



Project **National Electrification Strategy
& Plan for Universal Access to
Energy by 2030**

Document **Report 2 - National Electrification
Strategy (NES) - Draft**

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Prepared by AF-Mercados EMI in cooperation with Estudios Energéticos
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To the Minister of Energy and Mineral Resources:

The National Electrification Strategy represents a key milestone of the study “Development of the National Electrification Project”, as it aims at providing the necessary ingredients that will allow Mozambique to achieve the national goal of universal electricity access by 2030.

The Strategy is based on three pillars – institutional, financial, and technical – to determine the necessary activities that will support universal electrification in Mozambique. Institutionally, the Strategy assigns clear roles to institutions in charge of developing electrification: MIREME, EDM and FUNAE. MIREME is to lead the planning process; EDM, the national electrical utility, as the implementing arm for the main part of the electrification efforts, will be leading the extension of electricity service to on-grid customers; and the energy fund, FUNAE, to lead the implementation of energy solutions in rural areas, with an emphasis on off-grid technologies such as solar home systems and mini-grids. The Ministry of Economy and Finance also has an important role to play.

Financially, the Strategy detaches the electrification efforts from the regular provision of electricity services and plans cash flows that will involve EDM, its customers, FUNAE, a new Electrification Account, grants and loans from International Financing Institutions (IFIs), and the government of Mozambique. ARENE, as successor to CNELEC takes responsibility for setting tariffs that reflect the efficient costs of service provision. The Strategy calls for operations to be funded from tariffs while constructing new connections is supported in a variety of ways.

Technically, the Strategy calls for new workflows aimed at economically building a reliable system. New approaches for creating and enforcing technical standards are combined with ways to efficiently harness human resources for design, construction, and operation and new ways to procure materials.

Overall, the Strategy presents a new approach to electrification with the potential to meet the foreseeable challenges in undertaking this ambitious but necessary program for the electrification of Mozambique.

This report was prepared by the consultants AF-Mercados EMI, in cooperation with Estudios Energéticos Consultores and Royal Haskoning DHV

Executive Summary

Traditionally, the national power utility Electricidade de Moçambique (EDM) has taken the lead role in the Government of Mozambique's (GoM's) efforts to expand electricity access, complemented by FUNAE for the provision of electricity services for rural areas and community centers. In its most successful years, EDM was able to connect about 140,000 new customers per year but this figure has sharply decreased over the last few years, mainly due to lack of adequate business model.

To accelerate electrification and achieve universal access by 2030, the Government of Mozambique, through MIREME and EDM, sought support from the World Bank, which in turn engaged a consultant to assist in developing a National Electrification Strategy, and a complementary plan.¹ The objectives for this assignment are:

- To evaluate the current model for electrification.
- To propose a new business model for delivering both the commercial and social energy required to achieve universal access by 2030.

This business model will be part of a new National Electrification Strategy and Plan for Mozambique (NESP). The NESP will:

- Focus on the development of a framework for accelerating universal access in Mozambique.
- Include institutional, technical and financial considerations, which will need to be addressed to achieve universal access by 2030.
- Identify the appropriate regulatory framework to facilitate the implementation of the National Electrification Strategy
- Propose the Ministry of Mineral Resources and Energy (MIREME) as the main coordinator of the electrification program and EDM and the Energy Fund (FUNAE) as the main implementing agencies, in close coordination with the, the Energy Regulatory Authority (ARENE), and the private sector.

This report corresponds to Task 2 of the project "Development of the National Electrification Strategy and Plan (NESP)". It is based on the findings and recommendations of Task 1, the Diagnosis report, discussed with MIREME, EDM, FUNAE, ARENE, other government institutions and development partners.

This report proposes an approach to meet the objectives of future electricity access for Mozambique. This approach, the NESP, is organized around the three aspects: institutional, technical, and financial.

This report has also benefited from the consultation from the Energy Sector Working Group in Mozambique, in particular with the active participation from representatives from World Bank Group, Embassy of Norway, Embassy of Sweden, European Union Delegation, AFD, USAID, DFID, KFW, GIZ and others.

¹ AF-Mercados EMI in cooperation with Estudios Energéticos Consultores and Royal Haskoning DHV

Challenges

Task 1 of the project identified these key challenges to accelerating access to electricity:

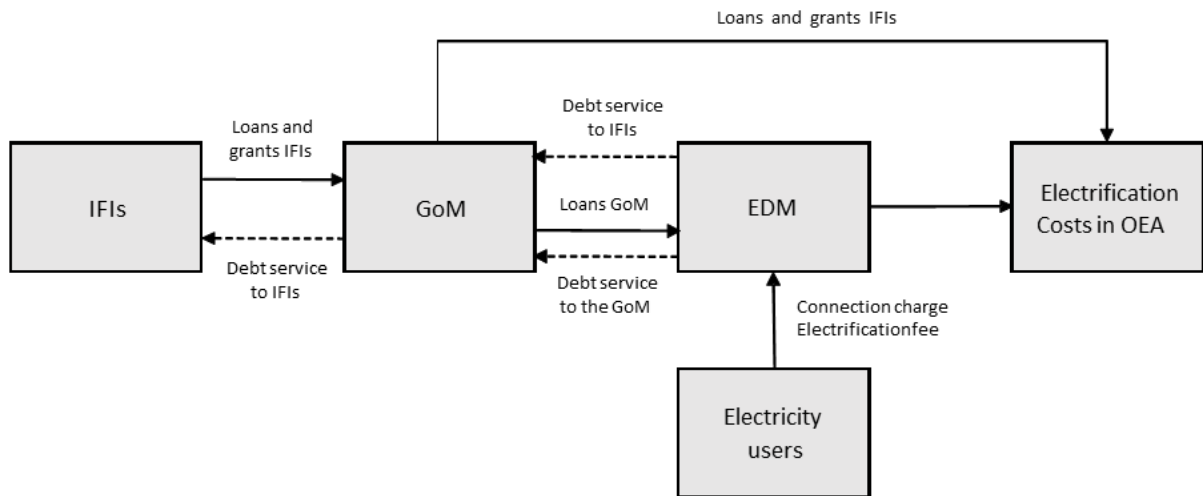
1. **Institutional challenges** include a lack of comprehensive and coordinated planning from MIREME; a lack of criteria for prioritizing projects; a need for EDM and the energy fund FUNAE to coordinate their activities better; and a need for the regulatory body ARENE to build capacity as it takes on greater authority in setting tariffs for electricity.
2. **Financial challenges** include the need for an adequate funding scheme for electrification projects (both on-grid and off-grid); bolstering the finances of EDM, which currently does not cover its costs through tariffs but is expected to bear the main burden of expanding access; discovering a way to make connection costs affordable for households newly getting electricity; and ensuring tariffs are affordable for poor households.
3. **Technical challenges** include assuring system reliability in the face of a great expansion in the number of clients; developing detailed standards and specifications for constructing electrical infrastructure; centralizing procurement of materials for the sake of economies of scale; using the most cost-effective technologies for on-grid electrification; and improving human resources capacity to rely less on external contractors.

The New Electrification Approach

The strategy to be prepared as part of this study assumes that electrification includes both on-grid and, where the on-grid connection cost is too high, off-grid services in order to meet the universal access goal for 2030. The strategy focuses on developing electrification regardless of locality of customers (rural, urban, peri-urban) and type of clients (commercial or social).

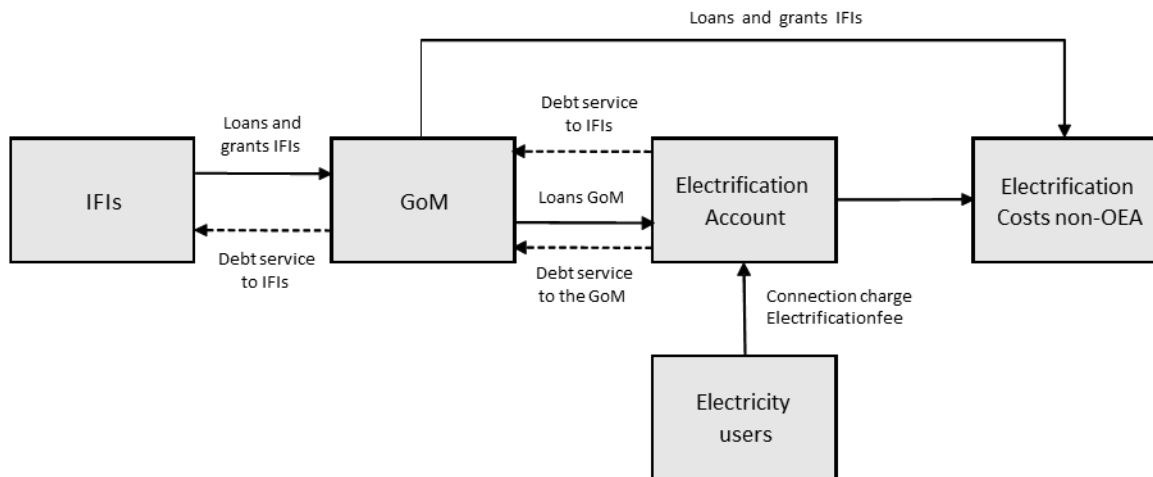
A new concept for dividing responsibility for electrification distinguishes Own Expansion Areas (OEA) from Non-Own Expansion Areas (Non-OEA). An OEA is an area within 100 meters of a main low voltage line. EDM is obliged to connect any customer in an OEA who requests service. The connection cost (a standard cost defined in the regulation) can be paid by the client in installments built into the tariff approved for EDM (even many clients in the top quintile of incomes in Mozambique would have difficulty paying for connections up front). The distance of 100 meters is set to minimize the financial and technical burden on EDM. It could be increased in a future regulation, but that step would have to be accompanied by increased tariffs to meet EDM's increased costs, both because of construction and because by then EDM would not have the support of loans from international financial institutions associated with expansion of access.

Cash flow of the electrification program inside the OEAs



A non-OEA area is any other area in the country. In the non-OEA, EDM has no obligation to supply any connection for potential customers, but it can do so if it decides to. A new instrument, the Electrification Account, a revolving fund managed by the Ministry of Economy and Finance, would finance the capital expenditure of these connections. EDM would not have to repay the capital expenditures for these connections, but it would be obliged to serve them.

Cash flow of the electrification program in non-OEAs



Building off-grid non-OEA power systems is the responsibility of FUNAE. Once a project is built, FUNAE will transfer it to EDM for commercialization, operations, and maintenance, and EDM can outsource operation to private operators or to the involved communities. FUNAE’s projects would also be funded by the Electrification Account without an obligation for FUNAE to repay them. FUNAE and EDM are to coordinate efforts on specific projects where their areas might overlap.

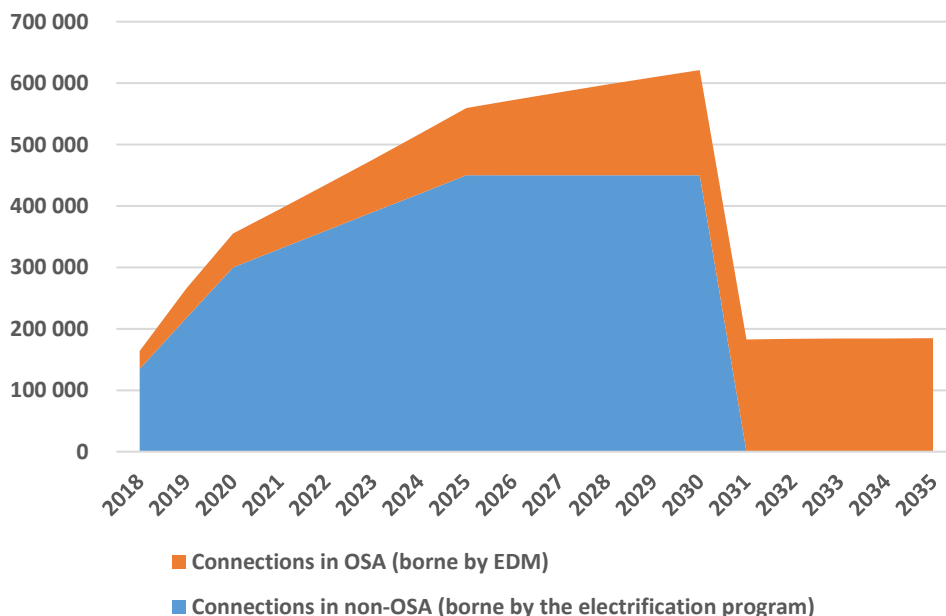
Other features of the new approach are:

- A planning process, with short-term enforceable outputs as the key element for strategy implementation. Only investments resulting from optimized planning process (both for system expansion and rehabilitation and electrification to connect new consumers) are implemented, following competitive procedures. Investments executed by EDM are implemented using the best financing arrangements available.

Investments should not be financed using tariff revenues while “soft” financing arrangements from the IFIs are available to Mozambique.

- Implementation of a levy where the proceedings are earmarked to fund electrification, including appropriate fund management.
- Balancing of on-grid and off-grid electrification in order to take into consideration social aspects and political priorities for economic development.
- Clear criteria to prioritize projects identified by the Power Sector Master Plan must be defined
 - Based on the least-cost option defined by the Power Sector Master Plan
 - Priority for projects that use existing assets with spare capacity, i.e. “densification” of existing grids (other criteria may complement this one).
 - Financial contributions from local governments.
 - Promotion of economic activities in certain zones, attention of areas with lower human development index (HDI) and development corridors.
 - Contribution to social inclusion through acceleration of access to energy.
- Uniform tariffs set for each category of customer. The tariff is to be sustainable (reflect the efficient cost of service provision) but balanced with adequate cross subsidies for the poorest population.
- EDM’s allowed revenues are to be sufficient for EDM to recover all operating costs (including financing costs). Tariffs will be periodically adjusted to reflect changes in uncontrollable costs. EDM’s operating costs include its own power generation, purchases of energy from independent producers and the hydroelectric dam operator HCB, transmission, distribution and sales, shared services and financing.

Projection of the number of connections of residential customers per year



Projected financing

EDM is currently not only leading but also mostly funding the electrification effort in Mozambique. Therefore, the fact that tariffs are non-cost reflective hinders the sustainability of on-grid electrification projects.

Regulations and institutional set-up must be ensured to allow EDM to recoup the efficient costs of providing electricity services if it provides the target quality of service.² The tariff should incorporate cost-reflective mechanisms such as an automatic pass-through of generation-related fuel costs, and adjustments for the exchange rate and inflation. The remuneration of EDM shall also include the depreciation of its assets and a reasonable return on investment. This is needed to allow EDM to provide an acceptable quality of service and to fund the replacement of its assets.

In case of the assets funded through the electrification program (including those funded by the Electrification Account or by the GoM channeling IFI grants and soft loans), ownership shall be transferred for free to EDM,³ and the tariff should exclude the remuneration for the capital expansion, since it is not funded by EDM, but should take into account operation and maintenance costs and the depreciation (including the depreciation of the low voltage drop and the customer meter).

The number of connections of residential customers in OEA was assumed to increase in line with the electricity access, the population, and the decrease of the average household size. The financing needs of these connections were not modelled in this report.

The number of new connections of residential customers in non-OEA was assumed to increase from 135,000 in 2018 to 300,000 in 2020 and 450,000 in 2025, at which point the number of connections per year was assumed to remain constant until 2030. The resulting average number of connections per year of residential customers to be borne by the electrification program in 2018–2030 amounts to about 373,000 customers (4,852,000 customers in total).

From 2031 onwards, where the country has been assumed to have already achieved universal access to electricity, all new customers have been assumed to be connected in OEA and their financing to be borne by EDM.

Projections of electricity access

	2017	2020	2030	2040
Population		28,644,358	33,713,497	37,859,444
Population growth rate per year (%)	2.5%	1.9%	1.4%	1.0%
Average household size	5.0	4.9	4.4	4.0
Average household size decrease (%)	-1%	-1%	-1%	-1%
Electricity access at the end of the year (%)	26%	38%	100%	100%
No. residential customers at the end of the year		2,240,413	7,606,967	9,445,610
No. connections (accumul. from 2018)	-	785,206	6,151,760	7,990,403
No. connections in OEA (accumul. from 2018)	-	132,706	1,299,812	3,138,455
No. connections in non-OEA (accumul. from 2018)	-	652,500	4,851,948	4,851,948

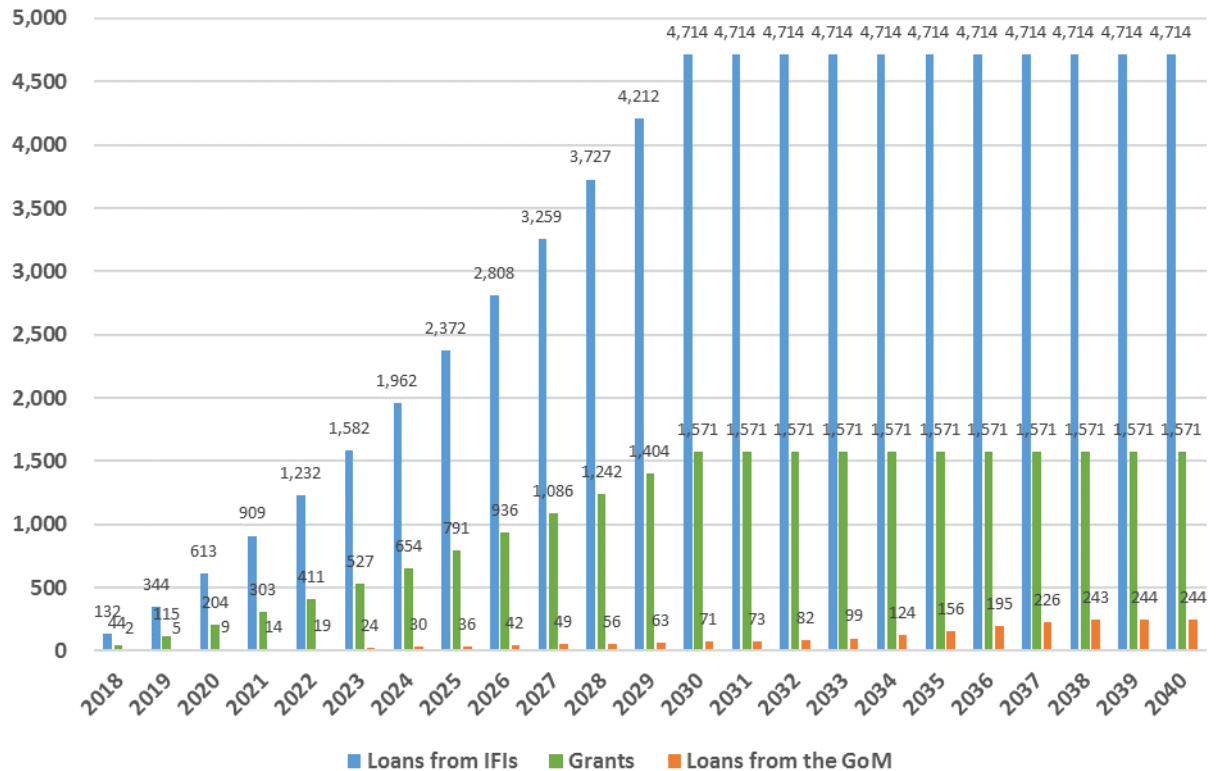
² This includes a reasonable level of losses; normally, it is agreed with the regulator a loss reduction program to evolve through a reasonable “glide path” to achieve the desired objective in terms of losses.

³ Free of any tax or charge.

Financing connections and service to non-OEA

Achieving universal access by 2030 requires about 6.65 Billion USD to be provided by IFIs and the GoM for financing the connections in non-OEA.⁴ In particular, loans from IFIs amount to about 4.7 Billion USD, grants from IFIs amount to about 1,6 Billion USD and loans from the GoM amount to about 244 Million USD

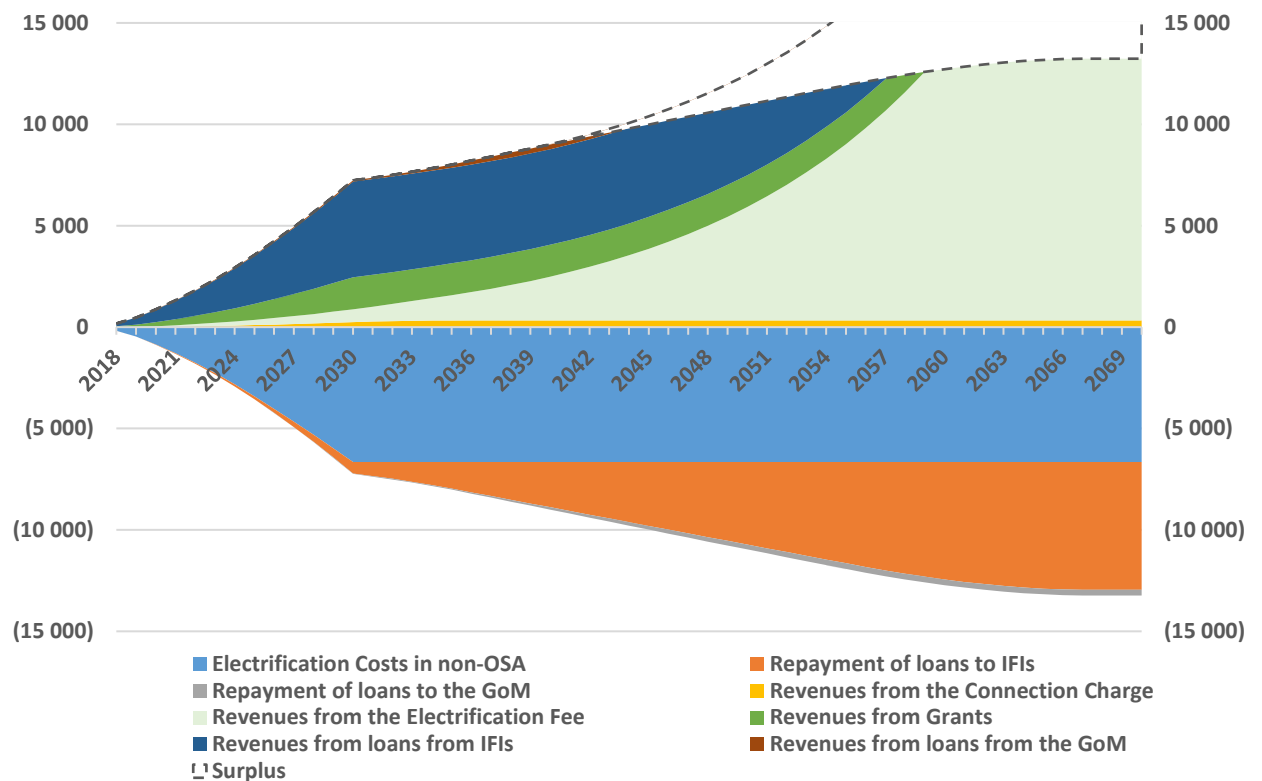
Projections of the accumulated financing needs for non-OEA from 2018 from IFIs and the GoM (million USD)



In 2040, the revenues obtained from the electrification fee are high enough to fully cover the financing costs so it is expected that there will not be a further need for funds from the GoM. Consequently, the electricity fee can be reduced below 5% for the first time, as the revenues obtained from the electricity users would exceed total costs otherwise, which would create the surplus that was represented as the white area within the following figure.

