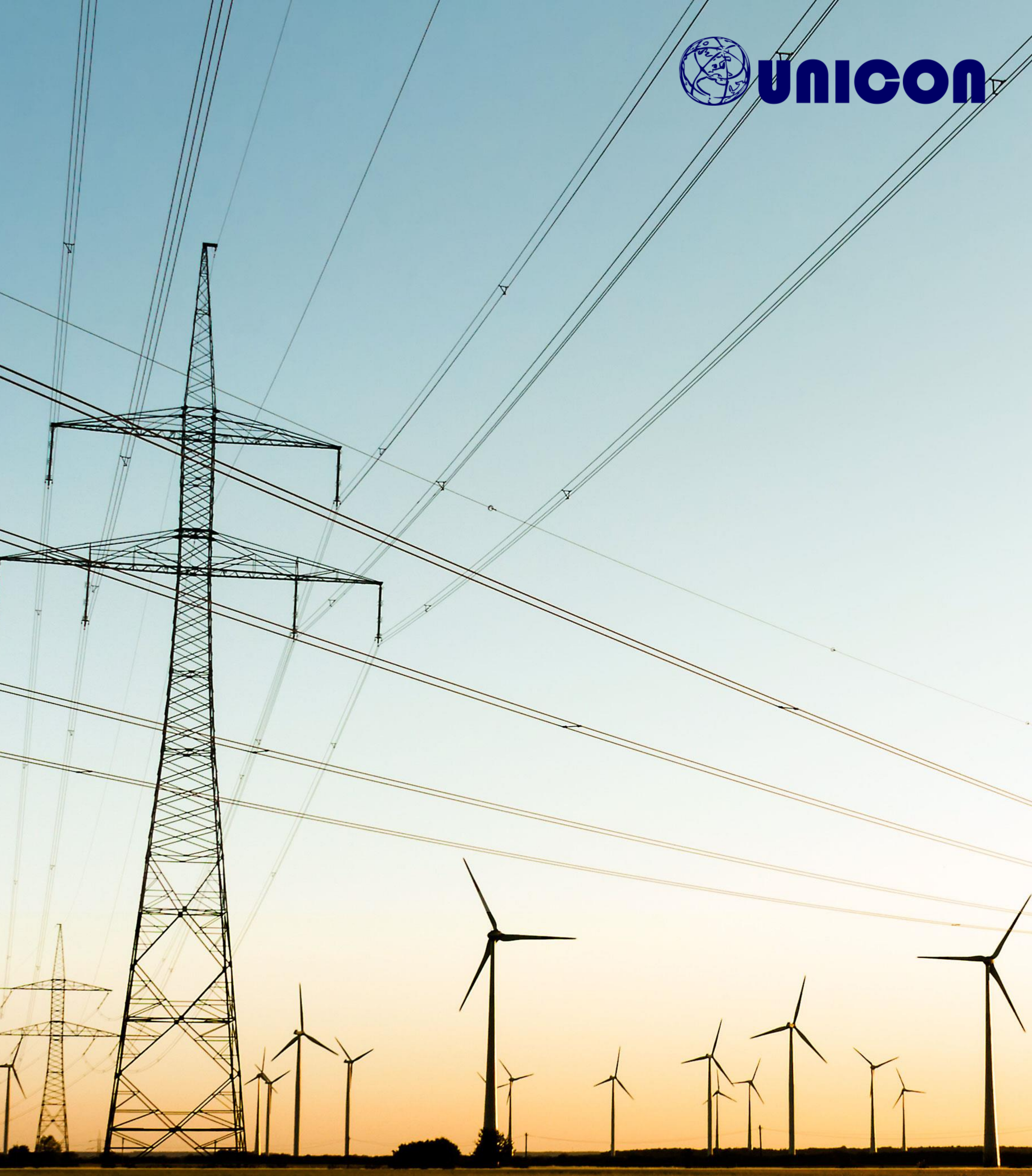

Power Master Plan

Development of a Power Master Plan for Somaliland Project

prepared for: Ministry of Energy and Minerals | World Bank

prepared by: UNICON Limited

Power Master Plan | Somaliland

DEVELOPMENT OF A POWER MASTER PLAN FOR SOMALILAND PROJECT

October 2018

Acknowledgements

Unicon Ltd (UK) was engaged by the World Bank to:

- produce power master plans for authorities and the sector that will guide the introduction and establishment of modern cost-effective reliable electricity supply systems over a 20 year planning period; and
- on the basis of the power master plans, produce detailed plan for developing the electricity in Hargeysa.

Unicon would like to acknowledge the assistance of the World Bank staff in assisting with the start of the Project in Somaliland during April and May 2017.

