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FWC Beneficiaries 2013 - Lot 4 - Energy and Nuclear Safety

FORMULATION OF THE LESOTHO ELECTRICATION MASTER PLAN

Action & Investment Plan

(Final Report)

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Formulation of the Electrification Master Plan

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Action & Investment Plan
(Final Report)

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List of Acronyms

AETS	Application Européenne de Technologies et de Services
BoS	Bureau of Statistics
BUSD	billion US dollars
DoE	Department of Energy
EA	enumerator area
EAPP	energy access pilot project
EMP	Electrification Master Plan 2017
EUD	European Union Delegation
EUR	Euro
FIRR	financial internal rate of return
FNPV	financial net present value
GDP	gross domestic product
GHI	global horizontal insolation
GIS	geographic information system
GoL	Government of Lesotho
IPP	independent power producer
kWh	kilowatt-hours
kWh/m^2	kilowatt-hours per square meter
LAA	Lands Administration Authority
LCOE	levelized cost of energy
LEC	Lesotho Electricity Company
LEWA	Lesotho Energy and Water Regulatory Authority
LHDA	Lesotho Highlands Development Authority
LPG	low pressure gas
LREBRE	Lesotho Renewable Energy-Based Rural Electrification Project (2007-2013)
LSL	Lesotho Loti
MEM	Ministry of Energy and Meteorology
MTF	multi-tier framework
MUSD	million US dollars
MW	megawatt
NAO	National Authorising Office
NEMP	National Electrification Master Plan 2007
NSDP	National Strategic Development Plan
OGA	Off-Grid Agency
PV	photovoltaic
REF	Revolving Electrification Fund
REU	Rural Electrification Unit
SAFEGE	Société Anonyme Française d'Etude de Gestion et d'Entreprises
SDGs	Sustainable Development Goals
SEforALL	Sustainable Energy for All
SHS	solar home system
TAF	Technical Assistance Facility
ToR	Terms of Reference
TWG	Technical Working Group of the EMP
UNDP	United Nations Development Programme

1 EXECUTIVE SUMMARY

This electrification master plan (EMP) covers a 20-year time horizon and caters for both grid and off-grid electrification. It is meant to enable systematic, predictable and equitable grid expansion and off-grid electricity roll-out, with a view to enhance quality of life, provide income-generating opportunities and alleviate poverty. A master plan also offers the possibility of unlocking targeted interventions that may be supported by development partners. While grid electrification proficiency is well established within the ambit of LEC, the delivery of modern energy services in off-grid areas lacks policy direction, institutional responsibility, effective delivery mechanisms and funding. The EMP makes recommendations in this regard, in addition to proposing a prioritised schedule of electrification projects and an action plan for implementation.

The EMP comprises of the following components:

- Socio-Economic Analysis Report
- Demand Analysis Report
- Prioritisation Algorithm (in MS Excel)
- Financial Model (in MS Excel)
- Grid Development Plan Report, including a prioritised schedule of grid projects and an annual roll-out plan in accordance with the available budget
- Off-Grid Master Plan Report, including a prioritised schedule of off-grid projects and an annual roll-out plan in accordance with the available budget
- This Action & Investment Plan Report.

The Action & Investment Plan specifies Government actions and makes recommendations on the implementation of the EMP as follows:

ACTION PLAN

Roll-out of the electrification programme as per EMP requires careful planning and consideration of various issues to overcome specific barriers to implementation. The key success factors to be addressed in this regard are as follows:

Adoption of the EMP by Government

It is important that there is demonstrated commitment to implementing the EMP, in order for it to become a powerful development facilitation tool for Lesotho. Commitment to the EMP means that the prioritised roll-out plan is followed as far as possible, which in turn provides certainty for stakeholders and enables a more coherent and effective development effort.

While an electricity connection or off-grid system enhances people's quality of life on household level in many ways, access to electricity also enables broader development objectives to be achieved, such as poverty alleviation, promoting productive activities and income generation, better healthcare and education, mitigation of ecological degradation and rural-urban migration, etc.

It is also important that Government accepts the significant contribution that off-grid electrification makes to the overall electrification effort and embraces this as a valuable stepping stone towards achieving universal electricity access and community upliftment in the shortest possible time. Off-grid electricity solutions are very affordable in comparison with grid electrification and offer better quality lighting than traditional energy sources. Off-grid electricity systems can also enable productive activities that are hitherto unassailable in remote areas. These qualities can therefore enable a rapid transition from traditional energy use to more cost-effective, better quality and more

sustainable energy application, and significantly enhance the quality of life of poor people.

Awareness Creation about the EMP

Once the EMP has been adopted, DoE needs to ensure that this is widely publicised so that its implementation can be considered in all spheres where it is likely to have an impact.

At policy level, government departments need to be aware of the broad roll-out schedule that includes pace and location, to direct other development efforts in those areas in the relevant years of EMP implementation.

At planning level, stakeholders need to be equally aware of the annual roll-out schedules to enable them to plan their investments accordingly.

At operational level, LEC needs to plan for upgrading of transmission networks and substations in good time to cater for the additional load that electrification will add to the national demand. Similarly, off-grid service providers need to plan for recruitment of customers, equipment purchases, and establishing their service and maintenance infrastructure.

At beneficiary level, potential customers need to know when the grid arrives in their area to enable them to decide whether to wait for this or invest in an off-grid system in the meantime.

Create Regulatory Certainty

*The **recommended market mechanism** for off-grid electricity supply hinges on three key elements, namely:*

- ✓ ***Beneficiary choice of system**: Similar to the mobile phone market, the decision of what off-grid system to purchase needs to be that of the user, and not be imposed by the implementing agency or service provider. Choice of system is determined by user preferences and affordability.*
- ✓ ***Private-sector driven**: Marketing, supply, delivery, installation and maintenance of off-grid electricity systems, components and services should be left to private-sector service providers so that a viable commercial market may have a chance to develop in Lesotho. If Government embraces off-grid electrification as recommended in this EMP there is a sizeable market to be served.*
- ✓ ***Enabled by revolving fund**: Making affordable and easily accessible credit available to beneficiaries (users) for acquiring off-grid electricity solutions is a most effective way of enabling a commercial off-grid market in Lesotho. A revolving fund as recommended is one such mechanism that provides affordable financing terms for users and de-risks projects by improving supplier cash-flow. Expecting users to purchase their systems and appliances at market prices (rather than reducing their capital costs through subsidies) creates a sense of ownership that enhances market viability. And since the loans are repaid – albeit possibly with low interest and over extended terms that make them affordable for poor rural households – the fund is replenished continually and can benefit new applicants over many years.*

LEC needs to have clarity about their obligations in serving electrification customers whose connection to the grid will mean escalating expenses for the utility as the load density decreases in remote areas. The present tariff regime is not supportive of the increasing capital and operational costs and the issue of where the money comes from to pay for this shortfall needs to be addressed with urgency.

Government needs to champion and drive the urgent establishment of a suitable regulatory framework that encourages private-sector investment in mini-grids and off-grid systems and services, with clear rules and requirements. Key issues to be addressed include off-grid tariffs (whether these are to be regulated or not) and investment certainty (eg rules about what happens when the grid arrives).

Create an Enabling Environment for Off-Grid

With off-grid electrification being a key focus of the EMP, and little existing experience in this regard in Lesotho, there is need to put effort into creating an enabling environment for it to take off and flourish. It is strongly recommended that development of the off-grid market centres on private-sector engagement and participation, with Government facilitating this through

a. Harmonising grid and off-grid electrification approaches: It is recommended that subsidised grid network extension is limited to the medium voltage backbone networks including stepdown transformers, but excludes the low voltage networks and customer connections, the cost of which is to be borne by the customers through a standard connection fee. In this way grid and off-grid options are comparable on an equal footing, with customers paying the actual capital cost of connection. Also, the 'scheme approach' that has been in practice in grid electrification for a number of years also has relevance on the off-grid side and can be adapted for an integrated electrification approach that incorporates the proposed revolving fund as the enabling market mechanism. Groups of interested parties (households and businesses) from a community apply to the revolving fund for a loan to pay for their connection fees (if a grid scheme) or system costs (if an off-grid scheme) and pay the relevant deposit. If approved, the revolving fund pays the costs directly to the service provider – LEC on the grid side and a certified private-sector company on the off-grid side – and the scheme group will repay the loan over a period of time. Dealing with scheme groups rather than individuals has advantages for both the revolving fund and implementing agencies (LEC or private sector companies) in that the viability of transactions is increased through higher quantities (of connections/systems) and a reduced administrative burden per customer served.
b. Focused off-grid efforts: For example, by transforming the REU into a mandated agency as per TAF SEforALL recommendation ("*the formation of an Agency-like Entity that shall take care of energy solutions in off-grid areas*"). Such an agency must have a clear mandate to facilitate and coordinate off-grid electrification, by guiding and monitoring private sector companies in their efforts to develop mini-grids and supply/install stand-alone solar PV systems in accordance with the EMP and the regulatory requirements. This agency should not be tasked to undertake off-grid electrification in its own name.
c. Appropriate policies and directives: Government needs to put in place specific policies and directives that focus on off-grid electrification, in order to facilitate an enabling environment. This could be in the form of off-grid electrification targets and incentives, rules and regulations for off-grid service providers, certification of off-grid service providers to be eligible for government incentives, etc.

d. Awareness creation: Creating proper awareness and understanding of off-grid energy solutions is a critical ingredient for the success of any off-grid programme. It is recommended that the DOE embarks on an effective awareness campaign in this regard, as soon as possible, to better prepare the market that is already emerging. Such an awareness campaign should have an initial term of not less than 12 months and may include dissemination of information brochures in local language(s); regular radio and TV infomercials about the uses, benefits and limitations of off-grid systems; regular radio programs dealing with off-grid issues, such as quality and cost, service levels, maintenance and after-sales service, financing options, etc; and billboard advertising.
e. Promotion of quality standards for off-grid systems, equipment and appliances, by way of product warranties; product certification and labelling; awareness creation and good after-sales and maintenance service.
f. Placing emphasis on after-sales service for off-grid systems, equipment and appliances; and
g. Enabling access to affordable financing for end users, which a specific revolving fund for this purpose, as previously proposed by the TAF SE4All team ("*Financing mechanism for Rural Energy Access within an Energy Fund*"), could provide. It is recommended that the revolving fund caters for both grid and off-grid electrification and is initially set up and resourced by Government (e.g. from the annual budget allocation, or as a once-off capital injection), with specific budgets for grid and off-grid electrification as per allocation decided by Government. These budgets may be supplemented with funds from other sources, for example development partners or the Universal Access Fund. The revolving fund offers low interest loans with lenient repayment terms to prospective LEC customers on the grid side and system buyers/users on the off-grid side, enhancing the cash-flow of LEC and off-grid system suppliers (which is a major barrier); and thereby de-risking private-sector participation on the off-grid side as suppliers are not burdened with having to arrange or provide the financing.

Accelerating Access to Electricity

Access to electricity stood at 38.5% in 2017, representing about 207,000 households, which leaves approximately 330,000 households to be electrified at this stage. With an annual investment of M150 million – of which 80% is going towards grid electrification and only 20% towards off-grid solutions – and an estimated population growth rate of 1.04% per annum, it will take 24 years for Lesotho to provide universal access to electricity for all its citizens.

This timeframe could be considerably shortened if there was greater focus on lower-cost off-grid solutions, by directing a larger portion of the available budget towards off-grid solutions over a short period of time (3-5 years, depending on the off-grid budget allocation). The following approach is proposed for consideration:

1. Set a target date, through a policy directive, for Lesotho to reach universal access to electricity.
    a. Universal access in this sense means that all households have access to some form of electricity which may be very simple – as in the case of a solar lantern – yet mean a huge improvement in quality of life for poor households.
    b. The lower the service level, the sooner the target can be reached. If Government opts for rolling out solar lanterns as a first step in the electrification programme, a large number of households can benefit in a very short time and the target will be reachable within 2-3 years.

   c. Lesotho can then claim universal access to electricity which significantly contributes towards achievement of the SDGs.

