Energy and Economic Growth
Applied Research Programme

Scaling up Rural Electrification in Uganda: Innovative Technical and Financial Solutions Being Explored to Address Access Challenges

Energy Insight

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March 2019

Oxford Policy Management

UKaid
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1.0 Background

Uganda, which has one of the most liberalised electricity sectors on the continent, offers a useful lens for examining the effect of power sector reform on social objectives, including energy access. Liberalisation was supposed to yield a better managed power sector. While the country's electricity sector has performed better financially than its neighbours, the electrification rate has lagged. The grid electrification rate is estimated at 22%[1] (rural 21% and urban 57%).

Since the institution of the Rural Electrification Agency (REA) and Rural Electrification Fund (REF) in 2003, the Government's primary policy and approach has been to promote private sector-led rural electrification initiatives focused on the provision of capital grants for the construction of grid infrastructure in far-flung rural areas, as well as enabling market penetration of the productive use of electricity equipment and appliances. While these nascent private sector-led rural electrification efforts have taken root, within a promising environment for the participation of investors, with a lack of hindrances, they leave a great deal to be desired, especially in scaling up electrification with alternative smarter and cost-affordable technologies. New customer connections have mainly been concentrated in urban areas and trading centres and have not prioritised the poor in peri-urban and rural areas. The high cost of providing electricity to sparse rural population settlements, high connection costs and tariffs for consumers, and the lack of financial resources of private companies to meet the capital investment and operating costs continue to render these areas financially unattractive even after reform.

Nevertheless, there has been a recent step change in electrification in Uganda, spurred by the REA's partnership with Uganda's largest private distribution utility, Umeme Ltd. This paper documents some of the key policy, institutional, technical, procurement, and financing initiatives being adopted by Umeme to fast-track rural electrification and access in Uganda.

Section 2 introduces the policies and key institutions in Uganda for promoting rural electrification. Section 3 outlines the key electrification planning considerations. Sections 4 and 5 outline solutions Umeme is adopting to reduce costs and stimulate demand. Section 6 outlines the ongoing and projected costs of electrification in Uganda, while Section 7 concludes by summarising the ongoing challenges, and steps to overcome them.

2.0 Policy, institutional, and planning context

Drawing from the National Development Plans, the Rural Electrification Strategy and Plan (RESP), the Energy Policy and Electricity Connection Policy, the primary technical planning function for rural areas rests with the REA (Kapika and Eberhard, 2013). Until late-2014, peri-urban and rural electrification planning was not considered a sector priority goal, owing to generation capacity constraints and a lack of funding for investment in the distribution network (The World Bank PPIAF, 1999). The lack of an integrated resource plan complicated planning further as different utilities with different priorities and datasets churned out individual electrification plans. As a result, national investment planning has been incoherent. Nonetheless, more recent developments indicate a positive shift towards coordinated planning between the REA and Umeme Ltd, as a more viable pathway to rural electrification in Uganda, as indicated in sections below.

2.1 Policy framework

Uganda's private sector-led model of electrification (The World Bank, 1999) has not achieved the access goals that were envisaged as one of the outcomes of power sector reforms in the *Uganda Power Sector Restructuring and Privatization: New Strategy Plan and Implementation Plan* (Government of Uganda, 1999) (ESMAP World

[1] Uganda National Household Survey 2016/2017.

Bank, 1999). During election periods, this lack of progress has from time to time been a sticking point for the President and the National Resistance Movement (NRM) leadership's unfulfilled promises.

One of the fundamental weaknesses with the programmes and policies is the lack of harmony and consistency in the design of electrification targets and strategies, which undermine institutional initiatives which seek to increase access. The Government's National Development Plan II (NDP II) included an electrification target of 30% by 2020 and Vision 2040[2] included an electrification target of 80% by 2040. In addition to these national strategies, the Government, in 2013, designed the RESP 2013–2022 (RESP II), with a primary objective of accelerating electricity access to 26% by 2022, 51% by 2030, and 100% by 2040, to meet national development goals. In 2012, the Government further engaged in a Sustainable Energy for All programme, which aimed, among other things, to ensure universal access (>98%) to modern energy services by 2030, and to promote cheaper and cleaner off-grid technologies (Kapika and Eberhard, 2013). The efforts to design national electrification development and policy programmes to a large extent demonstrate the commitment of Government to increase access rates in Uganda. However, these inconsistent targets lead to a lack of clarity, inconsistent decision-making, and reactive planning, without prioritisation, which in turn leads to expensive sub-optimal investments.

In a bid to minimise these risks, in March 2017, the Ministry of Energy and Mineral Development (MEMD) developed the Electricity Connections Policy 2018–2027 (MEMD 2018, n.d.), which became effective on 1 November 2018, with the aim of providing a coherent framework for funding and implementing access-driven programmes. The policy also aims to combine and achieve the NDP II (30%) and Vison 2040 (80%) electrification targets in its first phase and second phase, respectively.