⁴ The financing needs of connections of customers in OEA were not modelled in this section.

Projections of the accumulated yearly costs and revenues of the non-OEA electrification program (Million USD)



The feasibility of the new electrification approach requires sufficient funding, which can come from a combination of external, government, and utility sources. It also requires capacity to plan electrification projects, implement them, and operate and maintain services. This means the capacity to operate a utility that will have an exponential growth of number of customers from the technical and commercial point of view, requiring not just expanded finance, but expanded human resources.

* * *

Electrification has the potential to transform household and community life. Electrified households acquire lighting, mobile phones, TVs, and radios, material improvements in quality of life. Communities benefit from improved security, health, education, and social services. Existing businesses improve their performance, and new businesses are formed.

The National Electrification Strategy and Plan for Mozambique offers a framework for accelerating universal access in Mozambique. It will identify institutional innovations, regulatory structures for electrification’s development and operation, financial streams for the current task of building and the ongoing task of managing and maintaining, and an assortment of technical strategies, on-grid and off-grid, in a poor country with a largely dispersed rural population.

Background. Following the Government of Mozambique's (GoM's) efforts to expand access, the Ministry of Mineral Resources and Energy (MIREME) together with Electricidade de Moçambique (EDM), the national power utility, have taken the lead role by asking the World Bank to review the situation on the electrification and to support in identifying suitable approaches for Mozambique to increase access to electricity services while addressing the financial implications of such investment for the overall power sector.

Source of funds and process. Financial support is provided by the Government of Mozambique and World Bank (under the Sustainable Energy for All Trust Fund). Through this support, the World Bank will facilitate the discussion and share lessons learned from other successful electrification programs. The selection of the best approach for electrification for Mozambique is a government decision. The preparation of the strategy included the following milestones.

- TORs revised and approved jointly by MIREME, EDM and FUNAE in June 2016.
- Consultant hired to support the government in September 2016.
- Kick off meeting and internal workshop to share international good practices in October 2016
- Presentation of inception report to government authorities and development partners, and first visit to assess the progress and challenges of electrification in December 2016.
- Presentation of scope of work to development partners in December 2016.
- Diagnostic report presented and discussed with government authorities in February 2017.
- First draft National Electrification Strategy for discussion, including discussions with the national utility, government authorities and development partners in May 2017.

Objective of this draft document. To facilitate the discussion among the government institutions about the key principles for electrification and to receive guidance from the government about the policy decision to be incorporated in the strategy.

Next steps.

- National Electrification Strategy is approved by the Minister of Mineral Resources and Energy

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Acronyms

AAAC	all aluminum alloy conductor
ABC	aerial bundled cables
ARENE	Autoridade Reguladora de Energia (Energy Regulatory Authority)
CEO	chief executive officer
CNELEC	Conselho Nacional de Electricidade (National Electricity Counsel)
CTRG	Central Térmica de Ressano García (Ressano Garcia Power Plant)
EDM	Electricidade de Moçambique E.P. (Mozambique Electricity Company)
Eskom	Electricity Supply Commission of South Africa
FUNAE	Fundo de Energia (Energy Fund)
GoM	Government of Mozambique
HCB	Hidroeléctrica de Cahora Bassa (Cahora Bassa Hydroelectric)
HV	high voltage
IFIs	international financial institutions
IPP	independent power producer
MIREME	Ministério dos Recursos Minerais e Energia (Ministry of Mineral Resources and Energy)
Mt	Mozambican metical
NESP	National Electrification Strategy and Plan
OEA	Own Expansion Areas
PPA	power purchase agreement
SEC	Swaziland Electricity Company
SWER	single wire earth return
US\$	United States dollar

Electricity terminology

V	volt, unit of voltage
kV	kilovolt, 1,000 volts
LV	low voltage, voltage level less than 1kV (AC)
MV	medium voltage, voltage level exceeding LV and less than HV
HV	high voltage, voltage level exceeding 66 kV and less than 220 kV
W	watt, unit of active power
kW	kilowatt, 1,000 watts
MW	megawatt, 1,000 kW
Wh	watt-hour, unit of energy
kWh	kilowatt-hour, 1,000 Wh
MWh	megawatt-hour, 1,000 kWh
GWh	gigawatt-hour, 1,000 MWh
TWh	Terawatt-hour, 1,000 GWh
VA	volt-ampere, unit of apparent power
kVA	kilovolt-ampere, 1,000 VA
MVA	megavolt-ampere, 1,000 kVA
VAr	volt-ampere reactive, unit of reactive power

Definitions

This report employs the following definitions:

- **Access:** population (a household) having electricity service of any kind.
- **Commercial Energy:** energy delivered in areas / clients where it is feasible from the commercial point of view considering an efficient performance of the company and the existing tariff level.
- **Connected household:** A household receiving electricity supplied from the electrical grid
- **Consumer:** A person or entity who is provided electricity services for domestic, industrial or commercial use.
- **Efficient Cost:** The cost of providing electricity services, taking into account efficient grid operation and a limited amount of allowed system losses.
- **Electrified household:** A household with access to electricity.
- **Electrified village:** A village where most community facilities and more than 50 percent of households can be connected to the service without further lines extensions.
- **Grid:** A national electricity network comprising of power generation, transmission, distribution and consumers, managed by the national utility.
- **Grid conversion:** The process by which isolated grids or *mini-grids* are connected to the *main grid* and *pre-grid households* are converted to *grid-connected households*.
- **Grid densification:** The process of connecting new households to the existing *grid* in an area.
- **Grid-equivalent supply:** Electricity supply (through mini-grids or isolated solutions) capable of supplying a household with a quality of service similar to on-grid electricity. Quality of service is differentiated among different load density areas.
- **Grid extension:** Extension of lines from the main *grid* to supply new areas with on-grid electricity.
- **Internal reticulation:** This refers to the electrical wiring inside a household.
- **Mini-grid:** A low-voltage (LV) distribution *grid* that is isolated from other grids and has its own electricity generation source.
- **Non-own expansion area (non-OEA):** An area that is not an *own expansion area*.
- **Own Expansion Area (OEA):** Defined for this Strategy as an area close to existing lines where the utility is obligated to connect consumers when they request connection. This area is defined in principle as based on the upstream infrastructure capacity of the low-voltage (LV) 100 meters to each side of each existing line. Currently in Mozambique, the concessionaire has the obligation to supply in its concession area.
- **Off-grid area:** Areas that are not expected to be connected to the *grid* in the short to medium term and should be supplied with off-grid alternatives.
- **Off-grid household:** An *electrified household* supplied by electricity from a source other than grid electricity and that is not expected to be connected to grid electricity in the short to medium term. *Pre-grid households* and *off-grid households* together represent electrified households serviced by off-grid solutions.
- **On-grid area:** Area supplied by *grid electricity*. Depending on the context, this may refer to areas currently supplied by grid electricity, areas that are expected to be supplied by grid electricity in the near future, or areas that in the planning process have been defined as areas to be supplied by on-grid electricity.

- **Pre-grid household:** An *electrified household* that is supplied from a source other than *grid electricity* but expected to be connected to grid soon or at defined date in the near future as part of the outcome of the planning process.
- **Rural area:** An area with a low-density population that is not part of a provincial capital or designated municipality.
- **Social energy:** energy delivered in areas / clients where it is not feasible from the commercial point of view considering and efficient performance of the company and the existing tariff level.

1 Introduction

Since the end of Mozambique’s civil war in 1992, the country has had strong and sustainable economic growth, averaging 7.4 percent annually. However, GDP per capita is low (US\$600 in 2016), and approximately, 50 percent of the population still live below the poverty line.⁵ Moreover, most of the population lives in rural areas, and only 26 percent of people were connected to the electricity grid in 2016.⁶

Following the Government of Mozambique’s efforts to expand access to electricity, the national power utility Mozambique Electricity Company (Electricidade de Moçambique, EDM) has extended the electricity network throughout the country (tables 1.1 and 1.2). During its most successful years, EDM connected about 120,000 new consumers a year, but the number connected has decreased sharply since 2013, mainly due to lack of funding on concessional basis.

Table 1.1. Electricity consumers, 2006–2015

Clients	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of clients	415,667	510,848	614,732	736,085	858,108	1,010,780	1,140,835	1,257,809	1,377,003	1,450,953
Number of residential clients	373,795	464,197	559,433	680,583	790,858	934,995	1,050,735	1,156,089	1,263,234	1,335,207
Number of Non-residential clients	38,790	43,275	51,620	51,460	62,855	70,872	84,718	95,796	107,361	108,936
Growth of residential clients	71,580	90,402	95,236	121,150	110,275	144,137	115,740	105,354	107,145	71,973
Growth of non-residential clients	4,981	4,485	8,345	-160	11,395	8,017	13,846	11,078	11,565	1,575

Source: EDM statistical information

Table 1.2. Electricity consumption, 2006–2016

Consumption	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total energy sold [GWh]	1,669	1,873	2,029	2,404	2,449	2,777	3,186	3,306	3,642	3,851	4,764
Total energy sold national territory [GWh]	1,307	1,375	1,506	1,734	1,935	2,197	2,517	2,978	3,381	3,691	3,902
Energy sold special clients [GWh]	0	0	15	60	88	96	122	253	310	371	351
Energy sold by distribution division [GWh]	1,307	1,375	1,491	1,674	1,847	2,101	2,395	2,725	3,071	3,320	3,552
Energy sold to domestic clients by distribution division [GWh]	481	517	580	648	751	897	1,052	1,233	1,416	1,538	1,654
Energy sold by distribution division to other clients [GWh]	826	858	911	1,026	1,096	1,204	1,343	1,492	1,655	1,782	1,897
Exports [GWh]	362	498	523	670	514	580	669	329	260	160	862
Average consumption, domestic clients (kWh/year)	1,592	1,382	1,249	1,158	1,103	1,135	1,125	1,173	1,224	1,218	1,239
Average consumption, non-domestic clients (kWh/year)	24,422	22,119	21,405	21,045	23,010	20,677	20,667	20,594	20,521	20,054	20,634

Source: EDM statistical information

⁵ Poverty line as defined by the World Bank.

⁶ EDM, Historic Data 2001–2015.

Within this context, EDM, as the national power utility, sought support from the World Bank, which engaged a consultant⁷ to assist in developing a National Electrification Strategy and a complementary plan for accelerating universal access to electricity in Mozambique by 2030. Objectives for this consultancy were:

- To evaluate the current model for electrification.
- To propose a new business model for delivering both the commercial and social energy required to achieve universal access by 2030. This business model will be part of a new National Electrification Strategy and Plan for Mozambique (NESP).

The NESP will:

- Be undertaken by EDM in close coordination with the Ministry of Mineral Resources and Energy (MIREME), the Energy Regulating Agency (ARENE), the Energy Fund (FUNAE), and the private sector.
- Focus on developing a framework for accelerating universal access to electricity in Mozambique.
- Include the institutional, technical, and financial considerations that will need to be addressed to achieve universal access by 2030.
- Identify an appropriate regulatory framework to facilitate the implementation of the NESP.

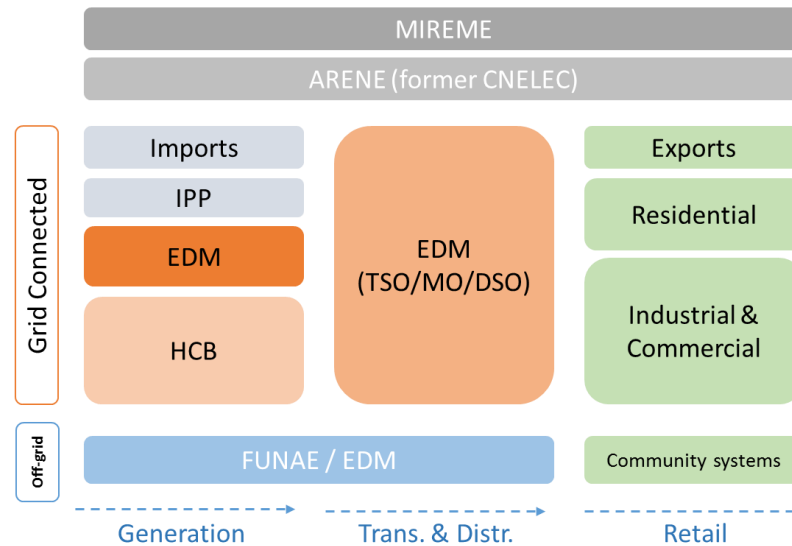
This report, which corresponds to Task 2 of the project “Development of the National Electrification Strategy and Plan (NESP),” is based on the findings and recommendations of the diagnosis report (Task 1) discussed with EDM, FUNAE, and government authorities in February 2017. The objective of this report is to propose an approach to meet the objective of electricity access in the future for Mozambique. This approach—the NES—is organized around three aspects: institutional, technical, and financial.

⁷ AF-Mercados EMI in cooperation with Estudios Energéticos Consultores and Royal Haskoning DHV.

2 Current institutional framework of the power sector

The key players in the power sector of Mozambique are described below and summarized in figure 2.1.

Figure 2.1. Organization of the electric power sector in Mozambique



MIREME: Ministry of Mineral Resources and Energy; ARENE: Energy Regulatory Authority; CNELEC: National Electricity Council; EDM: Electricity of Mozambique; HCB: Cahora Bassa hydropower plant; FUNAE: Energy Fund; TSO: Transmission System Operator; MO: Market Operator; DSO: Distribution System Operator

The Government of Mozambique (GoM): MIREME

MIREME is responsible for the overall policy, institutional, and regulatory framework of the energy sector, including the electric power sector, in Mozambique. In particular, MIREME has the following mandates with respect to electrification:

- Planning and setting electrification (access) targets.

Regulating Authorities: ARENE (former CNELEC)

Energy Regulatory Authority (ARENE), former National Electricity Council (CNELEC)

CNELEC was created by the Electricity Law of 1997 to protect the public interest in the provision of electricity services and to advise the government on conciliation, mediation, and arbitration on issues related to the power sector. The functions of CNELEC included:

- Informing the government on policy and objectives regarding the supply of electricity.
- Informing the government on and proposing regulations for the sector.
- Informing the government on requests for concessions to supply electricity and on proposed tariffs.
- Developing proposals to promote new technologies.
- Participating in bidding when new capacity is tendered.

In August 2017, the Parliament approved a law to transform CNELEC, established as a consultative body providing advice on issues related to the power sector, such as new

concessions and tariffs, into an independent regulatory body, ARENE, that will oversee the power sector. Among other things, ARENE will be responsible for (a) proposing and approving electricity tariffs; (b) promoting competition in the power sector and licensing; (c) quality control and (d) proposing legislation in the energy sector. The establishment and capacity building of ARENE are supported by Development Partners.

Electricidade de Moçambique E.P.(EDM)

EDM is the state-owned, vertically integrated utility in charge of electricity generation, transmission, and distribution and the commercialization and import and export of electricity service countrywide.

Significant progress has been achieved on these fronts since EDM's creation in 1977. The country's installed generation capacity is higher than its demand, due mainly to the Cahora Bassa Hydropower plant (HCB). Around 1,330 megawatts (MW) of HCB's 2,075 MWs installed capacity is committed to Eskom in South Africa under a long-term agreement, which ends in 2029. The national maximum demand has increased from about 320 MW in 2006 to about 900 MW in 2016. The current energy mix is 56 percent hydropower, 42 percent gas power, and about 2 percent imported from neighboring countries from various sources. The transmission network has expanded from 3,691 kilometers (km) in 2003 to 5,249 km in 2015. A key priority is the construction of the Sociedade Nacional de Transporte de Energia (STE), the national transmission backbone project to interconnect the country and to transmit electricity throughout the country and the regional market (Southern Africa Power Pool).

EDM has successfully mobilized private and public financing for several electricity generation projects commissioned over the last 2 years or to be implemented in the next 3 years.⁸ These power generation projects enables Mozambique to expand access, and they position Mozambique as an important player in the regional electricity market.

On the distribution side, EDM has increased access to electricity service from 8 percent in 2006 to 26 percent in 2015 thanks to investments in transmission and distribution assets and improvements in its operations and management activities.

The Electricity Law of 1997 allows for private sector investment, but it did not take off until 2014 and has been mostly in generation through independent power producers (IPPs). EDM has a mandate and concession, for an indefinite period, to supply electricity in the country. Decree 42/2005 designates EDM as the system and market operator of the national transmission grid.

Mozambique law includes provisions for awarding concessions for generation, distribution, or operation in a particular area to a private operator.⁹ EDM could also outsource operation in an area for part of its assets provided that it informs the MIREME and that the ministry does not object.

⁸ Operational: CTRG (175MW, gas), Gigawatt (100MW, gas) and Kuvaninga (40MW, gas). Under construction: CTM (100MW, gas) and Mocuba (40MW, solar).

⁹ The Vilanculos mini-grid with a private operator lasted only one year because consumers served by the system complained of higher cost of electricity compared with costs for people who were connected to the main system. Although unsuccessful in the end, this project showed that, from a legal and regulatory point of view, it is possible for a private agent to engage in power generation, distribution, and operation of grids.

Fundo de Energia (FUNAE)

Decree 24/97 following Article 9 of Law 2/87 formally created FUNAE as a fund. FUNAE's main objectives are:

- To develop and produce low-cost sources of energy for low-income population in rural and urban areas.
- To foster conservation and rational and sustainable use of energy resources.

FUNAE has a countrywide mandate and reports to MIREME.

FUNAE has been active in securing government and development partner funding for off-grid power production systems. Results have been impressive, including the electrification of 260 villages, 580 schools, 561 health centers, 74 administrative post buildings, and 3 fish markets and ice storage facilities; construction of mini-hydro generation facilities; installation of 19 water-pumping systems; and distribution of 1,500 cook stoves. Additionally, FUNAE has contributed to some on-grid electrification projects.¹⁰

Although FUNAE does not have a legal mandate to operate services and provide electricity to end users, it has also been performing these tasks in some cases.

Given the need to expand access in rural areas, FUNAE's mandate is also under review to address these challenges.

Other actors in the power sector

Other relevant actors in the power sector in Mozambique include:

- Cahora Bassa Hydroelectric (HCB), a 2,075 MW hydropower plant owned by the GoM (92.5 percent) and Redes Energéticas Nacionais of Portugal (7.5 percent).
- Independent power producers (IPPs). The first large-scale on-grid private generation plant was a 65MW emergency power plant that was commissioned as a temporary arrangement to reduce an energy gap in 2014. Other IPPs include the 175 MW gas-fired Central Térmica de Ressano Garcia (CTRG) plant, commissioned in 2014; the 100 MW gas-fired Gigawatt Power Plant in Ressano Garcia, commissioned in 2015; and the 40 MW Kuvaninga gas-fired power plant in Gaza Province, commissioned in 2017.
- Mozambique Transmission Company, a transmission company equally owned by EDM, Eskom of South Africa, and the Swaziland Electricity Company. It is responsible for supplying electricity to the Mozal aluminium plant in Mozambique and for transmitting power to EDM and the Swaziland Electric Company.

¹⁰ Information provided by FUNAE in meeting held at FUNAE's premises, October 6th 2016.

3 Challenges to increasing access to electricity services

Challenges to accelerated access to electricity services identified in response to the Diagnosis Report (developed under Task 1 of this project), are in three areas: institutional, financial, and technical.

Institutional challenges

- **Planning.** While multiple plans have been elaborated, planning has not been continuous or coordinated. There is neither an organization responsible for planning nor a planning procedure to follow, and the enforceability of plans is not clear.
- **Human resources.** There are not enough qualified technical staff at MIREME or EDM for effective planning, implementation, and monitoring.
- **Criteria for prioritizing electrification projects.** Once projects are identified, there is no clear procedure or criteria for sorting them by priority. EDM has established a new process for prioritizing electrification projects and is working to operationalize it.
- **Formal framework for EDM and FUNAE coordination.** Although EDM and FUNAE coordinate their areas of intervention, they do so on informal basis rather than a formally established framework.
- **CNELEC's consultative role in tariff setting and cost recognition in tariffs.** CNELEC has only a consultative role in tariff setting. A new law recently approved by the Parliament has strengthened its regulatory capabilities. This will require the new institution, ARENE, to build up the internal capacity to effectively develop the required tariff studies.

Financial challenges

- **Funding plans to develop electrification projects (both on-grid and off-grid).** The lack of an adequately specified process for planning future projects, as mentioned above, undermines planning for their funding and constrains the tools that can be used for funding. An Integrated Power Sector Master Plan is currently being undertaken, with the assistance of the Japan International Cooperation Agency, that could improve planning for funding.
- **Financial sustainability of EDM.** Under current arrangements, EDM bears the burden of expanding electricity access in a context where applicable tariffs do not reflect the efficient cost of electricity service provision and are below the power purchase cost.
- **Connection charges.** As in many other countries where connection charges have been a barrier to electrification and to densification, connection charges represent a substantial burden for Mozambican households.
- **Affordability of tariffs for rural households.** Some groups are unable to afford electricity tariffs for on-grid electricity supply. Tariffs and connection costs that reflect actual costs need to be adjusted to make them affordable to the poorest households, to protect their access.