2. Establish capacity and a mandate for dealing with the off-grid electrification program.
3. Increase the off-grid budget allocation such that the target can be achieved.
   a. This will require determination of an appropriate mix of off-grid systems that provide various service levels at corresponding cost (i.e. low service level = low cost, high service level = higher cost).
   b. Budget allocation for grid electrification will need to be reduced significantly, for a period of time.
4. Establish a revolving fund for electrification specifically.
5. Once the universal access target has been reached, the electrification programme will continue with the aim of increasing service levels.
   a. The grid electrification programme will continue, possibly with an increased budget.
   b. Households that have benefited from simple off-grid systems will have the opportunity to upgrade to higher-service-level systems in accordance with what they can afford.

Appropriate Grid Standards for Low-Load Rural Areas

Grid electrification is progressing into more remote areas that are sparsely populated, mostly by poorer communities. Applying the same technical standards for the grid networks as in high density high demand areas, therefore, would mean an ‘overkill’ that puts a severe strain on limited financial resources.

It is recommended that LEC reviews their technical standards for remote areas and considers alternative approaches that could include ‘light’ networks (such as single wire earth return systems) and ‘light’ customer connections without a costly meter (such as load-limited supplies).

Solicitation of Additional Funding

The EMP, once adopted as the guiding mechanism for rolling out the electrification program, offers the opportunity for Government to solicit funding from development partners and possibly reduce the burden on the fiscus.

Development partners are often eager to fund marginal projects that improve the livelihoods of poor communities, provide broader developmental benefits (like poverty alleviation, improved health care services, etc), promote productive activities and income generation, and address gender issues.

INVESTMENT PLAN

The primary outcome from the master planning exercise is the prioritised lists of grid and off-grid electrification projects. These are to be implemented in ranking order, starting with the highest priority projects – those at the top of each list – which give the most benefit (i.e. highest number of connections) for the least cost.

If projects lower down on the priority list are brought forward for reasons other than cost-benefit (for example: special development factors that were not known at master planning stage, or political reasons), the projects lower down will simply move up to fill the void left by those projects brought forward; the ranking order of the lists is not affected by such a move.

Electrification Budget

A sustained annual electrification budget of M150 million is assumed for the EMP, based on the current level of government budget allocation for this purpose. The Ministry of Energy and Meteorology (MEM) decreed that only 20% of this government budget – M30 million per year – shall be allocated to off-grid electrification for the time being, with the balance – M120 million per year – going towards grid electrification.

This will result in an average of 7 756 grid connections (at an average cost of M15,000 per connection) and 10 364 off-grid connections (at an average cost M2,646 per connection) being provided each year, yielding 364 207 connections over 20 years at a total cost M 2.88 billion.

	Grid	Off-Grid	TOTAL
Annual Electrification Budget	M 120 million	M 30 million	M 150 million
Average Annual Connections	7,756	10,364	18,120
Total Investment over 20 years	M 2.33 billion	M 547 million	M 2.88 billion
Total Connections over 20 years	155,127	207,280	362,407
Average cost per connection	15,000	2,646	8,823
Number of EAs electrified	1,399	2,143	3,542

The results indicate that, with the present budget allocation and split, 80% of the total investment only provides 42% of the connections (on the grid side), while 20% of the investment provides 58% of the connections/systems (on the off-grid side).

A sensible approach towards achieving universal access sooner would be a higher off-grid allocation initially, say for the first 3-5 years, which will result in the great majority of unelectrified households in Lesotho being connected in the next few years. Grid electrification will continue during that period too, albeit at a slower pace, and will be accelerated thereafter again with a higher budget allocation and continue for as long as necessary.

Budget for EMP Implementation Facilitation

Implementing the EMP in terms of the Action Plan requires a budget for establishing and maintaining the proposed facilitation structures and mechanisms, to cover the possible cost elements. An indicative budget of M 35 million for once-off establishment expenses and M 15 million recurring annual costs is proposed, to be funded from the Government allocation for electrification.

Resourcing the Revolving Electrification Fund

The revolving fund for electrification is to be resourced with capital from Government coffers and could be supplemented with possible contributions from development partners and/or the Universal Access Fund. Since the fund is a credit facility, it is replenished on a continual basis as the loans are being repaid by the beneficiaries.

Therefore, once the fund is fully operational and adequately resourced with budgets for grid and off-grid electrification, it will not be necessary for Government to inject capital on an annual basis, which will free up funds for Government to allocate towards other development efforts.

WAY FORWARD

Launching the roll-out of the EMP is envisaged to entail an initiation phase during which the proposed facilitation structures and mechanisms are established, with subsequent accelerated implementation of the electrification program.

Initiation Phase

This phase could commence as early as 2019 if the EMP has been approved and adopted by Government by the end of 2018 and can be expected to last for 2-3 years.

Two key structures are to be established during the initiation phase, namely the *Off-Grid Agency (OGA)* and the *Revolving Electrification Fund (REF).* The details of their set-up, mandates and operational functionality, however, are yet to be developed which is to be undertaken during the initiation phase.

The key mechanisms to be established for purposes of enhancing the facilitation of the electrification programme include:

- Awareness creation about the EMP;
- Establishing the market rules for electrification;
- Recruiting eligible private-sector off-grid service;
- Setting a target date for achieving universal access to electricity and determining appropriate grid and off-grid budgets for an accelerated electrification programme;
- Developing appropriate grid standards for rural electrification; and
- Soliciting additional funding for electrification.

In the absence of the above structures and mechanisms early in the program, the roll-out of the EMP can still commence with some initial steps, in preparation for the accelerated electrification program that will follow the initiation phase.

Accelerated Implementation of the Electrification Program

Once the OGA and the REF have been established and the key mechanisms are in place, the electrification program can be rolled out at full speed, within the limits of the available budget and prevailing capacity of the role players.

Universal access to electricity is achievable within a relatively short period of time if lower-cost off-grid systems are prioritised by a higher budget allocation for off-grid. Grid electrification will continue in parallel, in accordance with the prioritised schedules, and will eventually also reach villages that have previously benefited from off-grid solutions. Off-grid beneficiaries will also have the option to upgrade to larger systems at any time.

2 INTRODUCTION

In August 2017, the European Union Delegation (EUD) appointed AETS Consortium (the Consultant) to undertake the "Formulation of the Electrification Master Plan" for Lesotho, over a 4-month period from mid-September 2017 to early February 2018. This period was extended by four months to allow for additional data collection and preparing the GIS database.

This master plan specifically deals with increasing access to electricity and does not cater for non-electric energy sources that may also be considered in addressing Lesotho's energy needs.

This electrification master plan (EMP) covers a 20-year time horizon and caters for both grid and off-grid electrification. It is meant to enable systematic, predictable and equitable grid expansion and off-grid electricity roll-out, with a view to enhance quality of life, provide income-generating opportunities and alleviate poverty. A master plan also offers the possibility of unlocking targeted interventions that may be supported by development partners. While grid electrification proficiency is well established within the ambit of LEC, the delivery of modern energy services in off-grid areas lacks policy direction, institutional responsibility, effective delivery mechanisms and funding. The EMP makes recommendations in this regard, in addition to proposing a prioritised schedule of electrification projects and an action plan for implementation.

2.1 BACKGROUND

The Lesotho energy balance is dominated by biomass (mainly wood), with over 60% of the population dependent on it for energy needs. Fossil fuels such as petroleum also make up a substantial portion of Lesotho's energy mix. The rate of connection to the electricity grid is currently around 40%. Electricity only accounts for 7% of national energy consumed, as shown by the recently released "Lesotho Energy Sector Profile" [Foreign Investment Promotion Officer, Lesotho National Development Corporation, 2017].

Lesotho is experiencing a considerable energy deficit. The country generates around 72 Megawatts (MW) from the 'Muela hydropower station and requires about 145 to 150 MW in peak periods. Therefore, Lesotho must import around 68 MW, mainly from Mozambique (29% of peak demand) and further from South Africa (20%) at prices ranging from LSL 0.80 to LSL 1.50[1] per kWh [LEWA, 2017].

As a result of power shortages in South Africa in 2008, ESKOM (the South African utility) reduced the supply of electricity to Lesotho and other neighbouring countries, leading to widespread load-shedding in that year. There are fears that further load shedding might be required in the future until generation investments are completed in South Africa and other demand-side measures are implemented. For this reason, the Government of Lesotho wishes the country to become self-sufficient in the next few years[2].

Industry is the biggest electricity consumer at 39% followed by the domestic sector at 34%. The annual per capita electricity consumption is 253 kWh, significantly below the African average of 579 kWh. The electricity access rate is much higher for urban households as compared to rural households. The urban households are less reliant on

[1] June 2017: 1 EUR is around 14.5 LSL (Lesotho Loti).

[2] Policy Statement 6 in Lesotho Energy Policy 2015-2025 on Power Generation "Government will ensure … that base load requirements are met through local generation".

biomass and mainly use paraffin and gas for heating and cooking. Paraffin (kerosene) and candles are the main sources of fuel for lighting.

2.2 OBJECTIVES

2.2.1 Global Objective

The global objective of the EMP is to strengthen the energy sector in Lesotho and thereby facilitate economic growth in the country, as well as increase electricity access to support socio-economic development.

2.2.2 Specific Objective

The specific objective of the EMP is a 20-year master plan for grid and off-grid electrification that includes a prioritised annual project schedule, as well as an action and investment plan, for adoption by Cabinet.

2.3 SCOPE OF THIS REPORT

This report provides an overview of the EMP development process and proposes an action and investment plan for implementation and roll-out of the EMP. Key issues to be considered during implementation are also highlighted.

3 CONTEXT FOR THE EMP

Over the past 15 years, LEC's customer base has increased from around 22,000 to over 200,000, with most of the more densely populated areas now having access to grid electricity. The 2016 Census indicated electricity access in Lesotho as 38%. Providing the remaining 62% of the population with an electricity supply can be expected to be progressively challenging in increasingly remote and poor communities.

Lesotho's national development objectives and the existing electricity sector structure guided the development of the EMP.

3.1 STRATEGIC GOALS AND DEVELOPMENT OBJECTIVES

Electrification planning is influenced by a multitude of considerations. In order to achieve consensus in developing the EMP, a Technical Working Group (TWG) comprising key stakeholder representatives was established to guide the process in terms of strategic goals, master planning objectives and key planning criteria.

Lesotho's national development objectives are clearly spelt out in Lesotho Vision 2020 and the National Strategic Development Plan (NSDP), and for EMP purposes include targets and guidelines directly related to electrification as well as sector objectives that would be enhanced by access to modern energy services.

Other policy documents that provided directives for electrification planning include the National Sustainable Energy Strategy (2017 draft), Lesotho Energy Policy (2015), the Electricity Sector Blueprint for Lesotho (2014 draft) and the Renewable Energy Policy (2013).

3.2 ELECTRICITY SECTOR STRUCTURE

The generation and delivery of electricity in Lesotho is dominated by two state-owned entities: the Lesotho Electricity Company (LEC) and the Lesotho Highlands Development Authority (LHDA).

3.2.1 Sector Governance, Policy and Planning

The Department of Energy (DoE) in the Ministry of Energy and Meteorology (MEM) is responsible for energy sector governance, policy and planning. The SEforALL-TAF initiative had recommended that the DoE be transformed into an Energy Commission with four departments (Fuels; Electricity; Policy / Planning; Services).

3.2.2 Electricity Regulation

Lesotho has a functioning regulatory system which is already managing the fundamental elements – the regulations for the players impacting on the sector, checking quality and sanctioning of non-compliance, quality guidelines for technologies and systems.