All stakeholders in the electricity sector unanimously recognise that the core objective and desire is to increase electrification rates in the country, while ensuring programme efficiency and sustainability. Previous planning failures that plagued institutions involved in rural electrification are envisaged to be overcome by cooperation with a more efficient private distribution company. It is for this reason that the urge to involve Umeme Ltd in present and future electrification programmes has become very important.

2.2 Institutional structure and funding mechanism

Within the broader power sector structure there are two key institutions that are directly responsible for, and involved in, rural electrification programmes, pursuant to their mandate in Uganda, with differing funding modalities, as explored below. While there are seven other smaller concessionaires responsible for rural electrification in remote, geographically distant areas, this article will focus on the largest two institutions leading new programmes in Uganda, and how their new cooperation is causing an unprecedented step change in ramping up access rates.

2.2.1 REA

The REA, through the REF, which was established in 2003, is the main implementing agency of the rural electrification programmes in Uganda. The REA is a semi-autonomous body under the MEMD that is mandated as the main coordinator of Government- and donor-funded electrification schemes and programmes. However, most of its funds have focused on building backbone infrastructure, while electricity connections have previously largely remained unsupported or left to Umeme Ltd (depending on their economic viability). Funding for the REA is mainly generated from the national fiscus, concessional loans, donor funding, and grants, and is buoyed by a 5% transmission levy for rural electrification. The REA provides funding subsidies to private concessionaires within its footprint – termed service providers – as an incentive to increase rural electrification.

[2] Vison 2040 is a refined National Development Plan that provides development paths and strategies to operationalise 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. It aims to transform Uganda from a predominantly peasant and low-income country to a competitive upper middle-income country.

The intention of the subsidy mechanism is to buy-down the capital cost of investment to the extent that, at reasonable tariffs, the project is attractive to a project sponsor.

In 2001, MEMD published its first comprehensive RESP for 2001–2010, which it subsequently updated in 2013 to cover the years 2013–2022. The second plan was created by the REA using a zonal-concession model to tender and manage the rural distribution facilities. The RESP encouraged rural electrification through demand-driven, private sector-derived proposals, including public–private partnerships, where market conditions made rural electrification projects only viable with capital subsidies. The policy created the REF, to be administered by the REA. The aim of this REA and REF was to provide necessary capital contributions (viability gap funding) to create a market that would be attractive to the private sector. The underlying assumption was that rural electricity services would be able to recover all the operating costs and generate cash flow to service some, but not all, of the capital costs.

The second RESP, published in 2013, however, notes the difficulties of attracting and retaining sufficient commercial interest in the initial approach. It cites the high risk of capital investments in small-scale electricity projects.[3] To solve this dilemma, the plan formally increases Government participation by publicly financing grid extensions to lease to licensed operators. The Government has already begun providing this low-risk leasing option to the market, but the plan takes this a step further by formally drawing concession zones (service territories) for auction. The plan also highlights the willingness of the Government to substantively finance small, off-grid concessions.[4]

With the above initiatives in place, a persisting problem has been that the REA's grid extensions to communities do not by themselves lead to new customer connections. New connections, and their ongoing operation, is the mandate of licensed operators, like Umeme. The planned service territories (concessions) are too small, and alone are less financially viable due to geographic and economic situations, particularly for under-capitalised and inexperienced entities. It is for this reason that Umeme Ltd, the large financially solvent utility, offers the opportunity of large economies of scale to cause a step change in Uganda's rural electrification plans.

2.2.2 Umeme Ltd

Umeme Ltd, the largest power distributor, which is operating a 20-year concession in Uganda, is cognisant of the Government's electrification programmes and targets. Since 2015, Umeme has actively participated in the electrification agenda within its areas of operation (its 'footprint'). It should be noted that the Government and Umeme Ltd did not make electrification/connection targets a condition of the concession agreement at commencement in 2005, in the interest of keeping the newly unbundled utility commercially viable. In addition, Umeme's 2005 concession is limited to a 1 km footprint around the grid. Umeme therefore has neither the obligation nor the right to extend service beyond this area. For this reason, electrification rates have remained very low for over a decade.