We would also like to thank the Government and other stakeholders who always made time available for us for assisting with the provision of data and discussing their views on the issues facing Somaliland energy sector.

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Abbreviations

AfDB	African Development Bank
AVR	Automatic Voltage Regulator
BM	Biomass
BMS	Battery Management Systems
CHP	Combined Heat and Power
CI	Compression Ignition
DFID	Department for International Development
DoD	Depth of Discharge
ERC	Electricity Regulation Committee
ESA	European Space Authority
ESP	Electricity Service Provider
ESRES	Energy Security and Resource Efficiency in Somaliland
FF	Fossil Fuel
FOR	Forced Outage Rate
GDP	Gross Domestic Product
GHI	Global Horizontal Insolation
HSDG	High speed diesel-fuelled generators
HRD	Human Resource Development
IDP	Internally Displaced Persons
IEA	International Energy Agency
IMF	International Monetary Fund
IPP	Independent Power Producer
JNA	Joint Needs Assessment
kV	Kilovolt
kWh	Kilowatt-hour
LCPDP	Least-Cost Power Development Plan
LEC	Levelised economic cost
LED	Light-emitting Diode
LOLE	Loss of Load Expectation
LPG	Liquefied Petroleum Gas
LRMC	Long run marginal cost
MW	Megawatt
NPV	Net Present Value
O & M	Operations and Maintenance
PbA	Lead Acid (refers to batteries)
PESS	Population Estimation Survey
PV	Photovoltaic
RAPS	Remote Area Power Supplies
SCG	Sahal Consulting Group
SHS	Small Home Systems

SPS	Standalone Power Systems
SRMC	Short run marginal cost
TA	Technical Assistance
TOR	Terms of References
UN	United Nations
UNDP	United Nations Development Programme
UPS	Uninterrupted Power Supply
USAID	The United States Agency for International Development
US $	United States Dollar
VRLA	Valve Regulated Lead Acid battery
WB	World Bank
WBG	World Bank Group
Wh	Watt-hour

Contents

1. Introduction

1.1 Objectives of the Assignment

In early March 2017, UNICON Ltd was engaged by the World Bank to undertake consultancy services for the development of a Power Master Plan for Somaliland. In accordance with the Terms of Reference (TOR), the objectives of the assignment are:

- to produce power master plans for authorities and the sector that will guide the introduction and establishment of modern cost-effective reliable electricity supply systems over a 20 year planning period; and
- on the basis of the power master plans, to produce detailed plans for developing the electricity supply in one or more cities.

The Consultancy is to provide the following key deliverables:

- Gap analysis of requirements for regulations and laws;
- Note on distribution standards and voltage levels;
- Outline of institutional development needs;
- Report on human resource development needs;
- Somaliland Power Master Plan report; and
- City Development Reports.

This document covers the development of the power master plan; the other deliverables are presented in companion reports. For convenience, the first four of the above deliverables are included as annexes to this report.

City Development Plan for Hargeysa is submitted separately as a stand-alone report.

1.1.1 Report Structure

Upon consultations with the World Bank, and reflecting certain comments made, the structure of the report is the following:

- Chapter 1: Introduction (this section)
- Chapter 2: Executive Summary – Power Master Plan
- Chapter 3: Overview of the Current Energy Situation in Somaliland
- Chapter 4: Development of Load Forecasts
- Chapter 5: Generation Options
- Chapter 6: Development of Expansion Plans
- Chapter 7: Conclusions and Recommendations

In addition to these chapters, the report includes as annexes the following:

- Annex 1: Terms of Reference
- Annex 2: Human Resources Development Plan
- Annex 3: Power Sector Institutions, Regulations and Laws
- Annex 4: Note on Distribution Standards and Voltage Levels
- Annex 5: Energy Situation in Somaliland
- Annex 6: On-grid/Off-grid Issues
- Annex 7: Discussion of Generation Issues

There are also annexes that cover some of the more academic material used in responding to the terms of reference (the energy situation in Somaliland, on-grid/off-grid issues and a discussion of generation issues) for reader's easier reference.

1.1.2 Methodology and Assumptions

Overall Approach and Work Plan

After the submission and approval of the Inception Report, the Consultant carried out the work in the following steps:

- Unicon met with government officials and local teams to assess the situation regarding data availability. Concurrently, they collected available and relevant data from the government agencies and donors;
- as a result of the above assessment, a set of questionnaires was prepared and validated by discussions with Government officials;
- after approval of the field survey team, the locations to be surveyed and the survey questionnaires, a field survey was carried out that encompassed all the regions;
- the data received were reviewed, validated and digitised;
- because of the reluctance on the part of some electricity supply providers to respond to the surveys, the Consultant requested intervention and support from the government officials, which was accorded; and
- based on the above, reports were prepared on the (i) gap analysis of requirements for regulations and laws, (ii) distribution standards and voltage levels, (iii) outline of institutional development needs, and (iv) human resource development needs.