The Lesotho Electricity and Water Authority (LEWA) is mandated with regulating the electricity sector since 1st August 2004[3]. Established by the Lesotho Electricity Authority Act, 2002 (LEWA Act), LEWA is responsible to assure that there is a balance between profits made and the price paid for electricity and it independently deals with matters such as electricity pricing, complaints handling and resolution and the supervision of the implementation of the Quality of Service and Supply standards by its licensees. It must

[3] The Lesotho Electricity Authority (LEA) was established in 2002. In 2007 LEA was transformed into the LEWA, to act as a multi-sector regulatory body responsible for regulating electricity as well as urban water and sewerage services in the country. LEWA officially started regulating both sectors on 1st May 2013.

ensure there are no conflicts of interest and that there is transparency and non-discrimination not only for the day-to-day operational decisions but also for strategic investment decisions. LEWA gets funding from licensed electricity operators and a levy paid by electricity customers.

3.2.3 Power Generation and Import

LHDA is presently the primary generator of electricity through its 72-megawatt 'Muela Hydropower Plant, which is part of the Lesotho Highlands Water Project. LHDA sells 100% of the power generated at 'Muela to LEC. To make up for the supply deficit, LEC presently imports power from ESKOM in South Africa and EDM in Mozambique.

LEC also operates one diesel-hydro hybrid power plant at Semonkong that supplies electricity to the local isolated grid.

3.2.4 Transmission, Distribution and Supply

LEC is a state-owned electricity company responsible for the electricity networks and the electricity customer interface (connections, billing and payment). The electricity transmission and distribution networks comprise the main LEC assets.

In addition to the national grid and the Semonkong mini-grid, LEC also operates two isolated grids that are supplied cross-border from ESKOM in South Africa[4].

3.2.5 Electrification

The prime responsibility for electrification – both grid and off-grid – presently lies with the Rural Electrification Unit (REU), a project unit within the DoE that was never formally constituted as an institution and does not have a formal mandate. REU does not have off-grid electrification expertise and capacity, however, and solely focusses on grid electrification at present.

In the past, LEC also used to undertake electrification inside its service territory[5], a "*3.5 km buffer around the existing LEC distribution infrastructure*", and has connected some 180,000 new customers to the grid over the past 15 years. However, LEC no longer electrifies settlements from its own budget, but only implements electrification schemes proposed by REU and funded by GoL.

In order to clarify roles and separate responsibilities, the SEforALL-TAF initiative recommended that all grid-related projects and activities become the responsibility of LEC, while a new agency-like entity be established to take responsibility for and be focused on off-grid projects and activities. The skills and experience of the REU team would be absorbed into LEC, the new organization specifically set up for off-grid electrification, and/or the DoE.

The SEforALL-TAF initiative further recommended that an Energy Fund be established to consolidate all existing energy funds and accounts into a single fund, with one of its focal areas being access to energy in off-grid areas.

[4] Dilli-Dilli / Sixondo in Quthing and Ha-Sekake in Qacha's Neck.

[5] In 2000 the so-called Service Territory Study was carried out. Most of the commercially viable areas for electricity provision were in the Lowlands and some towns in the Highlands. Hence, the country was split into two areas. In one area electricity would be provided through a private company and the other area would depend on government supported energy services. The newly formed LEC was given the commercially viable service area and it was allowed to produce a Return on Investment (RoI).

3.3 ELECTRIFICATION STATUS

3.3.1 Access and Use of Energy in Lesotho

The 2016 census indicates that the country has a population of just over 2 million, 58% of which resided in rural areas in that year, 8% in peri-urban areas, and 34% in urban areas. Of the 537,457 households, 51.5% are in rural areas, 8.1% in peri-urban areas and 40.4% in urban areas. In terms of ecological zone location, 66.1% of households are in the lowlands, 8.8% in the foothills, 17.5% in the mountains and 7.7% in the Senqu River Valley.

The 2016 census found that 36% of all households are connected to the electricity grid, and 2% had a solar system. Of those with grid electricity, 21% are in rural areas, 12% in peri-urban areas and 67% in urban areas.

The most common form of energy used for cooking is wood fuel, with 65% of rural households, 33% of peri-urban households and 7% of urban households using this energy source (39% of all households on average). The second most common form of energy used for cooking is gas, which is mainly used by households in urban areas (49%) and peri-urban areas (33%), while only 14% of rural households use gas for cooking (30% of all households on average). Electricity as a cooking source is used by 27% of urban households, 19% of peri-urban households and 3 % of rural households.

The census does not provide information on whether, how much and for which productive purposes energy was used. The Consultant has, however, been able to source useful data in this regard from a private fuel-efficient stove manufacturer in Lesotho – African Clean Energy – who conducts before and after sales surveys among its target customers.

3.3.2 Grid Electrification

The present process for grid electrification involves REU receiving applications from schemes – a group of customers in the same area that wish to be connected to the gird and have started collecting connection fees – and evaluating these on the basis of number of customers in a scheme, distance from the grid and funds collected. REU annually applies for government funding to electrify these schemes, and once funding has been approved, allocates this to the various schemes in priority order.

REU then forwards the approved schemes to LEC for construction, in terms of an MOU between REU and LEC. LEC procures contractors to build the networks, and REU monitors progress during the construction period. Once completed, LEC takes over operation and maintenance of the schemes, including sale of electricity.

3.3.3 Off-Grid Electrification

Despite this being its responsibility, REU has not undertaken any off-grid electrification, partly because the unit is inexperienced and under-resourced for this purpose. A UNDP-GEF supported solar home system programme between 2007-2013 has not been implemented effectively, with the result that beneficiaries have a poor perception of this technology. A new approach to off-grid electrification is needed, with recommendation by the SEforALL-TAF initiative to establish a dedicated agency for this purpose.

3.3.4 Cost of Electrification

The SEforALL-TAF initiative has calculated that it will cost 1.8 BUSD to reach the GoL's target of 55% energy access by 2030 through grid electrification, while the same goal can be reached by off-grid solutions at a much lower cost of around 140 MUSD.

3.4 SCOPE OF THE EMP

The departure point for the development of this EMP was the 2006 NEMP, as well as the 2017 recommendations of the SEforALL-TAF initiative. The SEforALL-TAF initiative identified the need for a new EMP**,** rather than an update to the 2006 NEMP, for three reasons: a) the data used in the 2006 study is out-dated; b) the period of its projection (to 2020) is close to being completed; c) the much-improved cost and reliability of off-grid electricity solutions warrants the inclusion of a study that fully considers their use for the large number of dispersed rural households.

The DoE has confirmed during the inception phase that the electrification planning under the EMP shall be in terms of the 'grid' and 'off-grid' classification, rather than 'urban' and 'rural' and that off-grid electrification shall consider, where appropriate:

- mini-grids and micro-grids for settlements;
- diesel-renewable hybrid systems;
- stand-alone solar PV electricity systems for households, businesses and public institutions; and
- Tier 1 solar systems for basic lighting and phone charging for low income households.

DoE has further confirmed that

- Grid-connected power generation shall not form part of the EMP as this is taken care of by a separate generation master plan; and
- Non-electric thermal energy solutions (e.g. LPG appliances, improved wood stoves, solar water heaters, biogas systems) do not form part of the EMP scope.

During the Inception Phase it was motivated and agreed that a Technical Working Group be established to enable consensus decisions in developing the EMP, and that the EMP should be GIS-based.

3.4.1 Technical Working Group

The tight timeframe of the master planning process did not allow for comprehensive stakeholder consultation by way of workshops. It was therefore motivated and agreed that a Technical Working Group (TWG) be established, composed of representatives from various key stakeholders including: DoE, LEWA, LEC, REU, the planning division of the Ministry of Energy and Meteorology, the Ministry of Development Planning, LNDC and TED (civil society organisation). The TWG was chaired by DoE, with the Consultant serving as secretariat in a coordinating role.

The TWG met once a week to discuss matters pertaining to the development of the EMP, such as

- Definition of grid and off-grid areas
- Planning criteria and technical standards for grid and off-grid electrification
- Project prioritisation criteria
- Off-grid electrification standard systems and costs
- Electrification funding
- Off-grid electricity service delivery models

This ensured regular stakeholder consultation and alignment of approaches in meeting the outcomes in the short timeframe.

3.4.2 GIS Planning

Modern infrastructure master plans are nowadays captured and developed in a geographic information system (GIS) to enable accurate spatial planning, efficient analysis and sharing of information, and visual display of the status of infrastructure roll-out.

It was found during the Inception Phase that much of the essential information and data required for developing the EMP as a GIS planning tool is available for Lesotho. Also, LEC has already embarked on the GIS route for network planning and analysis, by capturing the transmission network in GIS, and the distribution network is presently being captured too.

It was therefore motivated and agreed that GIS is brought into the EMP development process, to enhance not only the value of the master plan but the planning environment for the energy sector as a whole, benefitting DoE, LEWA, LEC, REU and the planning division of the Ministry of Energy and Meteorology.

4 EMP DEVELOPMENT METHODOLOGY

The development of the EMP followed a structured methodology that was agreed during the Inception Phase, as follows:

4.1 SOCIO-ECONOMIC ANALYSIS

The socio-economic analysis served as a key input to the grid and off-grid planning. The analysis reviewed population demographics and trends based on previous and current census data. The analysis further assessed likely changes over the coming 15-year period based on information from the past 10-20 years such as GDP forecasts, job creation and other matters that influence demand for and ability to pay for electricity. It also assessed current use of and expenditure on energy and, where possible, mapped ability and willingness to pay.

The focus of the analysis was the assessment of social and economic conditions of un-electrified areas to enable estimation of the present and future electricity demand, keeping in mind affordability, willingness to pay, potential productive uses of electricity, and population growth.

The results of this analysis are captured in a separate *Socio-Economic Analysis Report*.

4.2 DEMAND ANALYSIS AND FORECAST

This analysis reviewed existing demand studies and projections, and analysed the effect of electrification on demand over the past 17 years, to enable load forecasting for the EMP. Socio-economic growth sectors for which data is available were included. Historical data on losses and load factor, where available, were reviewed to predict changes up to 2030.

For the demand analysis, the entire country was divided into load zones, based on the census Enumerator Areas (EAs). A load zone is defined by the number of connections (both existing and potential), per customer category. Prediction of future connections and electricity demand considered the effect of population migration and economic growth.

A diversified demand was calculated for each load zone and summed up to feeder and substation level. This was then calibrated against the existing demand before the future demand was determined which informed the additional future loading of existing upstream networks and substations. This in turn determined the need for upstream network reinforcement.

The results of this analysis are captured in a separate *Demand Analysis Report.*

4.3 ECONOMIC PRIORITISATION

In order to objectively prioritise the various electrification projects and rank them in priority order, the Consultant developed an Excel-based prioritisation algorithm in consultation with the TWG. The key indicators built into the prioritisation algorithm include:

- Road access
- Distance to the closest grid
- Number of potential household customers
- Number and type of public buildings (health facilities, police stations, agricultural centres, etc.)
- Evidence of income generation potential
- Weighting factors that give expression to the national development objectives

The scoring criteria were applied to each of the identified projects, yielding a prioritised ranking score for each project. These results then fed into the financial model to determine the priority order based on cost efficiency.

The prioritisation algorithm allows for promoting specific projects up the ranking order, for compelling reasons (political, business, economic, social or environmental) that the algorithm does not cater for. The criteria for and extent of allowing such promotions were debated and agreed within the TWG as follows: the combined capital cost of such projects to be promoted manually must not exceed 10% of the allocated budget within a given year.

The prioritisation algorithm and methodology are described in the Annex to this report.

4.4 FINANCIAL ANALYSIS

A financial model was developed in Excel to determine the financial viability of those projects that score highest in the prioritisation algorithm.

The financial analysis further reveals the impact of the projects on the financial situation of the implementing entity or operator, as opposed to the economic prioritisation analysis which considers national and sector-specific development objectives. In the case of grid projects, the owner / operator is LEC. For off-grid projects the operator / owner could be the (still-to-be-established) off-grid agency (OGA), a private operator or a community / cooperative entity.

