at no cost. Cost of wiring the premises to be borne by the customers.

Box 7: focus on The Revised Energy Policy 2019

The Revised Energy Policy was formulated in 2019 with the objective to ensure sustainable development and utilization of energy resources, services and products by all Ugandans towards transformation of the national economy.

1. <u>The specific objectives of the Policy include;</u>
    a. Increase access to reliable, affordable and modern energy services
    b. Stimulate economic development
    c. Improve the security and reliability of energy supply
    d. Manage environmental impacts of energy exploitation and consumption
    e. Promote efficiency and conservation in energy supply and utilization
    f. Improve energy sector governance, capacity building and integrated planning
    g. Promote renewable and alternative energy sources
    h. Raise public awareness on energy resources, services and programmes

2. <u>Summary of the main issues highlighted in the document</u>
    a. Low levels of access to affordable and modern energy services: Low connection rate with limited productive use especially in rural areas. Negatively impacting on demand growth and affordability
    b. Constrained economic development due to inadequate energy sector investments. The funding required for steady energy supply and matching infrastructure investments is inadequate
    c. Unreliable energy supply infrastructure: Constraints in transmission and distribution limit the domestic utilization and regional export of existing generation supply and increase the cost of service from unutilized capacity
    d. Inefficient utilization of energy; There are inefficiencies on the supply and demand sides, with relatively high losses in transmission and distribution, and proliferation of substandard energy equipment and practices on the demand side
    e. Inadequate technical capacity and lack of integrated planning; there is a shortage of skilled staff, lack of integrated planning and inadequate coordination in institutions and sectors.
    f. Vulnerability to climate change; the energy sector is vulnerable to adverse changes in climate which could disrupt energy supply.

g. There is insufficient public awareness of the potential, opportunities and economic benefits of various energy resources and technologies, as well as sector activities and programmes

3. Summary of the outputs in terms of access
    a. There is no clear definition and assumptions related to access. The policy give a statement that Government shall facilitate provision of reliable, stable and equitable electricity services to rural consumers towards achieving universal access by 2030

4. Summary of the main recommendations for the NES
    a. NEST needs to provide the definitions and set targets and assumptions for electricity access

Box 8: focus on The Energy Policy 2002

The goal of the Energy Policy was: "To meet the Energy needs of Uganda's population for social and economic development in an environmentally sustainable manner"

1. The overall objectives of the Energy Policy 2002 was to support GoU to;
    a. Establish the availability, potential and demand of various energy resources in the country;
    b. Increase access to modern affordable and reliable energy services;
    c. Improve energy governance and administration;
    d. Stimulate economic development; and
    e. Manage energy-related environmental impacts

2. Summary of the main issues highlighted in the document
    a. The policy had limited consideration for off-grid energy solutions, climate change mitigation actions and emergency thermal power generation during the energy crisis.
    b. Provisions for financing, communication and Monitoring and Evaluation were missing in the Policy.

3. Summary of the outputs in terms of access
    a. There is no clear definition and assumptions related to access. It only talks of bringing Energy for rural areas into the realm of national Energy planning.

4. Summary of the main recommendations for the NES
    a. There have been important market changes in the energy sector since 2002.
    b. The electricity sub-sector has shifted from generation capacity shortages between 2002 and 2012 to the current anticipated surplus of power generation compared to demand.

c. The Government is now focused on the development of domestic demand and regional power trade.
d. Other changes in market orientation include a progression from primarily private sector led growth to Public Private Partnerships (PPPs), and increased public financing of sector developments aimed at increasing affordability.

Following the submission of the NES draft report, the consultant received comments from stakeholders. These resulted in overall recommendations towards simple policies consisting in:

1. A holistic approach toward national electrification expansion to utilize the deep levels of investment already made in Generation, Transmission and Distribution.
2. Electrification strategies that will close the oversupply gap and benefit from high end to low end consumers and fuel the national economy.
3. Complete eradication of often senseless technical, financial and regulatory hurdles imposed, that will hamper accelerated electrification.
4. The imposition of flexible, modern affordable technologies that will reduce cost per connection and improve customer safety.
5. Encouragement of private sector investment in the grid and off-grid side of electrification and reduce hesitance on both sides of that spectrum because of perceived competitive risks.
6. Promote technologies, processes and systems that are compatible with the anticipated rationalization of the distribution sector.
7. Promote productive use of electricity to elevate Uganda towards modernization of the industrial, commercial and agricultural productive practices through provision of abundant, reliable electricity to be competitive with its neighbours.

5.2 International benchmark with comparative analysis of success

Comparative analysis of success in the access to electricity

African countries are increasingly implementing policies with a view to meet the United Nations Sustainable Development Goal 7 (*Ensure access to affordable, reliable, sustainable and modern energy for all*) by 2030, resulting for some of them in substantial progress in terms of energy access and rural electrification. South Africa, Ethiopia, Ghana, Kenya, Rwanda and Senegal are on the way to reach full access by 2030. The deployment of new technologies and business models are attracting investment from donors, development banks and leads to an increasing interest from the private sector.

Looking at the comparative figures from the last Africa Energy Outlook (IEA 2019), we observe that the share of the population with access to electricity in sub-Saharan Africa raised from 20% in 2000 to 43% in 2018 and is supposed to reach 62% in 2030 according to the Stated Policies Scenarios (IEA measured assessment of today's national policy frameworks and plans) with over 230 million people gaining access. Though not clearly defined by the IEA, we assume that all these figures refer to a minimum service level above Tier 2[5] as per SE4ALL multi-tier categorization.

Access to electricity figures (2000 – 2018) and target 2030

[5] > 73 kWh per year consumption level equivalent to lighting, phone charging, fan and TV equipment.

The following table present the evolution of electricity access since 2000 and the target for 2030 in various Sub-Saharan African countries, highlighting some of the successful implementation of strategies and policies.

Table 10: Electrification rate results (2000 – 2018) and target 2030

	Electricity access rate (%)		
	2000	**2018**	***2030***
Angola	12%	44%	*57%*
DRC	7%	9%	*16%*
Ivory Coast	50%	63%	*94%*
Ethiopia	5%	45%	***100%***
Ghana	45%	84%	***100%***
Kenya	8%	75%	***100%***
Mozambique	6%	29%	*60%*
Nigeria	40%	60%	*80%*
Senegal	31%	69%	***100%***
South Africa	77%	95%	***100%***
Tanzania	11%	37%	*70%*
Sub-Saharan Africa	**20%**	**43%**	***62%***

Source: IEA (2019), Africa Energy Outlook

According to these figures from the Stated Policies Scenario aggregated by IEA, the main grids will connect around 70% of the 230 million people gaining electricity access by 2030, the remaining 30% being supplied through mini-grids and SHS. Decentralised options (mini-grid and stand-alone systems) remain applicable for more remote areas. In 2030, 530 million people will still be lacking access to electricity.

According to IEA, "Projected progress in the Stated Policies Scenario is most rapid in East Africa, as it moves from a regional access rate of 43% today to more than 70% by 2030. Kenya, Ethiopia and Rwanda are all set to achieve universal access before 2030. Ethiopia brings access to the highest number of people in the region by 2030 (more than 70 million). Tanzania also sees rapid progress, with its electrification rate climbing to around 70% in 2030 from less than 40% in 2018. Progress is also made in West Africa and Southern Africa, where the regional access rates reach over 60% by 2030. South Africa and Ghana, which achieved two of the highest access rates on the continent in 2018 after two decades of effective government leadership, are expected to reach full electrification by 2030. Senegal is expected to achieve universal access in 2025. Strong efforts in Nigeria and Côte d'Ivoire result in their rates of access increasing to 80% and more than 90% respectively by 2030."[6]

[6] IEA (2019), Africa Energy Outlook

Key success factors and policy opportunities

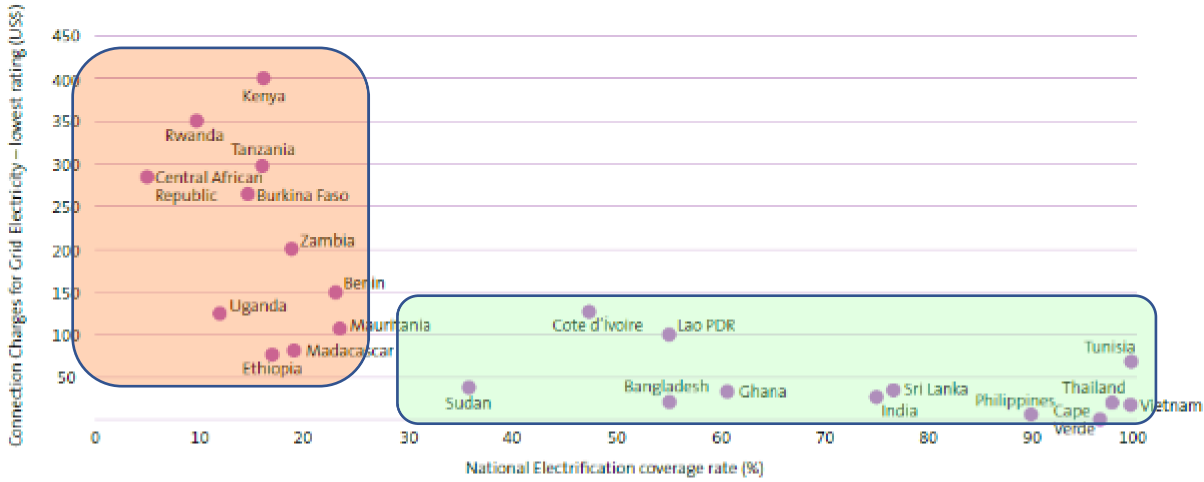
Table 11: Electricity access policies and targets in selected countries

Country	Target	Implementation measures
Kenya	Full access by 2022	Kenya National Electrification Strategy (2018): investment of $2.8 billion from 2018-22. Kenya Off-grid Solar Access Project: distribute 250 000 solar home systems to power households, schools, health facilities and agriculture by 2030.
Ethiopia	Full access by 2025	Electrification Program (2017): geospatial least-cost roll-out plans, **fast-paced extension of the grid** to reach 65% of the population with the grid and 35% with decentralised systems by 2025; **public-private off-grid programme** for 6 million households
Rwanda	Full access by 2024	Energy Sector Strategic Plan and Rural Electrification Strategy: connect 52% households to the grid and 48% to decentralised systems by 2024; **connect all productive users**; cut by half the duration and number of interruptions; **introduction of appliance efficiency standards**.
Senegal	Full access by 2025	National Rural Electrification Program (PNER), aiming to electrify 95% of rural clients through **grid extension**, 4% through solar only or solar-diesel hybrid mini-grids, and the rest through solar home systems.
Ivory Coast	All areas connected by 2025	Programme Electricité pour Tous: electrify 1 million households. Programme National d'Electrification Rurale: **connect all towns above 500 inhabitants** by 2020, and all areas by 2025. Tariff reductions for poor households.

Source: IEA (2019), Africa Energy Outlook

Various successful strategies are identified among which we can mention the strong effort in grid extension and effort to connect productive users. All of these implementation measures are relying on a high political commitment.

Figure 9: Relationship between Connection Charges and National Electrification Rates



Source: World Bank report (2013), 'Connection Charges and Electricity Access in sub-Saharan Africa: Raluca Golumbeanu and Douglas Barnes

Lessons learned: all countries beyond 30% electrification rate were having connection rate (including security deposit) below 127 USD. The graph shows that Ivory coast and Uganda were having the same connection costs, but the connection rate in Uganda was much lower, mainly because of lower purchase capacity in Uganda as well as poorer quality of electricity supply:

- **Relationship between connection charge and monthly income**
  - Comparing the connection costs with the monthly income is highly instructive: it represents 61,6% in Uganda versus 25,5% in Ivory coast and this may explain to a certain extent the difference in electrification rate.
  - Tanzania has increased its electricity access from around 13% in 2008 to 24% in 2012, with a reduction in connection fees (by 40% in urban areas and 60% rural areas) recognised as an important contributory factor.

- **Strong political commitment**
  - Ghana is among the most successful countries in improving electricity access, having shown long and strong political commitment since the launch of its National Electrification Scheme in 1989.

- **Fast-paced extension of the grid**
  - Ethiopia: to reach 65% of the population with the grid by 2025
  - Ivory Coast: to connect all towns above 500 inhabitants by 2020, and all areas by 2025

- **Mini-grids can play an important role in sparsely populated countries**
  - Mali, a large country with scattered settlements, has seen electricity access reach 27% in 2013, with a focus on mini-grid solutions.

- **Targeting public facilities and productive uses as a priority**
  - Kenya established a Rural Electrification Authority in 2006 with the goal of achieving universal access by 2030. In 2013, 90% of public facilities were already connected to electricity[7], while household's access was still remaining low. This rate has significantly increased in the following years, in order to reach 75% in 2018.

[7] Source: IEA (2014) Africa Energy Outlook

   - Rwanda intends to connect all productive users in its Energy Sector Strategic Plan and Rural Electrification Strategy

- **Deployment of ready-to-use switchboards (Electricity Access Rollout Programme)**
   - Rwanda's electrification rate increased rapidly from 6% in 2008 to 17% in 2012 benefiting from its Electricity Access Rollout Programme. Ready-to use switchboards that can be paid for in instalments and enable low income households to connect to grid electricity without the need for expensive house wiring.

- **Introduction of appliance efficiency standards**
   - Rwanda Utilities Regulatory Authority has pushed for the introduction of appliance efficiency standards

- **Deploying prepaid meters**
   - South-Africa: With 85% of official electrification rate in 2013, South Africa achieved the highest electrification rate on mainland sub-Saharan Africa. The 15% remaining were composed by 11% of households without any access to electricity and a further 4% relying on illegal access (non-paying) or obtaining access informally (from one household to another but paying)[8]. More than 75% of households were already using pre-paid meters, which helps overcome the problem of non-payment.

Classification of electrification models

Most of the Sub-Saharan governments have already put in place Agencies or Funds, under the supervision of the Ministry of Energy, with the mandate of promoting the development of Renewable Energies or/and Rural Electrification. Three main solutions are usually considered:

1. Grid expansion
2. Mini-grids deployment
3. Dissemination of stand-alone systems

Public resources being also limited, the private sector has been urged to take responsibilities, and play a bigger role by contributing to the electrification efforts and investments. Elaboration of specific business models, and conducive regulatory frameworks can be considered as a pre-requisite, a necessary but not sufficient condition to allow the private sector's participation. Beyond this, the question of financing initial investment remains a major barrier to overcome for private developers.

African countries having recently carried out large-scale rural electrification programs have chosen different path when looking at the regulatory and institutional frameworks. Three main models based on their level of centralisation can be distinguished, however a single system is rarely in force and many countries have chosen mixed-approaches:

1. **Centralized approach – Integrated state model**: the state defines policy and strategy, and the utilities run them: Ghana, Côte d'Ivoire, partly in Burkina Faso, partly in Mali.

2. **Public Electrification Agency or Fund model** which aims at decoupling rural electrification from the national utility and ensuring autonomous financing with a latent or asserted willingness to involve the private sector: Senegal, Mali, Burkina Faso, and partially in Benin.

3. **Private financing models** such as:
   - Decentralized service companies (Mali, Burkina Faso, and Senegal in the framework of large concessions)

[8] Statistics South Africa, 2013 / reported from IEA 2014 Africa energy outlook

- Lease-to-own associated with a maintenance service (in Burkina Faso with Fondem financing, and the network of credit unions and local operators in Senegal and Mali).
- Model based on NGOs, generally engaged in other development activities (health, water supply, irrigation).

1. Centralized approaches

Not all countries that have already successfully implemented rural electrification, like those that are still in the process of doing so, have systematically or exclusively relied on Public-Private Partnerships to finance their programs. In Africa, countries such as Algeria, Tunisia and Morocco have been able to complete their rural electrification programmes in the long term, by entrusting their national electricity utilities with this mission of electrification and the management of dedicated financial resources. It is up to them to delegate part of it to the private sector (the Solar PERG in Morocco for example).

To achieve this, Governments have not only shown a very strong political will, but have also been able to mobilize, on their own resources, the bulk of the financial resources required, supporting this effort for decades. The integrated state model is also in force in Ghana and Côte d'Ivoire, and partially in Burkina Faso.

2. Public Electrification Agency and Fund Model

This model is applied in several countries, such as:

- Burkina Faso, with the FDE (Electrification Development Fund)
- Senegal, with ASER (Senegalese Rural Electrification Agency)
- Mali, with AMADER (Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale)
- Benin with ABERME (Benin Rural Electrification and Energy Management Agency).

There are two main strategies for mobilising the private sector:

- Large territorial concessions, mainly under development in Senegal, but also planned in Mali and Benin,
- Small concessions such as PCASER (Mali), ERIL (Senegal) or COOPEL concessions in Burkina Faso.

3. Private Financing Models

<u>Large concessions:</u>

In the model of large concessions, the aim is to get a strategic operator committed to develop the electrification of a geographical area by using different types of technologies (main grid, mini-grid or stand-alone systems) and providing own funding (typically in the range of 40% to 50%) and receiving from the concessional authority (Agency and State) a certain number of guarantees (such as cost reflective tariffs) and support (such as subsidies and technical assistance) ensuring the business viability over the term of its concession, with a reasonable profit from its equity investment. The model is based on a contract and a public service concession award. The types of operators involved in concessions are:

- Foreign national Electricity companies such as EDF, ONE, STEG (e.g. In Senegal) which have applied to calls for tender,

- Local or international entrepreneurs interested in the business opportunity that represents the dealership (cable manufacturers, diesel specialists, PV panel manufacturers)

Small concessions:
This model is applied in Senegal (ERIL: Electrification Rurale d'Initiative Locale), in Mali (PCASER: Spontaneous Rural Electrification Application Project) and in Burkina Faso (COOPEL: Cooperative for Electricity).

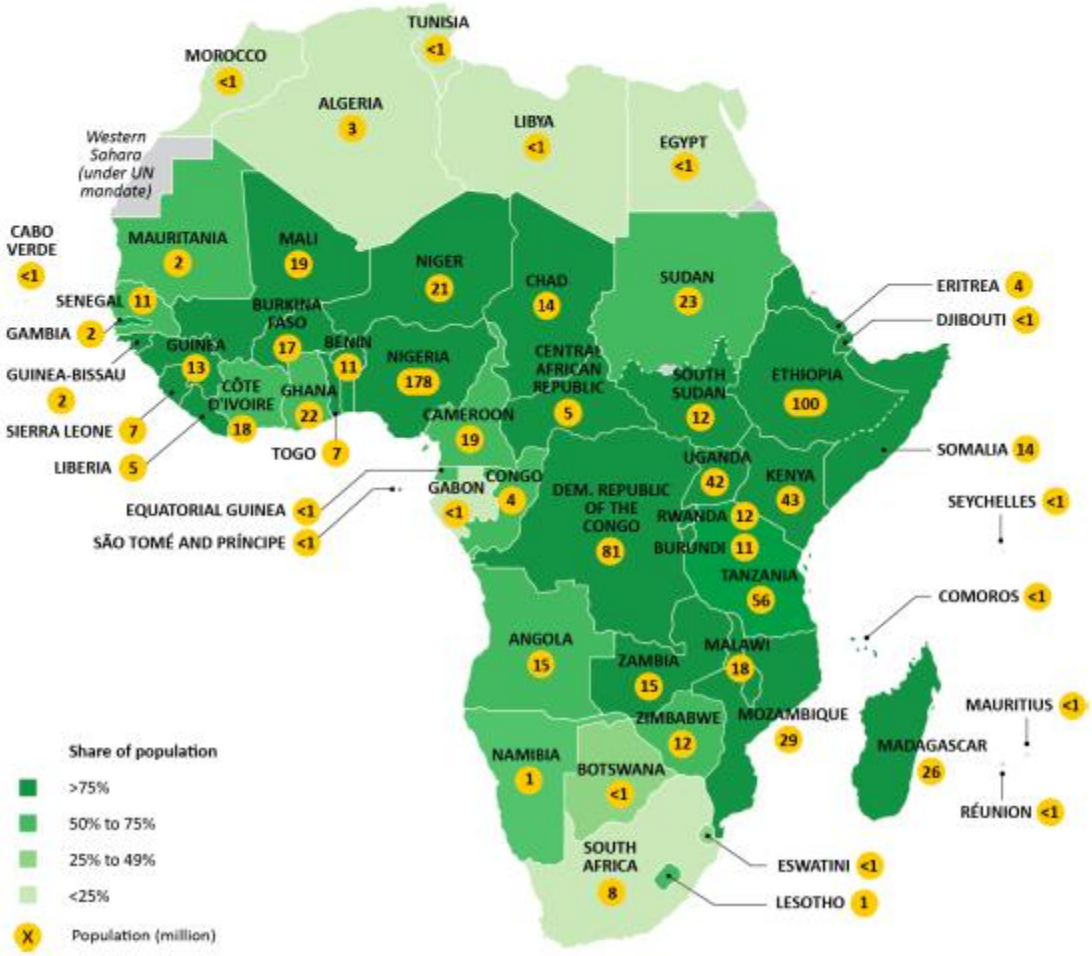
The dynamic is similar in all three cases. It basically consists in allowing the electrification of a settlement on the basis of a local public service authorisation or concession, granted to a physical or legal entity that takes over the management of a system and provides part of the funding.

Access to clean cooking (2000 – 2018) and target 2030

In Sub-Saharan Africa, the number of people leaving without access to clean cooking is still increasing significantly – no other region in the world are experiencing the same trend. Almost 500 000 premature deaths per year are related to household air pollution from the lack of access to clean cooking facilities, with women and children being the most affected. Lack of access to clean fuels is also one of the most significant contributors in low-income countries to women's workloads, and poses a barrier to the economic advancement of women. It leads to women collecting and carrying loads of wood that weigh as much as 25-50 kilogrammes, which can also damage their health (UNEP, 2017).

West Africa has made the fastest progress since 2010, with almost 3 million people gaining access each year, followed by East Africa with nearly 1.5 million people per year.

Map 2: Population without access to clean cooking in Africa, 2018



Source: IEA analysis; World Health Organization (WHO) Household Energy Database.

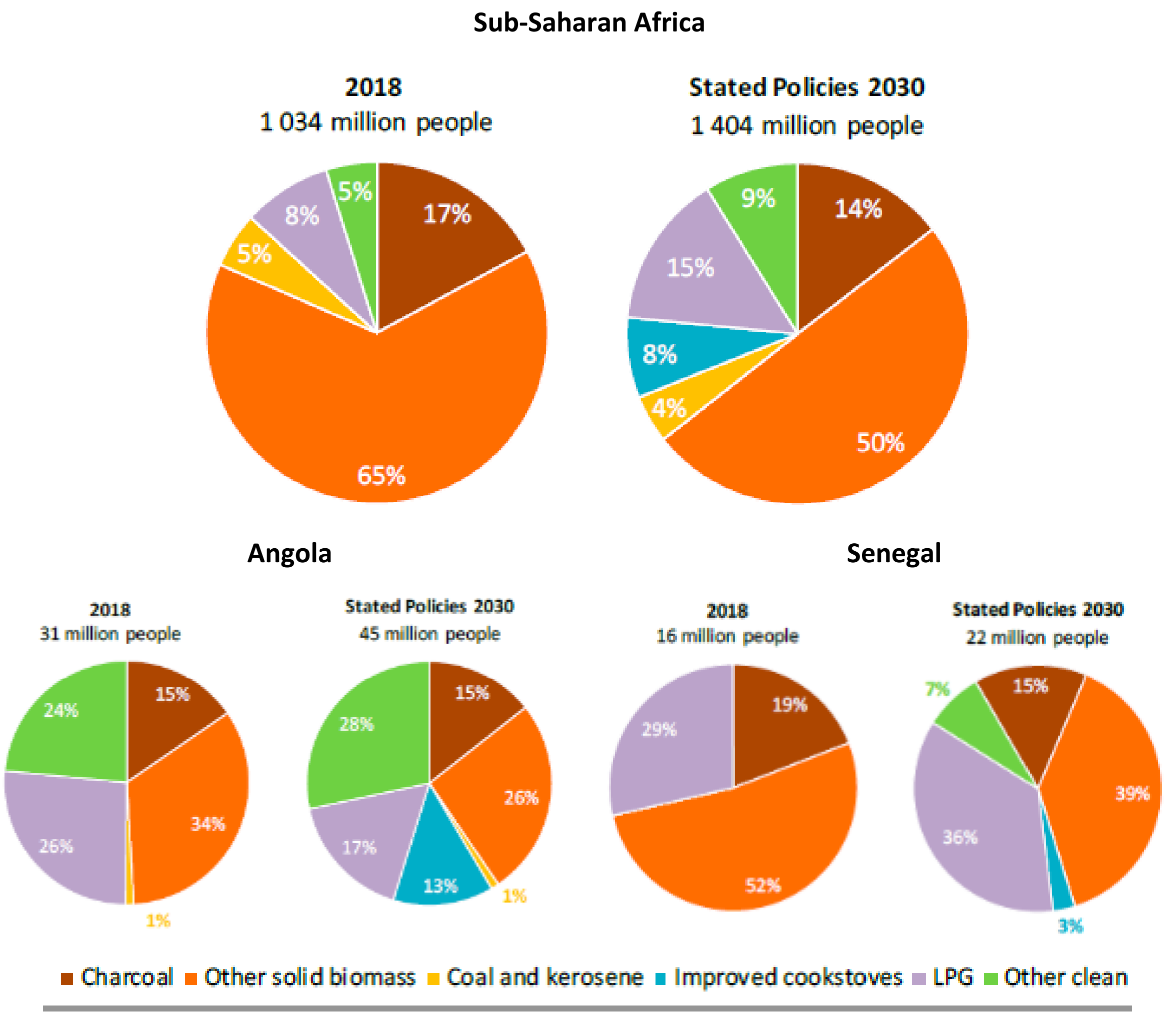
Table 12: Benchmark of population with access to clean cooking (%)

	Clean cooking access rate (%)		
	2000	**2018**	***2030***
Angola	37%	50%	*58%*
DRC	3%	3%	*4%*
Ivory Coast	18%	30%	*59%*
Ethiopia	1%	7%	*34%*
Ghana	6%	25%	*58%*
Kenya	3%	15%	*46%*
Mozambique	4%	6%	*11%*
Nigeria	1%	10%	*28%*
Senegal	32%	30%	*47%*

South Africa	56%	87%	*90%*
Tanzania	2%	6%	*46%*
Sub-Saharan Africa	**6%**	**13%**	***31%***

Source: IEA (2019), Africa Energy Outlook

Figure 10: Benchmark of fuels & technologies used for cooking



Source: IEA (2019), Africa Energy Outlook

Beside its high electrification access rate, Senegal has a singular situation regarding the fuels and technologies used for cooking. Liquefied petroleum gas (LPG) was already used for cooking by 29% of the population in 2018 one of the highest shares in sub-Saharan Africa which has an average of 8% only.

Even more, Angola has among the highest shares of access to clean cooking in sub-Saharan Africa (50% estimated in 2018), thanks to government policies supporting LPG and natural gas. A further push on access policies adapted to rural conditions could help provide clean cooking to 90% of people in rural areas through improved biomass cookstoves.

In the Stated Policies Scenario of Sub-Saharan Africa, more people will gain access to clean fuels and technologies for cooking by 2030, but 68% of the population still lacks access. As a solution to bridge the gap and achieve full access to clean cooking for all, the model of Senegal and Angola could be taken: LPG is seen by IEA as the most scalable solution for urban settlements, with improved biomass cookstoves doing the most to provide access in rural areas.

Recap of the gaps of national strategies taken into account international experience

- **Identified gaps to increase the number of connections in rural electrification:**
  - Logistical barriers and restrictions imposed on dwelling types,
  - High investment costs for end-user's connection,
  - Lack of end-user's access to appropriate financing for connection charges and internal wiring,
  - Lack of political commitment, national priorities
  - Obstacles for private sector involvement: unclear regulatory framework, administrative complexity,
  - Lack of technical and financial capacities from the local private sector,
  - Lack of road infrastructures (e.g., in DRC, Liberia, Madagascar)
  - Lack of technical and financial capacities of the utility in charge of rural electrification (e.g. wasteful practices consisting in oversizing the lines, lack of proper optimized planning process)
- **Four critical gaps must be addressed to foster a self-sustaining environment for investment:**
  - Increased financial performance of utilities,
  - Efficient procurement frameworks,
  - Sustainable business models for the decentralised sector,
  - Availability of long-term finance.
- **Four specific requirements to build an efficient strategy**
  - Accurate load forecast with comprehensive consumption patterns and evolution scenario,
  - Updated GIS database with information on housing, population, public services (health and education facilities) and infrastructures,
  - Economic and financial analysis related to the capacity to pay and true cost of implementation of the strategy.
  - System load flow analysis to verify the resulting network or scenario, voltage profiles and system losses within acceptable ranges.
- **Strategies used to address these gaps in mini-grids deployment:**
  - Strengthening policies and regulations have helped to promote investment and increase private sector participation in the mini-grid sector,
  - The ownership model for mini-grid which is seen as the most promising instrument for electrification scale-up is the PPP,
- **And in Stand-alone systems by using Pay-as-you-go (PAYG) sectors:**
  - Over the last years, access through stand-alone systems has impressively raised in sub-Saharan Africa, especially in East African countries. Almost five million people have gained access to electricity through solar home systems in sub-Saharan Africa in 2018. The pay-as-you-go (PAYG) method is most common approach, where private companies

sell solar services or solar products through a pre-paid model (in small instalments) to persons that can afford these services and become potential or actual customers. PAYGO is a pioneering, game-changing digital credit system that removes the initial financial barrier to solar energy access by allowing consumers to make a series of modest payments to purchase a week's worth of solar energy rather than paying upfront for the entire solar lighting system.

6 Strategy for the incorporation of productive uses into the NES

6.1 Demand for productive use

Most of the stakeholders (NGO, governments, DPs, TSPs) have been considering **income-generating activities** (IGAs) or **productive uses of Electricity** (PUEs), for two reasons:

- To improve the **quality of life**, by supporting the economic & social development of the electrified areas,
- To increase the **economic rationale** of infrastructure investments, by promoting the use of energy and strengthening the sustainability of electrification programmes, i.e. to maximise the benefits for operators and customers (win-win).

Lessons learnt from many rural electrification programmes such as the ambitious PERG programme in Morocco or the on-going on-grid Compact funded by MCC in Senegal show that the installation of electrification infrastructures should be designed along with accompanying measures to maximize the number of connections and support PUE activities. Indeed, the availability of electricity is most of the time a necessary but often not sufficient condition for socio-economic development. Based on Umeme data, we see that most rural connections are low consumption connections: it takes over 4 years for a rural customers' consumption to grow from 50Wh to 200 kWh per year. However, this phenomenon has been found contrary with other small suppliers like KRECS, indicating that with the introduction of active Service Providers, this disadvantage can easily be overcome. Productive Use of Electricity is determined by the result of increased demand of electricity and economic growth in the electrified area.

The Uganda Investment Authority (UIA) recorded about 4,400 SMEs profiles in its database[9]. The SMEs cut across various key sectors: infrastructural development like transport, services, industries, agriculture, fishing, agro-processing, natural resource extraction, tourism, real estate development, ICT, social services and commercial loans. Due to the absence of electricity, many of these economic activities such as hairdressing or sewing move to the nearest electrified settlement, where they can grow by taking advantage of evening lighting and the possibility of using motorized machines and welding/heating facilities. The non-electrified villages struggle to retain their work force (especially the young people) for lack of local economic and recreative opportunities. However, the introduction of PUE to these non-electrified localities will have a significant impact on agricultural activities, which will contribute to Uganda's food security and enable them to obtain the missing opportunities that would have driven them to the electrified areas.

The approach and business models to address the PUE market depends on the type of electrification: on-grid connections, mini-grid and stand-alone systems. Off-grid solutions are most of the time

[9] Uganda Development Authority: Annual Abstract FY 2018/2019

proposed by private operators and must fit with customers profiles taking into account an affordable tariff, power availability in particular for energy intensive engines, scalability, etc.

There are two main categories of IGAs: the existing ones and those to be set up.

Already existing IGAs:

1. A potential of **conversion to electricity by substitution** of other energy sources: this is particularly the case for the replacement of diesel gensets by electric pumps in irrigation or drinking water systems, or the replacement of a thermal engine of a rice husking machine by an electric motor;

2. A potential for **modernization**, through the mechanization of a production process and the introduction of electrical machinery: this is particularly the case of the transition from a traditional oil factory to a modern oil factory, or the introduction of an electric crusher to replace a manual unit[10]. The use of the refrigerator is still rare for commercial activities such as fish shops or snack bars. Usually, these activities use cool boxes with ice got from the nearest electrified localities. We can also mention the electric motorization of sewing machines, the equipment of hairdressers, etc.

Experience shows that these conversions or potential upgrades are not automatic with the arrival of electricity, because of the additional costs of electrical equipment purchase, and the lack of information, training, awareness of the new applications of PUE. Conversely, as experienced in the REA – NORAD funded projects (e.g. Mubende- Kyenjojo), awareness campaigns resulted in significant impact in PUE.

IGAs to create:

The potential for **innovation** can be for "traditional" activities (particularly for the processing of agricultural products), and for innovative activities that would result from the valorization of the economic development potentialities in each region (fish canning factory, fruits drying units, etc.). This potential for innovation also integrates the opportunities for relocation of certain economic activities from the city to the countryside (crafts for building construction, welding shop, etc.). This phenomenon can be observed in almost all rural contexts with the arrival of electricity.

The standardized energy usages for PUE can be characterized as follows:

[10] Such systems in Uganda are very few. The majority of the population are in expectation of being electrified. The electrification policy is in place since 1990, however due to lack of funds the implementation has delayed.

Targeted sub-sectors	Typical application & equipment
Agro-processing	Power packages for lighting & motors(*) needs thermal solutions for heating, cooking, steaming & drying processes, coffee processing, cotton ginning, etc.
Conservation	Storage room for vegetables, fish, meat, milk, … (cooling, chilling, freezing)
Eco-tourism	Power for lighting, refrigeration, air-conditioning, telecom & ICT, entertainments, tools, etc.
Irrigation	Power for irrigation and water supply systems & canals.
Other micro-scale businesses	Bakery, dairy, poultry, snacks, drinks, ice cream, …

(*) Common motors: mills, grinders, shredders, fans, oil press, compressor, carpentry tools, …

The accompanying measures necessary to maximize the socio-economic impacts of rural electrification (conversion, modernization and innovation) required appropriate investigations to each context, dedicated surveys, identification and sensitization campaigns, and follow-up. These studies include power demand assessment for potential SMEs (daily load curve, consumption as against incomes profiles, etc.) in order to define the least-cost options in off-grid areas. Note that pure solar might not be the best solution (cost wise) for some energy intensive applications (such as cooling or motors). Hybrid models are often recommended.

Due to lack of awareness in rural areas, the demand is not much driven by the final beneficiaries. The main channel of developing IGA projects is through join efforts between government, NGOs and sometimes TSPs. Local banks and MFIs may also be the relay to identify potential businesses/customers for productive power: e.g. most of the MFIs have many farmers among their customers and have developed specific loans for seeds, tools and irrigation. But market studies are lacking to promote on-grid and off-grid productive power for agri-businesses.

Gender issues

Currently the cost of electricity accentuates discrimination between economic operator’s women and men. Because of the limited financial capacity of women compared to men, this seriously affects the activities of women who mainly deal with food processing, conservation and marketing activities, often dependent on electric power availability. Consequently, the lack of access to modern energy sources is perceived as a major handicap to the development of women’s activities, which are usually concentrated in catering and in commerce.

6.2 PUE in the agricultural sector

In Uganda, agricultural based value chain provides about 70% of employment. The Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) Agriculture Sector Strategic Plan (ASSP) identifies 12 strategic commodities in 10 agricultural zones. Whereas the agriculture sector of the Ugandan economy provides 70% employment of the population, the growth of its production and productivity remains low. Between 2010 and 2014, the agriculture growth rose by only 2.2% lower than the average annual GDP of 5.2% and the target of 6% set by the MAAIF.

The study entitled *"Productive Uses of Electricity Program Initiative, 2018 – REA/NRECA"* and summarized above in the section 5.1 provides insightful analysis of PUE prospects in the agricultural sector. The NRECA/REA study focuses on 8 value chains that include maize, fruit, fish, poultry, vegetables, dairy, coffee and cassava in order to evaluate the impact of productive use of electricity on economic growth and improved livelihoods of the communities.

The REA Masterplan 2018 was developed towards intensification of electricity connection in the established 13 Service Territories to benefit less populated rural areas. The masterplan was developed within a GIS framework that can accommodate the agricultural production and productive use data for use in productive use initiatives. The GoU has established Zonal Agricultural Research and Development Institutes (ZARDI) in nine zones that include Mbarara, Mukono, Kachwekano, Buginyanya, Bulindi, Rwenbitaba, Lake Regions, Ngetta, Nabuin, Serere, and Abia. The initiative integrates data from ZARDI zones into geospatial platform of the 13 Service Territories to evaluate the areas where farmers can realise optimal productive use investments. The REA/NRECA study has carried out a detailed analysis of eight value chain business cases in agriculture sector. The business case analysis illustrates how the entrepreneurs can realise benefits from PUE by evaluating equipment, costs and benefits. The table below is a summary of examples of eight-value chain business cases.

Table 12 : Examples of Agricultural Value Chain Business Cases

Business Case	**Equipment**	**Cost (UGX)**	**Benefits over 5 years period**
Maize Flour	1x17kw Maize Mill Production: 400kg/hr	4,440,000	Loan repayments for a UGX 56,204,000 loan with a 48-month tenor and interest rate of 11%. Annual net profit reaching only UGX 25,915,260
	2x7.5kw Maize Huller Production: 400kg/hr	11,100,000	
Dairy Yoghurt	Pump: 0.6kw	851,000	Loan repayments for a UGX 53,280,000 loan with a 60-month term and an interest rate of 11%. Annual net profit of UGX 8,567,099
	Pasteuriser 13kw	1,702,000	
	Fermentation Cabinet 1.6kw	2,978,500	
	Refrigerator 0.2kw	1,850,000	
Irrigated Coffee and Huller	Pump	2,501,200	Loan repayments for a UGX 26,640,000 loan with a 36-month repayment term and interest rate of 11%. Profit margin of 61% is achieved in year 5, representing an annual net profit of UGX 17,837,795
	Huller	8,003,100	
Poultry Layers	Pump 0.55kw	851,000	Loan repayments for a UGX 38,480,000 with a 36-month term and interest rate of 11%. Profit margin of 22% is achieved in
	Infrared Lamp 0.18kw	407,000	
	Florescent Light 0.09kw	127,650	

	Temperature Control Unit 1.10kw	978,650	year 5, representing an annual net profit of UGX 18,974,220
Cassava Flour	Cassava Peeler/Grater 7.5Kw	3,500,200	Loan repayments for a UGX 44,400,000 with a 36-month term and interest rate of 11%. The net profit margin of 16% by year 5 shows this business case to yield a reasonable profit reaching only UGX 66,442,1455
	Hammer Mill 3.0Kw	6,660,000	
	Flash Drier 60KW	296,000,000	
Fish Processing	Ice Maker 7.5kw	18,500,000	Loan repayments for a UGX 22,200,000 with a 36-month term and interest rate of 11%. A net profit margin of 1.38% is achieved in years 4 and 5, representing an annual net profit of UGX 71,661,654
	Chiller 770kw	18,500,000	
Fruit Juice	Pulper, Pasteuriser, Mixing Tank, Homogenizer, Bottling Machine, Cooling Tank, Refrigerator, Pump, Capping Machine	67,235,699	Loan repayments for a UGX 133, 200,000 with a 24-month term and interest rate of 11%. A net profit margin of 36% is achieved in year 5, representing an annual net profit of UGX 242,727,511
Irrigated Vegetables and Chilled Storage	Pump 1.5kw	2,501,200	Loan repayments for a UGX 14,800,000 with a 24-month term and interest rate of 11%. A net profit margin of 42% is achieved in years 3 through 5, representing an annual net profit of UGX 18,671,164
	Chiller 3kw	18,500,000	

6.3 PUE in the industrial sector

In the table below, we identified the main PUE potentials in the industrial sector with recommendations for strategy implementation:

Table 13 : PUE Potential in the industrial sector

Sector	Justification	Recommendation
Minerals	Uganda is endowed with favourable geological environments that host a wide range and variety of mineral deposits. Some minerals required in electrifying transport like nickel & sand are abundant. However, mineral ores have been largely exported unprocessed depriving the country of employment and revenue. Mining operations run by individuals, families or groups of	There is need for a strategy that governs mineral processing and beneficiation. Instead of selling raw material, the minerals can be processed locally and also obtain overseas market. MEMD could incorporate this proposal in

	local communities & enterprises or migrant workers, the majority of whom have no formal technical training and depend on rudimentary tools.	Mining and Mineral Policy For Uganda.
Construction	Uganda has many rocky hills which can be used as construction materials. Currently people are crushing the stones with hands and hammer and then sale the stones. These stones are used for making concrete, road tarmac, soak aware pits, etc. However, rudimentary methods used to mine these stones have consequences eventually causing ill health.	Promote the different ways of extracting this material and incorporate electricity in their processes. Then, organize awareness campaigns on PUE opportunities.
Tourism	Uganda is blessed with a wide diversity of landscapes, abundant wildlife and many national parks.	Dedicated programmes especially with renewables energies to electrify tourist spots and its surrounding population.
Transport	Uganda is reviewing its transport policy and soon the train from Kenya is to be renovated and electrified and the same time by 2023, 16 cities will need to review their transportation within the cities. Some ports on Lake Victoria are under construction, other will be renovated. Trains and Lorries will pick the cargo from these ports.	Promotion of electric trains, trams and buses (e.g. hydrogen storage from solar panels).
Oil And Gas	Uganda has signed an agreement with Tanzania and major development companies to develop the oil infrastructure in Hoima near the industrial park of Bulisa, so extending supply to all booster pumping stations along the pipe line within Uganda and Tanzania is necessary.	What is missing is the distribution lines to Bulisa incorporating the oil and gas wells and to plan supply to booster stations along the pipeline.
Cosmetics	The cosmetic industry has registered tremendous growth in the last three decades characterized by aggressive marketing, factory expansions, increased importation and exportation.	Organize awareness campaigns on PUE opportunities (e.g., hair salons).
Light manufacture s	The Uganda manufacturing sector is dominated by agro-processing, food/beverages, household products, construction materials and fast-moving consumer goods. In Namanve industrial park, light industries have started.	Explore how to increase the growth rate of these industries.

6.4 PV for productive use: existing & new solar technologies

To supply power for income generating activities, there are basically 2 technology options:

- to provide **stand-alone power system** like solar kits for small productive appliances, solar pumps for irrigation, or larger hybrid systems for multipurpose activity;
- to interconnect productive equipment to a **RE-based mini-grid**, as commercial customers.

In this section, we consider only the first option with stand-alone systems. Except for water pumping, all other PU applications need energy storage if using RE sources. The 2 table below provide examples of solar PV solutions for common tasks in rural villages:

Table 14 : examples of solar PV solutions, power range and technology availability

Type of service (task)	Technology solutions	Typical power range	Efficient equipment	Technology availability
Refrigerator + freezer	Cold Kit (Level 1)	< 0.5 kW AC	Refrigerator A++	High
Freezer	Cold Kit (Level 2)	< 0.5 kW DC/AC	Freezer A++	High
Mill	Milling Kit (Level 1) Milling Kit (Level 2)	1 kW AC 2 – 4 kW AC	Mill, grinder	Low (not mature)
Domestic pumping	Pumping Kit (Level 1) Pumping Kit (Level 2)	0,5 kW AC 1 kW AC	Pump	Medium
Irrigation pump (0.5 – 1.5 ha)	Pumping Kit (Level 2) Pumping Kit (Level 3)	1 kW AC 2 – 4 kW AC	Pump	High
Carpenter, Car mechanic, …	Motor Kit (Level 1) Motor Kit (Level 2)	1 kW AC 2 – 4 kW AC	Motor	Medium
Hairdresser	Lighting Kit & small appliances	0.5-2 kW AC	Hair dryer, clippers	High
Dressmaker	Lighting Kit & small appliances	< 0.5 kW AC 2 kW AC	Sewing machine, iron	High
Restaurateur	Lighting Kit & AV/ fan	0.5 kW DC/AC	TV/fan	High
Shop	Lighting Kit & AV/ fan	0.5 kW DC/AC	TV/ fan	High
VDO cinema	Lighting Kit & AV/ fan	0.5 kW DC/AC	TV/ fan	High
MFI counter	Lighting Kit & PC/ fan	0.5 kW DC/AC	Computer	High

Need category	Solar Technology solution	Size/capacity	Services /performances	Cost (CAPEX)
Agroprocessing *(1-10kWp)*	Solar grind mill	**1500Wp**-24V (no battery)	Grind Stone Mill (500mm) with 1HP motor (3ph) → >25kg/hr (fine coarse, millet)	$4600 (exw[11])
		**10kWp** (no battery)	Grind Stone Mill (600mm) with 10HP/7,5kW motor (3ph) → >180kg/h (fine, maize) or 1ton/day	$17.600 (exw)
		750Wp + battery	Hammer mill with 1,6HP motor (24VDC) → 40kg/hr fine, 80kg coarse for 3h/d → 180kg/d	~3000$ (exw)
Preservation *(5-20kWp)*	Solar cold storage	**4kWp** + battery	20' container (33m^3); 1,8 ton; Refrigerator -18°to +13° (or Freezer -25°C to +4°C); Class A	$20.700 (5,2/Wp)
	Solar Chiller	**20kWp** (3ph) + battery 108kWh	40' container (~60m^3); 6-8 tons; Chiller (5° to 25°C; 65%-95% RH) → 15-20 days' storage! Consumption 35-60kWh/day → PBP: 9-10yrs	$34.000 ($1,8/Wp)
Irrigation *(4-20kWp)*	Solar water pumping	**4,5kWp** (no battery)	80m3/day @ 15m (TMH) → 1ha & 2 cropping seasons	$13.600 ($3/Wp)
Eco-lodge / tourism *(5-20kWp)*	Stand-alone solar generator	**2,4kWp** + 2kW wind + 24kWh batt	Kitchen, restaurant, office, reception, service area. (+Separate solar water heater: 80L/guest & 120Wp/2,4Wh/AC power system/guest)	*$15.000?* *($6/Wp)*
	Solar/diesel hybrid micro-grid	**50kWp** + batt +genset	Laundry, swimming pool, kitchen, business center, lighting, cooling, etc. >20.000$ annual savings and PBT ~5yrs	*100,000$* *($3Wp)*

The table below indicates a few assumptions of typical consumption levels and peak power of some of the rural community services and economic activities:

[11] Ex works

Figure 11: a few assumptions of typical consumption levels and peak power of some of the rural community services and economic activities

Activities	Monthly consumption (kWh)	Daily peak power (W)
Mills	365	2,000
Snack bars	55	150
Various shops	4	20
craft	23	50
Fish shop	256	350
Places of worship	4	20
Secondary school	437	2,100
Primary school	217	1,050
Full health center	393	2,800
Maternity ward	293	2,100
Dispensary	189	1,345

The **usual price for a system of a few kWp installed** is of the order of $2,400/kWp. Some solar solutions developed for rural activities in Benin are described hereafter:

1) Solar lighting kits and solar audiovisual kits

Most all solar suppliers in Uganda can provide such small solar systems for small businesses as shops, restaurants, …

2) Solar refrigerators

The demand for **refrigeration** (0 ° to 5 ° C) for food preservation and production of fresh produce is very important in many Ugandan villages. A standard fridge type A ++ (AC) can be offered with a solar installation and good inverter & battery. High efficiency DC solar refrigerators exist but are more expensive.

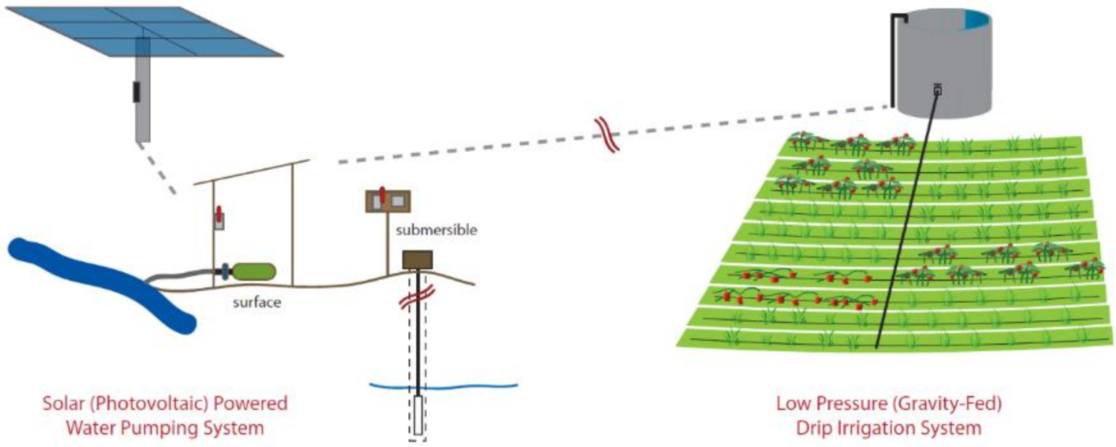
The demand for **freezing** (-18 ° C) for ice cream making and conservation is also common in rural areas, in particular for women business. Like for refrigeration, both DC and AC solutions exist but energy requirement is higher.

3) Solar pumps

The pumping requirements are high (many diesel pumps in some areas), the necessary equipment is well defined, solar technology suppliers and competent technicians exist for both small domestic water supply to larger irrigation pumps. One of the main advantages of solar pumping used for irrigation is that it does not require batteries.

Different initiatives of solar pumping applications for market gardening application are found in Uganda. One of the most recommended solutions is the drip irrigation as presented in the diagram below. This technique uses less water and provides higher yields especially during the dry season.

Figure 12: diagram of combination of drip irrigation with solar pumping



Planting (panels in background)

Dry season lettuce harvest

First market sales

Solar Market Gardens – Cost of $20,000 (excl. borehole) – payback time: 3 years

However, the **market of PV Pumping is mainly subsidized because of the very high upfront costs compared to motopumps**. The indicative cost of a solar pumping system at 60 meters depth for the irrigation of a ½ hectare of market gardening is $9,000 ($18,000 with accessories included). The initial investment of a solar pumping system is therefore heavy and in principle requires external financial support. In Uganda, the potential market for solar pumping are mainly small farms. The purchase of equipment could be promoted via groups of farmers.

However, once the barrier of the investment cost is overcome and providing that the system is properly designed, solar pumping can be more competitive than motopump as illustrated in the economic analysis below. The unit water costs are estimated for comparison: solar irrigation pumping costs c$6.7/m3 whereas gasoline irrigation motopump costs c$10/m3.

Figure 13: Cost Benefit Analysis between solar irrigation pump and gasoline motopump

Assumptions

Irrigation system for 1 hectare of 2 cropping seasons		
Type	Sprinkler system with Motpump	
Irrigated area	1	ha
Number of crroping seasons	2	per
Duration of each cropping season	120	days
Crops	Horticultural (ex. Potatoes and Carrotes)	

Irrigation needs		
Daily Water needs	80	m3/day
Yearly water need	19 200	m3/year

Gazoline Irrigation Motopump		
Motopump		
Type	Gazoline Centrifugal pump	
Discharge	50	m3/h
Power	3,7	Kw/hour
Life span	3	years
Price of pump	1 349	$

Pump Operation cost		
Gazoline need per hour	3	l/h
Gazoline need per day	4,8	liter/day
Gazoline need per year	1152	liter per year
Gazoline unt cost	90	c$/liter
Yearly Gazoline cost	1 036	$/year

Pump maintenance cost		
Pump oil cost	162	$ per year
Reparations cost	270	$ per year

Pump investment amortization		
Life span	3	years
Annual amortization	450	per year
cost (amortization+O&M)	**1 917**	**$/year**

Solar system: water cost including amortization and O&M		
Unit water cost	**0,10**	$/m3

Qualitative benefits & limits
- low investment cost
- high energy availability (>6000h)
- High flexibility (run-on-demand and movable!)
- Cost-effective if irregular or seasonal demand
- high demand level (suitable > 1500m4/day)
Limits:
- daily manual starts (& checks)
- high running cost
- fuel supply constraint
- High maintenance costs and issue of skilled staff
- spare parts quality in the context of developing countries
- environmental impacts
- skilled staff for O&M
- corrosion at steel riser pipes
...

Solar Irrigation pump		
Electrical pump		
Type	Electrical pump for solar system	
Discharge capacity	25	m3/h
Power	3,5	Kw
Life span	8	years
Price of pump	5 036	$

Solar panels		
Panel capacity	250	Wp
Life span	20	years
Number of panels	18	
Cost per panel	360	$/panel
Cost of 18 panels	6 475	$/year

Installation cost including equipments		
Installation cost	2 158	$
KW investment cost	4	$/Wp

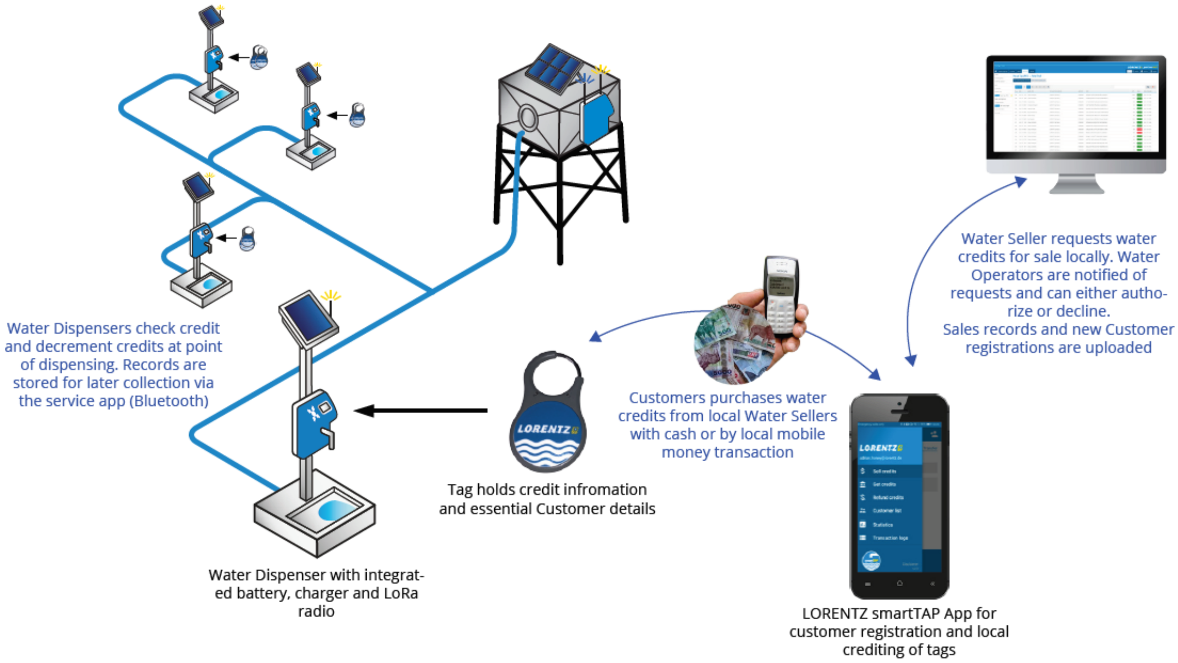
System investment amortization		
Panels system amortization	432	$/year
Pump amortization	629	$/year
Yearly Maintenance cost	230	$/year
Yearly Solar pump cost (amortization+O&M)	**1 291**	**$/year**

Gazoline system: water cost including amortization and O&M		
Unit water cost	**0,07**	$/m3

Qualitative benefits & limits
- starts automatically
- low operating cost
- scalable up to max 6kWp
- limited areas: 1 kWp ≈ 15 m²
- low skill staff, low maintenance
- independence / grid
- building up of institutional framework and capacity to deal with investors/ MFIs
- no environmental impacts (noise, smoke)
- local jobs creation
Limits:
- high investment cost
- low energy availability
- limited hydraulic load (2000 m4/d)
- low flexibility (<2000h) if solar only; best with genset for backup
- need proper sizing & resource assessment
- seasonal variation
- cost effective only if full use of solar water production
- risk of theft
- sophisticated techno ⍰ specialized service skills
- hybrid increases complexity

Following the existing case in Kenya, some suppliers are seeking financing and submit proposals to introduce the PAYG model in the water sector: “pay at tap” or “pay as you consume” model applied for public water points as illustrated in the diagram below:

Figure 14: Diagram of "Pay as you consume" model applied in the water sector



4) Grind mills

In Uganda, many villages are equipped with mills fed mostly by diesel engines (+ belt) or sometimes by electric motors (powered either by the grid or by fuel genset). The substitution of these thermal sources by solar energy is not trivial. Despite a lot of efforts from different local and international actors, there does not appear to be efficient and economically profitable solar mills on the market that are ready to meet the needs of these rural communities. The research follows two ways: (i) mills of relatively low capacity (with battery) targeting rather a community use such as group of women, and (ii) larger mills (without battery), close to mill performance conventional thermal devices, which can ensure a lucrative activity.

For comparison:

- a solar mill without battery developed by OMEGA Technologie: 1 kWp of PV + DC motor 0.5-0.7 kW with direct drive (3000rpm) can produce 15-25kg/h and may cost ~ $6,300. Adaptations include reduction of frictions, improvement of hammers, adjusting the flow rate, jam protection, etc.
- a conventional grind mill with a 6kW diesel engine can produce 200-300kg/hour (mill, corn).

5) Multifunctional Platforms (PTMF) & Solar kiosks

The multifunctional platforms offer a **set of services at one place**, powered by the same "production plant". Further surveys are needed to see if this formula including sometimes several businesses under the same roof (for example a battery charger, a miller, a shopkeeper) is acceptable for local entrepreneurs as it requires to move their activity. These types of projects require high level of external financial and technical supports. PTMF projects sound promising, but no market study with lessons learnt exists to confirm the actual demand, feasibility and success of such initiatives.

A **solar kiosk** usually offers less productive services than PTMF and more public services as community TV, computer, internet, phone & lantern recharge station, refrigeration, etc.

6.5 Banks and Financial Institutions engaged in PUE

Uganda is well endowed with financial institutions engaged in supporting economic activities. The main institutions in Uganda that offer credit to entrepreneurs, in particular in agribusiness are categorized under three categories:

- Banks-Centenary Bank, DFCU, Post Bank, UDBL
- Savings and Credit Cooperative Societies (SACCOs) e.g. Kyamuhunga Peoples Sacco
- Innovative Agricultural Financial Products-AHL Ventures, AgDevCo, Africa Rivers Bank, Pearl Capital Partners, AECF and Voxtra

The table below summarises characteristics of the main institutions active in Uganda and the credit facilities offered to support the productive use initiatives. This summery provides also an overview of financial products offered by the institutions, interest rates and required collateral.

Table 15 : Characteristics of banks, SACCOs and social impact funds

Financial Institution	**Loan Period** in years (Short – Long term)	Loan Amount	Interest Rate (%)	Credit/Equity Requirements
Centenary Bank	2 – 5	Various	25-42%	Account, Collateral, Cash flow projects, Business experience of 2 years
DFCU	N/A – 4	Various	18-24%	Bank Account, 2 seasons experience, Collateral, Resolution to borrow for coops/ groups
Post Bank	1 – 5	Various	22-23%	Bank Account, 2 seasons experience, Collateral, Cash flow projections
UDBL	1/1.5 – 5	Min 100 Million UGX	11-16%	Application, Business plan, Audited accounts, Tax clearance certificate
SACCOs	1Day – 2y	50,000 UGX	24-30%	Account, Application, Savings account for at least 3 months, Commitment fees 2% of Loan, Collateral Securities
AHL ventures	N/A	Min $500,000	Require acceptable ROI (below commercia l)	Business plan, Cash flow projections, Audited financials
AgDevCo	NA	$1 – 10 million	NA	Business Plan and financials
Africa Rivers Fund	N/A – 5/10y	N/A	Acceptable ROI	Track record, Business plans and financials, Experience in the sector

Pearl Capital Partners	N/A		Target ROI of 15%	Supporting businesses with significant social impact lower than market-leading
African Enterprise Challenge Fund (AECF)	N/A – 3/5y	Range from $300k- 1.5 million	ROIs below commercial	Track record, Audited financials, Business Plan
Voxtra	N/A – 3/7 y		Where a credible exit strategy exists	Invest in companies whose success is tightly linked to improving the livelihoods of smallholder farmers.

6.6 Gaps and constraints for PUE

The main gaps and constraints for PUE promotion in Uganda are listed below:

- Difficult credit access by entrepreneurs:
    - Very high interest rates (>25%) resulting in reduced profits
    - Limited grace periods making it difficult to manage cash flows during the early months of inception.
    - Lack of the required 2 years minimum seasons in agriculture sector. This also discourages young entrepreneurs willing to venture in productive use agribusinesses.
    - Lack of the mandatory collateral e.g. land, savings, personal guarantees, household property etc.
    - Weakness in developing business plans and cash flow projections
    - High loan application fees due to absence of banking facilities in the rural areas.
    - Low awareness levels among small-scale entrepreneurs on leasing facilities for machines and equipment offered by financial institutions. Under this arrangement, the client is required to contribute about 30% of the cost of equipment and the lender pays the balance.
- Low end user affordability.
- Suboptimal product-market fit and absence of appropriate machinery locally which is often inefficient and of poor quality, while maintenance cost of imported machinery is high.
- Limited consumer awareness & data on opportunities.
- Lack of specific policies that provide incentives for investment into the sector

6.7 Recommendations

The mission statement for Uganda Vision 2040 is 'A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 Year". PUE initiatives as embedded in the NES should spur the economic wellbeing of the people of Uganda particularly in the rural areas.

The following recommendations seek to narrow the gaps identified above (access to finance, lack of awareness and capacity, lack of conducive policy towards PUE, etc) and incorporate PUE promotional activities in electrification projects.

- MEMD to adopt cross sector approach and work with other ministries involved and constitute a central inter-ministerial planning unit to coordinate the initiatives and propose promotional actions such as: PUE potential confirmation, specific survey for increased markets (including export markets), sensitization campaigns, capacity building programmes, monitoring and evaluation tools in order to gauge the progress of all initiatives and design corrective measures.
- MEMD to ensure that any rural electrification projects take into consideration the PUE factor at design stage: financing of the PUE is to be determined alongside the conventional electrification process.
- Focus on PUE with regard to grid extension, densification and intensification: a successful electricity access project should target direct impact on livelihoods and economic growth of the target community. With this regard, REA should envisage delivery of a rural electrification project whose activities go beyond the energy meter. All upcoming rural electrification projects should take into consideration the PUE factor at design stage. Financing of the PUE is to be determined alongside the conventional electrification process.
- PUE promotional activities should be tailored in the ground based on existing PUE potential starting in the areas with the highest potential of socio-economic development. This is based on the ranking of development poles as described in the section 11.2 and the list of villages presented in Annexes.
- Private operators of off-grid solutions require concessional capital to support R&D, field pilots, consumer research, scalable business models adapted to seasonal income of different customer segments and strategic pivots to address challenges. Grants tied to measurable objectives can de-risk the sector and pave the way for commercial investors.
- In case of off-grid facilities, priorities should be given to projects which include socio-economic development activities, including gender equality, promotion of PUE, environmental preservation and solar battery recycling, etc.
- Establish and promote linkages between productive users, financiers (microfinance institutions, banks, Capital Development Funds), Development Partners, training centres, and electrical appliances suppliers and repairers (for example cold rooms, high power irrigation pumps).
- Increased access to electricity goes along with education to communities on productive options and access to financial services. The PUE initiatives should call for a concerted effort by the government agencies and all stakeholders. For example, REA could shoulder the creation of demo sites at the district level and provide consumer education on the benefits of utilizing PUE appliances in agriculture and how to efficiently operate and maintain the systems.