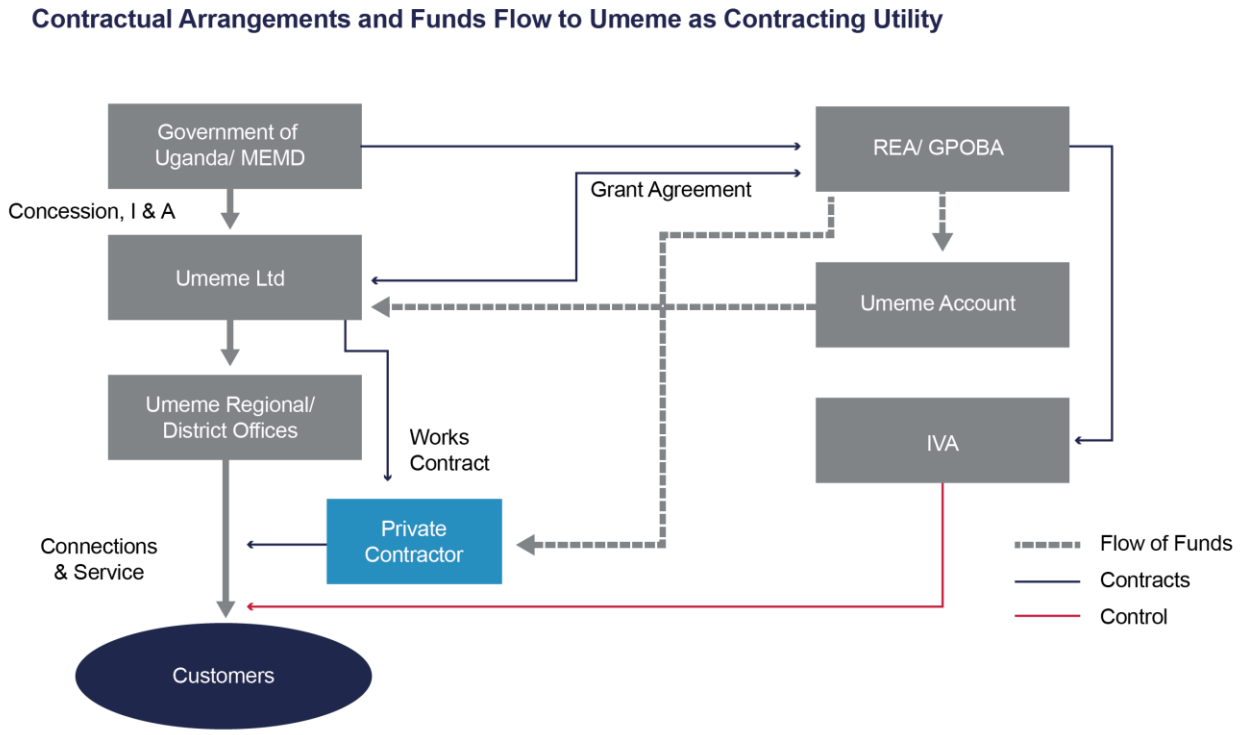
Umeme has nonetheless connected about 142,000 new customers through subsidised grid connections since 2015. The bulk of these household connections were executed under the Global Partnership on Output-Based Aid (OBA) programme, mainly funded by the Government of Uganda, World Bank, Kreditanstalt für Wiederaufbau (KfW), and the European Union through the REA. This joint cooperation, the first of its kind, between a private entity (Umeme Ltd) and public entity (REA) unlocked and demonstrated to stakeholders the opportunities of institutional cooperation in increasing access rates, if the right incentives are provided. Figure 1 illustrates the OBA contracting framework between REA and Umeme Ltd. Under the programme, Umeme pre-financed the connections and was reimbursed 100% of the connection cost, plus interest. The scope of this paper is not to discuss in detail the implementation arrangements of the OBA project. Somewhat similar programmes

[3] Republic of Uganda Ministry of Energy and Mineral Development (2013) 'Rural Electrification Strategy and Plan Covering the Period 2013 to 2022', 3 July 2013, p. 2.
[4] Ibid., p. 8.

arrangements have since been designed and implemented between Umeme Ltd and MEMD or other development partners.

It is worth noting, however, that the progress noted above is mostly not a direct result of power sector reform. Rather, the progress stems from special Government and utility programmes that have occurred in parallel with the reform process. What is clear, though, is that a hybrid of public and private funding and technical solutions is necessary if Uganda is to fast-track its access agenda.

Figure 1: OBA contracting framework between REA and Umeme Ltd



3.0 Strategic electrification planning

Uganda no longer suffers from generation capacity constraints. Installed capacity is currently 1,167 MW and is projected to increase by another 600 MW by the end of 2020, while *local* peak demand is only 615 MW. The existing excess capacity has stimulated intensive sector planning discussions on how to transmit and distribute electricity to unserved/underserved areas, to create demand for the new generation capacity, as well as the socioeconomic transformation of households. Umeme Ltd.'s role once again becomes critical in setting the pace for the distribution of this energy to unserved and suppressed demand areas, via set electrification targets.

At a strategic level, the Electricity Connections Policy sets a moderate plan and target to achieve a 60% connection rate by the year 2027, representing 6,303,923 households both on-grid and off-grid, of which 67% (4,223,628) are to be realised on the grid. The annual target has been set at 300,000 connections, although this is slightly lower than the required connection numbers. Nonetheless, Umeme Ltd, the largest utility, with donor/Government funding support through the REA, has been encouraged and is expected to plan and scale up the rate of *subsidised* connections countrywide to 225,000 per annum, while the other service provides (of which there are seven) are expected to connect the remainder. This strategic objective has meant that much of the technical planning has had to be executed jointly with the REA, and has required exploring the various technical planning requirements and cost-effective connection approaches.