The work on field data collection included (i) Interviews with government officials; (ii) Socio-economic surveys of small sample of residents; (iii) Interview and data collection with ESPs of communities visited. The survey was conducted in Hargeisa, Berbera, Laacaanood, Boroma, Burao, and Erigavo.

Principal Caveats and Resulting Limitations on the Analysis

Although the Consultant received significant support and cooperation from local consultants and Government officials and in spite of repeated efforts by the Consultant, there remained significant gaps in the data requirements for an effective and robust analysis. These include:

- absence of current and recent history of energy statistics (generation, sales by customer category and revenues) from some ESPs; and
- major gaps in the current basic data (population for the country and for each major community, sales by customer category, installed capacity, cost of operation, territory served by each ESP).

Two components of the work involved in a power master plan are impacted by the above limitations. The first is the load forecast, which, by definition, is based on the current level of population and load and historic trends in these parameters. The fact that this information was not completely available in some of the areas of the country severely affected the load forecast.

The second was that the actual installed generation is required as a starting point on the development of a plan to meet the load over the forecast period. This information was only partially available:

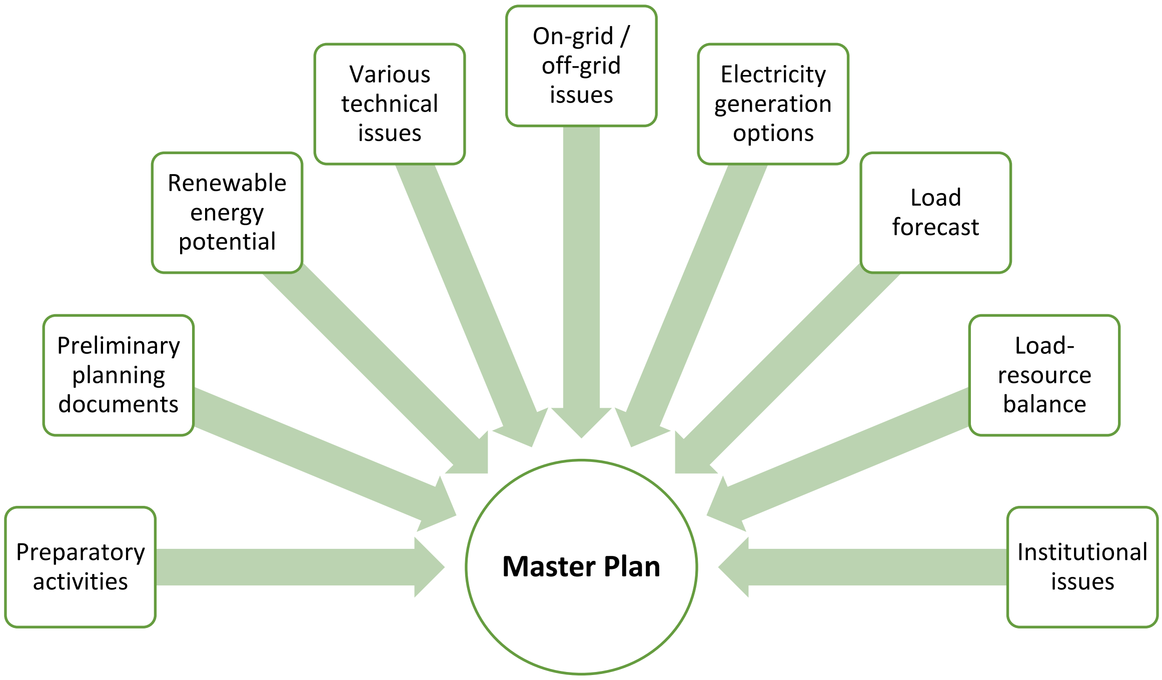
- in some locations served by several ESPs, one or more would not provide the required information;
- some locations could not be visited for security reasons and the government did not have information on those areas; and
- the record-keeping by some ESPs was inadequate for the needs of such a study as this one.

Box.
Because of data limitations, the Power Master Plan provided in this report is subject to greater uncertainty than that of a usual Master Plan in the estimate of the required generation installations and investments to meet the needs of the country. As additional data become available, the requirements of the electric power sector of Somaliland need to be reviewed and possibly revised.

1.2 Overview of Power Master Plan Elements

This Power Master Plan captures the current situation within the Somaliland power sector as well as suggests most efficient ways for improvement in this area. In preparing this document, (i) preparatory activities were conducted, (ii) preliminary planning documents produced, (iii) a set of electricity generation options identified, (iv) renewable energy potentials described, (v) technical issues discussed, (vi) solutions aimed to address the issues suggested, and (vi) on-grid/off-grid suggested expansion solutions developed. These are addressed in the Figure below.