A 20-year cash flow analysis of the highest priority projects in each district and nationally was undertaken, resulting in two financial indicators for each project, namely financial net present value (FNPV) and levelised cost of energy (LCOE). Where there are positive cash flows, the financial internal rate of return (FIRR) reflects the return actually achieved by the project. With the exception of the smallest off-grid systems, no projects have shown any profitability. Grants of between 40% and 60% of the project cost in average will be necessary for the project owners / developers in order to implement them under satisfactory conditions.

The inputs to the financial analysis include consumption by customer category, take-up rate of new connections, capital costs of connection, revenue, service delivery costs (including operation and maintenance costs), and discount rate. These were discussed and agreed within the TWG.

The results of the financial analysis are incorporated in the *Grid Development Plan* and *Off-Grid Master Plan* reports.

4.5 GRID DEVELOPMENT PLANNING

The development of the grid electrification master plan assessed the loading of existing networks in order to optimise how network extensions are carried out in the most economical way. LEC's network expansion and reinforcement plan was reviewed, and GIS mapping was used to conceptually plan network expansion, and to undertake spatial analysis of planning zones.

Load flow studies were done in DigSilent to comparatively analyse alternative planning zone scenarios, determine network reinforcement requirements, and identify optimisation options. Investment requirements were evaluated, categorised and quantified, based on historical data, existing development plans, planned investments, economic and demographic projections.

The grid planning results and prioritised annual grid project schedules are captured in the separate *Grid Development Plan Report*.

4.6 OFF-GRID ELECTRIFICATION PLANNING

The off-grid master plan takes account of national development objectives, recommendations of the SEforALL-TAF initiative and current thinking among key stakeholders about off-grid electrification, the criteria for which were discussed and agreed in the TWG.

The off-grid electrification master plan focuses on solar PV technology, because Lesotho has a high availability, abundance and uniformity of solar resource (GHI levels range between 5.4-5.6kWh/m^2 day). Except where identified potential for mini-grid application exists, hydro and wind technology is not considered as their application is very site specific and often prone to unpredictable intermittency due to weather patterns and seasonality.

The first step in the planning process involved the identification of off-grid areas – areas that will not be reached by the grid within the medium term – using the prioritisation algorithm and GIS. Previously identified mini-grid sites were assessed and the selection refined to a list of 14 projects that this EMP caters for. All other off-grid areas are to be served by solar PV stand-alone solutions of various types and capacities.

Five typical standard stand-alone solar PV systems were agreed upon in the TWG, catering for the energy needs and affordabilities of different income groups as represented by the housing types of the 2016 census. A typical distribution of these systems among the different housing types was also agreed upon in the TWG.

The results of the prioritisation – a ranking order of off-grid projects – informs opportunities for optimisation of high-priority candidates, in an iterative process with the financial analysis, to ultimately yield a prioritised off-grid energy roll-out plan, as is captured in the separate *Off-Grid Master Plan Report*.

4.7 FINAL ELABORATION, INCLUDING ACTION & INVESTMENT PLAN

The EMP comprises of the following components:

- Socio-Economic Analysis Report
- Demand Analysis Report
- Prioritisation Algorithm (in MS Excel)
- Financial Model (in MS Excel)
- Grid Development Plan Report, including a prioritised schedule of grid projects and an annual roll-out plan in accordance with the available budget
- Off-Grid Master Plan Report, including a prioritised schedule of off-grid projects and an annual roll-out plan in accordance with the available budget
- This Action & Investment Plan Report.

The Action & Investment Plan specifies Government actions and makes recommendations on the implementation of the EMP in the following chapters.

5 ACTION PLAN FOR IMPLEMENTATION OF THE EMP

Roll-out of the electrification programme as per EMP requires careful planning and consideration of various issues to overcome specific barriers to implementation.

Some of the key success factors to be addressed in this regard are described below.

5.1 TASK 1: ADOPTION OF THE EMP BY GOVERNMENT

It is important that there is demonstrated commitment to implementing the EMP, in order for it to become a powerful development facilitation tool for Lesotho. Commitment to the EMP means that the prioritised roll-out plan is followed as far as possible, which in turn provides certainty for stakeholders and enables a more coherent and effective development effort.

While an electricity connection or off-grid system enhances people's quality of life on household level in many ways, access to electricity also enables broader development objectives to be achieved, such as poverty alleviation, promoting productive activities and income generation, better healthcare and education, mitigation of ecological degradation and rural-urban migration, etc.

When the EMP is adopted by Government, then its implementation can be considered in a multitude of development programs and policy positions that aim to promote better conditions for the people of Lesotho.

5.1.1 Commitment to EMP Roll-Out

Once the EMP has been adopted, it is important that there is commitment to following the prioritised roll-out schedules as far as possible. This will create certainty for beneficiaries, as well as for other development efforts that are planned in accordance with the EMP schedules.

Deviations from the EMP – for example: because of prioritising certain projects for political reasons – should be kept to a minimum as these could have the consequence of changing the priority order of projects and may require recalibration of the roll-out schedules. It is important that there is transparency in this regard and that stakeholders are adequately informed of any deviations because these may affect their own planning.

5.1.2 Embrace Off-Grid

It is very important that Government accepts the significant contribution that off-grid electrification makes to the overall electrification effort and embraces this as a valuable stepping stone towards achieving universal electricity access and community upliftment in the shortest possible time. Off-grid electrification is supportive of Lesotho's draft *Sustainable Energy Strategy* goal of 75% electricity access by 2022 and the *Sustainable Development Goals*' target of universal access by 2030.

Off-grid electricity solutions are very affordable in comparison with grid electrification and offer better quality lighting than traditional energy sources. Off-grid electricity systems can also enable productive activities that are hitherto unassailable in remote areas. These qualities have the potential to enable a rapid transition from traditional energy use to more cost-effective, better quality and more sustainable energy application, and significantly enhance the quality of life of poor people.

It is furthermore important for Government to understand that embracing off-grid as an integral part of the electrification effort does not prevent or exclude grid electrification, which will continue in parallel. Together, these two electrification streams bring benefit to Basotho citizens in a far shorter timeframe than grid electrification alone can achieve.

The grid electrification effort will continue even beyond the time when universal access has been achieved (ie when all Basotho households have some form of electricity use), to also connect customers that have benefited from off-grid systems before.

Off-grid solutions mean that unelectrified households do not have to wait many years for the grid to arrive but can enjoy some form of electricity access in the meantime.

For many communities, especially those in remote parts of the country, it is not about a decision between grid and off-grid electricity, but between having some form of electricity (which may be basic like a solar lantern, or more sophisticated like a solar home system) and no electricity at all until the grid arrives.

5.2 TASK 2: CREATE AWARENESS ABOUT THE EMP

Once the EMP has been adopted, DoE needs to ensure that this is widely publicised so that its implementation can be considered in all spheres where it is likely to have an impact.

At policy level, government departments need to be aware of the broad roll-out schedule that includes pace and location, to direct other development efforts in those areas in the relevant years of EMP implementation. Involving Parliament and the Senate is important in creating broad awareness and sensitising politicians about the developmental benefits of electrification and how to achieve universal access fast.

At planning level, stakeholders need to be equally aware of the annual roll-out schedules to enable them to plan their investments accordingly. The regulator, local government structures and NGOs also play an important role in ensuring good governance during the implementation of the electrification programme by following the prioritised schedules, for the benefit of rural communities.

At operational level, LEC needs to plan for upgrading of transmission networks and substations in good time to cater for the additional load that electrification will contribute to the national demand. Similarly, private sector off-grid service providers need to plan for recruitment of customers, equipment purchases, and establishing their service and maintenance infrastructure.

At beneficiary level, potential customers need to know when the grid arrives in their area to enable them to decide whether to wait for this or invest in an off-grid system in the meantime.

The importance of Government commitment to the EMP as the guiding mechanism for electrification roll-out is again emphasised, as this creates certainty for all stakeholders and enables a more coherent and effective development effort.

5.3 TASK 3: CREATE REGULATORY CERTAINTY

LEC needs to have clarity about their obligations in serving electrification customers whose connection to the grid will mean escalating expenses for the utility as the load density decreases in remote areas. The present tariff regime is not supportive of the increasing capital and operational costs and the issue of where the money comes from to pay for this shortfall needs to be addressed with urgency.

Electricity tariffs should ideally be cost-reflective. This is not the case in Lesotho at present, with electricity revenue alone not being able to meet the costs of providing the service and subsidisation being necessary. While Government might wish to keep tariffs low and affordable, there needs to be clarity about where the shortfall comes from.

The EMP recommends and assumes active engagement and participation of private-sector service providers in the roll-out of the electrification plan, primarily for the provision of off-grid electricity systems and services. For such private-sector actors to provide meaningful and effective services and investments there needs to be regulatory certainty and transparency. In this regard Government needs to champion and drive the urgent establishment of a suitable regulatory framework that encourages private-sector investment in mini-grids and off-grid systems and services, with clear market rules and requirements. Key issues to be addressed include off-grid tariffs (whether these are to be regulated or not) and investment certainty (eg rules about what happens when the grid arrives).

*The **recommended market mechanism** for off-grid electricity supply hinges on three key elements, namely:*

- ✓ ***Beneficiary choice of system**: Similar to the mobile phone market, the decision of what off-grid system to purchase needs to be that of the user, and not be imposed by the implementing agency or service provider. Choice of system is determined by user preferences and affordability.*
- ✓ ***Private-sector driven**: Marketing, supply, delivery, installation and maintenance of off-grid electricity systems, components and services should be left to private-sector service providers so that a viable commercial market may have a chance to develop in Lesotho. If Government embraces off-grid electrification as recommended in this EMP there is a sizeable market to be served.*
- ✓ ***Enabled by revolving fund**: Making affordable and easily accessible credit available to beneficiaries (users) for acquiring off-grid electricity solutions is a most effective way of enabling a commercial off-grid market in Lesotho. A revolving fund as recommended is one such mechanism that provides affordable financing terms for users and de-risks projects by improving supplier cash-flow. Expecting users to purchase their systems and appliances at market prices (rather than reducing their capital costs through subsidies) creates a sense of ownership that enhances market viability. And since the loans are repaid – albeit possibly with low interest and over extended terms that make them affordable for poor rural households – the fund is replenished continually and can benefit new applicants over many years.*

5.4 TASK 4: CREATE AN ENABLING ENVIRONMENT FOR OFF-GRID

With off-grid electrification being a key focus of the EMP, and little existing experience in this regard in Lesotho, there is need to put effort into creating an enabling environment for it to take off and flourish. It is strongly recommended that development of the off-grid market centres on private sector engagement and participation, with Government facilitating this through

a. harmonising grid and off-grid electrification approaches;
b. focused off-grid efforts;
c. appropriate policies and directives;

d. awareness creation;
e. promotion of quality standards for off-grid systems, equipment and appliances;
f. placing emphasis on after-sales service for off-grid systems, equipment and appliances; and
g. enabling access to affordable financing for end users, which a specific revolving fund for this purpose, as previously proposed, could provide.

5.4.1 Harmonising Grid and Off-Grid Electrification Approaches

Grid and off-grid electrification need to be treated in the same way for the electrification effort to be effective, and for the two approaches to be complementary rather than in competition with each other. Ideally, customers should be able to choose from a range of electricity service options that include grid connection and various off-grid systems. In areas that are far from the existing power network a grid connection will hardly be an option as the cost will be prohibitively high, but in areas that are closer to the power network some communities will be able to afford a grid connection while others will still opt for the more affordable off-grid solutions.

While the grid will be extended in accordance with the prioritised schedules of the *Grid Development Plan*, within the annual budget allocation for this purpose, it is recommended that such network extension is limited to the medium voltage backbone networks including stepdown transformers, but excludes the low voltage networks and customer connections, the cost of which is to be borne by the customers through a standard connection fee[6]. In this way grid and off-grid options are comparable on an equal footing, with customers paying the actual capital cost of connection.