Technical challenges

- **System reliability.** Adding many new consumers in a short period of time will affect system reliability if the expansion is not well planned. Even if new consumers use little

electricity initially, the increase in number of consumers and in consumption per consumer over time may hurt system reliability if upstream investments do not accompany this demand growth. Location of the new demand may also affect congestion and system reliability for particular areas, if not for the system overall.

- **Standards and specifications at the distribution level.** Although EDM has produced standards for construction of distribution assets, they are not sufficiently detailed. The result is distribution infrastructure that is not standardized. A new set of standards, not yet approved, has been developed, that would contribute to standardization.
- **Centralized procurement of materials.** There is no centralized purchase of materials, and consequently engineering, procurement, and construction contractors provide all the necessary materials. There are alternatives that usually present substantial savings.
- **Use of cost-effective technologies for on-grid electrification.** Although EDM uses such cost-effective technologies as single-wire earth return (SWER), EDM does not use extensively enough to reduce electrification costs.
- **Project delivery.** Currently, an external engineering, procurement, and construction contractor and supervisor are appointed to deliver projects, this is often an expensive approach to grid expansion. This model can be improved to reduce costs.

4 Strategy

Government policy for electrification

The Government of Mozambique sets the electrification target for the country, which then guides the National Electrification Strategy

- **Access**, defined as having electricity service of any kind, may differ for on-grid and off-grid electrified households:
 - A household that is connected to the grid is considered to have full access to electricity service.
 - Households with off-grid electrification have different levels of access, depending on which off-grid system supplies them. The World Bank has developed a multitier framework for levels of electricity service (figure 4.1). Tier 0 represents households with no access that use traditional sources of energy such as Fuelwood and kerosene. The other tiers are ordered in increasing levels as measured by hours of supply, peak power, and consumption. While the target for Mozambique is to achieve universal electricity services equivalent to on-grid service, alternative transitional solutions providing lower levels of service (tiers 2–5) may be acceptable during the pre-electrification stage.
- **The official target** for access to on-grid-equivalent electricity services is 100 percent by 2030, up from 26 percent in 2016.¹¹

Figure 4.1. The World Bank has developed a multitier framework for levels of electricity service



Source: World Bank - Multi-Tier Framework for Tracking Energy Access - Update on the framework design and implementation of global surveys.¹²

The feasibility of achieving this target depends on:

- Funding, either from the government and EDM or from external sources.
- Planning and preparation of electrification projects.
- Logistics for implementing the projects.

¹¹ EDM, Historic Data 2001–2015.

¹² <http://www.se4all.org/content/webinar-multi-tier-framework-tracking-energy-access>

- Operation and maintenance of services in a technically and commercially fast-growing system.

New Electrification Approach

The following assumptions underlie the Strategy prepared:

- Electrification will be based on grid-equivalent service. Where the connection cost per consumer exceeds US\$2,000/kVA, off-grid alternatives will be considered.
- This Strategy is focused on developing electrification in the country (access to electricity service) independently of the geographical localization of customers (rural, urban, peri-urban) and type of clients (commercial or social) to meet that target.
- Own expansion area (OEA) is the area adjacent to low voltage (LV) lines up to a distance of 100 meters. Inside this area, EDM is obliged to connect to the grid any consumer who requests service. The connection cost is the standard connection cost defined in the regulation (or this Strategy) and can be paid in installments. The cost of connecting and supplying these consumers is recognized in the tariff approved for EDM.

Initially the distance is defined narrowly at 100 meters to minimize the financial burden on EDM. This distance could eventually be modified by regulation. If the distance is increased, higher costs of EDM will have to be recognized in the tariff and will be paid by customers, especially because EDM may not get soft loans from IFIs to expand access.

- Non-own expansion area (non-OEA) is any location that is not within an OEA. Inside a non-OEA, EDM is not obliged to connect to the grid everyone who requests service. Capital expenditures in non-OEAs will be financed by the proposed Electrification Account, to be managed by the Ministry of Economy and Finance, using resources received from the GoM and a proposed electricity fee levied on electricity sold. EDM is not obligated to repay any of these capital expenditures. However, households and other consumers connected in a non-OEA are EDM customers, EDM is responsible for operating and maintaining these assets, and the operational costs are recognized in the tariff.

Achieving the Government's policy objective in a least-cost, timely, and efficient manner requires setting clear guiding principles, identifying mechanisms for monitoring implementation, and establishing a revision process to accommodate changes based on progress achieved and lessons learned.

The following principles were considered in designing the Strategy:

- Access targets will be defined by the policy set by the GoM (coincident with UN development goals). These decisions can be made after various access scenarios for level and speed of achieving targets are evaluated.
- A planning process, with short-term enforceable outputs, will be a key element of the Strategy.
- Decisions on on-grid and off-grid electrification will take into account social aspects and political priorities for economic development. Areas with high poverty levels and areas with rapid economic growth will receive priority.
- Clear criteria for prioritizing projects identified by the Power Sector Master Plan include:
 - The least-cost option, as defined in the Master Plan.

- Use of existing assets with spare capacity on the grid (“densification”); other criteria may complement this one.
- Local governments making financial contributions.
- Economic activities in certain zones being promoted.
- Areas with lower human development index (HDI) and development corridors receiving attention.
- Social inclusion being promoted through acceleration of access to energy.
- Both building and operating on-grid electrification will be EDM’s responsibility.
- Building off-grid electrification will be the responsibility mainly of FUNAE.
- For operation and maintenance FUNAE will transfer its built assets to EDM; EDM may outsource operation of these assets to private operators or to the local community.
- Where areas of intervention might overlap in a project, EDM and FUNAE will coordinate their efforts.
- The tariff will be geographically uniform per type of consumer.
- Sustainable (cost-reflective) tariffs will be balanced with adequate cross-subsidies for the poorest population.
- An earmarked electricity fee levied on sales will fund electrification expansion as managed by the Electrification Account.















These principles are elaborated below under the three key aspects: institutional, financial, and technical.

Institutional aspects

Institutional roles and responsibilities

Figure 4.2 summarizes institutional roles and responsibilities in the proposed Strategy for electrification and indicates how ready each institution is. This representation refers exclusively to an institution’s involvement in the Strategy; its other activities are not discussed.

Figure 4.2. Proposed institutional roles, responsibilities, and readiness for implementing the Strategy for expanding electricity access

	Government (GoM)	Ministry of Finance	MIREME	EDM	FUNAE	ARENE	Electrification Account	Private Sector
Setting general policy objectives	Sets national policy and energy sector policy 		Translates GoM policy and defines targets, sets intermediate objectives to meet energy policy objectives 					
Planning		Participates	Leads the planning process 	Participates 	Participates 	Participates 	Participates	Participates
Plan approval	Approves 	Recommends approval (or not) 						
Setting construction standards				Sets standards for on-grid 	Sets standards for off-grid 	Undersigns standards 		
Setting quality of service						Sets quality objectives 		
Setting tariffs				Applies for tariff review 		Proposes and approves tariffs 		

Funding of projects	Provides guarantees for funds lent by IFIs; repays loans to IFIs and provides additional funding ●	Operationalizes funds received from international financial institutions and additional funding decided by GoM ●					Funds projects from the plan and repays loans (from IFIs and GoM) through collection of the electrification fee	
Plan implementation				Buils on-grid and off-grid infrastructure ●	Buils off-grid infrastructure corresponding to on-grid line extensions outside off-grid and transfers to EDM once commissioned ●			Participates as contractor building assets ●
Operation of assets				Operates and maintains assets ●				Operates assets outsourced by EDM (mostly off-grid) ●

- The institution can carry out the activity with the current resources and know-how, at least in initial stages.
- The institution can carry out the activity with the current resources and know-how with some difficulty and needs to improve the technical capacity of staff or increase the number of staff.
- The institution cannot perform today the activity with the existing human resources and needs serious resource capacity building of and additional staff.

The Government of Mozambique (GoM)

The GoM sets global and social objectives for energy policy at a high level of generality: they will be developed by MIREME and implemented by EDM, FUNAE, Hidroeléctrica de Cahora Bassa, and the private sector.

Objectives set by GoM represent the country's global strategy. For energy, they could touch on:

- Improving efficiency.
- Reducing reduce energy imports and increasing exports.
- Developing national energy sources, including renewable energy.
- Achieving universal access to electricity by 2030.

The GoM receives funds from international finance institutions (IFIs) to finance various programs, including programs for improving access to electricity, following policy objectives the GoM sets.

Ministry of Mineral Resources and Energy (MIREME)

MIREME has a central role in two aspects of electrification:

- As the part of the GoM, communicating energy sector objectives to sector stakeholders, developing the Strategy, and monitoring its implementation.
- Developing an integrated planning process with these characteristics:
 - The planning process becomes part of MIREME's permanent activities.
 - Though planning is a participative activity including all sector stakeholders, MIREME is the responsible institution and leads the process.
 - Planning is integral—covering generation, transmission, and distribution. It must consider the demands greatly expanded access will place on generation and transmission.
 - The results of planning are enforceable: only the projects included in the approved plan will be financed.
 - EDM can temporarily shoulder a larger share of planning responsibilities until MIREME builds up its capacities, skills, and tools.

So MIREME has to:

- Provide clear national objectives for the energy sector, specifically for electrification.
- Provide the electrification objectives and for projects emerging from planning with a reasonable degree of detail. Projects should be differentiated into at least these categories:
 - Projects for on-grid electrification:
 - Projects (connections) carried out by EDM on a commercial basis under its obligation to connect, paid with EDM funds gathered through the electricity tariff.
 - Projects carried out by EDM and paid totally or partially with international financial institution (IFI) funds.
 - Projects carried out by EDM and paid totally or partially with Electrification Account funds.
 - Projects for off-grid electrification
 - Projects carried out by FUNAE and paid totally or partially with IFI funds.

- Projects to be carried out by FUNAE and paid totally or partially with Electrification Account funds.
- Establish the sources of funding for projects—IFI funds (loans, grants), Electrification Account funds, and the tariff paid by those connected in EDM’s service areas—and the share of funding from each source.

The Energy Regulating Authority (ARENE)

ARENE has only recently been created, with the responsibilities of a typical regulator—setting independent tariffs, licensing operators, monitoring service, and setting standards for connections and for services. It is expected to take on these roles once the new Electricity Law that has been approved by Parliament is implemented.

As part of the new decree that establishes it, ARENE could have these responsibilities and roles in electrification:

- Participate in planning by advising the GoM and MIREME broadly on electricity sector issues.
- Endorse planning standards: this activity is directly linked with designating acceptable technologies and, therefore, defining service quality and setting the tariff on service.
- Establish service standards and performance indicators that EDM (and eventually other operators) have to meet. This is key for tariff setting and establishing service quality parameters and, in turn, construction standards. Standards vary depending on the technology and the locality (rural / urban).
- Enforce the grid code.
- Set tariffs taking into account the above-mentioned issues.
- Conduct the Licensing process.

Electrification Account

The Electrification Account, will have the following characteristics and roles:

- The Electrification Account will finance specific projects to improve electricity access as fast as possible.
- It will be an escrow account protected by ring-fencing, managed by the Ministry of Economy and Finance, with the unique objective of funding capital expenditures for electrification in non-OEAs.
- It receives resources from the GoM and from a proposed electrification fee levied on electricity sold (5 percent of tariff before tax for consumers who are not in the social tariff).
- It receives requests for funding projects from EDM and FUNAE and undertakes an investment analysis for each project.
- It reviews requests for funding projects, checks the eligibility of each project, prioritizes projects, and funds them according to funds availability, considering the GoM goals, the planning approved by the MIREME, and the initial categorization of projects.
- It regularly makes public the projects it finances and changes in the account as a matter of transparency.

EDM (Mozambique Electricity Company)—a new business model

For successful implementation of the new business National Electrification Strategy, there is need for EDM to adopt a new Business Delivery Model which recognizes and differentiates two key dimensions of electricity supply: commercial energy and social energy. Under this

model, EDM is responsible for on-grid electrification in OEA and delivers social energy under the non-OEA framework, under the following principles:

- EDM is obliged to connect all consumers in OEAs (defined as areas within 100 meters of existing LV lines) who request connection.
- The cost of the OEA connections and of supplying electricity to these consumers is recognized in the tariff.
- EDM may also approach such non-OEA projects as isolated mini-grids but is not obliged to.
- EDM is not responsible for paying for new connections and grid extensions in non-OEAs. These costs are paid with funds from the GoM (including IFIs) and the Electrification Account; EDM is not required to reimburse them, and ultimately the Electrification Account pays for the investment.
- EDM operates the new grids on commercial terms, so the cost is recognized and paid fully by the tariff.
- EDM participates as a substantive stakeholder in the planning process, initially leading planning until MIREME builds sufficient capacity.
- EDM, assigned a set of planned projects and objectives, develops the projects in detail, performs feasibility studies, and makes a tentative prioritization.
- Request for funding is made to the Electrification Account, which reviews the project definition and feasibility studies and decides on financing according to the plan, availability of funds, and directives from GoM/MIREME. Projects may be funded initially with funds from the GoM/IFI programs agreed with the GoM, but in the end this funding is paid back by the Electrification Account.
- Once the Electrification Account decides on the financing scheme and informs EDM of approval (and eventually makes these decisions public), EDM implements projects.
- In all cases, EDM disburses funds for capital expenditures according to predefined construction milestones.
- EDM must immediately transfer the electrification fee levied on tariffs to the Electrification Account.

FUNAE (The Energy Fund)

FUNAE is responsible for constructing off-grid community-based electrification and on-grid social energy electrification, under these principles:

- Capital expenditures for developing off-grid electrification are provided by the Electrification Account and the GoM (including IFIs).
- FUNAE is not liable to pay back the funds for off-grid connections, which are financed by GoM, IFIs, and the Electrification Account. Ultimately the Electrification Account pays for these connections.
- FUNAE does not operate assets; once a project is finished and commissioned, FUNAE hands it over to EDM, which can operate it or outsource operation to a qualified operator appointed through a competitive process.
- FUNAE participates as a stakeholder in the planning process.
- FUNAE is assigned a set of projects and objectives from the planning process, develops them, performs feasibility studies, and makes a tentative list of project priorities.
- FUNAE requests funding from the Electrification Account, which reviews the project details, eligibility, and feasibility studies and decides on financing according to the plan, availability of funds, and directives from GoM/MIREME. Projects may be funded

initially with funds from GoM/MIREME or IFI programs agreed with the GoM, but in the end, these funds are paid back by the Electrification Account to the creditors.

- Once the Electrification Account decides on the financing scheme and informs FUNAE (eventually makes these decisions public), FUNAE implements the approved projects.
- In all cases, funds for capital expenditures are disbursed according to predefined construction milestones.
- Electrification projects with a capacity higher than 1 MW need special treatment by FUNAE: construction standards should foresee a possible connection to the grid in the future, and they should be coordinated with EDM as “pre-electrification” projects.

Cahora Bassa and other independent power producers

Once electrification progresses, more capacity (and energy) will be needed to supply domestic demand. Energy can come from expanding the capacity of Cahora Bassa or from using existing capacity domestically once export contracts expire (rather than renewing them).

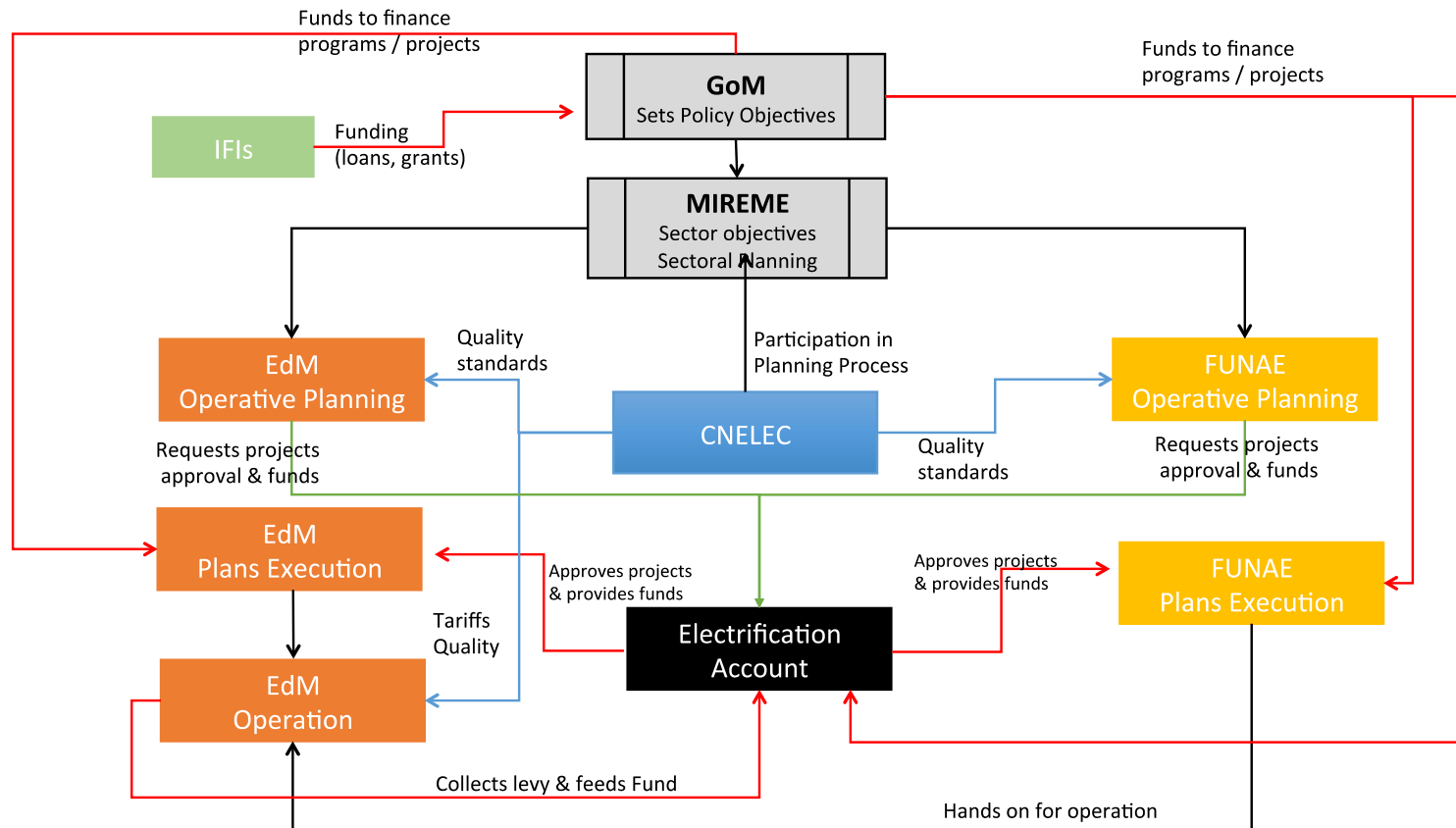
Part of the revenues from Cahora Bassa could eventually be used to supply the Electrification Account, but a tax or levy on exports is not recommended because of its effects on cross border trading.

And a tax or levy on IPPs to fund the Electrification Account is also not recommended because the IPPs are likely to transfer the cost to consumers by increasing the price of electricity. This would create a double charge for final consumers, who are already paying the electrification fee to fund the Electrification Account.

Institutions mapping

Figure 4.3 represents the relationship among institutions schematically.

Figure 4.3. Institutional roles in planning, funding, and executing the proposed Strategy for electrification



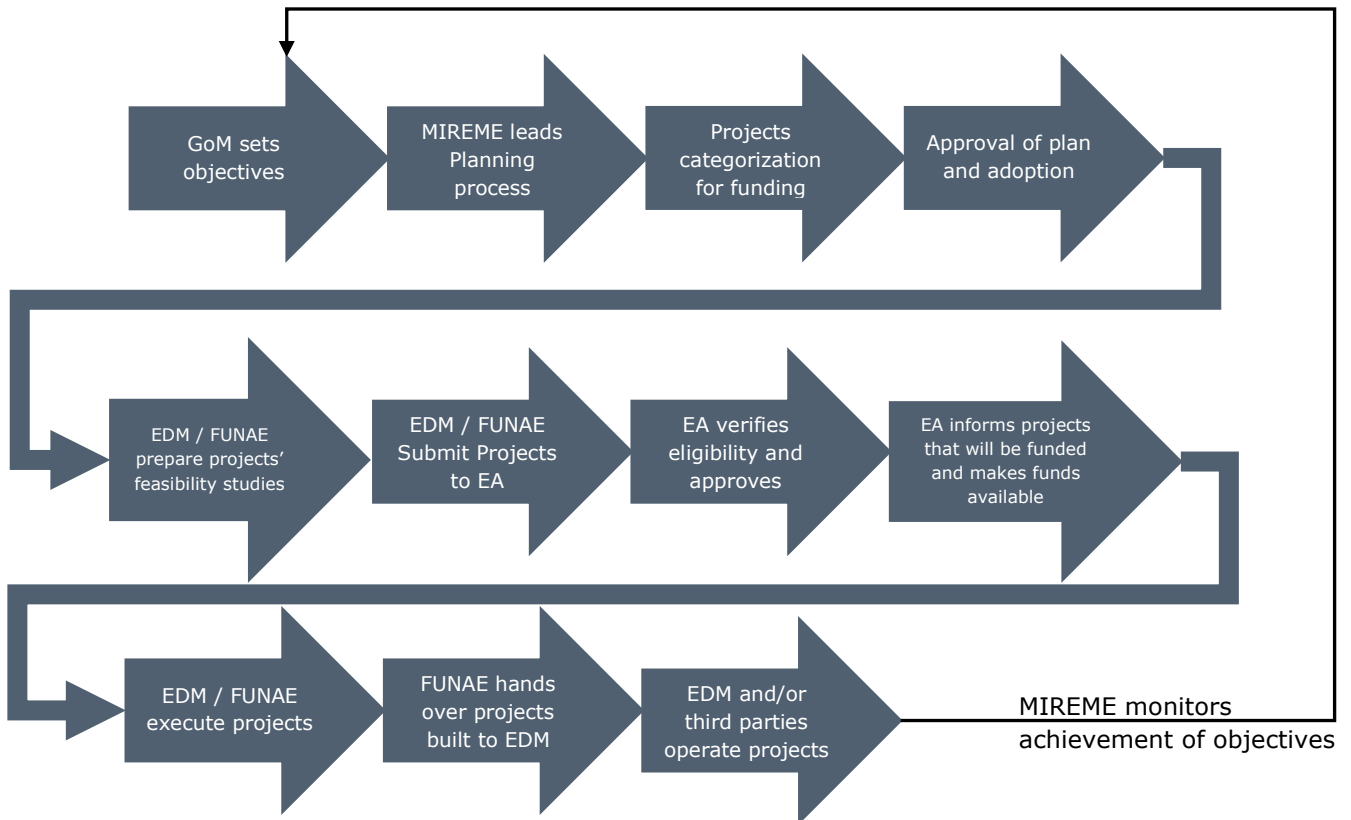
CNELEC is the National Electricity Council. EDM is the Mozambique Electric Company. FUNAE is the Energy Fund. GoM is the government of Mozambique. IFIs are international financial institutions. MIREME is the Ministry of Mineral Resources and Energy.