Figure 1. Project activities



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1.3 Current Energy Sources

The resources currently mobilised for energy consumption fall into two prime categories. The first main category is energy resources intended for generation of electricity and its subsequent utilisation, and the second category is energy used for generating heat.

Current primary sources for providing heat are (i) sunlight, (ii) biomass, (iii) bottled kerosene, (iv) compressed LP gas, and (v) electricity. The primary sources for providing electricity are high-speed diesel generation sets (HSDGs) with limited use of grid-tied solar photovoltaic (PV) and very limited use of grid-tied asynchronous wind power turbines.

Based on data collected by the field surveys, Somaliland currently consumes in excess of 36,000 litres of diesel fuel per day to support the installed generation capacity. Much of this is occurring in suboptimal and wasteful conditions of wet stacking. These figures will inevitably grow with additional capacity installed and the total daily consumption if diesel is expected to rise significantly in the medium term, following the curve of increasing demand.

There is also a quite significant interest in as well as utilisation of Pico photovoltaic (PV) systems and Small Home Solar (SHS) PV electricity systems for residential lighting in both urban and remote areas. The addition of sizeable grid-tied solar PV generation to the HSDG-based systems of some of the various electricity service providers' (ESPs) electricity generation and distribution networks has resulted in some synchronised hybrid diesel-solar PV electricity generation systems across Somaliland.

1.4 Energy Potential

It is evident that both solar and wind resources have significant potential for electricity generation in the northern and coastal regions of Somaliland. There are technical challenges to establishing distributed electric generation using solar and wind power and their integration into the electricity supply of urban centres. However, this has become much easier in recent years, with significant automation and the adoption of smart network management as part of electricity generation.

A significant benefit of using multiple renewable energy sources is that electricity generation is derived from diverse sources and can be situated in a distributed manner around urban centres. This contrasts with centralised thermal generation sites, requiring specific nodes for fuel delivery.

Renewable generation can also be placed closer to key demand areas within distribution network to assure active and reactive power requirements. Consequently, if needed, they can be modified more easily based on changing load demands. Moreover, their modular nature permits very easy upgrades as well as maintenance and repair.

Figure 2. Local station vs. thermal power

Source: Unicon

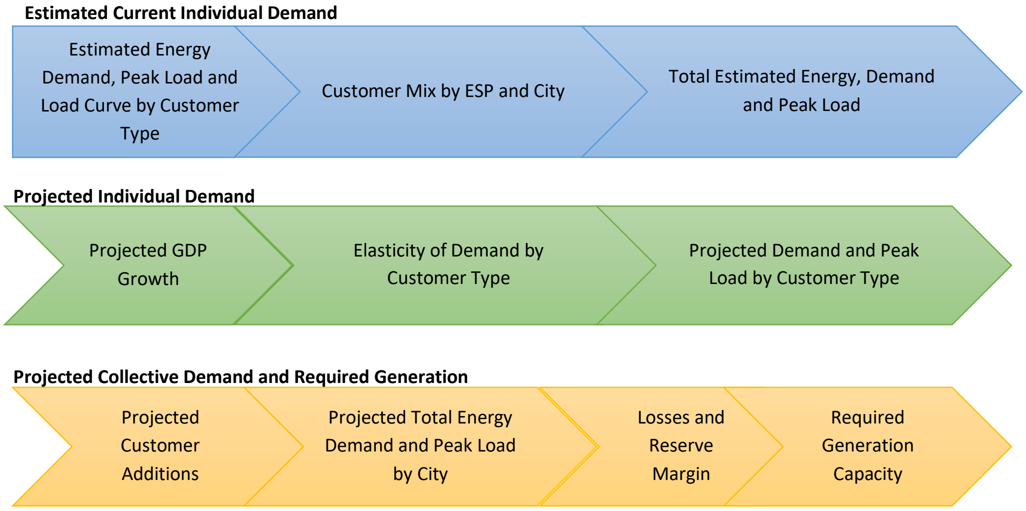
1.5 Load Forecast

1.5.1 Approach and Major Assumptions

The three main steps in the load forecasting process, as illustrated in the figure below were the following:

- Estimate current individual demand;
- Project individual demand;
- Project collective demand and required generation.

Figure 3. Load demand forecast process outline



Source: Unicon

In order to take into account uncertainties, three forecasts are derived – (i) a base forecast, (ii) a high forecast, and (iii) a low forecast. These have been developed around GDP growth assumptions presented below.