At a tactical level, the two institutions – the REA and Umeme – consider the following key factors in planning grid extensions: household settlement patterns, proximity to growth trading centres, design of infrastructure

required to cater for load requirements of the number of targeted households/institutions, the corresponding distances from the existing grid, and grid compliance standards, as well as grid intensification/upgrade requirements, including necessary transformer injections. Optimised cost assessments, including contracting and project management, are carried out too, to ensure the overall connection costs are within allocated budget amounts for any donor-funded budget allocation at any time. All the collected information is consolidated as baseline data to guide scenario modelling.

3.1 Baseline data

The baseline data used are drawn from the existing electricity network consisting mainly of medium voltage (MV) and low voltage (LV) lines up to 33kV. The aim is to target and locate social structures (health centres, police stations, churches, local government headquarters, primary and secondary schools, tertiary institutions, trading centres) and domestic homes that are currently not electrified. Initial assessments targeted over 280 high-growth areas near the existing grid identified to initiate the electrification drive, at a lower cost. The social structures and homes are linked to the 280 high-growth potential areas, as shown in the sample figures below.

Figure 2: Social structures (heath centres) and households

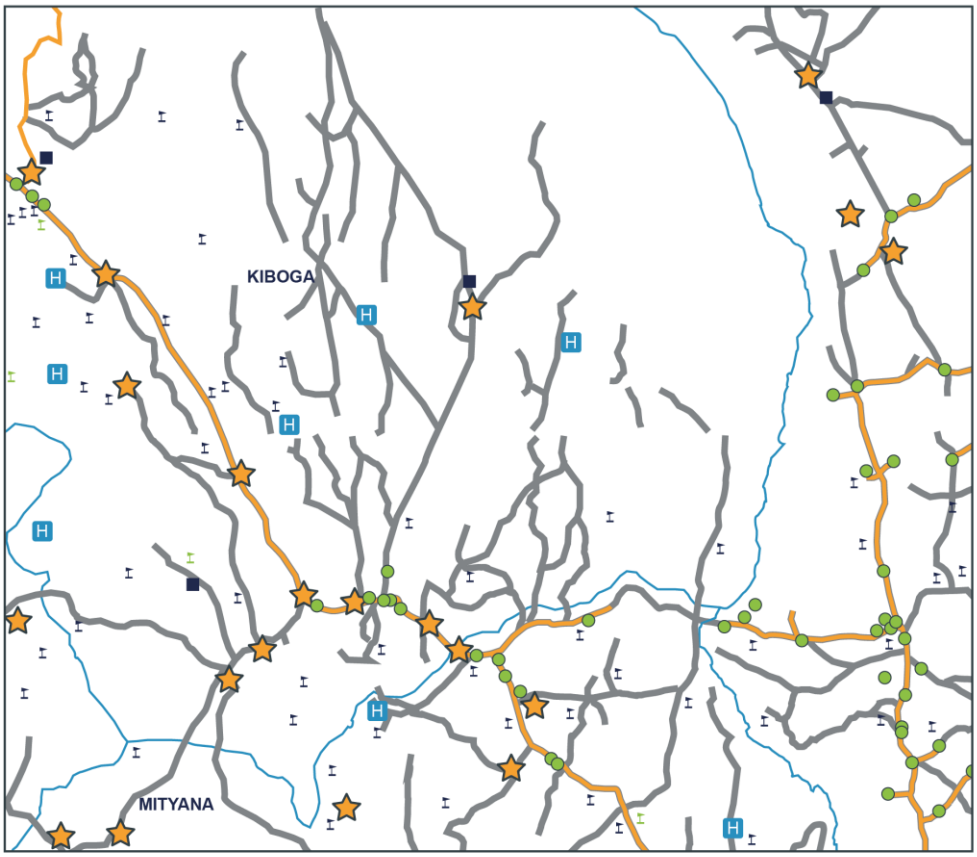
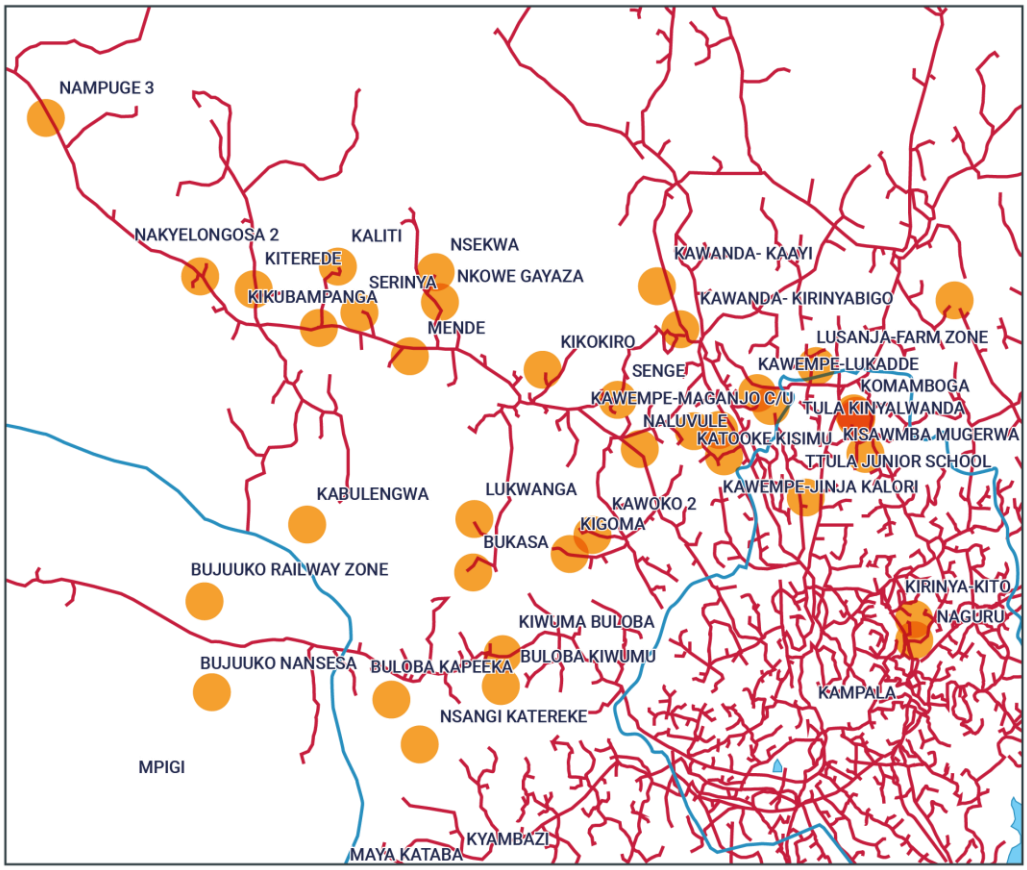