- Governments and development partners can also begin looking at quality assurance frameworks for appliances (e.g., through standardized certification), given that markets for appliances such as solar water pumps and small-scale refrigeration units are still flooded by sub-standard products.
- Run pilots and incentive programs to encourage innovation for high-potential industries identified such as coffee, nuts & oil seeds.
- Sharing experience and best practices. On the political and institutional level, it is very positive to note the increasing intercontinental cooperation through programmes such as the AEEP and the Africa-EU Renewable Energy Cooperation Programme (RECP). On the industry level, established associations such as ARE with their networks can support Ugandan initiatives, partnership approach between small(er) and big(ger) companies can result in new business opportunities.
- Lessons learnt show that the productive take-up of electricity should not be encouraged by all means. The reason is that it is not clear from the outset that a grid connection or switching to electric machinery is beneficial for the enterprise. Rather, the capacity to take reasonable decisions has to be strengthened at the level of the individual firm. Promotion activities could, for example, assist entrepreneurs in the drawing up of a firm-specific business plan that includes a thorough assessment of possible gains from connecting. The plan should then serve entrepreneurs as a basis for the decision whether to invest in electric appliances.
- Formation of a multispectral energy committee[12] is key in implementation of a successful PUE initiative. At the national level, the committee should be composed of representatives of key ministries domiciled in the rural areas (energy, industry, finance, education, health, agriculture and fisheries) and other stakeholders from local government, micro-finance, UEDCL, business lobby groups and NGOs. The committee, anchored at the MEMD may form sub-committees to address specific sectoral electrification needs at regional levels together with electrical equipment manufacturers and distributors. This approach has been tested and implemented in Senegal with the rural electrification agency, ASER accruing benefits of PUE from such collaboration with sectoral production stakeholders.
- Any electrification programme should include a specific component for PUE promotion, for example, by recruiting a service provider / NGO in charge of all accompanying measures, including administrative support to all connection applications, marketing, sensitization campaigns, market surveys of PUE potentials in targeted areas, etc.
- MEMD in partnership with other GoU ministries should use Uganda Energy Credit Capitalisation Company (UECCC) to manage the finances. REA shall be an implementing agency but not manage finances, since this will complicate the functions of REA. While designing a PUE initiative, REA could then come up with a specific loan facility that is well defined to the specific productive use business profile. Additional capacity building should be enhanced for both rural entrepreneurs and financial institutions This could be an enabler to youth and women involvement in the economic activities. The SPV should focus in establishing the following objectives:

[12] See *'Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs'*, ESMAP 2008

- Reduce transaction costs of borrowing
- Facilitate matching funds to offer medium and long-term credit products.
- Facilitate aggregation of borrowers to establishing loan products designed to meet the needs of specific productive use applications with due diligence pre-evaluated.
- Offer agricultural, fisheries, minerals, construction, tourism, cosmetics, enterprises light industries, etc access to reduced rates to stimulate investments provided it economically viable.

- At times there is a need to provide loan facilities to the SPV to manage electrification in the entire country according to its findings. Also, the loans can be easily accessible to the beneficiaries. For example, in the agriculture sector, the value chains of cassava, maize, vegetables and fruit could be aggregated to Uganda National Farmers Federation, Uganda Investment Authority (UIA) or industries or through financing institutions like urban authorities etc.
- The SPV right from the inception of the rural electrification project i.e., in the baseline study should already publicize/mobilize/educate people the different ways of how to implement the different ways of PUE through carrying out displays, mass media, mobile public address systems and flyers on how electricity will be used depending on the different resources/material and appliances available in that area.
- To initiate awareness campaigns for PUE opportunities in areas where densification and electrification projects are under development. The personnel of SPV should be knowledgeable of the tools, wires, other materials, specifications, and training. The SPV should provide optimum and efficient manpower needed to effect the implementation of the various aspects of PUE.
- GoU and utilities to continuously seek to improve electrification costs and quality in order to ensure abundant, reliable electricity and competitive with the neighbouring countries. This is achieved through technology intelligence, benchmarks, R&D and pilots on electrification technologies, specific studies to promote PUE for example by shifting to 3-phase connection and usages in off-grid areas, improved connection costs for productive users...
- To promote electrification of public institutions and social infrastructures (schools, health centres, water pumping facilities industrial hubs...) through dedicated programmes: off-grid Facilities, PPP arrangements (see also Promotion of off-grid solutions in section 7 below) and specific funds from GoU and Donors for on-grid connections. This calls for archiving and tracking progress of electrification of public infrastructure.

7 Analysis of off-grid business models and options

7.1 Inventory and categorization of existing mini-grids in Uganda

There are 7 distribution companies in Uganda namely, Umeme, UEDCL, KRECS, KIL, WENRECo, KIS and PACMECS. Of these, 6 are connected to the grid while 2 of them, namely WENRECo and KIS are off-grid. Furthermore, there are other small distribution companies, mainly with license exemptions because of size. They include Kisiizi Hospital Company Limited, Absolute Energy Limited, Bwindi Community Micro Hydropower Limited, and Pamoja Energy Limited, among other companies. The performance of these plants is not reported on as they are Licence-Exempted companies with less stringent reporting requirements. These small off-grid distribution companies are recruited by REA. The successful companies work with REA to develop the grids right from the beginning and REA usually subsidizes the companies that take on such areas. These areas are already identified in the REA master plan and they allocated to the operators after a bidding process.

7.2 Characterisation of the business models for investment and operations of MG

Actors and business models

From the most recent rural electrification programs that have been conducted in Asian, Africa and Latin American countries, the experience of 6 countries[13] are proposed here that can provide useful inputs to the NES.

Three main actors play an important role in the start-up of rural electrification projects:

a) Regional Governments: the main interest of regional governments is to increase the economic activities of the rural people by improving their living standard.
b) Local communities: local communities' aim in initiating rural electrification is to get access to modern energy.
c) Private Entities: who are interested in forming a for-profit energy business.

Based on worldwide experience, there are at least five business models to be considered in any rural electrification. These include:

1. Electric cooperatives
2. Community managed model
3. Electric distribution franchise
4. Fee-for-service model
5. Private sector model

All of these models have been tried in some Asian and African countries. Depending upon the prevailing legal, financial, energy policy and implementation strategy of the country concerned, the success rate of these models were different in each of the countries. The principal business models for MG is the government-led rural electrification approach with different supports. In any case, the operator has to go through the legal process: generation and distribution license to be delivered by the regulator, concession agreement, financing agreement with the backer. The salient features of these business models are summarized below.

1. Electric cooperatives

International experience shows that electric cooperatives where the members are the consumers themselves can be effective vehicles to expand the access for electrical energy in rural areas. However, incentives and capacity building activities are necessary for continued project success.

To date existing electric cooperatives being private non-profit organizations, provide electricity services to members either through the extension of the main grid or through the development of an off-grid generation capacity (MG's or Solar Home Systems (SHS)). An electric cooperative can also supply electricity to non-members, this would require a specific separate contract between the two

[13] P R, Krithika & Palit, Debajit. (2013). Participatory Business Models for Off-Grid Electrification. 10.1007/978-1-4471-4673-5_8. (https://www.researchgate.net/publication/261946063_Participatory_Business_Models_for_Off-Grid_Electrification)

parties as it would entail the sale of electricity on a commercial basis. The Electric Cooperative would be required to file for a license.

2. Community Managed Model

A village energy committee is created to manage a MG based project. The role of the committee can vary from simple supervision of the plant and overall monitoring to taking an active role in tasks such as operation, monitoring and oversight. This type of business model was applied in micro-hydro based plants developed in Nepal and Sri Lanka and was successful.

Community managed systems are like Cooperatives. The difference is that, in cooperatives all customers are members.

3. Electric Distribution Franchise

The objective of the Franchise is to distribute electricity within an identified territory for a defined period. Mainly the franchisee develops and /or operates the distribution system. In most cases, the Franchisee off-take from the power utility grid. Generally, Franchisee are of two types.

4- Revenue Franchisee: mainly involved in billing, revenue collection, complaint correction and ensuring the appropriate functioning of the grid network within its designated territory. Franchisee are tasked with the responsibility of providing feedback to the utility company in case of malfunctioning of the network.

b- Input based Franchisee: the Franchisee buys the electricity from the utility and pays the energy charges through collection of revenues from consumers. Often the Franchisee is responsible for operation and maintenance of the transmission and distribution system including transformers.

4. Fee-for-Services model (ESCO)

Two countries have experimented with the Energy Service Company (ESCO) model: Zambia and India.

Zambian ESCO model: The ESCO model was introduced in Zambia with the aim of diffusing solar systems. Initially it was supported by the Swedish International Development (SIDA). The existing ESCO's are subsidiaries of companies who have other business activities in fields such as farm implements, waste management and a farmer's cooperative.

ESCOs are private companies licensed to do business and installation of solar equipment. In the case of Zambia, the government buys solar photovoltaic systems (the initial supply came from SIDA donation), that are on lent to the ESCO, the cost of which is to be paid off in instalments over a period of 20 years.

The ESCOs install the solar equipment in the households and small businesses and charge an installation fee and collect monthly payments for the system. From the collection, a fund is created to replace the batteries. Part of the regular service fee is set aside and deposited in a bank account in order to replace batteries.

At the beginning, most ESCOs started to serve farmers, civil servants, businesses and schools. However, most farmers and businesses withdrew from the scheme and ESCOs were left with civil servants as their main customers. This is because civil servants had a regular uninterrupted income to be able to make the monthly payments without any default.

Indian ESCO model: In 2008, India launched the campaign initiative "Lighting a Billion Lives (LaBL)". The aim of LaBL was to bring light into the lives of one billion rural people by displacing kerosene and paraffin Lanterns with solar lighting devices. The anticipated benefit of the program was to facilitate education of children, provide illumination and create a kerosene-free indoor environment.

LaBL operated on a fee-for-service or rental model where centralized Solar Charging Stations (SCS) were set up in villages for charging lanterns and providing lanterns daily on rent to households and enterprises. Local entrepreneurs (self help groups and /or individual youth) operate and manage the charging stations.

The capital cost for setting up the SCS in remote locations are mainly grant supported from LaBL fund. In other places financing is made by joint support from government, Local NGOs and the community.

5. Private sector model

This model involves private companies in building rural energy infrastructure and/or selling electricity to rural people. Often the private sector will only enter such a business model if appropriate incentives are provided.

An example of Private Sector model is Argentina’s government program PERMER (Project for Renewable Energy in Rural Markets). This is a PPP model led by the federal government and implemented by provincial authorities involving the private sector.

Salient features of Argentina Experience include:

- Government funding is utilized to install generating equipment and subsidizing end-user tariff
- Concession contracts are given to private sector/cooperatives
- The bulk of the financing comes from loan from international financiers such as World Bank, GEF, national and provincial budget with small user contributions.

Financing mechanisms

For the detailed description of financing mechanisms, please refer to the section *10. Analysis of capital investment strategies & control mechanisms*. In short, there are usually 3 types of mechanisms to support the implementation of MG:

- Concession of rural electrification to be launched once the regulatory framework is well established
- Call for Proposals in the framework of GMG Facilities
- Other financing proposals from ECREEE, UNDP, WB, etc.

All those mechanisms should include the access to a grant facility financing a significant portion of investment costs including connection fees in order to make the tariff affordable to customers. Those grants can be investment-based and disbursed prior to construction, or result-based and disbursed once households are connected, hence paying back part the upfront investment done by the operator. While this entails a higher cost for the operator, this second solution enables lighter grant eligibility assessment process and therefore a faster deployment. Compensation mechanisms aiming at subsidizing running costs are tricky, notably because such a reliance is deemed as threat by the investors. In practice:

<u>Investment costs</u> (CAPEX): The level of subsidy depends on the financing sources. The operator needs anyway to submit his business plan to the regulator for approval. This plan is based on a standard financial model in order to set the tariff and the profitability of the business.

Operation expenditure (OPEX): in principle, the operating costs are not subsidized and must be covered by the tariff. However, the operator may not have sufficient working capital and may need access to credit for maintenance activities.

Connection fees: they are integrated in the business plan as part of the commercial approach proposed by the operator. In order increase the mini-grid penetration rate for lower-income households, some operators do not charge connection fees or get those fees paid over 1 or 2 years through a premium on the electricity purchased by the household rather than an upfront fee. There is a scope to partner with MFI to foster access to connection by supporting low or delayed connection costs.

Finally, the mini-grid sub-sector attracts many international actors and donors across Uganda and elsewhere in Africa and represents a great opportunity for the development of the rural electrification market, but there remains a number of social, institutional and techno-economic barriers.

A SWOT analysis for MG solutions is proposed below.

Table 16: SWOT analysis for minigrids in Uganda

Strengths	**Weaknesses**
● Reduction of fuel cost & dependency ● Reduction of environmental impacts ● Low maintenance vs. fuel genset ● Superior quality service (for PUE) vs. SHS ● Potential for 24h/24 service (with battery) ● Promotion of PUE and demand generation	● Intermittency of the RE resource ● Minimum density of households ● Tricky load management due to limited power/energy ● High cost of storage batteries + replacement ● Technical complexity vs. fuel genset ● Scale-up more complex than fuel genset ● More complex operation instructions especially for hybrid systems ● Maintenance organisation and spare parts for diesel genset and LV lines. ● Specific business model for each case ● Unclear roles & responsibilities of multi actors
Opportunities	**Threats**
● Develop innovative business models for MG & IGA promotion ● Develop innovative financing mechanisms for entrepreneurs & TSP to ensure working capital and to cover operating & maintenance costs ● Financing programmes from DPs ● Setup workshops for promotion and dialogue between various stakeholders (PPP), including potential for productive uses	● Low interest/confidence of domestic & productive users (service availability) ● Local or global economic downturn leading to lower users' purchasing power ● Slow administrative process, complicated for private developers ● High tariffs = low collection rates = risk of balance deficit for the operator ● Competition with national grid extension (lower tariff, more power, more availability)

7.3 Characterisation of the business models of solar PV kits

Business models

The following main business models coexist in Uganda for domestic and micro businesses solar systems:

1. the **cash-sale** is the classical approach for all suppliers trying to do business in Africa, but only small part of the population can afford the upfront cost of those solar systems.
2. the **sale on credit** offered by some MFIs (RENECA, PEBCO, ACFB, ALIDE), or by some organisation or sellers directly (AXCON, INETS). Typical loan conditions are max 2 years and 15%-19% interest rate.
3. the **Fee-For-Services** (FFS) offered by some programmes where customers pay a fixed amount for solar electricity service (tariffs are going to be regulated by the Government). This model refers mainly to mini-grids.
4. The **Pay-As-You-Go** model has been introduced in Benin for a couple of years and offers a more flexible prepayment solution for low-income customers. However, the development of mobile banking and prepayment with PAYG systems was undeveloped in Benin for the last few years but is improving now with lower cost of services offered by telecom operators for their new products (mainly MTN and MOOV). As mentioned earlier, PAYG model is now the main way for sales scaling up.

Financing mechanisms

On the one side, most customers need financing mechanism (savings or loans, subsidies) to overcome the upfront cost barrier. On the other side, the local suppliers / distributors are often constrained by their low self-financing capacity of stocks; they aspire to access credit to pre-finance their stock and to achieve economies of scale.

Only a few TSP suppliers (mainly through PAYG mechanism) and MFIs can offer credit over a few months for their clients to facilitate the acquisition of lanterns and solar kits. Some suppliers also express interest in forming a partnership with an MFI but the high interest rates (~19%) are generally the barrier. Their needs also lie in strengthening a network of agents for marketing and after-sales service.

Finally, specific programmes promoting and supporting last-miles SHS dissemination also require financing in the long term to supervise and to sustain the supply chain & stakeholders.

Challenges

The main challenges of the solar PV sector as identified in the Energy Compact funded by DFID in 2016[14] are summarized below:

1. Policy framework: Current policy focuses more on on-grid electrification. To date, the off-grid policy is not detailed: In the rural electrification strategy plan, no measurement of business as usual situation, clear approach with milestones for distributed solutions; The role of the government is not clearly defined; The National Energy Policy does not include specific measures targeting the small-scale solar market.

[14] The Energy Africa Campaign is a DFID-led initiative to accelerate the household solar market in Africa, and help achieve universal energy access by 2030.

2. Fiscal barriers: Lack of clarity and uncertainties of the fiscal policy both for the revenue authorities in charge of the application (URA) and the solar importers and distributors. The administration of this policy is not streamlined with resulting gaps in the interpretation, application and enforcement.

3. Consumer protection and awareness: Quality issues of solar products and services: Consumer protection bill has never been passed; No standards for small PV products, only for SHS (tbc); Solar market is saturated with low quality products; Lack of qualified technicians; Lack of resources of the Uganda National Bureau of Standard (UNBS) to control and enforce the standards. No proper facilities to test the products. This results in delays e.g. whilst waiting for suitable levels of sunshine. Lack of awareness of good quality products amongst end-users: households, NGO, public institutions, communities, businesses.

4. Supply chain financing: Limited capacity of distribution of solar products and services to the last mile. Lack of access to finance: Difficulty with hard currency financing, due to exchange risk and high inflation; High costs and risks for companies offering micro-financing facilities including PAYG solutions hence worsening the issue of affordability.

5. Consumer financing: Limited payment capacity of end-users and financing facilities in rural areas: Procedures from regulated banks and MFIs are too heavy and costly for low market consumers; In practice, private companies and SACCOs are more reactive and adapted to small consumers.

A SWOT analysis for solar PV kits and solar productive power are proposed below:

Table 17: SWOT analysis for solar PV kits in Uganda

Strengths	**Weaknesses**
● Cost-effective solution for off-grid customers ● Sole efficient power solution for scattered off-grid households ● Existing supply chain with several valuable suppliers	● Upfront costs for quality products & low access to soft loans ● Limited availability of power and energy ● Poor performances/ reliability of cheap products ● Lack of awareness (and/or confidence) of rural customers
Opportunities	**Threats**
● Large potential in off-grid areas: several millions potential users according to the different scenarios of the NES should be connected via stand-alone solar lighting systems. ● Develop new financing mechanisms (soft loans for TSP, Warranty fund, …) with local financing institutions (banks, MFIs) ● Promote partnerships & networking, particularly with MFIs, NGOs, installers, mobile operators, etc.	● Fast grid-extension programme ● Competition of low quality & low-cost products ● Lack of working capital for suppliers and lack of stock ● Lack of finance for O&M and replacement of components ● High coordination-supervision costs for last-miles programmes ● High MFI interest rates (~19%)

• Support awareness and marketing programmes from Government and DPs • Promote quality-control and labelling of products	

Table 18: SWOT analysis for solar productive power in Uganda

Strengths	**Weaknesses**
• High socio-economic impact in rural areas • Enough power to run a business at anytime of the day (battery) • Systems without batteries (pumping and special refrigeration) offer suitable payback time despite high upfront cost	• Competition from the main grid: lower tariff, higher power availability (e.g. for energy intensive engines) • Specifically sized to match the demand (limited power and energy). Little flexibility for varying demand (daily, seasonal, etc.) • Require the user to convert their old appliances (more efficient) • Risk of theft for pumping (remote sites) • ASS (After Sales Service) & stock are still limited • High upfront costs (e.g. solar pump vs motopump: see economic analysis in section 5.3 Strategies for incorporation of PU) • Finance access (for CAPEX and working capital). Require grant and credit facilities. • Need for business plan to check profitability • Need for multi-sectorial approach
Opportunities	**Threats**
• High potential for partnership with key actors as MFIs, DPs, TSPs; • Develop new financing mechanisms • Assess the potential for RE-based multifunctional platforms (PTFM) • Involvement of local associations (women, farmers, fishermen, etc.)	• Lack of awareness and confidence of rural entrepreneurs • High interest rates of MFIs and inadequate funding conditions

7.4 Strategic recommendations to develop off-grid solutions in the NES

The Government of Uganda is currently involved in promoting the off-grid electrification of its villages through REA; several projects and initiatives are in progress as listed in the section 3.3. The necessary and planned subsidy for mini-grids remains high (up to 75% of investment) and the involvement of private investors and international donors is necessary. At this stage, most of the implemented MG have been financed by donors and government. Obviously, demand exists in off-grid villages but the population generally prefers grid connection to solar mini-grids due to lack of awareness, or bad previous experiences, lower national on-grid electricity tariffs, greater power availability of the national grid, particularly for energy intensive uses.

The government has been concentrating on the facilities without giving enough importance to the operation & maintenance scheme. Most of the private or community operators have limited financial capacity to ensure good long-term operation, nor experience to develop a productive clientele to secure their investment; they must be accompanied and followed, especially in the perspective of the future MG projects that will scale up the business range.

Beyond the high investment costs, the major difficulty of mini-grid projects lies in finding the right business model that can ensure the viability and quality of the electricity service offered to rural customers. The right business model depends on the socio-economic and physical situation on site, size of the systems, the technology (PV, hydro, biomass), the promoter capacities, etc. The tariff for customers and the operation of these mini-grids remain problematic with a private/community sector that lacks capital and is cautious about the risks of activity, despite investment subsidies provided by various donors.

Regarding license duration, in most of the countries where MG are effective, license are valid for 15 to 20 years. Most of the MG operators prefer longer duration which gives visibility and allow long term commercial strategies and investments recovery: business plans developed over 20-25 years are more attractive for investors depending on the level of investment and how the tariff is affected.

MG key lessons learnt from previous programmes in Africa

A first lesson can be drawn from the difficulties encountered in building quality infrastructure in a rural context. Many projects show how difficult it is to complete the installation of electricity generation and distribution equipment. Contractors need to be strong, experienced with well-trained staff. The client and the institutions concerned must be involved in rigorous and regular monitoring: they must demonstrate sufficient will, human and material resources (these are often lacking).

A second lesson is that a close coordination between the different private and institutional stakeholders is always necessary to ensure the success of a mini-grid projects taking into account all stages of the project cycle: from its planning, financing, construction, accompanying measures, up to commercial management and operation of equipment including cost recovery mechanisms. Each MG project should result from a national planned and coordinated strategy in line with the NES. Many MG projects indeed proceeds from spot initiatives cropped up through funding opportunities, there is often no long-term operational mechanism to allow the replication or extension of MG programmes.

A third lesson is that the emergence of strong operators, private or community, is rare and difficult, because of equity requirements and lack of sustainability of rural electrification projects with renewable, even with subsidized investment. In addition, high tariffs lead to low recovery rates and increase the risk of a deficit balance for the operator. Other financing mechanisms (loans via micro/mesofinance, in some cases tariff compensation for the operator) may be necessary to ensure working capital and cover operating costs, notably the funds needed to replace the batteries (every 5 to 7 years). The operators must have the capacity not only to operate the power plants and the grid, but also to increase the power and develop the network to satisfy a growing demand which is often rapidly unmet in the evening peak and during the day when productive activities run.

A fourth lesson is that hybrid power plants, which are technically more complex than conventional thermal power plants, offer substantial savings, particularly in terms of investment and facilitate the integration of productive users (the genset component providing flexibility in terms of power usage: peak demand, starting currents, evening loads, etc.). The complexity lies in the need for a sophisticated automation scheme to manage the switching between energy sources, i.e. between solar generators, diesel and battery to optimize operation and maximize fuel savings. The operating instructions (operation and maintenance) are therefore also more complicated for the plant manager, depending on the degree of automation and the electronic equipment installed. Maintenance interventions can be substantially reduced (mainly gensets and battery maintenance) but the technical staff must be sufficiently qualified to deal with any power plant outages or particular incidents.

A fifth lesson concerns the adequacy between supply and demand, i.e. between energy production (availability) and the daily and seasonal consumption profile. The storage makes it possible to partially offset the daily differences but at a high cost and with limitations in terms of power output if the installation is not oversized. Encouraging economic activities during the day (solar production) improves the profitability of the operation but also risks disrupting the network stability and degrading the quality of the service. The profile of demand in isolated rural sites can be highly variable (e.g. starting currents of electric motors) and difficult to control over time (e.g. rapid growth of demand, increase of IGAs, etc.).

A sixth lesson emphasizes the importance of well-designed infrastructures (power plant and distribution grid) that can be interconnectable at lower cost when the national grid is extended to the site, especially in Uganda where the grid coverage is quite high: e.g. possibility of direct injection of the renewable energy power, dismantling and transfer of the groups and battery banks to other sites, connection of the mini-grid with a transformer, etc.

These lessons learnt are also illustrated through the very instructive case studies developed in the report entitled: "*Market study on available financial instruments in support of GMGs and assessment of GMG developer needs. Case Studies Report*" funded by AfDB under SE4ALL Green Mini-Grids Access to Finance. The case studies include the "PAMOJA Cleantech project in Uganda: Biomass Mini-Grid 32 kW".

Key success factors and recommendations from different experiences across developing countries are summarized as follows:

- **Team**: national management, national and international experts, all professionals of rural electrification.
- **Proper siting of mini-grid project sites**: the selection of densely populated villages, communities, trading centers in which to set up a mini-grid is critical.
- **Reliability of the service** (.e.g. 24/7) for SMEs and anchors loads such as telecom companies and agro-processors
- **Biomass MG: partnership with farmers' groups/cooperatives** is essential to secure continuous supplies of biomass feedstock to power the plant.
- **Working on several villages** allow an operator to cover different sizes of villages and ensure viability (big villages being more profitable than small ones).
- **Financial support of REA to make internal wiring** part of the project capital investment which would protect consumers from being overcharged by contractors

- **GSM metering systems with mobile money** (e.g. PAYG) guarantee cash-less and agent-less efficient collection of payments.
- **Short distances between villages** : this configuration simplify meter reading and recovery of bills (reasonable operating costs)
- **Affordability of the service**: tariffs to be determined after conducting willingness and ability to pay studies.
- **Feasibility and market studies** to determine the technical, financial and economic, environmental and social impacts. Of paramount importance of biomass projects is the availability of feedstock supplies.
- **All the techno economic and financial studies co-financed by grants** reduce the development cost supported by the developer
- **Low cost infrastructures**: the expertise of the team and the business model allowed the promoter to make least cost choices (concrete poles, meters, section of the connection cables…)
- **Availability of in-house knowhow at developer level** on aspects pertaining to feasibility, economic and financial studies and regulatory framework can be an asset to the project development. It is also a strength if the developer is already active in the country prior to the project development and hence already familiar with all the "procedures" and main players.
- Conducive regulatory framework: **fast track procedures for small projects** that are lower than a certain threshold (e.g. 5 MW in Cambodia).
- **Tax exemption** on imported equipment and on energy sales (tariff).
- **Support of REA to install the electric committees** in targeted villages.
- **Extended license duration** over 15 to 20 years.
- Recommendations **for sustainable operational management**:
    - Promotion of energy efficient appliances and customer information regarding rational use of energy should be a part of any rural electrification project. Such measures should avoid unplanned increase of the load (either caused by inefficient use of energy or by unexpected new loads).
    - As a basic minimum, any off-grid project should generate a cash flow sufficient to cover O&M costs, and be built around existing local businesses or public institutions in order to increase critical mass, revenue, and local involvement.
    - Access to service and spare parts is very critical in the case of electronic components. It is required that manufacturers and/or local distributors provide an adequate after-sales service for the PV system components.

Suitable ownership and responsibilities model: it is important that clear contractual agreements are made determining who invests, who develops the project, who owns the installation, and who operates and maintains the system. Various models of distribution of responsibilities are possible: community-based model, private sector-based model or even utility-based model: see section 5.4.2 above.

Specific recommendations for the PV sector

Based on the barriers identified and reported above, the Energy Compact report funded by DFID in Uganda proposes a set of concrete actions useful to accelerate and strengthen the local PV market:

Table 19: proposed actions to create an enabling environment for the PV sector in Uganda

#	Issue	Specific Action
1	**Fiscal barriers**	**ACTION 1: Provide clarity on fiscal policy and set up a conducive regulatory framework for importing and certifying products**, in particular: ● Clarify and strengthen existing mechanisms: Tax exemptions (import duty and VAT), on selected off-grid appropriate equipment, accessories and high energy efficient appliances; ● Adopt simplified procedures for imports and licensing[15]; ● Develop clear and updated documentation and guidelines to solar companies and authorities about the regulation, taxation and related conditions (e.g. list and features of tax exempted equipment, appliances and components); ● Need to streamline procedures for taxing new products without Harmonized System (HS) code; ● Build capacity of importers to understand regulation, tax policies, and its implementation and strengthen dialogue with Uganda Revenue Authority (URA) to understand the trade of solar products, parts and accessories; ● Donors and Government could help to strengthen the industrial Association (USEA) to lobby for tax exemption and clarity at the EAC and Ministry of Finance. Development Partners can further strengthen the role of USEA by supporting membership of USEA as a condition for finance provision.
2	**Consumer protection and awareness**	**ACTION 2: Disseminate and ensure enforcement of standards**: ● Apply standards on (i) importation (IEC and LA), (ii) design, (iii) installation and (iv) usage. Apply IEC and Lighting Africa as minimum standards requirements. Apply the new (Dec 2020) Isolated Grid Regulations set up by ERA with UNBS. Update installation code; ● Implement a certification process and self-regulation for solar companies incl. distributors and installers, e.g. through USEA;

[15] *Example: an importer can lodge a partial customs declaration by using an invoice. Then, by presenting the goods to customs, these are released against duties paid at a later stage. Thus the entire clearance process is accelerated and the trader has the goods at his disposal more quickly.*

3		● Train and certify solar technicians for design, installation and after-sales service; ● Strengthen the capacity of UNBS with staff dedicated to solar products and testing facilities (e.g. test bench that allows testing in simulated environments instead of waiting for the sun to shine). Reinforce spot controls at the distributors' outlets and at the entry points of import. ● In addition to UNBS, accredit and build capacity for a third institution[16] to perform tests on behalf of UNBS which provides certification. Furthermore, provision of financing to UNBS in order to outsource the pre-inspection of the products at customs; **ACTION 3: Inform and create awareness on good quality products**: ● Develop clear product specifications (performance, certification), trainings and user-manual for clients of PV products; ● Finance awareness campaigns, information platforms at national and local levels and guidelines (e.g. on certified products and companies). Include specific messages targeting women, children and potential productive activities; ● Strengthen the role of private sector representatives such as USEA for example, to finance awareness campaigns on certified products and companies. ● Build an information portal through websites and mobile technology to avail information to end-users regarding good quality solar products and services.
3	**Supply chain financing**	**ACTION 4: Support expanded distribution infrastructure** (e.g. sales outlets, sales force, distribution partnerships) of solar companies that are focusing or have plans of distributing to the rural areas and under-served regions such as Northern Uganda. Support includes Technical Assistance to develop scalable business models suitable management systems and incentives to expand sales outlets e.g. results based financing. **ACTION 5: Provide affordable financing facilities for solar and MG companies**: ● Conduct research on financial inclusiveness in RE sector[17] (focus on previous and existing financing models, challenges, lessons learnt, limited commitment from banks, successes and proposal of suitable incentive schemes); ● Put in place off-grid trust fund to pull concessional resources together from DPs and support Private Sector participation in off-grid electrification. ● GoU to coinvest in mini-grids by providing power network while private provide generation facilities and operate mini-grids. Investment in solar home

[16] *such as the Centre for Research in Energy and Energy Conservation (CREEC)*
[17] *for example through Financial Sector Deepening Uganda (FSD Uganda)*

		systems to be left to Private but GoU can intervene with subsidy or credit facilities. ● Create a dedicated solar fund, in particular targeting local systems integrators[18]; ● Launch off-grid facilities to enable private sector set up in Uganda by mobilizing and coordinating actions and funding with the DPs and institutions including SPV. Define the objectives and mode of financing: calls for proposals or spontaneous offers, areas identified by REA and SPV, results-based financing (RBF) or investment grants or combination of both... Give priority to projects that include social intermediation measures (for example promotion of productive usages, energy efficient appliances), innovative payment systems such as mobile money or PAYGo, systems of guarantee and after-sales service (in case of rental/sale of equipment or kits, mechanisms for components collecting, processing or reconditioning, especially batteries). Ensure transparency in projects appraisals by strictly meeting the timeline as set in the regulation. The regulatory framework in force in Uganda is intended to be attractive for off-grid project promoters and investors thanks to (i) simplified procedures, (ii) adequate and reasonable remuneration, (iii) maximum and binding deadlines set for institutional stakeholders for application processing. Meeting deadlines is a strong positive signal to potential investors. ● Create awareness and train financial institutions on business opportunities, e.g. by profiling and assessing bankable businesses (e.g. understanding of solar products and services); ● Loan guarantees to counter high interest rate and collateral requirement; ● Provide transaction advisory services, TA on financial management and guidelines on the different financing instruments.
4	**Consumer financing**	**ACTION 6: Provide financing facilities** (loans but no subsidy because of the risk of market distortion) in particular for base of pyramid (BoP) and **female consumers**: ● Provide information on financing instruments (mobile payment, MFI, PAYG, solar kiosks) and improved payment platforms (multiple language options, transactions security…); ● Inform and sensitize local financial institutions on the good quality solar products and their benefits; ● Support MEMD to work with the Bank of Uganda, the Ministry of Finance and local financial institutions to simplify lending requirements and repayment process for solar solutions[19]; ● Support MFIs to set up solar companies (e.g. success stories in Asia).

[18] *Could be managed by UECCC, PSFU or FSDU*

[19] *for example, using solar systems as collateral, supporting mobile money integration for solar companies and MFIs.*

8 Analysis of the legal and regulatory framework

8.1 Presentation of the current legal and regulatory environment

Main law: The Electricity Act 1999

The Electricity Supply Industry (ESI) in Uganda is underpinned by the **Electricity Act, Cap 145** enacted in 1999. The Act provides a comprehensive legal and regulatory framework to regulate the sub-sector. It was also the basis to implement wide ranging reforms and the restructuring of the sub-sector initiated by the GoU in the 1990s and the early 2000s.

The Electricity Act provides for:

- The separation of the policy, regulatory and operational functions of ESI under the Act
- Establishment of an independent sector regulator, The Electricity Regulatory Authority (ERA), its composition, functions, funding and guiding principles.
- Types of licenses, licensing procedures, amendment and revocation of licenses
- Obligations of the Government to undertake rural electrification develop the rural electrification strategies, funding, subsidies and the rural electrification data base.
- Acquisition of land for electricity projects
- Tariff structure and terms of supply rights and obligations of consumers
- Offences and penalties
- The dispute resolution mechanism under the Electricity Disputed tribunal (EDT)
- The unbundling of the Electricity utility Uganda Electricity Board into successor entities
- Transfer of assets to the successor companies
- Transitional provisions

The Electricity Act provides the regulator an opportunity and scope to develop a robust regulatory regime that is responsive to needs of the country and to adopt international best practices in electricity regulation in Uganda.

Under the Electricity Act, the Minister responsible for energy and the electricity regulator are empowered to make regulations and Statutory Orders to provide the detailed rules for the effective implementation of the Electricity Act and regulation of the different activities envisioned under the Act.

Subsidiary Legislations

Pursuant to the above powers the Minister and the Electricity Regulatory Authority has made the following subsidiary laws listed in the tables below which refer to statutory instruments, regulations, orders and regulatory notices under the Electricity Act:

Table 20: list of the current subsidiary legislations with purpose

1. Statutory Instruments made by the Ministry Responsible for Energy (MEMD)

No.	Name and Description	Year	Purpose
1	The Commencement of the Electricity Act, Instrument no 42 of 1999	1999	To bring into effect the Electricity Act, 1999.

2	Statutory Instrument 2001 no. 75 (Now repealed and replaced by SI no. 29 of 2021)	2001	It establishes the Rural Electrification Board (REB) to manage the Rural Electrification Fund (REF) and Rural Electrification Agency as a secretariat of the REB. The REA is mandated to facilitate GoU to achieve its goal of accelerating rural electrification. REA has now been wound up and absorbed into MEMD as a department.
3	Electricity Act (Commencement of sections 62 and 120) Instrument, 2002.	2002	To bring into effect operation of section 62 and 120 of the Electricity Act.

2. Regulations and Orders made by Electricity Regulatory Authority

SI No.	Name and Description	Year	Purpose
19	The Electricity (Installation Permits) Regulations	2018	Establishing the qualifications for persons authorized to undertake electrical installations in Uganda.
21	The Electricity (Quality of Service Code) Regulations	2020	To regulate the quality of service by licensees and/or operators relating to generation, transmission, system operation, bulk supply, distribution, and sale of electricity in Uganda.
22	The Electricity (Safety Code) Regulations	2003	To establish minimum safety requirements, precautions and procedures to be observed by Licensees and/or operators in the generation, transmission, distribution and sale of electricity in Uganda.
3	The Electricity (Tariffs Code) Regulations	2003	To establish the tariff structure and charges applicable in the electricity industry in Uganda.
24	The Electricity (Primary Grid Code) Regulations	2003	To provide for rules, guidelines and procedures to regulate the technical specifications of generation, transmission, distribution and sale of electricity in Uganda.
39	The Electricity (License Exemption) (Isolated Grid Systems) Order	2007	To establish the criteria for exemption of Isolated grid systems from regulations applicable to projects on the national grid.
60	The Electricity (Application for Permits, License and Tariff Reviews) Regulations	2007	To Regulate the procedure of application for permits, licenses and tariff review for projects established under the electricity sector.
99	The Electricity (License Fees) (Amendment) (No.3) Regulations	2014	Provide for the amendment of SI. No. 20 of 2003 and the schedule of License fees.

5	The Electricity (Installations Permit) Regulations	2018	To provide for the revocation of SI. No. 19 of 2003, and amend the required qualifications for persons authorized to undertake electrical installations in Uganda.
64	The Electricity (Reporting and Record Keeping) Regulations	2019	Regulate reporting and record keeping for licensees operating in the electricity sector.
138	Electricity Isolated Grid System Regulations	2020	To regulate stations of commercial purposes with a generation capacity not exceeding 0.5 MW; and to isolated grid systems where the generating capacity does not exceed 2 MW
76	The Electricity (Approval and verification of Investments) Regulations	2020	To prescribe the processes, principles and standards for the approval and verification of investments in the electricity supply industry; to prescribe the requirements for approval of investment plans and completed investments; and to prescribe stages of the investment planning and verification process.
77	The Electricity (Uniform System of Accounts) Regulations.	2020	To prescribe reporting procedures and requirements for licensees and holders of certificates of exemption, for purposes of achieving uniformity and consistent reporting of elements that are required for tariff setting, approval and monitoring.
69	The weights and Measures (Electricity Meters) Rules	2015	To provide for rules governing Electricity Meters to ensure accuracy in measuring electricity.

3. Regulatory Notices made by Electricity Regulatory Authority

No.	Name and Description	Year	Purpose
001	Implementation of Grid-connected Solar Power Generation Projects in Uganda	2015	Notification of the public that with effect from 1st January 2015, procurement of new capacity from solar technology will be subject to a competitive tendering process initiated by the Authority in accordance with the Electricity Act.
002	Generation of Electricity from Thermal Power Plants	2015	Notification that the Electricity Regulatory Authority shall not receive any applications submitted in accordance with Section 29, of the Electricity Act, 1999 for prospected development of thermal power plants that intend to utilize crude oil and associated gas from the Albertine Graben region, until such a time when the Ministry of Energy and Mineral Development advises the Authority otherwise.
003	Prohibition of unlicensed Generation, Distribution and Sale of Electricity.	2016	A notification that it is an offence for any person to generate, transmit, distribute, sale, export or import power for the purposes of giving electricity supply to any premises or

			enabling a supply to be given without a license or an exemption from the Authority.
004	Prohibition on Illegal Electricity Charges	2019	Directing Landlords of commercial buildings in Uganda to charge their tenants for actual energy consumption based on Electricity Tariffs/Rates and Structure as approved and published by the Electricity Regulatory Authority.
005	License Exemption Regulations for isolated off grid systems	2020	This provision aims at facilitating the development of off-grid mini-grids.

The other key relevant laws that enhance and/or impact on the Electricity Sub Sector include:

a) **The Investment Code Act, Cap 92** was amended in 2019 to improve the investment climate in Uganda which is critical for electricity projects that require long term heavy investment, and to attract private capital and investment.

b) **The Public Private Partnership Act (PPP) Act 2015** was enacted to provide a legal framework for the private Sector participation in infrastructure projects hitherto restricted to the public sector. This law is expected to benefit the Electricity Sector.

c) **The Procurement Act, 2003** impacts on the project procurement and execution because most of the key players are government owned or controlled entities which are required by law to comply with the Procurement Act. The law is under review and before Parliament to streamline procurement to avoid delays and other bottlenecks in the procurement and execution of public projects characterized by the current procurement regulatory regime.

d) **Weights and Measures (Electricity Meters) Rules, 2015** SI 2015 No 69, enacted by the Minister of Trade, Industry and Cooperatives to establish the Standards and operation of electricity metering equipment.

Apart from the enactment of the Electricity Act, the GoU has adopted policies, taken administrative actions and other interventions and reforms which have resulted in positive developments in the sector over the last twenty years.

8.2 Impacts of the laws and policies on the electricity sector:

Since the late 1990s when the government initiated reforms in the sector, the Electricity Industry has grown and expanded significantly. There has been rapid increase in the number of the sector players, the generation capacity, the amount of electricity generated, distributed and consumed and technology deployed. The number of customers and end users has increased significantly as illustrated in the table below:

Table 21: Comparison of the Position of the Uganda Electricity Sector in 1999 and 2019

Indicator	1999	2019
Licensed Players Generation Transmission	1 UEB the government owned vertically integrated Electricity Utility	Generating Companies 1 Transmission Company 8 Distributing Companies

Distribution		
Generation Capacity	150 MW	1,182 MW (May 2019)
Peak Demand (System)	180 MW (est.)	645 MW (August 2018)
Distribution Losses	35% (2002)	16.8% (during 2018)
Energy Generated	397,893 MWh (2006)	4084.5 GWh in 2018
No. of Electricity Consumers	240,000 (est.)	1,352,735 (2018)

The above developments, though significant, have fallen short of the GoU expectations and targets and Uganda is still ranked among the least electrified countries in the region as illustrated in the table below:

Table 22: Comparison of electricity access rate in Africa

Electricity Access in Africa (2018) Proportion of the population with access to electricity			
	National Average	**Urban**	**Rural**
East Africa	43%	78%	31%
Burundi	11%	69%	<5%
Djibouti	42%	53%	<5%
Eritrea	49%	89%	23%
Ethiopia	45%	>95%	32%
Kenya	75%	>95%	66%
Rwanda	49%	76%	44%
Somalia	18%	35%	<5%
South Sudan	<5%	<5%	<5%
Sudan	47%	73%	33%
Uganda	**23%**	**63%**	**11%**

Source: IEA, World Energy Outlook – 2019

The target rate of increase in the rural electrification under the Rural Electrification Strategic Plan 1 (RESP1) (2001-2010) was 10%. However, by 2010, rural electrification had only increased marginally from 1% to less than 5% despite heavy investment and expansion of the distribution network.

Under the Second Rural Electrification Strategic Plan (RESP 2) (2013-2022) the target is to increase rural access to electrification is 26% by 2022. However, the rural electrification rate by 2019 was estimated at 8% while the national electrification rate was estimated to be 19% (Source; BMAU Brief Paper 29/19, June 2019), even lower than the IEA statistics set in the table above, respectively 11% and 23%.

8.3 Challenges faced by the Electricity sector with key recommendations

An analysis of the main factors constraining electrification in Uganda indicates that the legal and regulatory framework has not been a significant barrier to increasing access to electricity. Though, some improvement in the regulatory framework could provide some impetus for further growth.

The poor performance in increasing access to the electricity in Uganda is attributable to both supply and demand side constraints and the institutional factors which are dealt with later in the study. Some of the supply and demand constraints are:

A) Supply side constraints

- Reliability on grid extension to increase access
- Choice of technology
- Use of expensive technology to provide access
- Inadequate funding to extend grid to less served areas of the country
- Lack of capacity by some of the service providers leading to back log
- High cost of connection
- High tariffs
- Poor reliability of supply
- Corruption by employees of utility companies

B) Demand side Constraints

- Non-productive use of electricity
- Substandard housing and inability to meet the cost of wiring houses
- The inability to meet the cost of connection charges
- The inability to pay electricity bills (consumption)
- The dispersed nature of rural settlement in some areas of the country

The other challenges and constraints are highlighted in the table below:

Table 23: Challenges and constraints faced by the electricity sector with key recommendations

#	KEY ISSUE	CURRENT PROVISION	GAPS	RECOMMENDATION
1	Definition of key terms and concepts a) Connection b) Electrification c) Coverage d) Rural Electrification	Different definitions are adopted by different bodies in different reports.	The use of different definitions cause confusions in the planning process and setting of targets	These terms need to be defined in the law to ensure the common understanding and uniform application of the terms, as provided in table 18, below
2	Definition of Access	Access has been defined as HH Level Tier 1 to cater for lighting and phone charging with target of 100% by 2030 (SE4ALL)	Tier 1 definition of access with an annual average consumption of less 75 kWh is too low to affect meaningful level of social and economic transformation, wellbeing and is incompatible with upper middle income status Uganda aspires to (as set in the Vision 2040 document).	This level should be considered as a temporary solution pending graduating to a higher level. Household Tier 3 should be regarded as minimum specification for access to the grid (on-grid and mini-grids), although Tier 1 and Tier 2 would also be considered for distributed solutions.
3.	Overlapping roles of different sector players, uncoordinated planning and implementation of GOU plans.	Umeme, REA, UETCL undertake separate network planning. The planning function is not properly co-ordinated	- Overlapping mandates between some of the key sector players - Planning function not centralized or coordinated. - Need to take a holistic view of the sector.	MEMD should take responsibility for sector planning, coordination and monitoring of NES implementation. MEMD should recommend adjustments where necessary. This should be formalized in the law. Need to take holistic view of the sector including link with MoFPED and financing sector.
4.	Market Structure	Single buyer model where UETCL is mandated to enter into all PPAs.	- Current market structure is a constraint to new investment in generation due to	-Proposed amendment to relax the role of UETCL to allow generators sell directly to some bulk consumers and distributors create

			reluctance of UETCL to take on new PPA obligations. - The issue of wheeling charges contributes to increasing costs and tariffs.	necessary flexibility. But caution is needed not to undermine UETCL existing PPA obligations. - The issue of wheeling charges should be addressed when demarcating new distribution territories to avoid payment of wheeling charges.
		-Distribution sector dominated by one distributor Umeme Ltd accounting for over 95% of electricity distributed and number of customers. - The Diagnostic Study proposes that the country be divided into one, two or three viable distribution territories. -Concessionaires would have obligation to provide electricity in the whole service territory.	- Umeme domination of distribution sector has affected the viability of concessions outside the Umeme footprint and, ability to attract serious investors to operate those areas. -Obligation to compel proposed licensees to provide services to everybody in their service territory is not realistic. In practice there will be population pockets and communities who will not be served within reasonable time.	-A recommendation to have one national distributor in the country as SPV under a PPP model with service obligation to communities in licensed territory is necessary. -Where a licensee fails to provide a service within a reasonable time, other operators should be licensed to fill in the gaps and/or provide off grid solutions.
5.	Roles of ERA to promote and attract investment in new technologies and new service delivery.	Current regulatory system is focused on grid connected power supply, off-grid solutions are basically left for market forces and donor support.	- Regulatory burden of compliance constrains small operators. - There are no incentives to attract investment and introduction of new technologies in the sector in particular, off-grid solutions.	- ERA should adopt light handed, simplified and flexible regulatory framework for small operators in rural electrification and incentives to attract new technologies and innovative ways of service delivery.

				- ERA should delegate some of its regulatory functions especially in relation to standards for new technologies and off-grid solutions.
6.	Licensing procedures	The law allows both competition and unsolicited offers to generate electricity.	Lack of competition in the procurement of project encourages lack of transparency and prioritization of projects with better value proposition for electricity consumers.	Competition should be encouraged in Procurement of all big electricity projects which should follow a generation plan. However, even small projects can be packaged and bidded out. Competition should be encouraged at all levels wherever possible.
7.	Tariff setting for rural concessionaires	The tariff structure for each concession may vary according to circumstances	Consumers who are required to pay high tariffs feel discriminated against.	There is need to standardize tariffs using targeted subsidies allowing for financial viability for the private investors both in off-grid and on-grid areas. There should be cross subsidization within same customer category.
8.	Financing of the Electricity Distribution projects	There is insufficient funding for distribution projects to meet demand for electricity in all parts of the country.	There is need to attract and involve private sector investment and participation in the electricity distribution.	The role of UECCC in mobilization of funds for electricity projects should be formalized in the law.
9.	Increasing demand for electricity to match generation by focusing on productive use of electricity	Electricity generation has far out-paced demand.	There are no sufficient incentives to encourage productive use of electricity	The productive use of electricity should be given priority over domestic use. There should be tariff incentives and more subsidies directed to production use of electricity in particular to SMEs Electricity for cooking is NOT recommended: this is not energy efficient and would quickly lead to overload demand.

				A strategy for promotion of productive uses is further developed in section 6.
10.	Capacity of smaller holders of distribution licenses	The performance of small operators in the rural electrification system is below expectation. However, there are few small operators on the national grid that are commercially viable.	Smaller operators lack Governance, financial and technical capacity to operate efficiently.	The necessity of smaller operators for off grid systems is obvious. However, on the national grid, Small operators should be phased out. Therefore there should be provisions for capacity building for them and addressing the operational constraints faced by small operators, operating off-grid systems.
11.	Distribution assets ownership and replacement	Depreciation is not charged for usage of distribution assets	The ownership and responsibility for replacement of government or donor funded distribution assets is not provided for in the law. There is a risk that this will make sector not sustainable.	The ownership and responsibility of government or donor funded distribution assets should be provided for under UEDCL, which is Government distribution asset owning company to ensure sustainability of the sector. REA recommends that a fund is created, perhaps charged on the tariff, to cater for the improvement and maintenance of the infrastructure.
12.	Land acquisition for project and way leaves.	The law allows compulsory acquisition of land for public projects and compensations are based on Government Valuer's recommendations.	The current process of land acquisition is long and allows land owners to reject Government valuation and obtain court injunctions to delay projects till length court processes including appeals are concluded. GoU efforts to resolve this has stalled.	The law needs to be amended to balance the right to compensation of private land owners and public interest to execute public projects in timely manner. The law should be amended to provide a mechanism to expedite the resolution of compensation disputes e.g. by setting up Special Tribunals to specifically handle such cases.

13.	ERA powers to enforce contracts and operator sanction for breach of license conditions or the law.	ERA has limited instruments to order licensees to comply with license conditions.	ERA's powers consist only in license withdrawal for breach of license conditions which is an extreme measure.	Proposed amendments in the Act to provide for fines and penalties are in right directions. The regulator should allow a range of other options to deal with errant licensees.
14.	Rampant vandalization of electricity installation	Proposal to amend the current law to provide sufficient deterrence against vandalization of the electricity installations	Proposed penalties are deterrent enough however fines and penalties will be paid to Government general account.	Proposed fines and penalties should be paid into special Energy fund to be utilized for electricity projects. REA recommends appropriate technology, such as conductors without multiple uses which can discourage theft if conductors cannot be converted to other uses.

These developments have brought new challenges and complexity of the issues facing the sub sector to the fore which the policy makers and the regulatory agencies have to grapple with. At the same time the global trends and expectations from the population has put pressure on the government to set a more ambitious agenda and targets for access to clean energy and connectivity to the electricity.

8.4 Government measures to accelerate access

Under Vision 2040, Uganda is anticipated to achieve an Upper Middle-Income status by 2040 and improve the quality of life and wellbeing of its citizens accordingly. The Government regards electricity as key driver in the economic transformation of Uganda.

One of the key indicators of this status is access to clean energy. The target for access to electricity under Vision 2040 is 50% by 2030 and 80% by 2040, assuming a definition based on Tier 1 minimum service level. The average electricity consumption per capita is also expected to increase from the 75kWh in 2010 to 3,668kWh, but the pathway to reach such load demand targets is not clearly stated. Government initiatives establishing industrial parks and demand centres is a correct way forward, though it will take some time to absorb the current generation capacity. There is a need to support SMEs which are located in many other places other than industrial parks and provide the bulk of employment and contribution to the GDP. However, access to electricity will be accelerated under the SE4ALL which has been adopted by the GoU and has set the target of 100% access to electricity by 2030 based on Tier 1 Level of access.

In order to achieve these targets, GoU has initiated a number of programs and adopted a number of sector policies and plans to guide the development of the electricity sector. The key policies include the following:

Table 24: Recap of the key policy documents

#	Name of the Policy	Purpose
1	Energy Policy 2002	MEMD formulated this policy to meet the Energy needs of Uganda's population for social and economic development in an environmentally sustainable manner
2	The Renewable Energy Policy 2007	This Policy goal is to diversify the energy supply sources and mechanisms with a strategic importance of promoting energy security and independence. The target is to obtain up to 60 % of electricity supply from renewable energy sources by 2017.
3	Revised Energy Policy 2019 (draft)	To ensure sustainable development and utilization of energy resources, services and products by all Ugandans towards transformation of the national economy. Several factors since 2002, including rapid growth in population, GDP, per capita income and international commitments have led to increased demand for clean energy. The technological advancements such as pre-paid meters have resulted in efficient operations, while improvements in solar technology have made off-grid solutions a viable alternative to grid power, have necessitated the current policy revision.

4	Electricity Connections Policy	This Policy was been introduced to address the challenge of low connection rates that previous policies have not addressed despite having invested considerable amounts of funds in grid extension, with the goal of achieving a 60% level of access to electricity for Uganda by 2027, assuming Tier 3 minimum service level.

In addition to the above interventions, the GoU found it necessary to review the legal, regulatory and institutional framework to enhance a conducive legal and regulatory framework to provide more impetus to scale up rapid growth in access and connectivity to electricity in line with the targets set for the Country in Vision 2040 and the UN Development Goals in SE4All.

To this end a number of studies have been conducted which were noted and reviewed in this study. In the area of the legal, regulatory and institutional framework, the following key reports have been presented to GoU:

- The Review of Power Sector Reforms in Uganda 2017
- The Electricity (Amendment) Bill 2019
- The Draft National Energy Policy, 2019.
- The Uganda Distribution Sector Diagnostic Review, 2019

8.5 Analysis of the recent legal amendments and provisions with key recommendations

Hence, our analysis of the legal and regulatory framework focuses on those challenges and constraints to scale up access to electricity to achieve the revised targets under the National Electrification Strategy: during the inception workshop of the NES, it was agreed to reach 100% connection rate by 2030 based on Tier 1 of the Multi-Tier Approach.

From the legal and regulatory perspective, the key areas of reform should include:

- Definition key terms and concepts to create a common understanding and harmonization of the respective positions. The Consultant has proposed some definitions of key terms as follows;

Table 25: Definitions of Key Terms and concepts

TERM	RECOMMENDED DEFINITION
Access	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).*
Connectivity	Population being directly served by, and paying for, either grid-based electricity services or stand-alone systems, providing at least Tier 1 access.
Electrification	The 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.
Coverage	The proportion of the population in a given area with access to electricity

Rural Electrification	The process of extending electrical power to rural and remote areas through the extension of the grid, isolated grids or solar home systems

- Clear demarcation of roles and the mandate of the key players to avoid the overlapping of mandates and duplication of roles leading to setting of conflicting targets and strategies as a result of uncoordinated planning. This problem results in constraining efforts to prioritize projects and applications of resources to maximize value and effectiveness of programs. The Consultant has recommended that MEMD be given clear legal mandate to co-ordinate the planning, implementation, monitoring and evaluation of electricity projects.
- Regulatory regime should reduce the cost of the regulatory burden by maximizing the cost benefit ratio using an approach that encourage:
  - Light handed and simplified regulation
  - Flexible and realistic targets
- Regulatory regime should provide adequate incentives to ensure:
  - Timely and cost-effective connections.
  - Using least cost technologies.
  - Promote the productive use of electricity
- Put in place mechanisms to ensure a faster way to acquire land for projects and way leaves and compensation for people affected by projects (PAP).

The GOU has initiated the process of amendment of the Electricity Act and the Electricity (Amendment) Bill, 2019 is before the Parliament for debate. While the proposed amendments address some of the above issues, some important aspects of the legal and institutional framework have not been addressed adequately: the important provisions below should be included in the Electricity Act. Eight areas described in the table below are identified:

Table 26: Analysis of the legal and regulatory framework with key recommendations

No.	SELECTED PROVISIONS	PROPOSED AMENDMENTS SUBMITTED TO THE PARLIAMENT	GAPS	RECOMMENDATIONS
1.	Definition of key terms and concepts	No additional definitions considered	Key terms and concepts used in planning process, setting targets and measurement of performance indicators are not defined and may lead to inconsistencies.	Provide for definitions of the key terms and concepts in the Amended Electricity Act, as set out in table 25 above, including the following: a) Access b) Connections c) Electrification d) Coverage e) Rural Electrification
2.	Enhancement of the institutional capacity and functions of the Electricity Regulatory Authority (ERA)	- Provides for staggered terms for members to ensure continuity and succession planning - Provides for increased license fees to enhance financial capacity to execute mandate - ERA to undertake consultancies and studies	- Five members of the Authority is a low number and does not allow for flexibility in setting-up of relevant committees, quorum for meetings and establishing Board committees to focus on different aspects of electricity regulation - ERA mandate should not be to carry out consultancies but research and studies for benefit of the sector.	- Increase number of authority members to a minimum of seven. - ERA should carry out research and/or commission research for benefit of electricity industry
3.	Licensing of projects	Provides for the Minister to make regulations for licensing of new projects, under sections 29, 30 and 31 and projects licensed under S.32	Some developers take advantage of the provisions to make unsolicited proposals to generate electricity and get licenses without being subjected to competition.	There is need for more clarity on the distinction between projects licensed under sections 29, 30 and 31 and projects licensed under S.32. Transparency and competition for licenses should be enhanced and all projects be procured or licensed

				according to the Least Cost Generation Plan.
4.	Factors to be considered in granting of license applications	Allows the Regulator flexibility to take into account size, technology and market segment to be served	ERA focuses the bulk of its regulatory activities on the traditional grid power generation, transmission, distribution and supply. Little attentions is devoted to new technologies and innovations	ERA to develop an incentive scheme to promote new and cost-effective technologies and innovation in service delivery, achieving of targets and Productive Use of Electricity (PUE).
5.	Market structure	Single buyer model is modified by allowing for generation companies to sell electricity in bulk to distribution companies or specified class of bulk customers in certain circumstances.	Despite the amendment, there is still potential that single buyer market structure may limit some potential investors. Bulk suppliers may be reluctant to take on new take-or-pay obligations in the PPAs because of the existence of surplus generation capacity, whereas investors need market guarantee. There is need to ensure the wheeling infrastructure and wheeling charges frameworks are established.	-There is need for more clarity on how the proposed amendment will guarantee market to potential investors in generation, which makes financial closure for such projects easier. -Amendment should ensure financial sustainability of UETCL arising from existing obligations under PPAs
6.	Electricity Infrastructure Investment Fund	Provides for the establishment of the Electricity Investment Fund	- There are no provisions for the body charged with the management of the fund other than the Ministry. - The role and mandate of UECCC has not been specified anywhere in financing of electricity projects yet UECCC is a GOU entity.	- The Fund should be ring fenced and clear criteria put in place to be fulfilled by projects financed under the Fund. - The Ministry powers should be guided by regulations. -Provide for role and mandate of UECCC in the financing of Electricity projects under the Act, and could play

				a role in the professional management of the Electricity Investment Fund.
7.	Royalties payable by renewable generation plants to local administrations	Provides for negotiations of the level of royalties payable to local administrations subject to a cap to licensees and local administrations.	Since royalty payments are a pass through in tariffs payable by consumers, licensees may have no incentive to negotiate for lower fees.	The Regulator or Ministry should prescribe royalties payable to local administration according to capacity, technology and other considerations. The rates should also be standardized.
8.	Offences related to licenses	Criminalizes breach of license conditions by Licensees	Breach of license conditions is a civil and license matter. The Act and License itself prescribes sanctions for breach of license conditions and tools available to regulator to enforce license conditions.	Breach of license condition should not be made a crime. The Regulator should be empowered to impose sanctions including revocation or suspension of license and should levy fines and penalties for breach of license conditions.

We recommend that the above proposed amendments be reflected in the proposed amended Electricity Act before Parliament.

8.6 Transitional Provisions for Mini Grids when Main grid arrives

In countries where MG are effective, the models of "Off-Grid Electrification Concession/Operation Agreement" take into account the necessary aspects to be considered for the connection of a mini-grid to the interconnected grid. The agreements usually offer 3 options to the operators:

1. The operator continues its generation-distribution activity, purchases electricity from the main utility at a price negotiated between the two and may sell energy to the utility grid at a price also negotiated and approved by the regulator. This case amounts to extending the scope of the off-grid concession/operation agreement to the interconnected grid (see next point).
2. The operator transfers the distribution assets to the main utility at a certain price, keeps the means of electricity generation and sells energy to the utility at a price negotiated and approved by the regulator.
3. The operator transfers all the assets to the utility at a certain price, the operator "loses" the concession/area of operation which integrates the main interconnected grid.

It is crucial to ensure at all stages of the MG projects that the technical standards are of quality and compatible with a possible future interconnection. Such a compliance is checked in particular during the application for license and then upon receipt and commissioning of the mini-grids.

We recommend that in the case of Uganda, when the main grid arrives, the distribution assets of the mini grid operator should be transferred to UEDCL at a Value established by a mutually agreed valuer to be operated by the National Grid operator (SPV) but the generation assets especially if it is renewable energy can be retained by the former mini grid operator as an IPP and the power generated sold to the grid.

8.7 Conclusion on the legal and regulatory framework

In conclusion, Uganda has a reasonable comprehensive basic legal framework and a developed regulatory environment.

The proposed amendments of the law submitted to Parliament if adopted, will go a long way to reduce the residual constraints in scaling up access to electricity in particular, in rural electrification endeavour. The proposed amendments of the Electricity Act have not yet been debated or passed by Parliament so if our proposals are adopted by MEMD further amendments can be submitted to Parliament in time before the current proposed amendments are passed.

However, the non-legal and regulatory constraints present more significant challenges to increase access and demand for electricity. In particular, the government agencies in the rural electrification could provide creative, innovative and technical solutions to alleviate the supply side constraints.

The Government has already made important steps towards this goal by encouraging the deployment of new and cost-effective technologies and innovative ways of service delivery.

Furthermore, targeted subsidies to provide free connections, use of ready boards and government funding of infrastructure to buy down tariffs should make electricity affordable and mitigate the demand side constraints.

The consultant view would be that provision of free connections is a policy issue which should be evaluated based on availability of resources and its long-term sustainability. In the consultant view, the strategy is to bring down the tariff[20] by increasing the consumption through connecting those who can pay for electricity but finding the connection fees an obstacle and hence become a bottleneck. The consultant mentioned in this report the various schemes the GoU can adopt (or has adopted such as in the ECP 2018-2027) to make connection costs more affordable such as use of ready-made boards. Instalment payments, extending credit facilities to consumers for connection and electricity appliances and such schemes.

9 Technological review and analysis

9.1 Current technologies used: on grid & off grid

Current Technologies used in on-grid and at times off–grid for effective and efficient connection process, REA has adopted robust standard technical guidelines for implementation of distribution projects. The primary beneficiaries of the projects are the rural households and enterprises who would benefit from on-grid and off-grid electricity delivery services in the different service territories/areas.

33 kV Medium Voltage Lines:
MV lines are constructed at 33KV voltage for distribution infrastructure. The 33 kV in Uganda is intended to replace all the 11 kV with the purpose of reducing the system losses. 33kV is also used as sub-transmission and distribution line. When used as a sub-transmission line the conductor used is 150 AAAC (Aldrey). When used as a distribution line, the conductor usually used is 100 AAAC. The spurs and T-offs to nearby areas a 50mmsq AAAC is used. During the consultation phase, it was stated that REA plans new lines at 33kV only. Furthermore, *Uganda National Electrification planning study* and *Loss reduction study* which was adopted by the ministry and the entire sector in 1992 and agreed to design and implement all 33 kV and 11 kV with the same structures (such as cross arms, clearances and insulators) with a view to upgrade 11 kV to 33 kV in order to reduce on the technical system losses and to eliminate 33/11kV substations in major town and cities and at times reduce the number (as referred in the following documents: *Distribution system Planning, Design and Loss Reduction Study Final Report Volume 3a; Economic Comparison of Distribution Voltages; Study by IVO International LTD – December 1992*). For the rural electrification: *National Electrification Planning Study* (NEPS) *Volumes 1-4 November 1992 by Electricite de France International*.

66 kV Medium Voltage Lines:

During the rehabilitation of Ugandan network under the project OFE-23/24 (Owen Falls Extension), it was found out that while rehabilitating the 66kV with new equipment, it was not possible to replace the equipment because they were not readily available on market, hence the voltage 66 kV was not suitable to be extended and was limited to one place Owen Falls – Lugazi. All the other areas were derated to 33kV and in other places replaced with 132kV. Therefore, The *National Electrification planning study* established 33 kV radius from where each corner of Uganda can be reached with reasonable voltages (see NEPS Basic Concepts). Nevertheless the sector has changed in 20 years and needs coordinated planning to be able to overcome the long 33kV lines and increase the number of

[20] Tariff is made up of two components: (i) the asset component including part of the Capex recouped in that year when is divided by the energy consumed and (ii) another component of the Opex costs divided by the energy served in that given year. The higher the consumption the lower the tariff becomes. Therefore more and more customers will be able to access the electricity as the tariff drops.

circuits hence improving reliability of the system rather than upgrading to 66kV which is no longer internationally economically viable and the 66kV equipment for the substation which are absolute.