Note: Red arrows represent flows of money. Blue arrows represent regulations. Green arrows represent requests for funding. The higher black arrow represents setting objectives and planning. The lower black arrow represents transfer of assets for operation after they have been commissioned. The figure does not represent the institutional hierarchy, but rather institutional relationships.

The flow of planning, deciding, funding, and carrying out projects

The flow of planning, deciding, funding, and carrying out projects goes through a series of institutions (figure 4.4).

Figure 4.4. Electrification program cycle



EDM is the Mozambique Electric Company. FUNAE is the Energy Fund. GoM is the government of Mozambique. IFIs are international financial institutions. MIREME is the Ministry of Mineral Resources and Energy. EA is the Electrification Account.

Legal requirements

The implementation of the process requires legal and regulatory instruments.

To create the electrification fee funding the Electrification Account, a new law would cover:

- The definition of which consumers will be taxed with this levy.
- The amount of the levy.
- The procedure to modify or eliminate the levy.
- The definition of who will collect the levy.
- Procedures and penalties in case the levy is not transferred to the Electrification Account.
- The obligation to earmark the resources so that they only fund projects aiming to improve access.
- Conditions for eliminating the levy because it ceases to be applicable.

Creating the Electrification Account may not need a law but can occur through a decree of resolution of the Cabinet. It should cover:

- Objectives of the Electrification Account.
- Governance.
- Sources of financing.
- Eligibility of projects.
- Activities and responsibilities.
- Principles for prioritization of projects.
- Conditions for disbursing funds.
- Monitoring of projects and fund disbursement.
- Penalties and procedures in case of non-compliance.
- Reporting and accountability.

Regulatory requirements

A regulation may be necessary to complete the provisions of the existing law. Additionally, it must define in detail:

- Tariff methodology, including tariff calculation formula, tariff setting procedures, periodic tariff revision (requiring public hearings), and automatic tariff adjustment due to key cost drivers.
- Tariff regulation explicitly establishing that:
 - The GoM and Electrification Account pay for capital expenditures for electrification for consumers in non-OEAs.
 - The tariff is a national tariff, with no differentiation due to geography, but for lower income consumers there is a lower social tariff, which additionally does not bear the electrification fee funding the Electrification Account.
 - The tariff is set in recognition of the efficient costs of operating and supplying all consumers.
 - The tariff is set in recognition of the efficient costs of connection in OEAs.
 - Assets transferred to EDM financed by the Electrification Account do not require remuneration for capital expenditures but do create operational costs, including a depreciation allowance, for EDM.
 - Some mechanism cross-subsidize operational costs of off-grid systems.

Preparation by the institutions to execute the proposed Strategy

The institutions have preparatory tasks before the Strategy can be fully implemented (table 4.1).

Table 4.1. Institutions' preparations for the electrification Strategy

Institution	Preparatory activities
GoM	Review and set access targets Instruct for the law or decree creating the Electricity Account
MIREME	Prepare initial activities and schedule regular planning

	<p>Institute a group or office within MIREME in charge of planning and monitoring the plan</p> <p>Find funding for building capacity of professional staff</p> <p>Discuss and agree with EDM and FUNAE the first electrification projects to be undertaken with available funds</p> <p>Train staff</p>
Ministry of Economy and Finances	<p>Prepare rules for implementing the Electrification Account</p> <p>Implement a transitional procedure using funds available from IFIs while the Electrification Account is being creating</p>
EDM	<p>Finalize and propose standards</p> <p>Select a small initial list of relevant materials for bulk purchasing</p> <p>Design and implement a procedure for bulk purchasing selected materials</p> <p>Define standard schemes for electrification projects (see table 4.2).</p> <p>Identify densification projects.</p> <p>Coordinate with MIREME a set of projects and schedule for a fast implementation.</p> <p>Prepare a program to strengthen planning and project implementation and monitoring capacities</p> <p>Begin developing logistic capacities for implementing an electrification plan.</p>
FUNAE	<p>Identify a set of low-cost off-grid projects.</p> <p>Coordinate with MIREME a set of projects and schedule for fast implementation.</p> <p>Define standard schemes for off-grid electrification.</p> <p>Prepare a program to strengthen planning and project implementation capacities</p>
ARENE	<p>Once the Law establishing the regulator is implemented, the regulator has to immediately approach the tariff setting task:</p> <ul style="list-style-type: none"> • Build capacity in terms of tariff setting • Analyze and implement results to the tariff study that is being carried out <p>Approve building and quality of service standards</p>

EDM’s standard cases or schemes for electrification provide a clear, transparent, and economical way to make decisions regarding technologies and engineering characteristic of typical projects for efficient fast-track electrification. The schemes classify electrification projects and for each category define a typical or basic engineering project benefiting from the standardization of construction materials, making it very simple to implement projects while reducing time and cost (table 4.2).

Table 4.2. Electrification scheme examples

			Indicative Design Parameters		
System	Methodology	Settlement Type	D = Distance from EDM Grid	P = Demand per household (kVA)	Population Density
On-grid	Connection of new users to existing LV network (220–400V)	Urban and peri-urban	$D < 10m$	$3.0 < P < 5.0$	High
	Densification (LV and urban MV extension)	Urban and peri-urban	$10m < D < 5km$	$3.0 < P < 5.0$	High
	3-phase rural MV (main and laterals) and LV extension	Rural	$5km < D < 30km$	$2.0 < P < 3.0$	High
	3-phase rural MV (main), SWER (19kV) for laterals and LV extension	Rural	$10km < D < 30km$	$1.0 < P < 2.0$	Medium
Off-grid	Mini-grid with centralized generation and LV network	Rural	$D > 30km$	$0.1 < P < 1.0$	Medium
	Solar home system	Rural	$D > 30km$	0.1	Low

EDM is Mozambique Electricity Company. kVA is kilovolt amperes. LV is low voltage. MV is medium voltage.

Note: Where there is an anchor consumer, the electrification methodology will be evaluated differently.

Financial aspects

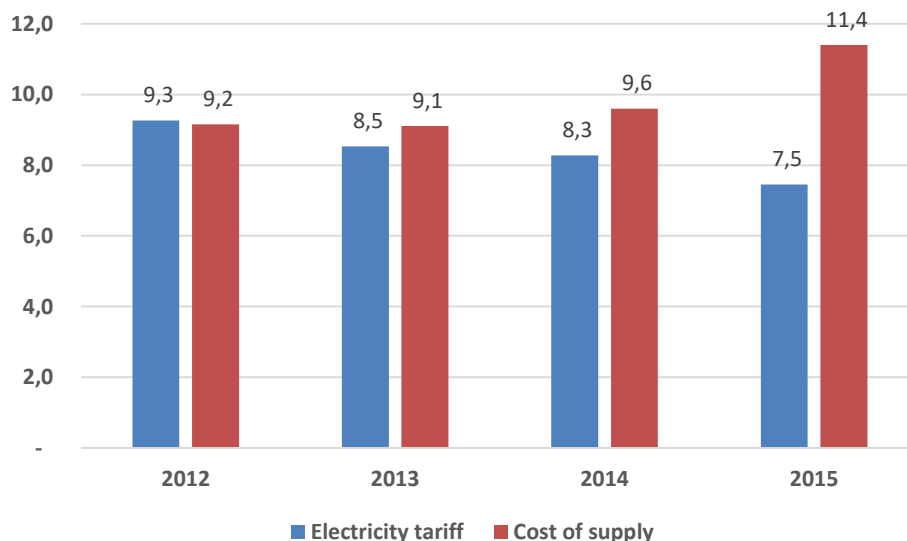
Tariff Policies

The following aspects of the current electricity tariff policy should be reviewed.

Tariffs should reflect the efficient cost of providing electricity services

Current electricity tariffs do not cover the cost of supply in Mozambique. The gap between the average electricity tariff and the average cost of supply has widened over recent years, mainly due to increased costs of acquiring energy (figure 4.3). The erosion of the tariff has been further exacerbated by the unusual huge depreciation of the metical (62 percent against the US dollar in 2015–16)¹³ and the fact that electricity tariffs had not been adjusted in accord with changes in the price of acquiring energy and the level of currency depreciation for many years. In particular, the average electricity tariff was estimated at 7.5 US cents/kWh in 2015, while the average cost of supply was estimated at 11.4 US cents/kWh. EDM is operating at a loss and is not financially sustainable with the current tariffs in a macroeconomic environment where access to funding has become extremely complex.

Figure 4.3. Evolution of gap between the average tariff and cost of supply, 2012–2015 (US cents/kWh)



Source: EDM, Historic data.

Additionally, EDM is currently not only leading but also mostly funding electrification in Mozambique. The non-cost reflective tariffs hinder the sustainability of on-grid electrification.

Appropriate regulations and institutions are necessary to ensure that EDM recoups the efficient costs of providing electricity if it provides the target quality of service.¹⁴ The tariff should incorporate cost-reflective mechanisms, such as an automatic pass-through of generation-related fuel costs and adjustments for the exchange rate and inflation. Remuneration of EDM should also include the depreciation of its assets and a reasonable

¹³ The metical depreciated by 27 percent against the US dollar in 2015, and by an additional 35 percent in 2016.

¹⁴ This includes a reasonable level of losses; normally, a loss reduction program is agreed with the regulator to create a reasonable "glide path" to the desired level of losses.

return on investment. EDM needs this compensation to provide acceptable electricity service and fund the replacement of its asset

The tariff should exclude remuneration for capital expenditures for assets funded through the electrification program—by the Electrification Account or by the GoM channeling IFI grants and soft loans—since they are not funded directly by EDM. Ownership of those assets shall be transferred to EDM free of any charge or tax, and the tariff should, however, include the EDM’s costs of operating, maintaining, and depreciating those assets. Remuneration to EDM should also cover depreciating the LV drop equipment and the meter.

Uniform tariffs

Electricity tariffs are currently uniform across the country. Rural on-grid users pay the same tariff as urban on-grid users despite higher electrification costs in rural areas, where households tend to be dispersed over remote and inaccessible areas and low consumption limits normal electricity sector economies of scale. Although uniform tariffs may not be the most financially efficient scheme, they are socially and politically acceptable worldwide. Uniform tariffs should be maintained in Mozambique as in many developed and developing countries (for example, Spain, Kenya, and Vietnam). This practice implies cross-subsidies among rural and urban consumers.

FUNAE usually charges off-grid consumers according to the EDM tariff. Sometimes FUNAE charges a flat tariff, not varying with the consumer’s energy consumption, that is usually higher than the EDM tariff but not necessarily cost-reflective. FUNAE should implement uniform tariffs for off-grid consumers, too, implying a cross-subsidy among on-grid and off-grid consumers.¹⁵

Additionally, EDM needs room to negotiate agreements with third parties for more efficient operation and maintenance of particular off-grid systems. Third parties may be private operators or even the local community, who can be trained to run the system. But their consumers should remain customers of EDM, which is legally responsible for service.

EDM, if it is the only operator of the network, can internally manage the implicit cross-subsidies among rural and urban on-grid consumers, and among on-grid and off-grid consumers. If private power distribution companies enter the sector, the cross-subsidy should be made explicit in a regional tariff subsidy fund managed by the energy regulator or MIREME. The cross-subsidy should allow private operators revenues for efficient operation and maintenance costs, asset depreciation, and a reasonable return on investment.

Affordability

Affordability can be assessed as an acceptable level of utility expenditure as a share of household expenditure. Setting this benchmark requires a value judgment that will change over time and place, so many governments and international financial institutions have developed *ad hoc* rules on acceptable utility expenditures (table 4.4). In Mozambique, the threshold for affordability of electricity should be 10 percent of total household expenditure, and affordability should not be a concern when the share is below 5 percent.

¹⁵ It is recommended that electricity tariffs cover the total cost of supply. It is also recommended that the tariff is uniform along the country. This implies there is a cross-subsidy among consumers as, if the tariff is uniform, some users will pay more than their corresponding cost of supply (e.g. urban and on-grid consumers) and some other users will pay less than their corresponding cost of supply (e.g. rural and off-grid users).

Table 4.4. Benchmarks for utility affordability (percentage of total household expenditure)

Source	Electricity	Heating	Water	All utility bills
World Bank (2002)	10-15		3-5	
WHO (2004)	10			
IPA Energy (2003)	10	20		
Ukraine government (2000)				20

WHO is World Health Organization. IPA is Instrument for Pre-accession Assistance
Source: EBRD¹⁶

Translating the affordability rate into a tariff requires estimating average household expenses. Table 4.5 provides estimated monthly average household expenses per income quintile, with quintile 1 the poorest and quintile 5 the richest. The estimates rely on these factors:

- The average expense per capita and per quintile are based on the 2014–15 Household Survey by Mozambique’s National Statistics Institute.¹⁷
- The average household size of 5.0 people came from the same study.¹⁷ In the richest quintiles the average household size was assumed to be slightly lower than in the poorest quintiles.
- Average household expenses were calculated as average expenses per capita times the average household size.
- Inflation indexes of 2.4 percent for 2015 and 16.7 percent for 2016 were applied to present the results in constant 2017 meticaís.¹⁸

Table 4.5. Estimated average household monthly expenses per quintile (Mt)

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Average expenses per capita, 2014	297	538	791	1,223	4,191
Average household size	5.50	5.25	5.00	4.75	4.50
Average household expenses, 2014	1,634	2,824	3,955	5,807	18,861
Average household expenses, January 2017	1,953	3,375	4,726	6,940	22,539

Source: Calculations based on data from Relatório Final do Inquérito ao Orçamento Familiar 2014/15, Instituto Nacional Estatística de Moçambique and World Data Atlas at <https://knoema.com/atlas/Mozambique/CPI-inflation>.

Table 4.6 shows current electricity tariffs.

Table 4.6. Current electricity tariffs in Mozambique

Monthly Consumption (kWh)	Social (MT/kWh)	Residential (MT/kWh)	Agricultural (MT/kWh)	General (MT/kWh)	Fixed rate (MT)
0-100	1.07	-	-	-	0
0-300	-	4.04	3.40	5.80	152.37
301-500	-	5.072	4.84	8.29	152.37
>500	-	6.00	5.30	9.07	152.37
Pre-Payment	1.07	5.14	4.71	8.31	-

Source: EDM as of June 2017

Table 4.7 estimates average monthly tariffs per income quintile. The estimates rely on these factors:

¹⁶ European Bank for Reconstruction and Development, Can poor consumers pay for energy and water? An affordability analysis for transition countries, Working paper No. 92, 2005.

¹⁷ Relatório Final do Inquérito ao Orçamento Familiar 2014/15, Instituto Nacional Estatística de Moçambique.

¹⁸ Inflation indexes obtained from: <https://knoema.com/atlas/Mozambique/CPI-inflation>.

- The average consumption assumed for the richest quintile (200 kWh) was derived from consumers in Maputo, Beira, and Nampula, three of the biggest cities of Mozambique. The average consumption assumed for the second richest quintile is derived from peri-urban consumers in the same cities.¹⁹
- The average consumption assumed for the rest of quintiles were much more moderate, based on experience with similar electrification projects in Kenya.
- The two poorest quintiles were assumed to be included in the social tariff.²⁰
- Current electricity tariffs for residential consumers were used (see table 4.6).
- The average variable rate of residential tariffs of consumers of the richest quintile was assumed to be 4.25 Mt/kWh, slightly higher than the rate of 4.04 Mt/kWh, in order to account for some consumers consuming more than 300 kWh a month.

Table 4.7. Estimated average monthly tariffs per household and quintile

	Unit	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Fixed rate of residential tariffs	Mt	0	0	152.37	152.37	152.37
Variable rate of residential tariffs	Mt/kWh	1.07	1.07	4.04	4.04	4.25
Expected monthly consumption	kWh	15	30	45	80	200
Monthly tariffs	Mt	16	32	334	476	1,002

See table 4.5 for average monthly household expenditures per quintile.

Table 4.8 estimates monthly connection charge expenses per quintile. Key factors include:

- Although the cost per connection was estimated at US\$500 in the Master Plan developed by Norconsult and Vattenfall,²¹ a connection charge of just US\$72, covering part of costs of the LV drop, the meter, and the labor, was assumed to promote affordability.
- The current exchange rate of Mt 62.88/US\$1 was assumed.²²
- All of quintile 5, the richest, was assumed to pay the connection charge upfront.
- Quintiles 1–4 were assumed to pay the connection charge in 72 equal monthly instalments, to be adjusted for inflation but without financing costs.

Table 4.8. Upfront connection charge for quintile 5 and monthly connection installment charge for other quintiles 1–4 (Mt)

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Connection charge	63	63	63	63	4,527

See table 4.5 for average monthly household expenditures per quintile.

¹⁹ These consumption figures were provided by the World Bank.

²⁰ Currently, only those consumers with a contracted capacity below 1.1 kVA, consuming less than 100 kWh per month, and having certified low-income status are eligible for the social tariff. The number of residential consumers on the social tariff amounted to only 3,596 in 2015, while the number of consumers on the residential tariff amounted to 1,259,638 consumers (The World Bank, Policy note on the Mozambique Energy Sector, 30th November, 2015).

²¹ Technical Assistance to Strengthen EDM's Capacity for Investment and Network Development Planning: Master Plan Update Project, 2012 – 2027: Final Master Plan Update Report: Volume III – Main Report dated 30 April 2014.

²² Obtained from: <http://www.xe.com/currencyconverter/convert/?From=USD&To=MZN>. Accessed on 2017/05/09.

Summary of affordability

Table 4.9 summarizes tariff and connection charge expenses as a share of total household expenses for each quintile under the assumptions used for tables 4.5–4.8:

- For the two poorest quintiles, there are no affordability concerns. For quintile 1, electricity expenses are 4.0 percent of household expenses, and for quintile 2, 2.8 percent.
- For the richest quintile, tariffs alone (4.4 percent of household expenses) pose no affordability concerns. But if these consumers pay the connection charge up front, their total electricity expenses would be 24.5 percent of household expenses, much higher than the 5 percent level of concern for affordability, due to connection expenses that amount to 20.1 percent of monthly household expenses. If the connection charge is spread over three months' household expenses, the monthly share of 6.7 percent is still above the 5 percent level of concern. So affordability would be a concern if the whole richest quintile were required to pay a US\$72 connection charge up front. To find what part of the population can afford to pay the connection charge up front, it would be convenient to break down the richest quintile into deciles or even percentiles, but that information was not available.
- For both quintile 3 and quintile 4 the shares of electricity expenses in household expenses are above the 5 percent level for concern about affordability, but still below the 10 percent threshold for affordability identified in international experience.

Table 4.9. Average electricity expenses as a share of and total household by quintile

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Average monthly expenses, January 2017 (Mt)	1,953	3,375	4,726	6,940	22,539
Estimated average monthly tariffs (Mt)	16	32	334	476	1,002
Tariffs per monthly expenses (percent)	0.8	1.0	7.1	6.9	4.4
Connection charges (Mt)	63	63	63	63	4,527
Connection charges per monthly expenses (percent)	3.2	1.9	1.3	0.9	20.1
Total electricity expenses (Mt)	79	95	397	538	5,530
Total electricity expenses per monthly expenses (percent)	4.0	2.8	8.4	7.8	24.5

Connection cost subsidy

Because of affordability concerns raised if the whole richest quintile of the population were required to pay a connection charge of US\$72 up front, only consumers with a contracted capacity above 3 kVA should be required to pay the charge up front (or else to negotiate with EDM more flexible payment terms), for LV connections. Consumers with a contracted capacity below 3 kVA should be required to pay in 72 equal monthly instalments to be adjusted for inflation (but with no financing costs). Consumers with a contracted capacity below 250 W should be able to apply for a ready-board²³ that will be fully subsidized.

²³ A ready-board is an equipment consisting of electrical plug points, switches and light bulbs, used in households without electrical wiring, to allow the consumer to connect and use electrical devices in a safe manner.

Consumers with medium voltage (MV) connections should be required to pay the connection charge up front or to negotiate with EDM more flexible payment terms.

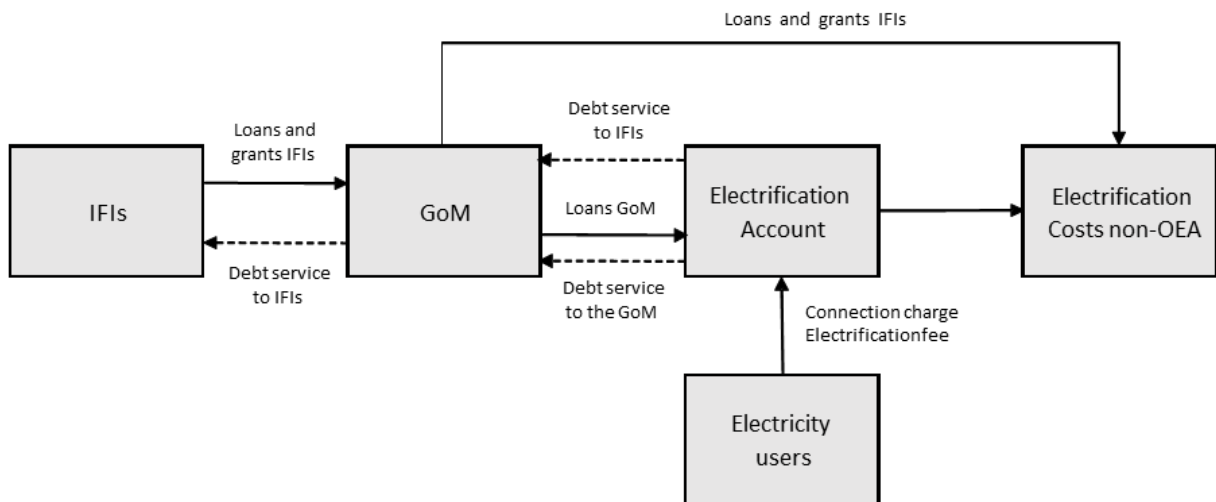
Funding electrification outside OEA

The following model estimates the financial needs of the electrification program outside the areas where EDM is obliged to provide service—that is, outside areas 100 meters to each side of existing LV lines.