Capital subsidies should be avoided as they distort the market and discourage private sector investment.

The 'scheme approach'[7] that has been in practice in grid electrification for a number of years also has relevance on the off-grid side and can be adapted for an integrated electrification approach that incorporates the proposed revolving fund as the enabling market mechanism. Groups of interested parties (households and businesses) from a community apply to the revolving fund for a loan to pay for their connection fees (if a grid scheme) or system costs (if an off-grid scheme) and pay the relevant deposit. If approved, the revolving fund pays the costs[8] directly to the service provider – LEC on the grid side and a certified private-sector company on the off-grid side – and the scheme group will repay the loan over a period of time. Dealing with scheme groups rather than individuals has advantages for both the revolving fund and implementing agencies (LEC or private sector companies) in that the viability of transactions is increased through higher quantities (of connections/systems) and a reduced administrative burden per customer served.

[6] The connection fee needs to reflect the average cost per connection, with all potential customers connected. It could be determined separately for each project or village at the time of detailed planning but could also be calculated as a uniform national average.

[7] A community that wishes to be grid-electrified applies to the REU as a group and pays a deposit. Once REU has evaluated – in terms of customer numbers, distance from the grid and deposit funds collected – and approved the application, the scheme is scheduled for electrification, with the balance of funding required for the scheme coming from the Universal Access Fund.

[8] The pay-out would typically be distributed over several instalments, e.g. an up-front mobilisation disbursement, a further disbursement upon delivery of materials or systems, and a final disbursement upon verification of project completion.

5.4.2 Off-Grid Focus and Coordination

The DoE is saddled with the responsibility of coordinating the electrification efforts in Lesotho. The Rural Electrification Unit (REU) of the DoE presently manages grid electrification efforts only and has no capacity to deal with off-grid issues. There is urgent need to establish such capacity, for example by transforming the REU into a mandated agency as per TAF SEforALL recommendation ("*the formation of an Agency-like Entity that shall take care of energy solutions in off-grid areas*").

Such an agency must have a clear mandate to facilitate and coordinate off-grid electrification, by guiding and monitoring private sector companies in their efforts to develop mini-grids and supply/install stand-alone solar PV systems in accordance with the EMP and the regulatory requirements. This agency should not be tasked to undertake off-grid electrification in its own name.

5.4.3 Off-Grid Policies and Directives

Government needs to put in place specific policies and directives that focus on off-grid electrification, in order to facilitate an enabling environment. This could be in the form of off-grid electrification targets and incentives, rules and regulations for off-grid service providers, certification of off-grid service providers to be eligible for government incentives, etc.

5.4.4 Off-Grid Awareness Creation

Creating proper awareness and understanding of off-grid energy solutions is a critical ingredient for the success of any off-grid programme. It is recommended that the DOE embarks on an effective awareness campaign in this regard, as soon as possible, to better prepare the market that is already emerging. Such an awareness campaign should have an initial term of not less than 12 months and may include the following elements, among others:

- Dissemination of information brochures in local language(s).
- Regular radio and TV infomercials about the uses, benefits and limitations of off-grid systems.
- Regular radio programs dealing with off-grid issues, such as quality and cost, service levels, maintenance and after-sales service, financing options, etc.
- Billboard advertising.

5.4.5 Quality Standards for Off-Grid Electrification

The promotion of quality standards for off-grid systems, equipment and appliances is an essential mechanism to ensure that the EMP is rolled out sustainably.

There is a vast range of off-grid products of various types, sizes, prices, technologies and applications available in the market, but not all these products are of sufficient quality to satisfy customers' needs and ensure that off-grid solutions are perceived as a sustainable energy source. Low-cost products with poor performance and short life expectancy potentially spoil the market which is severely counter-productive to national endeavours that aim to bring affordable energy solutions to remote poor communities. It also negates the considerable benefit that good-quality systems offer.

The off-grid agency should be tasked with ensuring that quality issues are mitigated in Lesotho, which could typically be achieved through

a. product warranties;
b. product certification and labelling;
c. awareness creation; and

d. good after-sales and maintenance service.

There are also international quality assurance programmes such as “Lighting Global” that list off-grid lighting products that are compliant with minimum quality standards to provide the user with some level of assurance about the product that is being purchased.

Awareness creation and after-sales service and maintenance issues could possibly be dealt with effectively by local ‘energy shops’ where users can purchase systems, equipment and appliances, receive advice and guidance on their use and installation, and have failing components repaired or replaced. For such energy shops to be sustainable however, there needs to be a significant market for them to serve which may be a challenge in Lesotho with its low population density in the Highlands and Senqu River Valley.

5.4.6 Maintenance and After-Sales Service

Maintenance and after-sales service of off-grid systems are often underestimated in terms of costs and effort required. A recurring issue with off-grid systems is the absence for the user of an after-sales scheme when there is a system failure or query.

The establishment of a viable distribution and servicing infrastructure – including guarantee of replacement of the components reaching the end of their lifecycle – is one of the most crucial aspects in the deployment chain for stand-alone systems.

Furthermore, users should not have to travel long distances at great expense to access after-sales and maintenance services.

5.4.7 Revolving Fund for Electrification

A revolving fund for electrification, as per TAF SE4All recommendation ("*Financing mechanism for Rural Energy Access within an Energy Fund*"), can be a catalyst for enabling faster roll-out of the master plan, by providing loans for electrification that will be repaid over time – in this way the fund remains accessible to future applicants on a revolving basis.

As explained in Section 5.4.1 above the revolving fund should cater for both grid and off-grid electrification in a harmonised way, by

a. providing affordable financing terms for beneficiaries (prospective LEC customers on the grid side, and system buyers/users on the off-grid side), with low interest rates and lenient repayment terms;
b. enhancing the cash-flow of LEC and off-grid system suppliers (which is a major barrier); and thereby
c. de-risking private sector participation on the off-grid side as suppliers are not burdened with having to arrange or provide the financing.

The revolving electrification fund could be housed within an institution specifically established for this purpose, or it could be incorporated in a broader energy fund institution that also deals with other energy funds (such as petroleum). It is recommended that the functions of the fund institution are focused on policy implementation and overall coordination and management of the various instruments, and that practical functions such as evaluation of loan applications, fund disbursement and collection of payments is outsourced to an established financial institution (eg a bank) with branches in all parts of the country. LEC and the OGA will collaborate closely with the responsible fund institution in coordinating the efficient roll-out of the master plan.

The revolving fund is initially set up and resourced by Government (e.g. from the annual budget allocation, or as a once-off capital injection), with specific budgets for grid and off-grid electrification as per allocation decided by Government. These budgets may be

supplemented with funds from other sources, for example development partners or the Universal Access Fund.

The concept for off-grid schemes specifically is as follows:

- The fund only supports pre-qualified system suppliers who offer quality systems **and** after-sales service.
- Scheme groups determine their system needs (based on clear information about the systems on offer) and preferred system suppliers. These groups collect deposit monies from their members.
- Once the full deposit funds have been collected, the group applies to the revolving fund for financing.
- The revolving fund consults with the OGA to confirm that the scheme is within an off-grid area.
- If approved, the revolving fund will pay a portion of the costs (e.g. 50%) to the preferred system supplier.
- The system supplier orders the systems and delivers/installs them.
- Once the systems have been delivered/installed and verified, the revolving fund will pay the balance to the system supplier.
- The group will collect instalments from its members and repay these to the fund on a regular basis. The off-grid agency could assist with this process, if required.
- The system supplier will provide after-sales service and maintenance support to the group.
- As the loans are repaid the revolving fund is replenished and can cater for new applicants.

The concept for grid schemes specifically is similar:

- The fund only supports contractors who are pre-qualified by LEC to provide grid electrification services (LV network construction and service connections).
- Scheme groups determine their grid electrification needs (number of customers to be connected) and apply to LEC for grid connection.
- LEC confirms that the scheme is within a grid area, determines the requirements and costs for network extension, designates a prequalified contractor to undertake the work, and informs the scheme group who now collect deposit monies from their members.
- Once the full deposit funds have been collected, the group applies to the revolving fund for financing.
- If approved, the revolving fund will pay a portion of the costs (e.g. 50%) to the designated contractor.
- The contractor orders the materials and constructs the network.
- Once the network has been constructed and all connections installed and verified, the revolving fund will pay the balance to the contractor.
- The group will collect instalments from its members and repay these to the fund on a regular basis. LEC could assist with this process, if required.
- LEC will sell electricity to the group and maintain the network.
- As the loans are repaid the revolving fund is replenished and can cater for new applicants.

5.5 TASK 5: ACCELERATE ACCESS TO ELECTRICITY

Access to electricity stood at 38.5% in 2017, representing about 207,000 households, which leaves approximately 330,000 households to be electrified at this stage. With an annual investment of M150 million – of which 80% is going towards grid electrification and only 20% towards off-grid solutions – and an estimated population growth rate of 1.04% per annum, it will take 24 years for Lesotho to provide universal access to electricity for all its citizens.

This timeframe could be considerably shortened if there was greater focus on lower-cost off-grid solutions, by directing a larger portion of the available budget towards off-grid solutions over a short period of time (3-5 years, depending on the off-grid budget allocation). The following approach is proposed for consideration:

1. Set a target date, through a policy directive, for Lesotho to reach universal access to electricity.
    a. Universal access in this sense means that all households have access to some form of electricity which may be very simple – as in the case of a solar lantern – yet mean a huge improvement in quality of life for poor households.
    b. The lower the service level, the sooner the target can be reached. If Government opts for rolling out solar lanterns as a first step in the electrification programme, a large number of households can benefit in a very short time and the target will be reachable within 2-3 years.
    c. Lesotho can then claim universal access to electricity which significantly contributes towards achievement of the SDGs.
2. Establish capacity and a mandate for dealing with the off-grid electrification program as described in subsection 5.4.2 above.
3. Increase the off-grid budget allocation such that the target can be achieved.
    a. This will require determination of an appropriate mix of off-grid systems that provide various service levels at corresponding cost (i.e. low service level = low cost, high service level = higher cost).
    b. Budget allocation for grid electrification will need to be reduced significantly, for a period of time.
4. Establish a revolving fund for electrification specifically as described in subsection 5.4.7 above.
5. Once the universal access target has been reached, the electrification programme will continue with the aim of increasing service levels.
    a. The grid electrification programme will continue, possibly with an increased budget.
    b. Households that have benefited from simple off-grid systems will have the opportunity to upgrade to higher-service-level systems in accordance with what they can afford.

GRID ELECTRIFICATION WILL NOT BE CROWDED OUT BY OFF-GRID SOLUTIONS

A sensible approach towards achieving universal access sooner is a higher budget allocation for off-grid initially, say for the first 3-5 years. This will accelerate the electrification roll-out and result in the great majority of unelectrified households in Lesotho being provided with an electricity service already in the next few years.

Grid electrification will continue during that period too, albeit at a slower pace. Once the desired access target has been reached by off-grid solutions, the grid electrification pace will be accelerated again with a higher budget allocation and continue for as long as necessary.

An added benefit of initially focussing on off-grid solutions is mitigation of rural-urban migration, particularly when incentives are put in place for enhancing productive use of electricity and income generation. A further benefit is mitigation of ecological degradation as reliance on fuelwood and other biomass resources decreases.

5.6 TASK 6: ADOPT APPROPRIATE GRID STANDARDS FOR LOW-LOAD RURAL AREAS

Grid electrification is progressing into more remote areas that are sparsely populated, mostly by poorer communities. Applying the same technical standards for the grid networks as in high density high demand areas, therefore, would mean an 'overkill' that puts a severe strain on limited financial resources.

It is recommended that LEC reviews their technical standards for remote areas and considers alternative approaches that could include 'light' networks (such as single wire earth return systems) and 'light' customer connections without a costly meter (such as load-limited supplies). To enable instant benefit, 'readyboards' can be installed to avoid customers having to invest in expensive house-wiring.