Design data:
The rating and design criteria for the Medium Voltage plant and equipment are provided in the below table:

Table 27: Medium Voltage Equipment Design Data[21]

Item	Parameters	System Parameter
1.	System description	50 Hz, 3 phase, 3 wire
2.	Neutral point earthing	Solid earthed
3.	Nominal voltage of networks	33kV
4.	Highest system voltage as defined by IEC-60038	36 kV
5.	3 phase & 2 phase Short circuit and earth fault current, symmetrical r.m.s. value (min breaking current) not less than	25 kA
6.	Thermal short-circuit current, not less than 3 second	25 kA
7.	Dynamic peak current (min making current) not less than	63 kA
8.	Rated current of bus bars and bus coupler.	1250A
9.	Insulation level according IEC 60071	
9a.	Lightning impulse withstand voltage (1.2/50 µs kVpeak) up to 1500m above Sea Level for all external insulation	200kV
	Lightning impulse withstand voltage (1.2/50 µs kVpeak) at 1500m Above Sea Level for the whole equipment	170kV
9b.	Test voltage at power frequency 1 min dry and wet. To earth and between phases up to 1500m Above Sea Level for all external insulation	85kV 70kV
10	For the design and erection of the conductors for the lines, the following minimum clearances shall be observed	
10b	Phase to phase [mm]	700-800
10c	Live metal to oil pipe work (e.g. in a transformer)	480
10d	Height to live parts above ground [mm]	6500
10e	Height to live parts above ground at transformer transport routes [mm]	5000
10f	Lowest part of insulators above ground [mm]	6000

[21] *The different regions in Uganda were found to have different climatic conditions leading to different insulation conditions and ratings. For more details See Distribution System Planning, Design and Loss Reduction Study December 1992.*

10g	Minimum Height when crossing main buzzy (Highways)[mm]	8000
11	Maximum temperature rise of conductors above ambient temperature (35 ºC)	40 ºC
12.	Maximum wind pressure on conductors and cylindrical objects	4According to the area
13.	Maximum wind pressure on flat surfaces	820 N/m^2
14.	Minimum nominal Creepage distance as defined in IEC 60815, Table II	25mm/kV

The rating and design criteria for the Low Voltage plant and equipment shall be as shown in the below table:

Table 28: Low Voltage Equipment Design Data

Item	Parameters	System Parameter
1	Rated voltage between phase	415V[22]
2	Connection type	3ph 4wire
3	Rated voltage between phase to earth	240V
4	Grounding system (multiple Earthing)	PME
5	Grounding Values (MV)	≤ 5Ω max
6	Grounding Values (LV)	≤ 5Ω max
7	Frequency	50HZ
8	Voltage variation	+/-6%
9	Frequency variation	+/-2%
10	Power frequency Test Voltage 1 min	3 kV
11	Thermal rating of conductors	120 % of load
12	Max short-circuit Current	25 kA

The table below summarizes the construction units currently used which is analysed here below.

[22] Note: During a conference held in Johannesburg, South Africa, it was agreed to unify voltages internationally. For example for IEC the rated voltage between phase was 220V and BS was 250V. 230V was agreed as the Rated voltage between phase to earth. Therefore the rated voltage between phase would be 398V. NES should propose and recommend these standards.

Table 29: Summaries of the main Construction Units for Grid Distribution

Construction Units	**Size**
33KV Feeders	50MMSQAAAC
	100MMSQAAAC
	150MMSQAAAC
Wood Poles (33kV)	12-14METERS
Wood Poles (LV)	9-11METERS
Distribution Transformers	15KVA 33/0.240KV
	25KVA 33/0.240KV 25KVA 33/0.415KV
LV Lines	50KVA 33/0.415KV
	100KVA 33/0.415KV
LV Lines	35MMSQABC
	70MMSQABC
Service Drops	16MMSQ AL Concentric 16MMSQ ABC 2C
Metering Prepaid	80A 230V 59Hz 5A 230V 59Hz

Distribution lines are normally in three phase, wish borne type of construction because of a number of reasons; reduced voltage drops above all lightning strikes in that part of East Africa, Isokereunic level in most places is 260 thunderstorm days a year or more across the REA network except at short tee-offs targeting say a village where a single phase transformer will be installed.

Over time, Utilities in Uganda are faced with theft of Aluminium Conductor Steel-Reinforced (ACSR). Because of this challenge, the distribution system planning Design and Loss Reduction Study adopted the use of all aluminium alloy conductor as a standard. The following sizes are available: and are widely used; 50, 100, 150MMSQ and will be used in this study. The conductors are manufactured as per IEC 60207.

ACSR 200mm² conductors carry continuous current of 590 Amps at 33 kV that is equivalent to 35 MVA for what distance can one transfer the power without excessive voltage drops and considerable system losses. Such a size of conductor is not suitable for rural Electrification, neither it is well suited for town distribution save, delivering power to nearby big industries or substation interconnection which are not far from the source i.e., not more than 20 kms. In the Loss Reduction Study and Standards for Uganda, the suitable conductors were recommended and were adopted. In that way, the NES does not go out of adopted technically sound practice and therefore does not consider ACSR 200mm² conductors.

- **Concrete Poles**

Used for low and medium voltage lines.

Earlier on concrete poles were used but of a different type (completely solid and square and others conical). Of recent round concrete hollow poles have been adopted and are widely used in isolated grids. Bidders have been using them in REA rural electrification projects. However, their cost and time of delivery is usually high. Otherwise, concrete poles are making a comeback in the Electric Supply Industry (ESI).

- **Underground Cables**

The medium voltage cable is mainly for the purpose of transmission line crossings, i.e. these include road crossings, where there is little line clearances and crossing petrol stations. Size for the 33kV lines is 70MM XLPE Cu 3C.

Most of the 33kV side of 132/33kV substation is usually indoor; to evacuate power from the substations to the overhead lines, underground medium voltage cables are used to connect the overhead lines to the indoor substations.

Underground cables are also used in LV network to connect usually 3 phase customers to utilities as service cables. These services are usually small factories like maize mills, cotton ginneries, coffee factories etc. The different underground cables sizes used are 16MMSQx4c, 25MMSQx4c, 35MMSQx4c, 70MMSQx4c 95MMSQx4c and 185MMSQx4c depending on demand requirements.

- **33kV Over Head Substations**

The 33KV transformer substations are built on a tee-off (T-Off) from a 33kV sub-transmission line with an H-Pole substation structure complete with a dropout fuse, LV protection fuses or an MCB with an earth leakage and surge arrester. The transformer HV bushings shall have arcing horns whose gap is coordinated according to the 33kV voltage (approximately 4 cm). From Tee off to transformer H pole two earth wires are connected in a V formation and earthed at all corners. At beginning of the tee off a surge arrester and surge arrester cross arm, pilot insulators with pilot spindle are mounted on pilot cross arm on the tee off.

The T-off is approximately 50 metres from the surge arrestor to the H-structure.

For single phase, 15KVA and three phase 25KVA, 50KVA, 100KVA depending on the load.

Single-phase structures are preferred in low load population areas while the three-phase installation will be preferred mainly in trading centers.

- **Transformer**

For single phase, 15KVA 33/0.240KV phase and three phase 25KVA 33/0.415, 50KVA 33/0.415KV, 100KVA 33/0.415KV

All transformers are oil type, hermetically sealed outdoor as per IEC 60076

- **PVC transformer wiring and LV ABC Cable**

PVC transformer wiring is of 70mmSQ CU. There are two sizes 35MMSQ ABC and 70MMSQ ABC. With bare conductors the transformer wiring is always 70MMSQ CU for all sizes.

- **Service drops**

For single phase, 16MMSQ Concentric cable (solidol) as per IEC 60502 and for three phase, 16MMSQ CU x 4c, 25MMSQ CU x 4c, 35MMSQ CU x 4c, 70MMSQ CU x 4c ,95MMSQ CU x 4c and 185MMSQ Al 4C depending on the size of the transformer and the load (demand) to be connected.

- **Metering**

Electronic static pre-paid meters (STS standards) with specs KWh Class 1, 230V, 50Hx, +/-5%, Current I_{max} 20A, 60A, 80A for productive users and 5A for factories and small scale industries. They must be tested before they are installed using a recommended test bench and methodology.

- **Wooden Pole Supports**

The design is based on creosote or tanalith impregnated Eucalyptus wooden poles being the standard distribution lines supports in on-grid and off-grid areas. For low voltages 9-11m length/height and for MV lines of size 12-14M complete with fittings.

- **Concrete poles supports**

The design is based on concrete. There are different types of concrete poles; these are completely solid and square concrete poles, conical concrete poles and round concrete hollow poles. The concrete poles are reinforced and have a long life. They are expensive to install but have low maintenance costs. Their assembly takes far less labour than the wooden poles. However they are very difficult to dispose off when retired.

To enable linesmen to climb the pole, concrete poles are made with steps or provisions for climbing the pole to fix accessories.

Due to the demand in electrical supports in Uganda, concrete poles are widely used now in isolated grid with REA projects.

HEIGHT (m)	**Bottom Diameter** (2m from the butt) (mm)	**Typical use**
14	270 – 280	Supports in urbanized areas, areas where vertical and heavy angles, H-Pole structure having a span 110 metre to 200 metres, H-pole double circuits and 3-member poles. The pole heights to offer enough clearances in cases of MV/LV combined construction. To be used in accordance with the line nature. Bare conductor or ABC cables
12	240 – 270	Considered as the MV line standard support.
10 -11	205 – 215	For LV network especially in trading centers and road crossings.
9	205 – 215	Standard support for the LV network. Lay poles for the T – Off structures. Cross arms for the three member structures.

Structures

The types of structures, heights, and span lengths are determined considering the project area terrain, physical features, soil texture, vegetation, and the allowable safety clearances in accordance with the overhead lines code of practice. The suggested structures are indicated in the table below:

ITEM	**STRUCTURE DESCRIPTION**	**REMARKS**

1	Intermediate (Single member support)	Restricted to no angle, however it can be used to angles of deviation up to 5 and with either horizontal or in a Wisbourne formation (staggered conductors). These structures are accompanied with Pin or post insulators with an earth wire but OPGW is recommended for rural electrification.
2	H – Pole Section	Has 2 pole structures with a cross arm mounted with strain polymeric/composite insulators or disc insulators with jumpers connecting both sections. The jumper where the power comes from is usually shorter and both sections are connected using a PG clamp. This structure has earth wire connected on top in a V- formation. It has stays on either side.
3	Vertical Section	It is a Single member structure with polymeric/composite insulators with jumpers connecting both sections. This structure has earth wire connected on top. It has stays on either side.
4	Single pole Section	It is a Single pole structure with polymeric/composite insulators or disc insulators with jumpers connecting both sections. One of the phases is connected directly through the wooden pole with eye bolt and eye nut. This structure has earth wire connected on top. It is used for angles of deviation up to 5° . It may have stays on either side.
5	H – Pole Dead End/ Terminal Structure	Dead end structures with Stays (guy wires) incorporated depending on the angle of deviation. These structures are accompanied with Disc or strain insulators.
6	Single–Pole Dead End/ Terminal Structure	Dead end structure using one pole with Stays (guy wires) incorporated only when the angle of deviation is 0°This structure is accompanied with Disc or strain insulators.
7	Heavy Angles	Structures designed to support deviation angles of over 300° (16° to 90°). Depending on the location, these could either be vertical structures or H – pole structures. These structures are accompanied with Disc or strain insulators with Pilot insulators.
8	Flying Angle	Single member structures, vertical conductor configuration, and angles of deviation of less than 300 (8° to 15°). These structures are accompanied with Disc or strain insulators.
9	Light Angle	Single member structures, vertical conductor configuration, and angles of deviation of less than 300 (2° to 15°). These structures are accompanied with Disc or strain insulators.
10	H – pole Support	Support in very long spans with wider conductor separation and higher structure strength. Depending on location site conditions the insulator types are sleeted.

11	Three – Member Section / Angle	Used where the spans are over 200m due to terrain, where extra strength and conductor separation is required. These sort of structures dominate the hilly regions. Depending on location site conditions the insulator types are sleeted.
12	Load break switch	Has 2 pole structures with a cross arm mounted with load break switch on the structure and operating rod on one side of the pole. In rural electrification, it is usually used to separate T-off from main trunk line and near line metering points. If employed with automated distribution system, this structure should have a communication link, solar panel and battery. That will save operators from driving long distances to separate the T-off for maintenance purposes and for isolating faults on the T-off. NES recommends using automated distribution system to operate the load break switch. In this case the load break switch structure should carry a solar panel and communication link. The solar panel shall charge the battery, and the battery will operate the closing and opening mechanism when controlled remotely from the National Control Centre.
13	Air break switch	Has 2 pole structures with a cross arm mounted with air break switch on the structure and operating rod on one side of the pole. In rural electrification, it is usually used for sectionalising the line to enable fault isolation located by fault locators. It usually located after every 8km along the line. NES recommends using automated distribution system to operate the Air break switch. In this case the air break switch structure should carry a solar panel and communication link. The solar panel shall charge the battery, and the battery will operate the closing and opening mechanism when controlled remotely from the National Control Centre.
14	T – Off	It is used where the line makes a junction from the main line. Either to a spur, independent isolated transformer substation(s) or to rink to another nearby line to provide an alternative supply hence improving liability to the area undergoing electrification, densification or intensification or extension in different direction. The structure carries an earth wire or /OPGW, most of the times it is fused. When it is fused, it carries across arm called pilot crossarm and another fuse support crossarm and a lay pole. A lay pole is shorter than the main line pole.

Stays

This are required for all angled, sections, T – Off, and terminal structures. The number of stays required per structure depends on the type of structure, and the deviation angle. At times during stringing Line stays are essential.

Wind stays are usually used on flat lands where the wind changes direction during day and night. This change in wind direction affects the poles. In order to prevent the poles from leaning wind stays are used.

Line hardware

The framing of the structures and the specification of the actual hardware (bolts, insulators, Cross arms, etc.) will follow the Equipment Standards and standard construction developed in 1992 (specifications). These specifications have proven to be not only adequate but the economic use of materials for rural electric systems in all cases in which they have been employed. Moreover, these same structures have been used in rural electric cooperatives in the service areas with remarkable durability and have proven to be safe both for consumers as well as utility personnel assigned to construct and maintain them. However, the clearances and specific insulators have to be chosen in accordance to the regions. Where there are strong rains and when passing over water surfaces great care should be taken to choose the hard ware and insulator class and type, cross arm width (clearances) and in order to maintain the line in service during such conditions, the line protection auto re-closer function shots (operates a number of times) must be increased according to the technical decision of the system operator.

System Control and Automation of network Operation.

The main purpose of automation is to obtain better system performance (optimization by quick automatic change of network configuration to suit the best network economic performance, contingency and operational flexibility) and to improve the reliability of supplies to customers by faster clearance of faults and restoration of supplies.

Uganda had a conventional distribution network arrangement with solidly earthed neutral. Any faulted MV feeder was identified solely from the operation of the protection relays, air gaps and fuses. In the 1990's the introduction of SCADA assisted to have the flexibility of controlling all the generation, all substations (132/33/11kV) and MV lines from one control centre which was located at Lugogo. In 1996, modern relays and microprocessor, computer-based relays were introduced. These were incorporated in the system together with logic–controlled sectionalizers (air break, knife blade link and load break switches) with fault locators. This led to more rapid and cheaper option of fault isolation, operation and restoration of supplies.

Introduction of tele-controlled disconnectors distributed around MV network were a further extension of automated system operation. This reduced further downtime for fault clearance, network maintenance and optimizing network flows to reduce system losses (minute to minute planning). Using suitable computer hardware and programmes (eg.DigSilent, PSSE), network configurations can be automatically re-arranged on occurrence of faults to minimize the consequences of further system outages.

The change from the Power Line Carriers (PLC) to OPGW cores or fibers made it possible for individual substation to control more lines, equipment, substation, generations as well as selling extra cores to telecommunication companies like MTN or Airtel, reducing on the cost of maintaining the electrical network. The original SCADA is operated from the National Control Centre and Umeme has its local SCADA in its local control centre. However the National Control Centre has a link to Umeme local control centre.

Current technologies off grid used:

Off-Grid Power Plants are not connected to the National Grid, thus they do not sell energy to UETCL. They generate and sell their energy directly to Customers. The main Off-Grids in Uganda are WENRECO and KIS.

The ERA has published Isolated Grid Regulations (December 2020), and ERA has worked with UNBS to set up standards. The Regulations have made it an obligation to a holder of certificate of exemption to adopt standards as stipulated in Distribution Lines Construction Guidelines 2017. Use of ready boards as an alternative means of connection from the conventional internal wiring is also enhanced in the regulations.

The table below shows the list of the Licensed Power Generation Plants as at the end of December 2018. All small Hydropower Plants (SHPPs), Thermal Power Plants, Co-Generation Power Plants and Solar PV in Uganda are operated by Independent Power Producers (IPPs) for off-grid purpose.

Table 30: List of current off-grid power plants operating in Uganda

No	Name	Category/Technology	Capacity (MW)
1	Pamoja-Tiribogo	Biomass	0.032
2	Pamoja-Ssekanyonyi	Biomass	0.011
3	Kalangala Infrastructure Services Limited	Diesel	1.000
4	Nyagak 1 – WENRECo	Hydro	3.500
5	Kisiizi	Hydro	0.400
6	Bwindi	Hydro	0.100
7	Swam	Hydro	0.040
8	Kalangala Infrastructure Services Limited	Solar	0.600
9	Absolute Energy – Kitobo	Solar	0.200
10	WENRECO – Thermal	Thermal	1.600
	Total		**7.483**

9.2 Recommendation on SWER: Not suitable in Uganda

Case study: In the 60's along the old Jinja- Kampala road SWER was installed and worked on until 1991 when people cut the trees that were in Namanve area. In other wards people started to clear the forest. The line was along the old road to Jinja. Then cattle keepers started grazing in the area where the trees had been cut and grass had grown.

On the fatal day, about 10 cows were grazing and herdsmen bear footed were chasing/taking the cows to the pasture ground when 6 cows died, including the herdsman.

The information/case was investigated and it was established that they had died of Step Voltage. Step voltage is a phenomenon where the current flowing into the ground builds up a potential between point 1 and point 2 (this step voltage is determined by measuring one meter on the ground and measuring the potential difference between those two points). The difference between the two potential points on the ground when it exceeds 67V according to IEC standards it can become fatal, which was the case. The Uganda Electricity board (UEB) decided to remove SWER from its system and wherever it existed a single phase system using two phase wires was put in their place. For that particular case UEB made it 3 phases immediately.

The problem is with the type of soil and nature of layers underground. Its also related to the way people wear as well as to the condition of the body and nature and gender of the person. Most people who are poor in the villages do not put on shoes which would have protected them from that phenomenon.

Secondary the majority of the herdsmen other people who depend on animals do not do Zero grazing, they move with their animals from place to place, therefore they are very prone to fall victim to that phenomenon.

The third reason the cattle type in Uganda (the Ankole Cows) are long much more than 1 meter between their hooves increasing the potential difference, thus the risk of the cows falling victim.

Fourth reason is improving the earthing one can say could eliminate the problem. In Uganda thefts of earth wires, stay wires and stay rods are common. This is most rampant in the rural areas. One can never know when the earth wire is stolen until more causality is found.

Fifth reason, the farmers in Uganda are not mechanized they use their hands while bare feet are on the soil cultivated. They at times use one arm interchangeably which can lead to very bad current path through the heart and a person dies instantly.

Sixth reason the entire system is solidly earthed, none of the medium voltages are Isolated hence a system with high earth current. This high earth current usually leads to big step voltages unless extra measures similar to those taken for substations are done.

In 1998 during the meetings that were trying to establish the eastern and southern power pool of southern and eastern African countries debated over this SWER (Set up Think Tanks) and concluded that it should not be used in Uganda. Copies of the deliberation could be found in the libraries (Former UEB Library).

Due to the fore said this system though may seem cheap it is not safe in the Ugandan context.

9.3 International benchmark of low cost technology options

Comparison of distribution technologies used for MV systems – Regional Benchmark (2015)

Low cost distribution solutions for rural areas can exist in the following options:

- Single Wire Earth Return (SWER): when the load density is small and its expected growth does not justify an upgrade of the system in the coming years,
- Shield Wire System (SWS): the best solution to supply remote areas where the transmission lines are crossing already,
- Single phase laterals: when the load density doesn't allow the previous solutions,
- Three-phase (backbones and laterals) is the standard technology, applicable when the load density is sufficiently high.

Table 31: Comparison of distribution technologies in countries of successful implementation

Characteristics	SWER	SWS	Single phase	Three phase

Load supply capability	≈1.5 x Ph-N	Substantially more as conductor cross section is higher	Ph-Ph: 2 x Ph-N	6 x Ph-N
% Voltage drop as times 3-Ph drop	≈4 times	Small	Ph-N: 6 times Ph-Ph: 2 times	1
Investment costs as ratio of 3-Ph cost	Less than 40 % of 3-Ph lower cost depending on terrain and use of longer spans	No significant MV cost at close proximity to Transmission line	About 70 % to 75 % of 3-Ph (inclusive of LV network savings)	1
Usual MV Voltage ranges used in kV	19.05, 12.7 kV	Usually around 33 kV	Ph-N: 19.05, 12.7 kV Ph-Ph: 33, 22, 11 kV	33, 22, 11kV
Issues related to selection of technology	Earthing system design needs special attention. Precautions need to be taken for theft and vandalism of the earthing system	Supply locations need to be close to transmission line	Ph-N will need a 4 wire MV system Ph-Ph can conveniently be extended from a 3 wire MV	Standard technology
Use of single phase transformers	Possible	Possible	Possible	Possible
Use of three phase transformers	Not possible	Possible with 3-Ph SWS	Ph-N: Not possible Ph-Ph: Possible with openY – openΔ	Possible
Countries with successful application	New Zeland, Australia, Brazil, **South Africa, Tunisia**	**Ghana,** Laos, Brazil, **Togo, Burkina Faso**	USA, Canada, **South Africa, Tunisia,** Philippines, Thailand, Bangladesh, south	**Widely used in all countries**

			American countries	

***Note:** The comparison is on MV systems[23]. Single phase includes both Phase-Neutral (Ph-N) and Phase-Phase (Ph-Ph). Three phase is indicated as 3-Ph. Load supply capabilities and voltage drops expressed in approximate terms as these will vary with conductor sizes used. The load transfer ratios are based on the use of the same conductor size and voltage drop is computed based on the same power transfer.*

Source : EUEI PDF (2015), Low Cost Grid Electrification Technologies – A Handbook for Electrification Practitioners

Case study 1: Technical standards for Rural Electrification as proposed in Benin (GTC, April 2010):

The following standards were introduced in Benin in 2010 through a decree in order to shift from usual standards originally designed for urban electrification to rural electrification patterns.

- Use of a Manually Operated Medium Voltage Air Break Switch at the head of a cluster of several transformers instead of at the head of each transformers: possible cost reduction of 66%,
- Use of wooden supports properly treated. Wooden poles are widely used throughout the world for alignments and for small angles (a few grades and without exceeding the limit of admissible forces) for both Medium Voltage networks and for Low Voltage networks. Wooden poles bring a budget reduction by 60% compared to concrete: the concrete pole is 2.5 times more expensive. But the use is subject to the following key conditions: make sure the poles have been well dried and impregnated. There is the possibility to use wooden poles at an angle with guy wires or strut-type poles. The wooden structures installed before 1990's which were well treated with creosote and mature eucalyptus saligna are still on the network.
- Use of twisted Low Voltage cables (Aerial Bundled Conductors ABC) 3x16 + 54.6 + 1x16 outside the main LV outgoing feeder network: possible cost reduction of 20%,
- For twisted LV conductors, the minimum guard height to be respected is reduced to 5m instead of 6m: possible cost reduction of 11%.
- Economic analysis of automated distribution system indicate considerable savings and quick restoration of power supply. Rather than considering initial installation costs, it is recommended utilising Distribution system Automation and incorporate Grid Metering with fault locators to enhanced economic development in the connected areas.

Case study 2: Comparison of generation costs for decentralized or connected configurations, Ivory Coast (2015):

In the specific context of Ivory Coast in 2015[24], IED has analysed the production costs of various technical options for rural electrification, among which solar, hydro and biomass. These options were both analysed for isolated rural systems and grid-connected configuration.

[23] The nature of settlement, the main distributing substations philosophy, and system losses are the main factors in selecting and optimizing the voltage the nation uses as referred to *Distribution system Planning, Design and Loss Reduction Study Final Report Volume 3a; Economic Comparison of Distribution Voltages; Study by IVO International LTD - December 1992*.

[24] IED (2015) PDER Côte d'Ivoire

For isolated systems, the conclusions gave priority in terms of costs to hydroelectric: from 0,15 to 0,21€/kWh depending on the remoteness of the site and the unit costs of the plant, and biomass (0,20€/kWh for gasification production) options.

For grid-connected options, 'biomass' thermal power plants and small hydropower remain very competitive with delivered energy costs ranging from 0,06 to 0,12 €/kWh for biomass and 0,07 to 0,13€/kWh for hydropower. For solar power plants, the production costs negotiated in Burkina Faso was in the range of 0,10 to 0,13€/kWh. It is noted that between 2015 and 2020, solar powerplants prices have decreased compared to other options.

9.4 Review of solar technology options

Today, the quality and performances of small PV products have improved with the entry of new technologies as LEDs, LFP batteries, PAYG. Smaller capacity and size systems offer the better lighting & service quality for lower prices.

Worldwide, the domestic PV market is booming, and many manufacturers offer innovative solar products (lanterns <5Wp, pico <10Wp and SHS <1,000Wp). This solar PV market is efficiently controlled by the **Lighting Global initiative** and certification. More than 192 solar energy kits and 425 solar appliances can be easily verified online (https://www.lightingglobal.org/products/).

Regarding standards, Uganda refers to the International Electrotechnical Commission (IEC). This includes notably standards and recommendations for solar PV modules & systems (CEI 61215-1:2016 and EC TS 62257-9-5: 2016), small hybrid systems for rural electrification (CEI TS 62257-1: 2015 and CEI TS 62257-9-2: 2016), batteries, charge controllers, lamps, etc. There is no national standard established yet, but as mentioned in the section 5.4.3, it is recommended to strengthen the capacity of UNBS in order to apply standards on (i) importation (IEC and LA), (ii) design, (iii) installation and (iv) usage. In Uganda, the PV products offer available today for domestic uses is rather large with various suppliers, brands, sizes, quality and prices.

Pico PV and SHS kits

Pico solar systems are characterized by:

- their small sizes (<20Wp);
- integrated or external modules;
- 1 or more light points; optional mobile charger,
- Plug-&-Play, robust, efficient, reliable;
- affordable by rural households (> $11);
- cost effective compared to traditional alternatives such as flashlights.
- Price: $17 (1Wp); $350 (20Wp)

The other solar products and applications are:

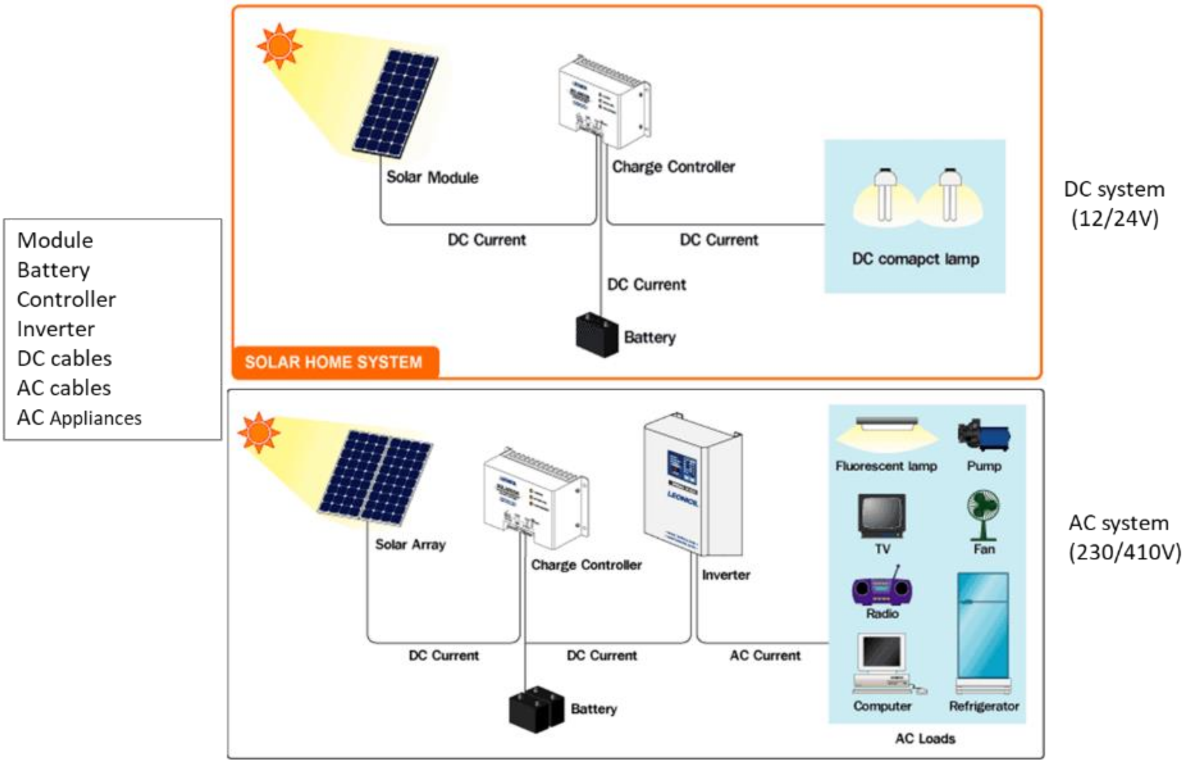
- Solar Home System (SHS): 20 -500Wp
- Public or community units: telecommunications, administration, health, education: 100 – 1000 Wp
- Productive units: refrigeration, motors, pumping, multifunctional platforms: > 1 kWp (see section 5.3.4 Characterisation of the business models of solar PV kits)
- Village mini or micro-grids :> 10 kWp
- Price: from 30 Wp: 250,000 FFC ($15 / Wc) ; from 1 kWp ($10 / Wp)

Pay-As-You-Go systems can be applied to pico and SHS. They allow :

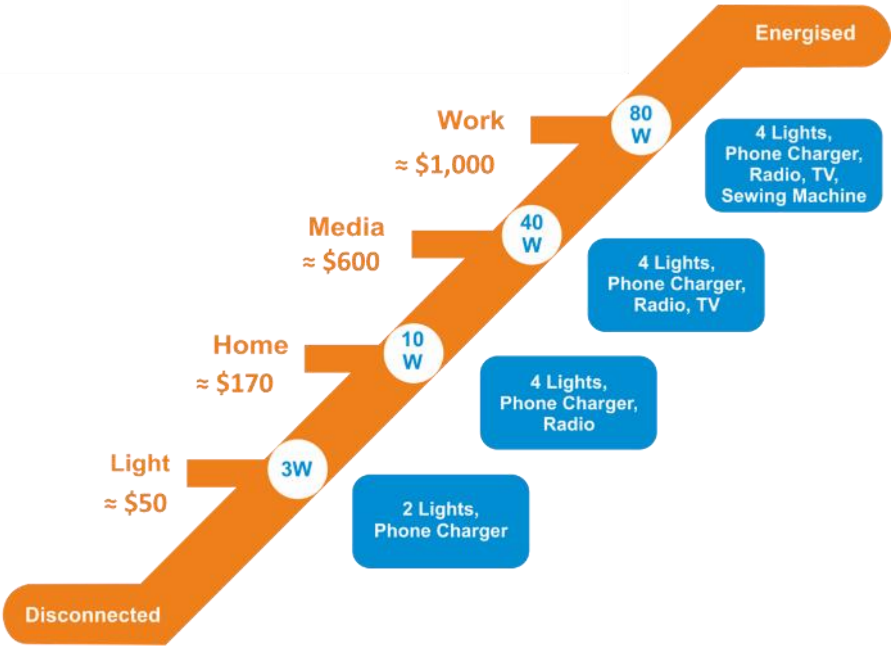
- Payment of a fraction of the price at the time of purchase (which eliminates the barrier of initial costs)
- Then the reimbursement of the remaining amount in small instalments at the pace of its use.

Solar components

A distinction is made between AC (alternating current) and DC (direct current) systems. The diagram below shows the components:



The range of use for small DC solar kits:



Solar PV modules:

Polycrystalline:

- Expensive
- High efficiency 13% to 18%
- Good performance over time
- Suitable for residential & small buildings

Monocrystalline:

- Most Expensive
- Most efficiency 15% to 20%
- Good performance over time
- Suitable for residential & small buildings

Amorphous thin film:

- Cheap
- Low efficiency
- Bad performance
- Not suitable for residential & small buildings

Battery storage:

- Technologies : NiCd – NiMH– LFP– Li-Ion – SLA – VRLA
- Capacities: few mAh/2V to 4000Ah/2V
- Performances: car batteries <> solar batteries
- Lifetime (cycling): 1-2 years 7-10 years (LA)
- Cost ($/Ah and $/kWh over the lifecycle)

VRLA

Li-Ion

SLA

Ideally, energy storage for mini-grid stabilization must have the following features:

- High power density (more important than high energy density).
- High efficiency and little change of efficiency with the change of the rate of discharge.
- Discharge duration at its rated power (or higher if possible) for a minimum of two minutes
- High reliability.
- Very fast response time.
- Flexible ramp rate.
- Low cost.

Charge controller:

- Charge and discharge protection
- Battery level indicator
- Fuse protection
- High efficiency (> 95%)

Different models of charge controller

Inverter:

- Technology :
  - Low cost small inverter (100-1000W)
  - Battery inverter (« grid-forming ») : set the voltage and frequency of the minigrid.
  - Grid inverter (grid injection) : match the voltage, frequency and phase with the utility-supplied sine wave of the grid.
- Efficiency: > 90% (>20% of nom. Power)
- Lifetime: > 7 years

Low cost small inverter

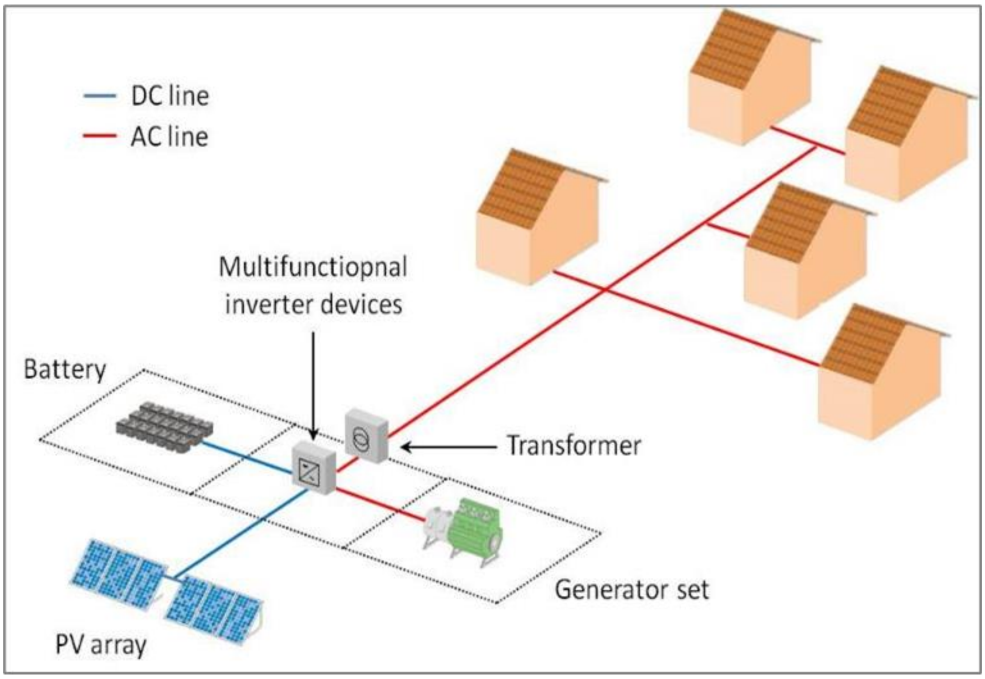
Battery inverter

Grid inverter

Solar mini-grids

PV / diesel genset hybrid-systems offer interesting opportunities and can be used productively within local minigrids. A hybrid generation system is a system combing two (or more) energy sources, operated jointly, including (but not necessarily) a storage unit and connected to a local AC distribution network (minigrid). As PV power output is DC and minigrids operate in AC, at the heart of the hybrid system are the multifunctional inverter devices able to convert DC and AC currents, control the generation and storage systems and set up the voltage and frequency of the minigrid.

Figure 15: Schematic view of a PV / diesel hybrid system for rural electrification



Micro solar plant Plug & Play

"Plug & Play" containerized micro-solar power plant solutions as illustrated below are increasingly used by developers (e.g. by RVE Sol developer in Kenya):

Common appliances of PV systems

Requirements: DC vs AC; Power vs Energy

Most common appliances for rural needs:

Light (1-20W)

Mobile phone (2-7 W)

Music player (5-20W)

TV – VDO (12-80 W)

Fan (20-60 W)

Refrigerator (35-150 W)

Water pump (> 600 W)

Motors (a few kW)

Iron (1-2 kW)

A list of different appliances with typical power ratings and daily usage durations are presented in the table opposite:

Appliances	Rating (Watts)	Operating Hrs/day
Incandescent Bulbs	40	6
Incandescent Bulbs	60	6
Fluorescent Tube light	40	10
Night lamp	15	10
Mosquito Repellent	5	10
Fans	60	15
Air Coolers	175	8
Air Conditioners	1500	6
Refrigerators	225	15
Mixer / Blender	450	1
Toaster	800	0.5
Hot Plate	1500	0.5
Oven	1000	1
Electric Kettle	1500	1
Electric Iron	1500	1
Water Heater - Instant type (1 to 2 ltr capacity)	3000	1
Water Heater - storage type (10 to 20 ltr capacity)	2000	1
Immersion Rod	1000	1
Vacuum Cleaner	700	0.5
Washing machine	300	1
Water pump	750	1
TV	100	10
Audio system	50	2

9.5 Technical recommendations

9.5.1 Technologies, design criteria and technical principles

The different modes of electrification and technologies are studied according to the planning criteria presented in the section 10. Overall, standard technologies described above are applied, while least cost techniques are studies on a case by case basis according to the local situation: topography, distance to the grid, load forecast, expansion perspectives, etc.

All projects to support the NES will be subjected to a baseline study in order to adhere to best electrification principles. The baseline study will be able to guide and direct the implementers how to proceed. i.e. what sizes of the conductor, material will be used, economic activities of the area, load forecast of the area, willingness and ability to pay, etc. On completion of the project, a closure report should outline the lessons learnt and from there the future changes, standards and costs reduction can be recommended. Consideration for technologies should be developed within the following design criteria and technical principles that will guide the implementation of the NES:

- Standard on-grid and off-grid technologies to be used overall (the NES refers to the distribution and not to the generation and transmission which need to be studied specifically).
- Least cost alternatives to be considered on a case-by-case basis
- Unit cost assumptions
- Standardization of supplies
- Standardization techniques for designs
- Centralized acquisition of goods
- Minimum operation costs and flexibility
- Quality, safety, health and environment of the expected service
- Mini-grids

- PV solar kits
- Suppressed demand

Table 32: Recommendations for distribution technologies

Principles	Description and recommendation
Description of distribution technologies to be used overall	As part of the NES, we recommend using three-phase as standard technology. Detailed planning and proper load forecasting of demand and system analysis will make it possible to size the grid to be built and optimise it as accurately as possible. The technologies described below concern future extension and densification projects, but also the needs to bring the existing grid up to right standards when it is in default (a point which should be the subject of specific studies). **The three-phase network** (backbones and branches) is the standard technology, applicable when the load is sufficiently dense and high. The use of light standards makes it possible to reduce the cost of connections: three-phase 25kVA transformers supplying low-section LV feeders (50mm²). For an average charge density, the advantage of using alternative technologies of the single-phase type is quite low compared to the use of three-phase light standards. A single phase supply increases system losses as a result of negative sequence induced in the network. For the correct implementation of the NES, we recommend the following technical specifications: **For the MV grid:** ▪ **11kV and 33 kV Medium Voltage Lines in 50, 100 and 150 mm²** AAAC. The following specifications will be followed: In case of densification and extension, in order to minimise resources and optimise the system operations, the existing medium voltage shall be used In case of 11kV, the material, clearance and standards shall be of 33kV but to be energised with the existing voltage 11kV. In case of rural electrification 33kV shall be used as recommended in the study made in 1992 and proved viable ever since. 11kV can be used when the existing voltage in the area is 11kV for lower density areas, while in other areas 33kV is the preferred distribution voltage. However in the future, the 11kV network shall be phased out to 33kV. When carrying out maintenance, refurbishment of these existing infrastructures during extension, densification and rural electrification, the designs of the structures should be for 33kV. ▪ **The MV overhead network** will consist of main lines made up of cables/conductors with sections 50, 100 and 150mm². They are overhead bare conductors and firmly and rigidly connected to the structures (urban environment). The secondary lines could be of sections of 50mm² for the short taps/spurs if the priority is to increase access in isolated areas with very low consumption: the supply of 50mm² is indeed 50% more expensive

	than 35mm² however during operation keeping store stock with many conductor sizes is more expensive than the approx. cost of 35mm², this is why NES recommends 50mm² after all from the recommendation made by the Diagnostic Review Study the Special Service Provider is expected to be aggressive in increasing consumption in a shorter period. . Conductor selection should be done using proper engineering techniques of using minimum cross sectional area for the expected demand and other factors. ▪ **The MV underground network** will be 3x70mm² XLPE 3C. This will be the case in particular for the connection of a cabin /metal clad/GIS underground substation to the overhead conductors, or from 132/33kV substation . The 3x35mm² sections could be considered if priority is given to access in low consumption areas. This arrangement is optimum for the rural electrification and also maintaining already existing store stock arrangement. ▪ **The distribution substations** will be sized according to a detailed study of demand forecast at the time of project preparation. They may be of the pole mounted type for powers from 25kVA to 200 kVA or cabin substations for powers from 250 kVA to 400 kVA. ▪ **The Air Break Switches / Disconnectors** could in principle be placed at the cluster ahead of several transformers for a cost reduction of 66%[25]. On spurs and trunk line Air Break Switches / Disconnectors /knife blade links should be placed at every 8km to minimise loss of many customers at any one given time. ▪ **Extend the national and local Control Centres** for remote management and automation and SCADA. (Air Break Switches, grid metering and fault location and isolation) of the whole grid system, in order to minimize operation costs, improve client management, reduce on outage time and improve reliability, identify losses and faults, etc[26]. **For the LV grid:**

[25] It is possible to reduce the outage time of an intervention on a cluster of transformers by disconnecting the fuses of the faulty downstream transformer and LV line. Thus, the disconnector switch is only open for a short time so that the operator can isolate with a pole only the LV part of the cluster that requires intervention. This type of intervention, recommended by installation companies, however, requires that a rigorous intervention protocol be followed because the rest of the network will be energized after closing the disconnector, once the fuse has been disconnected. To do this, we recommend the systematic installation of fuses at the level of the transformers: it allows the operator to visually signal the opening of the circuit. However, we recommend that a specific study be carried out before confirming the extension of this proposal.

[26] Whenever a new facility is commissioned, it should be integrated in the control centre. However, in order for the control centre to operate properly, there are other requirements that should be in place like (1) minute to minute forecasting and planning, (2) generation control, (3) incorporation of modern load shedding devices (area droop control), (4) availability of updated system drawings (Single Line Diagrams and operational drawings) (5) grid metering at the moment is being done on generations and HV and MV feeders only. This should be done for the distribution system and fully integrated to the grid system.

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The overhead LV network will be made up of ABC AAAC, 3x70mm^2 + 1x54.6mm^2 and 3x50mm^2 + 1x54.6mm^2 sections in urban and rural areas. The 3x35mm^2 + 1x54.6mm^2 section could also be used in rural areas depending on the load forecast.
The LV underground network, the sections used are 4x16mm^2, 4x25mm^2, 4x35mm^2, 4x70mm^2, 4x95mm^2, 4x185mm^2 depending on the load forecast. The LV is installed for transformer cabin stations (feeder pillar/cubicle) exits and for restrictive passages.
Making 100 or 50mm^2 aluminium earth downspouts (earthing rods): It is advisable to use 100 or 50mm^2 aluminium earth downspouts which have electrical characteristics at least equivalent to copper and which are 2 times cheaper. In addition, this prevents the theft of copper which weakens the grid: cost fallout of damage to cables (earth links and transformers) are often huge. Multiple earthing will be implemented on all LV network (earthing every after one pole and the terminal pole).

Regarding the mechanical sizing of the pole supports, we recommend:

Use of wooden poles complying with the standards of the Uganda National Bureau of Standards (UNBS)[27]. These supports can be used for low angles for both MV and LV networks. They are very widely used all over the continent.
<u>The quality of the treatment is essential to prevent negative opinions or experiences relating to the vulnerability of the poles to bush fires and termites</u>: the consultant was able to observe in many countries including Uganda wooden poles in perfect condition, yet established for more than 20 years in cultivated fields which are burnt annually.
During various calls for tenders, it was found that wooden poles treated with creosote are less expensive than concrete poles produced locally. The gain is around 25%. If creosote treatment is prohibited, then imported wooden poles (mainly from Europe) are as expensive (if not more) than local concrete poles. Special precaution if the ground is loose: strut or guyed posts or concrete posts. The installation of wooden poles with transport is in all cases much easier than concrete poles: installation cost 2 times cheaper. In all cases the poles are working for whatever angle of deviation in Uganda with a corresponding change of the structure.
Use of locally produced concrete poles; concrete poles can be used as an alternative to wooden poles.
The use of towers, PB structures, monopoles is possible in particular in lake areas (and if imposed by donors), but not recommended elsewhere

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[27] See ERA : The Electricity (Acquisition of Wooden Poles in The Electricity Industry) Guidelines, 2020

	because they are more expensive than wooden or concrete poles (50% more expensive than the quotation for concrete poles supply of the offers received in the framework of different programmes run by the consultant). ▪ **Deployment of ready-to-use switchboards** that can be paid for in instalments and enable low-income households to connect to grid electricity without the need for expensive house wiring. We finally recommend to develop cost models for standard voltage levels (33kV, 415V and 230-250V). 11kV models are not recommended since this system will be phased out.
Least cost alternatives that can be considered on a case-by-case basis	According to the recommendations of the World Bank, least cost alternatives should be considered as much as possible because the priority issue is to maximize access for a given budget. The alternatives listed below (in particular two-phase or Single-Phase Grounding) but also optimal electrical and mechanical sizing can significantly contribute to accelerating the achievement of universal access objectives. Within the planning process of the NES at national level, it is not envisaged to propose a priori one of the alternatives described below that would be selected according to an automated geospatial calculation. Indeed, the proposals below are to be studied on a case-by-case basis. Depending on the conditions apprehended locally. On the other hand, as described above, the electrical and mechanical sizing must be systematic and optimal in relation to the load. This principle should be applied in the implementation of the NES. ▪ **Shield Wire System (SWS)**: The best solution to supply remote areas where transmission lines are already existing. ▪ **Single-phase for the derivations (Single-Phase Grounding and Two-phase):** The **Single-Phase solution** is of interest in terms of investment cost. In the case where the load is highly dispersed and a large number of derivations are single-phase, cost savings of 18 to 24% compared to three-phase can be expected. However, this solution has drawbacks, such as complex operation and maintenance (and therefore high maintenance costs), and a high risk of theft of the distributed neutral conductor (very frequent theft of earth drop cables). In addition, the Ugandan three-phase network is of the European type (4 wires) and not the continental type (3 wires). It is therefore necessary to adapt the existing system. The single-phase is still advantageous when it comes to serving very large area territories with low load density. The adoption or not of single-phase technology in Uganda can only be confirmed in the context of a specific and comparative study with other options such as two-phase solution. It would seem a priority that the two-phase is more suited to the situation in Uganda: see next point.

	Two-phase MV lines are suitable for medium and low load densities and when there is no transmission line nearby (SWS solution not possible). Two-phase networks require very few specific devices and can easily evolve to three-phase. The mode of operation is little changed compared to three-phase. This technology therefore has many advantages, both in terms of limited technical implications compared to the three-phase solution and in terms of cost reduction. ▪ **Single Wire Earth Return (SWER)** : this technology is best suited for rural electrification when the demand is located more than 10 km from the existing network with a maximum load of around 380 kVA or when the population density is very low. Correct consideration of potential fault currents and current stress issues is the key to SWER's success. However, as mentioned in the section 7.2 above, significant risks exist if the resistance of the earth is variable during the seasons (which is generally the case with the alternation of rainy and dry seasons), in particular the dangerousness for people when the technology is poorly mastered, and the significant risks to the safety of people in the event of a failure in the quality of maintenance, or in the event of theft of the conductor and majority barefooted and not using mechanised farming. Therefore, this technology is not recommended in Uganda. ▪ **Reduction of the minimum guard (ground clearance) height from 6 to 5m in rural areas for the ABC and up to 6m for bare conductors,** depending on conditions and excluding roads crossings: the resulting cost reduction is 11%. ▪ **Use of ABC conductor i.e. the 3x16mm² conductor as LV cable**: when the expected load is low, the 3x16mm² + 54.6mm² section can be used. The cost reduction induced by this smaller section is about 20% compared to the 3x35 + 54.6 + 2x16 mm² cable. ▪ **Use of centralized poles for clusters of households:** Possible configuration of a higher central pole serving multiple homes around while respecting the guard distances: see example below in a urban slum (extremely dense area) in South Africa.

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Installation of LED-type public lighting: LEDS consume less than SHP-type public lighting.
Adoption of OPGW in the rural electrification set up and create a revenue base from data transmission.
Small capacity integrated substations: a promising development that offers potential for provision of supply to remote villages near a transmission line are pre-fabricated mini-substations with built-in features of a circuit breaker, disconnector, current transformer and surge arrester. Based on the design concept of a voltage transformer, these units were first developed to provide station supply to remote HV switching stations without power transformers, and for special applications such as mining sites and pumping stations close to HV lines. They are available at various capacities from ratings up to 500 kVA. The secondary voltage can be MV (33 or 11 kV) or LV (240V). All the key features of a substation are integrated to a single maintenance free unit which can be installed in a few days. This option has been recommended for consideration by the WB following the submission of the NES draft report.
A study of the distribution system to embrace emerging technologies in the sector.
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<tr><td>Unit cost assumptions</td><td>− See Table 44 in section 9.4.3.1</td></tr>
<tr><td>Standardization of supplies</td><td>− Public lighting boxes and type of public lighting (LEDs): The standardization of this equipment will allow better operation and facilitate maintenance in the event of a breakdown. In addition, LEDs consume less than HPS (high pressure sodium lamps).
− Prepayment meters: Prepayment meters with bi-directional transfer of data of the STS (Standard Transfer Specification) type are increasingly recommended:</td></tr>
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	they facilitate customer management and are compatible with each other, i.e. not linked to a supplier. These should be integrated to the grid metering system. – **Standardization of poles:** ensure stocks of spare parts on wooden poles and locally produced concrete poles (possibility of call-off contracts with manufacturers facilitating flexibility). – The **Design Manual and Technical Specifications** developed by ERA should form the guidelines for selection of equipment for primary substations, MV/LV lines, transformers and metering. The manual should guide on selection of conductors, poles and associated construction units. – **Standards for mini grids**. The ERA has published Isolated Grid Regulations (December 2020), and ERA has worked with UNBS to set up standards. It is a good step to have in place uniform national technical standards for mini grid development and operation. As described in section 7.4, one of the key recommendations is too strengthen UNBS capacities to ensure the enforcement of the quality standards. At the same time, the regulation should leave enough space for innovations and pilots.
Standardization techniques for designs	– Systematize planning via demand forecasting and software dedicated to optimizing the selection of localities and routes (e.g: integration of GEOSIM software into the working environment of the main institutions). – Systematize the electrical and mechanical sizing on the basis of a standard library. – Voltage Drop within Statutory limits: based on the continuous extension of MV lines, issues to do with voltage drop and loss reduction should be mitigated by creation of additional feeders at the primary substation, establishment of additional primary substations, provision for voltage regulators, conductor upgrade and supply radius for LV from the distribution transformer (the supply radius should ensure that the extent of the line does lead to voltage drop to be lower than 5%). – Overview of Uganda power system, load growth assessment, load forecast, distribution system management, accurate metering of feeders, input/output registers, prepaid metering for end users, completion of grid metering, adoption of designs that provide acceptable reliable requirements for the area. – Observe distribution system maintenance manual guidelines.
Centralized acquisition of goods	– consider a wide choice of procurement and contract management methods to be made available for efficiency purpose[28]. – Ensure that the procurement process of the framework/call-off contracts is transparent.

[28] For example call-off / framework contracts (flexible mechanism useful to take into account a short timeframes and ensure the budget is exhausted), international competitive biddings / PPDA (Public Procurement and Disposal of Public Assets), unit price or turnkey/EPC contracts, Transport and Labour contracts, supply and work packages: separate or not, EPC...

Minimum operation costs and flexibility	Enhanced operational cost reduction may be supported with the following measures: − SPV to ensure that material specifications establish standardised materials warehouse to avoid variations in costs of supply. − Create automated switching for efficient restoration of supply. − System interruption performance monitoring by regular review of data from System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI)[29].
Quality, safety, health and environment of the expected service	The document entitled "*ERA: Electricity Safety Code regulations 2003"* provides guidelines for safety. With reference to design manual, social and environmental impact assessment should be considered for: − Line clearance, weather and soil conditions, and applicable land laws for right of way of MV lines. − System protection for overcurrent, distance, earth fault. − Mechanical loads on MV/LV overhead lines. In addition: − Development of intervention protocols as part of the consolidation of the national and local Control Centres and monitoring of service quality (voltage drops, harmonics, protections). − Establishment of operational and preventive and curative CMMS maintenance indicators (incidence rate, duration of outage, repair time, establishment of incident feedback forms, etc.). − Regular verification of compliance with safety standards (e.g.: raised buildings after grid installation without respecting the standard distances from bare MV cables). Cases where the grid must adapt via remote armaments; case where the building must adapt to the existing grid (when issuing the construction permit).
Mini-grids	− Comply with the technical and safety standards of the national grid, in particular with a view to interconnection and safety standards (e.g.: guard height). − Minimum IEC certified equipment. − Establishment of a collection (and if possible, disposal) system for worn batteries.
PV solar kits	Solar kits are provided both in on-grid / mini-grid areas and in off-grid areas in order to supply households and infrastructures that will not be connected to a grid or mini-grid, given that a 100% grid connection rate is unrealistic. Below, we present the minimum characteristics recommended to guarantee quality: − PV equipment at least IEC certified. Recommendation of the "Lighting Global" label for pico and lantern systems.

[29] See : Uganda Distribution Sector Diagnostic Review and Directions for Future Reforms for Long-term Sector Development and Acceleration of Electricity Access Expansion : Report for the World Bank Group, 2019

	– Mandatory 168pprox.168g of equipment (manufacturing origin, performance) – Battery type: sealed lead-acid (SLA – maintenance free) or Li-ion or Li-Fe-PO4 – Type of lights for pico systems and lanterns: LED or CFL. Recommended minimum efficiency (brightness / power): 50 lm/W. Minimum lighting service: 600 lm.h/d (total quantity of light available, taking into account the capacity of the fixed battery). – Minimum output ratio of 3 Wh/Wp/day useful to assess the daily energy in Wh available in practice for the consumer in relation to the size of the panel in Wp. – Waterproof: minimum IP23 – Switch resistance to cycling: minimum 1000 'ON/OFF' – Socket capacity: 1.5W in DC and 100W in AC – Establishment of a collection (and if possible, disposal) system for worn batteries. – Labelling of distribution companies based on product quality, installation, guarantees and after-sales service – Encourage the development of the "pay as you go" system
specific measures to address the suppressed demand	This is due to load shedding, transmission or distribution capacities, poor quality and reliability of supply, strained network operating conditions... Specific measures to address the suppressed demand issues are described in Section 11.3.3. The overall suppressed demand including from industrial parks has been estimated at 2 420 MW.

9.5.2 Technical process for grid extension and densification

The implementation of settlement connection programmes to the main grid under the NES will be carried out in accordance with the following stages:

#	Stages	Points of attention
1	Selection of localities to be electrified	- If needed, update the criteria used in the NES plan and follow them to select localities in order to provide transparency in any planning process. - Systematically refer to the Plan proposed in the NES (regularly updated) for the choice and sequencing of the localities to be electrified. Any deviations from the NES should have technically, economically, environmentally and socially sound justification and approved by the MEMD. In that way, compliance to off-grid perimeters as defined in the NES should be guaranteed, otherwise this may create a prejudice for the promoters who planned their investments and may have performed surveys in selected off-grid localities. Lack of transparency and steadiness gives a negative signal for potential investors.

		- Project promoter (distributor who is the private operator(SPV)) must systematically involve UEDCL and the MEMD, which coordinates, collect project data and update the GIS and as need be, also involve other national and local stakeholders like REA: see section 4.3 on institutional aspects.
2	Demand forecast	Realistic demand forecasts based on existing data. The resulting sizing must proceed from realistic assumptions (and not on the supposition that any village can become a big town), taking into account the subsequent extensions provided for in the NES.
3	Carrying out of the basic preliminary design	- Study and confirm standard or low-cost technological choices by area and by locality to ensure that all relevant standards are conformed to. - Preliminary choice of the routes of the MV / LV networks at local level project by project on the basis of a geospatial optimization with basemap. - Environmental and Social Impact Studies (ESIA) will then decide on the possible adjustment of the routes. - Load flow analysis and Economic analysis for the selected options/ adjusted routes shall be carried out.- Choice of procurement method. E.g.:call-off / framework contracts, international competitive biddings / PPDA (Public Procurement and Disposal of Public Assets), local competitive bidding, unit price or turnkey contracts, supply and work packages: separate or not, Limited International Bidding (LIB), International and Local Shopping, Direct Contracting and Force Account. - Choice of supervision mode and project management: Recruitment of an engineering firm(an engineering firm can be EPC, BOT, BOO, turnkey) or internal supervision by the contracting owner - Define supporting programs: accompanying measures for income-generating activities, social intermediation for connections promotion and management, subsidy for ready-to-use switchboards (or 'readyboard') for low income end-users, etc. - Budgeting on the basis of updated cost references - Planning and coordination with stakeholders
4	Financing arrangement	- Choice of financial package (subsidies, mobilization of DPs, dedicated funds, national budget, etc. see section on financial aspects)
5	Carrying out of the detailed design studies	- Confirmation of line routes with regard to environmental and social constraints to limit impacts and risks

		- Electrical and mechanical sizing according to demand forecast, taking into account the surrounding localities around the network (<2km) regardless of the 2030 horizon of the NES. - Quantitative material slips with a % of spare parts (usually around 3%), especially on specific least-cost imported equipment. - Choice of allotment of supply and works contracts by considering geographic areas and types of works. - Drafting of the tender documents and description of the technical specifications of the projects.
6	Choice of suppliers, installation works companies and social intermediation	- Favor consortia of national and international works companies for large-scale projects - Establishment of certification for local works companies and suppliers / distributors of equipment - During the technical assessment of the offers, ensure the competence of the proposed key personnel (Check the actual experience, availability, material and financial resources of the companies in line with the scope of works). Carry out proper and unbiased bid evaluation according to the ICB/PPDA guidelines which should be closely monitored by MEMD and MoFPED, as well as solicitor general's office.
7	Carrying out of implementation studies by works companies	- Land surveys carried out by the company or selected contractor or company chosen to execute the works (connection point to the existing network, existing lines, obstacles, roads, buildings, etc.) to be carried out in conjunction with local authorities, in particular for wayleaves or possible projects in the settlement. - Final validation of the route with project management. Contract between the implementing partner, supervising consultant, the works contractor and local authorities. - Electrical and mechanical sizing of the infrastructures to be carried out, taking into account the BoQ[30] slip items and the ABC (Aerial Bundled conductor Standard)Submission of the implementation studies to the project management (grid map, staking logbook, longitudinal profiles for the MV lines and quantities, calculation notes, line route map plan, structural(technical engineering) drawings and systematic drawings taking into consideration the colour coding and installation, commissioning and operational instruction manuals). - Validation of the implementation studies by the project management

[30] Bill of Quantity

8	Execution and supervision of installation works	- Competitive selection of a contractor supervising consultant (key expertise may include distribution, procurement, social and environmental, evaluation and monitoring, etc) - Prequalification of material suppliers in conformity with set out distribution standards - Supply of the necessary material for the works - Carrying out the marking /pegging out of the selected routes which must be validated by the project management and the contracting owner and supervising consultant. - Carrying out the works (excavations, siting/pegging, unwinding of cables, and installation of equipment). - Monitoring of the works roll-out according to Engineering Memorandum No.14 and Uganda electricity construction set standards in the Distribution system Planning, Design and Loss Reduction Study by IVO International LTD, or their equivalent. Project management must ensure compliance with the planning of the works companies as well as the quantities according to BoQ plan, compliance with the safety distances of the cables in relation to the ground and the houses -> Establishment of works control sheets, etc.
9	Registration and management of connection requests and actual implementation	- An agreement card shall be filled between the utility and the customer. This agreement shall include security deposit of the meter, proof of land ownership or authorisation by the land owner, etc. - Choice of the payment and metering method of the customers (In case of Standalone Solar, DPs could fund the end-user or the utility. there can be a progressive reimbursement of the connection costs by the customer in line with his consumption). - Census and geo-referencing of people who can be connected to the grid (generally (500m in towns, 800m in trading centres and 1,000m in rural areas) from the nearest MV/LV distribution transformer in the urban area and 1km footprint from the nearest MV/LV distribution transformer in the rural area) consistent with their load demand (three-phase or single-phase meter, type of circuit breakers). - Commercial animation with all potential customers: setting up a stand and a sales team in the locality. - Baseline studies shall be carried out by the commercial department of the service provider to identify and register customers in an area who are willing and able to pay for electricity. When electrification starts, all customers shall be made aware through various awareness campaigns (e.g. through the service provider’s commercial department, social media, etc.) of what they need to do to be connected. If the area has no licensed wire men, the service provider

		shall prequalify a number of wiremen from the nearby localities from which the customers can choose at an already regulated standard and service cost. Customers who are not able to wire their houses but able to pay for electricity shall be given ready boards. Awareness should continue indefinitely. Registration should continue even when the project has ended for all emerging customers. - Physical connection of the customer to the network (meter, connection cable, and possibly ready-to-use switchboards/'readyboard') by the works company contracted and authorised by the service provider/utility or by the operator/utility. - Registration of the installed meters in regional and commercial databases (i.e., referenced to the grid) to ensure customer monitoring and that capacities of the transformers feeding the meters is not overloaded at any given time. The service provider should ensure that data transfer media for recharging the meter is properly commissioned and not overloaded. - Meters shall be integrated with grid metering-schemes, if not existing, these shall be introduced. - Training of end-users to recharge their meter via mobile money.
10	Case of a dedicated connection programme for grid densification	- The method of such a programme follows the steps and recommendations set out above. - Prior confirmation by area of demand in terms of consumption needs, capacity and willingness to pay by users for the electrical service (connection and consumption). Confirmation of the number of potential connections per target areas. - Three modes of financing considering that the cost price of a single phase connection amounts around $400: i. Connection funding for the end-user (with the support of the government or DPs); ii. Reduced initial connection tariff financed through a credit to the end-user (but not free of charge in order to guarantee the user's interest) and progressive reimbursement based on prepaid consumption with possibility of early repayments. To be included in the tariff for uniformity. iii. Capital contribution: in case the connection is economically viable, the customer does not need any support or to pay for the connection to the utility. But if after calculation (utility can have a simplified approach to establish whether the connection is economically viable or not using the data supplied by the customer), there is need to bring the connection to acceptable

		return on investment, then the customer shall be requested to pay a capital contribution. - Confirmation of the capacity of the existing network to absorb the additional load. Possible grid reinforcements to be planned. - Possible need to recruit a service provider (NGO, consulting firm) for the implementation support/or the strong commercial department. These will be responsible for identification and referencing of potential subscribers, marketing and commercial animation, registration, social intermediation, communication, promotion of productive usages, technical assistance for socio-economic development, training of end-users in recharging their prepaid meter via mobile money, etc. - Identification of potential synergies with other infrastructures and socio-economic development programmes. E.g. The “Electricity For All Program” funded by Power Africa is being launched in several African countries. This programme dedicated to grid densification and connections promotion can be useful to monitor and confirm technical, organizational and financial methods that have already been approved within the country are followed or complied to. - A proposed connection strategy for grid densification would be as follows: i. In towns/villages, electrifying all households within a radius of 600m from the 33kV /LV or 11kV/LV transformer and near pole 40 m away ,whose wiring has been completed , inspected and approved or willing to use ready boards. ii. In a radius of 1km from the 33kV /LV transformer, electrifying all commercial centres/trading centres whose wiring has been completed, inspected and approved or willing to use ready boards and willing to pay. iii. Transformer injections for villages whose population and economic activities justify densification criteria and in a radius of say 2km from 33kV network whose wiring has been completed, inspected and approved or willing to use ready boards have ability to pay and are willing to pay. iv. Power network strengthening to support densification to ensure reliable power supply and avoid supressed demand. All the above conditions shall ensure that the voltage drop of the furthest customer does not exceed 5% (11.5V) of the LV nominal voltage (230 V). From the value of voltage drop reduce or increase the radius accordingly.