In non-OEA, EDM should fully recoup the connection costs, which are to be borne by the electrification program. There are three financing sources (figure 4.4): (1) electricity users, who support electrification through a connection charge and an electrification fee and, (2) IFIs, which offer soft loans and grants and (3) GoM, which provides loans.

Loans and grants from IFIs are to be directly transferred to electrification projects, with the GoM as the party responsible for covering the resulting debt service. The Electrification Account is to manage the financial resources obtained from the electricity users and the GoM to cover part of the electrification costs and the debt service to IFIs and the GoM.

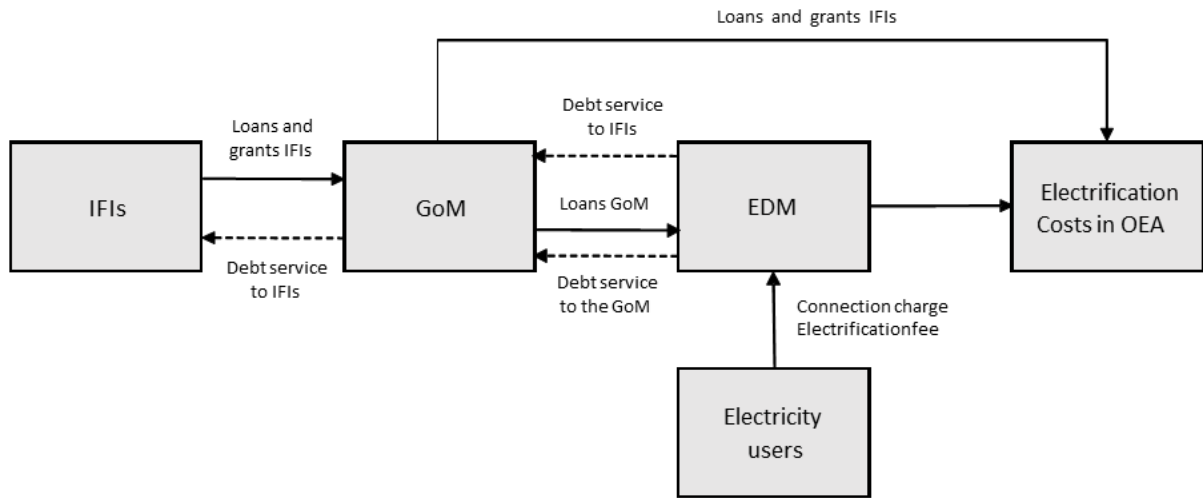
Figure 4.4. Cash flow of the electrification program outside the EDM’s own expansion areas



GoM is government of Mozambique. IFIs are international financial institutions.

In contrast, the cash flow of electrification in OEA is shown in figure 4.5. The electrification costs are borne by EDM and financed by the connection charge of electricity users and additional funds from IFIs and the GoM, so EDM fully recoups the connection costs in OEA as well as non-OEA. It is assumed that the tariff will be cost-reflective and large enough to ensure repayment of this financing.

Figure 4.5. Cash flow of the electrification program inside the areas of own expansion by EDM



EDM is Mozambique Electricity Company. GoM is government of Mozambique. IFIs are international financial institutions. OEA are own expansion areas.

The cost of electrification will grow with access to electricity. In 2016, 26 percent of the population were estimated to have access to electricity. The number of residential consumers amounted to 1,335,207, the average household size was estimated at 5.0 people, and the population was estimated at 25,727,603 people.²⁴

Access will slightly increase to about 26.8 percent in 2017 under the following assumptions:

- Only 120,000 residential consumers were be connected in 2016–2017.
- Average household size remained the same as in 2015.
- Population grew at a rate of 2.5 percent a year, the same rate as in 2005–2015.

From 2018 onwards, it has been assumed that the electrification program will support the electrification effort. Further assumptions are:

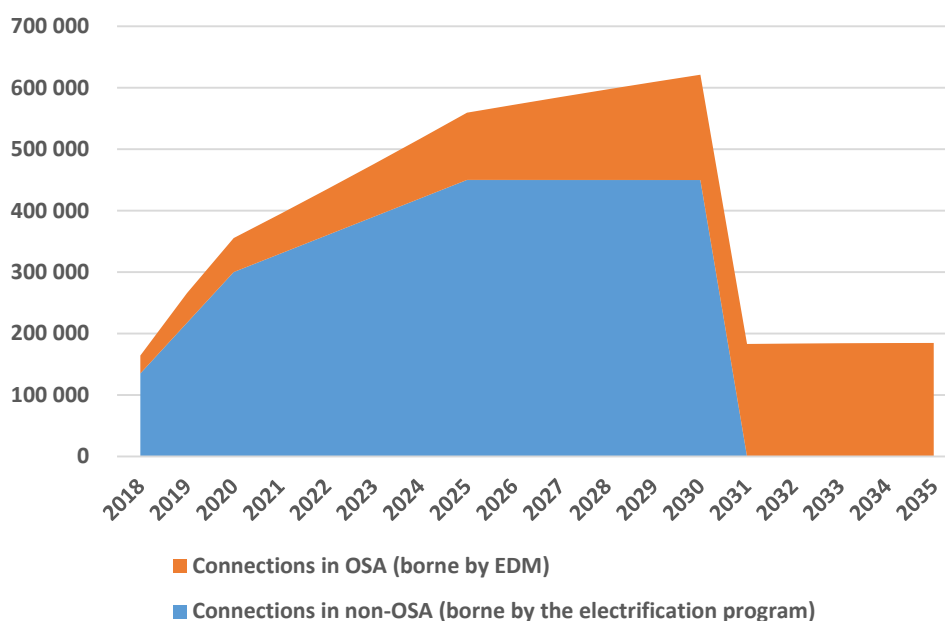
- The average household size will decrease by 0.1 percent a year, from 5.0 people in 2018 to 4.4 in 2030, 4.0 in 2040, and 3.3 in 2060.²⁵
- Population growth will decrease from 2 percent in 2018 to 0 percent in 2060.
- The country achieves full access to electricity by 2030.
 - The number of new connections of residential consumers in non-OEA increases from 135,000 a year in 2018 to 300,000 in 2020 to 450,000 in 2025, and then remains constant until 2030. Over 2018–2030 the average number of new connections is about 373,000 consumers a year—4,852,000 in total.
 - The number of new connections of residential consumers in OEA increases in line with the electricity access, population increase, and household size decrease (Figure 4.6 and Table 4.9).

²⁴ EDM, Historic data 2001–2015.

²⁵ This decrease is in line with the international pattern due to, among other reasons, more effective safer and cheaper birth control, the changing position of women, and a geographically mobile labor force. For instance, the average household size in South Africa decreased from 4.4 people in 1995 to 4.0 in 2004 and 3.6 in 2004 (Restructuring of Households in Rural South Africa: Reflections on Average Household Size in the Agincourt Sub-district 1992–2003, Southern Africa Labour and Development Research Unit). In Canada, the average household size decreased from 6.2 people in 1851 to 4.3 in 1941 and 2.5 in 2011 (<http://www.statcan.gc.ca/pub/11-630-x/11-630-x2015008-eng.htm>)

- From 2031 onwards, when the country has already achieved universal access, all new consumers are connected in OEA with the cost to be borne by EDM.

Figure 4.6. Projected residential consumers per year, 2018–2035



EDM is Mozambique Electricity Company. OEA is own expansion area.

Table 4.9. Projected access, 2020–2060

	2020	2030	2040	2060
Population	28,644,358	33,713,497	37,859,444	41,433,010
Population growth rate per year (percent)	1.9	1.4	1.0	0.0
Average household size	4.9	4.4	4.0	3.3
Average household size decrease per year (percent)	-1	-1	-1	-1
Electricity access (percent)	38	100	100	100
Residential consumers	2,240,413	7,606,967	9,445,610	12,638,582
New connections (accumulating from 2018)	785,206	6,151,760	7,990,403	11,183,375
New OEA connections (accumulating from 2018)	132,706	1,299,812	3,138,455	6,331,427
New non-OEA connections (accumulating from 2018)	652,500	4,851,948	4,851,948	4,851,948

OEA is own expansion area.

In non-OEA areas connections can be on-grid or off-grid. Electrification costs include the MV and LV systems required from the point of supply to each connection (see appendix B for further detail):

- Three technologies with different costs may be used in non-OEA on-grid connections (table 4.10).

- The costs of off-grid connections have been initially estimated at about US\$2,000 per connection. These include solar home systems and represent an average cost for off-grid only for estimations of funds needs at this strategy level.
- The share of on-grid connections per year is assumed to be 99 percent of all connections from 2018 to 2025, decreasing to 70 percent in 2030 (table 4.11).
- Estimates assume that for on-grid technologies, 5 percent of connections will be the most expensive and 47.5 percent of connections each of the less expensive.
- Off-grid connection over 2018–2030 would amount to 9.8 percent of non-OEA connections. This is in line with the currently estimated 9.5 percent share of off-grid connections required in Kenya to achieve universal access.

Table 4.10. Electrification costs per connection and per technology in non-own expansion areas

Technology	Average cost per connection (US\$)
Off-grid	2,000
On-grid	
Technology 1	1,200
Technology 2	1,300
Technology 3	2,300

Table 4.11. Share of new connections in non-OEA per technology (percentages)

Technology	2020	2025	2030
Off-grid	1	1	30
On-grid	99	99	70
Technology 1	47.5	47.5	47.5
Technology 2	47.5	47.5	47.5
Technology 3	5	5	5

Costs to be borne by the electrification program are assumed to increase over 2018–2025 due to the increasing number of connections and over 2025–2030 due to increasing average cost per connection (table 4.12). From 2031 on, no electrification costs to the program are assumed, as Mozambique will have achieved universal access and all new consumers will be connected inside EDM’s own expansion areas.

Table 4.12. Average electrification cost per connection and accumulated electrification costs in non-own expansion areas to be borne by the electrification program, 2020–2030

	2020	2025	2030
Average electrification cost per connection (US\$) ^a	1,309	1,309	1,512
Electrification costs accumulated since 2018 (US\$ million)	854	3,408	6,652

Note: a) Calculated using the electrification costs from Table 4.10. and the share of connections in table 4.11. Average electrification cost per year increases over 2025–2030 due to the increasing share of off-grid connections.

Revenue from the connection charge of residential consumers in non-OEA is the product of the connection charge and the number of connections (table 4.13):

- A connection charge of US\$72 has been assumed.

- The share of consumers required to pay the charge up front has been assumed to account for only 5 percent of connections. Most consumers who can afford the charge are probably already connected.
- Other consumers are assumed to pay in 72 monthly instalments (6 years) with no financing costs. To model that new consumers are connected throughout the year they were assumed to pay on average 6 monthly instalments in the first and last year and 12 monthly instalments in the 5 intermediate years.
- Only 95 percent of the connection charge revenues will be transferred to the Electrification Account. The remaining 5 percent will be charged by EDM for administrative costs in compensation for EDM's management of payment of the connection charge.
- From 2037 onward, no revenues from the connection charge are expected as Mozambique will achieve universal access by the end of 2030 and the payment period for the last non-OEA consumers will end in 2036.

Table 4.13. Revenue from the connection charge, 2020–2030

	2020	2030	2040
Number of non-own expansion area connections accumulated since 2018	652,500	4,851,948	4,851,948
Connection charge (US\$)	72	72	72
Share connections required to pay upfront (percent)	5.0	5.0	5.0
Payment period for the rest of consumers (years)	6	6	6
Share of revenues transferred to the Electrification Account (percent)	95	95	95
Revenue accumulated since 2018 (US\$ million)	11	244	332

Revenue from the electrification fee is the product of the electrification fee, the average tariff, and electricity consumption (table 4.14):

- The electrification fee was assumed to be implemented in 2020.²⁶
- The fee will not be charged on exports.
- The fee will not be charged to residential consumers on the social tariff. The number of residential consumers on the social tariff was only 3,596 in 2015, 0.3 percent of residential consumers.²⁷ Projections of the number of consumers on the social tariff are based on these assumptions:
 - 5,000 consumers on the social tariff by the end of 2017.
 - The share of new residential consumers on the social tariff will decrease from 50 percent of new connections in 2018 to 15 percent of new connections by 2060.
 - Three percent of consumers on the social tariff will leave the social tariff group every year.
- The fee is assumed to be 5 percent of the electricity tariff for all other consumers, residential and non-residential. The fee is not directly indexed to the exchange rate or to the cost of supply but is affected by them through the electricity tariff, which is affected by the cost of supply and exchange rate. The electrification fee is assumed to be reduced when revenues exceed electrification and financing costs.

²⁶ When the operation of the Electrification Account is assumed to become effective.

²⁷ World Bank, Policy note on the Mozambique Energy Sector, 30 November 2015

- The average tariff of consumers not on the social tariff is assumed to increase to Mt 7.55/kWh (US\$0.12/kWh²⁸) by 2020 and then remain constant in real terms.
- In 2015 the average annual consumption of consumers was estimated at 584 kWh per capita.²⁹ Over the first years of electrification (2018–2030) average consumption per household can be expected to slightly decrease as lower-income consumers³⁰ are electrified. By 2060, the average annual consumption is assumed to increase to 4,500 kWh per capita and then remain constant.³¹
- Revenues collected through the electrification fee will be transferred to the Electrification Account.

The resulting revenue increases in the short term with the increase in the number of consumers and in the long term with the increase in average electricity consumption per capita.

Table 4.14. Revenues from the electrification fee

	2020	2040	2060
Number of residential consumers	2,062,758	9,354,273	12,575,389
Share of residential consumers on the social tariff (percent)	14	24	14
Number of residential consumers on the social tariff	294,534	2,259,239	1,773,211
Average consumption per consumer on the social tariff (kWh/month)	33	52	100
Electrification fee on consumers on the social tariff (percent)	0	0	0
Number of residential consumers not on the social tariff	1,768,223	7,095,033	10,802,178
Average consumption per consumer on residential tariff (kWh/month)	109	179	400
Electrification fee on consumers on the residential tariff (percent)	5.0	5.0	5.0
Electric power consumption per capita kWh/year	523	994	4,500
Electrification fee, nonresidential tariff (percent)	5.0	5.0	5.0
Average tariff, domestic and nonresidential tariffs (Mt/kWh)	7.55	7.55	7.55
Rate of collection of invoices (percent)	98.0	98.3	98.5
Share of the revenues collected transferred to elect. account (percent)	100.0	100.0	100.0
Revenues obtained from the electrification fee (US\$ million)	33	198	136
Revenues from the electrification fee (cumulating from 2020) (US\$ million)	33	2,140	5,861

Additional financing from IFIs and the GoM is needed to close the deficit between the costs of electrification and financing and the revenues from electricity users. For a given year:

- The revenues from electricity users (through the connection charge and the electrification fee) were assumed to cover the repayment of previous loans and electrification costs.
- If the revenues from electricity users were high enough to fully cover financing and electrification costs, the electrification fee would be reduced so that revenues did not exceed costs.

²⁸ Assuming the current exchange rate of Mt 62.88 /US\$1.

²⁹ EDM, historic data, 2001–2015.

³⁰ Consumers with lower incomes than the consumers currently connected to the grid.

³¹ The average annual electricity consumption per capita of the population with access to electricity in South Africa was 4,229 kWh in 2014: <http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC>

- Grants and soft loans from IFIs would cover the gap between revenues from electricity users and electrification costs.³²
- Loans from the GoM would cover repayment of new loans from IFIs (if any), the repayment of the deficit between the revenues from the electricity users and the repayment of previous loans (if any).

Loans from IFIs were modeled under the following terms (table 4.15)³³

- Grace period: 6 years.
- Maturity: 38 years.
- Interest rate: 1.42 percent.
- Payment of interest during the grace period at a rate of 1.42 percent.
- No other fee was included in the model for the sake of simplicity.
- Currency: US dollar.

On the other hand, loans from the GoM to the Electrification Account were modeled under the following terms:

- No grace period.
- Maturity: 20 years.
- Interest rate: 1.42 percent.
- No other fee was included in the model for the sake of simplicity.
- Currency: Metical.

Table 4.15. Assumptions on the loan terms

	Grace period	Interest during the grace period	Maturity	Interest rate	Currency
Loans from international financial institutions to electrification projects	6 years	1.42 percent	38 years	1.42 percent	US\$
Loans from the government of Mozambique to the Electrification Account	No	—	20 years	1.42 percent	Metical

Additionally, it was assumed that:

- The Electrification Account does not hedge foreign currency risk.
- Neither revenues nor costs are adjusted for inflation.
- To express results in US\$, current exchange rate of 62.88 Mt/ US\$1 is assumed.³⁴

Total financing needs in non-own expansion areas

Achieving universal access by 2030 requires about US\$6,530 million to be provided by IFIs and the GoM for financing the connections in non-OEA.³⁵ In particular, loans from IFIs amount to about US\$4,714 million, grants from IFIs amount to about US\$1,571 million and loans from the GoM amount to about US\$244 million (figure 4.7).

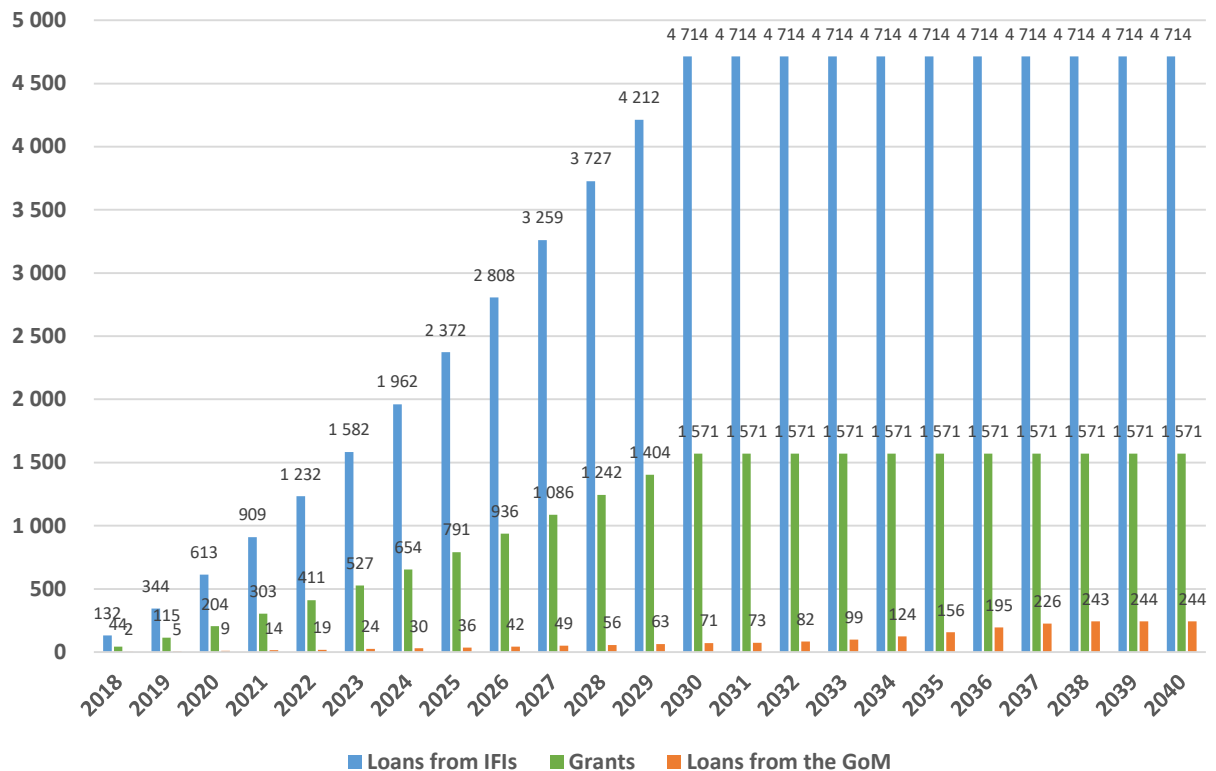
³² Grants from IFIs were assumed to cover 25 percent of the gap and loans from IFIs were assumed to cover 75 percent of the gap.

³³ International Development Association credit rates and charges and International Development Association fixed rates for FY17 Q4 (effective as of April 1, 2017) obtained from: <http://treasury.worldbank.org/bdm/htm/IDACreditPricing.html>.

³⁴ Obtained from: <http://www.xe.com/currencyconverter/convert/?From=USD&To=MZN>. Accessed on 2017/05/09.

³⁵ The financing needs of connections of consumers in OEA were not modeled in this section.