5.7 TASK 7: SOLICITATION OF ADDITIONAL FUNDING

The EMP, once adopted as the guiding mechanism for rolling out the electrification program, offers the opportunity for Government to solicit funding from development partners and possibly reduce the burden on the fiscus.

Development partners are often eager to fund marginal projects that improve the livelihoods of poor communities, provide broader developmental benefits (like poverty alleviation, improved health care services, etc), promote productive activities and income generation, and address gender issues.

6 INVESTMENT PLAN FOR THE EMP

The primary outcome from the master planning exercise is the prioritised lists of grid and off-grid electrification projects. These are to be implemented in ranking order, starting with the highest priority projects – those at the top of each list – which give the most benefit (i.e. highest number of connections) for the least cost.

If projects lower down on the priority list are brought forward for reasons other than cost-benefit (for example: special development factors that were not known at master planning stage, or political reasons), the projects lower down will simply move up to fill the void left by those projects brought forward; the ranking order of the lists is not affected by such a move.

6.1 ELECTRIFICATION BUDGET

The pace of electrification is determined by the available budget for this purpose but will also depend on the speed with which new structures can be established to facilitate private sector interest (and investment) in rolling out the master plan. This is particularly relevant on the off-grid side where little capacity and experience exists at this stage, while grid electrification is well established in Lesotho.

The prioritised EMP project lists are based on two key budget assumptions, namely:

- A sustained annual electrification budget of M150 million, based on the current level of government budget allocation for this purpose, and
- An 80% / 20% split of the available budget between grid and off-grid electrification, as decreed as by the Ministry of Energy and Meteorology (MEM), yielding M120 million per year available for grid electrification and M30 million per year for off-grid electrification.

This will result in an average of 7 756 grid connections (at an average cost of M15,000 per connection) and 10 364 off-grid connections (at an average cost M2,646 per connection/system) being provided each year, yielding 362 407 connections over 20 years at a total cost M 2.88 billion, as per Table 1 below.

Table 1: Investment and Connection Summary[9]

	Grid	Off-Grid	TOTAL
Annual Electrification Budget	M 120 million	M 30 million	M 150 million
Average Annual Connections	7,756	10,364	18,120
Total Investment over 20 years	M 2.33 billion	M 547 million	M 2.88 billion
Total Connections over 20 years	155,127	207,280	362,407
Average cost per connection	15,000	2,646	8,823
Number of EAs electrified	1,399	2,143	3,542

Table 2 below summarises the annual electrification schedule by number of EAs electrified, number of connections provided and electrification investment. Further detail is included in the *Grid Development Plan* and the *Off-Grid Master Plan* reports. The results indicate that, with the present budget allocation and split, 80% of the total investment only provides 42% of the connections (on the grid side), while 20% of the investment provides 58% of the connections/systems (on the off-grid side).

[9] This assumes that the entire budget is dedicated to providing the connections and that the cost of establishing the proposed structures and mechanisms required for implementation of the EMP as per Action Plan are over and above.

Table 2: Annual Electrification Roll-Out Summary

Implementation Year	Number of EAs Electrified			Number of Connections Provided			Electrification Investment [Maloti]		
	Grid	Off-Grid	***TOTAL***	Grid	Off-Grid	***TOTAL***	Grid	Off-Grid	TOTAL
Year 1	70	106	***176***	7 932	10 692	***18 624***	118 980 000	25 379 000	***144 359 000***
Year 2	72	100	***172***	8 054	10 452	***18 506***	120 810 000	25 492 400	***146 302 400***
Year 3	76	95	***171***	7 987	10 606	***18 593***	119 805 000	25 501 800	***145 306 800***
Year 4	77	92	***169***	7 975	10 609	***18 584***	119 625 000	25 362 400	***144 987 400***
Year 5	74	92	***166***	8 002	10 509	***18 511***	120 030 000	26 202 400	***146 232 400***
Year 6	64	113	***177***	7 971	10 611	***18 582***	119 565 000	24 849 600	***144 414 600***
Year 7	65	117	***182***	8 072	10 848	***18 920***	121 080 000	25 213 800	***146 293 800***
Year 8	66	87	***153***	7 920	10 587	***18 507***	118 800 000	25 344 800	***144 144 800***
Year 9	68	77	***145***	8 024	10 454	***18 478***	120 360 000	25 434 600	***145 794 600***
Year 10	79	98	***177***	7 957	10 938	***18 895***	119 355 000	25 635 000	***144 990 000***
Year 11	81	104	***185***	8 096	10 976	***19 072***	121 440 000	25 308 800	***146 748 800***
Year 12	74	97	***171***	8 003	10 962	***18 965***	120 045 000	25 515 800	***145 560 800***
Year 13	72	103	***175***	7 953	10 974	***18 927***	119 275 000	25 734 000	***145 009 000***
Year 14	74	107	***181***	8 004	10 762	***18 766***	120 060 000	25 476 000	***145 536 000***
Year 15	75	91	***166***	8 045	10 719	***18 764***	120 675 000	25 563 000	***146 238 000***
Year 16	71	116	***187***	7 974	10 610	***18 584***	119 610 000	25 322 800	***144 932 800***
Year 17	72	96	***168***	7 946	10 567	***18 513***	119 190 000	25 485 200	***144 675 200***
Year 18	71	95	***166***	8 053	10 605	***18 658***	120 795 000	25 742 400	***146 537 400***
Year 19	72	117	***189***	8 014	10 416	***18 430***	120 210 000	25 309 000	***145 519 000***
Year 20	26	103	***129***	3 145	10 406	***13 551***	47 175 000	25 490 200	***72 665 200***
TOTAL	**1 399**	**2 006**	***3 405***	**155 127**	**213 303**	**368 430**	**2 326 885 000**	**509 363 000**	**2 836 248 000**
	41%	59%		42%	58%		80%	20%	

6.2 BUDGETING FOR EMP IMPLEMENTATION FACILITATION

Implementing the EMP in terms of the Action Plan described in Section 5 above requires a budget for establishing and maintaining the proposed facilitation structures and mechanisms to cover the possible cost elements as summarised in the table below. Please note that the costs are indicative only and will need to be determined more accurately.

Table 3: Indicative Costs of Facilitating EMP Implementation

Action Plan Task	Possible Cost Elements	Indicative Budget
Once-Off Costs		
Task 1: EMP Adoption	***Consultancy services*** related to ▪ Drafting a white paper on electrification ▪ Extending the energy policy to include electrification targets (e.g. an electrification strategy)	M 1.5 million
Task 2: Awareness Creation	***Awareness campaign***	M 4 million
Task 3: Establish Regulatory Certainty	***Consultancy services*** related to ▪ Establishing electrification market rules ▪ Assessing pros and cons of off-grid tariffs	M 3 million
Task 4: Create Enabling Environment	***Consultancy services*** related to ▪ Harmonising grid and off-grid electrification approaches ▪ Establishing the proposed off-grid agency ▪ Establishing and promoting quality standards for off-grid systems, equipment and appliance ▪ Establishing eligibility criteria (and a monitoring & evaluation system) for off-grid service providers that may participate in revolving fund electrification roll-out ▪ Procurement of eligible service providers ▪ Establishing the revolving fund for electrification roll-out	M 10 million
	Establishing the off-grid agency ▪ Transaction costs (e.g. integrating REU into LEC or transforming it into OGA) ▪ Recruitment of staff ▪ Establishing systems and procedures ▪ Capacity building	M 5 million
	Establishing the revolving fund for electrification ▪ Transaction costs (e.g. establishing the electrification fund within the framework of a broader energy fund; accommodating the Universal Access Fund) ▪ Procuring the services of a financial institution to manage the loan processes ▪ Recruitment of staff ▪ Establishing systems and procedures ▪ Capacity building	M 10 million
	Procurement of eligible off-grid service providers ▪ Call for proposals ▪ Evaluation and selection	M 0.5 million

Action Plan Task	Possible Cost Elements	Indicative Budget
Once-Off Costs		
Task 5: Increase Access to Electricity	***Consultancy services*** related to ▪ Advising on appropriate budget split	M 0.25 million
Task 6: Appropriate Grid Standards	***Consultancy services*** related to ▪ Developing appropriate grid standards for rural electrification	M 0.25 million
Task 7: Fund Solicitation	***EMP road show and/or donor conference***	M 0.5 million
	ONCE-OFF COST TOTAL	**M 35 million**
Annually Recurring Costs		
Task 4: Create Enabling Environment	***Operational expenses of the off-grid agency*** ▪ Staff costs ▪ Other operational expenses	M 5 million
Task 4: Create Enabling Environment	***Operational expenses of the revolving fund for electrification*** ▪ Executing financial institution cost ▪ Staff costs ▪ Other operational expenses	M 10 million
	ANNUALLY RECURRING COST TOTAL	**M 15 million**

In order to launch the EMP roll-out effectively and immediately, it would be practical to allocate a certain portion of the annual Government budget for electrification towards EMP implementation facilitation in the first 2-3 years. For example, if M 150 million is available annually, commencing in 2019, then the following budget allocations may be considered:

In 2019:
- M 20 million for once-off EMP implementation facilitation costs[10]
- M 10 million for operational expenses of the off-grid agency and the revolving fund[11]
- M 120 million available for electrification through the revolving fund of which
  - M 96 million is reserved for grid electrification (80%)
  - M 24 million is reserved for off-grid electrification (20%)

In 2020:
- M 15 million for once-off EMP implementation facilitation costs
- M 15 million for operational expenses of the off-grid agency and the revolving fund
- M 120 million for available for electrification through the revolving fund of which
  - M 96 million is reserved for grid electrification (80%)
  - M 24 million is reserved for off-grid electrification (20%)

Future years:
- M 15 million for operational expenses of the off-grid agency and the revolving fund
- M 135 million available for electrification through the revolving fund of which
  - M 108 million is reserved for grid electrification (80%)
  - M 27 million is reserved for off-grid electrification (20%)

[10] It is likely that the facilitation costs will need to be spread over at least 2 years, therefore a reduced budget will be required.

[11] These will not be fully operational yet during the first year, therefore the budget is slightly less.

6.3 RESOURCING THE REVOLVING ELECTRIFICATION FUND

The revolving fund for electrification is to be resourced with capital from Government coffers and could be supplemented with possible contributions from development partners and/or the Universal Access Fund. Since the fund is a credit facility, it is replenished on a continual basis as the loans are being repaid by the beneficiaries.

Therefore, once the fund is fully operational and adequately resourced with budgets for grid and off-grid electrification, it will not be necessary for Government to inject capital on an annual basis, which will free up funds for Government to allocate towards other development efforts.

6.4 ACCELERATING ACCESS TO ELECTRICITY

According to the latest census, 38% of the population already had an electricity connection in 2016, with 36% of households grid-connected and 2% using solar power. With an estimated average population growth in Lesotho of 1.04% per year, and assuming that the average household size will remain constant at 3.7 persons, the number of unelectrified households will grow from about 330,000 to 406,000 in 20 years' time. This means that access to electricity will increase to about 91% by 2038 with the assumed annual electrification budget – and split between grid and off-grid – from Government, and universal access will be reached by 2043.

If more funds were allocated to off-grid electrification, either from Government or external funding sources, or if the budget allocation split between grid and off-grid is tilted more in favour of off-grid (even by as little as 10%), the universal access target can be reached significantly earlier since the average cost per connection of off-grid solutions (M2,646) is much lower than that of grid electrification (M15,000).

To illustrate the point, three scenarios for achieving the key SDG target of universal access by 2030 are presented:

a. For a budget split of 80% / 20% between grid and off-grid electrification an annual budget of M270 million would be required;
b. For a fixed budget of M150 million per year, the split between grid and off-grid electrification needs to be 33% / 67%;
c. And if only off-grid solutions were considered and no funding was made available for grid electrification, an annual budget of M101 million would suffice to achieve the target.