11	Pre-installation activities	- Most likely, most of the equipment shall be bought from abroad. Factory Acceptance Test (FAT) must be carried out: these tests demonstrate that the equipment and parts have been manufactured to meet the requirement of technical specifications and that the various systems and assemblies as a whole function as specified. The utility can employ a company or it can send its representative or consultant to witness the tests on their behalf before the equipment leave the factory.
12	Site Acceptance activities	- On arrival on site, poles, line accessories, conductor drums, transformers and all equipment including cables and accessories shall be inspected and verified to ensure that there will be no delay in installation and commissioning due to supply of incorrect or damaged equipment or material.
13	Site Acceptance Tests, Commissioning and operation	- A Technical Acceptance Test (SAT) are to be carried out before network commissioning with the Project Manager / Supervisor, a representative from UEDCL/REA and the contracting owner/client (SPV) to demonstrate and prove that equipment and facilities provided are in full compliance with the technical requirements and performance (caution: ensure that the tested installation is not connected to the live grid). This acceptance must include assessment of the quantities and the technical specifications of the equipment installed (transformers, switch-disconnectors, auto reclosures), any reservations, conformity of the earth resistance measurement as well as control sheets. The equipment must also be tested to ensure that they operate as required according to the specifications and desired function. - During commissioning, the phase/phase and phase/neutral voltage must be checked and phased out (the phases are synchronised with the grid) as well as the proper functioning of the equipment (Opening/Closing of the switch-disconnectors for example) - Integration of the grid into the national and local control centres. - Monitoring of indicators with CMMS tool. Preventive and curative maintenance. Track record monitoring sheets. - Commissioning report/tests must be written and signed by three parties – contractor, contractor supervising consultant, client (UEDCL/REA/SPV)
14	Defect Liability Period	- After successful Commissioning, the Operational Acceptance (OA) certificate shall be issued. - Minor omissions, defects noted during the commissioning shall be recorded in the List of Outstanding Items which are refered to as defects which shall to be attached to the Operational Acceptance

		Certificate. These outstanding items shall be corrected within the defect liability period. The compiled set of the Commissioning Test Records shall be incorporated into the Project Completion Documents (Project Closure). - A copy of the Project Completion Document. This including the total project cost, as built drawings, operation drawings, manuals and test certificates shall be submitted to SPVs /utility Head Office (i.e., Finance and accounts department for asset register, Planning department for recording keeping, Maintenance and operation department for updating system drawings and SCADA data) and also for operational and maintenance purposes.

9.5.3 Technical process for off-grid electrification

The implementation of PV mini-grids and PV kits distribution programmes under the NES will be carried out in accordance with the following stages:

#	Stages	Points of attention
1	Formulation and launching of an off-grid Facility	- Mobilize and coordinate actions and funding with the DPs and institutions including SPV. - Definition of objectives and mode of financing: calls for proposals or spontaneous offers, areas identified by REA and SPV , results-based financing (RBF) or investment grants or combination of both, etc. - Possible choices by SPV of recruitment of a manager of the Facility - Dedicated communication actions (ex: website, OPGW)
2	Appraisal of project proposals carried by private promoters, selection of localities to be electrified, signature of financing agreements and concession agreements	- Systematically refer to the updated NES for the choice and sequencing of the localities to be electrified. Any deviations from the NES should in principle be justified and approved by MEMD (avoid the risk of off-grid perimeters which are not guaranteed for potential investors). - Private project promoters must be part of SPV and must be approved by UEDCL & MEMD, which coordinates, collects project data and updates the GIS. Also involve other national and local stakeholders: see section 4.3 on Strategic recommendations on institutional framework. - Give priority to projects that include social intermediation measures (e.g. promotion of productive usages, energy efficient appliances), innovative payment systems such as mobile money or PAYGo, systems of guarantee and after-sales service (in case of rental/sale of equipment or kits or /economically justifiable). - REA evaluates project proposals (as the case may be, with the support of the Facility Manager-SPV) and ensures a follow-up to ensure that the inconsistencies are corrected before the projects are submitted to the Regulator for approval. During the evaluation process, MEMD checks the

		consistency of the proposals on the basis of usual technical and economic indicators[31]. - The Regulator with UEDCL first checks the overall consistency of projects using standard indicators[32]. On this basis, it can approve authorizations without detailed studies which may be subject to a condition precedent and accepted by SPV, UEDCL, REA and ERA. This period between signature and entry into force is necessary for promoters to complete their financial closure and detailed studies settlement by settlement. - The Regulator approves an initial tariff, which will be revised after the first years of operation according to a simple and flexible mechanism, by ensuring, for example, an "adequate and attractive rate of return" for the promoter or by setting a "ceiling tariff”. This involves evaluating the off-grid projects with flexibility, taking into account the pilot nature of off-grid projects, the associated risks, the diversity of business models[33], the references/experiences of the project promoters in particular in relation to the tariff applied and accepted elsewhere, the uncertainties on demand forecast for the first years of operation, etc. As a reminder, the regulatory framework in force in Uganda is intended to be attractive for off-grid project promoters and investors thanks to (i) simplified procedures, (ii) adequate and reasonable remuneration, (iii) maximum and binding deadlines set for institutional stakeholders for application processing. Meeting deadlines is a strong positive signal to potential investors.
3	Procedures for projects implementation	- Lifting of conditions precedent of authorizations (e.g. land securing with the support of REA, SPV and UEDCL financial closure, construction permit, etc.). - Detailed studies, awareness campaigns and customer registration. - For MG projects based on biomass, hydraulic and/or diesel resources, ensure the continuous and guaranteed availability of the feedstock

[31] In practice, the points of attention where inconsistencies are most frequent, are as follows: battery life span taking into account Depth of Discharge DoD; Battery capacity / PV power ratio (minimum 3); PV power / inverter ratio (from 1 to 1.1); annual power production / demand ratio taking into account the drop in PV yield; system autonomy; ratio of the number of HH connections / LV km (60 maximum); ratio LV km / number of poles; realistic demand forecast, especially from non-captive productive users (condition for switching from a diesel to electric mill); cost ratios of the LV grid and PV plant per connection; etc.

[32] Such as: Annual energy (kWh/year/connection); Share of domestic demand; Annual growth in demand; Installed PV power (Wp) per connection; Investment ($) per kWp installed; number of LV clients per km (in year 1); grid CAPEX ($/LV km); CAPEX Connection ($/client); Investment ($) per client (in year 1).

[33] The scope of the regulatory framework in Uganda is open and does not necessarily imply too much interference in the business models of promoters, although it is essential to ensure the consistency of the data and assumptions of project proposals.

		throughout the year: site accessibility and supply during rainy and dry seasons, storage infrastructure, collection system, waste treatment, etc. A particular point of attention concerns the recruitment, training and supervision of local technicians, in particular on biomass projects since this technology has not yet been tested in rural and isolated conditions. - Supply, delivery, construction of mini-grids. - Commissioning, operation, preventive and curative maintenance, after-sales service with contact points (call center, local agency). - Implementation of monitoring sheets with indicators, analysis of incidents, track records and lessons learnt. - Establishment of mechanisms for components collecting, processing or reconditioning (especially batteries) through incentives (e.g. discount prices for batteries replacing of PV kits). - Continuous monitoring / evaluation of REA is essential. Need to set up reporting tools based on remote monitoring to minimize the site visit requirement.

10 Analysis of capital investment strategies & control mechanisms

10.1 Financial introduction of electrification options

Grid Extension, intensification and densification:

The three types of electrification based on the existing grid can be summed up below:

- **Grid extension** is the expansion of the country-wide network distribution to underserved areas. No buffer zone around the existing distribution system is applied in the NES. The selected option between grid extension and mini-grid results from an economic comparison: see Table 67: Criteria to select the base case scenario of section 12.3.
- **Grid densification** consists in installing additional transformers on existing medium-voltage feeders and laterals to connect housing clusters within 600 meters of existing distribution transformers.
- **Grid intensification** is when the area to be electrified is up to 1,5 kilometer away from an existing line. New transformers could be installed, and short medium-voltage lines extended to connect housing clusters that are beyond the reach of existing transformers and the medium-voltage system.

Those solutions leverage on existing assets and leverage on economies of scale in power production. However, while a large grid will ultimately result in the lowest-cost power prices, grid extension, intensification and densification require large upfront investments. Given that non-electrified areas tend to have a low economic output, the connected customers have low electricity consumption levels, which can hardly provide quick payback on the upfront investment. Grid extension investments therefore tend to require subsidies, either directly from the State or through additional fees on the existing grid-tied customers. Moreover, it is recommended to include accompanying measures while designing on-grid electrification programmes. These measures include promotion activities for productive use, sensitization and marketing actions to increase the connection rate of potential users located within the grid areas, social tariffs for grid connection and acquisition of readyboards, etc.

In practice:

- **The grid is usually managed by a single operator to ensure its stability**

The grid operation and maintenance are usually centralized with a monopoly undertaking electricity transmission and distribution. With this model, the electricity market is not vertically integrated. A separation between production, transmission and distribution forces operators to remain competitive. Nevertheless, the grid needs central management and planning to ensure its stability. There is a need to enhance the coordination between all actors of the power system.

- **Private players undertake heavy investment through PPP**

A single player can be fully public with private concessionaires through PPP agreements. In such cases the grid is generally attributed to a single player for 10 to 20 years through competitive tender, leading to a grid operator with mixed public and private shareholding and governance. In such schemes, the responsibility for investing in grid extension can be shared between public and private parties. However, due to the non-commercial nature of those investments, financing will usually include a significant share of concessional funding through low-cost debt or subsidies. Such financing will largely be issued by the State or require a guarantee from the State.

- **Grid distribution can be split among several operators**

This makes the sector more competitive and the cost of grid maintenance and extension is shared among multiple players. Uganda has different players in its distribution network whereby UEDCL manages multiple concessionaires.

Mini-Grids

A Mini-Grid is an integrated electricity generation, storage and distribution system that serves a closely clustered population or group of people. The clustered population is considered to be distant from the main electricity distribution grid and is not feasible to connect the population to the grid.

Power generation and grid development have high initial capital requirement with a long payback time, hence not profitable for private investors unless they are subsidized. As such, private investors prefer investing at the advanced stages of power generation and distribution as the returns are more attractive. Accordingly, PPAs are more likely to be the preferred option of financing mini-grids whereby initial investments are done by the government with the advanced generation and distribution activities privatized. The government may own the grid while the private companies conduct their services.

In practice :

- **Mini-grid development and management can be split among several operators between generation, storage and distribution**

Setting up mini-grids encompasses both power generation and distribution running independently to the main grid. Given that the projects are target specific, they require an in-depth understanding of the population to develop customized solutions. Usually mini-grids include production, storage and distribution.

- **The PPP can foster investment on mini-grids**

GoU under the Public Private Partnership framework distributes power to non-electrified areas. For instance, Kyegegwa Rural Electrification Cooperative Society (KRECS) which is the sole distributor of electricity in rural areas covering 13 districts as per the Central Service Territory demarcated by REA.

Stand-alone Systems

This method seeks to distribute power to individual households that cannot be centrally supplied with electricity through grid connection. It includes use of solar homes systems ("SHS").

Distributed power requires the most customized approach to electrification given that the target population is remote and may not be able to afford their electricity consumption. As such as DFIs heavily inclined to social and grassroot empowerment and other charity or donor organizations like foundations and charities are more inclined to participate in distributed power initiatives. This is because the target areas are remote and electricity generation and distribution in those areas require significant amounts of initial investments and subsidies to make them commercially viable. Developing governments tend to provide indirect financial support e.g through preferential tax regimes or exemptions. The use of subsidies is not financially sustainable in the long-term hence not adequately budgeted for.

In practice :

- **There are no licensing issues but the government should control the quality of products**

As stand-alone systems have a low capacity, they don't need to be licensed and operate as individual commercial products. Special tenders could be set-up by the ministry of energy to identify the most competitive companies that distribute the systems and propose it to the population.

- **Micro-finance institutions or PAYG operators undertake the up-front investment**

Most of the individual systems such as Solar Home Systems are coupled with a micro-credit to spread the initial investment over the project lifetime. After a certain time, the buyer owns the system.

10.2 Financing plans for ongoing strategies and policies

- **Electrification policies formulated usually do not include clear financing plans**

GoU has rolled out several plans to enhance the country's electrification as outlined in section 5. While some plans include elements regarding the financing mechanisms that may support their implementation, most strategy and planning documents do not include a detailed costing nor clearly address the financing question.

- **Current policies and strategies are not synchronised**

In as much as the NDP II and Vision 2040 make reference to the necessity of developing the Renewable Energy sector, there is no detailed financing plan to implement this development. However, RESP and CSTB Plans outline their projected budgets. It is estimated that RESP will require minimum funding of $951.6 million. Targeted finance sources include grants, long term loans, licensing revenues and subsidies. On the other hand, the CSTB Plan estimates its total capital expenditures for grid connection at $101.38 million, of which $65.03 million from 2018 to 2022 and the balance from 2023 to 2027.

- **Strategies are being coordinated and financing sources identified**

As the ECP 2018-2027 report shows, by developing budgets based on previously implemented projects. It estimated that 300,000 grid, mini grid and stand-alone connections should be done annually to achieve the 60% electricity access target by 2027. This will require an estimated annual funding of $ 55.8 million.

Item	Amount in $	$/connection
Connection materials	48,000,000	160.00
Verification of connections	3,000,000	10.00
Publicity mobilization	645,000	2.15
Ready boards	4,200,000	14.00
Total	**55,845,000**	**186.15**

Source : ECP 2018-2027 funding requirements

The ECP 2018-2027 tries to synchronize the NDP II and CSTB plans and budgets for successful implementation. It has outlined the intended funding sources to achieve 60% electricity access, targeting 30% of NDP II national connection target and 26% RESP II rural connection target, by 2027. In the formative stages, subsidies are expected to be the main funding strategy for consumer financing assistance for faster connection. At advanced stages, energy rebates and credit support mechanisms will be employed. ECP's funding sources are as shown below:

Government of Uganda

At Least 50% of the Consolidated Fund and Transmission Levy

Additional funding will be sourced from finance infrastructure, taxes, administration costs and compensation for right of way

Development Partners

GoU will engage development partners and source financing from global funding programs supporting electrification activities

Growth Factor Revenue

Annual Growth Factor Revenues of ESPs is expected to finance 10% of ECP's budget.

- **A clear financing plan is needed to match the needs with the sources from scratch**

While most policies fail to attract sufficient financing to reach the initial objectives, numerous Government-led initiatives, development institutions and private companies are active in the Ugandan electricity sector. There is therefore important funding available for the sector, however the complex ecosystem of stakeholders and funding facilities can prove difficult to navigate for public or private project developers. In addition, most funders have specific demanding financing criteria with limited flexibility and strong risk-adversity. It is therefore important to include a realistic financing plan from the strategy drafting stage, in order to make sure policies are promoting bankable solutions.

10.3 Analysis of the electricity sector financing

Key Financing Stakeholders

GoU is the anchor player of the sector by setting policies, regulations, frameworks and the overall direction of the sector. In addition, significant segments of the electricity sector are directly or indirectly Government-owned, such as the Transmission and Distribution as well as part of the Generation facilities. However, the development of the electricity sector in general, and electrification in particular requires massive investments. To meet the ambitious objectives set in the various plans, those investments cannot be solely carried on the State's balance sheet and budget. A large ecosystem of financing partners is participating to the sector, both commercial and development/impact driven.

Below are the **main categories of financiers** along with non-exhaustive lists of participants:

1. **The Government of Uganda:** GoU participates through providing state budgetary allocations, public debt, establishing REF and funding UECCC
2. **DFIs (Multilateral and Bi-lateral partners):** World Bank, AFDB, ADB, JICA, Power Africa, UKAID, USAID, DFID, KfW, SIDA, AFD, EU, GIZ, UN, NEPAD, Uganda Development Bank Limited. Private sector financing branch (IFC, PIDG, Proparco, DEG, CDC, NORFUND, UNCDF, etc) and of recent Exim Bank of China.
3. **Foundations:** Shell Foundation, Phillips Foundation, Mastercard Foundation, Rockefeller Foundation, Bill & Melinda Gates Foundation, etc.
4. **Commercial Banks**: Equity Bank, Stanbic Bank, Ecobank, Bank of Africa, NCBA Bank and Centenary Bank. However, the participation of commercial banks to the electricity sector remains very limited due to their lack of understanding of the specific associated risks.
5. **Investment Funds**: GroFin, I, SunFunder, Novastar, Energy Access Ventures, Acumen, Root Capital, Berkeley Energy, AIIM, Frontier, etc.
6. **Off-grid companies**: Bboxx, Mobisol, Powergen, PowerHive, PowerCorner, Fenix Intl, M-kopa solar, Solar now, Bright life, Village power, Solar today, One lamp, etc.

It should be noted that a number of investment funds and off-grid companies have DFIs among their main shareholders or founders. DFIs are therefore fundamental players in the financing of the sector. In fact, Energy is among the largest portfolios and a core focus area for most DFIs.

Current government-led initiatives

Given that the energy sector is a core enabler in achieving GoU's development targets, specific measures and initiatives have been set up to provide a platform for the development of the renewable energy sector. Some of the state driven mechanisms are:

1. **Uganda Energy Credit Capitalisation Company (UECCC)**

UECCC is the Trustee of the Uganda Energy Capitalization Trust ("the Trust"), which is a framework for pooling resources from Government of Uganda (GoU) and Development Partners for development of renewable energy projects and programs. These programs are extended through Credit Support Facilities ("CSF") instruments to Financial Institutions.

UECCC was set up with a specific mandate as a Credit support institution to promote Private Sector-led Renewable Energy Projects and Programs. As such, it has developed products and services to meet these needs such as:

1. Solar refinancing facility
2. Power connection loan facility
3. Working capital facility
4. Biomass refinancing facility.

5. Partial risk guarantees

Most of the CSF instruments are designed to be provided through eligible Participating Financial Institutions (PFIs) to lend to eligible beneficiaries for Renewable Energy projects/programs and provides technical assistance to IPPs by delivering trainings and business clinics sessions. UECCC relies on Development Partners and GoU for funding which is limited to the project period.

2. Rural Electrification Fund (REF)

REF was established to meet the financial needs of implementing the RESP 2013-2022. This is a unique funds repository for approved rural electrification financing. The fund is financed using GoU budget allocations, loans, grants, donations and REA service provider financing in-flows. In the long-run, REF is expected to be self-financing with the ability to run a revolving financing facility.

It is estimated that the fund will require a minimum of $951.6 million of funding.

Item	Amount in $ million
On the Grid Electrification	866.5
Off-Grid Electrification Financing	55.4
Other[34]	29.7
Total	**951.6**

This funding is exclusive of contributions in aid of construction for on-grid electrification, electricity distribution (including system upgrades and replacements) supplementary financing and REA's operational costs in excess of the construction account financing inflows. It is worthwhile to note that UECCC funding supplemented by private capital sources are expected to finance power generation costs relating to RESP 2013-2022.

3. State Budgetary Allocations

The state has budgetary allocations specifically for the sector and initiatives directed to the sector's development. For the financial year 2019/2020, the state has a total allocation of **USD71 million to MEMD**. Out of this amount, USD1.04 million[35] and USD0.2 million were allocated for promotion of renewable Energy & Efficiency and the Renewable Energy Department of MEMD respectively while **REA was allocated USD27.9 million**[36]. Moreover, hydro power financing is currently being treated independently from other renewable energy financing complicating the cost-reflective analysis of the sector.

In addition, the state has set up policies that directly enhance financing to the sector including providing supplementary financing support such as subsidies, consumer financing assistance, provision of working capital and grants. Despite those specific budget allocations and policies, the sector is still heavily reliant on third party financing to meet the financing gap.

[34] Other costs will cover technical assistance and training costs, working capital costs and customer financing assistance costs.

[35] FY 2017/2018 average FX rate of USH 3,659.2/USD

[36] These amounts are net of the hydropower budget allocations.

4. **Public debt**

Some projects are being funded by the State through third party borrowing. Bi-lateral and multilateral development institutions as well as Ex-Im banks are the most active lenders, providing loans at concessional rates to support high impact projects.

Concessional Government to Government financing is a common solution for large and cost intensive infrastructure projects without a clear path to stand-alone commercial viability such as grid extension projects.

Non-government-led initiatives

Below is a non-comprehensive list of key programs and financing mechanisms available for Uganda

Table 33: key programs and financing mechanisms available for Uganda

Entity	Programme	Subsectors*	Description
Agence Française de Développement (AFD)	Sustainable Use of Natural Resources and Energy Finance in East Africa (SUNREF)	- Generation - Transmission - Distribution - Mini-grid - Standalone	Line of credit to selected local banks which are then on-lent to energy projects with development and environmental impact. The facility also includes technical assistance for mandated banks and project developers as well as a subsidies component.
Department for International Development (DFID)	Energy Africa Campaign	- Standalone	Provide financial, policy and regulatory support to enhance universal energy access through stand-alone systems.
Department for International Development (DFID)	Transforming Energy Access, (TEA)	- Standalone	Development of innovative technologies, business models, partnerships and skills to accelerate access to affordable and clean energy services.
United Nations	UN Capital Development Fund CleanStart	- Mini-grid - Standalone	Co-invests in early stage innovations from financial institutions, distributed energy service companies and other providers of wholesale or retail financing for clean energy.
European Union	Scaling-up rural electrification using solar PV distribution model	- Mini-grid - Standalone	The focus on energy security involves capacity-building and awareness-raising among stakeholders to ensure sustainable development.

Shell Foundation	Building an ecosystem to accelerate access to energy	- Mini-grid - Standalone	Provide business support by providing financing and technical assistance to entrepreneurs in the off-grid sector.
USAID	Scaling Off-grid energy Enterprise Awards	- Standalone	A platform for donors and investors to develop Africa's off-grid energy sector and coordinate investments to connect more households and businesses to electricity, faster. It will incentivize technological innovation, fund early stage companies, and support critical elements of the off-grid ecosystem.
USAID	The Power Africa Uganda Electricity Supply Accelerator	- Generation - Transmission - Distribution - Mini-grid - Standalone	With an estimated cost of $11 million, the facility will assist the Uganda government in establishing 1,000,000 new connections by providing grants and technical support.
USAID	The Scaling Off Grid Energy Enterprise Awards	- Standalone	Provide grants and incentives to off-grid initiatives through expansion and distribution activities ultimately subsidizing consumer costs.
World Bank	Energy for Rural Transformation, ERT I-III	- Generation - Transmission - Distribution - Mini-grid - Standalone	Increase access to electricity in rural areas of Uganda through business development support, provision of credit and capacity building.
World Bank	Lighting Africa	- Mini-grid - Standalone	Catalyze markets to deliver affordable, high-quality off-grid lighting and energy products by providing consumer education, access to finance and business development support.
KFW	Get Access	- Mini-grid	KfW on behalf of Government of Germany and the EU is in the process of finalizing the

			concept and investment decision for the implementation 185 approx. 100 MG

10.4 Analysis of financing solutions available

Legal Structures and Financing

The legal and financing schemes adopted on projects are largely driven by the type of electrification method employed:

- On grid (grid extension and connection of new customers)
- Off-grid (mini-grids and stand-alone systems)

Off-grid methods are likely to be adopted for areas that are isolated from the main grid network and/or with low population density, where there is no electricity supply or where existing supply is inadequate. It is highlighted by the geographical analysis in section 10 of the report. The risk profiles of projects in different electrification methods are very different, which will directly dictate the type of financing instruments and players that can be used. In addition, to enable a risk allocation in line with various players' expectations, 3 key types of legal structures can be used:

- Government owned projects.
- Private owned projects with commercial risk and minimal government risk-taking.
- Public-Private Partnership with shared risks and ownership.

Below are some key advantages and disadvantages of each of those structures:

Table 34: key advantages and disadvantages of legal and financing schemes

Structure	Advantages	Disadvantages
Government Owned	• **Long term vision**: capacity to accept very long-term returns or to subsidize projects, e.g. capacity to fund non-commercially viable activities. • Can be used as a **catalyst to reduce the perceived risk** and attract private investors and thus leverage on public funds. • **Country-wide vision**: A single government owned off-taker can strategically leverage on cross subsidies so as to finance electrification activities in areas considered expensive and unprofitable. • Can **engage local** government authorities to create a sense of ownership and responsibility by the local communities hence better local participation and meeting local needs better.	• Can be highly politicized. • In a case of monopoly, the services may be poor and expensive due to **lack of incentive to perform**. • **Puts pressure on the State budget and debt levels**, and therefore needs to be blended with other sources as financing needs are very large in the sector.

Private Owned Commercial	● **Specialized players** expert in their field ● Can try new solutions on small scale and therefore **innovate** ● **Commoditized solutions** rather than project by project development: once a business model is economically viable and having strong demand, the activity **can scale up very quickly country-wide**.	● Commercial activities are not plan-driven and therefore only focus on **economically viable opportunities** ● Quality/relevance of solutions proposed (e.g. solar lanterns) needs to be controlled
Private Owned PPP	● **Specialized players** expert in their field ● Private investment: **small commitment and risk for the Government**	● Time and cost-consuming development process due to complicated PPP frameworks and contracts, requires expert teams on the Government side. ● Government often still needs to provide guarantees to make projects bankable

<u>**Electrification Methods and Financing Mechanisms**</u>

- **Electrification of rural areas is not commercially viable and therefore requires subsidies**

Rural populations that never had access to power start with a very small power consumption per connection, as they gradually get used to the new service, and buy additional appliances. In addition, households density tends to be low, especially in agricultural areas. This generates extensive grid works to connect very small customers, making upfront investment cost payback time very long.

As a consequence, regardless of the electrification method, the cost-reflective tariff is very high, however tariffs must be kept in reasonable ranges to make the service attractive. In addition, large tariff discrepancies between urban and rural citizens may create turmoil and not be politically acceptable.

In order to account for this, different electrification methods rely on various solutions:

- Grid extension to rural areas is either subsidized by the whole energy sector, often through "rural electrification fees" on all the electricity bills: urban consumers fund electrification, or subsidized through government support to the sector, on the State balance sheet.
- Mini-grids will require subsidies to cover a large share of the upfront investment costs, either investment-based or results-based (once connections are achieved) or a mix of both.
- Stand-alone Systems usually don't sell electricity but services along with the necessary appliances. This way no electricity tariff is displayed, and the focus is solely on service.

<u>**Grid extension, intensification and densification**</u>

- **Grid investment needs are very large and a common bottleneck for electricity sectors**

In relation to the point above, investments in extension, intensification or densification of the grid do not provide a clear path for financial returns. As a consequence, Government and DFIs support is often needed to subsidise or to provide concessional loans for grid maintenance and extension in order to fast track grid plans. However, due to that lack of commercial viability, grid extension and maintenance tends to lag behind the generation capacity increase on one end, and demand increase on the other end. Grid instability is one of the major hurdles in the implementation of grid strategies and can become a financial burden for the sector.

- **Cost efficiency can be achieved through competitive tendering**

Competitive international bidding and tendering to build, and possibly operate the grid is often considered as the most cost-efficient solution. In such a case, UMEME will remain hands on during the entire process and retain a stake in the outsourced services e.g conducting quality control checks and certifications, performance reviews and owning installed infrastructure.

- **Private-funded grid requires a mature energy market**

However, tendering rarely includes the infrastructure financing by private companies as might lead to increased transmission fees and therefore impact end-user tariffs.

<u>Mini-Grids</u>

- **The development of productive uses shall be supported through appliance financing**

In order to increase electricity consumption per connection, the development of productive uses is essential. Appliance-financing programs based on micro-credit models can be efficient in supporting customers to acquire appliances. This credit activity is complementary with mini-grid operations as the lender can rely on electricity payment records to define the credit capacity of borrowers. In this integrated approach, the Mini-grid operator therefore becomes a central partner in the village's economic development.

- **Mini-grids in rural areas are creating a new energy market for energy, but commercial viability remains a challenge in areas where demand and household budgets are limited**

Rural populations that do not have access to power take time to build demand. By generating this demand through connections and support to productive uses, mini-grids act as market-openers for the electricity sector.

- **Mini-grids require cheap and long term financing to fund their large upfront costs**

Financing mini-grids is challenging since it requires long term financing at low cost of capital. As such, local financial institutions may not only have the capacity to finance them but are also unable to understand and assume the risks and uncertainty relating to mini-grid development. In addition, project developers may not have the required technical capacity to set up bankable projects hence unable to raise the minimum capital requirements or provide the required collateral to attract financing. These setbacks have collectively limited UECCC's ability to offer additional financial support.

- **Generation and distribution activities may be separated**

Separating generation and distribution helps in attracting financiers as it ring-fences the respective risks exposures. Accordingly, power generation can be financed by private sources while distribution, which is exposed to demand risk, requires more subsidies and/or government backing. This structure can also enable Independent Power Producers to sell power to different consumers, such as a village mini-grid, an industrial company and the national grid often located closeby, hence enabling larger generation scale than for solely a village mini-grid's needs, and reducing the production cost. This structure has notably been used in Tanzania on small hydro sites with dual village / main grid off-takers.

- **Local community should get involved in mini-grids financing and operations**

Having local cooperatives as both owners and operators of the mini-grid encourages quality service and output. However, substantial technical assistance should be provided either by the government or a private entity and proper structures set up to manage potential internal disputes.

In instances where projects cannot be implemented directly, subsidized programs can be launched to extend financing to community and cooperative owned mini-grids. Nepal, through its Alternative Energy Promotion Centre (APEC) successfully scaled up electrification initiatives by providing mini-grid subsidies to community owned and operated mini-grids.

Stand-alone Systems

- **Stand-alone Systems are commodities which financing differs greatly from the project-based mini-grid or grid-tied transactions**

To have a significant impact, those systems need to be sold in very large numbers and therefore be treated as a commodity. To be capable of such large-scale deployment, companies in the sector require important corporate capital fundraising to develop their operations and inventory on one hand, and to fund the very large working capital needs associated with the PAYG service. Those corporate needs shall be funded primarily through equity, followed by working capital debt as companies reach a sufficient size. Eventually, large and stable portfolios of systems' receivables can be sold to third party, more financial investors, enabling the company to focus on its development.

Historically, GIZ through the Endev program (2009 to 2016) supported five solar companies in solar power products distribution. Currently, the ERT III program provides credit and guarantee facilities through UECCC to facilitate consumer financing needs and working capital for solar businesses supporting off-grid access.

- **Successful Africa financing solutions are being leveraged upon and tailored to needs**

Stand-alone Systems are strongly consumer based and mainly accessible on cash or PAYG basis to make them more affordable. This model can be made more convenient by leveraging on mobile penetration and growing digitisation using the PAYG model as it is implemented in Kenya. Given the individual use of the systems, financing products are designed to enable customers to obtain the ownership of products after a 1 to 3 years period.

Accordingly, a strong microfinance ecosystem provides for tailored financing products benefiting populations. Bangladesh was able to fast track its electrification process given that individuals could easily access financing based on their credit profile. Consumer tailored financing products were provided with a focus on long term sustainability and market development.

- **GoU can help to finance stand-alone systems through dedicated financial instruments**

Stand-alone distribution companies require significant capital injections to finance set up costs and operational needs. In addition, given that hands on follow up activities are done after disbursing the systems to customers and that customer repayment programs span a period of time, the companies therefore need higher levels of working capital financing.

GoU has ongoing programs and facilities that can be instrumental in financing stand-alone systems. These include provision of Credit Support Instruments (CSIs) through Uganda Energy Credit Capitalization Company (UECCC), Provision of credit for renewable energy technologies (RETs) through commercial banks, Provision of soft loans by NGOs Quality control and certification through the

Uganda National Bureau of Standards (UNBS) and Uganda National Alliance for Clean Cooking (UNACC).

- **Successful deployment of the technology hinges on consumers' trust**

Strong consumer confidence in the new technologies and respective organizations undertaking the electrification initiatives is paramount so as to encourage the consumers to not only adopt the new technologies but also take up loans to finance them.

Summary of the electrification methods and the financing sources available

The table below maps out electrification methods with financial sources through a breakdown of the uses and the related instruments.

Table 35: Summary of the electrification methods, financing instruments and sources available

Methods	Uses	Instruments	Sources
Grid extension, intensification or densification	Transformers, transmission and distribution lines, meters	Loans, grants, subsidies	UECCC, State Budget allocation, REF, DFIs, Foundations, Public debt
	Additional capacity	Equity, loans, guarantees	DFIs, Commercial banks, IPPs, Investment funds, UECCC
	O&M	Working capital	IPPs, UECCC, State Budgetary allocation
Mini grids	Production capacity	Equity, loans, guarantees, grants, subsidies	DFIs, UECCC, IPPs/ off-grid companies, Investment funds, Micro-finance institutions, Local communities
	Distribution lines and meters	Loans, grants, subsidies	UECCC, State Budget allocation, REF, DFIs, Foundations, Public debt
	O&M	Working capital	IPPs, UECCC, State Budgetary allocation
Stand-alone systems	Kit (production + storage + connection)	Equity, loans, guarantees, grants, subsidies through corporate finance	IPPs, Investment funds, Foundations, DFIs, State budgetary allocation, UECCC, REF, Micro-finance institutions, Local communities
	Money collection, last mile	Working capital	UECCC, REF, State budgetary allocation, IPPs, Micro-finance institutions, Local communities

10.5 International benchmarking and best practices

A number of electrification programmes have historically been rolled out and implemented, with several successes recorded as well as challenges. A number of lessons can be learnt in as much as some aspects may be unique to a particular jurisdiction or programme. The table below provides an overview of several national electrification strategies and associated financing plans.

Table 36: International benchmarking and Best Practices of electrification strategies with associated financing plans

Country	Key elements	Financing Plan	Key successes	Difficulties encountered	Learning points for Uganda
Bangladesh	High community involvement and ownership as every consumer was a member of a rural cooperative Performance based incentives were used by having cooperatives commit to a performance agreement. Using a blend of centralised oversight by the government with decentralised operations to the cooperatives.	On-grid financing was mainly through funding at favourable terms, subsidies were not relied upon heavily. For off grid financing, the government injected equity into the Infrastructure Development Company (IDCOL) and extended loans and grants from other development partners. IDCOL would then extend loans and grants to Partner Organisations.	IDCOL was competent and committed hence aggressively conducted electrification activities and at times surpassed its target e.g. it initially targeted to install 50'000 SHSs by June 2008 but achieved this in 2005.	Political influence that stalled some projects and institutional operations. Unsustainable tariffs that were artificially low hence the rural electrification program was not financially stable.	Community involvement can not only help in increasing outreach to remote areas but can also facilitate economic empowerment. Having a well-structured financing program helps in phasing out subsidies in the long term.
Vietnam	Had extensive hydropower resources. Appropriate tariff policies Centralized planning conducted by a single state-owned utility	Funding sources included: Central, EVN/Power Distribution Company, Provincial and Local Authority Governments, Banks, Private entities and Consumers. Each engaged in specific electrification segments e.g government provided financing	The country boosted its economic growth as it was able to electrify its leading export industry, rice farming. Supplementary financing sources	Low prioritization of households led to unelectrified households in electrified districts.	A long term vision with prioritization and flexibility is paramount. Cost sharing and collaboration among stakeholders are key

	Electrification process was aligned with industrial development A culture that placed a premium on electrification	for major projects while EVN and Provincial Governments provided funding for construction of high and medium voltage and low voltage respectively	were obtained from sector prioritization.		
Laos	A robust and supportive ecosystem was established by the government that supported the power delivery mechanisms. The government also set up a framework to restore the national utility (Electricité du Laos) EDL's financial stability by channelling export dividends to EDL and onlending funds at concessionary terms from DFIs. Community engagement further attracted donor support.	The government encouraged IPP investment into hydropower generation that was later exported and earned revenue for the national utility EDL Grid operation and extension was EDL's responsibility as guided by stipulated policies. Off Grid electrification was mainly done through public private partnerships; a special purpose delivery mechanism was set up with oversight from the Ministry of Energy and Minerals.	An optimal balance was achieved for financing subsidies and tariffs that encouraged electrification within a profitable environment In the long term, EDL was able to regain financial stability.	Conflicting fiscal and political pressures that necessitated striking a balance between restoring EDL's financial stability and providing financial incentives for electrification. Mountainous terrain with low population density made electrification expensive.	A financially stable utility company with government support is fundamental in enabling electrification initiatives. A clear framework on financing and participation in the electrification mechanisms encourages more efficient resource allocation.

Morocco	The program for global rural electrification (Programme d'Electrification Rurale Global, PERG) was launched in 1995 to address the lack of electricity access in Morocco.	The government of Morocco set up different funds and institutions (MASEN, SIE, "Fonds pour le développement énergétique") to bridge the financing gap. Moroccan banks and DFIs provided concessional debt. The funds and institutions help the Office Nationale de l'Electricité (ONE) to finance a significant part of the off-grid projects together with municipalities and households.	Connection of ONE to finance institution. Achieved a fast pace electrification strategy: the rural electrification rate rose from **18%** in the 1990s to **99.4%** at the end of 2016	Developing financially sustainable solutions for off-grid where most of the population couldn't afford. As a response, the municipality and the ONE financed part of the installation and allowed households to spread the installation investment over time (7 years).	A clear vision and a continuing political commitment to follow the plan. An institutional framework that brings into action the strength of the utility and national and international actors Financing model that includes all stakeholders; both international financial institutions. Capacity building within intermediary institution, the Moroccan Agency for Solar Energy (MASEN).
Jordan	There was a rapid increase of the electricity capacity injected on the grid as part of the electrification strategy that aimed at being oil independent.	Tenders launched by the Ministry of Energy and Mineral Resources (MEMR) targeting IPPs. The grid was operated by NEPCO, the state-owned utility. Financial guarantee provided by the government of Jordan.	Fast pace development of utility-scale renewable energy projects through public auctions or direct proposal submission.	High tariff due to the amounts invested. A lack of coordination on energy policy meant that conventional thermal power plants developed under the IPP model and operating within fixed	A regulatory framework is key to develop utility-scale renewable energy projects Coordination of the licensing for projects and a mapping of the needs is required to avoid overproduction.

		The Jordanian Renewable Energy and Energy Efficiency Fund (JREEEF) provides loan guarantee for small-scale projects.		PPAs slowed down the development of utility-scale renewable energy projects. Excess electricity production that cannot be handled by the grid.	Investment needs to be done on the grid capacity to evacuate the extra production.
Egypt **[on-grid]**	1.8 GW Benban solar park, including 41 solar plants. The Benban solar park will have four state-of-the-art high-voltage substations developed by New and Renewable Energy Authority and Egyptian Electricity Transmission Company	Benban solar park relied on two-rounds of FiT scheme beginning in 2014.	The solar plants are about to be commissioned, pool of financiers created and a developers' association formed.	Logistical challenges and grid constraints, This was addressed through the creation of the Benban Solar Developers Association – soon to become an NGO.	There was a pool of 16 DFIs: crowding in a consortia of development financiers Developers should join hands by creating an association. It must enhance to coordination of actors Transmission delegated to the public sector

As shown above, strong government support with hands on participation is at the core of successful electrification programs as they define not only the policy framework but the financing programs. Key takeaways include:

1. **A financially stable national utility company** facilitates the subsidization of non-profitable electrification activities. One of the preliminary initiatives the government of Lao undertook was to ensure that the national utility company was financially sound through direct capital injection and extending loans on concessionary terms.
2. **Grid investment is critical and a common bottleneck.** Jordan overestimated the capacity of the grid to absorb additional power thus slowing down the electrification process. The lack of investment in the transmission and distribution infrastructures lead to a production that could not be fed into the grid, generating important financial losses for the utility. A rigorous matching of production and grid plans is therefore essential.
3. **Consumer financing programs** leveraging on a strong pre-existing microfinance framework enabled Bangladesh to extend consumer financing programs. As such, the government was able to design loan products through the microfinance institutions. A stronger capitalization of UECCC by GoU could enable the structure to act as the central provider for credit support facilities.
4. **Cooperative societies** encourage a culture of collective responsibility through engagement and ownership by local populations in not only financing of the programs but also in the implementation of the initiatives. It can also enable more efficient deployment through mutualized logistics and learning, as highlighted in Egypt where developers of a solar park gathered in one association. This has a dual effect of electrification and creation of employment. Uganda already has a number of cooperatives in operation including Kyegegwa Rural Electrification Cooperative Society (KRECS), Pader-Abim Community Multi-purpose Electric Cooperative Society Limited (PACMECS), among others of which some are licensed electricity distributors and are participating in REA initiatives.
5. **Strong consumer confidence** in the new technologies and respective organizations undertaking the electrification initiatives encourages the consumers to not only adopt the new technologies but also take up loans to finance them. Weak consumer confidence can also increase the risk perceived by local financing institutions which are new to those solutions. The absence of enforceable quality standards for the products sold in Uganda tends not only to discourage investment but also to exacerbate public perceptions that the new technologies are not reliable alternative sources of energy.
6. **Systematic prioritization of productive sectors' electrification** can also provide supplementary financing. This can be done by focusing on sectors that are considered the backbone of Uganda's economy e.g agriculture (electricity powered pumping systems, farm drain tile or post-harvest processing machines could enhance production) in order to generate more income to increase the tax base. It may also increase the living standards of individuals enabling them to adopt and finance new electrification technologies as evidenced in Vietnam which electrified areas prominent for rice production ultimately supplementing the electrification budget.
7. **Stakeholder Associations** provide better risk pooling and diversification opportunities for investors hence leveraging on economies of scale when providing financing. Solar developers in Egypt formed an association that enhanced access to finance and facilitated dialogues.
8. **De-risk private sector investment** in on-grid and off-grid in addition to moving towards mergers and consolidating distribution concessions. Perceived competitive risks are mitigated through transparency in the planning process, simple and quick licensing processes, swift and predictable instruction periods by public authorities for any administrative procedure,

facilitation to financing access for private developers (concessional loans, guarantee funds, facilitation of partnerships with the banking sector...).

Ultimately, the GoU should work towards striking an optimal balance between providing favourable returns to investors at prices that align with the consumers' willingness to pay. When working towards providing a consumer financing program, the new electrification programs should not cost the consumers significantly more than their traditional energy sources e.g kerosene and dry cells, even when the service provided is improved.

10.6 Conclusion

Whilst Uganda has a rather active investor and policy ecosystem, almost of the past electrification policies and strategies fell short of their objectives. In addition to objectives that may not always have been realistic, all those plans were lacking the same thing: a well-defined yearly cost and a financing strategy to meet those costs. As a result, while Donors and private investors have been actively supporting the sector through numerous initiatives, those initiatives tend to lack coordination with the public agenda as well as with other initiatives already in place.

To achieve a successful strategy, a financing plan will be developed by matching the electrification needs and sources of finances. Setting up bankable projects and aligning investment opportunities across different investor requirements, for each market segment, will be a key area of focus.

For NES, large toolkit of financing solutions from different types of players will be considered in order to align with the specific characteristics of each subsector. For example, easy to access and fair subsidies programs shall be instrumental to the development of mini-grids, while consumer finance and credit support will be key to the acceleration of standalone systems deployment. Key donors and stakeholders' consultations should be done from the strategy design stage in order to ensure alignment with financiers' appetite and needs.

Moreover, a consolidation and alignment of policies related to electrification will be essential in determining a clear and realistic path to follow in achieving the electrification strategies. This has been initiated by The ECP 2018-2027 and can be further updated with the outcomes of the NES. Nevertheless, GoU and its associated entities active in the sector will remain core enablers for the actual implementation of the strategy.

11 Least cost electrification planning approach and methodology

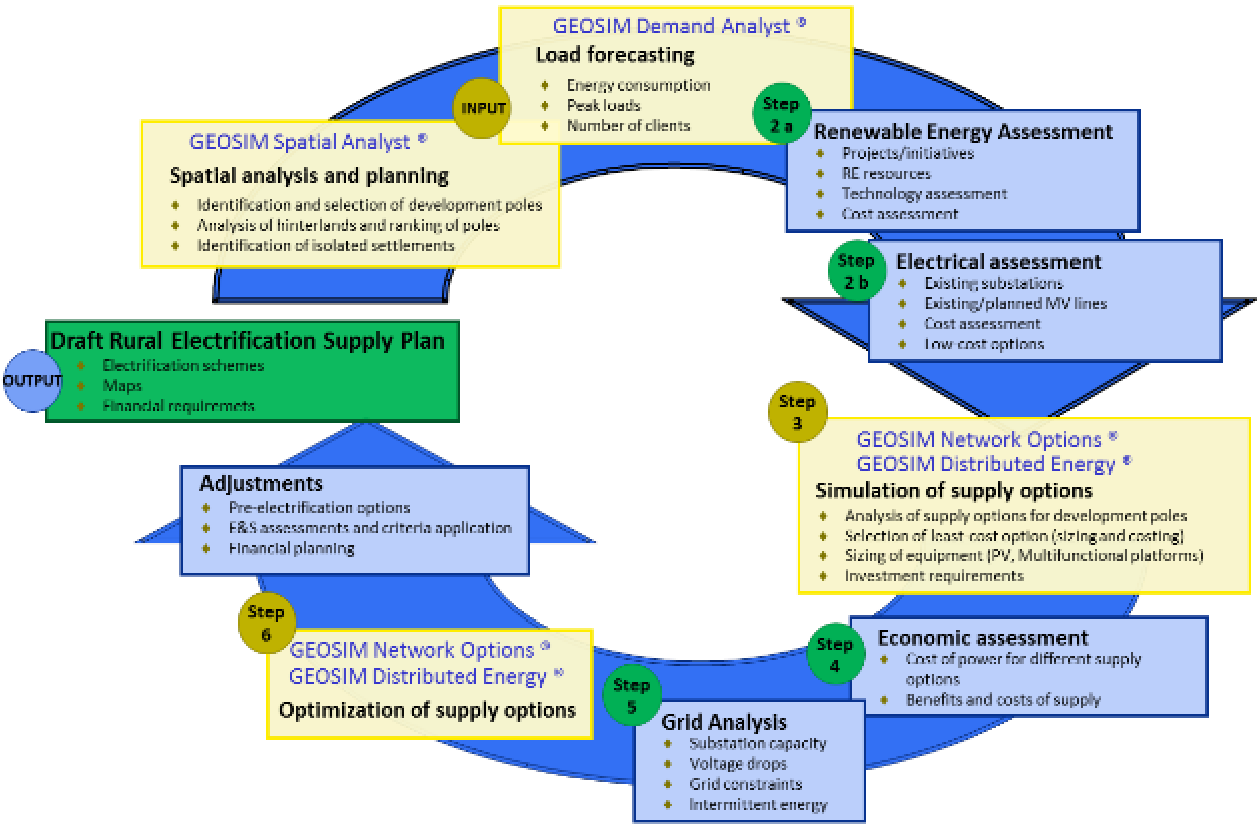
The key purpose of the Consultant's work is to define and recommend the energy access options that are available, and their associated requirements in terms of budgets, institutional implementation capacity, and policy and regulatory priorities. This will ensure that the National Electrification Strategy appropriately reflects a holistic view of the Ugandan physical, financial and socio-economic reality.

At the core of the process are technical and economic analyses and the modelling of multiple potential approaches to achieving the national electrification objectives of Uganda. Other criteria, related to grid constraints for electricity as well as qualitative criteria and constraints will be applied to optimize the proposed electrification strategy and recommended action for implementation during the planning period.

In order to achieve this objective, the consultant adopted a least-cost geospatial planning approach, using IED's proprietary electrification planning software, GEOSIM (see Annex 15.3 for a specific presentation of the functionalities, method and added value of the software. This also shows a few snapshots of the possible outputs).

This is illustrated in the figure below.

Figure 16. Analysis and Optimization of Electrification Options to contribute to the NES Uganda



This approach is divided into successive key steps in order to draw the investment plan:

1. Establish the data base
2. Determine the main principles for system layout/renovation strategy
3. Technical analysis of different system alternatives. After verifying the various options, the recommended option must be verified using technical system analysis (load flow study, fault calculations, contingency analysis, reliability studies and if the system is near or between the generating plant, transcend study is recommended)
4. Establish investment costs and operation costs
5. Cost minimization
6. Decision of investment plan.

11.1 Establishment of a geospatial database

In order to carry out the geospatial planning process, the Consultant used both geospatial and alphanumeric data collected from electricity sector stakeholders and independent research to construct a consolidated database covering the following areas:

- **Demography:** Population, Population density
- **Administrative units:** Regions, Districts, Sub-counties, Parishes and Villages
- **Geographic features:** Water features, protected areas, land cover, etc.
- **Socio-economic infrastructure:** Schools, administrative buildings, health infrastructure, commercial infrastructure, etc.

- **Electrical infrastructure:** Existing and planned generation, transmission and distribution infrastructure, distribution transformers, geo-referenced meter locations, etc.

Data was processed, cleaned and crosschecked with stakeholders to ensure a maximum level of accuracy. An exhaustive list of the geospatial data layer inputs used in the course of the planning is available in the annexes to this report, and the final database will be communicated to stakeholders at the end of the project.

11.1.1 Village database

Crucially, geospatial electrification planning requires a detailed knowledge of (1) where populations are located, (2) their electrification status and (3) the mode of connectivity (on or off-grid) at the highest possible level of detail.[37] **Concretely, this required the construction of a georeferenced human settlements database of Uganda's administrative villages (as per UBOS nomenclature), with their current population, electrification status, and socio-economic infrastructure.**

Planning connections to the village level presented several challenges from a data perspective. First, population estimates from the national census are not disaggregated to the village level. Second, to the consultant's knowledge, no exhaustive list of Uganda's localities (at the parish or village level) with a current electrification status is maintained by ERA or other sector stakeholders, with electrification progress below the parish level being monitored purely from the perspective of infrastructure (km of lines constructed) and connections (number of registered clients).

Finally, the number of administrative villages in the country changes on a regular basis, meaning that village boundaries and nomenclature change each year. Indeed, the Ministry of Local Government projects that the total number of villages will continue to evolve, with the 2022-2023 census expected be conducted on the basis of approximately 80,000 villages versus the roughly 69,000 currently established units as of end-2020.

Given the rapid changes in the number of recognized local governments and the lag time to generate sufficient demographic and geospatial data for these units, the consultant therefore recommends that electrification planning be conducted on the basis of village data that is updated a regular intervals (for example, every three years) or in conjunction with the publication of new UBOS census or intercensal household survey data every five to ten years. This would permit a single common reference point for all stakeholders and also minimise the risk of errors that could be generated from the constant adjustment of the village base layer for the NES. At the latest, NES GIS database base layer will require an update in 2023-2024 to move to the new number of villages when the results of the next comprehensive census (which should encompass the electrification data, demographics, level of equipment and so on) are released.

In June 2020, at the time of revising this report following stakeholders' comments, UBOS provided an updated file of 64,369 villages with established village boundaries[38]. At the request of MEMD, the consultant updated the NES Planning Database to reflect this new input. The current GIS database of

[37] For project planning exercises, this can be done using satellite rooftop imagery to reconstruct clusters of habitations to be electrified, as was done for the Rural Electrification Masterplans in each of the service territories. For a high-level national strategy, this approach is not feasible, and the consultant has therefore based its planning process on Uganda's smallest administrative unit, its villages.

[38] This is slightly lower than the number of villages confirmed by the Ministry of Local Government for the year 2020 (68, 738), as not all of these villages had formally approved administrative boundaries at the time of the NES analysis. The UBOS file contained 64,393 features, however not all of these corresponded to administrative villages, with some simply covering water areas, etc.

64,369 villages covers the entire surface of the country, and future administrative divisions will not have any technical or financial impact on the NES results as the NES approaches universal access based on population, with the aim of providing an appropriate electricity connection to each household.

It should however be noted that the reconstitution of the village database on the 64,369 UBOS villages for 2020 as well as updated population density layers (see the following section for more information) and domestic customer meter data from ERA obtained in March 2021, significantly changes the electricity connectivity/access analysis presented in the NES Draft Report. These statistics are therefore *not* comparable between the NES Draft document and the NES Final Report.

11.1.1.1 Demographic assumptions

In the absence of census data at the village level and in order to account for population growth, as well as the acceleration of rural-urban migration, the consultant computed an estimated 2020 population for each settlement using UBOS's village boundaries database and the CIESIN population density database for Uganda[39], which combines high-resolution satellite rooftop imagery from DigitalGlobe with UBOS demographic statistics from the 2014 National Census and the 2016/17 Uganda National Household Survey, and population growth projections from the United Nations Population Fund in order to produce up-to-date population estimates with a resolution of 30 metres. The CIESIN population figures were then verified and normalised against UBOS district population projections 2015-2030 to ensure maximal alignment with official figures.[40] The table below shows the population estimates for the various service territories as well as for Uganda as a whole.

The primary unit of population analysis for electrification planning is the household. To calculate the number of households from the estimated population figures, **IED has used an average household size of 4.7 people**, which corresponds to the average national household size for rural and urban zones presented in the UBOS Uganda National Household Survey 2016 (UNHS 2016).

In keeping with the official national definition of rural areas, all villages outside of 197 major towns and municipalities are considered to be rural, regardless of their population densities. **The consultant has assumed the urban share of the population will remain constant at 76%, as indicated in the UBOS UNHS 2016**. However, as current customer statistics for the various distributors do not allow for the categorization of urban versus rural customers, and in order to more accurately estimate needs and costs for the various villages in rural zones, the consultant has constructed its analysis on the basis of population density zones rather than on a strict rural-urban categorization. To do this, the consultant divided Uganda into high, medium and low-density zones, as summarized in the table below.

- High density zone: > 500 Population/km²
- Medium density zone: 100 – 500 Population/km²
- Low density zone: <100 Population/km²

In order to project populations through 2030, the consultant adopted national population growth assumptions consistent with national projections and with the UN Population Division 2019 Median

[39] Facebook Connectivity Lab and Center for International Earth Science Information Network - CIESIN - Columbia University. 2016. High Resolution Settlement Layer, update MAY 20 2020. (HRSL). Source imagery for HRSL © 2016 DigitalGlobe.
[40]

Population Projection Scenario for Uganda.[41] The average annual national population growth assumptions are as follows:

- 2020-2030: 3%

[41] United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition.

Table 37: Population estimates by service territory in Uganda (2020-2030)

Service Territories	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UMEME CONCESSION	14 991 660	15 441 410	15 904 652	16 381 792	16 873 246	17 379 443	17 900 826	18 437 851	18 990 987	19 560 717	20 147 539
MID WESTERN	1 707 902	1 759 139	1 811 913	1 866 270	1 922 258	1 979 926	2 039 324	2 100 504	2 163 519	2 228 425	2 295 278
CENTRAL NORTH	1 847 038	1 902 449	1 959 522	2 018 308	2 078 857	2 141 223	2 205 460	2 271 624	2 339 773	2 409 966	2 482 265
EASTERN	4 371 779	4 502 932	4 638 020	4 777 161	4 920 476	5 068 090	5 220 133	5 376 737	5 538 039	5 704 180	5 875 305
NORTH EASTERN	2 442 010	2 515 270	2 590 728	2 668 450	2 748 504	2 830 959	2 915 888	3 003 365	3 093 466	3 186 270	3 281 858
NORTH NORTH WEST	1 484 964	1 529 513	1 575 398	1 622 660	1 671 340	1 721 480	1 773 124	1 826 318	1 881 108	1 937 541	1 995 667
NORTH WESTERN	2 921 925	3 009 583	3 099 870	3 192 866	3 288 652	3 387 312	3 488 931	3 593 599	3 701 407	3 812 449	3 926 822
SOUTH	1 549 823	1 596 318	1 644 208	1 693 534	1 744 340	1 796 670	1 850 570	1 906 087	1 963 270	2 022 168	2 082 833
SOUTH WESTERN	1 178 944	1 214 312	1 250 741	1 288 263	1 326 911	1 366 718	1 407 720	1 449 952	1 493 451	1 538 255	1 584 403
WEST NILE	2 723 435	2 805 138	2 889 292	2 975 971	3 065 250	3 157 208	3 251 924	3 349 482	3 449 966	3 553 465	3 660 069
NORTHERN	1 374 984	1 416 234	1 458 721	1 502 483	1 547 557	1 593 984	1 641 804	1 691 058	1 741 790	1 794 044	1 847 865
RWENZORI	604 704	622 845	641 530	660 776	680 599	701 017	722 048	743 709	766 020	789 001	812 671
WESTERN	1 234 551	1 271 588	1 309 736	1 349 028	1 389 499	1 431 184	1 474 120	1 518 344	1 563 894	1 610 811	1 659 135
CENTRAL	2 949 302	3 037 781	3 128 914	3 222 781	3 319 464	3 419 048	3 521 619	3 627 268	3 736 086	3 848 169	3 963 614
UGANDA	**41 383 021**	**42 624 512**	**43 903 245**	**45 220 343**	**46 576 953**	**47 974 262**	**49 413 491**	**50 895 898**	**52 422 776**	**53 995 461**	**55 615 324**

Source: Center for International Earth Science Information Network – CIESIN – Columbia University 2020 and Consultant’s calculations

Table 37: Households estimates by service territory in Uganda (2020-2030)

Service Territories	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
UMEME CONCESSION	3 189 715	3 285 406	3 383 968	3 485 487	3 590 052	3 697 754	3 808 687	3 922 948	4 040 636	4 161 855	4 286 711
MID WESTERN	363 383	374 284	385 513	397 078	408 990	421 260	433 898	446 915	460 322	474 132	488 356
CENTRAL NORTH	392 987	404 777	416 920	429 428	442 311	455 580	469 247	483 324	497 824	512 759	528 142
EASTERN	930 166	958 071	986 813	1 016 417	1 046 910	1 078 317	1 110 667	1 143 987	1 178 307	1 213 656	1 250 066
NORTH EASTERN	519 577	535 164	551 219	567 756	584 789	602 333	620 403	639 015	658 185	677 931	698 269
NORTH NORTH WEST	315 950	325 429	335 192	345 248	355 605	366 273	377 261	388 579	400 236	412 243	424 610
NORTH WESTERN	621 686	640 337	659 547	679 333	699 713	720 704	742 325	764 595	787 533	811 159	835 494
SOUTH	329 750	339 643	349 832	360 327	371 137	382 271	393 739	405 551	417 718	430 250	443 158
SOUTH WESTERN	250 839	258 364	266 115	274 098	282 321	290 791	299 515	308 500	317 755	327 288	337 107
WEST NILE	579 454	596 838	614 743	633 185	652 181	671 746	691 898	712 655	734 035	756 056	778 738
NORTHERN	292 550	301 327	310 367	319 678	329 268	339 146	349 320	359 800	370 594	381 712	393 163
RWENZORI	128 660	132 520	136 496	140 591	144 809	149 153	153 628	158 237	162 984	167 874	172 910
WESTERN	262 670	270 550	278 667	287 027	295 638	304 507	313 642	323 051	332 743	342 725	353 007
CENTRAL	627 511	646 336	665 726	685 698	706 269	727 457	749 281	771 759	794 912	818 759	843 322
UGANDA	**8 804 898**	**9 069 046**	**9 341 118**	**9 621 351**	**9 909 993**	**10 207 292**	**10 513 511**	**10 828 916**	**11 153 784**	**11 488 399**	**11 833 053**

Source: Center for International Earth Science Information Network – CIESIN – Columbia University 2020 and Consultant's calculations

11.1.2 Attribution of socio-economic infrastructure and village population centres

For the purposes of the spatial analysis and load forecasting (described further in section *9.2 Spatial analysis*) the consultant attributed the 120,000 georeferenced infrastructure points provided by UBOS (including schools, clinics and health centres, administrative and NGO offices, trading centres, markets, religious facilities, and wells and boreholes) to corresponding villages.

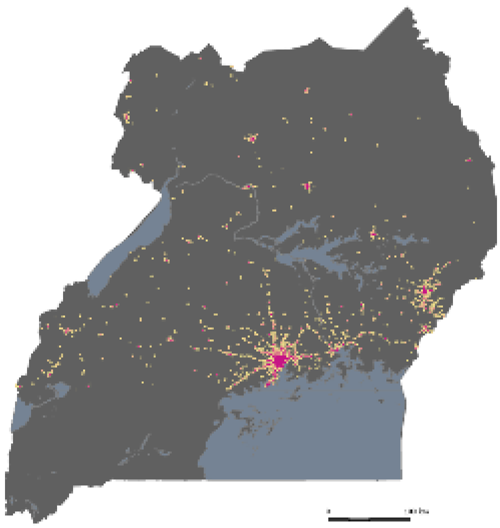
In order to facilitate the electrification planning process, each village administrative boundary area was assigned a central point at the presumed location of the largest population centre within the village boundaries. Where possible, this point was assigned to areas that presented a cluster of infrastructure points. In areas where no additional data was available to guide the placement of village centre points, a weighted centroid algorithm was used. The accuracy of village centre points was verified on a random sampling of villages versus satellite images with rooftop data.

11.1.2.1 Attribution of electrification status

In order to estimate the level of national access to electricity services, the consultant used current grid and distribution infrastructure (including transformers and meter locations where available) as well as client listings to determine the electrification status of each settlement with the greatest possible accuracy.

There nevertheless remains a certain degree of uncertainty around the status of each individual settlement, as some communities may be proximate to electrical infrastructure without themselves being connected or may be electrified by off-grid solutions without being identified among the mini-grids officially reported to ERA.

Example of night time light radiance values for Uganda



In order to correct for potential errors of this type, high-resolution composite night images generated by the Earth Observation Group (NOAA) were used to verify the status of zones identified as potentially electrified.[42] These datasets provide an annual average luminosity value, corrected for intermittent lights, stray light, and cloud-cover at a resolution of approximately 30 metres (15 arc seconds).

Villages were considered to be electrified if they met at least one of the following criteria:

- At least one connection referenced in client or meter datasets communicated by distributors
- Village name listed as site for mini-grid or distributor service in documentation provided by distributors or other stakeholders (REA, GIZ, etc.)
- MV/LV transformer present within village boundaries
- Had a night radiance value equal to the minimum radiance value for known electrified villages at a 90% confidence level **and** were crossed by the MV network
- Had a night radiance value at least 1.5 times greater than the minimum radiance value for known electrified villages at a 90% confidence level

[42] Earth Observation Group, NOAA National Centers for Environmental Information (NCEI). Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB), Composite annual VRS/OCM dataset (2016).

Villages identified as candidates for electrification through planned on or off-grid projects, including mini-grid tenders managed by REA and international donors, or MV network extensions listed by REA as "under construction" were identified as such in the geospatial database, and are therefore not considered to be candidates for electrification for the purposes of the geospatial electrification plan in order to avoid double-counting of required connections and projects.

11.2 Spatial analysis

11.2.1 Approach

The spatial analysis process will select and rank areas where the social and economic impact of electrification is the highest. To conduct spatial analysis, data on health, education and economic facilities for each village is processed through a multi-criteria analytical matrix, based on the Human Development Index, that measures the potential of each village to provide crucial basic services (education, healthcare) and economic activity for surrounding population. The matrix scores each village on the basis of several weighted characteristics in each of three thematic areas – Health, Education and 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 table below shows the analytical matrix used to calculate the DPI for Uganda's villages.

Table 38: Development Potential Indicator (DPI) multi-criteria matrix

THEME	WEIGHT	INDICATOR	WEIGHT	SUB-INDICATOR	VALUE
HEALTH	1/3	Health facilities	½	Hospital (National referral, regional referral, or district general)	1
				County Health Centre (HC IV)	0.8
				Sub-county Health Centre (HC III)	0.6
				Clinic (HC II, Clinic)	0.4
				Pharmacy, Other	0.2
				None	0
		Access to clean drinking water	½	Water network/Tap water	1
				Water tank, Kiosk	0.8
				Well, Protected Spring, Pump	0.5
				Open well, Other	0.2
				None	0
EDUCATION	1/3	Education facilities	1/1	University	1
				Tech Institute, other professional training	0.8
				Secondary School/Vocational School	0.5
				Primary School	0.3
				Pre-school, Other	0.2
				None	0
LOCAL ECONOMY	1/3	Population	1/6	> 5000 inhabitants	1
				>2000 and ≤ 5000 inhabitants	0.8
				>500 and ≤ 2000 inhabitants	0.5

				>200 and ≤ 500 inhabitants	0.3
				≤ 200 inhabitants	0
		Distance to closest main road (Primary or Secondary Road according to GoU classification)	2/6	≤ 2 km	1
				> 2 and ≤ 5 km	0.8
				> 5 and ≤ 10 km	0.6
				> 10 and ≤ 20 km	0.4
				> 20 km	0
		Commercial structures	2/6	Trading centre, shops	1
				Daily Market	0.8
				Weekly Market	0.5
				Monthly Market, Other	0.3
				None	0
		Administrative offices	1/6	Subcounty (or higher admin unit) headquarters	1
				Parish headquarters	0.7
				Other public structure, NGO offices, etc.	0.4
				None	0

Electrifying a given village will, of course, benefit the population directly living within its administrative boundaries. However, electrification is also likely to provide benefits to the 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 candidate villages, it is therefore important to take into account the overall size of the “covered” population that would benefit both directly and indirectly from electrification.