Figure 3: Potential growth trading centres



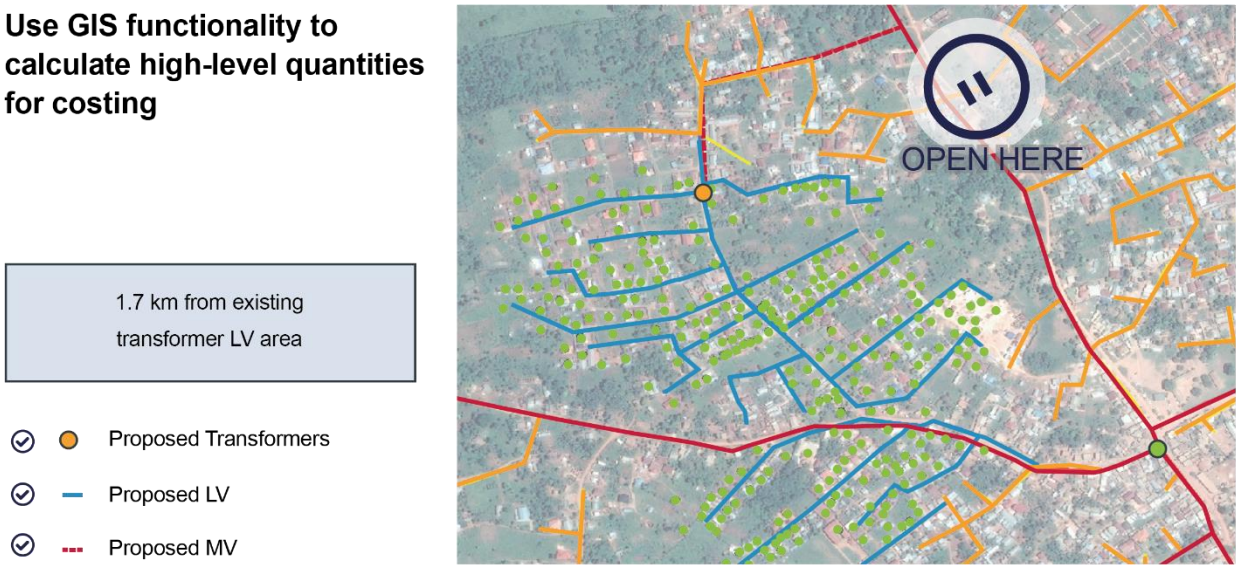
3.2 Connection mapping methodology

Identification of potential growth centres, social institutions, and households is paramount, for they offer an opportunity to recover costs in the near future, a criteria that is of interest to the private utility Umeme. This potential is physically identified by planning engineers in areas without electricity grids (greenfield areas), as well as those with existing grids that traverse trading centres and social institutions that are not connected to the grids (fill-in areas).

a) Greenfield areas – *Potential load growth areas without a grid*

Aerial mapping using Google Earth Maps and GIS is ideally used to locate the potential customers in greenfield areas (see Figure 4). Unfortunately, this technology is applicable/available only for the Kampala region. The first step involves designing greenfield areas of at least 1.7 km from existing transformers and to consider existing LV networks so as to minimise losses and improve LV supply. The planning team then use GIS functionality to calculate high-level quantities for costing. The transformer sizes (kVA) are then calculated basing on aggregate demand forecasts, based on population and income data obtained from the Uganda Bureau of Statistics poverty classification, averaging at 0.367 poverty levels to signal minimum forecast demand.