Similarly, to achieve the stated goal of 75% access to electricity by 2022, as per draft Sustainable Energy Strategy of 2017, would require

a. A M480 million annual budget with the 80% / 20% allocation to grid and off-grid electrification respectively; or
b. A M175 million annual budget if the goal is to be reached by off-grid means alone.

7 WAY FORWARD

Launching the roll-out of the EMP is envisaged to entail an initiation phase during which the proposed facilitation structures and mechanisms are established, with subsequent accelerated implementation of the electrification program.

7.1 INITIATION PHASE

This phase could commence as early as 2019 if the EMP has been approved and adopted by Government by the end of 2018 and can be expected to last for 2-3 years. While the focus of the initiation phase is on establishing the structures and mechanisms proposed for facilitating the electrification program, the EMP roll-out will commence in parallel with detailed planning for the highest ranked grid and off-grid projects as per prioritised schedules.

7.1.1 Key Structures

Two key structures are to be established during the initiation phase, namely the *Off-Grid Agency (OGA)* and the *Revolving Electrification Fund (REF).* Their establishment has been proposed previously, most recently by the TAF SEforAll intervention, and their purpose and concept as summarised in previous sections of this report are therefore well known. As part of this process *the REU is to be dissolved, either by transforming it into the OGA or by incorporating it into LEC.*

The details of the set-up, mandate and operational functionality of the OGA and the REF, however, are yet to be developed which is to be undertaken during the initiation phase. Once the EMP has been adopted, Government needs to issue an instruction in this regard and make available an appropriate budget.

7.1.2 Key Mechanisms

The key mechanisms to be established for purposes of enhancing the facilitation of the electrification programme include:

- Awareness creation about the EMP (Task 2 of the Action Plan);
- Establishing the market rules for electrification (Task 3 of the Action Plan);
- Recruiting eligible private-sector off-grid service providers (Task 4 of the Action Plan);
- Setting a target date for achieving universal access to electricity and determining appropriate grid and off-grid budgets for an accelerated electrification programme (Task 5 of the Action Plan);
- Developing appropriate grid standards for rural electrification (Task 6 of the Action Plan); and
- Soliciting additional funding for electrification (Task 7 of the Action Plan).

Similar to the key structures above, the establishment of these mechanisms requires a clear instruction from Government and an appropriate budget allocation.

7.1.3 Commencement of EMP Roll-Out

In the absence of the above structures and mechanisms early in the program, the roll-out of the EMP can still commence with some initial steps, in preparation for the accelerated electrification program that will follow the initiation phase.

The starting point would be the detailed planning for the highest ranked projects listed in the prioritised grid and off-grid electrification schedules. Communities affected by these projects are to be notified and encouraged to constitute themselves as scheme groups that apply for funding from the soon-to-be-established REF.

On the grid side, the detailed planning involves both the medium voltage (MV) and low voltage (LV) networks with all customer connections. It is proposed that the MV networks are to be built with funding from the Universal Access Fund, but that the low voltage networks and customer connections are only constructed in response to approved scheme group applications once the REF is operational.

For off-grid communities the detailed planning involves demonstration of and awareness creation about the off-grid systems on offer (by eligible service providers, initially supported by DoE and REU until the REA is operational), and the invitation for scheme group applications with concomitant deposit collection from members.

7.2 ACCELERATED IMPLEMENTATION OF THE ELECTRIFICATION PROGRAM

Once the OGA and the REF have been established and the key mechanisms are in place, the electrification program can be rolled out at full speed, within the limits of the available budget and prevailing capacity of the role players.

Universal access to electricity is achievable within a relatively short period of time if lower-cost off-grid systems are prioritised by a higher budget allocation for off-grid. Grid electrification will continue in parallel, in accordance with the prioritised schedules, and will eventually also reach villages that have previously benefited from off-grid solutions. Off-grid beneficiaries will also have the option to upgrade to larger systems at any time.

8 ANNEX

8.1 PRIORITISATION ALGORITHM AND METHODOLOGY

8.1.1 Introduction

A site prioritisation algorithm has been developed for the future electrification in Lesotho. The criteria evaluated the different sites taking into consideration: road access, number of households, number public buildings, number of businesses, grid distance, number of potential consumers, registration schemes and development potential between others. This data has then been utilised to calculate a ranking score for the different sites. The site data was used to decide the type of electrification to be developed whether a grid or off grid. For the prioritisation criteria the settlements were clustered in Enumerator Area (EA) based on its proximity. This is because the data was provided by the Bureau of Statistics per EA rather than per village.

The developed electrification criteria allowed to decide between undertaking grid extension, mini-grids and standalone systems assessing quantitative and qualitative parameters for each specific EA with its circumstances:

- Grid electrification: this involved the grid extension to EAs that are in the vincinities or service territory of LEC.
- Off-grid electrification: this includes all areas that are not suitable for grid and mini-grid electrification. The off-grid solutions will involve solar lanterns, solar kits and solar home systems.
- Mini-grid electrification: this will involve the electrification of densely populated settlements or cluster of settlements that are in close proximity. The Mini-grid sites were already identified in prior assignments: Access Study (2001), NEMP (2007) and UNDP SE4All PD (2016).

Each of the system types has advantages and disadvantages. Therefore, in order to decide which option was more suitable for a given community a prioritisation algorithm has been developed and discussed with the Technical Working Group (TWG) to select the type of electrification depending on the features of the specific EA. For example, if an area is just a kilometre from the grid then it might be relatively cheap to extend the grid. However, if the grid is 20 kilometres away then it may be prohibitively expensive.

8.1.2 Prioritisation Algorithm

The prioritisation methodology follows a 2-stage process, with the first stage determining whether a settlement should be electrified by grid or off-grid means and the second stage ranking projects in order of importance in accordance with national development goals and policy/strategy targets. For the classification and prioritisation of the electrification projects for the different EAs a standardised scoring system was developed in consultation with the TWG.

The prioritisation algorithm is graphically depicted in Figure 1 below:

(a) Stage 1 Prioritisation

The Stage 1 Prioritisation is described in the flow diagram show in Figure 2. The description of the decision process is as follows:

For each EA that is not electrified there are 2 possibilities:

- **Option 1**: YES there is road access to the EA. From the diagram it can be observed that there are further questions to be answered to reach a decision:

- IF the EA is located in the Senqu Valley or Highlands AND the distance to the closest grid is lower than 5km AND with a number of customers greater than 70, then a grid extension is the prioritised solution.
- IF the EA is located in the Lowlands or Foothills AND the grid distance is lower than 7.5km with a number of customers greater than 70, then a grid extension is the prioritised solution.
- IF the two previous conditions are not verified an off-grid system will be prioritised. For the off-grid solutions there are two main potential alternatives: Mini-grids or Standalone solutions:
  - IF the EA is part of the already pre-planned mini-grid schemes then a mini-grid solution would be implemented.
  - IF the EA is not part of the already pre-planned mini-grid schemes then a standalone solution would be selected. This involves a Solar Lantern, Solar Kit or SHS. The detailed description of the different system types can be found in the *Off-Grid Master Plan Report*.

- **<u>Option 2</u>**: IF there is NO road access to the assessed EA an off-grid system would be the choice for that particular EA.

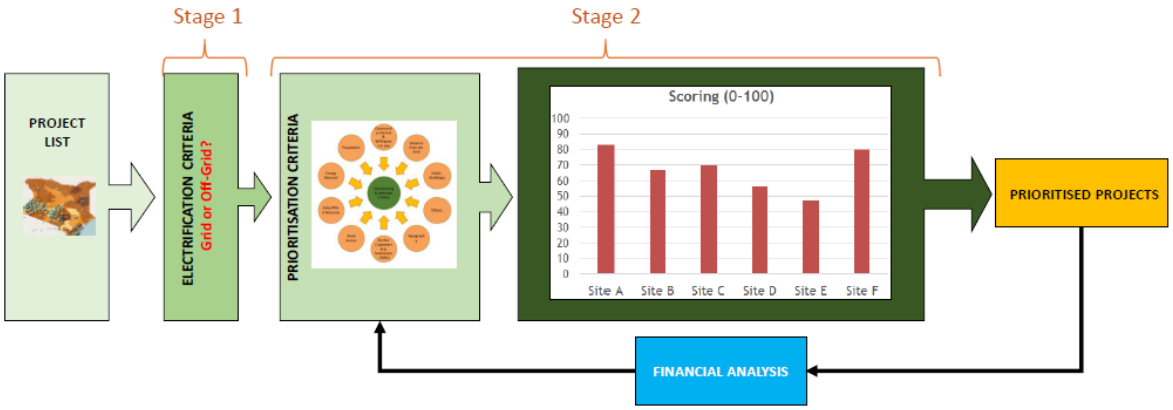


Figure 1: Prioritisation Algorithm

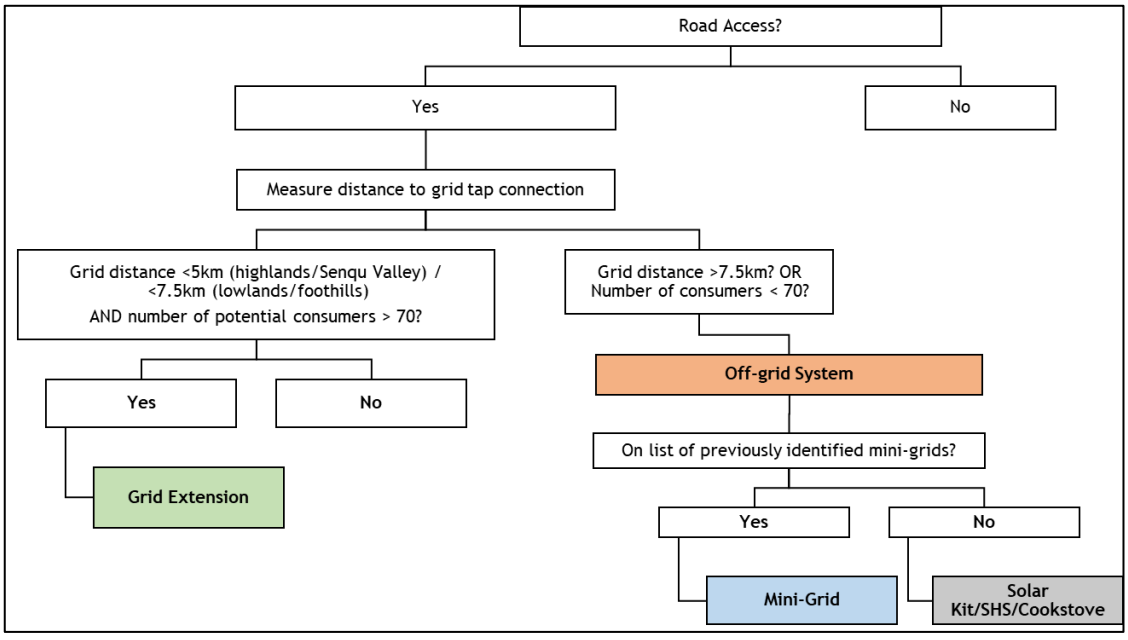
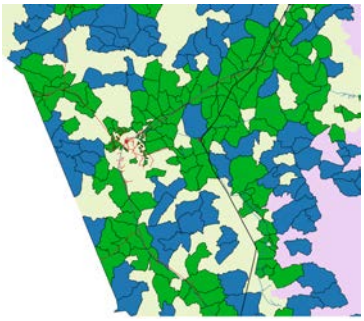


Figure 2: Electrification Decision Diagram

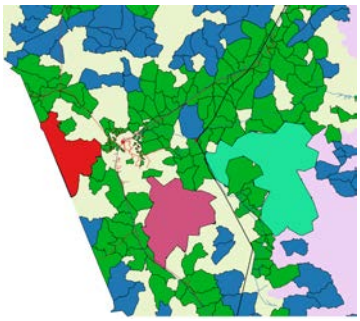
(b) Stage 2 Prioritisation

Stage 2 evaluates each EA on the basis of its characteristics (number of households, schools, health facilities, etc) using a standardised scoring algorithm and resulting in a point score that determines the EA's priority ranking.