GEOSIM automatically calculates a covered population for each village 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 populations, physical mass is replaced by the “mass” of services and development, represented by the DPI. 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.

Equation 1 : Basic Huff gravitational model used in GEOSIM (Attraction of population j toward pole i)

$$P_{ij} = \frac{\frac{IPD_i}{dist_{ij}^2}}{\sum_k \frac{IPD_k}{dist_{kj}^2}} \quad \text{or} \quad P_{ij} = \frac{\frac{IPD_i}{dist_{ij}^2}}{U_j}$$

k: any Pole in the targeted territory

$\frac{IPD_i}{dist_{ij}^2}$: Attraction of settlement j towards Pole i

U_j: Potential of settlement j

$$0\% < P_{ij} \leq 100\%$$

$$U_j = \sum_k \frac{IPD_k}{dist_{kj}^2}$$

Equation 2: Calculation of covered population used in GEOSIM

$$POP_{cov_i} = \sum_j P_{ij} \times POP_j = \sum_j \frac{IPD_i}{dist_{ij}^2 \sum_k \frac{IPD_k}{dist_{kj}^2}} POP_j$$

The 10% of villages with the highest covered population are identified as "Development Poles". In addition to the economic criteria habitually used to prioritize electrification projects, **development poles will be given a higher priority in electrification planning, as in theory their electrification should have a larger overall impact on the socio-economic development of the surrounding populations.**

In addition to prioritizing electrification projects, the development poles and covered population methodologies can also contribute to screening criteria for other related demand support or productive uses policies. The methodology can also be used to identify isolated localities that lack access to basic services, in order to target programmes to vulnerable populations and ensure a minimum standard of service across the Ugandan territory.

11.2.2 Results

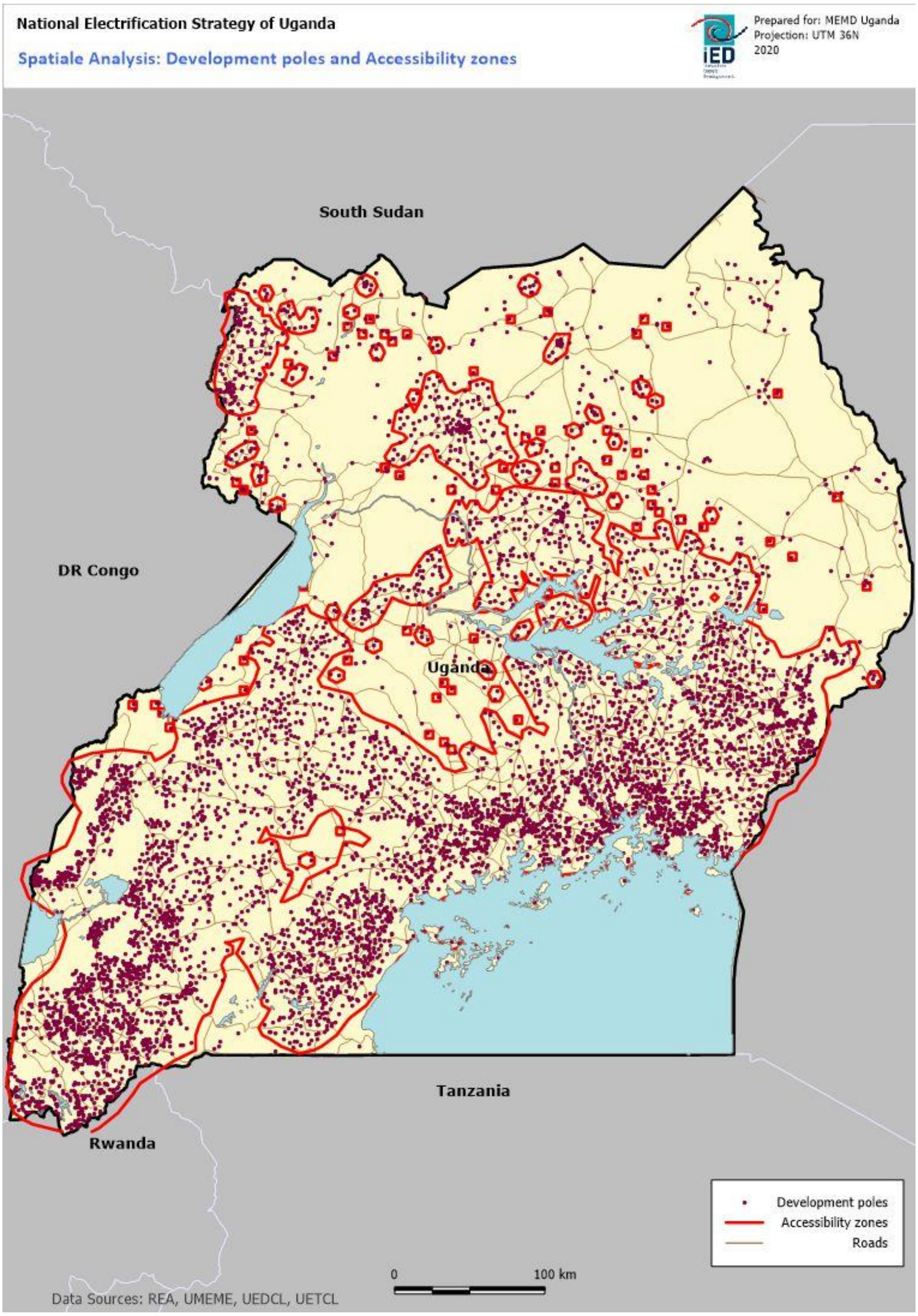
Spatial analysis identified 6,400 development poles in Uganda, of which 3,439 (54%) are unelectrified as of 2020. Poles tend to be concentrated in the Eastern and Western Regions, with the Northern Region having the smallest number of identified development poles at 938. More than 12,873 villages in Uganda are designated as isolated; that is, they are too distant from existing poles to benefit from their services.

Table 39: Development Poles & Isolated Villages Identified in Spatial Analysis (by Region)

Development Poles and Isolated Villages Identified in Spatial Analysis (by Region)									
	Development Poles			**Isolated villages**			**Total Villages**		
Regions	**Electrified**	**Non electrified**	**Total**	**Electrified**	**Non-electrified**	**Total**	**Electrified**	**Non-electrified**	**Total**
NORTHERN	362	576	938	799	8 279	9078	2302	13 280	15 582
EASTERN	625	998	1623	72	1189	1261	3976	15 969	19 945
CENTRAL	936	722	1658	243	740	983	4585	5 927	10 512
WESTERN	1 038	1 143	2181	403	1 148	1551	5586	12 744	18 330
UGANDA	**2 961**	**3 439**	**6 400**	**1517**	**11 356**	**12 873**	**16 449**	**47 920**	**64 369**

The map below shows the position of the selected development poles, with accessibility zones delimited in red. Villages falling outside of these zones are considered to be isolated localities with limited access to the services and economic activity present in development poles. In an electrification strategy that prioritises socio-economic impact, these zones may require additional measures to ensure a geographical balance in electrification investments.

Map 3: Development poles and accessibility zones in Uganda



11.3 Load forecasting

Load forecasting is a critical step in the planning process, as these forecasts will contribute both to the dimensioning and economic analysis of on and off-grid electrification investments generated in the geospatial least cost plan. Electricity load forecasting is undertaken for each individual village using an aggregated ("bottom-up") approach, via GEOSIM's Demand Analyst module. The main characteristics of currently un-served electricity demand are 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.).

Since the scope of the NES does not provide for surveys to directly assess demand potential, IED has used data from ERA and several on and off-grid distributors, as well as its experience in other countries in the region, to generate average end-user demand profiles. End user load profiles are modelled in two scenarios, one scenario to simulate demand in grid-connected localities and one scenario to simulate end user demand in off-grid systems. The demand profiles for various end users are then combined and adjusted using an assumed mismatch factor, to give total demand for a given locality.

At this stage, the demand forecasts remain purely theoretical; the electrification simulations (grid extension and off-grid projects) will calculate the expected demand for each village and each year based on the end user parameters developed here, the village population and the connection rate assumptions adopted in the various planning scenarios.

As an output, the model will provide energy demand, peak load and number of customers for each village based on its individual demographic, economic and infrastructural characteristics, as well as forecast values for each year of the planning period.

11.3.1 Domestic load forecast assumptions

For the purpose of load forecasting, domestic consumers are split into three categories: H1 (Low consumption), H2 (Medium consumption) and H3 (High consumption). Table 31 and Table 32 below present the assumptions for monthly household demand in the first and tenth years after initial connection, as well as the assumed category share in the total number of consumers. IED has assumed a 3% consumption growth rate for the first five years after a household is connected, and a growth rate of 1.5% thereafter. It should be noted that the share of H1 low consumption households increases slightly between year 1 and year 10, as the consultant has assumed that H2 and H3 households will be more likely to connect immediately after electrification.

Table 40: Domestic load forecast assumptions – On grid

	Y1		Y10	
	Weight (%)	Average monthly cons. (kWh)	Weight (%)	Average monthly cons. (kWh)
H1 – Low	**60**	20	70	45
H2 – Med	**35**	54	25	121
H3 – High	**5**	170	5	380

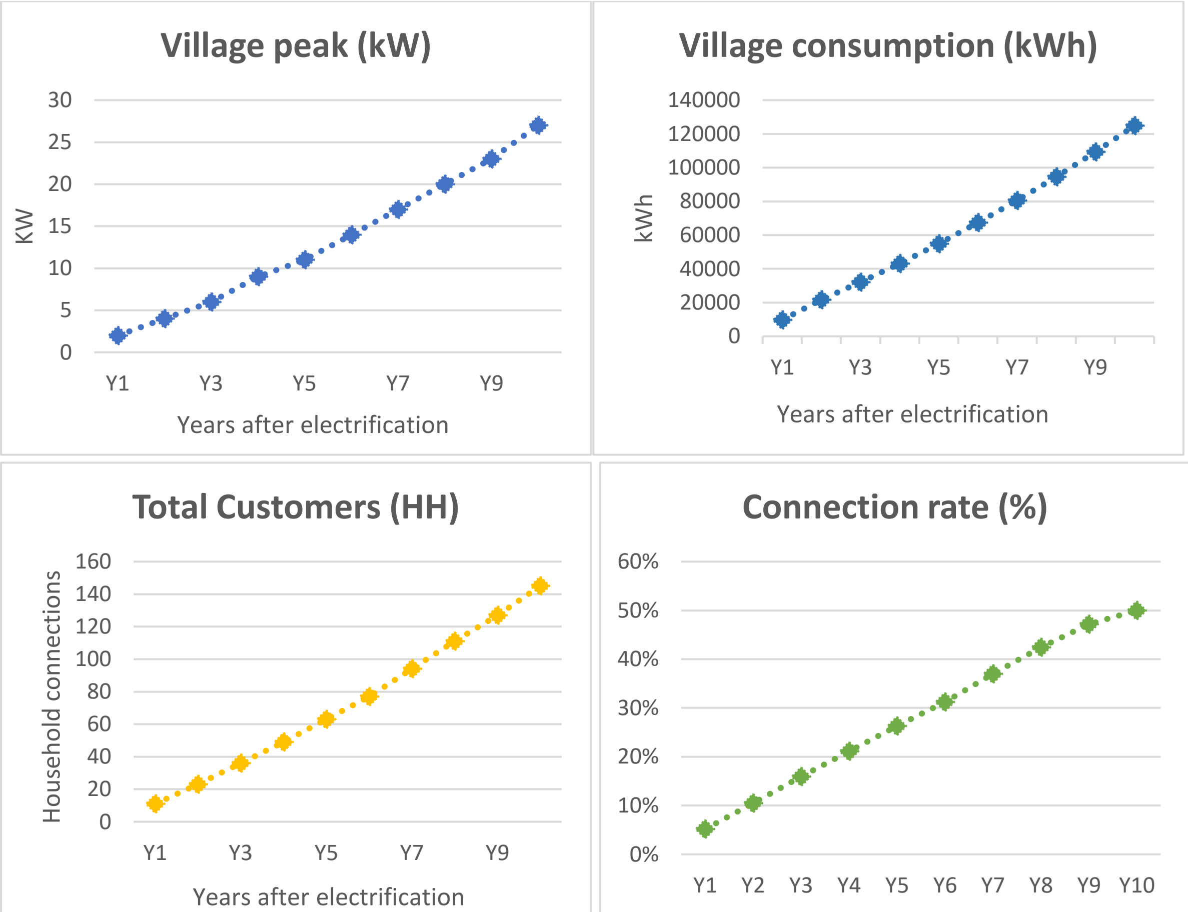
Table 41: Domestic load forecast assumptions – Off grid

	Y1		Y10	
	Weight (%)	Average monthly cons. (kWh)	Weight (%)	Average monthly cons. (kWh)
H1 – Low	**60**	5	70	11

H2 – Med	**35**	9	25	20
H3 – High	**5**	16	5	36

Final demand figures are calculated for each village in the grid extension and mini-grid design simulations using GEOSIM according to the connection rate and year of electrification assumptions used in a given simulation scenario. Figure below shows an example of peak energy, consumption, customer number and connection rate outputs generated for the Base Case scenario described later in this report, for a hypothetical village with a population of 1000 in 2021.

Figure 17: Example demand forecast (hypothetical village of 1000 people – base case scenario)



11.3.2 Infrastructure and services load forecast assumptions

To model the demand from infrastructure (public lighting, water pumping, etc.) and services (public buildings, commercial demand, etc.) In the absence of data on the energy consumption of different types of non-domestic end-users, IED used benchmark consumption figures based on its experience on other countries in the region to construct a load profile for several typical end users. Table 33 below presents the monthly consumption figures in years one and ten for a selection of non-domestic end-users connected to the grid. For non-domestic demand, the consultant assumed that off-grid end-users would consume 33% of the on grid average consumption values.

Table 34: Non-domestic load forecasting assumptions – On grid

	Y1	Y10

	Average monthly cons. (kWh)	Average monthly cons. (kWh)
School	116	258
Health Centre	408	913
Town hall	152	341
Administrative / Police building	373	834
Place of worship	188	419
Commercial Basket for 1000 people	806	1803

UBOS georeferenced infrastructure layers were used to assign infrastructure and services demands to villages of varying populations for all end-user types except for commercial demands. Commercial demand was calculated as a basket of typical commercial demands per 1000 people (shops, video clubs, small mills or carpentry, etc.), based on IED planning experience in Kenya and Tanzania.

Additional details on demand forecasting assumptions and results are available in the annexes to this report.

11.3.3 Assessment of suppressed demand

a) Definition

Suppressed demand is characterized by the power that ought to be consumed by the system (existing and potential consumers), but because of various reasons these existing and potential consumers cannot be fully accommodated and the existing ones curtailed.

In the power sector, suppressed demand is the difference between the unconstrained demand required by potential customers and the maximum demand of the grid and off grid suppliers.

Suppressed demand can be determined by establishing an unconstrained demand level, and by any obstacle such as the lack of adequate generation, transmission or distribution facilities. It is therefore the demand which is curtailed as well as unavailability and absence of supply facilities to the population in both rural and urban areas, where locals are willing to pay and have ability to pay for power but not connected to the grid. It includes those who have applied for connections and not yet connected due to various reasons by utilities. The following components are therefore part of the suppressed demand:

1. Load shedding due to the demand exceeding the available generation, transmission or distribution capacities,
2. Suppressed demand due to poor quality and reliability of supply,
3. Suppressed demand due to strained network operating conditions,
4. Pending connections of applicants not yet connected because of connection bottlenecks.
5. Suppressed demand due to the current tariff structure.
6. Suppressed demand due to lack of infrastructure; transmission, generation and distribution.

The partial unavailability of the network (failure of having access to the Grid/or supplying alternatives) is partially being handled by the NES.

b) Overview of the methodology used to assess the suppressed demand

This section provides an overview of the methodology and the key assumptions used in the assessment of the supressed demand. Since it is intended to be used for establishing supressed demand in the electricity sector, the unconstrained demand has to be determined and should therefore include demand which is curtailed by the lack of supply, transmission, distribution facilities and their limitations as well as unavailability and absence of supply facilities to the population. Two approaches were used to determine the suppressed demand.

The first approach uses the entire population of the country power consumption per capita, the entire population of the country is given by UBOS. This per capita consumption considers all categories of consumers (domestic, industrial and commercial consumers). Further, suppressed demand due to poor quality, strained network operating conditions, and pending connections of applicants are added to the per capita consumption to get the total system demand of the country. In addition, the country's obligations to export requirements are also added.

The second option uses the entire population of Uganda from UBOS, and converts it to number of households (assuming a ratio of 4.7 inhabitants per household). Using the NES category of consumer appliances by NES survey: high, medium and low, the energy and peak demand per category is estimated. They are added up together with their diversity factors and that gives the total domestic demand required, assuming 100% Ugandan population is electrified. However, using the historical domestic peak growth demand, the growth rate was established, and the forecasting of the 26% of population electrified will lead to 45% of the fraction that will be electrified by the period covered by NES (source: UBOS). After which, the other fractions of other different consumer categories, that is commercial and industrial were determined and added from electricity distribution statistics, (from ERA comprehensive electricity supply industry data base). After establishing that demand, the Uganda commitments for exports, industrial parks, suppressed demand due to poor quality, strained network operating conditions, pending connections of applicants and those curtailed due to the unappropriate tariff structure (demand charge while the power factor is very good) are added to obtain the uncurtail total system demand.

c) Demand estimation from population and power consumption per capita

The methodology was based on two approaches, using the national census and UBOS' forecasted population and per capita energy consumption, assuming that the entire population are entitled to using electricity.

Table 42 : Theoretical domestic power needs for 100% electrification

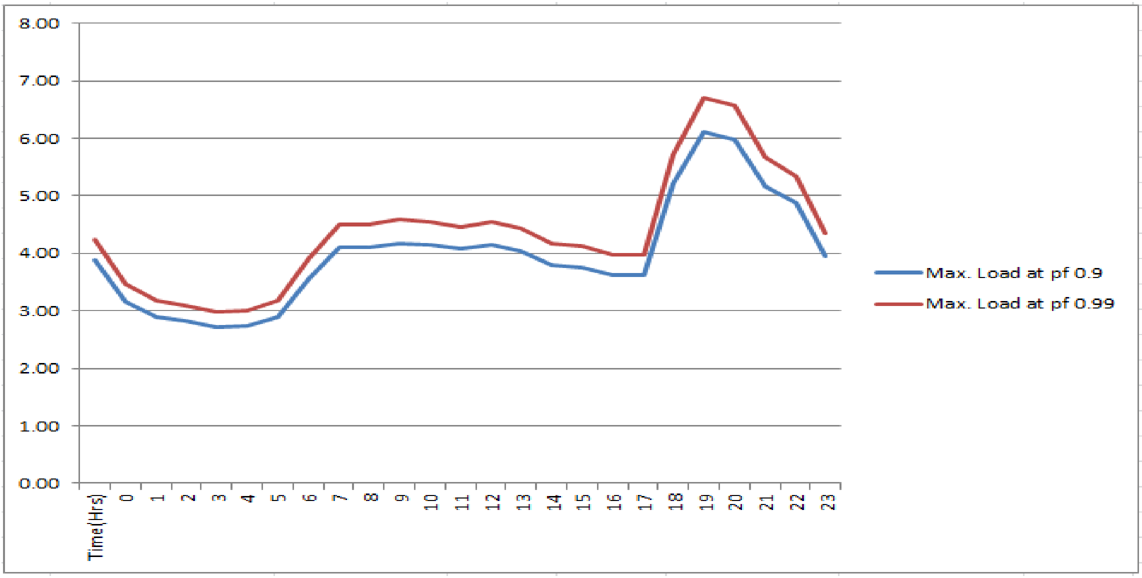
Uganda Population 2020	Power per Capita (kWh)	Energy for Uganda (GWh)	Peak Demand (MW)	Required domestic demand (MW)
45,463,845	118	5 365	942	**890**

Source: UBOS

Data obtained from UBOS was used to establish Uganda's population multiplying it with power per capita energy consumption and peak demands were determined. NB: the power per capita includes all tariffs categories.

The load factor used to calculate the peak demand is 0.65 which is derived from the typical daily load curve of Uganda shown in the figure below.

Figure 18: Typical Ugandan daily load curve



NB: The y -axis represents x 100 MW and x- axis represents hours.

An additional diversity factor of 0.95 is added to calculate the simultaneous required domestic demand.

The results show that if 100% of Ugandan homesteads were connected to the grid in 2020, a power need of 890 MW would be needed to supply domestic demand only. The 890 MW needs to cover the domestic demand is detailed by household's categories.

d) Detailed consumption assumptions from household's categories:

Table 43 : Domestic electricity consumption

Household's categories	Weight (%)	Energy (kWh/day)	kWh /month	Peak load (W)
High income consumption	5%	5,662	170	676
Medium income consumption	35%	1,809	54	192
Low income consumption	60%	0,664	20	110

Source: Estimates from NES

Table 44 : Estimated breakdown of household's categories

Uganda Population 2020	Nb of homesteads	High income	Medium income	Low income
45 463 845 inhabitants	9 673 158	483 658	3 385 605	5 803 895
		5%	35%	60%

Considering a national average of 4.7 persons per homestead, the estimates is based on 9 673 158 home steads in 2020.

Table 45: Estimated breakdown of household's consumption

	High income	Medium Income	Low Income	Total HH

Energy (GWh)	987	2 194	1 393	**4 573**
Peak (MW)	179	455	265	**899**

Aggregation of the 3 households profiles leads to a **peak demand of 899 MW** when using the coincidence factors derived from CADLF (coincident after diversity load factors) assumptions as shown in the table below.

Table 46: CADLF assumptions

Domestic consumer groups	High income	Medium income	Low income
CADLF	0.63	0.55	0.60

The result found is very close from the previous estimate using the power consumption per capita: 899 vs 890 MW in the first Table.

Those figures are related to a 100% electrification scenario. According to the NES assumptions, electrification rate from the grid should reach 45%, **hence the peak demand would be estimated between 401 to 405 MW.**

On the top of the domestic consumption, industrial demand and exports have still to be considered to assess the overall suppressed demand.

e) Estimation of industrial needs and export obligations

Industrial parks

The power consumption of industrial parks based on the declared power needs is estimated at **812 MW**, using a 0,65 load factor.

Export obligations

The table below has been formulated from the studies of the East African Master Planning Study, The Nile Basin Initiative and the NorPlan study of 2013. The East African Power Masterplan43 strategy on interconnectivity of the utilities of the member states was due for full implementation by 2017. Some of the identified projects are still ongoing. The suppressed demand is estimated at 605MW

Table 47 : Export obligations

Country	Exports (MW)
Kenya	300
Tanzania	200
Rwanda	20
South Sudan	45
Congo	40
Total	**605**

43 EAC Website

f) Additional suppressed demand due to poor quality and unreliability supply

Poor quality and unreliability supply leads to suppressed demand in several ways. The quality of electricity is characterized by the following parameters: voltage, frequency and harmonics.

i. Many devices trip or go off the network. Other people have their equipment damaged and after this, several people fail to replace these gadgets leading to suppressed demand.

ii. Sensitive people who are aware of the situation/ consequence, switch off their equipment. For industries, they have automatic change over switches to their stand by generators. So that load becomes suppressed demand.

iii. There are some loads which are voltage dependent, so when voltages change, loads change according to voltage variations, either the off load or over load the network. Currently in Uganda the system experiences over voltages more often than under voltage and they lead to massive tripping of lines from transmission to distribution and even in rural areas due to low consumption of a given line under a given nominal voltage. That information was obtained from the system's operation data, however it's important to capture the total demand tripped off due to over voltage. We considered the outages during which time the consumers change over to their standby Diesel Generators. Looking at data from operators, the outages and established outages due those conditions (Surge impedance loading (SIL), concept and voltage fluctuations/oscillations consequences) which are not due to planned maintenance.

For the frequency, normally there is a standard range the network operates in and at the same time the wave form, i.e. concept of harmonics. However due to poor frequency regulation/ poor quality and harmonics some loads, off-load and others over-load leading to massive load shading, at times to a complete system black out. There are loads which are frequency dependent and voltage dependent (e.g. motors/pumps). In the electricity systems, there are over frequency and under frequency load shading devices, which are frequency regulating/controlling devices.

When the frequencies are out of range, massive tripping takes place leading to suppressed demand.

g) Estimation from ERA comprehensive electricity supply industry data base 2019

Table 48: Estimates of supressed demand due to poor quality and unreliability supply in 2019

Category	Commercial	Medium Industries	Large Industries	Extra Large Industries
Total Energy Sales (GWh)	347	499	887	763
Demand in MW	122	175	311	268
CADLF	0,7	0,8	0,9	0,9
Demand in MW after CADLF	85	140	280	241

In the NES, this has been estimated by using the energy sales data received from ERA as earlier above stated from the commercial, medium, large and extra-large industries for 2019. The domestic consumers who change over to diesel generators have been neglected because very few have diesel generators. However, for the latter (commercial, medium, large and extra-large industries) an approximate value of 30% of their total peak demand has been estimated as the suppressed demand due to poor and unreliability supply, **resulting in a value of 224 MW**.

h) Declared suppressed demand

The sector players have initiated projects to mitigate on declared suppressed demand across the country. for example the 132kv Mutundwe-Entebe project which has delayed in completion. The identified projects cutting across the country are estimated to **contribute 378MW** in suppressed demand.

i) Resulting global estimates of the suppressed demand

Table 49: Estimates of power needs during peak hours

Types of suppressed demand	Peak load (MW)
Peak load of domestic demand (@ 45%grid electrification)	401
Power consumption of industrial parks	812
Exports / Imports	605
Total Requirements	**1 818**
Current Maximum Load	700
Direct suppressed demand	**1 118**
Additional suppressed demand (poor quality)	224
Declared Suppressed Demand	378
Global suppressed demand	**2 420**

Considering 45% electrification rate supplied by the main grid, the total requirements can be estimated at 1 818 MW, by aggregating the domestic demand, the industrial needs and export obligations. Compared with the current 700 MW maximum load observed on the grid, the direct suppressed demand can be estimated at 1 118 MW. When considering in addition the suppressed demand due to the poor quality and unreliability of current supply and delayed projects implementation, **an overall estimated reach 2 420 MW.**

An overview of the suppressed demand components with recommendations is presented below: it encompasses the following items:

- Estimated kind of suppressed demand
- quantity/demand in MW
- Some identified locations
- Reason behind suppressed demand
- Recommendations

Type	1. Declared suppressed demand[44]
Estimate in MW	378
Some Identified Locations	Entebbe, Lugazi, Gulu, Bombo and Kampala Metropolitan, Tororo, Mbale, Adjumani, Bibia/Elegu, Iganga, Jinja, Kayunga, Mukono

[44] Data from UETCL, UMEME and UEDCL.

Reason Behind Suppressed Demand	Delayed project implementation such as: ▪ Mutundwe-Entebbe 132 kV line and associated substations. ▪ Lira-Gulu-Nebbi-Arua 132 kV line project and associated substations. ▪ Kampala Metropolitan Transmission System Improvement Project involving the construction of new 220 kV substations and upgrade of existing 132 kV substations ▪ Kawanda-Nakasongola 132kV line ▪ Tororo-Opuo-Lira 132 kV line ▪ Bujagali Tororo 220kV ▪ Olwiyo-Nimule-Juba 220kV ▪ Mbarara- Mirama -220 kV ▪ Nkenda- Beni -220 kV
Recommendations	▪ Creation of 33kV lines ex-Iganga substation to improve quality of power supply in Kayunga, Iganga and part of Jinja ▪ Establishment of 132/33kV substation at Mbale Industrial Area ▪ The approximately 300 km long, Gulu-Adjumani-Moyo line is problematic in terms of voltage control. Therefore, the introduction of Gulu, Nimule/Elegu and Arua UETCL substations with corresponding rearrangement and construction of 33kV lines will eliminate the curtailed energy. ▪ Construction of approximately 21km of 33 kV line between Lalogi and Gulu substation. ▪ The emerging development of shopping malls in Kampala has created operations challenge to the distribution network. It is recommended to lay a 132kV underground cable from Kampala North substation, introduce a 132/33kV substation at Wandegeya, and make a link to supply the metropolitan area. ▪ Review of statutory laws on right of way(wayleaves)

Type	**2. Maximum Demand Domestic**
Estimate in MW	401
Some Identified Locations	Cuts across the country
Reason Behind Suppressed Demand	Slow pace in customer connectivity by the distribution service providers
Recommendations	▪ Introduce commercial departments and build capacity in all existing commercial offices with marketing, surveyors, design, construction, metering and billing workforce ▪ Establish additional commercial centres to take commercial services closer to the communities. ▪ ERA to enhance compliance by service providers to their of service charters

Type	**3. Unreliable, Poor Quality supply of Electricity and Distorted Tariff Structure**
Estimate in MW	224
Some Identified Locations	cuts across the Country

Reason behind Suppressed Demand	▪ Poor and uncoordinated system planning leading to excessive reactive power and frequency deviation. ▪ Application of inappropriate demand tariff structure. ▪ Tariff-Demand charge when the power factor is close to one. ▪ Lack of well-planned maintenance schedules to match the Ugandan climatic conditions. ▪ Lack of skilled work force in the sector to maintain the automated distribution network for efficient restoration of supply.
Recommendations	▪ MEMD (ERD) to set up a centralized and well-coordinated planning unit with competent planners, good system analysts, good system Operators, GIS and survey teams and adequate data storage facilities. ▪ Localize this demand when the network is constrained. Recommend online maintenance of network. ▪ Incorporate training programs for the sector staff upon commissioning of new projects. ▪ Establishment of a national training centre for technical sector players ▪ Ensure availability of operational single line updated diagrams. ▪ ERA to review the customer installation standards for industrial customers on modern distribution automation equipment for voltage and frequency control measures. These measures shall need a separate coordination study which could curtail some suppressed demand when industries do not shut down and their equipment are not damaged when voltage and frequency are not favourable but within the set ranges. ▪ Bad structured tariffs – mainly affects medium and large commercial customers due to improper tariff structure affecting maximum demand charges.

Type	**4. Planned & Existing Industrial Parks**
Estimate in MW	812
Some identified locations	Spread across 34 Locations in the country
Reason behind suppressed demand	Failure by would be investors to declare the correct and realistic demand at the project planning stage.
Recommendations	▪ To set up a fiscal planning unit in the ERD working in conjunction with UIA. ▪ PUE to be put in perspective during establishment of industrial parks and isolated high power consumption industry or Factories. ▪ Investors electrical requirements to be collaborated with the utility development plans as soon as an enquiry is made by the developer.

Type	**5. Export/Import Commitments**
Estimate in MW	605
Some Identified Locations	Kenya, Tanzania, Rwanda, South Sudan and DR Congo
Reason Behind Suppressed Demand	Ugandan commitments from regional summit meetings.
Recommendations	▪ Uganda to reaffirm with their counterpart progress of works.

	▪ MEMD to expedite completion of the following projects. >Bujagali-Tororo 220kV line and associated substations >Mbarara-Mirama 220kV line and associated substations >Masaka(UG)-Mutukula-Mwanza(TZ) 220kV line and associated substations >Karuma-Olwiyo-Nimule-Juba 132 Kv on 220kV line structures and associated substations ▪ DR Congo to construct the line from Beni to Nkenda and 33/132/220 kV substation.

11.4 Electricity – Technical analysis, economic assessment and GEOSIM analysis

The Consultant's starting hypothesis is that **grid-based electrification (extensions and or densification) is generally the most cost-efficient way of providing electricity to 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 population centres that are located at more remote distances, where local energy resources are available. Stand-alone solutions for basic energy services such as lighting (Pico PV products) will not be overlooked, both as temporary "bridging" options for those communities and/or households for which grid or mini-grid electrification is slated later in the planning period, and as a long-term energy access option for very isolated rural populations or communities.

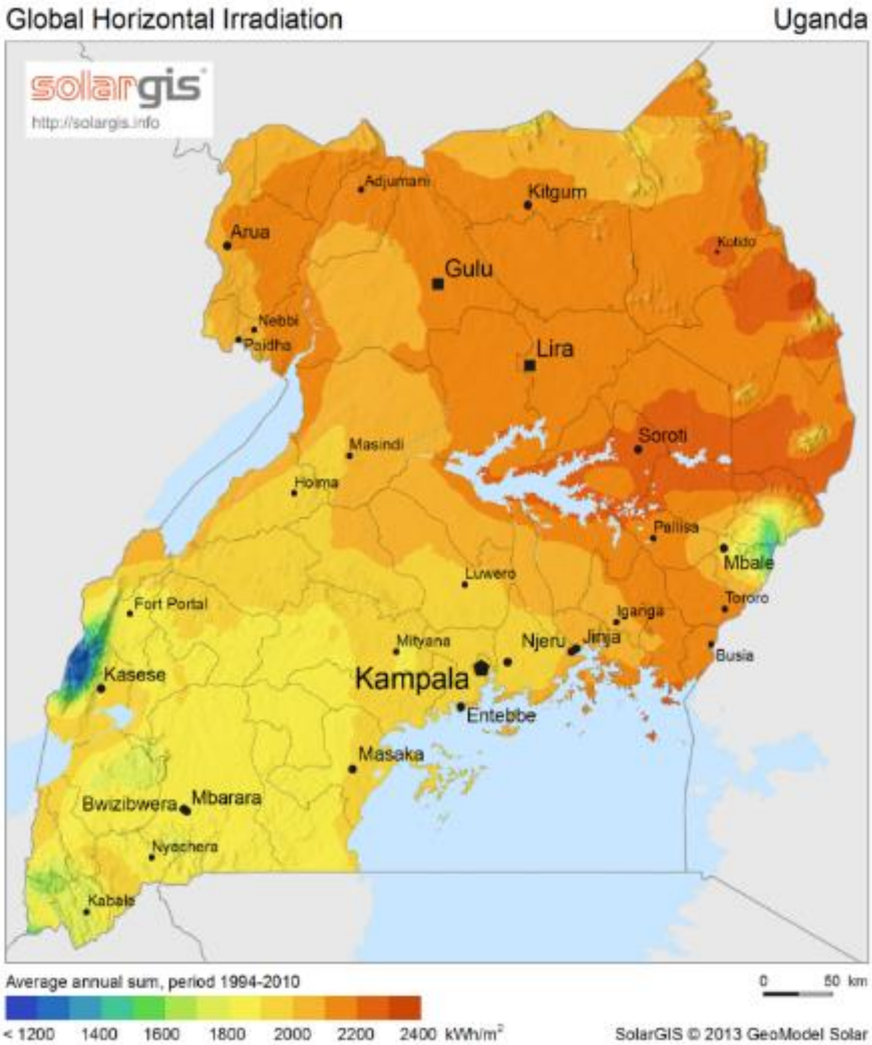
The methodology to identify the optimal mix of these different access options in terms of electrification schemes/energy access packages follows the process illustrated in the flow chart in *Figure Analysis and Optimization of Electrification Options* to contribute to the NES Uganda and is described in detail in the following paragraphs.

11.4.1 Renewable energy assessment

The purpose of the renewable energy 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 planning process. However, in the context of the current National Electrification Strategy, the Consultant will consider the potential role such resources can play to support local power supply, notably in the event that proposed MV network extensions in remote may require network reinforcements or additional local power injection to ensure an acceptable quality of service. The results of the renewable resources assessment will serve as input to both the economic assessment and the GEOSIM electrification simulation and optimization process.

The starting point for this analysis was the review of existing assessments of Uganda´s renewable energy resources (wind, small hydro, solar, biomass), undertaken during the inception phase of the NES. The review revealed that there is little systematic information on renewable resources for biomass and small hydropower currently available for Uganda. As such, in previous planning studies, such as the REA Rural Electrification Master Plan, only solar PV potential was considered for decentralized renewables generation to support mini and microgrid development. Nevertheless, hydro and biomass represent an important potential for decentralized renewable energy production in Uganda and merit further study in order to be considered in the future.

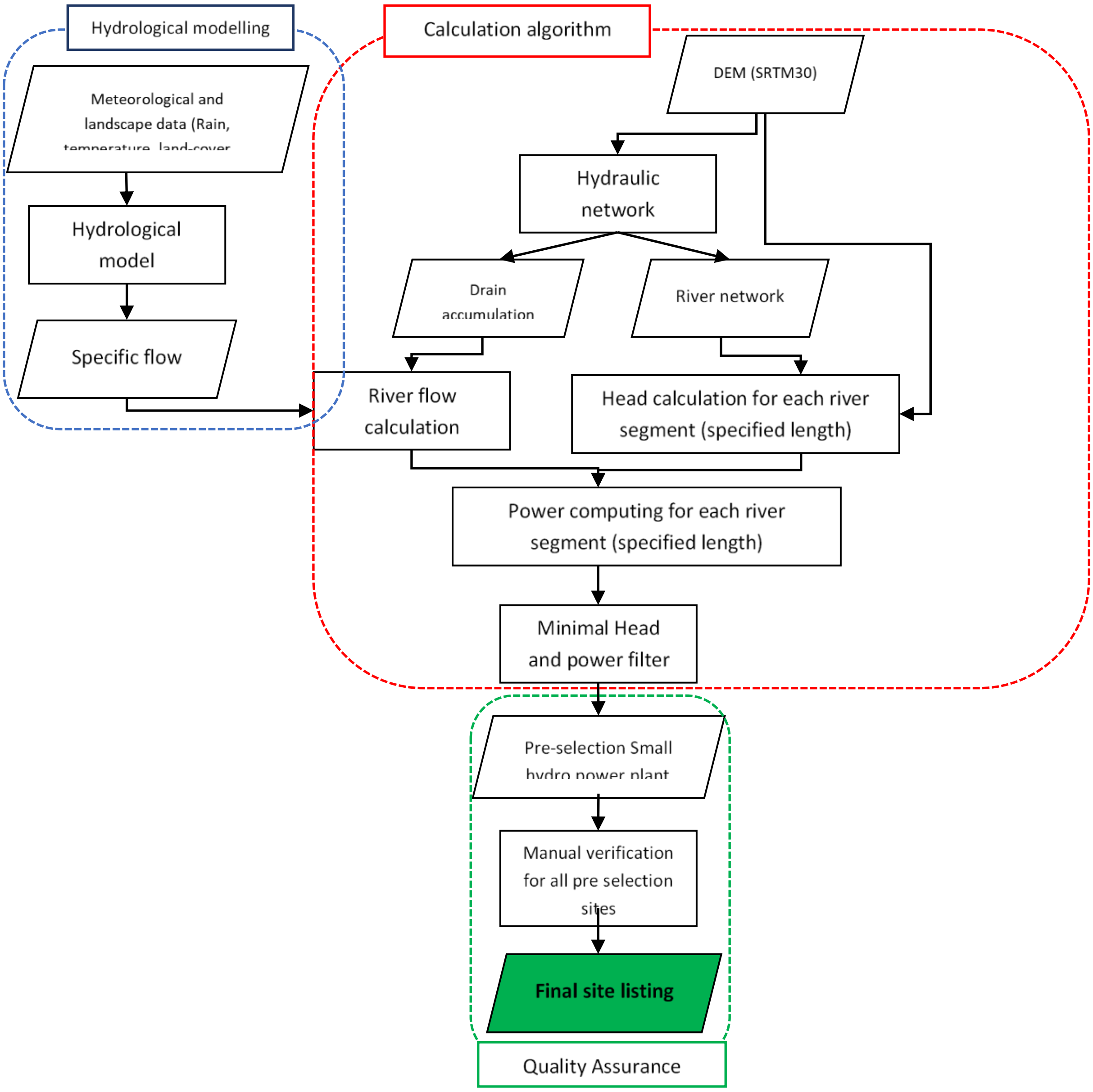
Map 4: Solar resources in Uganda – Global Horizontal Irradiation



While biomass potential requires further detailed study in order to map and quantify the potential from various resources, **IED has undertaken a high-level hydro potential assessment of Uganda in order to identify small hydropower generation potentials in areas that are over 10 km from the main grid, or over 100 km from an existing or under construction UETCL substation**. This process identified 36 potential hydropower generation sites (listed in the annexes to this report), that will be included alongside solar PV potentials as generation options for mini and micro-grids in remote areas. Some of the 36 sites are sites already catalogued in MEMD's generation potential sites listing, however many sites are newly identified.

The hydro potential assessment process involves two major workstreams: First, hydrological modelling of the territory under consideration is carried out on the basis of HydroATLAS v1.0 (Linke et al. 2019). Second, calculation algorithms developed by IED to calculate the available head, the flow rate, and the associated nominal and guaranteed capacity based on the outputs of the hydrological modelling. The figure below shows a visual representation of the methodology used to identify and assess potential hydropower generation sites, and the map below shows the locations and nominal capacities of identified sites.

Figure 19: Calculation flow chart for IED methodology for identifying hydro sites



Map 5: Isolated hydro potentials identified by IED

11.4.2 Electrical assessment

As there are several ongoing or planned electrification projects in Uganda, as well as several sources for electrical network data, including UETCL, UMEME, UEDCL, and REA, the first step of the electrical assessment was to establish an overview of the present status of national electrification, including the location of existing and planned distribution and transmission lines, as well as the location and status of existing and planned off-grid electrification projects. The map below shows the assumed state of the Ugandan MV grid in 2021, the first year of planning in the NES 10-year horizon; more information on the Ugandan electrical system is presented in Section 7 of this report.

For the purposes of this study, the consultant has assumed the following:

- All MV grid extension projects designated by stakeholders as "under construction" will be completed in 2021 (the first year of planning in the NES 10-year horizon)
- All villages located within 1 km of a MV line listed as "under construction" will be connected to the grid
- All planned mini-grid projects in the context of REA-donor organisation cooperation will be completed and will not be considered for electrification in the NES planning process
- All grid extension projects listed by REA as "proposed" will *not* be considered to have been launched in 2021

11.4.3 GEOSIM Simulation – Grid extensions and off-grid solutions

Based on the results from the demand forecast combined with the input from Step 1 an assessment of MV grid expansion was conducted on the basis of an automated GIS cost optimisation algorithm for each of the designated scenarios.

11.4.3.1 Grid extension

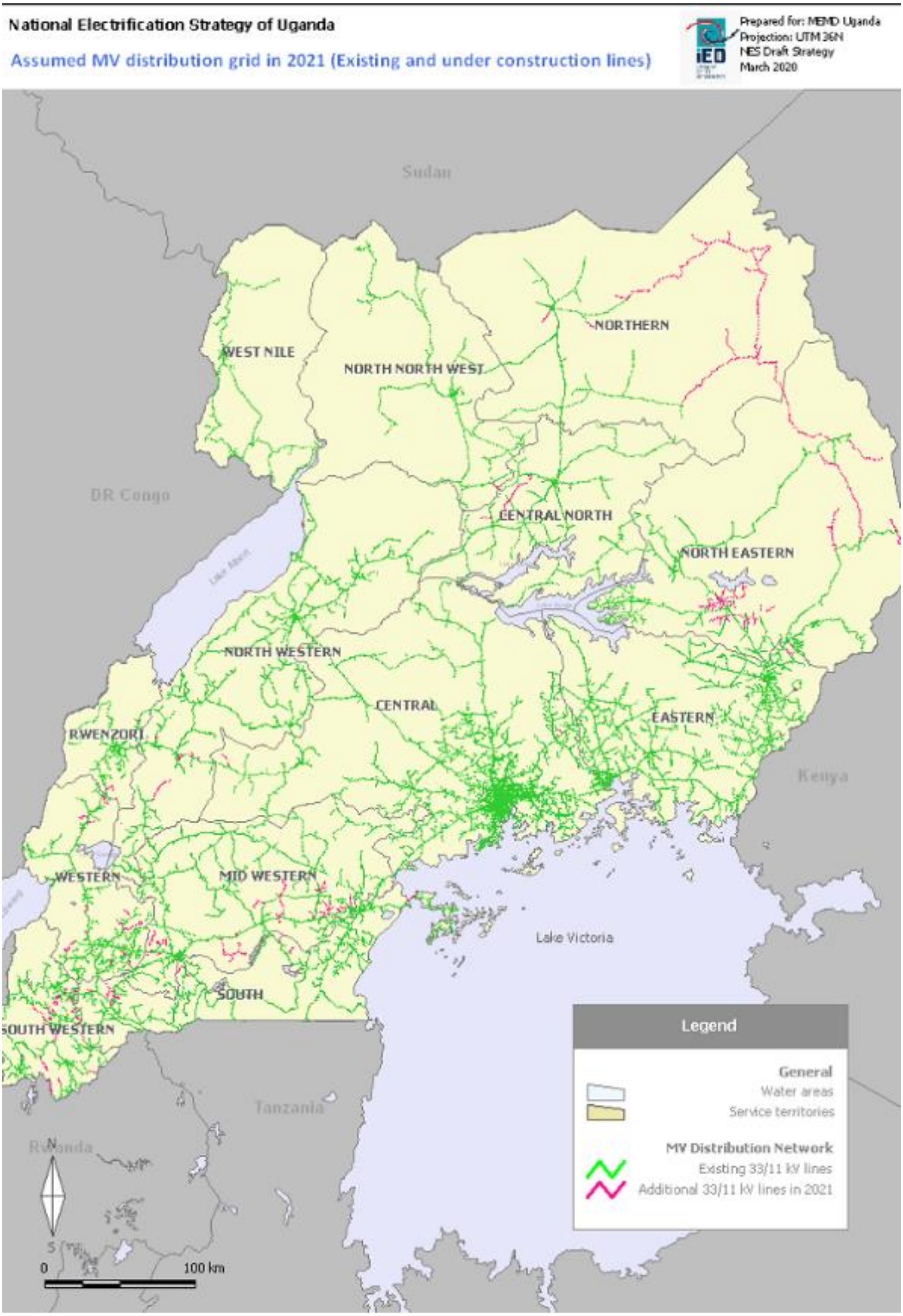
Least cost grid extension pathways

The GEOSIM least-cost grid-extension path algorithm uses a system of "favourable", "unfavourable" and "forbidden" data layers to trace grid extensions. Extensions will align with layers designated as favourable where possible, as the cost of constructing electrical lines along these paths – for example along an existing road – is generally lower than the alternatives. Unfavourable layers are zones such as protected areas or wetlands, where it is technically and legally possible to construct electrical lines but where the costs associated with construction are higher as a result of physical or environmental constraints. In order to electrify a zone that requires crossing an area designated as unfavourable, GEOSIM will compare the costs of avoiding the unfavourable zone to reach a given target village with the cost of constructing in the zone, and select the least-cost alternative. No grid infrastructure is constructed in areas designated as forbidden.

Table 50: Input data layers for least-cost grid extension pathways

Favourable	Unfavourable	Forbidden
Roads (Main)	Protected Areas	Water Areas
	Rivers	
	Wetlands	

Map 6: MV Network in 2021 (Lines existing and under construction)



Grid dimensioning

The load forecast and demographic assumptions discussed in section 9.3 are the primary inputs for the dimensioning of grid investments such as transformers.

However, dimensioning the LV network around a transformer requires information on the density and placement of customers in the surrounding area. In order to adopt accurate assumptions regarding the dimensioning of LV networks for both grid densification and grid extension simulations, such as the number of clients per kilometre of LV line, and the internal ratio of MV to LV lines inside an electrified locality, **IED conducted high-level dimensioning studies on a sampling of existing transformers on the UMEME and UEDCL networks in low, medium, and high population density zones using the internally developed GISELEC© software.** The figure below shows an example of the results from the dimensioning study for a transformer in a medium-density zone, while Table below summarizes the resulting key parameters in the grid extension simulation process.

Figure 20: Example GISELEC study output

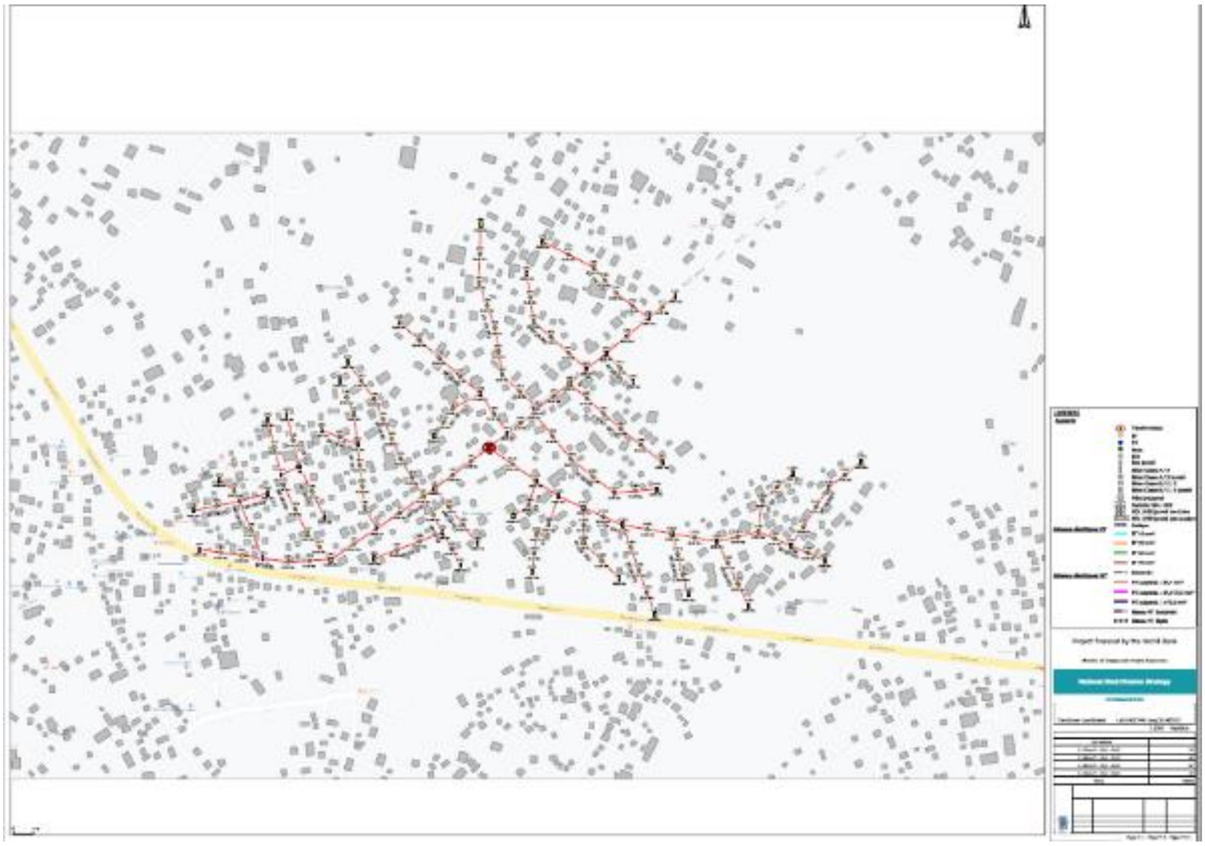


Table 51: LV grid dimensioning assumptions

Zone 1	Population density	Clients/km LV	Additional LV grid requirements (densification only)
1	H (>5000 pop/km²)	62	20%
2	M (1000-5000 pop/km²)	41	30%
3	L (<1000 pop/km²)	23	40%

Costs and economic analysis assumptions

The tables below shows the general economic parameters and investment cost assumptions for GEOSIM grid extension simulations. The information used here in the cost and economic analysis assumptions were obtained from UMEME officially. The percentage breakdown was obtained from UMEME. ERA provided the consultant with a stamped copy of the standard connection costs, reference connection drawings, connection material, labour and transport which are here included in the tables below.

Table 52: General Parameters Grid Electrification Simulation

TECHNICAL PARAMETERS	Indicative value	Unit
Cost of distributed power (Weighted average UMEME/UEDCL 2018)	0.084	USD/kWh
Income to the distributor per kWh (Weighted average commercial/domestic 2018)	0.154	USD/kWh
Lifetime of LV line (poles treated with creosote)	25	Years
Lifetime of MV line (poles treated with creosote)	25	Years
Lifetime of transformer	25	Years
System LV O&M annual cost	4	% of investment
MV O&M annual cost	4	% of investment
Transformer O&M cost	3	% of investment
Peak hours per day (/24)	5	Hours/Day
Hours of service on grid	24	Hours/Day

Grid extension cost assumptions were developed for the NES on the basis of data, technology preferences and national standards communicated to the consultant by stakeholders. This information was supplemented by international benchmarking (see section 9.3).

Importantly, the international benchmarking of electrification prices identified that Uganda's official connection costs are pretty higher than the regional benchmark prices for equivalent materials. Connection costs therefore represent an area for future cost savings for electrification projects.

Considerations on the cost assumptions:

The cost of works used in the implementation of ERT III project by GoU was compared with similar costs from the region especially from Kenya. The conductor sizes used by REA for MV lines are 50, 100 and 150mm² AAAC while Kenya has adopted 75mm² ASCR as a standard for rural areas. 1km of 33kv MV Line 3Ph in 150mm² AAAC with REA costing goes for USD 30,854 compared 33kV MV 3Ph in 75mmSQ ASCR for Kenya costs USD 14,331. The consultant included in the cost breakdown of surcharges levied to material costs. They include VAT, L&T, RoW, C/OH, Consultant, Change of Line Route and Miscellaneous charges. In addition, the connection prices indicated are the approved prices by ERA in the Tariff Study.

A comparison matrix with common costs applied in the REA Master Plan, KPLC in Kenya and in Sub-Saharan countries (as standard cost assumptions stemming from the international experience of the consultant) is presented below:

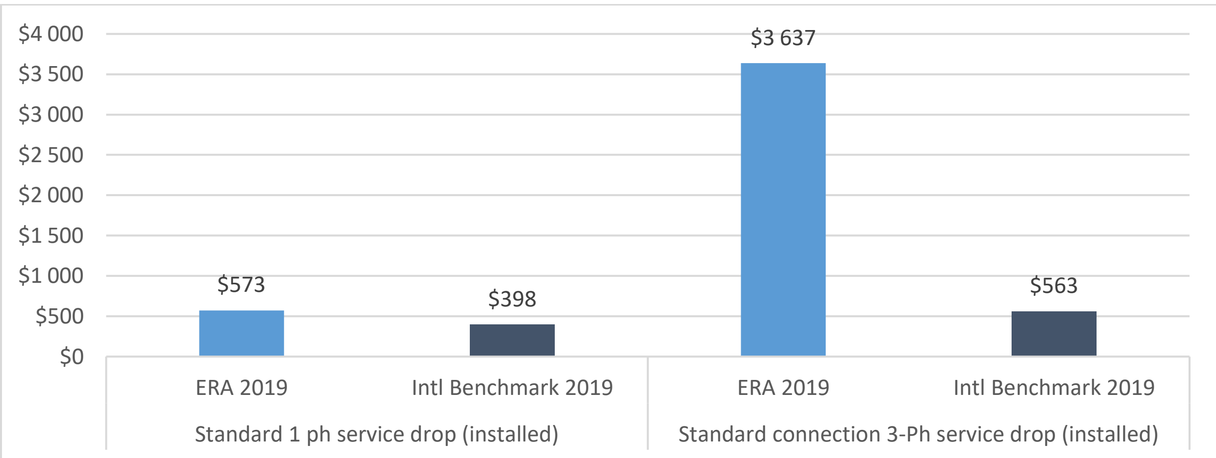
Table 53: Comparison matrix of grid costs

				Cost by Source (USD)				
#	Descrition	Size	Per	REA-MP	KPLC	hmark PERCO - Congo	onal benchmark-	IED NES
1	Substation	10KVA 33/0.250kV	Unit	2 350				
2		25 KVA 33/0.433kV	Unit	4 800		24 647	5 237	9 640
3		25KVA 33/0.250kV	Unit		1 984	24 647	5 237	
4		50KVA 33/0.433kV	Unit	5 900	3 111	25 609	5 237	10 349
5		100KVA 33/0.433kV	Unit		4 676	31 831	6 419	16 937
6		250KVA 33/0.433kV	Unit			49 911	59 919	17 319
7		200KVA 33/0.433kv	Unit		6 202			
8	33kV Line	150 MMSQ AAAC	km		18 534	29 467	26 004	30 854
9		100 MMSQ AAAC	km	28 000		27 587	26 004	21 630
10		50 MMSQ AAAC	km	26 000		25 290	22 318	18 539
11		75 MMSQ ASCR 3-Ph	km		13 823	26 334	25 893	
12	LV Line	70MMSQ AA ABC 3-Ph	km		10 532	22 942	17 958	15 763
13		70MMSQ AA ABC 1-Ph	km		7 927			12 610
14		3x35mm²+54,6mm² 3-ph	km			20 291	15 481	
15		4x25 MMSQ-3Ph	km	12 200		18 876	14 862	
16	Service Drop	16MMSQ S/C AL - 1ph	Unit	180	455	367	115	398
17		25MMSQ 4/C AL - 3ph	Unit	230		702	182	563
18	Metering	Pre-Paid 230V Imax 80A-1	Unit	157	148	71		145
19	Ready Board	1 pc	Unit	48	92			71

(*) all inclusive: supply, transportation to the sites, works, engineering studies and works preparation, overhead costs, testing and commissioning. PERCO project in Congo: includes bank fees and substations built on a T-Off with metal H-poles. Transportation costs are very high. KPLC Costs are derived from the KPLC MP 2013

The local consultants engaged with the stakeholders to confirm the costs assumptions to be applied in the consolidated scenario.

Figure 21: Connection cost comparison – ERA connection costs versus international benchmark



Based on consultations with MEMD, UMEME, ERA and REA, the table below presents the key cost assumptions used as inputs for GEOSIM grid extension simulations for the NES.

Table 54 : Principal cost assumptions for grid extension simulation

Item	Per	Description	Mate rials	Labour (15%)	Trans port (18%)	C/oh (10% of (materia ls+ labour+ transpor t)	Right of way (row) costs (1%)	Consult ant (1%)	Change of structu re/ line route/ opgw (2%)	Miscell aneous (1%)	Total cost
33KV OH LNE CONDUCTOR	Km	50MMSQ AAAC	12,253	1,838	2,206	1,630	123	123	245	123	**18,539**
33KV OH LNE CONDUCTOR	Km	100MMSQ AAAC	14,296	2,144	2,573	1,901	143	143	286	143	**21,630**
33KV OH LNE CONDUCTOR	Km	150MMSQ AAAC	20,393	3,059	3,671	2,712	204	204	408	204	**30,854**
LV 3PH ABC (km)	Km	35MMSQ	8,446	1,267	1,520	1,123	84	84	0	84	**12,610**
LV 3PH ABC (km)	Km	70MMSQ	10,558	1,584	1,900	1,404	106	106	0	106	**15,763**
33KV SUBSTATION 1PH with accessories	Unit	15KVA 33/0.240KV	4,211	632	758	560	42	42	0	42	**6,287**
33KV SUBSTATION 3PH	Unit	25KVA 33/0.415KV	6,457	969	1,162	859	65	65	0	65	**9,640**
33KV SUBSTATION 3PH	Unit	50KVA 33/0.415KV	6,932	1,040	1,248	922	69	69	0	69	**10,349**
33KV SUBSTATION 3PH	Unit	100KVA 33/0.415KV	11,344	1,702	2,042	1,509	113	113	0	113	**16,937**
33KV TRANSFORMER 3PH	Unit	200KVA 33/0.415KV	11,600	1,740	2,088	1,543	116	116	0	116	**17,319**
33KV TRANSFORMER T-OFF STRUCTURE	Unit	50MMSQ AAAC	1,850	278	333	246	19	19	0	19	**2,762**
Standard connection 1-Ph Service Drop 16MMSQ Al	Connec tion	incl. 50m max Cable, fix, 1 pole, circuit breaker, fuse, prepaid meter (Exl. Ready board)	266	40	48	35	3	3	0	3	**398**
1-Ph Pre-paid Meter (only)	Unit	For information	97	15	18	13	1	1	0	1	**145**

Standard connection 3-Ph Service Drop 25MMSQ Al	Connection	incl. 50m max Cable, fix, 1 pole, circuit breaker, fuse, prepaid meter (Exl. Ready board)	377	57	68	50	4	4	0	4	**563**
3-Ph Pre-paid Meter (only)	Unit	For information	186	28	33	25	2	2	0	2	**278**
1pc Ready Board (only)	Unit	For information, as an option for low-income HH	47.67	7	9	6	0	0	0	0	**71**

Densification assumptions

A significant number of connections to be made in the context of the NES Uganda will be located in localities already benefitting from electrical infrastructure, and will, instead of requiring new grid extension or mini-grid projects, simply require the addition of new connections to existing infrastructure. IED used the CIESIN population data and information on existing transformers to calculate a “densification zone” around existing MV/LV transformers and calculate the population living within this zone. The densification zone to consider was fixed using a buffer that varied according to the population density of the area in which a given transformer is located, as shown in the table below.

Table 55: Densification zone buffer assumptions

Item	Low-Density Areas	Medium-Density Areas	High-Density Areas
Distance from existing transformer considered in densification zone	1,500 m	1000 m	500 m

To calculate densification costs, IED applied a connection cost as well as a transformer and LV grid extension cost intended to represent the costs of network reinforcement or investments required to accommodate new connections. To attribute these costs, IED assumed that 1 additional km of LV line would be required for every 60 new connections, and 50 KVA of transformer capacity would be required for every 150 new connections. The table below summarizes these assumptions.

Costs were applied using the grid extension assumptions developed in Table 37: Principal cost assumptions for grid extension simulation.

Table 56: Densification connection investment assumptions

Item	Shared Meter Replacements	Low-Density Areas	Medium Density Areas	High-Density Areas
Meter	1	1	1	1
Standard drop line (50m, 1 pole)	0	1	1	1
Standard drop line distance surplus	0%	40%	20%	0%
Clients per 50 KVA transformer capacity	150	150	150	150
Clients per additional km of LV	60	60	60	60

11.4.3.2 Off-grid simulations

Once the initial grid extension simulation is carried out, GEOSIM then identifies single villages or a cluster of settlements where local renewable energy supply options and demand profiles could potentially support the development of a mini-grid. Only villages/clusters with a population of at least 500 in 2021 will be considered for mini-grid connections, as smaller populations are assumed not to have a large enough base of customer demand to make a mini-grid commercially feasible.

Hydro, and PV-battery systems (with diesel backup) will be considered as potential mini-grid supply options for the NES (for more information on the hydro potentials identified for the NES, see section *9.4.1 Renewable energy assessment*). Where multiple supply options exist, a hierarchy of potential mini-grid options will be defined for each cluster with the objective of minimizing the LCOE (levelized cost of electricity) calculated for each proposed project.

Off grid electrification cost assumptions are based on international benchmark prices, and are adjusted based on prices observed in the Ugandan market. The 3 tables below show the key assumptions for solar PV, diesel and hydro generation investments.

Table 57: Solar PV cost and economic assumptions

Item	Unit	Value
Solar panel cost	US$/kWp	450
Structure cost	US$/kWp	110
Inverter cost	US$/kW	220
Battery cost	US$/kWh	200
O&M cost ratio	%	4
Solar panel lifetime	Yrs	25
Inverter lifetime	Yrs	10

Table 58: Diesel backup cost and economic assumptions

Item	Unit	Value
Genset investment cost	US$/kW	400
Max capacity	kW	5000
Genset safety margin	%	20
Maximum lifetime	Yrs	5
O&M cost ratio	%	12
Maintenance down time	%	5
Assumed delivered fuel price (diesel)	US$ BBL	140

Table 59: Hydropower cost and economic assumptions

Item	Unit	Value
Hydro investment cost	US$/kW	3000
Maximum lifetime	Yrs	40
O&M cost ratio	%	4
Use of diesel backup possible?		Yes

The cost assumption presented in the table above were obtained from ERA, AfDB, World Bank and UEGCL official websites from the already completed Hydro Power projects. The related costs do not include only the generating plant but also the associated transmission facilities to connect to the grid.

11.4.3.3 Simulation outputs

For each simulation GEOSIM provides the following information:

- 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 on and off-grid project
- O&M costs and the resulting supply cost for each project

Each option is sized to achieve the lowest levelized cost, taking into account the technical, economic and financial parameters. Finally, the least-cost option will be selected for each village. This will result in a list of potential electrification projects via both grid extensions and mini-grid developments.

11.4.4 Economic assessment

The economic assessment follows the same principle for both grid and off-grid 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 on the other**. This process enables the Consultant to recommend approaches to the supply energy services that maximize the net benefit.

As the NES seeks to achieve universal access in Uganda by 2030, rather than ranking or selecting projects based on their economic and financial benefits (e.g. net present value), the cost-benefit for grid-based connections for a village will be compared with cost-benefit profiles for connections through alternative solutions, such as mini-grids. In areas where grid connection costs exceed the costs of alternatives, the consultant will scrutinize the feasibility of such options.

Table 60: Additional economic analysis assumptions

Item	Unit	Value
Planning period for economic and financial analysis	Years	20
Base year for costs		2019
Discount rate for economic and financial analysis (CBR June to Sept 2019)	%	10

11.5 Distributed energy solutions

Achieving 100% access to electricity in Uganda by means of grid-extension and/or mini-grids will inevitably take time and investment that will likely continue well beyond the identified planning horizon. Additionally, even in areas with electrical infrastructure in place, domestic connections might, at least temporarily, remain outside some households' or settlements' payment capacity. This may be due to the remoteness of the household/settlement, its population or socio-economic characteristics, or other criteria.