Figure 4: Greenfield mapping



Project Name	Proposed MV (km)	Proposed LV 35mm² (km)	Proposed LV 70mm² (km)	Proposed trf size 1 (kVA)	Proposed trf size 2 (kVA)	Potential customers
Kawoko 2	0.444	1.68	0.53	200	0	297

The following process is used to plan a grid extension to greenfield areas:

i. Umeme district teams estimate the number of households for connection, as well as the required LV and MV reticulations. This estimate requires field verification by Umeme Design Auditors to ascertain the appropriate transformer locations, and the actual number of households to be connected, and to classify them by the number of poles required (no pole, one pole, or two poles).

ii. Using the submitted data, the total line, equipment and connection costs are calculated and aggregated to generate the total scheme cost.

iii. Transformer sizes are calculated based on the aggregate demand (ADMD), estimated based on the number of households in an area and their income levels.

iv. Connections for potential customers are subject to a full field study to ascertain the exact connection type required: i.e. *no-pole connections* require just a cable each from the existing electric pole to the house with a pre-paid meter; *one-pole connection* requires installation of a new pole, cables, and accessories to serve a customer within a distance of 90 metres; *two-pole connections* are considered for distances beyond 100 metres. Clusters of the same potential customers within the same geographical area are then considered as quick load centre targets for connection prioritisation.

v. It is then assumed that 50% of the identified potential households are not able to afford internal house wiring and earthing installation costs. The final cost therefore includes a ready board and earthing material and installation costs for 50% of the households.

vi. The LV reticulation is of an aerial bundled conductor (ABC) construction type, to minimise potential hooking and illegal connections, while the MV is of a bare conductor type.

vii. The final step involves acquiring field data and performing desktop planning in Umeme to get actual scheme costs, bill of materials, and drawings for procurement and contracting.

It is from this planning exercise that Umeme will select a pack of schemes to be implemented under the Last Mile and Densification programmes that will help to increase electrification rates in Uganda.

b) Fill-in areas – *Areas with existing distribution grid but not serving any customers*

The fill-in areas for the programme mainly target high-growth areas where there is already existing networks, and long distribution feeders. Consideration is also made for LV lines to ensure minimum acceptable voltage limits, which also helps to avoid or minimise high losses and transformer overloading. In addition, long single-phase lines are replaced with three-phase lines.

The approach aims to create new transformer zones (Figure 5) and capture potential consumers in that particular zone (Figure 6), and to use these to calculate conductor sizes to be installed or replaced, and to calculate transformer sizes using typical load data for residential, commercial, health uses, etc.

Figure 5: Transformer zone in LV areas

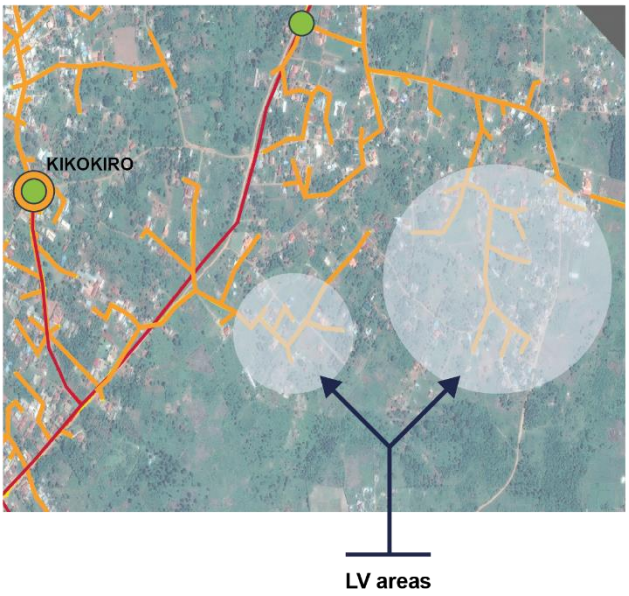
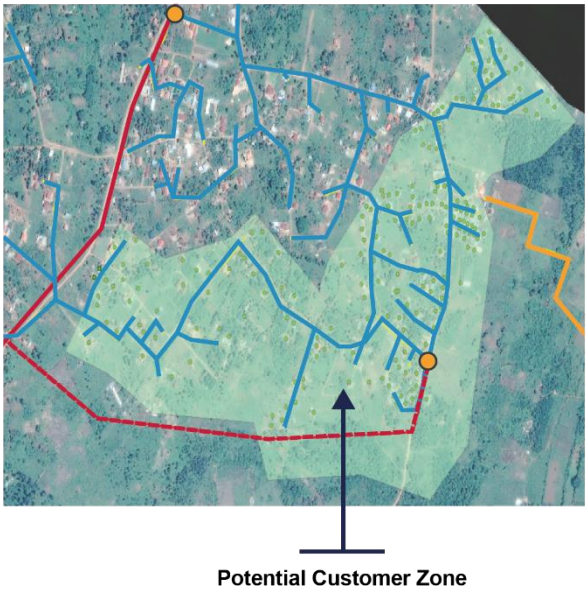