Figure 4.7. Accumulated needs for financing from IFIs and the GoM, 2016–2040, for electrification in non-own expansion areas (US\$ million)



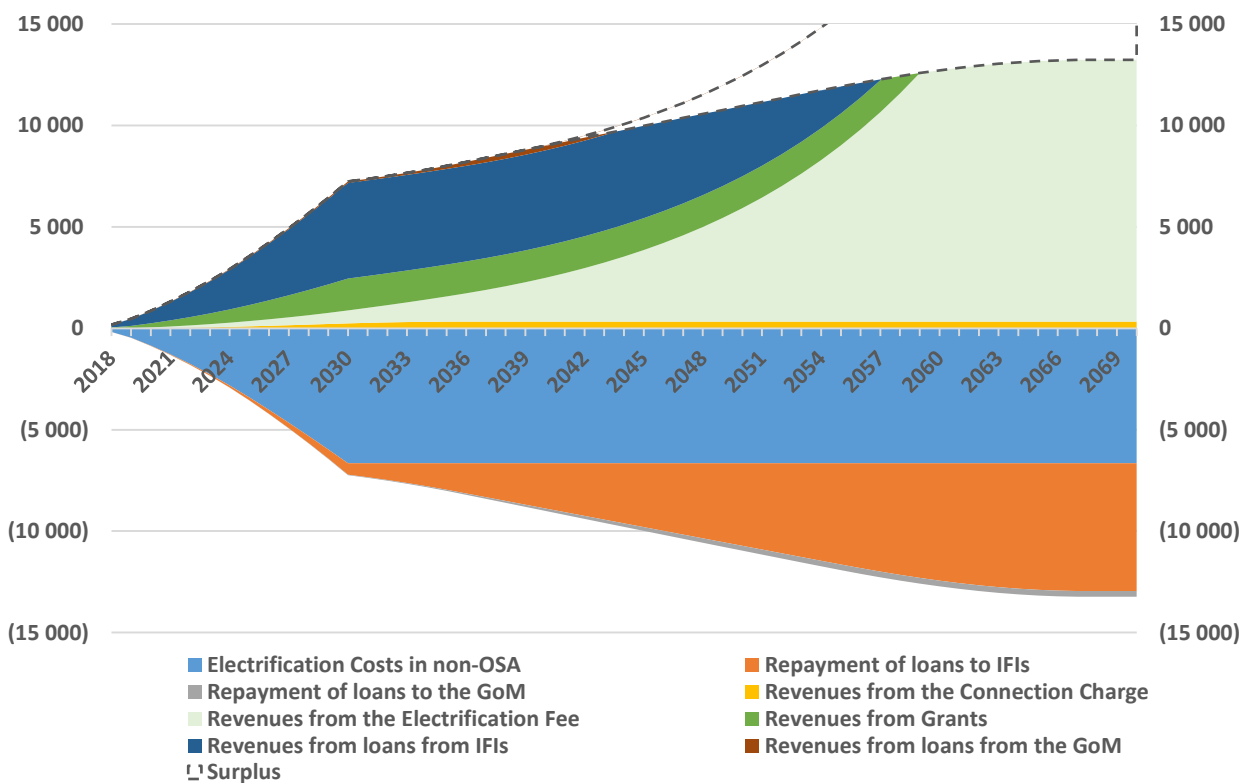
GoM is government of Mozambique. IFIs are international financial institutions.

Projections of the accumulated yearly costs and revenues from 2018 to 2070 of the electrification program in non-OEA are shown in figure 4.8 and Table 4.16:

- The electrification costs increase in line with the increasing number of non-OEA connections over 2018–2025 and with the increasing average cost per connection over 2025–2030. From 2031 on, there are no electrification costs because Mozambique is assumed to have already achieved universal access, so that all new consumers will be connected inside OEA.
- The trajectory of connection charge revenues is guided by both the assumed number of non-OEA connections and the six-year payment period of most consumers. From 2037 on, there are no connection charge revenues because Mozambique is assumed to have achieved universal access by 2030 and payment by the last consumers connected will be completed in 2036.
- Revenues from the electrification fee increase in the short term in line with the increase in the number of residential consumers and in the long term with the increase in the average electricity consumption per consumer.
- Over the first years, the gap between electrification costs and revenues from consumers is closed by grants and loans from IFIs. In turn, financing costs for those loans are covered in part by loans from the GoM. And over the first years as electrification costs increase, financing from IFIs and the GoM also increases (see figure 4.8).
- In 2031, there are no electrification costs, but the revenues from electricity users are still not high enough to fully cover the financing costs, so additional funds from the GoM are needed (see figure 4.8).

- In 2040, the revenues from the electrification fee are high enough to fully cover the financing costs, so there is no need for further funds from the GoM. The electricity fee can be reduced below 5 percent for the first time (figure 4.9), because otherwise the revenues from users would exceed total costs and create a surplus (represented as the white area in figure 4.8).
- In 2058, the last repayment of loans is made to the GoM, and those loans are repaid in full.
- In 2067, the last repayment of loans is made to the IFIs, and those loans are repaid in full.
- In 2068, the Electrification Account can be closed, as all the electrification and financing costs have been covered.

Figure 4.8. Accumulated yearly costs and revenues, 2018–2069, of the electrification program for non-own expansion areas (US\$ millions)



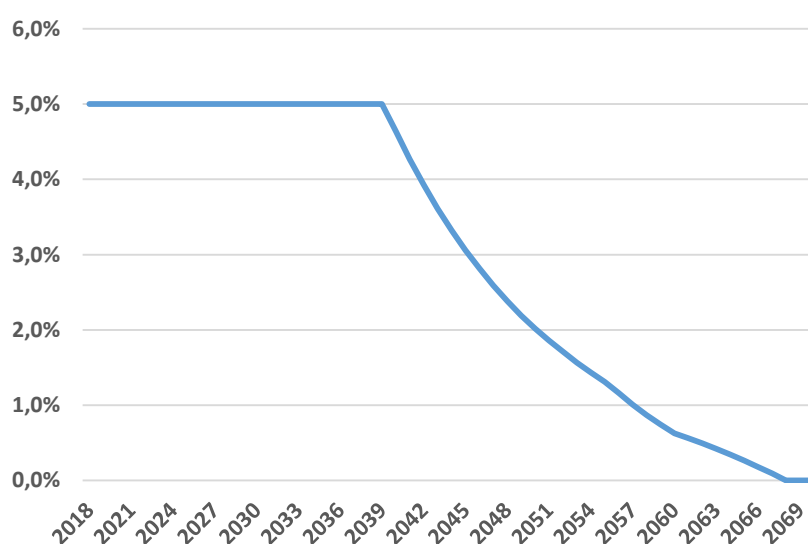
GoM is government of Mozambique. IFIs are international financial institutions. Non-OEA are non-own expansion areas.

Table 4.16. Accumulated yearly costs and revenues, 2018–2070, of the electrification program for non-own expansion areas (US\$ millions)

	2020	2030	2040	2050	2070
Electrification costs	854	6,652	6,652	6,652	6,652
Repayment of loans to IFIs	15	564	2,229	4,072	6,301
Repayment of loans to the GoM	1	24	121	238	282
Total Costs	871	7,240	9,001	10,962	13,234
Revenues from the connection charge	11	244	332	332	332
Revenues from the electrification fee	33	639	2,140	4,101	6,373
Grants	204	1,571	1,571	1,571	1,571
Loans from IFIS	613	4,714	4,714	4,714	4,714
Loans from the GoM	9	71	244	244	244
Total Revenues	871	7,240	9,001	10,962	13,234

GoM is government of Mozambique. IFIs are international financial institutions.

Figure 4.9. The electrification fee, 2018–2069 (percentage of residential and non-residential tariff)



Additional scenarios

Two other possible scenarios were modeled—one with lower electrification costs and another with lower electricity access.

Lower electrification cost scenario

In this scenario, on-grid electrification costs were estimated to be 30 percent lower than in the base scenario under the assumption that optimal procurement and execution procedures will be implemented (table 4.17, see “Technical aspects” for discussion of the assumed procedures).

Table 4.17. Electrification costs per connection in non-own expansion areas under lower-cost scenario (US\$)

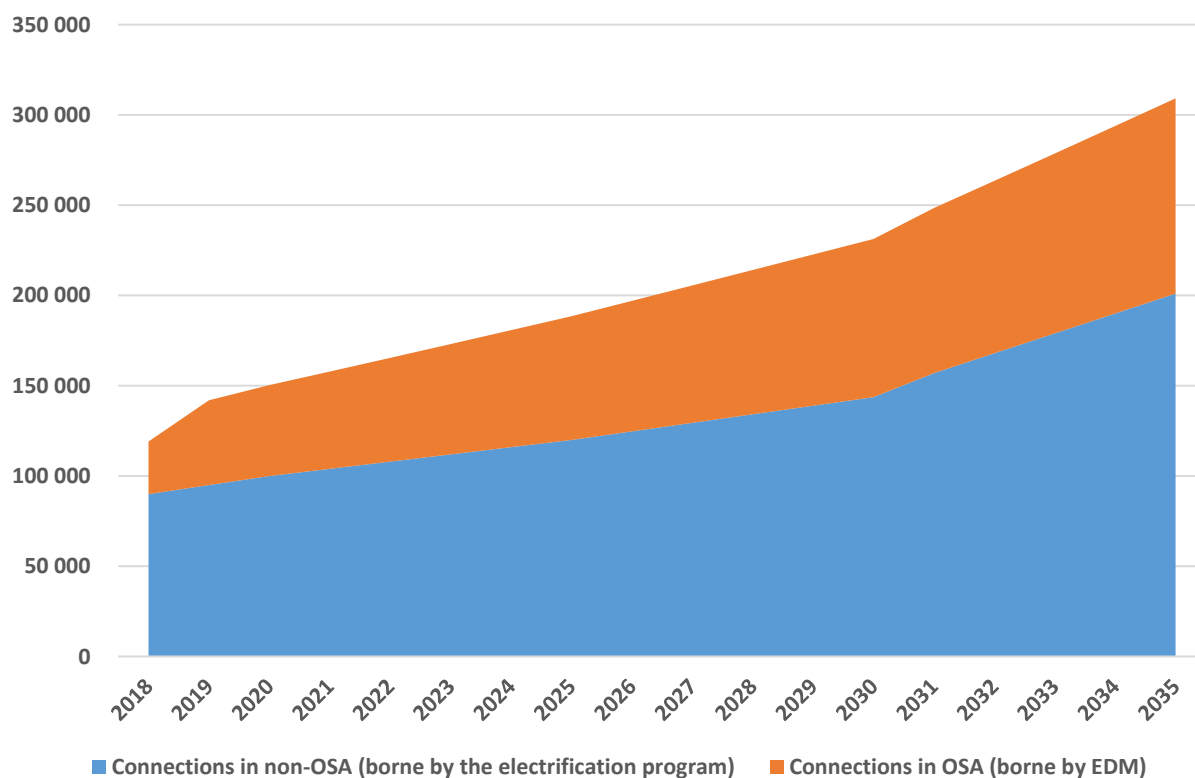
Area	Technology	Average cost per connection
Off-grid	Off-grid	2,000
On-grid	Technology 1	840
	Technology 2	910
	Technology 3	1,610

Lower electricity access scenario

The scenario of electricity access lower than in the base scenario used these assumptions:

- Electricity access increases to 50 percent in 2030.
- Universal access is achieved by 2055.
- The number of new non-OEA connections a year of residential consumers increases from about 90,000 in 2018 to 140,000 by 2030 and 200,000 in 2035, after which the number remains constant until 2055. Over 2018–2030, the average number of new connections a year is about 116,000 (1,516,100 in total) (figure 4.10 and table 4.18).

Figure 4.10. Connections of residential consumers per year under lower electricity access scenario



EDM is Mozambique Electricity Company. OEA is own expansion area.

Table 4.18 Connections under lower electricity access scenario

	2020	2030	2040	2060
Population	28,644,358	33,713,497	37,859,444	41,433,010
Population growth rate per year (percent)	1.9	1.4	1.0	0.0
Average household size	4.9	4.4	4.0	3.3
Average household size change (percent)	-1	-1	-1	-1
Electricity access, end of year (percent)	32	50	72	100
Residential consumers, end of year	1,866,617	3,803,121	6,803,875	12,638,594
Connections (accumulated from 2018)	411,410	2,347,914	5,348,668	11,183,387
<i>Connections in OEA (accumulated from 2018)</i>	126,410	831,814	1,931,983	4,750,532
<i>Connections in non-OEA (accumulated from 2018)</i>	285,000	1,516,100	3,416,685	6,432,855

OEA is own expansion area.

Tables 4.19 and 4.20 compare the base scenario with the lower electricity cost scenario and the lower electricity access scenario.

Table 4.19. Electrification costs and revenues in non-own expansion areas, 2018–2030, under base, lower cost, and lower access scenarios (US\$ millions)

	Base scenario	Lower cost scenario	Lower access scenario
Electrification costs in non-OEA	6,652	4,942	2,038
Repayment of loans to IFIs	564	386	167
Repayment of loans to the GoM	24	17	7
Total costs	7,240	5,344	2,212
Revenues from electricity users	884	884	648
Grants from IFIs	1,571	1,103	387
Loans from IFIS	4,714	3,308	1,160
Loans from the GoM	71	50	17
Total revenues	7,240	5,344	2,212

GoM is government of Mozambique. IFIs are international financial institutions. OEA are own expansion areas.

Table 4.20. Electrification costs and revenues in non-own expansion areas, accumulated 2018–2070, under base, lower cost, and lower access scenarios (US\$ millions)

	Base scenario	Lower cost scenario	Lower access scenario
Electrification costs in non-OEA	6,652	4,942	8,802
Repayment of loans to IFIs	6,301	4,421	3,839
Repayment of loans to the GoM	282	58	50
Total costs	13,234	9,420	12,691
Revenues from electricity users	6,705	4,960	8,818
Grants from IFIs	1,571	1,103	957
Loans from IFIS	4,714	3,308	2,872
Loans from the GoM	244	50	43
Total revenues	13,234	9,420	12,691

GoM is government of Mozambique. IFIs are international financial institutions. OEA are own expansion areas.

The Electrification Account

General structure and sources of funding of the Electrification Account

The Electrification Account will manage the financial resources obtained from electricity users and the GoM to cover part of the electrification costs in non-OEAs and the debt service to IFIs and the GoM (see figure 4.4). Loans and grants from IFIs are to be directly transferred to electrification projects, with the GoM responsible for the resulting debt service, so loans and grants from IFIs are not to be transferred to the Electrification Account.

The resulting sources of funding of the Electrification Account would be:

- The electrification fee.
- The connection charge.
- Loans from the GoM.
- Annual budget allocations by the GoM.³⁶
- Fees from independent power producers.

Disbursements from the Electrification Account would be:

- Debt service to IFIs.
- Debt service to the GoM.
- Electrification costs.

Administration and oversight of the Electrification Account

The Electrification Account would be an escrow account under the management of the Ministry of Economy and Finance and under fiduciary administration of a bank or agency.

The Electrification Account should be ring-fenced to protect it: the only outflows should be electrification costs and debt service to IFIs and the GoM. Legislation should require EDM to transfer all funds from the electrification fee to the Electrification Account.

All transactions of the Electrification Account should be public, and they should be published regularly by the agency or bank administering the account.

No additional institutions would be needed to fund non-OEA electrification, and the account would be transparent, accountable, and fit for tracing money and auditing.

Eligibility of electrification projects for financial support from the Electrification Account

All non-OEA electrification projects identified in the planning process to be developed by MIREME would be eligible for financial support from the Electrification Account.

Requests for funding electrification projects would come from EDM and FUNAE to the Ministry of Economy and Finance. The ministry, considering the GoM goals, the planning approved by the MIREME, and the initial categorization of projects, would review the eligibility of each project and fund the selected ones.

³⁶ Modeling in the section "Funding electrification outside OEA" did not include any budget allocations from the GoM.

Cumulative revenues and disbursements of the Electrification Account

Table 4.21 projects the accumulated annual revenues and disbursements of the Electrification Account from 2020 (when the account is assumed to become effective) 2080. Tables 4.22 and 4.23 project those amounts under the additional lower electricity cost and lower electricity access scenarios. It is here noted again that:

- The Electrification Account does not hedge foreign currency risk.
- Neither revenues nor costs are adjusted for inflation.
- The current exchange rate of 62.88 Mt/ US\$1 is assumed.³⁷

³⁷ Obtained from: <http://www.xe.com/currencyconverter/convert/?From=USD&To=MZN>. Accessed on 2017/05/09

Table 4.21 – Accumulated annual revenues and disbursements of the Electrification Account, 2020–2080, base scenario (US\$ million)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2040	2050	2060	2070	2080
Electrification Costs in non-OEA	34	72	112	156	201	242	279	310	335	353	363	363	363	363	363	363
Repayment of loans to IFIs	9	22	39	62	93	135	190	259	343	442	558	2,222	4,065	5,782	6,294	6,294
Repayment of loans to the GoM	1	1	2	4	5	8	10	13	16	20	24	120	238	282	282	282
Total Disbursements	44	95	154	222	299	385	479	582	694	815	945	2,706	4,667	6,427	6,939	6,939
Revenues from the connection charge	6	16	30	48	70	95	121	150	179	209	240	327	327	327	327	327
Revenues from the electricity fee	33	70	110	155	204	260	321	389	464	547	639	2,140	4,101	5,861	6,373	6,373
Loans from the GoM	4	9	13	19	24	31	37	44	51	58	66	239	239	239	239	239
Total Revenues	44	95	154	222	299	385	479	582	694	815	945	2,706	4,667	6,427	6,939	6,939

GoM is government of Mozambique. IFIs are international financial institutions. OEA are own expansion areas.

Table 4.22 – Accumulated annual revenues and disbursements of the Electrification Account, 2020–2080, lower electrification cost scenario

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2040	2050	2060	2070	2080
Electrification Costs in non-OEA	36	76	121	171	224	278	331	383	434	482	528	528	528	528	528	528
Repayment of loans to IFIs	6	15	27	42	63	91	129	176	233	301	381	1,541	2,835	4,042	4,416	4,416
Repayment of loans to the GoM	0	1	2	3	4	5	7	9	11	13	16	44	57	57	57	57
Total Disbursements	42	92	149	216	291	375	467	568	678	797	925	2,114	3,420	4,627	5,002	5,002
Revenues from the connection charge	6	16	30	48	70	95	121	150	179	209	240	327	327	327	327	327
Revenues from the electricity fee	33	70	110	155	204	260	321	389	464	547	639	1,740	3,046	4,253	4,628	4,628
Loans from the GoM	3	6	9	12	16	20	25	30	35	40	46	46	46	46	46	46
Total Revenues	42	92	149	216	291	375	467	568	678	797	925	2,114	3,420	4,627	5,002	5,002

GoM is government of Mozambique. IFIs are international financial institutions. OEA are own expansion areas.

Note: In the lower cost scenario, on-grid electrification costs are 30 percent lower than in the basic scenario

Table 4.23 – Accumulated annual revenues and disbursements of the Electrification Account, 2020–2080, lower electricity access scenario

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2040	2050	2060	2070	2080
Electrification Costs in non-OEA	33	68	107	149	192	237	283	330	381	434	490	1,381	3,588	4,971	4,971	4,971
Repayment of loans to IFIs	4	8	14	21	31	45	62	82	106	133	164	712	1,696	2,768	3,534	3,824
Repayment of loans to the GoM	0	1	1	1	2	2	3	4	5	5	7	22	40	49	50	50
Total Disbursements	36	77	122	171	225	284	348	416	491	572	660	2,115	5,324	7,788	8,554	8,845
Revenues from the connection charge	3	7	12	18	26	33	41	49	57	66	74	192	329	436	437	437
Revenues from the electricity fee	32	68	106	148	194	244	298	358	423	494	571	1,889	4,954	7,311	8,076	8,367
Loans from the GoM	1	2	3	5	6	7	9	10	12	13	15	34	41	41	41	41
Total Revenues	36	77	122	171	225	284	348	416	491	572	660	2,115	5,324	7,788	8,554	8,845

GoM is government of Mozambique. IFIs are international financial institutions. OEA are own expansion areas.

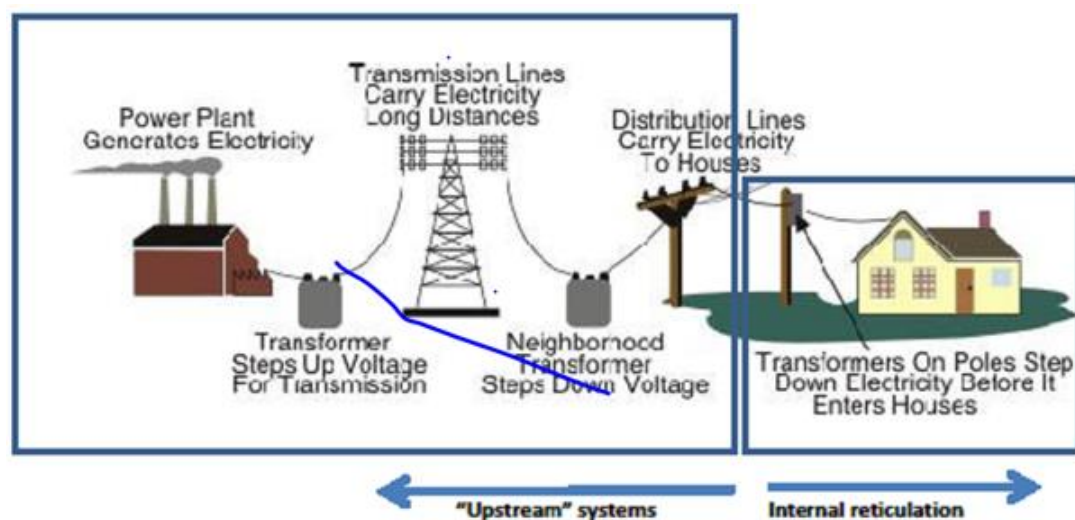
Note: Under the lower electricity access scenario, electricity access includes 50 percent of the population in 2030, and universal access is achieved in 2055.

Technical aspects

Achieving universal access to electricity has deep impact on the entire power system. Quintupling the number of consumers from about 1,550,000 today to about 7,800,000 by 2030 challenges not only distribution and commercial practices but also transmission and generation. It will require a complete internal restructuring of EDM's management, operations, logistics, technical staff, and systems. And although the first impact of new consumers may be small because of their limited consumption, in a very few years, if the number grows to meet current objectives, it will directly stress the transmission system and, given a situation of low reserve, require new generation capacity.

This Strategy focuses only on connections, the transmission system up to MV (33 kV), and off-grid solutions (while recognizing that further reinforcements in generation and transmission may be required). Figure 4.12 shows intervention area of this study.

Figure 4.12. Intervention area for the draft Development of National Electrification Strategy report



Technical considerations

The main technical parameters, constraints, and current and planned projects are extensively covered in two documents prepared by Norconsult/Vattenfall:

- Technical assistance to strengthen EDM's capacity for investment and network development planning: Master plan update project, 2012–2027: Final master plan update report, volume III—Main report, April 30, 2014 (referred to here as the Master Plan).
- Design manual for distribution networks (referred to here as the Design Manual).

The integrated Master Plan report includes unit costing for a variety of line, transformer, and substation types and components. This report, in order to use the same costing database, uses the Master Plan's costs escalated by 2.5 percent a year to bring them to 2017 values. Absolute accuracy of cost estimates is not essential for comparing costs of alternative systems.