In areas where conventional electrification options will not be provided at the end of the planning period, 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 Uganda already exists, driven by both local and international private sector actors but also by public programs.

Unlike grid and off-grid costs, costs for solar lamps and home systems are likely to be borne, at least in part, by the private sector. At this stage, the objective is to estimate the total cost of investments in distributed stand-alone solutions; different scenarios for public and private investment in the sector will be explored in the financing plan. The table below shows the cost and dimensioning assumptions for a Tier-1 equivalent solar lighting system, and for larger stand-alone systems that can be used to electrify public services such as schools or clinics.

Table 61: Key assumptions for distributed energy solutions

Item	Power (W)	Description	Assumed use in the NES	Unit cost (USD)	Assumed average lifetime (Years)
Solar Lighting System	3	3W pico-solar system with high-efficiency panel, 2 lighting points and phone charging	Tier 1 HH Connections	50	6
Standalone-1	500	500W stand-alone solar system, AC	School or public administration buildings electrification.	7,000	6
Standalone-2	1000	1000W stand-alone solar system, AC	Productive uses electrification, including refrigeration and water pumping. Electrification of health centres.	10,000	6

The consultant has assumed that all household connections *not* served by the main grid or by mini-grids will be made via the 3W solar lighting system. Similarly, all schools and administrative buildings not electrified through grid or mini-grid connections will be connected through *Standalone-1* at 500 W systems, while all health clinics and productive uses will be electrified through the *Standalone-2* system at 1000 W. For all distributed solar solutions, reinvestment in the full value of the solution is assumed to be required at the end of the product’s useful life.

12 Development of a National Electrification Strategy for Uganda

12.1 Introduction and objectives

The Government of Uganda has set an objective for the National Electrification Strategy to reach universal tier-1 connectivity by 2030. This means that each household in Uganda should have an electrical connection capable of fulfilling *at least* the requirements of a tier 1 connection as defined by the ESMAP multi-tier framework.[45]

Achieving universal connectivity in Uganda will involve the massive expansion of both grid connectivity, through densification and grid expansion, as well as off-grid connectivity through the development of mini-grids and the expansion of stand-alone solar connections. However, there are multiple possible pathways to achieving this ambitious goal. The role of the NES is to explore these potential pathways in order to optimize the electrification strategy from a cost perspective, while also maximizing the quality and durability of electricity services and accommodating potential capacity constraints and/or political objectives. The NES final Study report presents the final scenario for electrification in Uganda selected in concertation with stakeholders.

12.2 Assessing the connectivity gap in Uganda – A geospatial approach

Section 3 of this report describes existing measurements of access to electricity and connectivity in Uganda. The following paragraphs aim to complement previous analyses using the output from the geospatial database constructed for this project, with the dual objective of both estimating the number of household connections required to achieve universal connectivity by 2030 and understanding how unserved populations are distributed geographically, in particular with respect to the existing MV distribution network. The following analysis assumes 2021 as the base year, as this is the first year of the planning horizon established for the NES.

12.2.1 Access to electricity at the village level in Uganda

Measuring access to electricity at the village level is a critical step in the process of expanding access to modern energy and achieving universal connectivity in Uganda. The reasons for this are twofold: Firstly, understanding which communities already benefit from electrical infrastructure and of what kind allows electricity sector stakeholders both to monitor progress in electrification efforts and measure the actions required to increase connectivity and access. The effort required to achieve universal connectivity in a village with an existing MV/LV transformer will necessarily be different from the effort required in a remote village with no existing or proximate grid infrastructure. Given the scope of the challenge and the resources required to achieve universal connectivity within the next ten years, it is critical that electrification and connectivity actions be appropriately targeted.

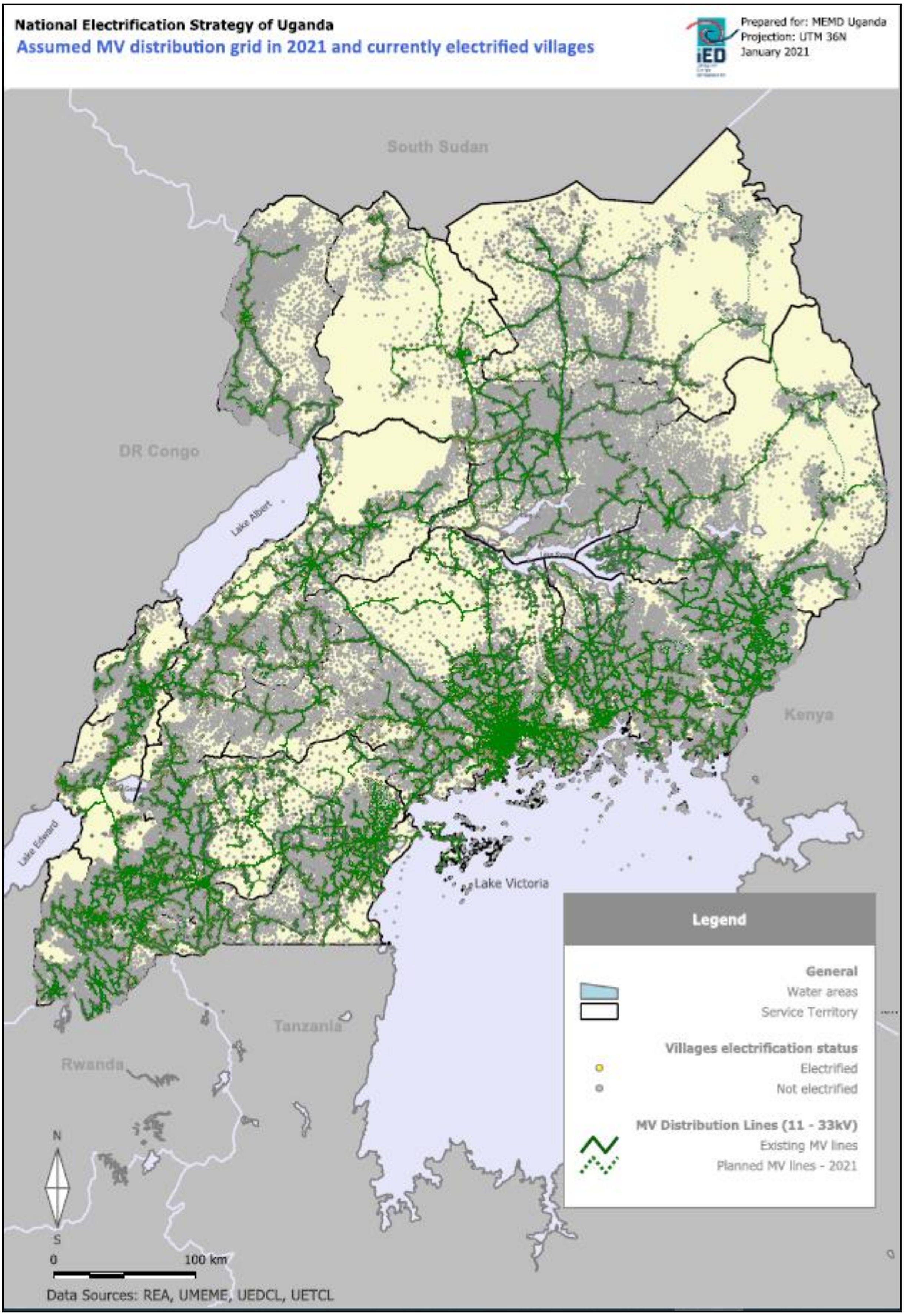
Secondly, from a socio-economic standpoint, while the policy goal stated by the Government of Uganda for the National Electrification Strategy is to achieve universal household connectivity by 2030, village level access to electricity can provide benefits to the surrounding community irrespective of whether or not individual households are connected. A priori, all households in an electrified village will benefit from services linked to electrified public infrastructure such as schools, clinics, or boreholes, and electrification can also support commercial and economic activity in such localities by reducing the costs of certain activities or making possible new activities through the productive use of

[45] According to this framework, a tier 1 connection corresponds to at least 4.5 kWh of electricity consumption per year, enough energy to ensure basic task lighting and phone charging.

electricity. These indirect benefits, often referred to as access to electricity services or proximate access (see *Table 2 : Central definitions* for more information), constitute an important potential welfare impact that should be measured in parallel to household connectivity.

The map below shows the extent of the grid distribution infrastructure, as well as the electrified villages identified by the procedures described in section 9.1, with currently electrified villages shown in yellow and villages with planned electrification projects slated for completion by 2021 shown in orange. As shown by the map below, once REA completes the distribution lines under construction in the north-eastern part of the country, nearly all of the districts in Uganda will benefit from at least some MV grid infrastructure, with only a few districts such as Kapelebyong and Obongi totally unconnected to the main or a large isolated grid such as that operated by WENRECO in the West Nile service territory. We note that all district headquarters and sub-counties are connected.

Map 7: Electrified and planned villages in Uganda 2019



At national level, assuming the completion of slated electrification projects, **IED estimates that of the 64,639 villages in the planning database, more than 16,449 (26%) will be electrified through the interconnected grid, or via mini-grids, by 2021.** At sub-national level, there is a relatively high degree of variability in coverage rates (number of electrified villages versus total number of villages) from service territory to service territory. About 54% of the villages located within the UMEME concession are expected to have village level access to electricity in 2021[46], while fewer than 10% of villages in the Central North, Eastern, North Eastern service territories benefit from electrification.

Table 62: Electrified and non-electrified settlements by service territory

Service Territories and UMEME concession	A – Total electrified villages in 2019	B- Villages planned for electrification 2021	C – Coverage rate 2021 %[47]	D-Total non-electrified villages 2021	D -% Villages non electrified 2021	E- Average population of electrified villages 2021	F- Average population of non-electrified villages 2021
UMEME[48]	9 539	26	54%	8 043	46%	1 220	415
MID WESTERN	477	67	19%	2385	81%	794	537
CENTRAL NORTH	254	5	6%	3904	94%	623	432
EASTERN	610	100	9%	6968	91%	947	536
NORTH EASTERN	338	73	8%	4447	92%	919	460
N-N WEST	327	7	19%	1383	81%	1 318	754
NORTH WESTERN	816	59	22%	3138	78%	977	665
SOUTH	561	93	29%	1629	71%	887	595
SOUTH WESTERN	537	3	20%	2226	80%	527	402
WEST NILE	662	29	14%	4269	86%	769	515
NORTHERN	304	147	13%	2909	87%	827	349
RWENZORI	220	12	18%	1025	82%	658	442
WESTERN	578	20	27%	1643	73%	710	493
CENTRAL	571	14	13%	3951	87%	856	621
TOTAL	**15 794**	**655**	**26%**	**47 920**	**74%**	**1 069**	**501**

While there is not a major difference in the population sizes of electrified versus non-electrified villages on average, remaining non-electrified villages do tend to have lower populations. As shown in the tables below, 60% of Uganda's non-electrified villages are expected to have a 2020 population of fewer

[46] For grid connected localities, the consultant has considered a village to have access to electricity if the village boundaries contain either an MV/LV transformer, or a georeferenced meter, or are crossed by an MV line and meet minimum night radiance standards. Projects are defined as village boundaries that contain at least one MV line marked "under construction" by REA/distributors in the NES Planning Database. See section 1.1.2.1 for more information.

[47] Includes villages slated for electrification in planned grid extension or mini-grid projects

[48] Service territory figures exclude the Umeme concession area in each of the territories.

than 500 inhabitants. Only 250 villages without access to electricity have a projected population of more than 2500 inhabitants.

Non-electrified villages are also overwhelmingly located close to existing grid infrastructure, with 81% of non-electrified villages located within 5 km of the interconnected grid or a major isolated grid.[49] This not only reflects the approach taken to electrification via the interconnected grid over the previous decade in Uganda, which was primarily focused on the construction of MV backbones to maximise grid coverage in the country, and sheds light on the required efforts for the period 2020-2030. Clearly, future grid-based electrification efforts will need to be largely focused on densification and intensification efforts around the existing grid consisting of numerous, relatively short grid extension projects, rather than on long-distance extension of MV backbones.

Table 63: Villages without access to electricity in Uganda by population and distance from MV grid

Maximum distance from MV grid 2021 (km)	Densification (0-1.5 km)	>1.5 <= 5km	>5 <= 10km	>10 <= 20km	>20 <=30 km	>30 …	Total	*% Total*
Pop. 2020	*Number of villages*							
0-250	4 468	6 671	1 558	809	185	55	13746	29%
250-500	3 307	9 038	1 877	760	146	63	15191	32%
500-1000	2 703	9 178	1 781	717	157	59	14595	30%
1000-2500	622	2 628	547	245	67	29	4138	9%
2500-5000	14	115	41	34	11	2	217	0%
>5000	2	8	6	14	3	0	33	0%
Total	11 116	27638	5810	2579	569	208	47920	100%
% Total	23%	58%	12%	5%	1%	0%	100%	

12.2.2 Household connectivity

Given the objective of universal Tier-1 connectivity set by the Government of Uganda for the NES, the number of household connections is the primary metric that will be used to develop the electrification strategy and measure progress against its goals.

Setting objectives for required household connections requires first an estimation of the level of household connectivity in 2020 from grid, mini-grid or stand-alone connections meeting at least the tier 1 minimum standard. This is achieved by combining reported client statistics from various electricity distribution companies, the results from the ERT-III 2018 Baseline Survey, as well as sales statistics for various solar home solutions. Grid connectivity statistics (including mini-grid connections) have been estimated by service territory. However, without disaggregated statistics on sales and ownership of solar home systems or other stand-alone solutions, global connectivity statistics can only be estimated at the national level.

Grid and mini-grid connectivity

According to the latest available statistics from ERA, the estimated total number of domestic customers connected to a grid or a major mini-grid is 1.47 million.[50] Table 62 below shows the

[49] Densification and 0-5KM Assuming the completion of REA grid extension projects by 2021; major isolated grid refers to the WENRECO-operated isolated grid in the West Nile service territory.
[50] Last available data on domestic customer connection from ERA dates to Q4 2019 as of March 2021.

assumed number of customers in 2020 for the UMEME concession as well as for the distribution service territories.

However, as in many other countries in the region, domestic customer statistics (represented by an active meter and a contract with an electricity distribution company) do not accurately represent the actual number of Ugandan households benefiting from a connection to grid-based electricity. This is because in reality one meter may serve multiple households, or conversely, one household may have multiple meters. **Comparing the number of households that report having access to a grid-based connection in the 2018 ERT-III Baseline Survey to the number of domestic customers reported by distribution companies in the same year shows that each metered domestic customer, represents on average 1.5 household connections in Uganda in 2018.**[51] The number of household connections for each meter is referred to here as the "meter adjustment factor." Applying this factor to the estimated number of domestic customers permits a more accurate estimation of the actual number of households with a grid-based connection (Column B in the table below), suggesting that for 1.47 million currently reported domestic customers, 2.2 million Ugandan households benefitted from a household connection to a grid or mini-grid.

Table 64: Domestic customers and connected households in 2018 and 2020 (Q4 2019)

ST and UMEME concession	D-Domestic customers Q4 2019	E- Connected households Q4 2019	F-Grid connection rate Q4 2019
UMEME	1 351 629	2 027 444	64%
UEDCL – MID WESTERN	4710	7065	2%
UEDCL – CENTRAL NORTH	3530	5295	1%
UEDCL – EASTERN	6106	9159	1%
UEDCL – NORTH EASTERN	5467	8200,5	2%
UEDCL -NORTH NORTH WEST	8872	13308	4%
UEDCL – NORTH WESTERN	18856	28284	5%
UEDCL – SOUTH	13922	20883	6%
UEDCL – SOUTH WESTERN	10227	15340,5	6%
UEDCL – RWENZORI	8597	12895,5	10%
WENRECO – WEST NILE	12584	18876	3%
PACMECS – NORTHERN	3893	5839,5	2%
KIL -WESTERN	14569	21853,5	8%
KRECS – CENTRAL	7185	10777,5	2%
TOTAL	**1 470 147**	**2 205 221**	**25%**

ST and UMEME concession	Domestic customers	Connected households (incl. meter adjustment)	Grid connection rate (incl. meter adjustment)

[51] The ERT III Baseline survey indicates that 24% of the population (2.1 million households) have access to a domestic grid or mini-grid connection in 2018, while ERA statistics from the same year indicated 1.4 million total domestic connections. 2.1 million connected households / 1.4 million domestic customer meters = 1.5 connected households per metre.

UMEME	1 351 629	2 027 444	64%
UEDCL – MID WESTERN	4710	7065	2%
UEDCL – CENTRAL NORTH	3530	5295	1%
UEDCL – EASTERN	6106	9159	1%
UEDCL – NORTH EASTERN	5467	8200,5	2%
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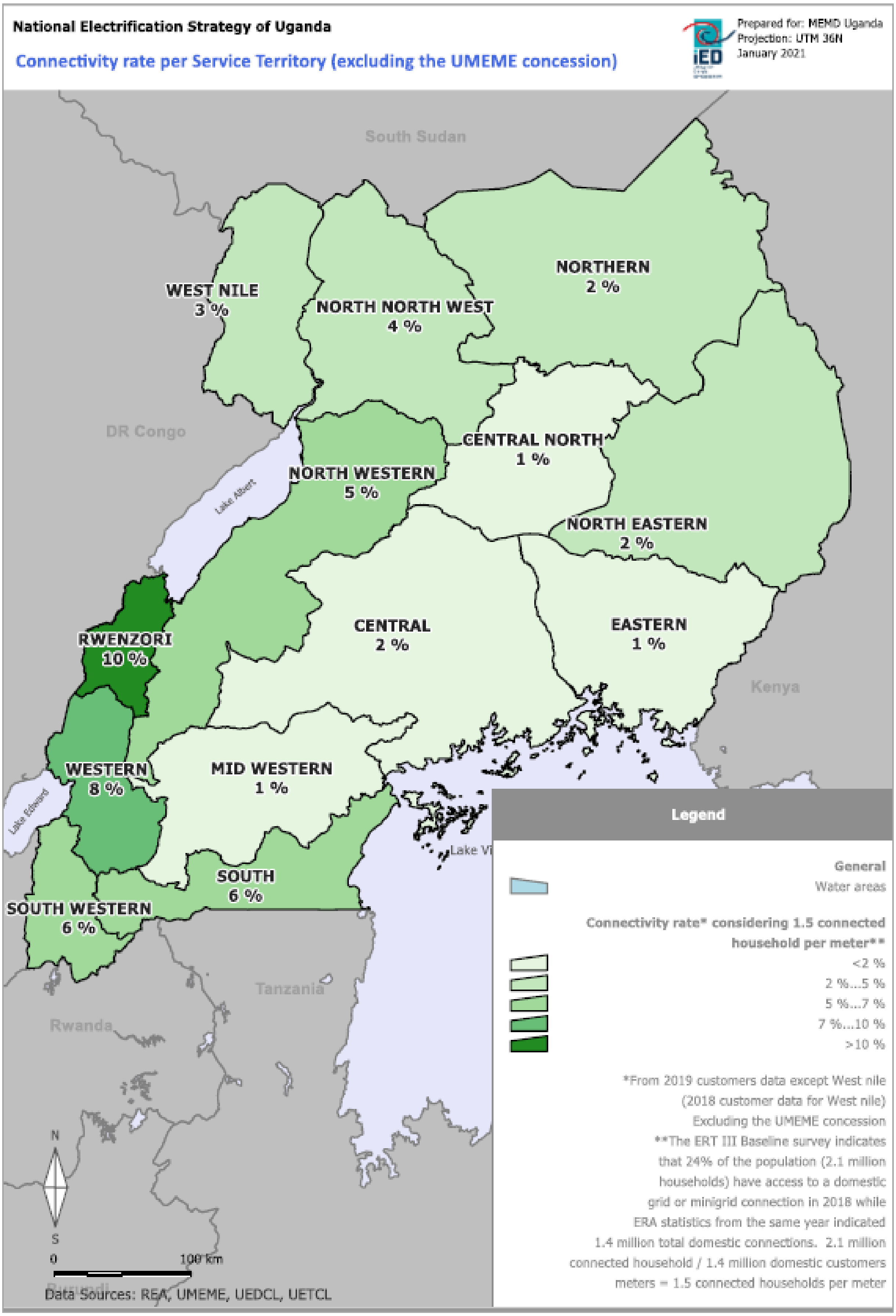
KRECS – CENTRAL	7185	10777,5	2%
TOTAL	**1 470 147**	**2 205 221**	**25%**

As with previous village-level analysis, there is substantial variation between the UMEME concession area which covers most major urban centres in Uganda and the more rural and more recently established service territories. IED estimates that within the UMEME concession area, the household connectivity rate was 64% in 2020, while in most service territories – with the exception of Rwenzori – the connectivity rate does not surpass 10% in 2020.

Map 8: Grid connectivity rate per Service Territory 2020 (share of households with household connection to grid or major mini-grid)



Stand-alone connections

While grid connections are relatively easily quantifiable on a disaggregated regional basis, based on distributor reported figures and geospatial analysis, no disaggregated geographical data is available for mini-grid and stand-alone solutions. The consultant has therefore relied upon the results from the ERT-III Baseline Survey in 2018 to estimate the number of connections to mini-grids and via stand-alone solutions at the national level. The table below shows the assumed number of mini-grid and stand-alone connections for 2020. The 2020 stand-alone connections projections presented below assume that the ECP[52] connections commitment for off-grid solutions will be met for 2019 and 2020, and that all subsidized stand-alone connections will be of at least a Tier 1 minimum standard.

Table 65: Stand-alone connection projections 2020 and rate (%) compared to total connections

Item	Connections in 2018 (ERT-III)	%	Projected connections in 2020 (Consultant assumption)[53]	%
Stand-alone connections (incl. solar home systems, diesel gensets, tier 0 solar lanterns, etc.)	2,225,407	26%		
Of which Tier 1 capable [54]	911,210	14%	**1,351,000**	**15%**

Aggregated national connections statistics and required connections to 2030

Aggregating grid and off-grid connections projections, and assuming that **IED estimates that in 2020 3.6 million households in Uganda have Tier 1-minimum household electrical connection through either the main grid, a mini-grid, or a stand-alone solution, generating an overall national connectivity rate of 40%[55].** This leaves approximately 5.2 million households without a connection that meets the Tier 1 minimum standard of service in 2020. The table below summarizes the connections assumptions for 2020 as well as the estimated total number of unconnected households in the country.

Table 66: Aggregated household Tier 1 connection statistics for Uganda

	Estimates 2020
Grid/mini-grid household connections	2,205,221
Stand-alone household connections	1,351,000
Non-electrified households	5,248,677
Total households	8,804,898
Connectivity rate	40%

However, achieving universal connectivity in Uganda requires not only connecting the 5.2 million unserved households in 2020, but also connecting the new households that will result from population growth over the period 2020 to 2030. The figure below shows the required number of connections

52 Uganda Connections Policy 2018

53 The consultant has only projected Tier 1 figures in the context of the NES.

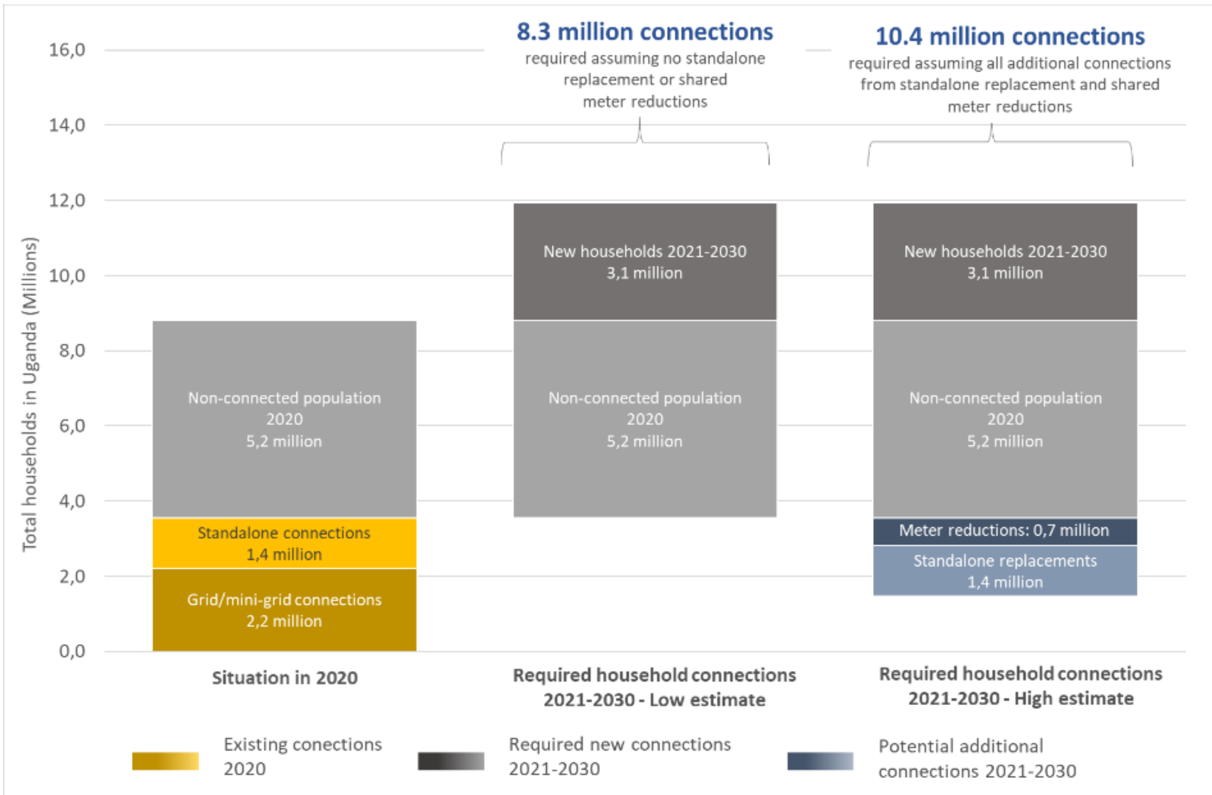
54 ERT-III estimates that in 2018, 24% of solar lighting systems were Tier 0. Remaining SLS, all solar home systems and all genset connections are assumed to be at least Tier 1 capable.

55 The difference with the ERT-III survey statistics (which suggest 50% overall access rate in 2018) is that Tier 0 connections (solar lanterns that do not meet the Tier 1 standard) are here excluded from the baseline.

through 2030, broken down by category. **At minimum, an estimated 8.3 million additional connections are required between 2021 and 2030 to achieve universal Tier 1 access in Uganda**.

It should also be noted that there is a large amount of uncertainty with respect to overall number of connections to be carried out over the planning period, driven primarily by two factors. First, due to the shorter useful lifetime of stand-alone solar or genset solutions (generally 5–7 years) and the lack of scalability[56] of many such solutions, a connection via a stand-alone solution and a grid-based connection are not necessarily exclusive. Concretely, this means that, for example, a household connected today with a stand-alone solar solution as its primary connectivity modality may choose to abandon its system for a grid connection once electricity arrives in its vicinity through a mini or the main grid. This would ultimately increase the total number of connections to be made in order to achieve universal connectivity as some households would ultimately benefit from both a stand-alone and a grid-based connection during the planning period.

Figure 22: Required household connections in Uganda 2021-2030



The second factor contributing to uncertainty in the total number of required connections are customers who are already connected to the grid, but who are currently sharing a meter. As discussed above, the 2018 customer numbers and ERT-III survey results suggest that each meter serves 1.5 households on average in Uganda. With the expansion of grid connectivity and the continued penetration of prepaid meters and subsidized connections, households currently a sharing a meter may choose to "regularize" their connection by obtaining their own meter and distributor contract, generating an increase in the required connections. The trend towards the reduction in the average

[56] Lack of scalability refers to the ability of a household to increase its level of consumption using the same stand-alone technology. For example, if a household currently consumes at a Tier 1 level with a solar lighting system, it would need to purchase a larger solar home system or connect to a grid/mini-grid if available in order to increase its consumption to a Tier 3 level.

number of households per meter is already being observed in Uganda, with the meter adjustment factor falling from 2.4 households per meter in 2014 to 1.5 households per meter in 2018.

Taken together these factors imply the potential need for an additional 2.1 million connections over the planning period, or 10.4 million total connections by 2030, as shown in Figure 21 above. Given the implausibility of a policy mechanism that would effectively limit subsidies or incentives only to "first-time" connections for households that do not currently have a household-level connection of any kind, IED recommends that the additional connections resulting from both the replacement of stand-alone solutions and the "correction" of domestic meter sharing be included in total number of estimated required connections in order to avoid an under-estimation of the total required investment.

Geographic distribution of required household connections

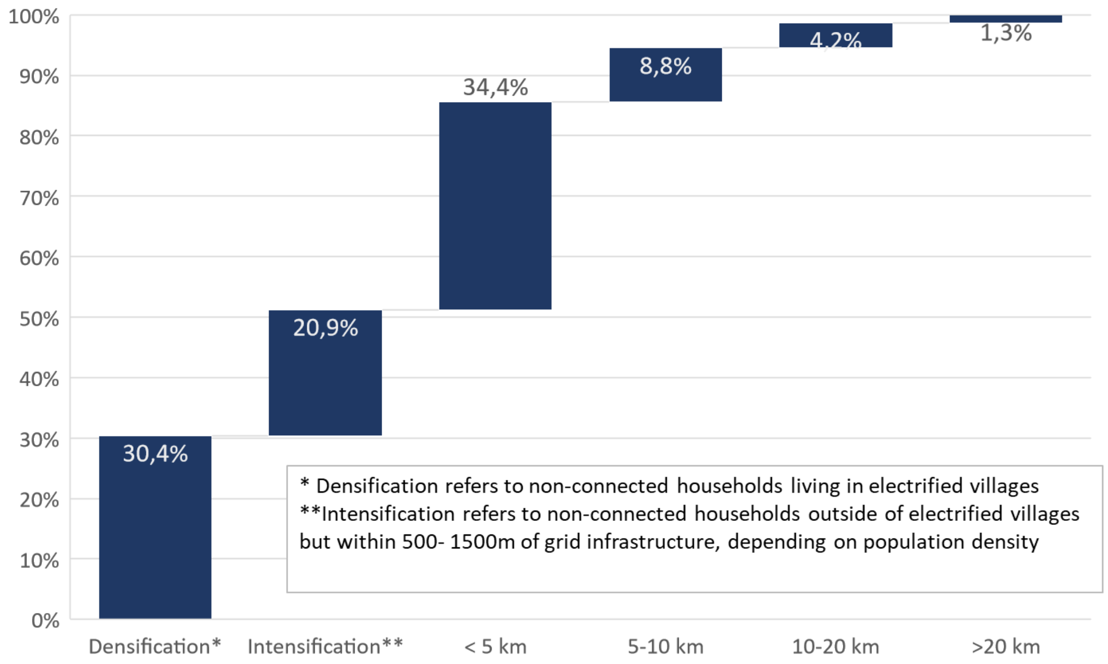
In a geospatial least cost planning approach, the types of infrastructure and the total level of investment required to achieve the objective of universal minimum Tier-1 connectivity will be driven in large part by the geographic and demographic profiles of the populations requiring a household electrical connection by 2030. Concretely, this means the number of potential household connections and electricity demand forecasts for a given unserved population, as well as the distance of the population from existing electrical infrastructure, in particular the MV distribution grid. Consequently, it is important to know where unserved populations are located with respect to the existing grid, in order to get a better sense of the nature and magnitude of the various types of electrification projects required, be it grid densification, grid extension, the construction of mini-grids, or the distribution of stand-alone solar solutions.

The figure below shows the percentage of required connections by distance from the existing MV grid. Strikingly, over half of the required connections through 2030 in Uganda are located in areas proximate to existing grid infrastructure*:* **51% of the required connections to achieve universal connectivity in Uganda by 2030 can be achieved through simple grid densification or intensification**[57] **requiring investments only in potential grid reinforcements and additional droplines to connect new customers**.

An additional 34% of total connections are located less than 5 km from the existing grid, and can therefore be reached through short-range grid extension projects from existing MV backbones to connect unserved populations. Only 13% of the required connections through 2030 are located between 5 and 20 km from the existing MV grid. These populations would likely require longer MV grid extensions and/or the construction of new backbones in order to be connected, or connection through an off-grid modality where this is the least-cost alternative. Finally, only 1% of the unserved population is located in the most remote villages located more than 20 km away from the nearest MV grid network.

[57] In the context of this study, grid densification refers to non-connected households living in electrified villages; intensification refers to non-connected households outside of electrified villages but within 500- 1500m of grid infrastructure, depending on population density

Figure 23: Share of required connections by distance from existing MV grid



12.3 Base case final scenario criteria resulting from the NES draft

1 The draft report had studied two potential variants to develop the NES: one based on a classical geospatial least cost optimisation with a uniform grid/off-grid footprint, and a second variant in which the grid footprint through 2030 is determined by the REA proposed extensions developed as part of the Rural Electrification Master Plan developed with NRECA international. Both variants were modelled using the GEOSIM software. After evaluation by stakeholders, a final base case scenario has been drawn to develop a further geospatial planning analysis.

2 The base case final rest on an approach to universal connectivity that is both ambitious with respect maximising the overall quality of service achieved -i.e. maximising the number of grid and mini-grid connections provided to households and infrastructure- and realistic with respect to the capacity of key stakeholders, as well as the capacity and willingness of households to take advantage of the opportunity to connect.

3 Electrification projects selection and design are designed are carried out using GEOSIM's path extension algorithms as described in the methodology section of this report. Concretely, grid extension is simulated without distance limits from the 2021 MV grid.

4 In order to electrify at the lowest cost providing a Tier 3 service level, grid electrification was prioritized and all the villages in the parishes whose average connection cost was greater than US$ 2000 were considered for off-grid electrification, either through the construction of a renewables-based mini-grid (solar PV or mini-hydro) or through the provision of 3W solar lighting systems for households (Tier 1) or larger 500-1000W stand-alone solar systems for public or productive infrastructures. To ensure that mini-grid projects were commercially viable, only villages with a 2021 population of at least 500 inhabitants were considered for off-grid projects, unless they are part of a multi-village cluster resulting, for example, from the development of a mini-hydro site. For household connected to electricity through grid or mini-grid, the level of service is accorded to household categorization (high, medium, low incomes).

5 Connection rates within grid connected villages are expected to progressively reach at least 50% by year 10 after initial electrification for all grid and mini-grid connected zones, with the exception of the UMEME concession area, which is expected to reach at least a 95% household connectivity rate (from approximately 77% currently) by the end of the planning period. Households in these zones that remain unconnected by 2030 will be equipped with solar lighting systems. The specific connection rate targets (95% and 50%) result from a compromise between the current connection rates, the connection trends over the years which reflect the electrification capacities of the different operators (Umeme and others) and the technically and financially achievable perspectives in order to maximize the grid connectivity versus Tier 1 connectivity. The consultant believes these connections rates are ambitious yet feasible.

6 Criteria for the technology to be deployed for a particular village are based on average cost of making a connection for that particular village. The cost per connection is determined by proximity of the targeted village to the grid and the population size of the village. A model (computer software for optimized planning) is used to automatically select technology options and grid layout to be deployed in each particular village as follows:

i. Densification: for already electrified villages with connection targets of 70% to 100% depending on the initial access rate ;
ii. Grid extensions: Cost per connection is less than USD 1,999;
iii. Mini-grids: Cost per connection is USD 2,000 and above with a population of not less than 500 homesteads;
iv. Solar Home Systems: For all non-connected household either in grid/mini-grid areas or in off-grid areas

Then, for each particular technology to be deployed, villages are prioritized on a calculation which integrates two criteria:

- first, the level of socio-economic infrastructures available in the settlement (significance of the educational, health or economic infrastructures that exist);
- second, the size of the population which can benefit from these services (inhabitants of the locality and inhabitants living in the surroundings: “population coverage”).

These 2 criteria are aggregated through the “covered population indicator”. The higher is this indicator, the better the ranking of the localities. The planning criteria are further developed according to the consensual base case scenario in the table below.

Table 67: Criteria to select the base case scenario for the NES final report updated on July 22 and October 15

#	Criteria	Base case final	Comments
1	**Budget**	No limit	– No specific constraint. The NES Final scenario presents the budgets required to achieve the selected optimum access
2	**Institution**	IED optimisation	– This is the techno-economic and social optimum grid footprint attained by using geospatial analysis and GEOSIM software.
3	**Connection rate in y10**	50% to 100%	– This criterion refers to connection rate within grid/MG connected villages. All non-connected HH = SHS Tier 1.
4	**Grid footprint in Y10**	no buffer	Threshold for technology selection – grid vs. off-grid zones: – 1: Grid-preferred – USD 1600 or less – 2: Mini-grids preferred – USD 2000 or more – 3: Mixed mode zones where MG projects were studied in competition with grid extension – USD 1601-USD 1999. – 4: Standalone Solar for all remaining non-connected HH
5	**Standard of service of household connections and others**	Tier 1 to 5	– For connected HH to grid or MG: service according to HH categorization (high, medium, low incomes) specific to on-grid and off-grid connection – For non-connected HH either in grid/MG areas (see criterion #3) or off-grid areas (see criterion #4): Tier 1 service and sensitivity analysis to a service level equivalent to MG option. – Infrastructures: Tier 3 to 5 depending on requirements
6	**Number of solar MG**	no limit.	– During the WS of July 22, it was agreed to reduce the threshold from 1000 to 500 inhabitants allowing for microgrids.

12.4 Geospatial planning results

12.4.1 On-grid electrification: densification

As shown in section 10.2.2, over half of the required connections to be made by 2030 in Uganda to achieve universal connectivity are *densification* connections, located in areas that already benefit from electrical connections in 2020. These connections are spread over areas with varying characteristics, with approximately 18% in low population density areas, 38% in medium population density areas and 44% in high population density areas[58].

The NES proposed Base Case assumptions for densification assume that many, but not all connections in this area will be achieved. Specifically, the Base Case assumes that within the UMEME concession (which already benefits from a relatively high connectivity rate) the connectivity rate will reach 95%, and that other distributors operating in the rural service territories will reach a 50% connection rate, up from approximately 10% today. Together, this achieves a combined, weighted average connection rate for all densification zones of 67% or 84% with shared meter replacement. **Under these assumptions, the total number of household connections to be achieved through grid densification by 2030 is approximately 3.4 million, or 340,000 connections per year on average, including shared meter replacement.** This number of annual connections is twice the number of connections achieved through "business as usual" growth in connections over the last several years (approximately 150,000 connections per year at the national level) plus the dedicated annual grid connections through the Uganda Connections Policy 2018 (200,000 per year through 2027).

Table 68 : Densification connections targets – Base Case scenario

Operator	Target Cnx rate	HH to connect 2021-2030	*Of which shared meter replacement*	*Of which low-density*	*Of which medium-density*	*Of which high-density*
	%	N. HH	*N. HH*	*N. HH*	*N. HH*	*N. HH*
UMEME	95%	*2 094 813*	*675 815*	*136 605*	*494 755*	*787 638*
UEDCL – MID WESTERN	50%	*98 998*	*2 355*	*47 031*	*42 406*	*7 205*
UEDCL – CENTRAL NORTH	50%	*52 214*	*1 765*	*21 340*	*25 880*	*3 230*
UEDCL – EASTERN	50%	*216 490*	*3 053*	*12 821*	*86 143*	*114 473*
UEDCL – NORTH EASTERN	50%	*114 447*	*2 734*	*26 064*	*47 911*	*37 738*
UEDCL – NORTH NORTH WEST	50%	*84 804*	*4 436*	*48 374*	*20 630*	*11 364*
UEDCL – NORTH WESTERN	50%	*164 461*	*9 428*	*42 888*	*77 493*	*34 651*
UEDCL – SOUTH	50%	*110 993*	*6 961*	*24 290*	*58 768*	*20 973*
UEDCL – SOUTH WESTERN	50%	*74 738*	*5 114*	*7 202*	*33 832*	*28 590*
UEDCL – RWENZORI	50%	*33 996*	*4 299*	*1 332*	*8 970*	*19 395*

[58] For more information on population density data sources and investment and grid dimensioning assumptions, please see Chapter 9.

WENRECO – WEST NILE	50%	*118 157*	*6 292*	*9 189*	*26 101*	*76 575*
PACMECS – NORTHERN	50%	*70 748*	*1 947*	*27 520*	*13 086*	*28 195*
KIL – WESTERN	50%	*79 753*	*7 285*	*4 305*	*22 998*	*45 165*
KRECS – CENTRAL	50%	*124 025*	*3 593*	*59 037*	*49 049*	*12 346*
TOTAL	**67%**	***3 438 634***	***735 074***	***467 999***	***1 008 022***	***1 227 540***

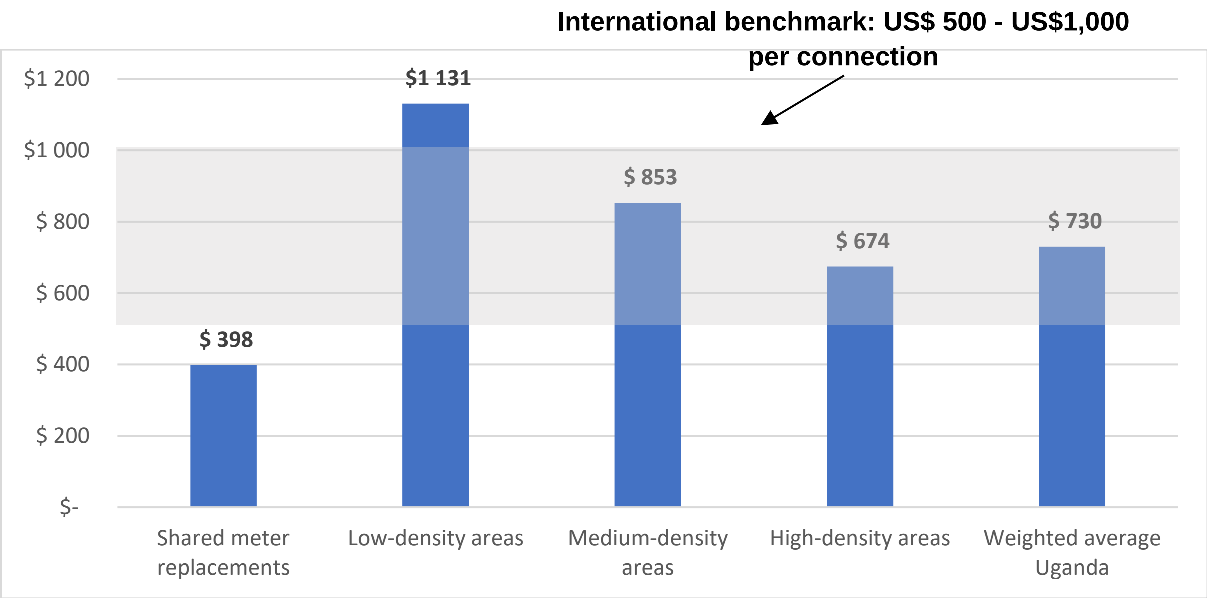
Densification connections are less costly on average that household connections achieved through grid extension or mini-grid construction, as they benefit from existing infrastructure and therefore require less investment. In general, a densification connection requires at minimum a meter and dropline, as well as potential additional investment in the LV grid to reach new households and additional transformers or other reinforcements to accommodate the additional demand resulting from new connections. Table 67 below shows the investments required to achieve the targeted connections in the proposed Base Case by operator/zone. **At the national level, the consultant estimates that the total cost of densification to achieve the target household densification connection rate of 84% will be approximately US$ 2.5 billion over the period 2021-2030,** of which approximately 54% would be required in the current UMEME concession with an additional 32% required in UEDCL's combined eight distribution zones.

Table 69: Estimated densification investments by operator and zone

OPERATOR/ZONE	Meters and droplines	Transformers	LV & MT lines	Shared meters replacement	Total Cost	*Share of total cost*
	US$	**US$**	**US$**	**US$**	**US$**	***%***
UMEME	625 891 188	97 437 863	384 145 204	268 974 171	**1 376 448 425**	*55%*
UEDCL – MID WESTERN	49 326 857	6 636 153	38 250 561	937 290	**95 150 861**	*4%*
UEDCL – CENTRAL NORTH	25 535 981	3 464 165	19 383 092	702 470	**49 085 708**	*2%*
UEDCL – EASTERN	93 845 967	14 656 007	56 644 875	1 215 094	**166 361 943**	*7%*
UEDCL – NORTH EASTERN	52 424 836	7 670 959	35 685 586	1 087 933	**96 869 315**	*4%*
UEDCL – NORTH NORTH WEST	41 329 790	5 518 603	33 113 485	1 765 528	**81 727 406**	*3%*
UEDCL – NORTH WESTERN	74 699 423	10 645 599	52 613 375	3 752 344	**141 710 742**	*6%*
UEDCL – SOUTH	49 949 737	7 143 531	34 640 916	2 770 478	**94 504 662**	*4%*
UEDCL – SOUTH WESTERN	31 549 911	4 780 848	19 944 553	2 035 173	**58 310 485**	*2%*
UEDCL – RWENZORI	12 745 433	2 039 194	7 447 842	1 710 803	**23 943 272**	*1%*
WENRECO – WEST NILE	48 062 808	7 681 397	28 534 096	2 504 216	**86 782 516**	*3%*
PACMES – NORTHERN	32 805 670	4 724 335	23 761 203	774 707	**62 065 915**	*2%*
KIL – WESTERN	31 358 245	4 976 136	18 598 453	2 899 231	**57 832 065**	*2%*
KRECS – CENTRAL	61 234 931	8 269 664	47 417 193	1 429 815	**118 351 602**	*5%*
TOTAL	**1 230 760 778**	**185 644 453**	**800 180 433**	**292 559 253**	**2 509 144 918**	***100%***
Share of total cost	49%	7%	32%	12%	**100%**	

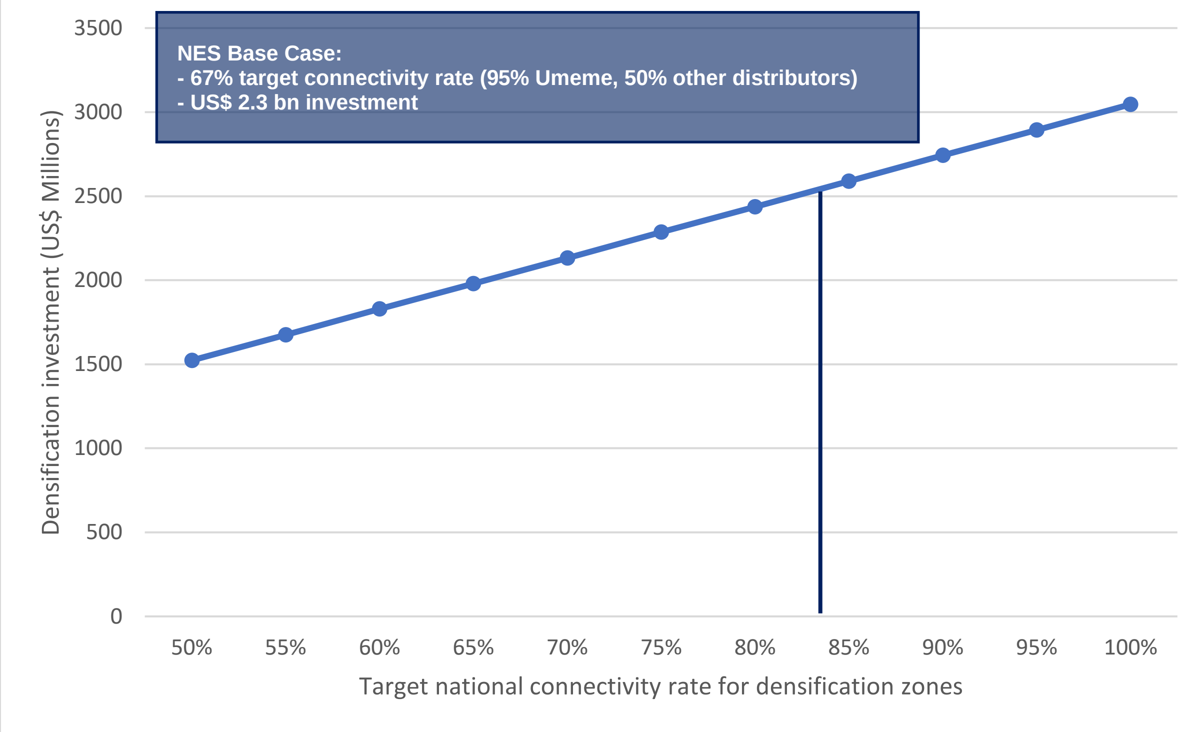
At the national level, we see that a densification connection in Uganda ranges from US$ 398 for simple shared meter replacement to US$ 1 131 for longer drop line and LV infrastructure in low density areas. Logically, costs are higher in areas with a lower population density, as potential clients are spaced further apart and will therefore require slightly more infrastructure on average. On average in Uganda, considering the varying population densities throughout the grid densification zone, **a household densification connection is expected to cost $US 730**, including the meter and drop line, and the household's assumed share of additional LV and transformer investments. This compares positively with international benchmarks, which generally assume a combined connection cost for grid densification of between US$500 and US$1000 per connection. However, it should be noted that this average cost is based on IED's adjusted connections costs as presented in section 9.4.3. Applying the 2019 ERA approved connection costs for 1 phase connections, this average combined cost of densification connection would be nearly $US 950 and even higher if the approved 3-phase costs are included for a percentage of connections.

Figure 24 : Average cost per densification connection by population density



Achieving a higher level of overall connectivity via densification connections would require additional investment. Figure below shows the estimated required investment in densification assuming various national target connection rates, applying the weighted average cost per connection of US$ 730. IED estimates that achieving a 100% connectivity rate in all villages currently connected to the grid would require approximately US$ 3bn. Of course, in reality the total cost implied by a given target connection rate will depend on where investments are made – with costs rising as the share of investment in low density, presumably rural areas, rises.

Figure 25: Estimated densification investment levels for varying target connection rates



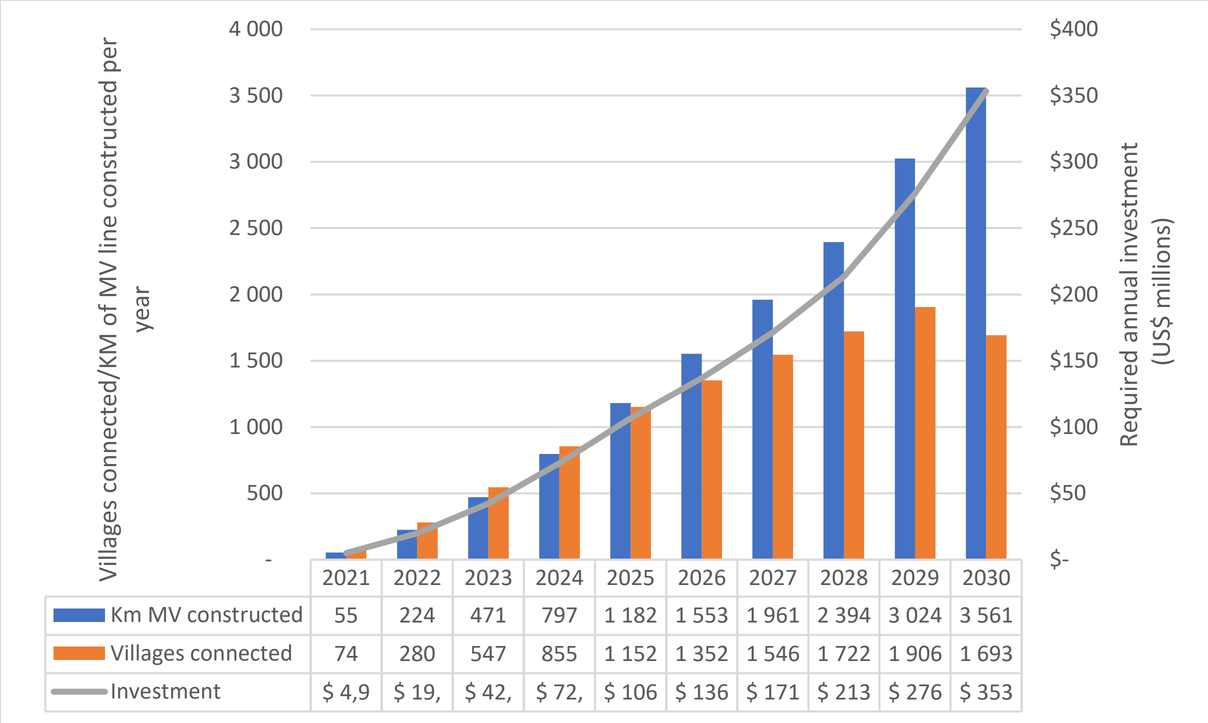
12.4.2 On-grid electrification: grid extension

According to the base case final scenario, the extension of the existing MV grid was studied without any distance limitation from the existing grid network. **In total, over the 10 years period, up to 2030, the scenario implies electrifying 11,127 villages via the construction of 15,222 kilometres of additional MV lines for a total investment budget of US$ 1,4 billion.** Of these 11,127 villages electrified, about 1,948 villages were identified as development poles in the spatial analysis described in previous Spatial Analysis section, with a high socio-economic impact associated with electrification.

Figure below shows the evolution of the number of villages connected and kilometres of MV line constructed per year on the left-hand axis, with the annual required investment on the right-hand axis. Between 2021 and 2025, more than 2,908 villages (26 % of total villages) will be connected to the MV grid. During this period, villages connected tend to be closer to the existing network, and therefore require fewer kilometres of MV constructed per village, as well as a lower overall level of investment, averaging approximately US$ 49 million per year. During the following period (2026-2030), villages in increasingly remote areas are connected to the grid, the number of required kilometres of MV line and the annual investment budgets increase rapidly year on year. **At this rhythm, grid extension would require mobilising US$ 246 million for the period 2021-2025 (or approximately 18% of the total investment budget), while US$ 1.15 billion will be required for the period 2026-2030 (or 82% of total investment).** “Backloading” the investment in grid expansion could allow time to mobilise the significant budget required for years 6 through 10, and could potentially be combined with a “frontloaded” investment in grid densification described above.

On an annualised basis, the grid extension projects would imply the construction of around 1,522 km of new MV lines per year with a maximum of 3,561 in year ten. Stakeholders indicated that REA constructs between 3,000 and 4,000 km of MV lines per year on average. Therefore**, the rate of construction does not represent a significant trend of construction relative to the current baseline**, and is not expected to pose a significant capacity constraint.

Figure 26: Villages connected, km MV lines constructed and required investment per year



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Km MV constructed	55	224	471	797	1 182	1 553	1 961	2 394	3 024	3 561
Villages connected	74	280	547	855	1 152	1 352	1 546	1 722	1 906	1 693
Investment	$ 4,9	$ 19,	$ 42,	$ 72,	$ 106	$ 136	$ 171	$ 213	$ 276	$ 353

Map 9 shows the expected status of MV grid infrastructure when completed in 2030.

Map 9: Grid extension 2021-2030

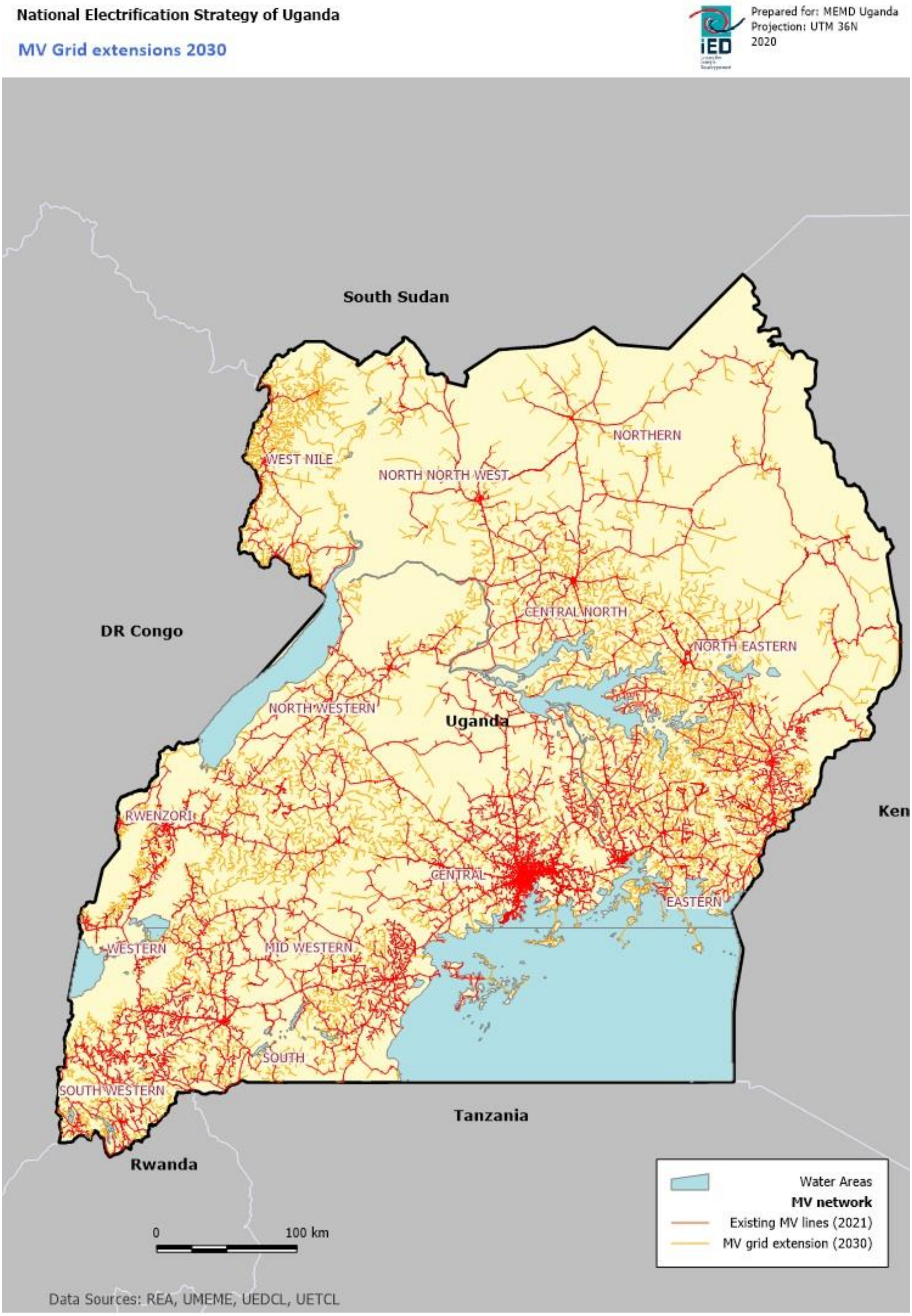
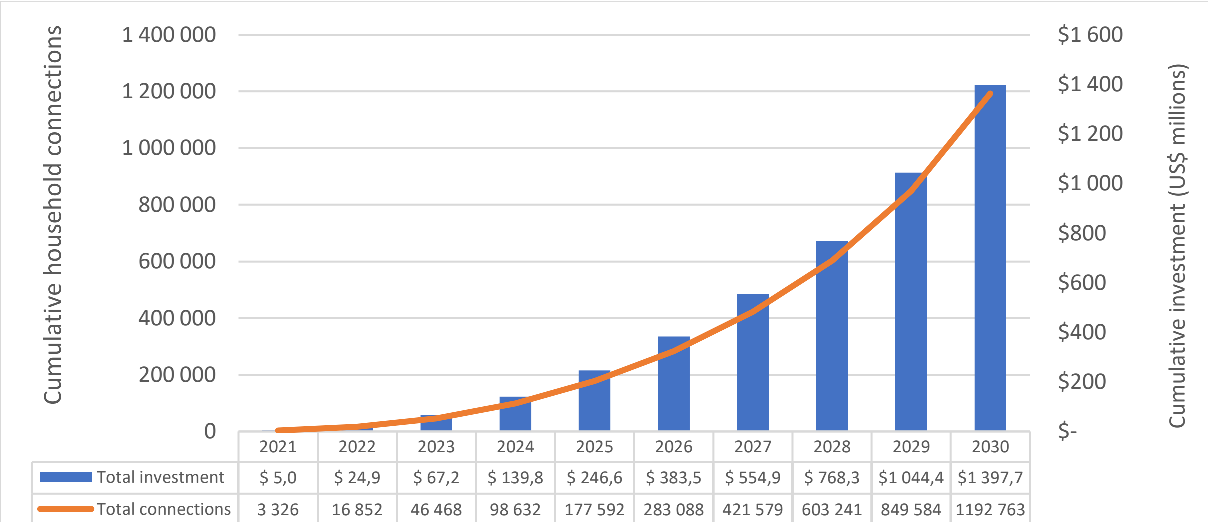


Figure below shows the total cumulative connections and investments expected for grid extension at a national level. Based on feedback from local stakeholders, the consultant has assumed a steady progression of the household connection rate from 5% in the initial year of electrification to 50% of households connected in year ten. Consequently, for a village electrified in 2021, the 50% connectivity milestone will be reached in 2030; however, for a village electrified in 2025, this milestone will only be reached 10 years after initial electrification, in 2034. **Consequently, the total number of connections to be achieved through on-grid electrification stands at only 1.2 million in 2030**.

These new connections are expected to generate an additional 200 MW of peak demand for electricity by 2030. Additional demand includes only electricity consumption from households, small commerce and public infrastructure as indicated in section 9.3.2. Further demand potential could be captured if specific productive uses are encouraged or commercial and industrial demands that are currently self-producing are connected to the grid.

Figure 27: Cumulative connections and investment



Tables 70 and 71 below list the expected connections, MV lines constructed, and additional electricity demand in detail by service territory and operator, while Figure 27 below compares the share of total investment to the share of total connections for each service territory.

From a regional perspective, the largest number of new connections are expected to be made in the Eastern service territory followed by Central, West Nile, North Western, North Eastern service territories which are expected to add respectively 232 612, 148 418, 130 180, 128 627, 111 930 connections by 2030. Together those five service territories concentrate over 64% of expected connections to 2030. Given UEDCL's operations footprint which currently covers 8 of Uganda's 13 distribution service territories, the vast majority of new connections and grid extension investments are expected to be made in UEDCL's current zone of operation: UEDCL is expected to absorb over 65% of new connections by 2030 as well as over 66% of the total new MV lines constructed. WENRECO and KRECS operations would also be significantly impacted by these extensions[59], given the projected expansion of connections and grid footprint in the West Nile and Central service territories.

[59] The GOU is currently not planning to connect WENRECO to the main grid before 2023.