Table 1. Assumptions for GDP growth

Scenario	Period of forecast	
	2018-2027	2028-2037
Baseline	4.9%	2.5%
High	4.9%	7.5%
Low	2.5%	2.5%

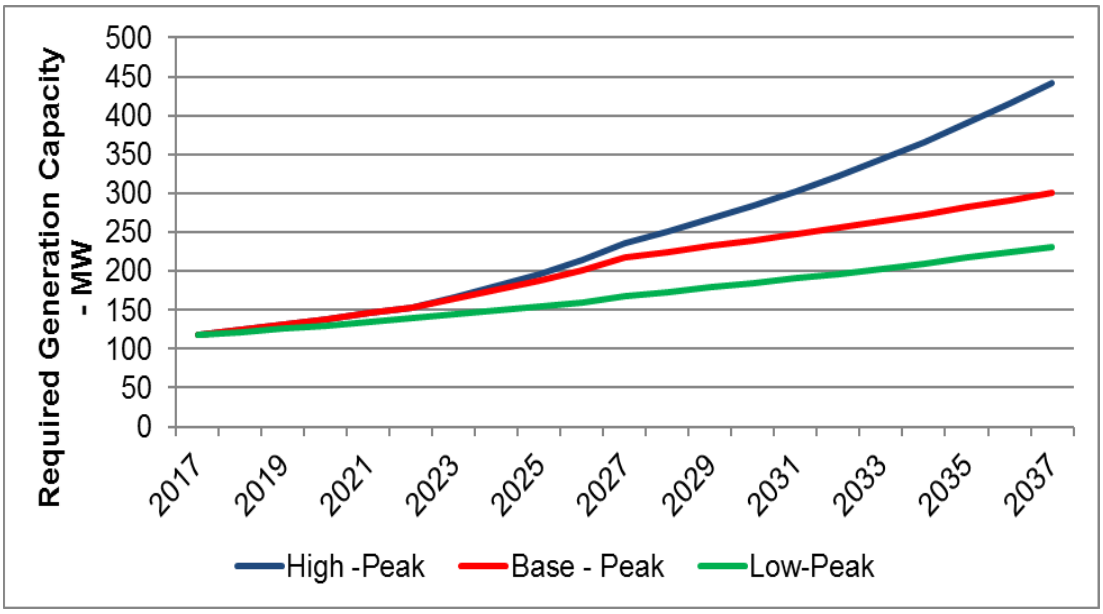
Source: Unicon

The rate of penetration of electricity supply was also varied between each scenario.

1.5.2 Main Results

Based on the information received and collected throughout the duration of the assignment, as well as our analyses, below is the forecast of generation capacity requirements by each scenario. The base scenario assumes about 1,000 MW of installed capacity by year 2037.

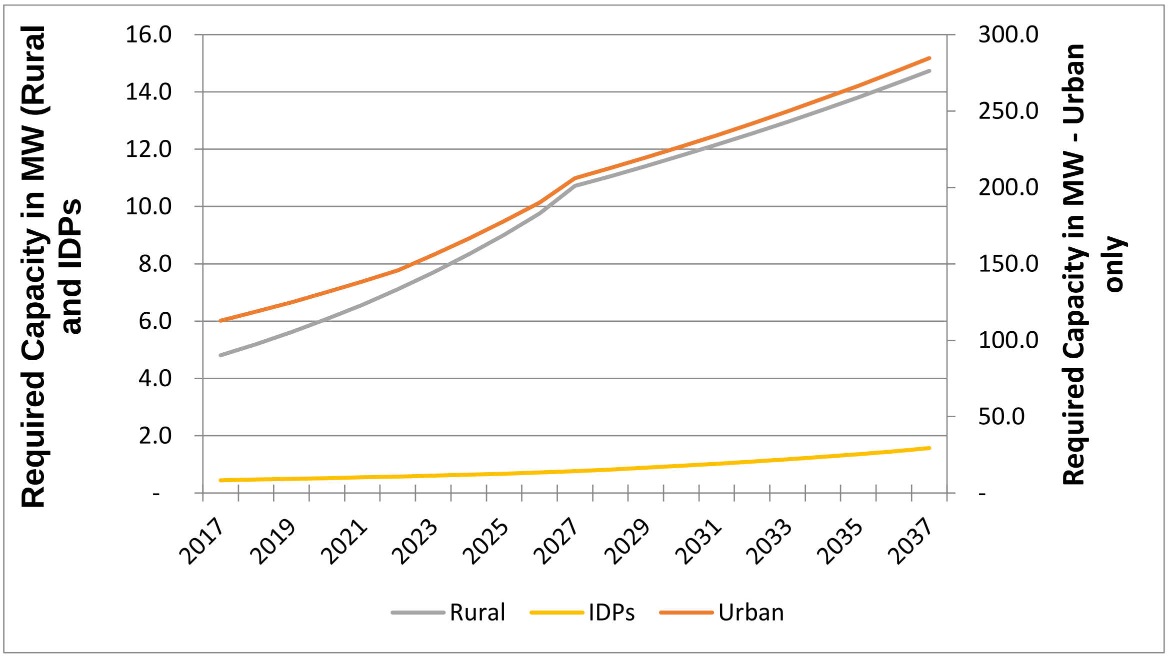
Figure 4. Forecast of generation capacity requirements by scenario



Source: Unicon

This figure is further segregated by population type in the graph below.