Before applying the Stage 2 prioritisation, EAs may be clustered according to the location of nearby electricity substations. In this manner, additional EAs not initially prioritised for grid electrification may also be included in the grid electrification program due to being surrounded or in close proximity with other EAs to be grid electrified, as illustrated in Figure 3 below.



Stage 2 grid-prioritised EAs (in blue)



Clustered EAs (in red/pink/turquoise)

Figure 3: Clustering for Grid Electrification

The red cluster is all from initially prioritised EAs, while the pink and turquoise clusters include some EAs not initially prioritised for grid electrification.

These results are then fed into the financial model to refine the priority ranking based on cost efficiency.

Projects that are prioritised for other (eg political) reasons can be excluded from the prioritisation process. Such "special projects" should be restricted to a maximum 10% of budget allocation, however, so as not to render the objective prioritisation process meaningless.

8.1.3 Prioritisation Methodology

The agreed prioritisation criteria relate to actions that contribute positively to one or more of the national development goals (including reduction of poverty, contribution to economic growth, improved access to education, reduced child mortality and early deaths, reduced negative impact on the environment). An algorithm was developed, in consultation with the TWG, that enables prioritisation of EAs on the basis of the potential electricity customers, by applying the agreed criteria.

These criteria can change over time. The Government may, for example, decide to prioritise that all schools have access to electricity (grid or off-grid), just like electrification of health facilities has been prioritised in the past. New priorities may be added, or those that are no longer a priority for the Government may be deleted.

The criteria definition for the ranking of the electrification projects was based on the stated national development objectives reflected in the NSDP 2012/13 – 2016/17, Lesotho Vision 2020 and the Lesotho Energy Policy 2015-2025:

Electrification Focus	National Development Objectives Addressed
Public institutions	• Achievement of SDGs • Poverty reduction
Households	• Improvement of livelihoods
Businesses / productive activities	• Economic growth • Income generation

Furthermore, the criteria took into consideration the energy goals defined in the Draft Sustainable Energy Strategy 2017:

Sustainable Energy Strategy Target	Electrification Focus
75% household electrification by 2022	Low-cost high-impact solutions: affordable solar kits
5000 households to be provided with off-grid solutions	Solar home systems and solar kits

The prioritisation algorithm uses 2 types of parameters to represent the national and energy development goals, namely the attributes of EAs and weighting factors.

(a) Data Collection

In order to develop the prioritisation algorithm specifically for Lesotho a large set of data was requested from different ministries and other sources. The Consultant has consulted with various stakeholders to obtain relevant information and data for developing a bespoke prioritisation algorithm suited to the country characteristics taking into consideration among others: households, public institutions, private business, mining areas, agricultural facilities, industrial zones, road access data etc. The data collected for the prioritisation algorithm was categorised in following groups:

- Public and private building developments
  - Number of Households (data source: Bureau of Statistics)
  - Number of Businesses (data source: TWG consultation meetings)
  - Primary Schools (data source: Ministry of Education)
  - High Schools (data source: Ministry of Education)
  - Clinics (data source: Ministry of Health)
  - Health Centres (data source: Ministry of Health)
  - Hospitals (data source: Ministry of Health)
  - Agricultural Resource Centres (data source: Ministry of Agriculture)
  - Hostels (data source: Ministry of Tourism)
  - Guest Houses/Hotels/Lodges (data source: Ministry of Tourism)
  - Community Council Offices (data source: Ministry of Local Government)
  - Principal Chief's Offices (data source: Ministry of Local Government)
  - Local Courts (data source: Ministry of Justice)
  - Police Stations (data source: Ministry of Police)
  - Post Offices (data source:Post Office)
  - Churches (data source: Bureau of Statistics)
- EA household data: The Bureau of Statistics provided 2016 Census data on population and number of households at EA level. Census data at village level was not ready yet for use when the EMP was developed.

- Ecological zones: The utilisation of GIS maps allowed identification of the different EAs and the ecological zones. The defined ecological zones include: Highlands, Senqu Valley, Foothills and Lowlands.
- Grid data: The Consultant utilised data from LEC and LEWA about the settlement electrification status as well as information regarding the present and future network plans. This information is of relevance for understanding if a given location already has grid electricity access and, if not, where the closest grid connection point would be.
- Road access data: This information allowed to understand the road accessibility for a given site. This data was obtained from the LAA and through GIS mapping.
- Registered Schemes: REU provided a list of the EAs that were registered for future electrification plans.
- Affordability and willingness to pay data: This information could only be provided at district level but not per EA when the EMP was developed.

(b) EA-Level Attributes

These are the potential electricity customers in an EA and include public institutions, anchor customers and households. EAs with a higher number of potential electricity customers, especially public institutions and anchor customers, generally achieve a higher priority ranking than those with few potential customers.

Electrification of public institutions is essential to improve service delivery. Such institutions include:

- Primary schools
- High schools (secondary schools)
- Clinics
- Health centres
- Hospitals
- Agricultural resource centres
- Hostels
- Community council offices
- Principal chief's offices
- Local courts
- Police stations
- Post offices
- Churches

Anchor customers are those that have income generating activities and support business expansion, such as

- Businesses (small and large retail outlets)
- Agricultural estates (farms)
- Mines

These are generally dependent on availability of electricity. High economic activity will give a higher score than low economic activity. Information and relevant data on anchor customers – number, type and location – was unfortunately very scant (for example, the Ministry of Trade & Industry indicated that, while all businesses in Lesotho are registered, the relevant information is not available in digital format). It was therefore decided during the TWG meetings that a ratio of 1 business (small shop) for every 50 HH would be reasonable to assume.

The various EAs were evaluated and prioritised in terms of number of households, public buildings and anchor customers, by allocating point values for individual attributes.

Higher point values were assigned to attributes with higher importance in terms of the development objectives, and to avoid that households dominate the prioritisation because of their high numbers. The TWG debated and agreed the following attribute weightings relative to a household:

Table 4: Attribute Weightings Relative to Households

Attribute		Weighting relative to HH	Affected National Development Objectives
A	Hospitals	10x	SDGs, poverty reduction
B	High schools Health centres Agricultural Resource Centres Hostels	5x	SDGs, poverty reduction
C	Primary schools Clinics	3x	SDGs, poverty reduction
D	Businesses Guest houses	3x	Economic growth, income generation
E	Other public institutions Churches	2x	SDGs

These translated to the following attribute point values, when using a 0.1 point value for a household:

Table 5: Infrastructure Point Values

Attribute	Affected National Development Objectives if Electrified	Attribute Point Value
Households	Improvement of livelihoods	0.1
Businesses	Economic growth, income generation	15
Primary schools	SDGs, poverty reduction	20
High schools	SDGs, poverty reduction	100
Clinics	SDGs, poverty reduction	20
Health centres	SDGs, poverty reduction	100
Hospitals	SDGs, poverty reduction	200
Agricultural Resource Centres	SDGs, poverty reduction, economic growth	100
Hostels	SDGs, poverty reduction	20
Guest houses/hotels/lodges	Economic growth, income generation	20
Community council offices	SDGs	40
Principal chief's offices	SDGs	40
Local courts	SDGs	40
Police stations	SDGs	40
Post offices	SDGs	40

Attribute	Affected National Development Objectives if Electrified	Attribute Point Value
Other institutions (eg Wasco, IEC)	SDGs	40
Churches	SDGs	8

(c) Weighting Factors

Qualitative features are defined with weighting factors that assign a lighter or heavier importance to an EA.

It was intended to apply 'ability and willingness to pay' through weighting factors in the algorithm. Unfortunately, however, BoS could not extract the relevant data from the 2016 census which meant that these indicators could not be used.

Instead, it was agreed in the TWG that a 'development potential' indicator shall be applied where possible. EAs with existing or future development potential are of great relevance as these locations support economic growth, job creation and poverty reduction. In this regard, some information on earmarked "economic zones" was available from LNDC, where agricultural, mining or other industrial activities are envisaged to be developed. EAs containing such economic zones attract a multiplication factor of 2 for their total point score.

Table 6: Development Potential Weighting Factors

Qualitative Indicator	Measured By	Multiplication Factor	
		Normal	High
Development Potential	MDP/LNDC classification Mining activity	1	2

Another weighting factor is assigned for distance from the grid, by ecological zone, to signify topographical obstacles to electrification. This enables separation into grid and off-grid areas.

Table 7: Location Weighting Factors

Ecological Zone	Distance from Grid	Weighting Factor
Highlands	Less than 5km	0
	Greater than 5km	1
Senqu Valley	Less than 5km	0
	Greater than 5km	1
Foothills	Less than 7.5km	0
	Greater than 7.5km	1
Lowlands	Less than 7.5km	0
	Greater than 7.5km	1

Once all information about a project is captured these data is fed into the prioritisation algorithm model, calculating a score for each project. For clarity purposes an example calculation is shown in section (d).

(d) Example Scoring Calculation

In order to explain the calculation process and to obtain the scoring for a given project named as "Project 1", an example has been added below (Table 8). It consists of an EA with the following attributes:

- 255 households

- 1 primary school
- 1 high school
- 2 health centres
- 1 agricultural resource centre
- 4 hotels
- 1 community council office
- 1 principal chief's office
- 1 church

Other data:

- The EA contains an economic zone where mining activities take place.
- The closest grid tap is at a distance of 15km.

The settlement information combined with the point values gives a total EA score of 613.5 points as can be observed in Table 8.

Table 8: EA Attributes & Point Scoring Example

EA Attributes to be Electrified	Attribute Point Value	Number of Connections	Point Score
Households	0.1	255	25.5
Businesses	5	0	0
Primary schools	20	1	20
High schools	100	1	100
Clinics	20	0	0
Health centres	100	2	200
Hospitals	200	0	0
Agricultural resource centres	100	1	100
Hostels	20	0	0
Guest houses/hotels/lodges	20	4	80
Community council offices	40	1	40
Principal chief's offices	40	1	40
Local courts	40	0	0
Police stations	40	0	0
Post offices	40	0	0
Other institutions	40	0	0
Churches	8	1	8
		Total	613.5

The following weighting factors are applied:

- The project has development potential, as it contains an economic zone, which attracts a weighting factor of 2 as per Table 6.
- The EA is more than 5km away from the nearest grid, which attracts a weighting factor of 1, which means that the project is off-grid.

Applying the relevant weighting factors to the point score yields the following results:

- 613.5 x 2 x 1 = **1,227points**

The next step is calculation of capital costs for the project, by multiplying the number of attributes by their respective typical connection cost (for example: 255 households x ((24% x M600) + (37% x M1,600) + (34% x M2,400) + (4% x M14,000) + (1% x M24,000)) as per system distribution by type based on Table 2 in the *Off-Grid Master Plan Report* and the system cost information of Table 1 of the *Off-Grid Master Plan Report* this results on a total CAPEX of 791,010 Maloti. If we calculate the **"project ranking score"** this results 1,227/(791,010/1,000,000)≈**1,551points.**

This ranking score calculation process is repeated for all other projects with their respective scores that would then allow a comparison for prioritisation purposes as shown in Table 9.

Table 9: Ranking Scores for 5 Projects

	Ranking Score
Project 1	1 551
Project 2	1 161
Project 3	372
Project 4	683
Project 5	283

The project rankings are then cross-tabulated with financial assessment results for the different projects (Table 10) to arrive at a final prioritisation.

Table 10: Financial assessment for 5 sites

Financial Indicator	Project 1	Project 2	Project 3	Project 4	Project 5
LCOE (M/kWh)	4.1	4.8	4.4	4.2	3.8
IRR (%)	6	7	8	8	9