Figure 6. Consumer Zone



4.0 Cost-saving technical solutions

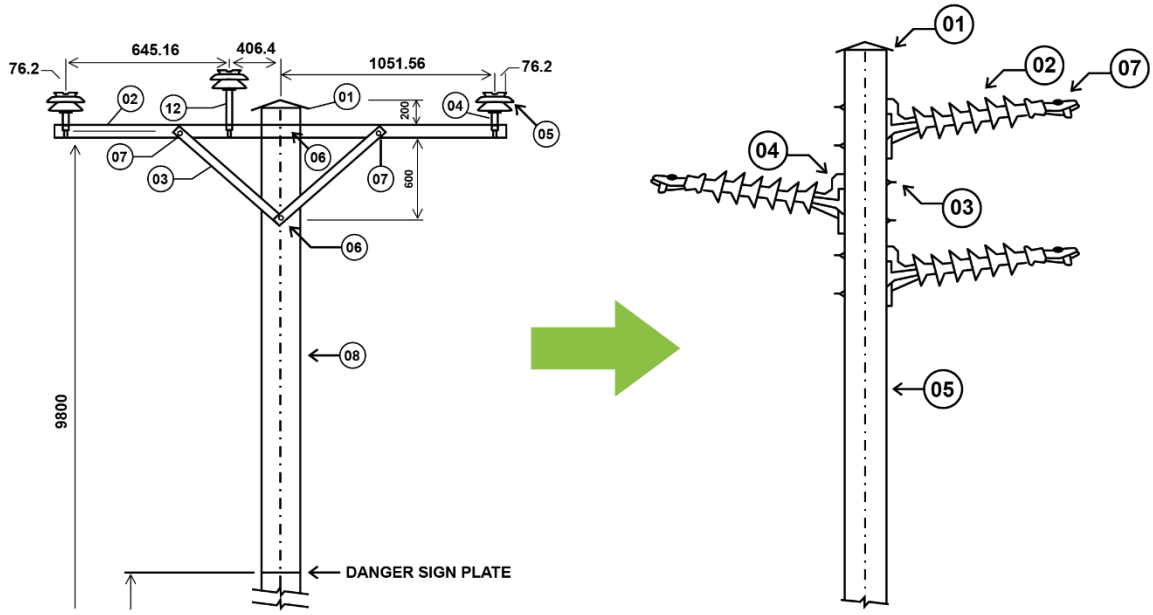
The selection of low-cost technology – combined with the rationalised planning targeting social institutions and households, with Umeme Ltd's participation – has and will be key in enabling a required step change in access rates in Uganda. Technological development during the electrification programme is mainly driven and facilitated by the necessity to reduce costs. Given the political pressure to increase connection targets and difficulty in altering tariff structures, the cost per connection is one of the few areas in which the financial performance of the electrification programme can be improved.

The following cost-saving measures have been proposed by Umeme and are yet to be adopted:

- ***Design specification for the poles.*** Replacing the horizontal steel cross-arms structure, which is expensive, heavy, and consumes more materials, with the simpler and cheaper staggered vertical configuration for the MV lines will significantly reduce the material needs and costs (see Figure 7).
- ***Reduce the size of service cable from the pole.*** The size of the service cable should be reduced from 16 mm to 10 mm since most of the domestic consumer voltages can be supported by this standard.
- ***Reduce quality of supply specifications.*** Customers with continuous production systems and sophisticated machinery are generally known to be financially sensitive to supply quality problems. However, for most

domestic customers these problems are more of a nuisance than a cost. In the light of this, the allowable voltage regulation on LV systems should target voltages level of ±5 and float to within ±10. This relaxation of LV quality of supply specifications, in association with other network design specification changes, will allow network designers to specify a 'light' rather than a robust MV and LV network, with associated reduction in investment costs.

Figure 7: Shift from horizontal steel cross-arms structure to the simpler and cheaper staggered vertical configuration for the MV lines



Complementary to the above, Umeme has also embraced innovative technologies that help to reduce costs, have shorter lead times to procure locally in bulk, improve utility performance, and ultimately yield better electrification results, including;

- ***ABCs*** for all LV lines, rather than bare conductors, provide for a safer and reliable network that is free from illegal connections and hooking, which ultimately helps to minimise losses.
- ***Prepayment meters,*** which are already in use, remove the need for bill delivery costs, reduce the costs of reading meters, and reduce non-payment by helping customers to avoid incurring unaffordable consumption costs. The access programme utilises prepayment metering technology for all domestic connections.
- ***Ready boards*** are being used to circumvent the high cost of internal wiring, which is a big hindrance to connection for the rural poor. Ready boards are placed in a central location in a house or shack and contain one or two plug sockets and a light, facilitating electricity use without further house wiring. It is anticipated that the consumers will eventually decide to fully wire their homes in their entirety, and at that time will need staggered internal wiring that they can pay for through instalments.