Figure 5. Required generation capacity by population type



Source: Unicon

1.6 Generation Options

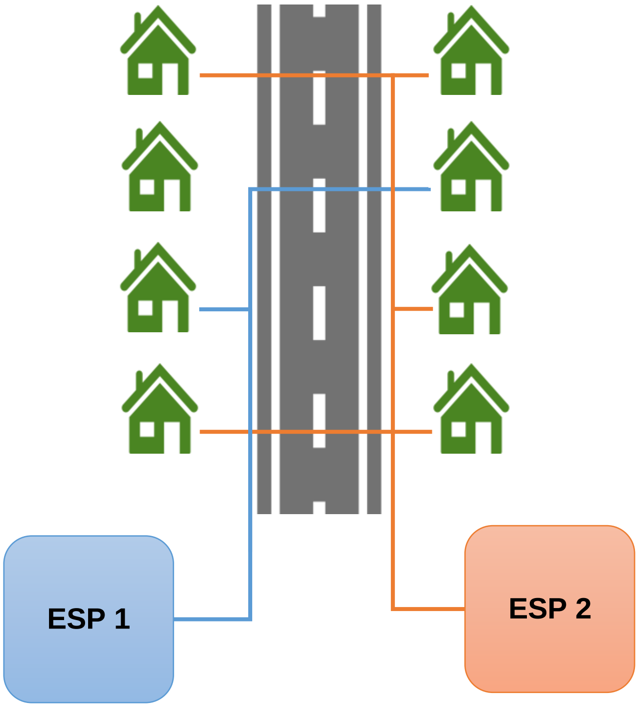
1.6.1 Current Generation Patterns

Observations from urban field data collection and discussions, indicates that until recently, the renovation or upgrading of generation sites by the ESPs, generally involved either replacements or additions, by using similar or larger HSDGs. Very few of the urban ESPs and captive generators have implemented synchronisation and automation as part of their generation processes. As a consequence, dedicated generators are allocated to exclusive feeder lines, which leads to inefficient use of the generation.

All of the ESPs operate independently and, as a consequence, there is significant duplication of generation, distribution, technical, maintenance and human capability infrastructure, as illustrated in the figure below. This duplication severely limits the scaling up of electricity generation and, moreover, hampers delivery and servicing for larger customer loads. Duplication is especially acute for ESPs within the cities having multiple ESPs. Currently, no ESPs share distribution networks, and these combined ESP electricity delivery limitations within the urban parallel island networks, have resulted in large load customers opting for:

- Utilising two different ESPs, in effect multiple networks supplying one customer; or
- Creating their own on-site, captive generation stand-alone "mini-grids".