Table 70: Summary results by service territory connections, MV lines constructed, additional

ST	Connected villages 2030 (N.)	*Of which develop - ment poles*	Total HH connections 2030 (N.)	Total population covered 2030 (N.)	MV lines constructed (km)	Additional demand from new connections in 2030 (GWh)	Peak demand new connections in 2030 (MW)
MID WESTERN	674	*190*	67 246	765 717	1 011	53	11
CENTRAL NORTH	942	*104*	84 773	957 754	1 268	66	14
EASTERN	2132	*406*	232 612	2 646 197	2 428	183	39
NORTH EASTERN	1031	*173*	111 930	1 336 488	1 629	86	19
NORTH NORTH WEST	405	*102*	63 158	791 803	848	47	10
NORTH WESTERN	1107	*233*	128 627	1 556 089	1 757	99	21
SOUTH	521	*93*	54 023	626 591	756	42	9
SOUTH WESTERN	438	*49*	39 380	416 086	432	32	7
WEST NILE	1264	*118*	130 180	1 511 645	1 438	101	22
NORTHERN	376	*48*	43 152	523 121	630	33	7
RWENZORI	249	*39*	25 244	271 780	230	20	4
WESTERN	474	*91*	47 283	514 993	462	38	8
CENTRAL	1355	*302*	148 418	1 792 734	2 201	114	24
UGANDA	**10 968**	**1948**	**1 176 026**	**13 710 999**	**15 090**	**914**	**197**

Figure 28: Share of investment and connections by service territory

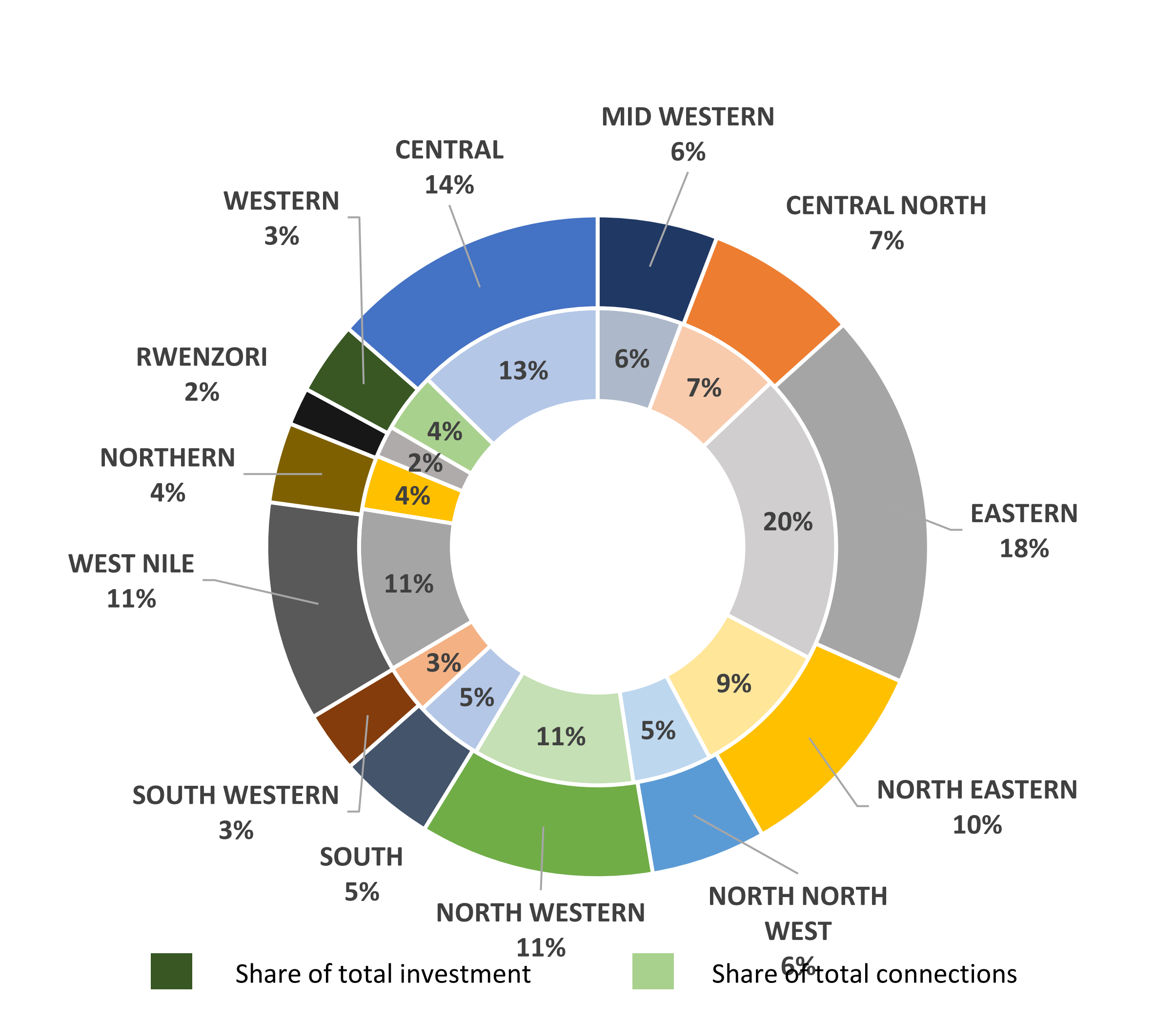


Table 71: Summary results by operator MV lines constructed, additional demand

Operator	Connected villages 2030 (N.)	Total HH connections 2030 (N.)	Total population covered 2030 (N.)	MV lines constructed (km)	Additional demand from new connections (GWh)	Peak demand new connections (MW)
UMEME	159	16 737	173 256	132	14	3
UEDCL	7 499	806 993	9 368 506	10 359	628	135
WENRECO	1 264	130 180	1 511 645	1 438	101	22
PACMECS	376	43 152	523 121	630	33	7
KRECS	1 355	148 418	1 792 734	2 201	114	24
KIL	474	47 283	514 993	462	38	8
UGANDA	**11 127**	**1 192 763**	**13 884 255**	**15 222**	**927**	**200**

The expected investment breakdowns is provided on the below tables by major infrastructure category for the various service territories and distribution operators in Uganda. At national level, MV and LV lines represent approximately one-third of the total investment. Generally, MV lines would be expected to occupy a greater overall share of investment than LV lines. In the Ugandan rural context however, given the large number of villages to connect and the relatively high dispersion of populations within each individual locality, the requirements for local investments in LV infrastructure inside villages constitute relatively large part of overall investment budgets. Transformers and customer connections are expected to account for 13% and 20%, respectively.

Table 72: Summary investment results by service territory

ST	Total Investment 2030 (US$)	*Of which MV* (US$)	*Of which LV* (US$)	*Of which transformers* (US$)	*Of which drop lines/meters* (US$)
MID WESTERN	**81 038 123**	*21 858 672*	*26 513 296*	*10 860 530*	*21 805 624*
CENTRAL NORTH	**102 902 386**	*27 433 329*	*33 061 486*	*15 185 962*	*27 221 608*
EASTERN	**253 595 832**	*52 528 239*	*91 438 565*	*34 459 564*	*75 169 464*
NORTH EASTERN	**139 249 525**	*35 244 593*	*47 619 700*	*17 177 059*	*39 208 174*
NORTH NORTH WEST	**77 513 163**	*18 333 610*	*28 757 048*	*6 774 141*	*23 648 364*
NORTH WESTERN	**157 970 603**	*37 994 523*	*55 796 915*	*18 317 625*	*45 861 540*
SOUTH	**64 907 773**	*16 357 385*	*21 935 271*	*8 572 981*	*18 042 136*
SOUTH WESTERN	**41 018 114**	*9 339 942*	*13 695 570*	*6 721 988*	*11 260 614*
WEST NILE	**148 304 506**	*31 094 877*	*53 063 746*	*20 483 292*	*43 662 590*
NORTHERN	**54 050 260**	*13 633 324*	*18 782 264*	*6 194 262*	*15 440 410*
RWENZORI	**25 307 388**	*4 972 953*	*9 045 264*	*3 851 347*	*7 437 824*
WESTERN	**49 044 787**	*9 984 084*	*17 351 167*	*7 441 236*	*14 268 300*
CENTRAL	**187 408 784**	*47 615 136*	*64 358 504*	*22 516 667*	*52 918 478*
UGANDA	**1 382 311 242**	***326 390 665***	***481 418 795***	***178 556 654***	***395 945 126***

Table 73: summary investment results by operator

Operator	Total Investment 2030 (US$)	*Of which MV* (US$)	*Of which LV* (US$)	*Of which transformers* (US$)	*Of which drop lines/meters* (US$)
UMEME	**15 420 972**	*2 856 025*	*5 567 667*	*2 427 841*	*4 569 438*
UEDCL	**943 502 906**	*224 063 245*	*327 863 115*	*121 921 197*	*269 655 348*
WENRECO	**148 304 506**	*31 094 877*	*53 063 746*	*20 483 292*	*43 662 590*
PACMECS	**54 050 260**	*13 633 324*	*18 782 264*	*6 194 262*	*15 440 410*
KRECS	**187 408 784**	*47 615 136*	*64 358 504*	*22 516 667*	*52 918 478*
KIL	**49 044 787**	*9 984 084*	*17 351 167*	*7 441 236*	*14 268 300*
UGANDA	**1 397 732 214**	**329 246 690**	**486 986 463**	**180 984 495**	**400 514 564**

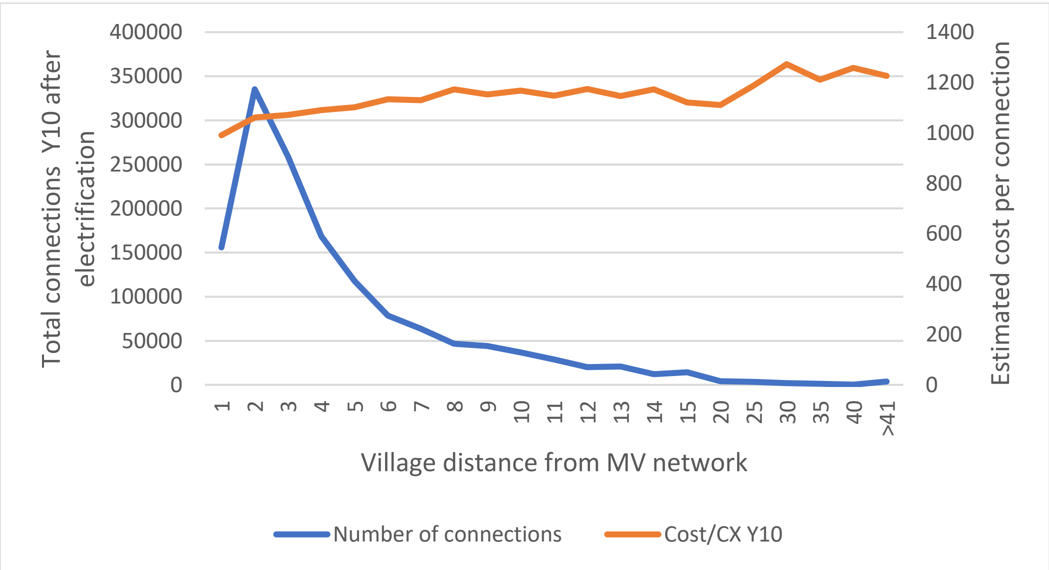
The overall connections figures achieved in 2030 lead to 1,192,763 total new connections over the 10 years period, or approximately 107 household connections per new electrified villages on average. These results highlight the importance of national policy measures aimed at encouraging faster household connection growth, both from the perspective of expanding household quality access, scalable electricity connections provided by the grid, but also from the perspective of maximising the return on investments through grid expansion. Since the medium-voltage extensions represent a large share of the cost in grid extension projects, the average cost per connection is highly sensitive to the number of connections supported by a particular extension project.

IED considers the 50% connectivity cost per connection figure to be a more accurate representation of "real" costs per connection than the average cost per connection in 2030. Considering **an average cost per connection of US$ 1,090, the grid extension investments stand roughly in line with international benchmark figures,** which generally consider US$ 1,100 – US$ 1,650 to be an acceptable cost range for similar distances and technologies.

As observed in the figure below, costs per connection generally increase as distance from the existing network increases. Costs per connection are at their lowest in villages located close to existing grid infrastructure, standing at approximately US$ 990 per connection at a distance of 1 km from the existing grid. The trend then rises progressively as the grid reaches villages increasingly distant from the existing infrastructure, as a function of both the declining number of overall connections in these zones and the increasing MV investment requirements, reaching approximately US$ 1,200 for villages located more than 25km from the existing grid.

It should nevertheless be noted that the trend is not entirely linear, and population dispersion and density can have a large impact at costs per connection. For example, at 15 km from the existing grid, villages tend on average to be slightly denser (with a population roughly equal to the population in villages located at 14 km from the grid spread over 8% fewer villages), which drives the average cost per connection down by over US$50 from 14km to 15km.

Figure 29: Estimated cost per connection at 50% connectivity by distance from existing MV grid



This sensitivity to the distance from existing networks and population density also generates important regional differences across service territories. Table 74 below shows the estimated average costs per connection in 2030 under the Base Case connectivity assumptions, as well as assuming 50% overall connectivity for all villages electrified from 2021-2030 nationally and by operator. Logically, in the northernmost parts of the country, where grid infrastructure is less developed relative to the rest of Uganda, average costs per connection are higher regardless of the calculation method used. Inversely, costs are lower in the Eastern and West Nile service territories operators, where current grid coverage is more extensive and populations are generally denser and located closer to existing grid infrastructure.

Table 74 : Estimated average costs per connection 2030 projected versus 50% connectivity

	Base Case 17% connectivity			Overall 50% connectivity		
Operator	**Total investment (US$)**	**Total connections**	**Average cost per connection**	**Total investment (US$)**	**Total connections**	**Average cost per connection (US$)**
UMEME	15 420 972	16 737	921	16 684 183	18 431	905
MID WESTERN	81 038 123	67 246	1 205	91 634 071	81 459	1 125
CENTRAL NORTH	102 902 386	84 773	1 214	115 662 189	101 889	1 135
EASTERN	253 595 832	232 612	1 090	290 049 564	281 510	1 030
NORTH EASTERN	139 249 525	111 930	1 244	161 800 607	142 180	1 138
NORTH NORTH WEST	77 513 163	63 158	1 227	93 225 584	84 234	1 107
NORTH WESTERN	157 970 603	128 627	1 228	185 490 312	165 541	1 121
SOUTH	64 907 773	54 023	1 201	74 327 643	66 659	1 115
SOUTH WESTERN	41 018 114	39 380	1 042	44 659 457	44 264	1 009
WEST NILE	148 304 506	130 180	1 139	171 141 627	160 813	1 064
NORTHERN	54 050 260	43 152	1 253	63 368 424	55 651	1 139
WENZORI	25 307 388	25 244	1 003	28 042 480	28 913	970
WESTERN	49 044 787	47 283	1 037	54 638 612	54 786	997
CENTRAL	187 408 784	148 418	1 263	218 942 194	190 716	1 148
UGANDA	**1 397 732 214**	**1 192 763**	**1 172**	**1 609 666 947**	**1 477 048**	**1 090**

12.4.3 Mini-grid projects

Villages not reached by grid extension are considered for mini-grid development, either through solar PV with diesel hybridization or through small hydropower projects. Only villages with a population of at least 500 inhabitants were considered for mini-grid development. Hydro projects were considered for cluster development, while solar projects were developed on a single-village basis.

Small hydropower projects

Through the geospatial hydropower potential analysis described in section 9.4.1, IED identified 36 small hydropower potentials. Table 75 below shows the hydro potential sites with an estimated investment cost and other key characteristics. While the identified sites that fall inside the grid zone were not considered for mini-grid development, these sites may nevertheless present a potential opportunity for grid-injected power particularly within the West Nile service territory.

A high-level study was conducted on each off-grid potential site using GEOSIM, in order to estimate the initial dimensioning of each mini-grid cluster and the LCOE[60] for each site. However, with limited site information, these estimates remain preliminary and should be considered as purely indicative of which sites may merit further study based on local demographics and potential demand. Potential hydro mini-grid sites were studied assuming isolated operations (i.e. no grid interconnection) and the

[60] Levelized cost of electricity

presence of substantial diesel backup. Additional savings could be potentially captured by connecting projects to the grid over the medium-to-long term to offtake excess generation capacity, by locating and estimating productive demand potentials to serve as anchor loads, or by reducing or eliminating the diesel backup option depending on site hydrology. However, determining the impact of these elements would require a more in-depth site study in order to be confirmed.

Table 75 : Identified small hydropower potential sites

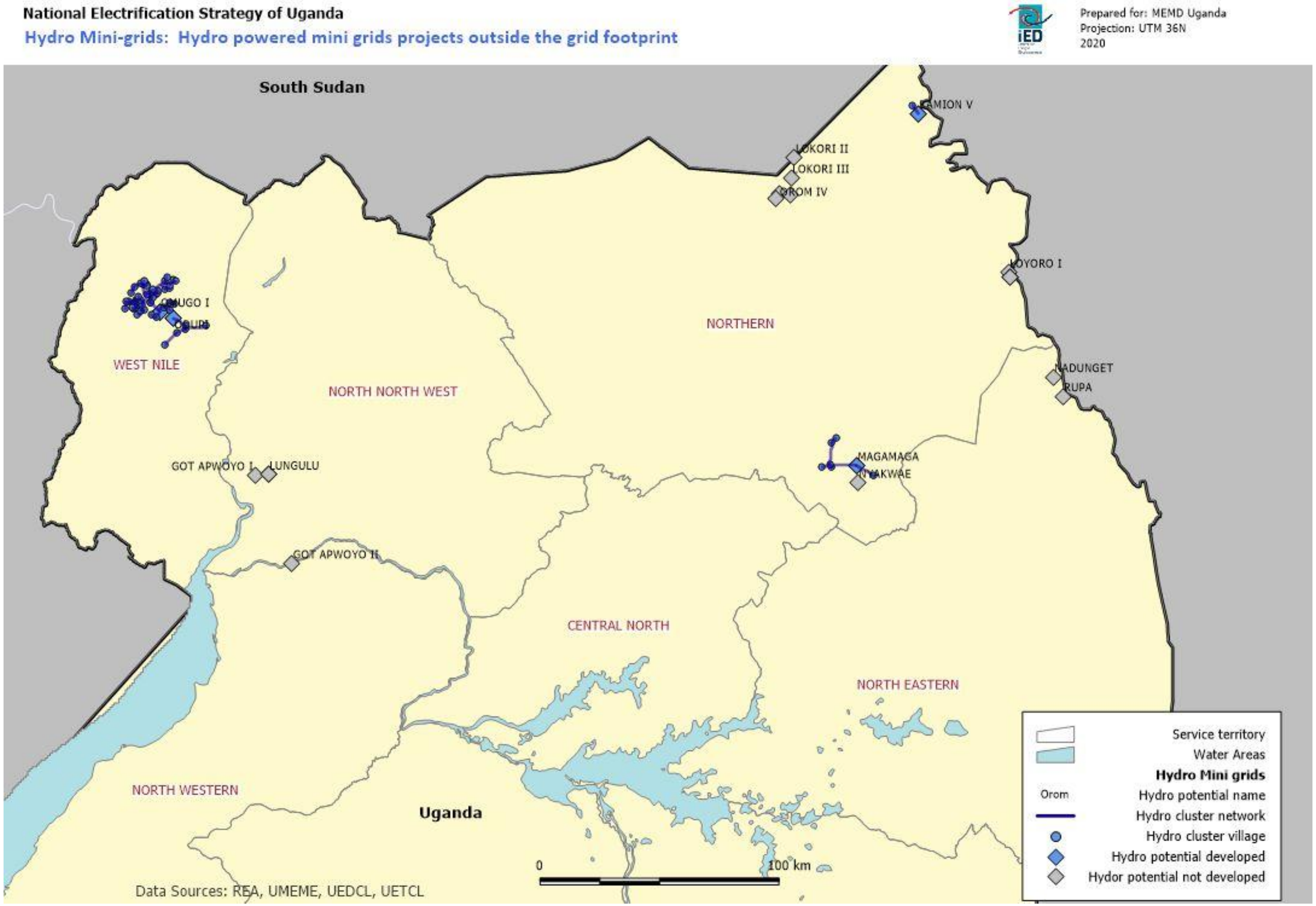
NAME	Nominal capacity (kW)	Guaranteed capacity (kW)	Investment US$	Time at guaranteed capacity (%)	Distance from existing MV grid (km)
KAWALAKOL I	737	171	4,790,500	20	14
KAMION I	1151	313	4,949,300	20	11
KAMION II	133	34	864,500	20	9
KAWALAKOL II	1660	414	7,138,000	20	5
KAMION III	256	66	1,664,000	20	11
KAMION IV	542	139	3,523,000	20	13
LOKORI I	405	93	2,632,500	20	9
OROM I	1181	270	5,078,300	20	4
OROM II	201	45	1,306,500	20	4
OROM III	390	87	2,535,000	20	5
KAMION V	244	57	1,586,000	31	27
LOKORI II	551	123	3,581,500	29	18
LOKORI III	1511	336	6,497,300	29	18
OROM IV	840	187	5,460,000	29	21
LOKORI IV	197	44	1,280,500	29	17
OROM V	912	198	5,928,000	28	21
LOYORO I	662	174	4,303,000	36	27
LOYORO II	1350	356	5,805,000	36	28
NADUNGET	224	64	1,456,000	40	36
RUPA	445	127	2,892,500	40	38
MAGAMAGA	286	90	1,859,000	46	16
NYAKWAE	338	106	2,197,000	46	18
OMUGO I	767	184	4,985,500	32	22
LUNGULU	882	311	5,733,000	55	20
ODUPI	495	121	3,217,500	33	26
GOT APWOYO I	1280	913	5,504,000	40	17
GOT APWOYO II	4599	3522	19,775,700	71	29
OMUGO II	537	129	3,490,500	32	22
NYAPEA	2115	468	9,094,500	29	4
NEBBI I	224	75	1,456,000	51	3
NEBBI II	129	43	838,500	50	2
OFFAKA	182	51	1,183,000	40	6
ZEU	17	5	110,500	41	3
OLUKO	60	15	390,000	34	2
KIJOMORO	129	31	838,500	32	1
MIDIA	28	6	182,000	29	2

The main results for potential hydro mini-grid are presented on the below table, while Map 10 shows their location on the map. Further details on project economics are available in the annexes to this report. **In all, 4 potential hydro mini-grids were identified with a combined nominal capacity of 1,7 MW. These grids could potentially supply 62 villages through 4 clusters, providing access to a population of approximately 40,000 people.**

Table 76 : Hydro mini-grid results

Hydro site Name	LCOE	Investment	Population 2021	N. villages	LV clients (2021)	Energy (2021)	LV clients (2030)	Energy (2030)	Inv/Client (Y5)
	US$/kWh	*US$*	*N.*	*N.*	*N.*	*kWh/y*	*N.*	*kWh/y*	*US$/Cx*
KAMION V	1,13	1 586 000	2 621	1	224	176 346	818	543 792	1 939
MAGAMAGA	1,24	1 859 000	1 900	6	314	243 112	1 140	801 701	1 631
OMUGO I	0,63	4 985 500	3 755	50	2 550	1 983 985	9 261	6 647 241	538
ODUPI	1,59	3 217 500	32 249	5	321	246 682	1 173	866 149	2 743

Map 10: Identified hydropower potentials and mini-grids



At over US$ 0.63 – US$ 1.59 per kWh, the LCOE for all of the 4 identified sites remains too high to justify inclusion in the NES planning scenario, driven primarily by the relatively low demand generated in each of the clusters relative to the capacity of the generation asset. However, given the cost reduction potentials enumerated above, sites should undergo further study in future planning stages to identify potential anchor loads and/or cost savings measures.

Solar projects

Since no economically viable hydro projects were identified in the GEOSIM high-level LCOE analysis, all mini-grid projects in the off-grid zone are planned as solar PV projects. Projects were studied for villages of at least 500 inhabitants without economically viable hydropower resources or grid access. In order to identify the most relevant solar PV projects, the methodology proposes to focus on remote areas where projects won't be in competition with grid extension in short and medium terms. The Base Case final scenario prioritizes therefore on solar electrification villages with an higher cost per connection than US$ 2000 and with a total demand of greater than 5,000 kWh/day to insure technical feasibility. For villages with a total demand lower than the 1 000 kWh/day threshold, solar mini-grids with battery storage and a more limited diesel backup system were proposed[61]. Solar PV projects are electrified on an isolated basis through micro-grids.

A total of 2,712 potential solar mini-grid projects were identified. Projects distribution can be visualized on Map 11 locating identified solar mini-grid projects. Solar mini-grids were dimensioned with battery storage and limited diesel backup. All projects are studied like if they were constructed in 2021. **In total, these projects are expected to electrify 182 Development Poles, provide access to electricity services for approximately 2.2 million people, and serve an estimated 234,280 households connections 10 years after electrification.** Table 77 shows the number of projects per service territory and the national total. Projects are distributed all over the country.

While the number of villages electrified through the development of mini-grid is small relative to the overall number of villages electrified by the grid, **the target of 2,712 mini-grid projects over 10 years is highly ambitious, both from a perspective of proven mini-grid development capacity and potential operators in Uganda, and with respect to international benchmarks**. In Kenya, for example, which is often seen as a regional leader in renewables-based mini-grids development and benefits from several major projects to support the growth of these solutions, only 60 such mini-grids (both publicly and privately operated) were in operation or in advanced stages of development as of 2019[62]. If the minimum population limit is increased to 1,000 inhabitants in 2021 to qualify for mini-grid development, then the total number of mini-grids to be developed over the period 2021 to 2030 falls from 2,712 to 72. Were this higher population threshold to be adopted, villages with a population of between 500 and 1,000 inhabitants would require connections through stand-alone solar lighting systems.

[61] Diesel backup is recommended for technical and operational reasons. It also supports productive use development.

[62] "The Role of Renewable Energy Mini-Grids in Kenya's Electricity Sector: Evidence of cost competitive options for rural electrification and sustainable development," New Climate Institute and EED Advisory (November 2019).

Map 11: Identified solar mini-grid projects

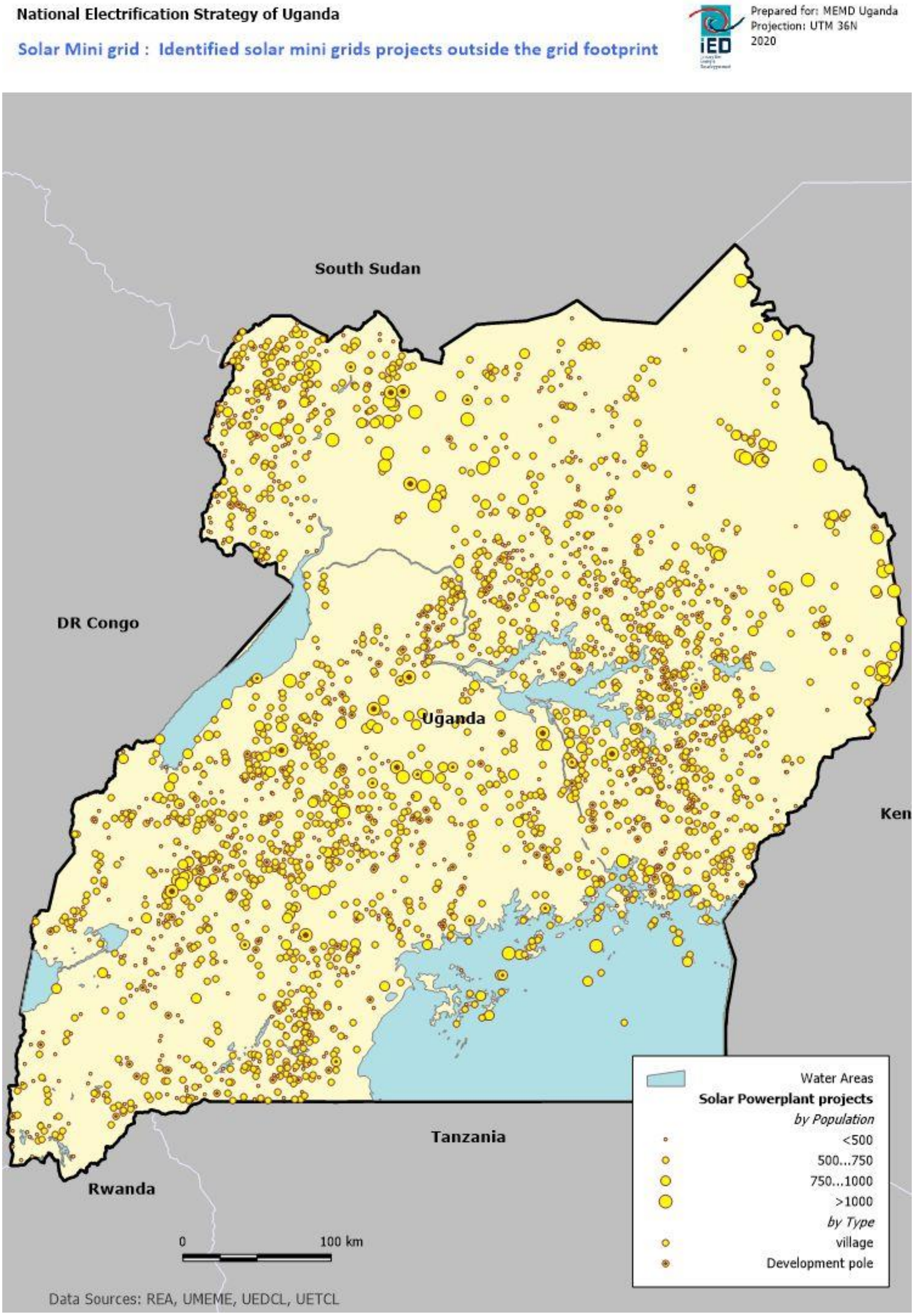


Table 77: Solar Mini-grid results projects, connections and demand

ST	Number of solar projects	*Of which development poles*	Total population covered 2030	Total connections 2030/Y10	Total demand 2030/Y10 (GWh)
MID WESTERN	194	19	152 411	16 214	10
CENTRAL NORTH	229	9	169 324	18 013	11
EASTERN	368	24	287 550	30 590	19
NORTH EASTERN	295	14	245 194	26 084	16
NORTH NORTH WEST	138	13	135 232	14 386	9
NORTH WESTERN	343	33	288 939	30 738	19
SOUTH	162	11	125 721	13 375	8
SOUTH WESTERN	42	3	29 681	3 158	2
WEST NILE	247	10	192 073	20 433	12
NORTHERN	153	4	128 480	13 668	8
RWENZORI	35	1	27 117	2 885	2
WESTERN	57	3	43 222	4 598	3
CENTRAL	449	38	377 286	40 137	24
UGANDA	**2 712**	**182**	**2 202 230**	**234 280**	**143**

Together, these mini-grid projects would represent US$ 356 million in total investment, or a combined cost of US$ 1,519 per connection including generation and distribution cost which render projects competitive compared to grid extension projects. Table 78 below shows the total investment requirement, estimated average cost per connection and the estimated average LCOE[63] for solar mini-grids in the thirteen service territories and for Uganda as a whole, which range from US$ 1,433 per connection in the North North West service territory to US$ 1,570 per connection in the Central North service territory. As for grid-based average costs per connection, mini-grid cost per connection figures are highly sensitive to economies of scale and consequently to population density in a given area. Differing population densities are the primary driver of regional differences in estimated unit costs for solar PV mini-grid development as presented here.

Table 78: Summary results solar mini-grids investment, average cost per connection, LCOE

ST	Total investment 2030 (Mio$)	Average cost per connection (US$, Y10 50% connectivity)	LCOE (US$/kWh)
MID WESTERN	25	1 535	0.89
CENTRAL NORTH	28	1 570	0.91
EASTERN	47	1 538	0.89
NORTH EASTERN	39	1 507	0.88
NORTH NORTH WEST	21	1 433	0.86
NORTH WESTERN	46	1 504	0.88
SOUTH	21	1 540	0.89
SOUTH WESTERN	5	1 591	0.92
WEST NILE	31	1 541	0.89
NORTHERN	21	1 505	0.88

[63] Levelised cost of electricity

RWENZORI	4	1 547	0.89
WESTERN	7	1 549	0.89
CENTRAL	60	1 502	0.88
UGANDA	**356**	**1 519**	**0.88**

Required investment and estimated LCOE figures for the solar-powered mini-grids are on the high-end to regional benchmarks. Based on its experience with renewables-based mini-grids in Kenya, IED estimates that cost per connection figures average between US$1,000 and US$ 1,500 for similar assets.

12.4.4 Solar lighting systems and other stand-alone solutions

In order to achieve universal Tier 1 connectivity by 2030, all households unconnected to the main grid or a mini-grid in 2030 must have a household solution to guarantee the Tier 1 minimum standard of service. This corresponds to a 3W solar lamp with two lighting points and phone charging capabilities[64].

Table 79 shows the expected number of solar lighting systems connections expected in the Base Case Scenario. **In total, 5.5 million total household connections are expected to be required via stand-alone solar lighting systems**. At approximately US$ 50 per system, and assuming required reinvestments to replace the product at the end of its useful lifetime, this implies a **total budget of US$ 385 million** for household connections of this type over the period of 2021-2030.

Table 79: Stand-alone solutions connections and required investment

Operator/zone	**Total stand-alone HH connections**	**Total cost HH units US$**
UMEME	823 533	57 647 275
UEDCL – MID WESTERN	301 188	21 083 168
UEDCL – CENTRAL NORTH	369 612	25 872 824
UEDCL – EASTERN	764 268	53 498 731
UEDCL – NORTH EASTERN	440 341	30 823 870
UEDCL – NORTH NORTH WEST	253 390	17 737 274
UEDCL – NORTH WESTERN	492 812	34 496 824
UEDCL – SOUTH	250 845	17 559 177
UEDCL – SOUTH WESTERN	209 605	14 672 346
UEDCL – RWENZORI	102 189	7 153 209
WENRECO – WEST NILE	497 384	34 816 859
PACMECS – NORTHERN	261 702	18 319 171
KIL – WESTERN	206 804	14 476 310
KRECS – CENTRAL	523 558	36 649 041
UGANDA	**5 497 230**	**384 806 079**

64 See section 9.4 for further details on solar lighting system assumptions.

In order to ensure that the smaller communities in the off-grid zone reap the socio-economic benefits of electrification beyond simply providing household level lighting and phone charging, public infrastructure, including schools, clinics and administrative buildings will be electrified using 500W stand-alone solar systems. The 352 remaining development poles not electrified through grid extension or solar mini-grid deployment will also be equipped with larger, 1000W stand-alone systems capable of supporting limited productive uses. **The electrification of public infrastructures and productive uses in development poles adds an additional budget of US$ 33 million totalizing 3,065 stand-alone solar systems**, as indicated in Table 80 below.

Table 80: Stand-alone solutions public infrastructure investments

Operator/zone	Administrative buildings		Schools		Health centres/clinics		Development poles		Total public infrastructure
	N.	**US$**	**N.**	**US$**	**N.**	**US$**	**N.**	**US$**	**US$**
UMEME	3	29 400	53	519 400	4	56 000	4	56 000	**660 800**
UEDCL – MID WESTERN	23	225 400	233	2 283 400	16	224 000	38	532 000	**3 264 800**
UEDCL – CENTRAL NORTH	8	78 400	161	1 577 800	20	280 000	24	336 000	**2 272 200**
UEDCL – EASTERN	21	205 800	263	2 577 400	35	490 000	39	546 000	**3 819 200**
UEDCL – NORTH EASTERN	15	147 000	177	1 734 600	49	686 000	21	294 000	**2 861 600**
UEDCL – NORTH NORTH WEST	7	68 600	56	548 800	16	224 000	5	70 000	**911 400**
UEDCL – NORTH WESTERN	9	88 200	154	1 509 200	12	168 000	30	420 000	**2 185 400**
UEDCL – SOUTH	13	127 400	68	666 400	10	140 000	11	154 000	**1 087 800**
UEDCL – SOUTH WESTERN	14	137 200	194	1 901 200	39	546 000	54	756 000	**3 340 400**
UEDCL – RWENZORI	8	78 400	57	558 600	11	154 000	18	252 000	**1 043 000**
WENRECO – WEST NILE	11	107 800	175	1 715 000	31	434 000	27	378 000	**2 634 800**
PACMECS – NORTHERN	5	49 000	182	1 783 600	28	392 000	26	364 000	**2 588 600**
KIL – WESTERN	19	186 200	176	1 724 800	20	280 000	38	532 000	**2 723 000**
KRECS – CENTRAL	15	147 000	269	2 636 200	33	462 000	17	238 000	**3 483 200**
UGANDA	**171**	**1 675 800**	**2218**	**21 736 400**	**324**	**4 536 000**	**352**	**4 928 000**	**32 876 200**

Sensitivity analysis

The Consultant carried out a sensitivity analysis on the level of electricity service offered to the 5.5 million of households, while the level of service offered to socio-economic infrastructure remains unchanged. In this sensitivity analysis, consumption levels specific to each of the 3 categories of household equivalent to those defined in the Mini-grid option are applied. In that way, the consumption of households is not restrained in order to simulate the economic impact for mini grid-standards usages including for microbusinesses. The table below shows the consumption levels of each category of household and the unit costs associated with each type of SHS.

Table 81 - sensitivity analysis: key assumptions for distributed energy solutions

Type of HH	Average yearly cons. (kWh)	Indicative Power (W)	Description	Unit Cost (USD)
H1 - Low	132	100	Tier 2 (Tier1 + TV)	1 600
H2-Med	240	225	Tier 2+ (Tier1 + TV + fan)	3 375
H3 -High	432	350	Tier 3 (Tier 2 + med. Power device)	5 075

The following table shows the number of connections required by household category and the associated costs.

Table 82 - sensitivity analysis: number of stand-alone solutions connections

Operator/zone	HH 1 - Low	HH 2 - Med	HH 3 - High	Total HH connected by SHS
UMEME	576 473	205 883	41 177	823 533
UEDCL - MID WESTERN	210 832	75 297	15 059	301 188
UEDCL - CENTRAL NORTH	258 728	92 403	18 481	369 612
UEDCL - EASTERN	534 987	191 067	38 213	764 268
UEDCL - NORTH EASTERN	308 239	110 085	22 017	440 341
UEDCL - NORTH NORTH WEST	177 373	63 347	12 669	253 390
UEDCL - NORTH WESTERN	344 968	123 203	24 641	492 812
UEDCL – SOUTH	175 592	62 711	12 542	250 845
UEDCL - SOUTH WESTERN	146 723	52 401	10 480	209 605
UEDCL - RWENZORI	71 532	25 547	5 109	102 189
WENRECO - WEST NILE	348 169	124 346	24 869	497 384
PACMECS - NORTHERN	183 192	65 426	13 085	261 702
KIL – WESTERN	144 763	51 701	10 340	206 804
KRECS - CENTRAL	366 490	130 889	26 178	523 558
UGANDA	**3 848 061**	**1 374 307**	**274 861**	**5 497 230**

Considering a level of consumption equivalent to those defined for mini-grid connections, **the total cost would amount to US$ 17,066 million[65] (to be compared to US$ 418 million budget for SHS Tier 1 of base case scenario)**. The overall unit cost per connection is estimated at US$ 3,104[66].

Table 83 - sensitivity analysis: investment for stand-alone solutions

Operator/zone	Tier 2 - Cost (Mio$)	Tier 2+ - Cost (Mio$)	Tier 3 - Cost (Mio$)	Total Cost (Mio$)
UMEME	1 291	973	293	2 557
UEDCL - MID WESTERN	472	356	107	935
UEDCL - CENTRAL NORTH	580	437	131	1 147

[65] This amount includes the replacement of the PV systems after 6 years of operation (life span of SHS).
[66] This cost includes the replacement of the PV systems after 6 years of operation (life span of SHS).

UEDCL - EASTERN	1 198	903	272	2 373
UEDCL - NORTH EASTERN	690	520	156	1 367
UEDCL - NORTH NORTH WEST	397	299	90	787
UEDCL - NORTH WESTERN	773	582	175	1 530
UEDCL – SOUTH	393	296	89	779
UEDCL - SOUTH WESTERN	329	248	74	651
UEDCL - RWENZORI	160	121	36	317
WENRECO - WEST NILE	780	588	177	1 544
PACMECS - NORTHERN	410	309	93	812
KIL – WESTERN	324	244	73	642
KRECS - CENTRAL	821	618	186	1 625
UGANDA	**8 620**	**6 494**	**1 953**	**17 066**

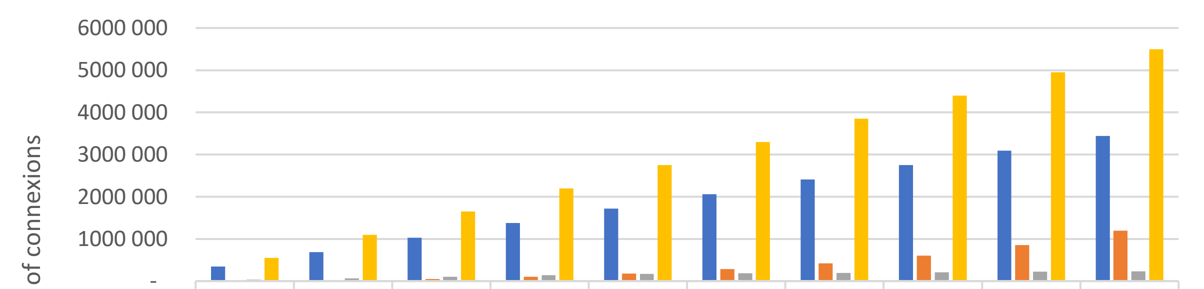
12.4.5 Consolidated results – connections and costs

Connexions:

The Base Case Final Scenario achieves the national electrification strategy objective of universal tier 1 connectivity by 2030, through a strong grid densification and extension component, the development of 2,712 solar mini-grids, as well as the distribution of 5.5 million stand-alone solar lighting systems and approximately 3,065 stand-alone solar systems for public infrastructures and productive uses.

The graph below shows the cumulated number of connections (domestic and non-domestic) between 2021 and 2030 for each electrification approach (Densification, Grid extension, Mini-Grid and Solar Home System). This graph should be taken into account with the following table which shows the total number of connections that will need to be made year after year throughout the planning period.

Figure 30: Cumulative numbers of connexions by electrification approaches



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Densification	343 863	687 727	1031 590	1375 454	1719 317	2063 180	2407 044	2750 907	3094 771	3438 634
Grid Extension	3 326	16 852	46 468	98 632	177 592	283 088	421 579	603 241	849 584	1192 763
Mini-Grid	34 486	66 645	101 243	136 499	173 837	184 526	195 721	207 597	220 194	234 280
SHS	549 723	1099 446	1649 169	2198 892	2748 615	3298 338	3848 061	4397 784	4947 507	5497 230

Table 84: Summary breakdown of connections by electrification approach

Approach	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Densification	343 863	343 863	343 863	343 863	343 863	343 863	343 863	343 863	343 863	343 863	3 438 634
Grid Extension	3 326	13 526	29 616	52 164	78 960	105 496	138 491	181 662	246 343	343 179	1 192 763
Mini-Grid	34486	32159	34598	35256	37338	10689	11196	11876	12597	14086	234 280
SHS	549 723	549 723	549 723	549 723	549 723	549 723	549 723	549 723	549 723	549 723	5 497 230
Total	**931 398**	**939 271**	**957 800**	**981 006**	**1 009 884**	**1 009 771**	**1 043 273**	**1 087 124**	**1 152 526**	**1 250 851**	**10 362 907**

Of the 22,630 public institutions listed in the database, 16,184 (72%) and up to 76% of schools are currently not electrified. At the end, 57% of non-electrified institutions will be electrified by grid extension and densification and 43% by off-grid intervention.

Table 85: Electrification of public institutions

	Administrative Centers	Health Centers	Schools	Total
Electrified	**1 156**	**1 265**	**4 025**	**6 446**
Electrified (%)	50	37	24	28
Non elecrtified	**1 154**	**2 127**	**12 903**	**16 184**
Non electrified(%)	50	63	76	72
Targeted by intensification	**399**	**526**	**3 196**	**4 121**
Targeted by intensification (%)	35	25	25	25
Targeted by grid extension	**324**	**672**	**4 058**	**5 054**
Targeted by grid extension (%)	28	32	31	31
Targeted by Mini-Grid	**260**	**605**	**3 431**	**4 296**
Targeted by Mini-Grid (%)	23	28	27	27
Targeted by SHS	**171**	**324**	**2 218**	**2 713**
Targeted by SHS (%)	15	15	17	17
Total	**2 310**	**3 392**	**16 928**	**22 630**

The NES results stemming from the geospatial optimization simulations are compared with the recent NDPIII objectives (stated in December 2020) related to electricity access. The table below shows the NDPIII targets for the next five years. No target has been defined for the period 2026-2030. The NES covers the period from 2021 to 2030.

<table>
<tr><td colspan="10">Sub Programme Transmission and Distribution (NDP III)</td></tr>
<tr><td colspan="10">Sub Programme Objectives contributed to by the Programme Outcome:
Increase access and utilization of electricity</td></tr>
<tr><td colspan="10">Intermediate Outcome:
Increased electricity access
Reduction in Electricity Cost</td></tr>
<tr><td rowspan="2">Objective</td><td rowspan="2">Intermediate Outcome</td><td rowspan="2">Intermediate Outcome Indicators</td><td rowspan="2">Baseline FY2017/18</td><td colspan="6">Targets</td></tr>
<tr><td>2020/21</td><td>21/22</td><td>22/23</td><td>23/24</td><td>24/25</td><td>26/30</td></tr>
<tr><td>1. Increase access and utilization</td><td>Increased electricity access</td><td>% of HH with access to electricity</td><td>24</td><td>50</td><td>55</td><td>60</td><td>65</td><td>80</td><td>--</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

	Baseline 19/20	2020/21	21/22	22/23	23/24	24/25	**26/30***
Comparison with NES planning Results	26	30	39	48	57	65	100

	***2026 - 2030**				
	2025/26	26/27	27/28	28/29	29/30
NES planning results	73	80	87	95	100

Additional demand:

The graphs below represent the evolution of additional demand - consumption (GWh) and peak (MW) -between 2021 and 2030 depending on the electrification approach. Theses consumptions include domestic and non-domestic electricity users. All the annual consumption of the SHS approach is based on data from the sensitivity analysis. An additional consumption of 4,615 GWh is expected following the connections made by grid extension and densification. The mini-grids will have to cover a total consumption of 178 GWh by 2030.

Figure 31: Evolution of the consumption by electrification approach (2021 - 2030)

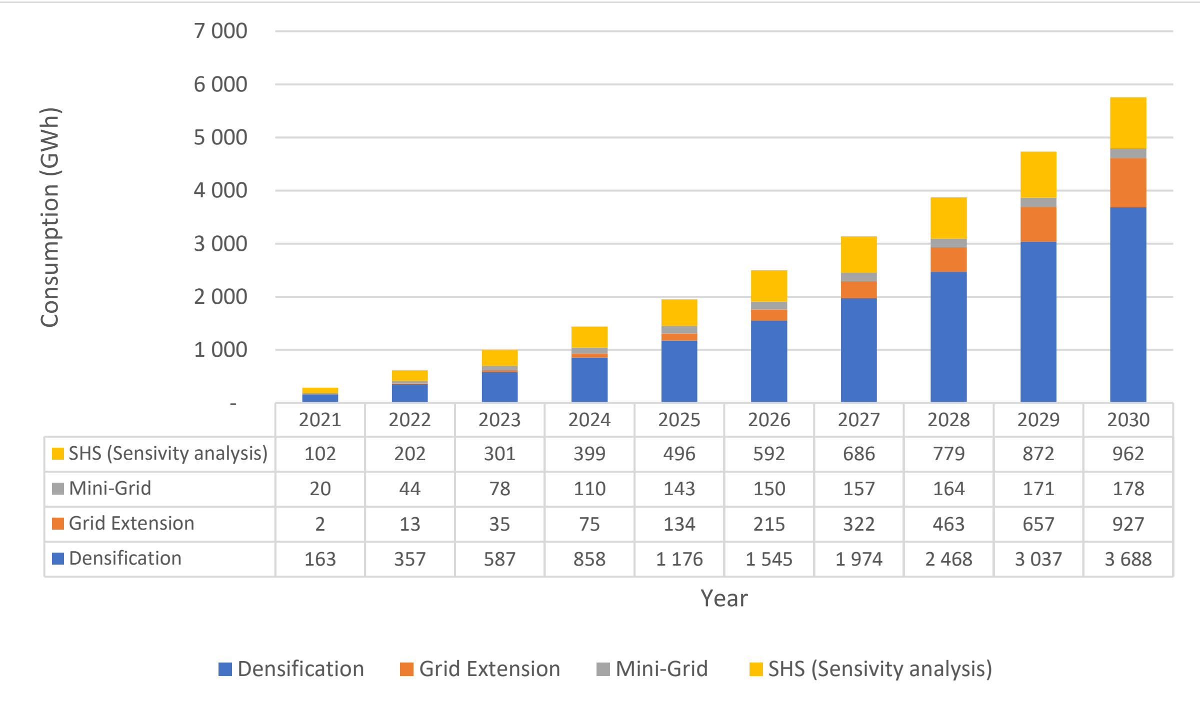
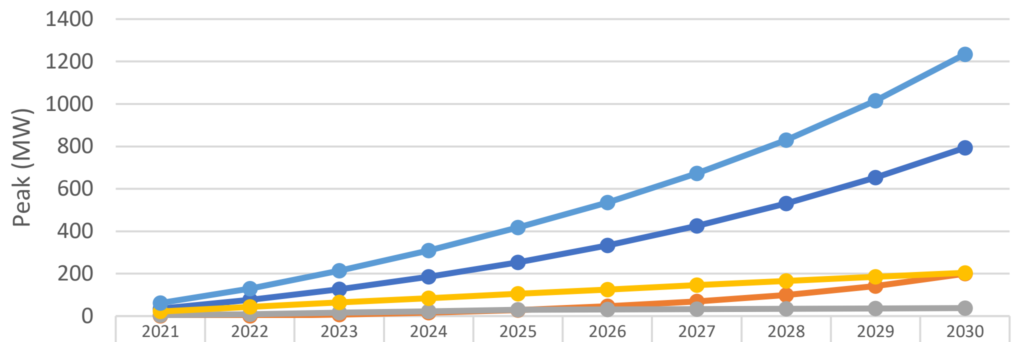


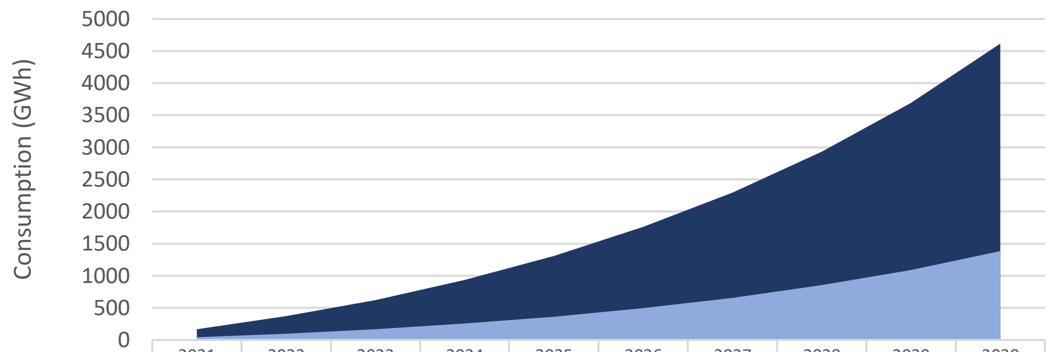
Figure 32: Peak evolution between 2021 and 2030 (MW)



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Densification	35	77	126	185	253	332	424	531	653	793
Grid Extension	1	1	8	16	29	46	69	99	141	200
Mini-Grid	4	9	16	23	30	32	33	35	36	38
SHS (Sensivity analysis)	22	43	64	85	105	125	145	165	185	204
Total	61	129	214	308	417	536	672	830	1015	1234

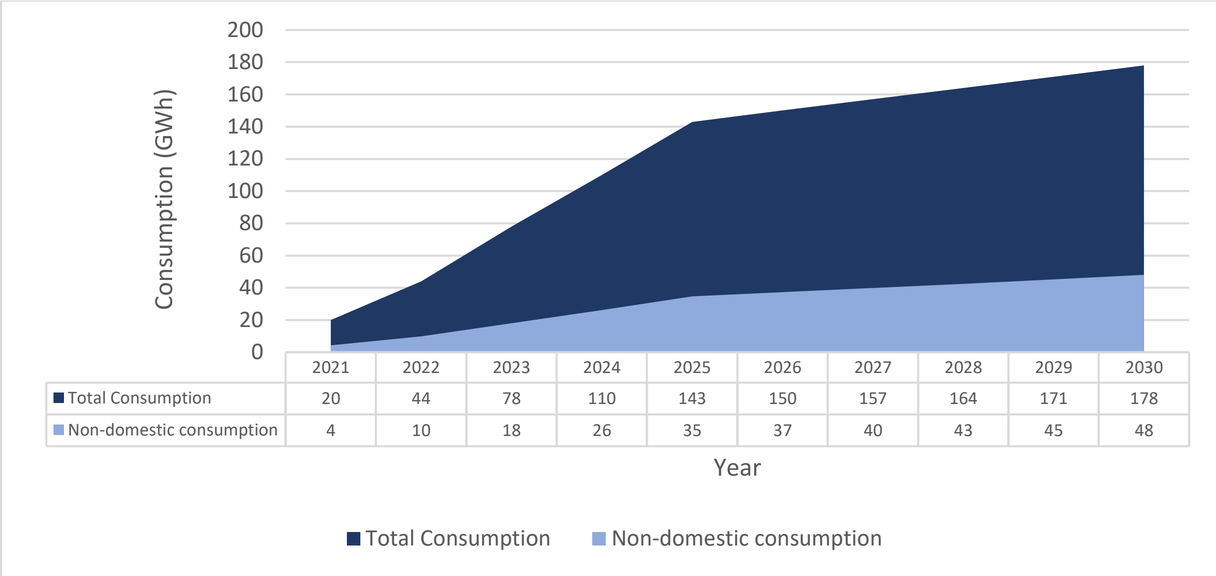
The graphs below show the share of non-domestic consumption in overall consumption. On grid, the share of consumption is estimated by GEOSIM Demand Analyst® at 26% the first year against 30% in 2030. These proportions vary on mini-grids: non-domestic consumption represents 22% of overall consumption in 2021 against 27% in 2030. The deceleration in consumption on mini-grids is due to the fact that all the localities targeted by a mini-grid solution are planned to be connected between 2021 and 2025. The increase in consumption between 2026 and 2030 is linked to the increase number of customers in the localities and the related growth of their consumption.

Figure 33: Share of non-domestic consumption on grid (2021 - 2030)



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total consumption	166	371	624	934	1311	1761	2296	2932	3694	4616
Non-domestic consumption	43	98	168	255	364	497	659	854	1092	1385

Figure 34: Share of non-domestic consumption on mini-grids (2021 - 2030)



Investment:

The total estimated investment budget for the Base Case final scenario is US$ 4.68 billion, with 84% of the total investment to be dedicated to on-grid connections (54% densification, 30% grid extension) and the remaining 16% of investment dedicated to off-grid solutions (7% solar mini-grids, 9% stand-alone solutions). Combining the investment costs with the number of connections allows for the calculation of a weighted average cost per connection as a whole. The national weighted average cost per connection is estimated around US$ 387. The total number of new connections will be 10.4 million.

These overall results are summarized in the table and figures below:

Table 86: Consolidated results of connections, budget and av. cost per connection

	Total	Densification	Grid extension	Solar mini-grids	Standalone solar systems*(*)*
Connections (million)	**10.4**	3.44	1.19	0.23	5.5
Investment ($ million) [sensitivity analysis on SHS service level: Tier 2+3]	**4,680** [21,328]	2,509	1,398	356	418 [17,066]
Costs per connection ($) [sensitivity analysis on SHS service level: Tier 2+3]	**387**	730	1,088	1,519	76 [3,104]

(*) including the replacement of the PV systems after 6 years of operation (life span of SHS).

Figure 35: consolidated results - number and type of connections

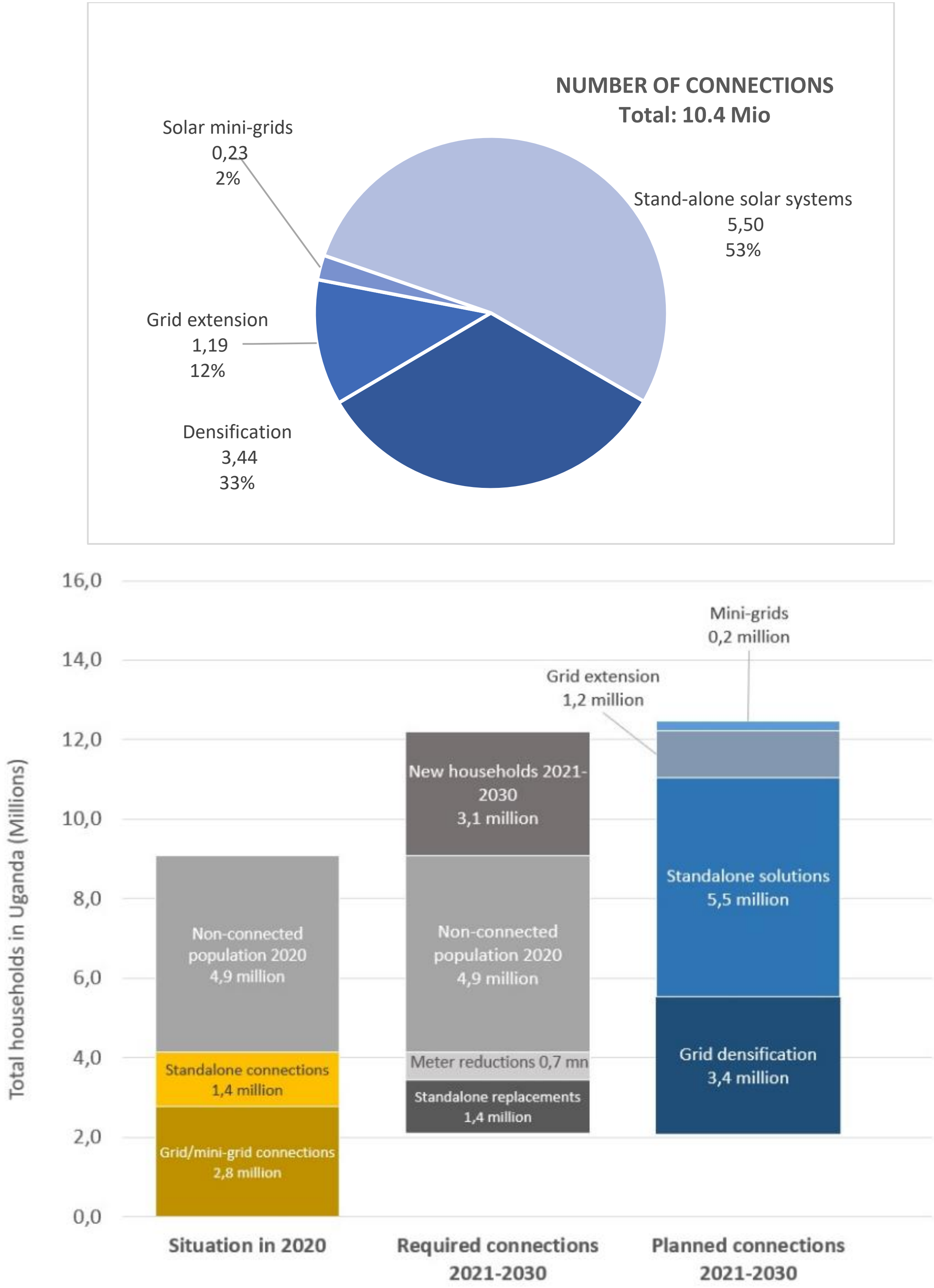


Figure 36: consolidated results – investment requirements

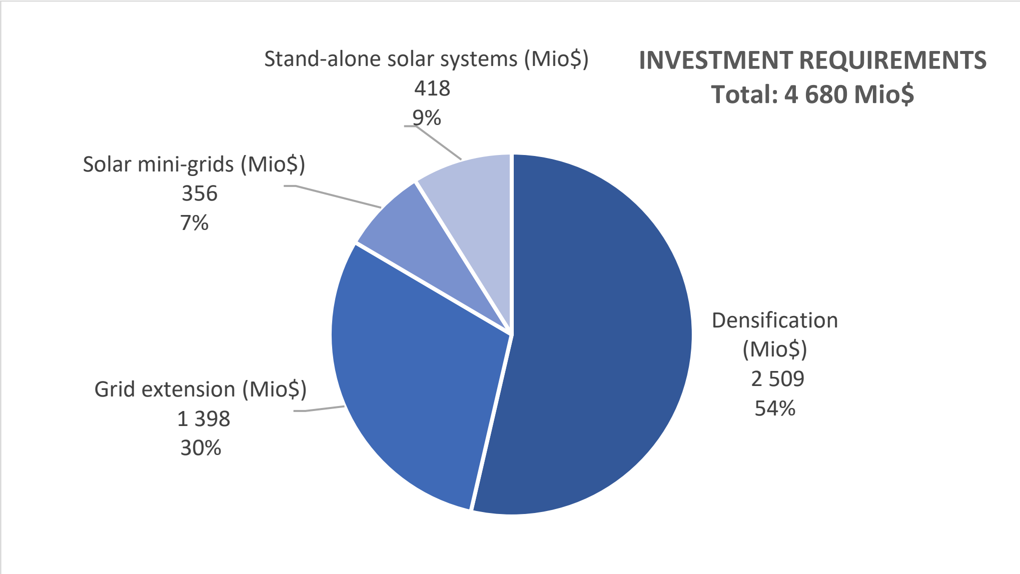


Table 87: Consolidated connections results per operator/zone

Operator/zone	Existing HH connections 2020 (exl. HH sharing meters)	Densification	Grid extension	Solar mini-grids	Stand-alone solar systems	Total households connected in 2030(*)
UMEME	1 351 629	2 094 813	16 737	-	823 533	**4 286 711**
UEDCL -	4 710	98 998	67 246	16 214	301 188	**488 356**
UEDCL – CENTRAL NORTH	3 530	52 214	84 773	18 013	369 612	**528 142**
UEDCL – EASTERN	6 106	216 490	232 612	30 590	764 268	**1 250 066**
UEDCL – NORTH EASTERN	5 467	114 447	111 930	26 084	440 341	**698 269**
UEDCL – NORTH NORTH WEST	8 872	84 804	63 158	14 386	253 390	**424 610**
UEDCL – NORTH WESTERN	18 856	164 461	128 627	30 738	492 812	**835 494**
UEDCL – SOUTH	13 922	110 993	54 023	13 375	250 845	**443 158**
UEDCL – SOUTH WESTERN	10 227	74 738	39 380	3 158	209 605	**337 107**
UEDCL – RWENZORI	8 597	33 996	25 244	2 885	102 189	**172 910**
WENRECO – WEST NILE	12 584	118 157	130 180	20 433	497 384	**778 738**
PACMECS – NORTHERN	3 893	70 748	43 152	13 668	261 702	**393 163**
KIL – WESTERN	14 569	79 753	47 283	4 598	206 804	**353 007**
KRECS – CENTRAL	7 185	124 025	148 418	40 137	523 558	**843 322**
UGANDA	**1 470 147**	**3 438 634**	**1 192 763**	**234 280**	**5 497 230**	**11 833 053**
%	12%	29%	10%	2%	46%	100%

(*) include existing connections in 2020

Table 88: Consolidated financial results per operator/zone

Operator/zone	Densification (Mio$)	Grid extension (Mio$)	Solar mini-grids (Mio$)	Stand-alone solar systems (Mio$)[67]	Total investment to 2030 (Mio$)
UMEME	1 376	15	-	58	1 450
UEDCL – MID WESTERN	95	81	25	24	225
UEDCL – CENTRAL NORTH	49	103	28	28	208
UEDCL – EASTERN	166	254	47	57	524
UEDCL – NORTH EASTERN	97	139	39	34	309
UEDCL – NORTH NORTH WEST	82	78	21	19	199
UEDCL – NORTH WESTERN	142	158	46	37	383
UEDCL – SOUTH	95	65	21	19	199
UEDCL – SOUTH WESTERN	58	41	5	18	122
UEDCL – RWENZORI	24	25	4	8	62
WENRECO – WEST NILE	87	148	31	37	304
PACMECS – NORTHERN	62	54	21	21	158
KIL – WESTERN	58	49	7	17	131
KRECS – CENTRAL	118	187	60	40	406
UGANDA	**2 509**	**1398**	**356**	**418**	**4 680**
%	54%	30%	8%	9%	100%

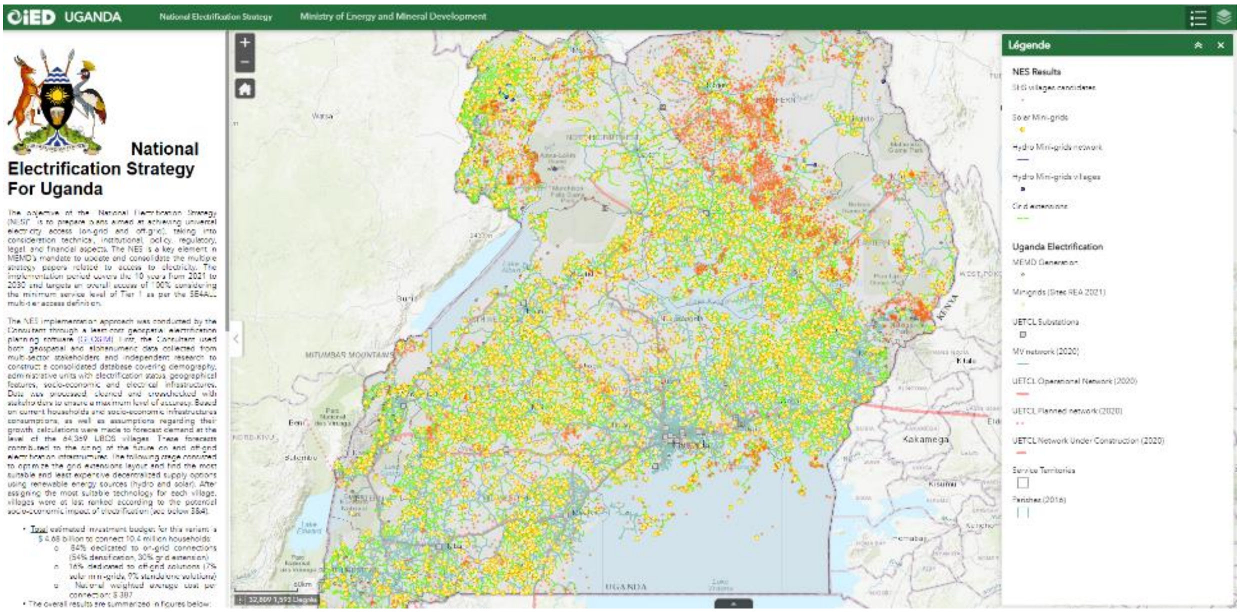
Table 89: Consolidated average costs per connection per operator/zone

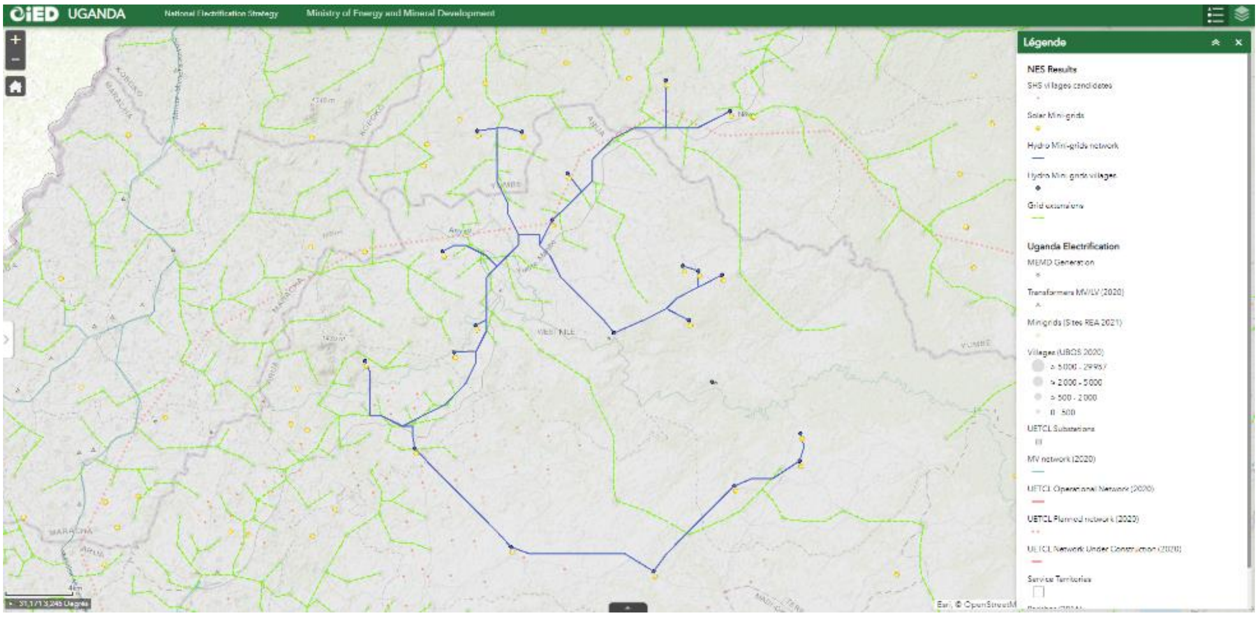
Operator/zone	Densification (US$)	Grid extension (US$)	Solar mini-grids (US$)	Stand-alone solar systems (US$)[68]	Weighted average cost per connection (US$)
UMEME	657	905	-	71	338
UEDCL - MID WESTERN	961	1 125	1 535	81	451
UEDCL - CENTRAL NORTH	940	1 135	1 570	76	382
UEDCL - EASTERN	768	1 030	1 538	75	408
UEDCL - NORTH EASTERN	846	1 138	1 507	76	426
UEDCL - NORTH NORTH WEST	964	1 107	1 433	74	450
UEDCL - NORTH WESTERN	862	1 121	1 504	74	441
UEDCL - SOUTH	851	1 115	1 540	74	438
UEDCL - SOUTH WESTERN	780	1 009	1 591	86	359
UEDCL - RWENZORI	704	970	1 547	80	353
WENRECO - WEST NILE	734	1 064	1 541	75	378
PACMECS - NORTHERN	877	1 139	1 505	80	388
KIL - WESTERN	725	997	1 549	83	366
KRECS - CENTRAL	954	1 148	1 502	77	461
UGANDA	**730**	**1 088**	**1 519**	**76**	**387**

[67] These amounts include the replacement of the PV systems after 6 years of operation (life span of SHS).
[68] These amounts include the replacement of the PV systems after 6 years of operation (life span of SHS).