The technical aspects considered in this report include:

- Rationalization of standards that affects

- System reliability for network design contingency criteria (in addition to the proposed N-1 for urban and N-0 for rural).
- Possible review of design standards as proposed in the Design Manual, specifically to seek ways to speed and simplify standards in a mass electrification drive.
- Systematic selection of technologies.
- Guidelines for the selection and prioritization of projects based on consumer type, grid availability parameters, and a continuously updated least-cost planning approach.
- Procurement strategies aimed at:
 - Standardization of designs and design criteria.
 - Bulk purchases of basic system components.
 - Capacity of the organization, including human and other resource issues in planning design, procurement, construction, and operation.

The Master Plan focuses on generation, transmission, and distribution and the associated standards. Therefore, they are not discussed in this report, which focuses on the downstream networks from a bulk MV supply to a residential area.

Standards

EDM, with many years' experience in electrification projects, has developed certain standards, but they are often not properly documented. Delegation of the detailed design of turnkey projects to design-build contractors also leads to different designs and construction practices. And funders sometimes influence design and construction, for example by imposing geographical limits on the procurement of materials.

The comprehensive Design Manual was compiled to create more standardization. The last revision was issued on September 24, 2009, but it had not been formally accepted as of October 2017 by EDM for compulsory application on all new electrification projects.

In general, all distribution standards should be reviewed, either by EDM or by an external consultant appointed by EDM with the following objectives:

- Design of line and cable components and equipment should maximize standardization. For items, such as line structures, standardization should reach the nuts and bolts level of detail, and for other more complex plant items such as switchgear, transformers, and circuit breakers it should reach the dimensioning level of detail (especially fixing detail). The exact level of detail required for various items will be determined during the review.
- Designs must be detailed enough to eliminate construction contractor interpretation. The technical guidance for designers must be similarly detailed.
- Construction-only specifications for construction contractors should be written in terms simple enough to ensure that a large core of contractors can be trained in their use.

EDM, to achieve these objectives, will have to:

- Provide, or externally source, teams qualified to design projects to the level of detail anticipated in these requirements, and to review the Design Manual.
- Standardize relationships with competent material and equipment suppliers, and create multi-year supply contracts (see this report's section on Procurement).
- Provide, or externally source, network design teams who before procurement will detail all design aspects currently relegated to contractors.
- Train suitable site staff to minimize the decisions required of construction contractors by undertaking line surveys, structure selection and spotting, foundation type selection, earth resistivity surveys, and earthing design on site.

Preparation for these steps requires suitable planning criteria and the recruitment and training, or external procurement, of suitable staff and planning/design software, including an integrated GIS system (see the sections of this report on Resources, Training, and Procurement).

The seven-volume Design Manual constitutes a solid basis for general application, and this report's further comments on standards aim at adding further value to the document by suggesting ways to apply it fully, and to develop it for the uniquely challenging prospect of 100 percent electrification by 2030. These steps will develop a fuller set of standards:

- Investigating whether the broad Design Manual guidelines can be developed to reduce the number of allowable structure, conductor, and hardware variations to a smaller, more manageable subset.
- Further detailing structures and network components to streamline procurement and construction
- Splitting the standards into:
 - Design and procurement standards.
 - Construction standards.
- Reviewing the Design Manual for criteria to tighten the standards for a mass electrification drive. Standards could include planned upgrades to build an interim network initially, and the final network as load growth occurs.
- Reviewing the Design Manual to identify design criteria not optimal for Mozambican weather, resources, labor, or other conditions.
- Identifying other aspects of the proposed standards that may require independent review in support of EDM's own review.

Review of current standards

The review of current standards raises the types of questions that the compilers of standards should regularly examine.

The number of options for 11 kV and 33 kV structures should be reduced from the ten types currently specified for each voltage level. Although 22/24kV has been applied on a small scale in Mozambique, it should not be used as a distribution voltage given the extensive 11kV and 33kV infrastructure. However, if it were deemed advantageous, MV lines at 22/24kV could be constructed due to the negligible cost difference between 11kV and 22kV line hardware.

Because the Design Manual allows the design-build contractor to provide Loading Diagrams and Application charts for each type of structure, design and construction remain restricted to a relatively few contractors with design expertise and exclude small local contractors who can be trained in construction but lack design capability. EDM should undertake design centrally, and once only, using competent design resources (whether its own or external consultants). This step avoids duplicated design effort and allows for of relatively unskilled construction contractors, who in effect become suppliers only of labor. To achieve maximum electrification within a limited time, EDM needs construction-only contractors of all sizes.

EDM should also employ experienced independent teams for line route survey, structure and foundation type selection, and pole positioning. These teams can function more effectively and more cheaply than construction contractors, especially smaller construction contractors who would have to subcontract such services.

The level of survey required in each case needs to be determined through a decision matrix. The simplest cases may need only GPS-determined coordinates for each pole position. On

the other extreme, the project may require a full ground-based or aerial LIDAR survey for input into a line design/tower spotting software application such as PLS-CAD/POLE.

If structures are explicitly detailed, EDM can:

- Standardize completely on design and hardware.
- Make kits of all hardware, insulators, and stay components for each structure type, reducing costs and saving construction contractors the cost and effort of compiling their own quantity schedules and ordering components, mostly from different suppliers. Procurement for line construction contractors thus requires only ordering the required number of each kit type.

In general, design, procurement, and construction should be simplified to the point where many relatively unskilled contractors (essentially labor suppliers) can be trained to undertake simple distribution asset construction, while more complex design, procurement, and structure and foundation selection and placement are undertaken centrally.

The Design Manual's standards could be divided into separate sections for Design and Procurement, and Construction so that:

- Given enough technical support, designers can produce designs and specifications compliant with stated norms, obviating the need for construction contractors to undertake any design.
- Large numbers of relatively unskilled construction contractors can work with simple specifications dealing only with construction.

Off-grid systems, not covered in the Design Manual standards, will require specifications to be added to the distribution standard, integrated fully with the distribution standard's specifications for on-grid connections.

Design after diversity maximum demand (ADMD) at distribution transformer level, MV feeder level, and high voltage substation level must be agreed upon. Initial systems can be designed to be upgraded as the load and demand per consumer increases.

The transmission planning exercise must be coordinated with distribution planning standards. The interaction between planning functions requires close attention and may need to be addressed in the grid code.

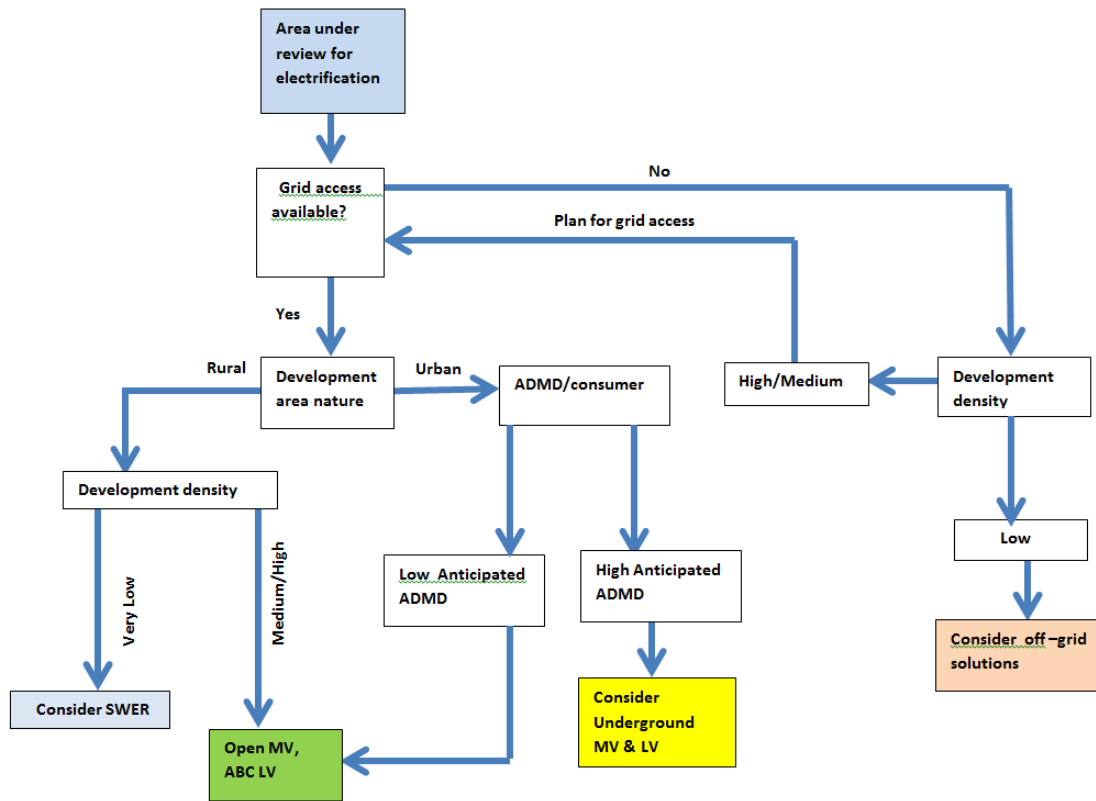
Determining the best technology for each project

Areas should be selected for electrification based on this order of priority (figure 4.13 and table 4.24):

- Infill areas, where either the MV system or both the MV and LV systems are already in place and have the capacity to accommodate additional connections.
- High-density, high-demand urban areas, where income generated from the connections could justify the capital expenditure and where the MV system already exists and has capacity.
- High-density, low-demand urban areas where the MV system already exists and has capacity.
- High-density rural areas where the MV system already exists and has capacity.
- High-density, high-demand urban areas where income generated from the connections could justify the capital expenditure, but a MV bulk supply must still be provided.
- High-density, low-demand urban areas where a MV bulk supply must still be provided.
- High-density rural areas where a MV bulk supply must still be provided.

- Low-density rural areas where alternative and off-grid systems may be indicated.

Figure 4.13. Determine the best technology for each project



SWER is single wire earth return. Open MV means above ground medium voltage. LV is low voltage. ABC is aerial bundled conductors. ADMD is after diversity maximum demand.

Table 4.24. Indicative design parameters for electrification systems

System	Methodology	Settlement type	Indicative design parameters		
			D = Distance from EDM grid	P = Demand per household (kVA)	Population density
On-grid	Connection of new users to existing LV network (220–400V)	Urban and peri-urban	D < 10m	3.0 < P < 5.0	High
	Densification (LV and urban MV extension)	Urban and peri-urban	10m < D < 5km	3.0 < P < 5.0	High
	3-phase rural MV (main and laterals) and LV extension	Rural	5km < D < 30km	2.0 < P < 3.0	High
	3-phase rural MV (main), SWER (19kV) for laterals	Rural	10km < D < 30km	1.0 < P < 2.0	Medium

	and LV extension				
Off-grid	Mini-grid: centralized generation and LV network	Rural	D > 30km	0.1 < P < 1.0	Medium
	Solar home system	Rural	D > 30km	0.1	Low

EDM is Mozambique Electricity Company. kV is kilovolt. kVA is kilovolt Ampere. LV is low voltage. MV is medium voltage. SWER is single wire earth return.

Procurement procedures

At present, design-build contractors build on-grid electrification projects on behalf of EDM. The 2009 Design Manual contains the standards used for the design (sections of the manual's distribution standard that may warrant review were discussed above with the distribution standard).

The procurement of materials for projects leaves room for significant improvement and cost-saving. The design-build contractors currently procure all their own materials for construction, and EDM does not supply the contractors with any materials. The proposed rationalization of standards will also reduce set of materials required for construction.

EDM should set up term contracts for the provision of major materials including at least:

- Wood poles.
- MV bare-wire conductor (standard sizes).
- LV ABC conductor (standard sizes).
- Service connection conductor.
- Distribution transformers (standard sizes).
- MV and LV switchgear.
- MV insulators.
- MV line hardware.
- LV line hardware.
- MV and LV stay hardware.
- Pre-payment meters.
- Ready and populated Distribution boards ("Ready boards").

A term contract should include different materials; for example, the same contract should include all conductors and associated hardware. This will simplify procurement and ensure compatibility between, in the example, line conductors and hardware. EDM will free issue the materials procured on term contract to the contractors, based on an approved design and installation schedule.

Because EDM does not currently store significant stocks of these materials (keeping some for maintenance only) and the quantities anticipated for the electrification program are large, during the setup of term contracts, the manufacturers/suppliers of materials could set up and maintain stock at agreed locations around the country and take responsibility for delivering materials to construction sites. Payment would need to be negotiated with the manufacturers/suppliers with due regard to the risk they are carrying. In this way EDM would be neither responsible for the logistics of getting materials to site, or holding stock. This will be a temporary solution until EDM builds the capacity to manage the logistics.

EDM must establish strong capacity for approving electrification designs in order to enforce compliance with the agreed national standards. An experienced external consultant could initially perform approval, if the consultant's contract required training EDM staff and building EDM's internal capacity. Standardized design philosophies will simplify design, and all designs will undergo approval before construction begins.

Given the size of the task, external consultants could also initially design electrification projects, again with the contracts requiring training and capacity building within EDM. When EDM has the competence, it can reduce or eliminate the use of external consultants. Separating design from construction obviates a major drawback, the ability of design-build contractors to make changes during construction without the approval of the client (EDM) or its representative.

External consultants could also initially supervise construction supervision, if their contract required training and capacity building within EDM. To ensure implementation of planned designs, resources different from the design resources should monitor construction, so that the external consultant does not make design changes during construction in agreement with the contractor. Some design changes may be necessary during construction, but they will be limited if design is independent of construction.

External parties should identify and log future consumers and survey MV line routes. Although EDM may choose to employ some of these resources, large-scale establishment of this competence within EDM will not be necessary once the 2030 target has been reached.

With design and construction monitoring being done by outside parties, labor-only contractors can be used for construction. Initial construction contractors must be contracted to develop local emerging contractors for specific skills. For example, the main contractor might appoint and supervise an emerging contractor as a nominated sub-contractor to dig holes and plant poles on a first project, appoint the same emerging contractor to string conductor on the next project, and so on until the subcontractor has covered all aspects of a project. Then the emerging contractor can undertake complete construction projects, smaller ones initially and larger ones as the contractor's competence is confirmed. Such an emerging contractor development program must be managed by either EDM or an appropriate government agency such as the Ministry of Labor.

EDM, as implementer of the electrification strategy, must conduct overall project management, from project identification to commissioning, in-house as much as possible, though EDM may initially seek supplementary assistance from external consultants. Financial resources already available for project implementation may be used to this end.

Procurement for constructing off-grid projects must follow the standards for on-grid projects because in time the off-grid project may be connected to the grid and will need to meet EDM design, building and materials standards. This requirement will also allow common materials to be used for off-grid construction procured by the mechanism just described. Use of external consultants for off-grid electrification will need to be discussed with FUNAE to establish effective solutions and will depend on the scale of the projects.

Human resources

EDM's network has exceeded the growth of staff resources, straining them. The intended mass electrification drive may severely exacerbate this situation.

EDM should consider recruiting a cadre of recently qualified young technical resources, who will participate in the training and capacity building for design and construction monitoring proposed in this report's sections on procurement. Once trained as designers under an external consultant's contract, the resources move on to monitoring construction of the same project, and then receive training to serve as operations and maintenance resources for the project once completed and commissioned. In this way, the field staff ultimately required participate from the beginning, and their numbers follow the development of the projects. Field staff will have a comprehensive understanding of the design philosophy, construction methods and standards, and operation and maintenance of the networks.

All contracts awarded to designers, project managers, and construction contractors should include provision for the training of EDM staff.

The following areas may require focus:

- Staffing consumer service centers. Under current practices each center has technical and administrative staff to handle about 80,000 consumers, 1 substation, and 100 distribution transformers.
- All design aspects.
- Training staff who could perform route selection and surveys.
- Compiling and maintaining design standards.
- Procurement and storage.

Strategy implementation

Short term

The full implementation of the Strategy may take some time because it requires GoM approval and because it depends on developing institutional arrangements such as the Electrification Account, capacity building, and approval and implementation of standards and procedures. However, electrification can be started with funds already available from IFIs while final decisions are made and intermediate tasks are implemented.

EDM can take the lead in the initial stage until MIREME acquires the necessary capacities and instruments. In the very short term, the following activities will allow beginning electrification projects while remaining activities advance toward being implemented:

- Decision on the application of available funds: on-grid/off-grid electrification. **Responsible: MIREME.**
- Identification of “densification projects”: EDM can quickly identify projects where there is already infrastructure and consumers are not connected. These projects should be low-cost they take advantage of already existing MV infrastructure (or even LV infrastructure) in zones where the population has not been connected to electricity. **Responsible: EDM.**
- Agreement between EDM and MIREME on the prioritization of on-grid electrification projects considering the availability of funding. **Responsible: MIREME and EDM.**
- Identification of low-cost off-grid electrification projects. **Responsible: FUNAE.**
- Agreement between EDM and FUNAE on the prioritization of off-grid electrification projects considering the availability of funding. **Responsible: MIREME, EDM and FUNAE.**
- Finalization and approval of standards for construction of on-grid projects. **Responsible: EDM.**
- Development of “electrification schemes”—standard on-grid electrification projects—to reduce engineering costs. **Responsible: EDM.**
- Development of “electrification schemes”—standard off-grid electrification projects—to reduce engineering costs. **Responsible FUNAE.**
- Transitory arrangements for using IFIs funds. **Responsible: Ministry of Economy and Finance/MIREME.**
- Launch at MIREME of a small group to coordinate and lead initial efforts to implement the electrification strategy. This group would lead to a larger cell from which an office in charge of planning and monitoring electrification would later be built. **Responsible: MIREME.**
- Implement bulk purchasing of at least a few important supplies for project construction. **Responsible: EDM.**

Road Map

The section “Preparation by the institutions to execute the proposed Strategy” presented a series of activities that each institution should undertake. Although the Strategy still needs discussion and to be approved by the government, a high-level road map for implementing it can be sketched out under the assumption that the approved Strategy will not differ too much from the proposal (table 4.23). This road map is independent from but compatible with the short-term just described.

Table 4.23. Road map for implementing the Strategy

Institution	Activity
<i>Preparatory stage</i>	
GoM	Set policy objectives.
GoM – Ministry of Economy and Finance	Implement/create Electrification Account. Implement levy to fund the Electrification Account.
MIREME	Establish an electrification group for planning and monitoring plans. Capacity building.
EDM	Define building standards. Define and implement bulk purchase procedures. Establish schemes for on-grid projects. Strengthen planning and monitoring capacity.
FUNAE	Establish schemes for off-grid projects. Strengthen planning and monitoring capacity.
<i>Initial Stage</i>	
Ministry of Economy and Finance	Operationalize Electrification Account.
MIREME	Set objectives for planning. Establish criteria for project prioritization. Monitor electrification projects.
EDM	Initially take the lead in planning. Finish implementing bulk purchase of material. Implement on-grid projects following project prioritization criteria and electrification schemes. Finalize capacity building of professional staff for implementing and monitoring projects. Improve general systems and procedures. Prepare standard procedure to outsource operation of isolated systems.
FUNAE	Build projects following the established plans and standards.
ARENE	Implement tariff methodology and calculation of tariffs.
<i>Final Stage</i>	
GoM	Set policy objectives.
MIREME	Establish targets. Lead planning once professional staff, tools, and capacity building have been achieved. Monitor plan implementation.
EDM	Build and connect on-grid consumers.
FUNAE	Build and connect off-grid consumers. Hand commissioned projects (assets) to EDM.
ARENE	Set tariffs. Monitor quality of service.
Ministry of Economy and Finance	Manage the Electrification Account. Manage relationship with IFIs.
Private sector	Participate in building assets and operating outsourced systems.

Appendix A. Cost estimates

Estimated cost of alternative grid-based distribution technologies

This appendix deals only with electrification/reticulation costs although both the distribution costs (for a point of bulk supply at or close to the area to be electrified) and the electrification, or reticulation, costs (for the MV and LV systems between the point of supply and each service connection) are important. Sub-transmission and transmission distribution costs are dealt with in the Master Plan.

Electrification costs per connection differ substantially from project to project. The most important cost-determining factors are:

- Density of development, expressed as number of households per square kilometer.
- Design after diversity maximum demand (ADMD) per household.
- Service quality levels, expressed as annual availability.
- The inherent reliability of the technology employed.
- The nature of the terrain: rocky, hilly, and other similar conditions will increase costs.
- Site location, which determines the ease of access and cost of transport.
- The project size or number of connections to be made under the contract: smaller contracts will cost more per connection.

Costs estimates with the detail required in an electrification Strategy only deal with approximate relative costs between projects executed under different conditions.

The most common systems or schemes will typically allow for:

- "Standard" three- and single-phase distribution systems and service connections.
- Bare overhead MV conductors.
- Insulated LV aerial bundled conductors (LV ABC).
- Pole-mounted distribution transformers.
- Wood poles.
- Low level street lighting.
- Prepaid type meters.
- A design ADMD at the distribution transformer of 0.5-0.6kVA/household for rural consumers, and 2.5-3.5 kVA for low-income peri-urban and urban consumers.³⁸

This is referred to further in the "standard" scheme.

For planning design ADMD, the Master Plan assumes annual domestic consumption of 1,128 kWh, where electricity is used almost exclusively for low-level lighting application. A design ADMD of 1.0-1.2 kVA per residential consumer (as seen at the distribution transformer) will suffice in most applications.

Table A.1 offers high-level criteria for design ADMD, which should wherever possible be verified against data on affordability, consumer needs, and experience obtained via field surveys of similar consumer groups in other areas.

³⁸ If medium- and high-income residential areas will be electrified, the design ADMD should be reviewed case by case. For the moment it has been assumed that medium- and high-income areas are already electrified.

Table A.1. Parameters for deciding design ADMD (after diversity maximum demand)

Typical area to be electrified	Typical main sources of residential income	Expected ADMD, 5 th year after electrification (kVA)	Expected ADMD., 15 th year after electrification (kVA)
Rural group of dwellings	Subsistence farming, pensions, migrant labor remittances	0.35	0.5
Rural village	Some local small industry, farming, pensions	0.7	0.9
Informal settlement near an urban area	Mostly informal commerce, work in nearby town or city	1.0	1.4
Formal township area	Mostly formally employed, semi-skilled	1.7	2.4
Medium income urban residential	Formally employed, blue collar work	2.7	3.5
High income urban residential	Semiprofessional and professional jobs, entrepreneurial occupations	4.0	6.0

kVA is kilovolt amperes.