Figure 6. Example of Duplication of Investment

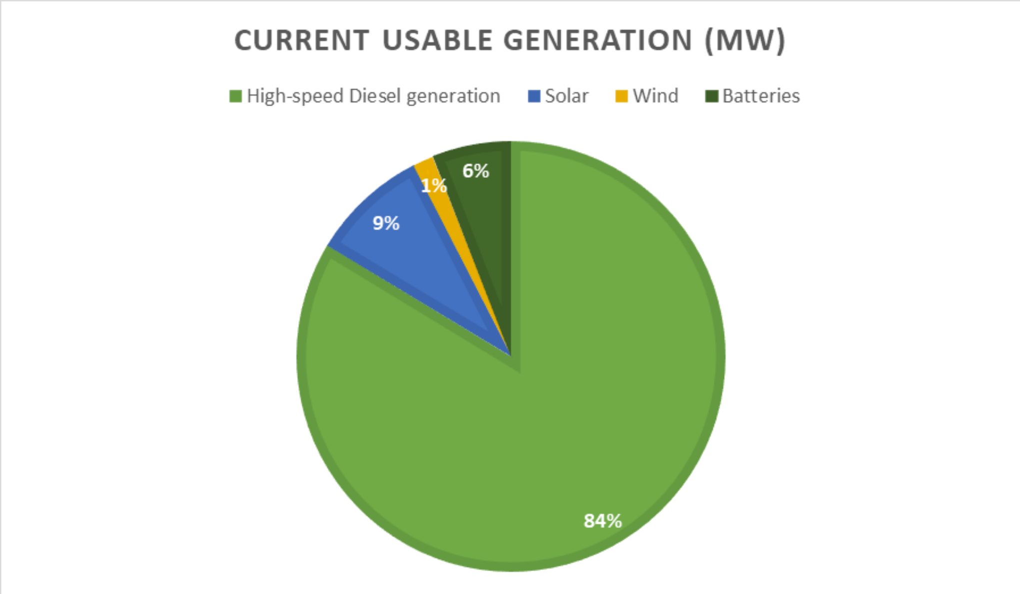


Source: Unicon

There is a significant limitation to the amount of electrical energy any one vertically integrated ESP can deliver when the ESP is not able to provide parallel (synchronised) interdependent generation and distribution to their user loads. This – along with the impact of multiple radial island network duplication by ESPs – constrains the amount of electrical energy any one ESP can deliver to load users, especially for large electricity users.

Summary of totals from collected data for "current usable" generation presented below in percentage terms.[1]

Figure 7. Installed capacity by type (expressed as a percentage of the total)



Source: Unicon

1.6.2 Diagnostic of Current Generation

Currently, many urban based HSDGs are operating well below their expected and designed performance criteria. This kind of operation results in significant amounts of "wet stacking" (diesel fuel waste, extra pollution, performance degradation and shorter HSDG lifespans) amongst electricity producing HSDGs.

If properly addressed by introduction of synchronisation between the generating units and, ideally, supplemented by a renewable source, immediate effectiveness gain could be a substantial contributor to electricity price reduction – by up to 25% compared to single until operation, as shown in the bar chart below.

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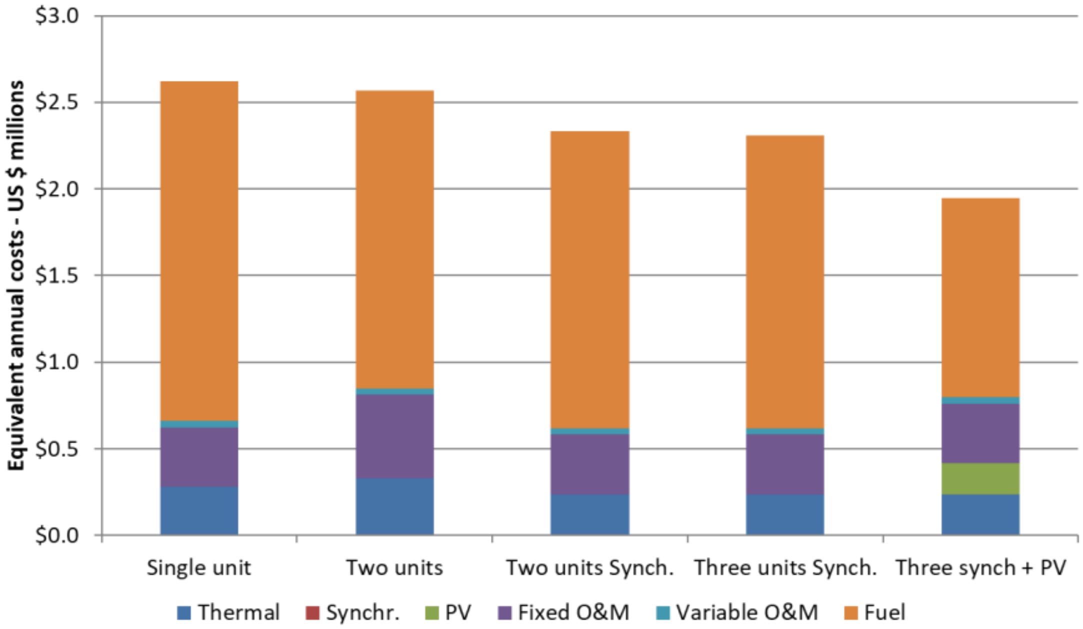
[1] *Generation data for the city of Hargeysa was incomplete, with approximately 50% of Hargeysa's ESPs not having provided information. Some generation data was obtained for Berbera via ESRES data.*

Figure 8. Benefits of synchronisation



Source: Unicon

1.7 On-Grid/Off-Grid

Currently, there is no physical national grid in Somaliland. The system of delivering the electrical energy to users comprises of a network of isolated distribution grids with isolated generation providers. These island networks are anchored to specific urban centres with dedicated Electricity Supply Providers (ESP). Each ESP owns and operates their complete generation-distribution-customer-revenue chain using a radial distribution island network. Generation is primarily, close to 100%, by high-speed diesel fuel powered generators (>1,000 rpm).