5.0 Proactive demand stimulation

Since the start of the Umeme concession, its customer connection approach has been demand-driven. This approach has failed to yield the high connection numbers that are targeted by the Government's access agenda. Umeme has therefore proposed a more radical and proactive outreach campaign, including sensitisation and marketing to solicit eligible connection applications.

From the aforesaid campaign, the trend of verified subsidised connections executed during the period 2015–2018 (excluding connections under verification) and funded under the initial World Bank/KfW OBA programme, with co-funding from the Government of Uganda, is shown in the table below. Without Umeme's involvement in the programme to date, this step change in the number of customers gaining access to electricity since 2015 would not have been feasible.

Table 1: Trend of verified subsidised connections executed during the period 2015–2018

Category	2015	2016	2017	2018	Total
World Bank/ KfW- OBA connections	79,601	4,472	16,608	25,175	125,856

Source: author's own compilation

6.0 Required funding for access programmes

Funding for access-related programmes, especially those being implemented under the electricity connection policy, will largely come from the Government of Uganda (Consolidated Fund), the 5% transmission levy, various development partners, and growth factor revenues (~10% annually). So far, about USD 31 million has been utilised by Umeme to connect over 142,000 subsidised connections, as outlined in Table 2.

Table 2: Funding utilised by Umeme for subsidised electricity connections

Category	2,013	2,015	2,017	2,018	2,019	Total
Funds (USD)	2,817,000	7,485,391	4,999,981	9,787,109	6,800,000	31,889,481

Source: author's own compilation

Going forward, the Electricity Connections Policy has quantified the required funding to achieve a 60% access rate by 2040 as USD 558.4 million. Table 3 shows indicative funding requirements to meet this electrification target.

Table 3: Funding requirements to achieve 60% access rate by 2020

Item	Annual (USD)	10-year requirement to reach 60% access rate (USD)
Connection materials	48,000,000	480,000,000
Verification of connections	3,000,000	30,000,000
Publicity and mobilisation	645,000	6,450,000
Ready boards	4,200,000	42,000,000
TOTAL	55,845,000	558,450,000

Source: Electricity Connection Policy 2018–2027

Only USD 80 million has been committed for last-mile connections and is to be mainly provided by World Bank, the UK Department for International Development (Energising Development), the German Development Bank, the European Union, and the French Development Agency. A full cost estimate incorporating grid backbone intensification requirements to give a holistic view is currently being developed jointly by the REA and Umeme. Nonetheless, electrification activities are progressing with the limited funds made available, albeit at a slow pace. This funding gap reality contextualises some of the limitations and challenges being faced in the electrification programme.

7.0 Conclusion

Uganda faces an uphill task in overcoming the policy, structural, and implementation barriers hindering widespread rural electrification. Key challenges can be summarised as follows:

- conflicting targets and strategies that stymy coordinated progress and most effective use of scarce investment;
- inadequate institutional capacity and understaffing;
- inadequate prioritisation and funding for construction of the distribution backbone infrastructure to support the increasing connection numbers;
- bureaucratic processes and conditionalities to access development partner funds which delays the programs;
- wayleaves acquisition challenges and complex land rights;
- dispersed rural populations and settlements, which makes grid extensions and connections economically unviable;
- inadequate incentives for service providers to make timely and cost-affordable connections; and
- limited productive use of electricity interventions to create demand beyond simple lighting (World Bank, 2015; McCall and Santana, 2018).

Despite these challenges, Uganda is on track to accelerate electrification rates using a combination of innovative policy, programme, and technical initiatives implemented since 2015. The REA's concessions, supported by the World Bank's Electricity for Rural Transformation and the REF, have provided an enabling platform for co-participation with Umeme, the largest utility, which has capacity to accelerate connection numbers.

Umeme's increasing connections trend is a step in the right direction. The utility should be provided with adequate incentives to keep on track. Umeme has proposed a number of technical cost-saving solutions geared towards making the cost per connection affordable for all consumers. These include changing conservative, high-cost construction standard design specifications to much simpler and cheaper designs that are suitable for rural areas, the realisation of which will lead to positive changes in both quality of supply and cost. In addition, the use of prepayment electricity meters and the broader adoption of single-phase lines will significantly reduce capital costs per connection while increasing revenue collections.

In tandem to these measures, productive use initiatives and household clustering[5] should be promoted to help grow the load in remote areas, to help absorb excess capacity and justify large-scale investments in grid and mini-grid infrastructure.

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