Cost per connection for standard three- and single-phase reticulation systems

Table A.2 presents impacts of construction type, design ADMD, and population density on the relative cost of electrification systems downstream from a point of bulk supply in or at the border of the area to be serviced.

Table A.2. Impact of various factors on the cost of "standard" three and single-phase distribution systems ³⁹

Construction type	Design ADMD	Population density (households/km ²)	Relative cost ⁴⁰	Relative faults expected per year
Bare MV, ABC LV	1.0–1.2 kVA	More than 2,500	0.8	1
		750–2,500	1	
		Less than 750	1.4	
	3.0 kVA	More than 2,500	1.3	
		750–2,500	1.5	
		Less than 750	2.0–2.2	
Bare MV, bare LV	1.0–1.2 kVA	More than 2,500	0.8–0.85	4-6
		750–2,500	0.85–0.95	
		Less than 750	1.2–1.3	
	3.0 kVA	More than 2,500	1.2–1.3	
		750–2,500	1.4–1.5	
		Less than 750	1.9–2.0	
Underground cable	3.0 kVA	More than 2,500	1.5	0,8
		750–2,500	2.2–2.5	
		Less than 750	2.7–3.5	

ABC is aerial bundled conductors. kVA is kilovolt amperes. LV is low voltage. MV is medium voltage. Note: Assumes reasonably easy access and terrain conditions.

³⁹ These are relative costs only. Table A.2 contains the assumptions made for the hypothetical project, based on the unit rates as per the Norconsult Masterplan

⁴⁰ Mainly based on indicative Eskom values and discussion with other (municipal) distributors in South Africa.

Comparative cost estimates for alternative reticulation systems

The final cost of an electrification project depends on design ADMD, technology, terrain, grid connection costs, and other factors. This report presents typical costs as a basis for initial budgets for a full program of electrification (the estimate for any single project needs to be calculated at the detailed planning stage in view of the number of connections, design criteria, technology, and grid connection availability). The general planning criteria for system configurations in the Master Plan are:

- The normal MV system is a 3-phase, 3-wire system.
- If the load fed by a branch connector does not require a three-phase system, a two-phase, two-wire feeder could be employed, feeding one or several single-phase transformers.
- Due their limited load capacity, SWER (single wire earth return) systems—both single wire- and shield wire-based—should only be considered where the total load is low—up to about 200kVA—and the lines are relatively long—more than approximately 10km.
- To rate relative costs of alternative system configurations, options are priced with the rates in the Master Plan, dated April 2014, escalated by 2.5 percent a year to meet 2017 values.
- In the initial calculation, to maintain comparability to previous studies, this report considers a price scenario consistent with these previous studies such as the existing Master Plan. The following alternatives were investigated:
 - Standard 3-phase bare wire MV, 3-phase transformation, and LV ABC reticulation (no single-phase circuits).
 - 3-phase and 2-phase bare wire MV, dual-phase transformation, and single- and dual-phase LV ABC reticulation (with a 1:2 split between single and dual phase LV for simplicity).
 - 3-phase and SWER MV reticulation, isolating transformers, and essentially no LV reticulation in the more rural environment with scattered dwellings in an informal layout.

A shield wire-based SWER and HV voltage transformer supply will only be feasible in exceptional circumstances where the cost of regular reticulation is high but less relevant in deciding whether to provide a service. The current EDM practice of designing SWER systems for later upgrading to 3-phase systems is sound, and should be retained.

Table A.3 presents a hypothetical typical case in order to compare the relative costs of alternative systems.

Table A.3. Hypothetical electrification project for comparing alternative technology costs

	Design ADMD /connection (kVA)	Number of connections	Estimated load on MV lines (kVA)
Rural village	0.7	5,000	3,500
Rural group of dwellings	0.35	1,200	420
<i>Total connections</i>		6,200	
<i>Total estimated load on MV lines</i>			3,920
<i>Average ADMD /connection</i>	0.63		

ADMD is after diversity maximum demand. kVA is kilovolt amperes. MV is medium voltage.

Costing the alternative systems is based on unit rates in the Master Plan plus several other assumptions:

- Unit rate/km of 2-wire MV lines is valued at 75 percent of the equivalent 3-phase line cost.
- Single- and 2-phase transformer prices are valued at 90 percent of a 3-phase unit.
- 3-wire ABC conductor costs are valued at 80 percent of similar sized 4-core ABC conductor, and 2-wire costs at 65 percent.
- The Master Plan allows for a single-phase service connection cost of US\$500, which presumably covers a suitable meter, aerial conductor connection, and additional poles, conductor, and hardware where the connection is across the street from the LV line. This amount is definitely on the high side but to maintain consistency with the Master Plan is used in this initial calculation (until Report 4—10 Year National Electrification Plan—is fully developed).
- The Master Plan correctly allows for contingencies, design and other fees, spare parts, and mobilization costs over and above the basic network costs. But it does not include any allowance for interest on loans during construction.

Table A.4 presents the resulting cost estimates for three alternative systems.⁴¹ (See appendix B for more detail.)

Table A.4. Estimated costs of alternative internal MV and LV reticulation systems in a hypothetical project (US\$)

Component	3-phase 4-wire LV and 3-wire MV	Mixed 2- and 3-wire MV and 4-, 3-, and 2-wire LV	SWER in rural group of dwellings
MV line	157	137	184 ^a
Transformer	220	198	187
LV line	212	181	143
Subtotal for basic reticulation scheme excluding service connections and street lighting at April 2014 unit rates	589	516	515
Single-phase consumer connections	500	500	500
Streetlights	75	75	75
Total internal system construction costs/connection at April 2014 base rates	1,164	1,090	1,089
Increase in unit rates up to April 2017 base (2.5 percent a year)	7.7%	7.7%	7.7%
Total internal system construction costs/connection at April 2017 base rates	1,253	1,174	1,173
Provision for spare parts (1.5 percent of total)	19	18	18
Mobilization costs (2 percent of total)	25	23	23
Contingencies (10 percent of total)	125	117	117
Design, tendering, and supervision (10 percent of total)	125	117	117
Compensation for MV lines (4 percent of MV line costs)	6	5	7

⁴¹ Terrain and access conditions could increase these estimates by as much as 50 percent.

Component	3-phase 4- wire LV and 3-wire MV	Mixed 2- and 3- wire MV and 4-, 3- , and 2-wire LV	SWER in rural group of dwellings
PROPOSED TOTAL BUDGET/CONNECTION FOR INTERNAL RETICULATION	1,554	1,455	1,456

a. SWER unit costs (\$/km) are cheaper, but the hypothetical project assumes, as would normally be the case, that longer average MV lines/connection will be required because of dispersed development, but savings in LV line lengths.

Comparable projects report a wide band of cost per connection from US\$600 to US\$2,300, although it is not always clearly stated what exactly is included in the estimate (table A.5).

Table A.5. Costs for electrification projects comparable to the hypothetical project

Utility	Estimated April 2017 cost (US\$/connection)	Comments
Eskom, South Africa	1,660	Excludes street lighting, average country population density of 42/km ² .
Major metro in South Africa	2,310	Includes street lighting, residential unit density of circa 2,000/km ² , design ADMD of 3.5 kVA.
Major metro in South Africa	1,550	Includes street lighting, residential unit density of circa 2 000/km ² , design ADMD of 1.5 kVA.
Cambodia	592	No street lighting, average population density of 82/km ² , design ADMD not stated.
Ethiopia	1,400–1,600	No street lighting, average population density of 83/km ² , design ADMD not stated.

Sources: South Africa Department of Energy Integrated National Electrification Programme feedback report, June 2013. Royal Haskoning. 3. Cambodia Rural Electrification Strategy Plan, December 2009. 4. Ethiopia National Electrification Strategy Final Report, June 2016), Report comments on high costs and suggests it can be reduced significantly.

Given these calculations, the following values may be used for budgeting at a strategic level and for initial estimates to be fine-tuned in later reports as more specific data are gathered:

- For high-density urban areas or peri-urban areas close to main population centers, with reasonably easy access, topography, and soil conditions, and an average design ADMD of 3 kVA/connection: US\$2,300.
- For lower-density rural areas and low-income high-density urban areas close to main urban centers, with reasonably easy access, topography, and soil conditions, and an average design ADMD of 0.6–0.8 kVA/connection: US\$1,200–US\$1,300.

Beyond these reticulation costs would be the cost of upstream network components, including transmission and sub-transmission systems and MV systems to supply the hypothetical project.⁴² As an initial estimate, the additional cost per connection of upstream network components can be set at about US\$600 (see appendix C).

⁴² The hypothetical project will require the installation of a HV/MV transformer in an existing substation. Additionally, a 30 km section of backbone 33kV line will have to be constructed from such an existing substation to a point at the hypothetical project site.

Cost of off-grid systems

The costs of off-grid systems vary drastically between technologies, and also varies depending on reliability and availability parameters. For example, a fixed photovoltaic plant can cost as little as US\$1,000/kVA for 0.6–0.8 kVA, but battery storage for full availability doubles the estimate.

Off-grid systems, just as SWER systems, should only be considered where load requirements are low, population densities are low, electrical supply is a necessity, and the cost of standard systems would be excessive.

Different off-grid systems, such as solar home systems with storage and mini grids, were considered, and an average cost of US\$2,000/connection was assumed (off-grid systems will be further considered in the next report, Implementation of the national electrification strategy).

Appendix B. Estimating cost of alternative reticulation system technologies

Tables B.1–B.8 detail the estimates of the hypothetical project described in the main body of the report.

Table B.1. Internal medium voltage line costs with alternative medium voltage systems

Medium Voltage requirements	Branch feeder from T-off through area to be electrified	Branch feeder from T-off through area to be electrified	SWER in rural group of dwellings, 3-phase MV in town
Total internal MV line length (km)	44	44	65
Length/connection (m)	7.1	7.10	10.48
Length of 3-wire system lines	44	20	20
Length of 2-wire system lines	0	24	15
Length of SWER lines	0	0	30
Conductor 3-phase circuits	Pine	Pine	Pine
Conductor cross-sectional area	72mm ²	72mm ²	72mm ²
Current carrying capacity of 3-wire system	175A (10 MVA)	175A (10 MVA)	46A (1.5MVA)
Conductor SWER circuits	N/A	N/A	Bantam
Conductor cross-sectional area	N/A	N/A	16mm ²
Cost/km (US\$/km) for 3-wire lines	21,000	21,000	21,000
Cost/km (US\$/km) for 2-wire lines	16,800	15,750	15,750
Cost/km (US\$/km) for SWER lines	14,500	14,500	14,500
MV line costs (US\$/km)	924,000	798,000	1,091,250
Recloser and line isolator at T-off	49,500	49,500	49,500
MV Line costs per connection (US\$)	157	137	184

Table B.2. Pole-mounted distribution transformer costs

Transformer sizes	Unit price (US\$/transformer)	Total	Total Cost (US\$)	Total installed capacity
32kVA	17,200	15	258,000	480
50 kVA	22,600	10	226,000	500
100 kVA	26,800	22	589,600	2,200
160 kVA	29,200	10	292,000	1,600
Total		57	1,365,600	4,780
Average transformer cost per connection (US\$)			220	
Average loading (percent)				82.0

Table B.3. Low voltage distribution system 3-phase 4-wire using ABC

Description	Rural village	Rural group of dwellings	MV Line unit costs (US\$)	Total LV line costs (US\$)
Average length/consumer (km)	9	22		
Total length (km)	45	26		
Average mix of conductors				
4x95mm ² +25mm ²	15	5	25,000	500,000
4x50mm ² +25mm ²	20	9	18,900	548,100
4x25mm ²	10	12	12,000	264,000
Total LV line costs				1,312,100
Average LV line costs per connection				212

Table B.4. Low voltage distribution system cost, mixed 2- and 3-phase and mixed 3- and 4-wire using aerial bundled conductors (ABC)

Description	Rural village	Rural group of dwellings	LV Line unit costs (US\$)	LV line costs (US\$)
Average length/consumer (km)	9	22		
Total length (km)	45	26		
Average mix of ABC conductors				
4x95mm ² + 25mm ²	6	2	25,000	200,000
3x95mm ² + 25mm ²	6	3	20,000	180,000
2x95mm ² + 25mm ²	3	2	16,250	81,250
4x50mm ² + 25mm ²	8	3	18,900	207,900
3x50mm ² + 25mm ²	8	5	15,120	196,560
2x50mm ² + 25mm ²	4	3	12,285	85,995
4x25mm ²	4	1	12,000	60,000
3x25mm ²	4	4	9,600	76,800
2x25mm ²	2	2	7,800	31,200
Total LV line costs				1,119,705
Average LV line costs per connection				181

Table B.5. Low Voltage distribution system with SWER medium voltage distribution in the Rural area

Description	Rural village	Rural group of dwellings	MV Line unit costs (US\$/km)	LV line costs
Average length/consumer (km)	9	10		
Total length (km)	45	12		
Average mix of conductors				
4x95mm ² + 25mm ²	6	0	25,000	150,000
3x95mm ² + 25mm ²	6	0	20,000	120,000
2x95mm ² + 25mm ²	3	0	16,250	48,750
4x50mm ² + 25mm ²	8	2	18,900	189,000
3x50mm ² + 25mm ²	8	2	15,120	151,200
2x50mm ² + 25mm ²	4	1	12,285	61,425
4x25mm ²	4	2	12,000	72,000
3x25mm ²	4	2	9,600	57,600
2x25mm ²	2	3	7,800	39,000
Total LV line costs				888,975
Average LV line costs per connection				143

Table B.6. Estimated internal reticulation costs of alternative systems (US\$)

Cost component	3-phase 4-wire LV and 3-wire MV	Mixed 2- and 3-wire MV and 4-, 3- and 2-wire LV	SWER in rural group of dwellings
Internal MV line	157	137	184
Transformer	220	198	187
LV line	212	181	143
Subtotal for basic reticulation scheme excluding service connections and street lighting at April 2014 unit rates	589	516	515
Single-phase consumer connections	500	500	500
Street lights	75	75	75
Total internal system construction costs/connection at April 2014 base rates	1,164	1,090	1,089
Increase in unit rates up to April 2017 base (2.5% a year)	7.7%	7.7%	7.7%
Total internal system construction costs/connection at April 2017 base rates	1,253	1,174	1,173
Provision for spare parts (1.5% of total)	19	18	18
Mobilization costs (2% of total)	25	23	23
Contingencies (10% of total)	125	117	117
Design, tendering, and supervision (10% of total)	125	117	117
Compensation for MV lines (4% of line costs)	6	5	7
PROPOSED TOTAL BUDGET /CONNECTION FOR INTERNAL RETICULATION COSTS	1,554	1,455	1,456

Table B.7 Medium voltage main feeder line costs

Medium voltage line costs	Main feeder from existing MV distribution station to T-off
Assumed length (km)	30
Length/connection (m)	4.84
Conductor	Mulberry
Conductor cross-sectional area	250mm ²
Current carrying capacity	275 A (15 MVA)
Cost/km (US\$)	32,000
MV line costs (US\$)	960,000
Recloser and line isolator at T-off (US\$)	49,500
MV Line costs /connection (US\$)	155

Table B.8. Medium voltage substation costs (assuming extensions to an existing substation)

Item	Cost (US\$)
New line and transformer bays (US\$60,000/bay)	120,000
Additional 5 MVA transformer and associated costs	71,250
Total substation costs	191,250
Substation extension costs/connection	31

Appendix C. Cost of upstream network components

The cost of providing the infrastructure from a suitable local point of bulk supply to the project site depends wholly on the load size and location relative to the capacitated generation and transmission infrastructure. The estimated total cost per connection can therefore not be stated with accuracy. Table C.1 provides costs only as an indication of the upstream costs back to a suitable HV/MV substation given these assumptions:

- The hypothetical project will require the installation of a HV/MV transformer in an existing substation.
- A 30-km section of backbone 33kV line will have to be constructed from such an existing substation to a point at the hypothetical project site.

Table C.1. Indicative upstream medium voltage system costs to supply the hypothetical project (US\$)

Cost component	Unit rate	Total
30 km of 33kV line using Mulberry (250mm ²) AAAC conductor	32,000/km	960,000
New 33 kV line and transformer bays at existing HV/33kV substation	60,000/bay	120,000
Additional 5 MVA HV/33 kV power transformer and associated plant and costs	71,250	71,250
Total assumed upstream distribution system costs based on 2014 Master Plan unit rates		1,151,250
Update of costing (2.5 percent a year) to April 2017 base		1,240,000
Contingencies, engineering costs		1,538,000
Assumed cost of the upstream MV network per consumer connection for the hypothetical project		248

The infrastructure created in this way will likely provide excess capacity, which will have to be funded as part of the project, but which will reduce the cost of additional later supplies from the same line and substations.

Table C.2 proposes a high-level initial indication of budgetary requirements:

Table C.2. – Suggested capital expenditures to be budgeted per typical service connection

System level	Cost per service connection (US\$, April 2017 base)
Transmission system	150
Sub-transmission system	200
Sub-transmission/medium voltage system from a bulk point of supply to a project site	250
Average internal MV and LV distribution system, including service connection, meter, and streetlights (average low density/high density areas)	1,800
Total per average service connection	2,400

These suggested costs are to be used only as reference in initial budgeting, with a more comprehensive and detailed cost library to be continuously built up on the basis of actual contract awards.

Appendix D. Technical considerations for electrification

Reliability of supply

The reliability of supply needs to be considered in order to ensure a certain quality of electricity services either provided by the grid or isolated systems. The reliability of supply to customers is dependent on a number of factors including:

- System design aspects.
 - The basic technology employed has an impact of service reliability; fully underground systems would normally be subject to far fewer interruptions than bare wire overhead distribution systems.
 - Design criteria incorporating aspects such as factors of safety, will impact on reliability.
 - The geographical and environmental factors at the place of installation: population density, terrain, lightning levels etc.
 - Redundancy criteria, i.e. the extent to which system elements are duplicated to allow for continuous supplies even under certain system fault conditions.
- The quality of initial construction.
 - Quality of the materials used.
 - Quality of construction.
- Operational aspects: the time to respond to interruptions of supply, which in turn is dependent on a variety of factors such as:
 - Location, accessibility, availability of spares and resources and the nature of the fault.
 - Availability of suitable maintenance staff and the number of localities from where faults are attended to.
- Continuous maintenance.

A number of indices are used to measure the reliability of supplies. The most commonly used are:

- System Average Interruption Frequency Index (SAIFI) which measures the average annual number of interruptions per customers.
- System Average Interruption Duration Index (SAIDI) which measures the average annual number of hours during which the supply to a customer is interrupted.
- System Average Repair Index (SARI) which measures the average time to repair a fault.

The reliability, therefore, cannot be quantified through the technology employed at the distribution system level only. This, however, does not imply that targets for SAIFI and SAIDI should not be set. Targets should therefore be set in relation to what is deemed acceptable to the specific customer base (table D.1).

Table D.1. Indicative Reliability Indices for the EDM MV and LV systems

Area	SAIFI (Faults/consumer)		SAIDI (Consumer Interruption duration in hours) ^a		SARI (System restoration time in hours) ^a		MV Line faults (No./ 100km) ^b	Number of LV breakdowns
	MV system	LV system ^b	MV system	LV system ^b	MV system	LV system ^b		
Maputo	0.3		0.31		1.02		100	
EDM overall	2.01	0.44	1.01	3.51	0.51	8.0	64	609,844

a. EDM Performance Report for the Distribution Network for 2014, with LV data derived from comments in the report.

b. Above EDM Report with data calculated from text in report.

Based on the information provided, a customer is likely to experience around 2.5 interruptions per year per consumer, each of 8.5 hours' duration due to problems on the distribution/reticulation networks. This indicates that improvements should be made in infrastructure and management of the distribution network if additional customers are to be connected to the grid.

The definition of reliability of supply will differ between rural and urban distribution systems. This in turn will be informed by the average annual or monthly consumption of residential consumers: high energy users employing electricity for lighting, heating, cooling, cooking and communication will demand greater reliability than the consumer only requiring electricity for lighting. The decision to select the most appropriate technology in each particular project could be guided through the approximate relative technology reliability values.

Review of design criteria with the aim of relaxing certain standards

The following are mentioned as examples of issues that will be further investigated during elaboration of the plan (Task 4):

- The use of staggered vertical conductor arrangements on 33kV, 11 kV and bare wire low voltage lines where loads allow for the use of small conductor sizes. Overall procurement and construction costs can be decreased at the expense of a small increase in pole length. Also, to be noted in this regard is the potential danger to larger birds (vultures, eagles and similarly sized birds) of using a horizontal bare wire conductor configuration on structures.
- The use of all-aluminum alloy conductor only. Aluminum core steel reinforced (ACSR) conductor should be suitable and possibly cost beneficial in inland areas, but the cost of alternative stock holding of both conductor and fittings needs to be evaluated.
- It would appear as if the use of preformed type splices, dead ends, stay grips and similar preformed type components are not permitted in the standards; the use of these could have cost and construction benefits.
- The specified reliability of supply (availability) criteria may warrant review. A lower level of reliability may be acceptable in exchange for cost savings, especially in low-demand installations where use may be limited to lighting only.
- Ground clearances specified for overhead lines could possibly be reconsidered. The specified clearances of 6.0m (within urban areas) and 7.0m (for road crossings) for both 11kV and 33 kV lines would appear to allow for some reduction. This could in turn allow for the possibility of staggered vertical conductor configurations without any increase in pole lengths. Cognizance needs to be taken of the statutory environment within which such changes would take place.

- With regards to structure design:
 - The relatively high design wind speed of 40m/s may not be a reasonable assumption in all areas.
 - Would it be beneficial to increase the specified lightning impulse withstand voltages (BIL) of 33kV, 11 kV and 19 kV SWER lines by means of simple gaps in earth down leads in areas with high lightning intensity
 - The elimination of cross arms, where possible and advisable, as set out above.
- The section of the Design Manual dealing with environmental protection requirements must be reviewed and approved by the relevant Mozambican environmental authorities.

The adequacy of the references to labor practices and health and safety matters similarly need to be reviewed and approved by the respective responsible governmental authorities.