In the framework of the development of the NES, GIS consolidated database and geospatial planning simulation, a dynamic GIS web platform has been prepared in order to facilitate and foster the multisector dialogue. Theis platform will be displayed on the websites of the key institutions. The snapshots below show the results of the electrification planning by 2030:

Map 12: snapshots of the dynamic GIS web platform





12.5 Financing options and investment plan

12.5.1 Investment requirements per Segment

Based on the NES geospatial planning, **the total investment requirements to implement the NES amounts to US$4.68 billion. This plan should enable 10.4 million additional connections in the next**

10 years. On-grid initiatives will require account for the larger amount totalling to US$3.9 billion or 84%, with the remaining 16% dedicated to mini-grids and stand-alone systems connections.

Figure 37: Total NES investment requirements (USD millions)

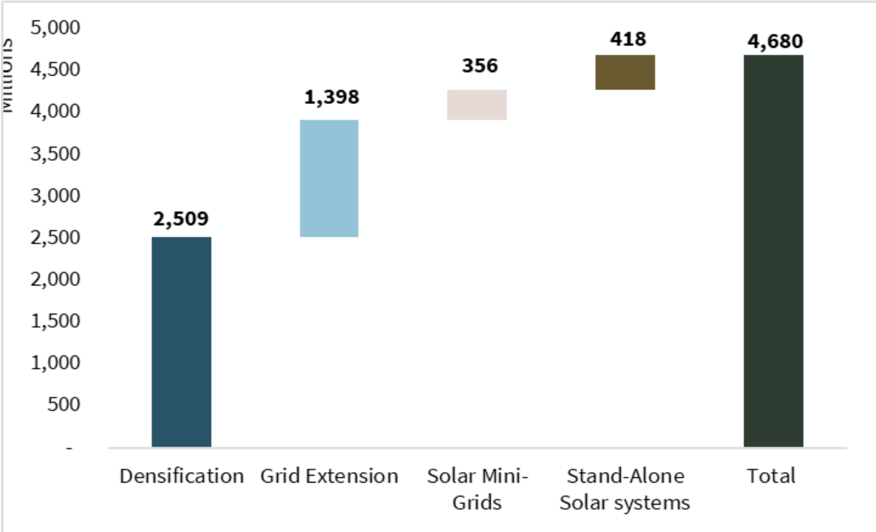


Figure 38: Total NES connections

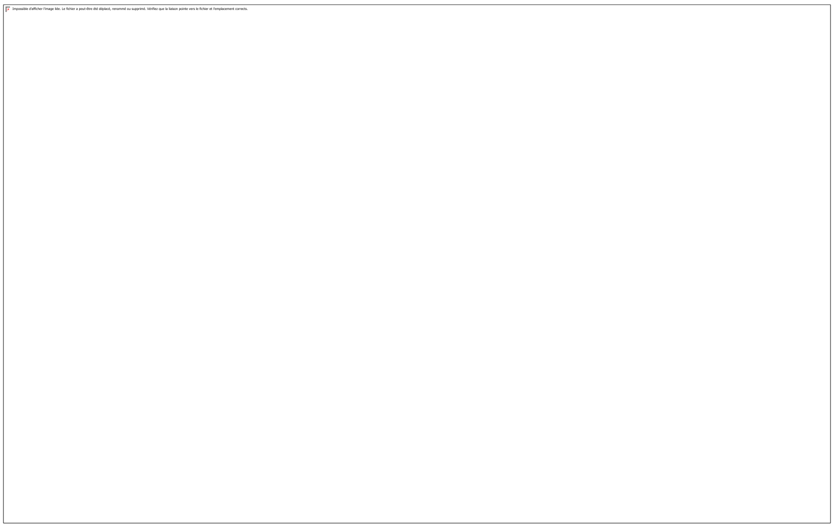
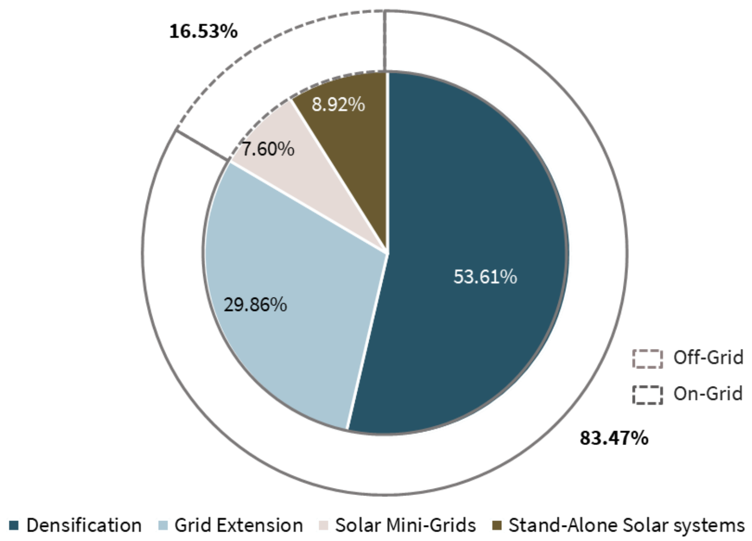


Figure 39: Financing requirements repartition



12.5.1.1 On-Grid

Grid Densification

Densification should represent the larger share of grid connections in the NES with a total of 340,000 connections per year, totaling 3.44 million grid densification connections by 2030.

Densification is the cheapest grid electricity connection mechanism as it doesn't require long grid extensions, nor the installation of stand-alone generation systems as for mini-grids. Grid Densification cost per connection in Uganda ranges from US$ 398 for simple shared meter replacement to US$ 1,131 for longer drop line and LV infrastructure in low density areas. **On average, a grid densification connection is expected to cost $US 730/connection.** Accordingly, grid densification will require a total investment of approximately $ 2.5 billion. This should help to achieve the target of 84%[69] house densification connection rate. Approximately US$ 3 billion will be required in order to attain 100% connectivity rate in all villages currently connected to the grid.

Grid Extension

Grid extension will primarily be done in 2 time phases with an investment requirement of $1.4 billion. The first phase (villages connected closer to the existing grid) will require US$ 246 million for the period 2021-2025 (or approximately 18% of the total investment budget), while the second phase would require US$ 1.15 billion for the period 2026-2030 (or 82% of total investment). **The average cost for grid extension connections is $ 1,088/connection, which is more or less 50% higher than grid densification connections.**

12.5.1.2 Off-Grid

Mini-Grid

The economic viability of Mini-Grids is affected by a number of factors including economies of scale and population density. Based on the GEOSIM assessments, solar mini-grids might be more

[69] With shared meter replacement

economically feasible compared to hydro mini-grids. The identified solar mini-grids require an estimated investment of $ 356 million for 234,280 connections, leading to an **average cost of $ 1,519/connection using mini-grids**. This cost per connection in the NES planning is on the high-end to recent mini-grid industry standards in the $ 1000-1500/connection range. This is explained by the fact that mini-grid sites in the NES were limited to sites which are too costly to connect to the main grid, while in most cases mini-grids are electrifying areas close to the grid, filling the grid extension gap rather than connecting truly remote areas that can hardly be reached by the grid. In addition, NES targets a 50% connection rate in year 10 complemented with Stand Alone Systems, while most developers tend to quickly connect a majority of households even when not profitable with very low consumption figures.

Stand Alone Systems

A budget of $418 million is needed to finance the distribution of 5.5 million stand-alone solar lighting systems and approximately 3,065 stand-alone solar systems for public infrastructures and productive uses for the period 2021-2030. Investments of $385 million and $33 million will be required respectively. Basic Stand Alone systems have a cost of $50/kit for a 3Wp kit, leading to a **cost per connection of amounts to $ 76/connection across the 10 years of NES plan** due to the short lifespan of kits which need to be renewed. The large gap with the cost per connection using mini-grids is mostly explained by the following items:

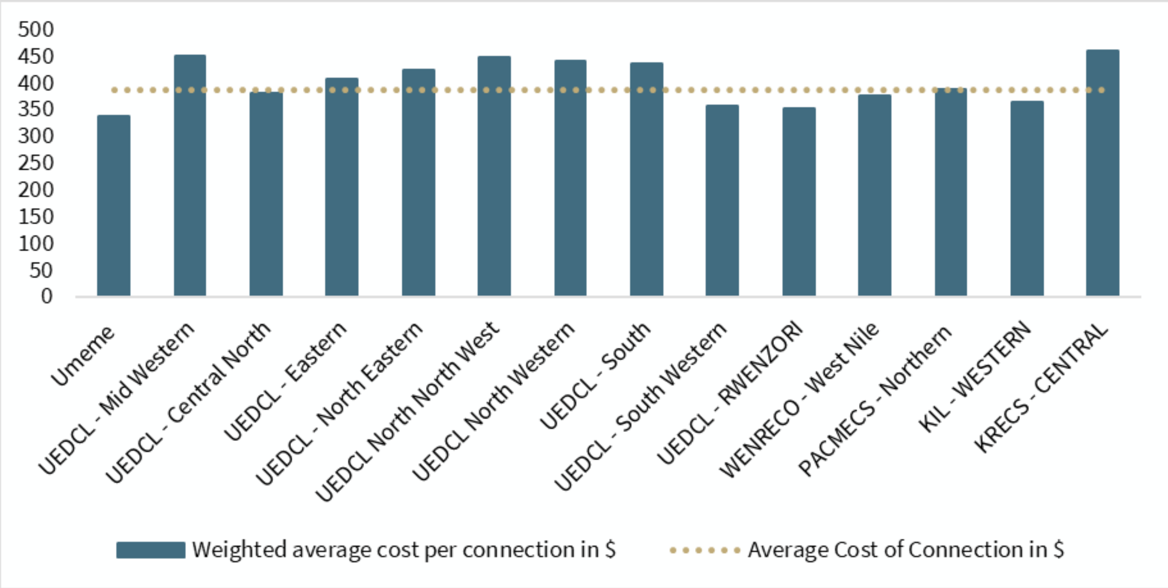
- **Stand-alone systems need to be renewed every 6 years compared a 20-year lifespan for mini-grids with limited equipment renewal**
- **Stand-alone systems can only power basic appliances and can enable productive uses only through larger systems of much higher cost/connection ($7,000/co for a 500Wp solar system).**

In addition, compared to grid connected solutions, the investment cost of off-grid solutions include not only power distribution but also generation.

12.5.1.3 Investment requirement per region

Cost per connection is geographic specific as each region has its unique needs and characteristics. However, there is no significant difference in the cost per connection across all the regions. Umeme regions are expected to have the least cost per connection since it has the most extensive grid network and hence can leverage on economies of scale. The national weighted average cost per connection is estimated at US$ 387. A brief overview of the connection costs per region is provided below.

Figure 40: Regional Weighted Average Cost per Connection



12.5.2 Existing sources of financing and available resources

Table 90: Existing sources of financing

Entity	Sector	Status	Facility
Government of Uganda	On-Grid Off-Grid	*Ongoing*	Fiscal financing through budgetary allocation for example approximately 8% of 2020/2021 budget was allocated to Renewable Energy related activities.
World Bank	On-Grid Off-Grid	*Case by case basis*	**Grants** Capital grants for off-grid solar and project preparation grant for feasibility studies.
	On-Grid Off-Grid	*Case by case basis*	**Line of credit and guarantee** Support through financial intermediary (UECCC) – working capital line of credit and guarantee facility for solar companies.
	Off-Grid	*Start: 2009 End: 2030*	**Lighting Africa Campaign** Improve households' off-grid solutions through VeraSol quality standard and assurance for solar kits and appliances.
	On-Grid	*Start: 2015 End: 2021*	**World Bank's Energy for Rural Transformation (ERT-3) RT of US$ 135.00 million** Rural electrification through on-grid energy access, off-grid energy access and institutional strengthening and impacts monitoring.
European Union	On-Grid Off-Grid	*Start: 2016 End: 2020*	**Scaling up rural electrification using innovative solar photovoltaic (PV) distribution models** Focuses on energy security involves capacity-building and awareness among stakeholders.
USAID	On-Grid Off-Grid	*Start: 2018 End: 2020*	**The Power Africa Uganda Electricity Supply Accelerator program of $ 11 million** Assists in establishing 1,000,000 new connections by providing grants and technical support.
	Off-Grid	*Start: 2016 End: 2030*	**The Scaling Off Grid Energy Enterprise Awards of $ 36 million**

			Provides grants and incentives to off-grid initiatives through expansion and distribution activities.
KfW	Off-Grid	*Ongoing*	**Get Access** KfW on behalf of Government of Germany and the EU is in the process of finalizing the concept and investment decision for the implementation approx. 100 MG (GetFit programme is dedicated to generation)
GIZ	Off-Grid	*Start: 2016* *End: 2021*	**Promotion of Mini Grids for Rural Electrification in Uganda** Supports mini-grid electricity distribution through policy and steering, regulatory instruments, technology and design and productive use.
	Off-Grid	*Start 2019* *End: 2023*	**Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP)** Advices on coherent policy framework, improvement of market development, skills development for technicians and mainstreaming of energy in rural and peri-urban areas.
DFID	Off-Grid	*Start 2015* *End: 2030*	**Energy Africa Campaign** Provide financial, policy and regulatory support to enhance universal energy access through stand-alone systems.
Agence Française de Développement	On-Grid Off-Grid	*Start: 2018* *Ongoing*	**Sustainable Use of Natural Resources and Energy Finance in East Africa (SUNREF)** Line of credit to select banks for on lending to energy projects, technical assistance and subsidies.
United Nations	On-Grid Off-Grid	*Start: 2016* *End: 2020*	**UN Capital Development Fund CleanStart** Co-invests in early-stage innovations from financial institutions, distributed energy service companies and other providers of wholesale or retail financing for off-grid clean energy.
MFIs at project level	On-Grid Off-Grid	*Ongoing*	In addition to specific programmes defined above, MFIs finance public and private-led initiatives on a project-by project basis
Foundations	Off-Grid	*Ongoing*	Several foundations such as Shell Foundation, Phillips Foundation, Mastercard Foundation, Rockefeller Foundation, Bill & Melinda Gates Foundation are financing off-grid electrification projects.
Commercial Banks	On-Grid Off-Grid	*Ongoing*	The participation of commercial banks remains limited as they are not familiar with energy projects and project financing risks.
Impact investors	Off-Grid	*Ongoing*	Infrastructure and impact investment funds are investing in mini-grid and standalone systems through equity and debt investments into off-grid companies and directly at the projects level.
Off-Grid companies	Off-Grid	*Ongoing*	A growing ecosystem of private companies developing financing and operating off-grid solutions is active in Uganda, with companies such as Bboxx, Mobisol, Powergen, PowerHive, PowerCorner, Fenix Intl, M-kopa solar, Solar now, Bright life, Village power, Solar today, One lamp, etc.

In 2019, Uganda was a beneficiary of various funding programs that are geared towards electrification initiatives. Some key institutions active in the electricity sector show the following data about funding flows into the sector:

Table 91: Summary of the sector funding flow in 2019

Institution	Sub-sector	funding Flow Amount (million)
Umeme	Grid investments	$ 513
REA	Rural areas electrification (grid & mini-grid)	$ 264
USEA (Private sector)	Stand-alone systems	$ 44
Total		**$ 820 million**

It should be noted that the above funding reflects total funding used in various activities including operations, sector efficiency, electrification, etc. For example, on average, Umeme uses approximately 30% of its funding on new connections. Key focus and investment areas have been load growth, loss reduction and system improvements to enhance power supply reliability and availability.

Significant funding to REA is from the Government and levies having contributed 28% and 16% respectively of REA funding in 2019. ERT and IDB programs have also been instrumental to REA's budget as they each contributed to 13% of the total funding. The balance of the funding was sourced from other DFI and government institutions. Based on historical averages, slightly less than $ 30 million is invested in new assets every year, which is lower than the NES requirements.

The Stand Alone Systems sector has posted increase capital flow having recorded on average $100 million per year in 2017 and 2018. However, this declined to $44 million in 2019 due to 56% and 59% decrease in DFI and private sector debt respectively in 2019 compared to 2018. Having a requirement of about $ 42 million per year, it may be the segment that can easily bridge the financing gap of approximately $ 2 million with continued regulatory and government support.

12.5.3 Financing Challenges

On-grid and off-grid rural electrification is among priority sectors for DFIs, who already have several programmes active in the sector in Uganda, and a strong incentive to deploy more funds. While not yet mature, an ecosystem of developers and impact investors dedicated to off-grid power has been booming in the past 5 years. However, financing remains insufficient, and electrification is still not happening as fast as needed due to several financing challenges and the nature of rural electrification activities:

- **Electrification of rural areas is not commercially viable and therefore requires grants to keep tariffs affordable.** Low purchasing power and low electricity needs combined with low population density in rural areas lead to very high cost-reflective tariffs regardless of the electrification method.
- **Development Partners and Government of Uganda funds are usually program-based with a limited availability period**. Public and private project developers therefore can't plan for the mid to long term due to the lack of visibility on future programs. This also weakens public institutions such as UECCC who is unable to meet its financial demand internally due to mismatch in financing horizon.
- **Local commercial banks do not propose adapted financing solutions** due to a lack of appetite for complex transactions that require strong in-house expertise to assess the risks specific to those sectors, as well as long-term, low-cost financial resources.

- **Development Finance Institutions and large international investors have strict bankability expectations and complex processes**, which slows down projects' deployment and increases costs as they remain the only option for most projects.
- **High risk perceived by financiers** leading to high financing costs, limited appetite or very strict bankability expectations, therefore slowing down large-scale replication.
- **Off-grid projects and companies are usually small and complex**, which makes them difficult to address for large financial institutions who rarely fund < $ 10M projects
- **Absence of enforceable quality standards for the products sold in the market** hindering investors/financers from investing in the renewable energy sector and consumers adopting the alternative sources of energy that are more efficient.
- **Plans and policies generally do not include a financing plan**, leading to objectives not being achieved.

12.5.4 Financing options per segment

The table below provides an overview of the pros and cons of the main financing sources considered for the NES.

Table 92: pros and cons of the main financing sources

	Pros/rationale	**Cons/limitations**
Government Grant	- Reduce tariff for end users and/or financial burden for the utility - No external constraints for deployment	- Cost on the State budget à limited scale - Financed by the general budget and not by the electricity sector which isn't cost-reflective
Rural electrification fee on electricity bill	- Funded by the sector, cost reflective - Can bring a predictable amount every year	- Increase the cost of power for grid customers à limited scale - Towns and industries which are mostly connected bear the cost of rural areas development
DFI Grant	- Reduce tariff for end users and/or financial burden for the utility - No cost for the State nor the Electricity sector	- DFIs usually have a yearly budget per country for all sectors à limited in scale - Potentially slow deployment as DFIs require important due diligences and comfort on projects impact.
DFI Concessional loan	- Long term, low-cost debt matches well with the return profile of grid electrification projects - Can be deployed on a large scale provided the State is bankable	- Limited to public borrowers - Loans are backed by the State, generating contingent liabilities - Limited to large projects due to heavy deployment process.

Commercial loans	- Can be deployed on a large scale provided bankable projects are available - Can finance private projects - No liability for the State	- Significant financing cost - Requires bankable projects
Equity	- Can be deployed on a large scale provided profitable projects are available - Specialized sponsors can lead projects from scratch and bring strong sector expertise - Sponsors can also originate new projects, hence accelerating the electrification pace - Private players can be more agile to deploy numerous small projects	- High returns expectations - Require projects with visibility on short to mid-term profitability à may be dependent on grant/concessional funding support

The business models and risk profiles in the various electrification methods are distinct, which directly dictates the type of financing instruments and players that can be engaged.

<u>On-Grid</u>:

Grid extension and reticulation is usually **public owned through a national utility.** Grid investments are profitable only in the long-term, depending on the future economic development of the area, especially when connecting rural areas with a low economic output. Such long-term investments combined with demand risk that is difficult to control make private-owned solutions expensive and complex to set up due to important risk-sharing mechanisms to put in place.

Utility grid electrification projects shall be financed through:

- **Rural electrification fees on power bills** to existing customers to support the investments that the transmission & distribution companies need to incur to extend the grid. Such fee may also be taken without displaying it by having the utility spend part of its revenues from current customers on electrification investments, as it is the case today.
- **Long-term concessional loans from DFIs** supported by the State to give enough time for the utilities to make the new connections profitable as demand/customer base grows.
- **Subsidies from Government or DFIs** to further reduce the financial burden for the electricity sector and ensure the utility company remains financially viable whilst offering affordable tariffs. This is essential to private investments and viability of the sector.
- **Private financing for grid extension should remain limited** as the connected customers are not profitable on the short to mid-term. Private financing backed by State-guaranteed revenues through a PPP structure may be considered when projects are more profitable, or with a subsidy component.

<u>Mini-Grids</u>:

Projects can be private or public-owned with private EPC and O&M contractors. **Private projects seem more adapted** as public mini-grid projects have been slow to deploy. In addition, they are not always well built and operated as projects are very small, making it hard for the authorities to manage contractors who have no incentive to optimise projects performance.

Private investments could be financed through:

- **Investment grant facilities** to fund part of projects construction costs in order to reduce the financing costs and to make end-users tariffs affordable. Country-wide result-based facilities with pre-defined, standardized conditions should be privileged to give visibility to developer.
- **Long-term debt** through dedicated DFI funded initiatives managed by local banks or fund managers with mini-grid experience.
- **Equity funding** by impact investors, private equity or large energy companies with a long-term vision.
- **Consumer financing programs to promote and fund productive uses** helps in building better credit profiles from revenues earned through productive uses.

Enabling by Government:

- **Scale is essential to decrease costs and reduce dependence on subsidies.** Projects should be attributed by large batches to a few promoters rather than distributed to numerous players with limited capacities.
- **Licensing processes need to be quick and simple** due to the small individual size of projects to enable rapid deployment and scale up.
- **Tax incentives** on solar panels and batteries with no duties and VAT during projects deployment phase.

Stand Alone Solar Systems:

Private companies can deploy this solution as a viable commercial activity with Government intervention limited to regulation. Those companies should be funded through:

- **Working capital and inventory-finance** facilities through local banks with funding and technical assistance from DFIs.
- **Equity funding** by impact investors, private equity or large energy companies with a long-term vision.
- **Commercial risk guarantees** by DFIs covering part of the projects risk to make projects attractive to lenders.
- **Consumer financing programmes** leveraging on existing microfinance experience is instrumental to assess the solvency of customers and eventually strengthen their credit rating.

Enabling by Government:

- **Quality control** and regulation by Government
- **Tax incentives on solar kits equipment and import**

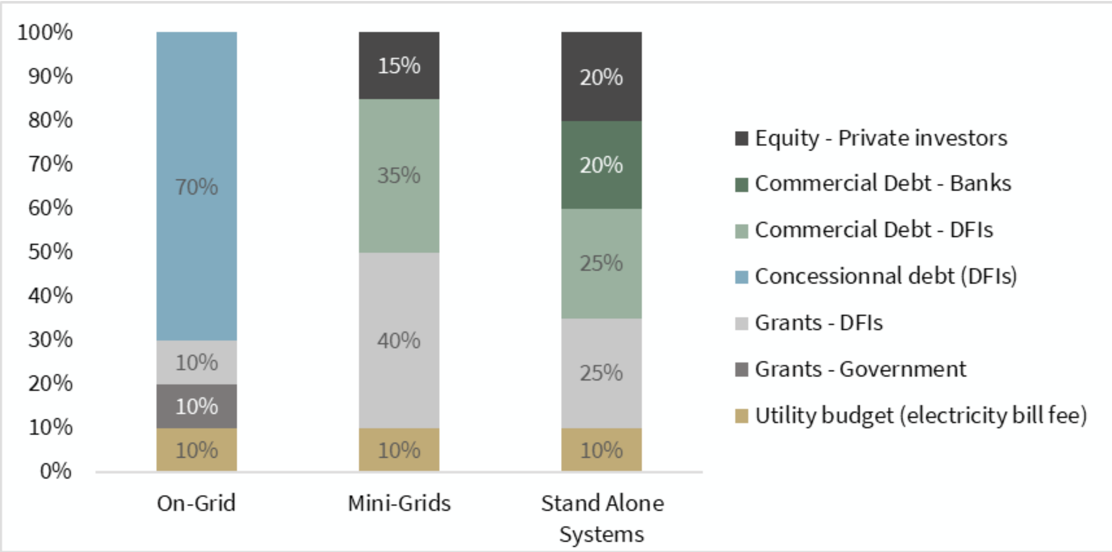
12.5.5 Recommendations for NES financing

12.5.5.1 Financing Sources breakdown

Based on the financing options analysis per segment, the following financing plan is recommended to cover the $4.6 Billion investment required to deploy the NES until 2030.

NES Financing plan (sources repartition)	On-Grid	Mini-Grids	Stand Alone Systems
Grants	**30%**	**50%**	**35%**
From DFIs	10%	40%	25%
From State Budget	10%	0%	0%
From electricity bills	10%	10%	10%
Concessional loans (DFIs)	**70%**	**0%**	**0%**
Commercial Debt	**0%**	**35%**	**45%**
From DFIs	0%	35%	25%
From Commercial banks	0%	0%	20%
Equity - Private investors	**0%**	**15%**	**20%**
Total	**100%**	**100%**	**100%**

Figure 41: NES financing sources repartition per subsector



Including a rural electrification fee into the electricity bills of current customers is a common tool to support rural electrification costs. An amount of 10% of total electrification costs or USD 47m per year is proposed here to stay in line with current electrification investment levels by UMEME estimated at USD 40m. As such, the current tariff structure to existing customers already includes a rural electrification fee, although not clearly displayed. However, the balance between concession/grant financing support from DFIs and GoU and utility financing (with potential electricity tariffs increase) may be adjusted depending on GoU's constraints and priorities, and shall be considered as part of the end-users tariff policy, and general cost structure of the sector.

On-Grid:

Concessional loans backed by the state, with sufficient long-term maturities and low cost should be gradually covered by the additional utility revenues generated by the new connections. As such, this is a scalable and sustainable tool which can fund a large portion of the grid extension and densification costs. On the other hand, a sufficient dose of grant financing is important to reduce the electrification burden for the utility. However, a too high reliance on grants may jeopardize the plan as those instruments have limits in scale which could quickly be overwhelmed by the heavy investments required by grid electrification.

A 70/30 balance between Concessional debt and grants from GoU/DFIs/electricity bills therefore enable grant funding requirements from GoU and DFIs to remain achievable. The level of grants achievable will largely depend on GoUs priorities and decision making, in relation with other commitments in the energy sector and in other sectors. Indeed, GoUs ability to mobilize funding from the Government budget depends on priorities and political decisions. Similarly, most DFIs function with a yearly aid envelope per country, which may be dedicated to electrification or to other development projects depending on GoUs priorities. Achieving the required level of grant and concessional financing is therefore primarily a political decision.

In case of insufficient grant and concessional funding availability from GoU and DFIs, the funding gap could be covered by commercial debt to utility companies. Such debt should preferably be backed by GoU as last resort payer in order to reduce costs and make transactions more bankable. Regardless, the cost of more expensive and shorter-term debt will not be covered by additional revenues from new connections, therefore utility companies will likely have to increase tariffs to current customers in order to face those costs.

Mini Grids:

To enable mini grids to propose a reasonable tariff to customers, a significant portion of grant financing is required as those projects include both distribution and generation. A typical 70/30 debt/equity project finance structure is then applicable to the remaining portion. However, to mobilize lenders, a significant scale will be needed thanks to an efficient sites attribution process to developers. Besides, we expect mini-grid lending to be mostly led by DFIs and specialized impact funds, or commercial banks with DFIs funding and technical assistance due to the complexity of those projects and long tenors required. Contrary to grid connected projects where Private sector finances generation assets and GoU grid network, generation and grid components of each mini-grid shall be financed as one single project as each mini-grid is a standalone solution requiring both generation and grid to operate. Government may contribute to grant financing through REA/MEMD to effectively support the grid cost of each mini-grid.

Stand Alone Systems:

Stand Alone Systems sale is a largely commercially viable activity, which can be funded by equity investors active in the sector as well as DFI and commercial lenders to cover short term financing needs such as 1-3 years receivables financing, once players have achieved a sufficient portfolio scale and track record. A typical 70/30 debt/equity ratio should be achievable once the scale is sufficient, in line with lender's risk mitigation expectations in terms of Debt Service Coverage Ratio and Minimum Equity commitment. However, a significant portion of grant (35%, about 1/3 of costs) will enable SHS companies to serve every household including lowest-income ones rather than targeting the most bankable customers.

Public institutions' electrification should be financed similarly to other connections depending on their geographical situation and the privileged electrification method as per the NES planning.

12.5.5.2 Financing Plan

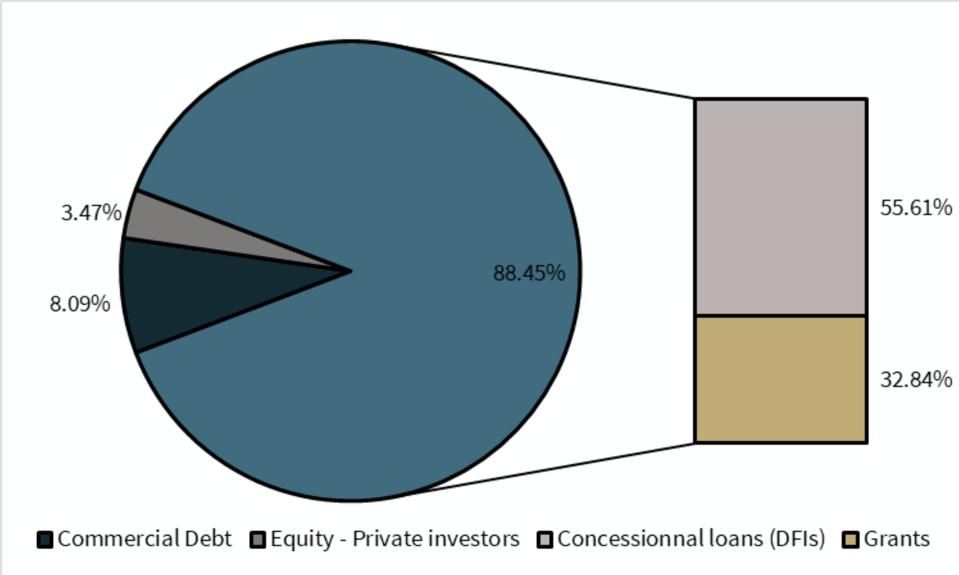
Based on the NES investment needs per subsector, the financing needs for each instrument are as follows:

NES Financing plan ($ millions)	**On-Grid**	**Mini-Grids**	**Stand Alone Systems**	**Total**	**%**
Uses:					
NES 2021-2030 Investment	**3,907**	**356**	**418**	**4,680**	
Sources:					
Grants	**1,172**	**178**	**146**	**1,496**	**32%**
From electricity bills	391	36	42	468	10%
From State Budget	391	0	0	391	8%
From DFIs	391	142	104	637	14%
Concessional debt (DFIs)	**2,735**	**0**	**0**	**2,735**	**58%**
Commercial Debt	**0**	**125**	**188**	**313**	**7%**
From DFIs	0	125	104	229	5%
From Commercial banks	0	0	84	84	2%
Equity - Private investors	**0**	**53**	**84**	**137**	**3%**

This 10-year plan leads to the following average yearly budget and financing needs:

NES Yearly Financing plan ($ millions)	**On-Grid**	**Mini-Grids**	**Stand Alone Systems**	**Total**	**%**
Uses:					
Average 1 year needs	**391**	**36**	**42**	**468**	
Sources:					
Grants	**117**	**18**	**15**	**150**	**32%**
From electricity bills	39	4	4	47	10%
From State Budget	39	0	0	39	8%
From DFIs	39	14	10	64	14%
Concessional debt (DFIs)	**273**	**0**	**0**	**273**	**58%**
Commercial Debt	**0**	**12**	**19**	**31**	**7%**
From DFIs	0	12	10	23	5%
From Commercial banks	0	0	8	8	2%
Equity - Private investors	**0**	**5**	**8**	**14**	**3%**

Figure 42: Total NES Financing sources repartition



Grants and concessional loans collectively account for about 90% of total financing. This is explained as grid electrification represents 80% of the total NES investment plan, and is expected to be financed through grants and concessional funding only. **This large reliance on non-commercial financing sources to keep financing costs and ultimate costs to the consumers under control highlights the importance of proper planning and preparation on the State side to 1/ dedicate sufficient budget and 2/ work with DFIs to obtain their necessary contribution.**

In order to achieve those high financing flows requirements, MEMD and other key stakeholders should organize consultations with Development partners in order to design specific programmes to implement the NES with DFIs support and ability to crowd-in private capital.

13 Monitoring and key indicators

13.1 Mobilising geospatial data and improving coordinated planning processes

The high-level electrification plan generated in the context of Uganda's National Electrification Strategy must be updated maintained over the medium to long-term to allow the MEMD and electricity sector stakeholders to measure progress against the objectives set in the NES and to adapt the NES to emerging circumstances and information over time. This will require the establishment of a monitoring and evaluation framework for the NES, focused on the implementation of the plan and the progression of electrification indicators from year to year. This framework should be tightly focused on electrification progress across all identified segments (grid, off-grid and standalone) and should complement existing project monitoring and evaluation indicators and processes that, for example, measure the impact of electrification programmes on local populations, or control specific implementation and/or procurement processes at the project level.

As such, the primary objectives of the NES monitoring and evaluation framework should be:

- Monitor progress toward electrification objectives in each electrification segment (projects implemented and connections achieved)
- Track and update the electrification status of Uganda's villages, parishes, sub-counties and districts

- Produce reliable, official statistics on electrification in Uganda
- Maintain and update the NES Planning Database as needed to provide an up-to-date geospatial view on electrification status in the country and a basis for future planning exercises

The table below recaps all performance indicators for monitoring the NES implementation:

items	Densification	Grid Extension	Mini-Grids	SHS
Number of connexions completed	✓	✓	✓	✓
Number of villages / projects completed		✓	✓	

These performance indicators are provided for each Service Territories in a separated Excel file called “NES Implementation Monitor”. This NES Implementation Monitor should be completed at the end of each year by the MEMD using the data compiled by the GIS Working Group. By the end of each year, the completed NES Implementation Monitor should then be transmitted to the MoFPED to enhance accountability. The consultant designed an Excel monitoring tool for that purpose by considering (i) densification, (ii) grid extension, (iii), mini-grids, and (iv) SHS: see in Annex.

As a result of their oversight and coordination roles as well as their convening power in the sector, MEMD and ERA will be the leading institutions for the NES monitoring and evaluation framework. However, other electrification stakeholders (REA, distributors, UETCL, development partners, USEA, etc.) will also contribute to and benefit from the process, by inputting key information from their activities and benefitting from the overall coordination provided by the tracking of key NES objectives. The table below outlines the roles (i.e. what stakeholders are expected to contribute to the monitoring and evaluation processes) and needs (i.e. how stakeholders will use information generated during the monitoring and evaluation process) for a selection of key electrification stakeholders.

Stakeholder	NES M&E Need	NES M&E Role
MEMD	▪ Verify whether electrification objectives are met in various segments (on-grid, off-grid, decentralised) and feed information into the policy-making process ▪ Identify bottlenecks or other issues that must be addressed to meet long-term objectives ▪ Measure and demonstrate impacts of electrification on the population to citizens and development partners ▪ Provide visibility to operators, potential investors, other government agencies, development partners etc.	▪ Oversee electricity sector statistical data collection, consolidation and dissemination by ERA ▪ Manage inter-Ministerial and inter-agency collaboration on electrification statistics with the Ministry of Finance and Economic Planning (UBOS), the Ministry of Education and Sports, the Ministry of Health and the Ministry of Local Government, among others ▪ Aggregate and evaluate data on connections and investments made, villages electrified, and ongoing/completed projects to track progress ▪ Maintain the national electrification reference database with bi-annual updates and make available to key stakeholders ▪ Simulate electrification scenarios, budgets, impact, etc. using GEOSIM on an as-needed basis to evaluate projects/initiatives, or understand the impact of new developments on electrification programmes
ERA	▪ Provide official information and statistics on the overall status of the sector for stakeholders and citizens ▪ Monitor developments in the electricity sector to facilitate tariff setting, benchmarking etc. ▪ Measure commercial and operational performance of key operators ▪ Monitor implementation costs and capacity ▪ Verify respect for key standards and norms ▪ Alert the public and sanction operators or companies providing sub-standard solutions, notably in the standalone segment	▪ Collect, consolidate and publish raw data on electrification progress on the grid: number and location of new connections made, number of villages electrified, investments, km of grid extension, etc. ▪ Collect and consolidate raw data on electrification off-grid: number and location of mini-grids, number and location of connections, investments, tariffs, etc. ▪ Collect and consolidate raw data on standalone electrification: sales per region and per service tier, benchmark costs, etc. ▪ Publish data through statistical abstracts and reports ▪ Distribute consumer information
REA	▪ Monitor developments and progress in rural electrification ▪ Identify bottlenecks or other issues in rural electrification that must be addressed to meet long-term objectives ▪ Monitor performance of operators in rural ST, consumer behaviour, rural productive uses needs etc. to improve electrification performance and project implementation ▪ Identify white space and/or electrification challenges on the ground in order to accompany operators or other entities interested in contributing to rural electrification	▪ Create, consolidate and disseminate data (to GIS working group and MEMD in particular) on ongoing or planned grid extension or mini-grid projects within REA's remit ▪ Create, consolidate and disseminate data (to ERA and MEMD) and information on project implementation progress, costs, and timelines ▪
MoFPED	▪ Identify the number of connections and projects planned each year.	▪ Provide the necessary funds for the implementation of electrification projects

Stakeholder	NES M&E Need	NES M&E Role
	▪ Monitor the progress of electrification at the level of the Service Territories. ▪ Ensure enhanced accountability	▪ Monitor the NES general accounting (investments, disbursing in the electrification sector…) according to projects implementation
Operators/ Private Sector	▪ Monitor overall progress in electrification, benchmark connections progress, etc. ▪ Identify opportunities to contribute to electrification progress ▪ Operational and financial reporting for management/regulatory purposes	▪ Create, consolidate and disseminate data (to ERA) data on number/location of connections, costs/tariffs, operational performance and consumption for various consumer categories ▪ Create, consolidate and disseminate georeferenced existing infrastructure and connections data (to REA for small operators and mini-grids, and directly to GIS Working group for UMEME/UEDCL) ▪ Create consolidate and disseminate georeferenced data on planned infrastructure data (to REA for small operators, and directly to GIS Working group for UMEME/UEDCL) ▪ Flag implementation issues and/or challenges and successful strategies to REA for best practice support
Energy Sector GIS Working Group	▪ Monitor overall progress in electrification and infrastructure development for inclusion into GIS databases ▪ Use consolidated analysis for multi-stakeholder or cross sectoral analysis	▪ Consolidate and harmonise GIS data received from stakeholders into an electrification reference database on a biannual basis ▪ Update the number of customers and village electrification status for contribution to the reference database on a biannual basis ▪ Monitor UBOS, NPA, other government agencies to incorporate new socio-economic, demographic or other data into the electrification reference database on an ad hoc basis ▪ Contribute expertise to MEMD planning/strategy projects on an ad hoc basis. On a yearly basis, the GIS Working Group should transmit electrification progresses (number of new connections and villages electrified by ST…) for the "NES implementation monitor" (see in annex)
USEA	▪ Understand evolving market conditions and opportunities for standalone solar systems	▪ Communicate sales statistics for standalone systems
UECCC	▪ Understand evolving market conditions and opportunities in the renewable energy sector to orient financing programmes	▪ Communicate information on financing mobilised for renewable energy projects with a direct connection to rural or urban/peri-urban electrification
Development partners	▪ Monitor overall progress in electrification, impacts on population, etc. ▪ Identify opportunities to contribute to electrification progress in collaboration with local stakeholders	▪ Communicate information on financing mobilised for electrification projects in Uganda ▪ Communicate project site information, status, expected results etc.

13.2 Role of ERA

Collection and consolidation of complementary distribution statistics

ERA currently plays a critical role in collecting and consolidating statistics for the electricity sector in Uganda. In particular, for the electricity distribution sector, ERA collects quarterly performance indicator statistics on customer numbers, key infrastructure (distribution network and transformers), energy sales and purchases, distribution losses, and O&M costs. These statistics are collected for the major grid distributors, as well as for larger isolated grid operators[70] such as WENRECO or Kalangala Infrastructure Services.

The consultant suggests that this role in centralising key statistics from distributors should be leveraged and expanded to include several new items to be included in ERA's quarterly statistical bulletins. These additional statistical elements are outlined in the table below.

Statistical item:	Detail:	Information collected from:	Presented by:	Periodicity:
Connections backlog	Number of connections paid for but not yet completed	Distributors	Service Territory	Quarterly

The consultant further suggests that ERA, in consultation with MEMD, REA and other key stakeholders, develop "benchmark values" to allow distributors and other actors to evaluate the performance of the sector versus targets, and by extension, to identify key areas for performance improvement. This system has, for example, been successfully implemented in Namibia[71], where distributors' performance is tracked against regulator-defined benchmarks in the context of an annual report. The benchmarking values and analysis described in the context of the 2019 Distribution Sector Diagnostic Report[72] could provide the basis for the development of a similar procedure for ERA.

Collection and consolidation of off-grid electrification statistics

With the continued development of private sector investments in the electricity sector, notably through the development and/or operation of mini-grids and the distribution of standalone solar systems, the consultant further recommends that ERA collect additional statistics from licensed operators and vendors in these electrification sub-sectors. These statistics will help provide additional visibility to MEMD and other electricity sector stakeholders to monitor progress on the off-grid

[70] The term isolated grid is used here to distinguish from mini-grid statistics discussed below. In this section, mini-grids are considered to be small, isolated operations that lack the capacity to report statistics to the same level as formally recognized distributors.

[71] See Namibia Electricity Control Board Annual Reports for more information. Annual benchmarking reports have a more limited distribution than the ESI Statistical Bulletin, which provides similar statistics for public distribution via the ECB website. The benchmark values for performance statistics applied in this case cover a large variety of subjects beyond electrification, efficiency and quality of service targets, as all distributors in the country have at least some share of ownership by public authorities.

[72] See: Final Report: Uganda Distribution Sector Diagnostic Review and Directions for Future Reforms for Long-Term Sector Development and Acceleration of Electricity Access Expansion (ESMAP/World Bank), appendices 14-17.

components of the NES. Private sector statistics on the off-grid segment could further be anonymized and consolidated at the district, service territory or regional level for public dissemination.

In particular for standalone systems, USEA is a natural partner for sector monitoring. However, the consultant considers that ERA should have the ultimate responsibility for collection and dissemination of statistics on these operators. These statistics should be disseminated on an annual basis as a part of the annual statistical bulletin.

Statistical item:	Detail	Information collected from	Presented by (geographical unit)	Periodicity
Sales of standalone household /business systems	Units sold per MTF Tier (based on system Watt ratings; 0-50W; 51-200W; etc.)	Licensed distributors and/or USEA	National	Annual
Standalone distribution licensees	Total number of licensed standalone system distributors	Licensed distributors and/or USEA	National	Annual
Number of mini-grids currently in operation	Number and location (parish) of mini-grids in operation in Uganda	Licensed operators (via licensing process) and/or REA	By Service Territory	Annual
Mini-grid installed capacity	Total installed capacity per mini-grid	Licensed operators (via licensing process) and/or REA	By Service Territory	Annual
Mini-grid hours of daily service	Number of hours of service provided to customers on a daily basis	Licensed operators (via licensing process) and/or REA	National	Annual
Number of mini-grid domestic connections	Domestic connections to mini-grids (excluded those treated in the distribution statistics)	Licensed operators (via annual reporting) and/or REA	By Service Territory	Annual
Mini-grid energy cost benchmark	Average tariff per kWh	Licensed operators (via tariff approval and/or annual reporting) and/or REA	National	Annual
Mini-grid connection cost benchmark	Average cost per domestic connection	Licensed operators (via tariff approval and/or annual reporting) and/or REA	National	Annual

Calculation and dissemination of annual electricity access headline statistics

- **Grid-equivalent domestic connectivity rate (MTF Tier 4+)**

The grid-equivalent connectivity rate measures the share of Uganda households with a household electricity connection that provides a level of service equivalent to that provided by the interconnected grid. In practice, this includes all interconnected grid and isolated grid domestic connections, as well as any mini-grid domestic connections with *at least* 16 hours of daily service per day. The rate is calculated as follows:

$$Grid\ equivalent\ domestic\ connectivity\ rate\ in\ year\ N:$$
$$= \frac{Total\ grid\ equivalent\ domestic\ connections\ in\ year\ N}{Total\ households\ in\ year\ N}$$

It should be noted that this calculation may under estimate the actual number of households benefitting from an electricity connection, as one client meter or contract may not directly correspond to one household. In order to take into account this distortion, a shared meter correction factor can be applied to the number of reported domestic clients, based on the methodology described in section 10 of this report.

This statistic also potentially excludes households that have an electricity connection through a standalone system such as a solar lamp. However, these connection modalities cannot be captured through the statistical grid-equivalent approach for two key reasons: first, many standalone systems may supplement a household electricity connection as a backup option, and second, while it is possible to track annual sales of standalone systems, it is not possible to know the exact number of standalone systems in circulation at a given moment.

For this reason, the “comprehensive” connectivity rate for all MTF tiers, including standalone electrification options, can only be determined through household surveys. These should be collected every 3 to 5 years as part of the UBOS household expenditure and census survey cycles, or as a part of a separate energy survey as with the ERT-III survey carried out in 2018. Please see section 11.3.3.2 for more information.

- **Electrification coverage rate (MTF Tier 4+)**

The electrification coverage rate measures the share of planning or administrative units with grid or mini-grid infrastructure versus the total number of units. A village is considered electrified if it has at least one active connection (grid or mini-grid)[73], a parish or subcounty is considered electrified if it contains at least one electrified village. This indicator, while not directly related to the number of household connections in Uganda, provides important information about progress against the territorial electrification goals (e.g. to electrify 100% of sub-counties), as well as about the nature of the electrification work remaining to be done (e.g. customer densification versus grid densification/mini-grid development) and the access of populations to electrified services such as clinics, schools, etc.

In the absence of a comprehensive listing of village electrification statuses maintained by ERA, this statistic should be based on the annual update of the NES National Planning Database. The NES database manager(s) at MEMD should be responsible for delivering a list of villages, parishes and sub-counties and their respective electrification statuses to ERA at each annual

[73] In the absence of comprehensive georeferenced connections data, other infrastructure – for example a known operating mini-grid or an operational distribution step-down transformer can be used as a proxy for active connections. Standalone systems are not counted as “electrified”, as technically these systems can be deployed anywhere and serve only a single client.

update of the database.[74] ERA can then use the data on electrification status to calculate the coverage rate. The coverage rate is expressed as follows:

$$Electrification\ coverage\ rate\ year\ N:$$
$$= \frac{Total\ units\ considered\ electrified\ in\ year\ N}{Total\ units}$$

13.3 Role of UBOS

Collection and consolidation household electricity access data in National Household Expenditure and National Census surveys

UBOS, while not directly responsible for Monitoring and Evaluation in the energy sector, has a role to play as a complement to the statistics collected by ERA. The consultant recommends that MEMD and UBOS coordinate to expand the energy content in the UBOS household expenditure and national census surveys. The role of the UBOS survey data will be (i) to collect additional information on household energy consumption patterns and challenges to electricity access, (ii) to complement the annual national electricity sector statistics calculated on an annual basis by ERA by providing survey-based connectivity statistics by segment (grid, mini-grid, standalone), by MTF Tier (Tier 0 – 5) and by administrative unit (district, sub-county, parish, …) approximately every three to five years, depending on the timing of the national census and intermediary household surveys. Similar questions regarding electricity connectivity and quality of service should be posed to businesses as a part of any commercial surveys conducted by UBOS.

The ERT III survey conducted in 2018 provides a strong basis for the development of additional survey questions on household electricity access. While it is outside of the scope and expertise of the National Electrification Strategy to develop the precise formulation of the questions to be posed to households, the consultant suggests that the following elements be considered for inclusion in future UBOS household surveys. As a part of the discussions with UBOS to request the adaptation and expansion of electrification survey questions, list should be refined with sector stakeholders, in particular MEMD and REA, as well as with UBOS experts.

- **Per administrative unit (Subcounty, Parish, Village):**
  - Electrification status (electrified/non electrified/in progress) of the administrative unit and technologies used (grid/mini-grid)[75]
  - Electrification status (electrified/non electrified/in progress) of key public infrastructure (schools, clinics, administrative offices, trading centres, etc.) and technology used (grid/mini-grid/standalone system)
  - Electrification status (electrified/non electrified/in progress) of businesses and technology used (grid/mini-grid/standalone system)
- **Per household:**

[74] Process described in section 11.3.3.3 below.

[75] The consultant suggests that only administrative units with grid or mini-grid access be considered "electrified" since in theory, any area can benefit from the installation of a standalone electrification system such as a solar home system. This diverges from the definitions applied for households or public infrastructure, since a household or infrastructure with a standalone solution meeting the minimum standard set by the government (Tier 1 in this document) is considered to be "electrified".

- Electricity connection in the household (Yes/No) and technology used (grid/mini-grid/solar home system/genset/…)
- Number of hours of electrical service per day (4/8/16/24, etc.)
- MTF Tier electricity consumption
- Type of backup generation used if any (solar home system/ genset, etc.)
- Share of household expenditure spent on electrical energy
- Electricity use for revenue generation activities (Yes/No and type of activity)

Data collected from representative surveys should allow for the calculation of several important indicators to guide the implementation and adaptation of the NES, including the comprehensive connectivity rate mentioned above (the ratio of households reporting an electricity connection of any kind to total households), the modal shares of grid, mini-grid and standalone connection types, and the MTF tier-level of households' electricity consumption by geographical area and connection type.

⇨ **Key actions for decision-makers:**

- Organize regular census survey conducted by UBOS to determine the connectivity rate and level of consumption by geographical area and connection types (medium term).
- Share data with relevant institutions (medium term).

13.4 Role of MEMD

Centralising key M&E information for the NES

While MEMD does not have a specific mandate to create or disseminate statistics or information on the electrical sector, it does play a role in centralising information from the various agencies under its aegis and feeding this information into policy decision-making processes as well as in the coordination of electrification rollout in Uganda. In this capacity, MEMD is well placed to maintain "ownership" of the NES M&E process. Moreover, the absorption of the Rural Electrification Board and Agency in the main Ministry could provide an opportunity to MEMD to build its technical capacity by utilizing former staff of REA who were already involved in the planning, monitoring and evaluation of rural electrification schemes.

Maintaining the NES Planning Database & GEOSIM planning tool

MEMD is in the process of strengthening the Directorate of Energy Resources to enhance its capacity to coordinate sector planning and monitoring and evaluation of the implementation of plans and projects. In particular, MEMD should be responsible for maintaining and updating the NES Planning Database on the basis of data provided by ERA, REA, UBOS, or other institutions. MEMD is already playing a centralising role for energy sector data by maintaining a GIS database covering all aspects of the sector and participating actively in the Energy Sector GIS Working Group. The maintenance of the NES Planning Database would build on this existing activity within MEMD, requiring – in addition to the infrastructure and other feature updates already carried out in the existing database – annual or semi-annual updates of the village electrification database layer to track changes in electrification status, socio-economic infrastructure or other key information for following up on the NES.

These updates would then permit the calculation of general indicators contribute to monitoring of NES progress and provide the basis for any required updates to the electrification planning described in the NES. In addition to the unlimited licenses for Manifold 8.0 and GEOSIM delivered to MEMD during the NES Draft Restitution, the consultant has also developed an Excel-based dashboard to assist in this process, to be delivered to MEMD at the closure of the project, and has planned additional training activities to ensure that the GIS team has the tools and knowledge required to maintain and update the database and simulations.

Technical and Personnel requirements

The personnel requirements associated with NES M&E at MEMD are for one GIS expert to act as an Electrification Planning Data Manager, with a time requirement estimated at 0.25 FTE (full time equivalents) on average each year. The time requirements for this position will be concentrated in specific periods of the year, in order to integrate and process new information from various stakeholders on an annual or semi-annual basis. The Planning Data Manager should also be responsible for centralising and maintaining a data library for non-GIS data and/or studies related to electrification in Uganda to contribute to information requests from MEMD decisionmakers or future studies on the sector. MEMD has strong existing expertise in its GIS team capable of managing such a role; however, adding additional duties to this one-person team may require additional hiring on a part time or consulting basis.

Technical requirements for managing the database and associated planning software have been communicated to MEMD in the context of the transfer of software licenses and the preliminary training sessions held in December 2020.

Role of the Energy Sector GIS Working Group

The Data Manager would need to work closely with other stakeholder institutions to collect and process data including from REA, UETCL, UMEME, UEDCL, etc. through the existing Energy Sector GIS Working Group. This initiative is key to ensuring sharing of data and best practice sharing across various electrification stakeholder organisations and should be reinforced through the allocation of dedicated time for working group members to contribute to the collective work of maintaining, centralising and updating electricity sector data, as well as through the establishment of training and activity budget to allow members to access training, participate in relevant conferences, maintain a website to share information publicly, etc.

13.5 Recap of the main strategic actions

Restructure and strengthen the role of MEMD and GIS working group required for NES implementation and Monitoring and Evaluation:

a) Adhere to Sustainable Energy Programme approach to efficiently and effectively deploy resources.
b) Creation of a Department or Division to handle development of sector plan and regularize the adhoc sector GIS Working Group into a Division to support development of sector plans.
c) Assign the Ministry of energy to liaise with the Ministry of Local Government to update and maintain georeferenced village data which is the primary data in planning and monitoring electrification.
d) Appoint a data manager to maintain and update the NES Planning database (immediate term).
e) Ensure an active and dynamic role in monitoring the NES Planning Database (long term).
f) Ensure that the National Electrification Plan is updated every three years (mid term).

g) Ensure the upgrading of the skills of the GIS Working Group staff by organizing regular training every three years or in case of recruitment.
h) Prepare the publication of annual reports with statistics on electrification progress and policy adjustment recommendations with action implications.
i) Integrate monitoring and financing of the electrification plans (progress of electrifying villages) in the Parish Model.
j) Coordinated communication of Sector plans.

14 Conclusion

This NES Study final report provides orientations and recommendations targeting universal access of electricity in Uganda by 2030. The following topics were addressed in the report:

- Analysis of the institutional framework,
- Analysis of electrification policies and strategies with international benchmark,
- Strategy for the incorporation of productive usages,
- Analysis of off-grid business models and options,
- Analysis of the legal and regulatory framework,
- Technological review including least cost options and focus on solar PV technologies,
- Analysis of the capital investment strategies and control mechanisms,
- Least cost electrification planning approach and methodology,
- Presentation of the new consolidated geographic information system (GIS) and,
- Development of the NES with planning results of the simulations.

After processing and verification, the consultant considers that the resulting databased and results presented in this report are robust for such a national master plan, which aims to provide the overall targets, budgets and guidelines for electrification on and off-grid. At the detailed planning stage for specific studies, this data should nevertheless be confirmed at project level through specific studies. This is generally carried out through customer surveys and site visits.

The NES Draft report presented two potential variants on the base case, one based on an optimized least cost approach starting from the presumed state of the existing MV grid in 2020, and one based on the construction of the proposed grid extensions developed by REA in its Rural Electrification Master Plan 2018. Both variants were modelled using the GEOSIM software. These options were presented and discussed by stakeholders during several workshops in 2020. They resulted in a **selection of a final base case** variant around which further geospatial planning analysis was developed for the final NES consolidation and report. The planning work included the reshuffle and reconsolidation of the GIS database based on the new administrative units of 64,369 villages (instead of 44,032 units processed for the NES Draft report).

The final base case scenario is ambitious in terms of maximizing the quality of service for connections, but is also be feasible, taking into account the various constraints faced by the sector from a capacity, financial and market perspective. All these constraints were identified and analysed with recommendations in this report. One of the future challenges will be to support stakeholders to enable them to take ownership of the elements of analysis, recommendations and improvement proposals contained in the NES final Study report with a view to operationalizing the strategy**. A prerequisite is the effective involvement of decision-makers and managers of the institutions concerned, who should act in a spirit of continuous consultation, information sharing and proactivity. As mentioned**

above, in particular in the international benchmark of success stories, a strong political commitment that places electrification as a national priority is sine qua non of the ambition of universal access following in the footsteps of Kenya, Tunisia, or Morocco which have achieved or about to achieve such goals. Fundraising through transparent planning processes readable for all public, private and international stakeholders (without major changes along the way) is a key success factor.

The private sector is also called upon to play a leading role in the implementation of the NES. The off-grid regulatory framework is favourable to this but still needs to be implemented with flexibility and pragmatism, considering the pilot and risky nature of off-grid and MG projects (especially for the private sector who bears the main financial risks): these projects are essential for all actors (public, private, development partners, users) to gain know-how, experience and, ultimately, confidence in off-grid electrification solutions.

A national workshop was organized in order to present the main findings of this NES final report. Two sessions geared to the GIS working group members on the GIS database consolidation and geospatial optimization tool GEOSIM were already performed in 2020. In addition, **the consultant provided advanced training in use of GIS/GEOSIM and Database management.** Participants were staff in charge of electrification planning in their respective institution, and with a well-established expertise in computer science, databases and/or GIS. The training course was split into the following sessions:

- Short refresher course on understanding and using GIS – creating data sets, importing data, geo-referencing images, creating queries, developing maps and tools for searching information. Links with existing institutions collecting GIS data such as UBOS will be made so as to ensure a flow of data exchange between various organizations.
- Spatial analysis: Understanding the spatial context of a region through socio-economic criteria. Rank settlements in an order of electrification priority so as to maximize the potential for development in those settlements having already important services or population densities.
- Load forecast: Topics will include surveying techniques, analyzing data, assigning load curves, consumption patterns for different users, growth rates etc. Interpreting results.
- Supply options: Building up a database that covers the range of supply options available (exact location, installed capacity, aspects pertaining to seasonality, investment costs and O&M costs, existing and planned grid network, costing of transformers, LV and MV networks…).
- Running GEOSIM® and interpreting results: the plans, the short medium and long-term investment requirements, financial engineering, updating parameters and plans.

The above elements were restricted to relevant subjects for the stakeholders present and geared toward implementing and updating the NES. The objective of the training activities was to internalize the planning skills within MEMD and other key institutions which are responsible for the enactment of the plans.

Ideally, a specific session (1/2 day) could be organized for decision makers as they will have to build their own understanding and expectations from the rural electrification planning activities and the functionalities offered by GIS and GEOSIM planning tools. Such a knowledge is essential to make the most of existing internal planning resources and GIS expertise within their respective organizations, and should help decision makers guide and monitor the NES updates and implementation. Decision-makers play a key role in supporting multisectoral dialogue: the GIS and planning tools made available to the GIS working group during the NES process could indeed be valuable instruments to enhance the necessary planning coordination not only within the electricity sector, but also across other key development sectors. The short training proposed to decision makers would be useful to foster such communication channels with planners across institutions and sectors.

Finally, this NES Study report led to the preparation of Strategy Paper geared to decision makers. It summarizes the key issues by highlighting the points of attention required for NES adoption, implementation and supervision. This includes a list of strategic actions which will contribute to meet the national objectives of universal access by 2030 by considering a holistic approach. These actionable recommendations developed in this NES Study report encompass concrete and enabling measures useful to establish the conducive environment necessary to achieve the NES goals.
Three objectives have been defined in order to achieve the NES target of universal access, which will be implemented by focusing on key priority areas. These objectives will result in outcomes that will be completed through the strategic interventions and actions described in this report and streamlined in the NES Paper for decision-makers: see in Annex.

Objective 1: increase access and utilization of electricity.

Objective 2: promote Productive Use of Electricity for socio-economic development and financial sustainability of the electricity sector.

Objective 3: strengthen institutional capacity for coordination, M&E of the implementation of the NES.

Mapping of Outcomes to Objectives

Strategic objectives	Outcome	Outcome indicators
1) Increase access and utilization of electricity.	Universal access by 2030	Timely implementation of the electrification plans Access rate (%)
2) Promote Productive Use of Electricity for socio-economic development and financial sustainability of the electricity sector.	Increased productive use of electricity	Proportion of electricity used for commercials, industries and other productive use
3) Strengthen institutional capacity for coordination, M&E of the implementation of the NES.	Universal access by 2030	Timely implementation of the electrification plans Access rate (%)

All proposed strategic actions are in line with the strategic directions set out in the document entitled “Sustainable Energy Development Programme Structure” published in September 2021, namely objectives 1 (Increase access and utilization of electricity), 3 (Increase adoption and use of clean energy) and 4 (Promote utilization of energy efficient practices and technologies).

15 Annexes: see Volume 2 (separate document)

15.1 Detailed figures on Access to Electricity Services by District and Service Territory

15.2 Excel monitoring tool for NES implementation

15.3 Presentation of GEOSIM®

15.4 NES Uganda: list of Villages to be Electrified via grid Extension in years 2021 and 2022.

15.5 NES Uganda: list of Villages to be electrified via PV Mini-grid.

15.6 NES Uganda: list of Development poles that can be electrified both on-grid and off-grid

15.7 NES paper for decision-makers

See separate document