In addition, across Somaliland, there are distinct and unique features defined by both socio-economic activities and geographic localities. These determine the kinds of useable electrification delivery. An important proportion of Somaliland populations are identified as rural, which encompasses a level of diversity that produces an electrification context that is quite complex. For many rural communities and, particularly, very rural regional populations, these communities are very mobile pastoralists. These populations subsist as livestock herders, constantly seeking new fresh pastures and water for their livelihoods. Consequently, they do not have a fixed location for electrical energy to be delivered and used by them. In fact, they operate in a constant state of flux, adapting to the local climate, and at best currently have access to telephone communications and types of Pico solar devices.

Clearly, these mobile rural communities are not connected to any electricity grid and are remote and, naturally, off-grid. On the other hand, the communities within the large urban centres like Hargeysa, Burao, Erigavo and others, are stationary and obtain electricity from an existing electrical energy network – a grid – and are therefore on-grid.

In terms of generation, it is clear that the off-grid electricity supply needs to follow different growth patterns from those served by-grids.

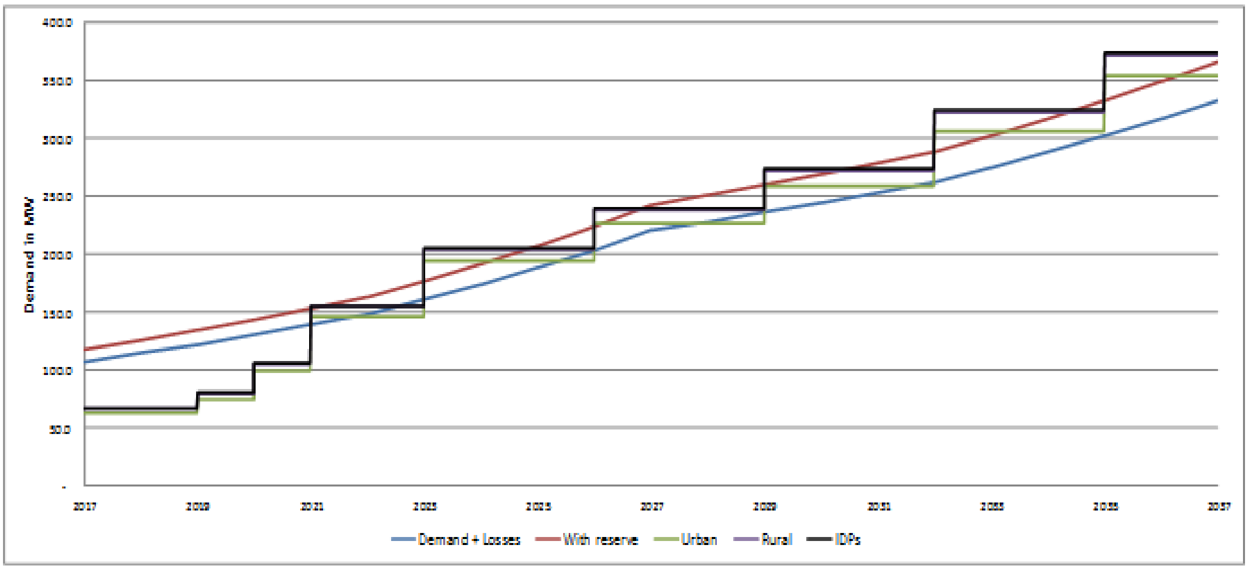
1.7.1 Generation Options

The generation options retained for meeting future load requirements are as follows:

- Improve the efficiency of existing generation by automation and synchronisation of generation units thereby reducing 'wet stacking';
- Convert existing generation to hybrid systems using solar photovoltaic installations;
- Consider the use of wind generation in zones with high wind potential:
  - Ensure that the implementation of such systems includes appropriate training to avoid repeating the mistakes made with earlier installations.
- New generation options retained include:
  - High speed diesel generators in size ranges from those existing in each system up to 2,000 kW;
  - Medium speed diesel generation in the common size ranges of 1,000 kW to 10,000 kW;
  - Simple gas turbines burning diesel fuel in size ranges of 1,000 to 10,000 kW;
  - Solar photovoltaic systems to be added to the fossil fuel generation;
  - Wind generation to be considered in high potential areas.

1.8 Expansion Plans

Figure 9. Summary of instalations required



Source: Unicon

The approach used was to select several expansion scenarios that represent different types of generation and prepare an expansion plan for each scenario that meets the forecast load with defined reserve margin.

Figure 9 above presents a summary of the installations required and is the aggregation of the capacities required as derived for the different population types. As illustrated in the figure, the country is in a deficit situation regarding generation until 2022. There are two main reasons for the deficit:

- Insufficient investment in generation; and
- Inability to operate the existing generation in a synchronous manner.

1.9 Conclusions

The main conclusions drawn from the analyses are:

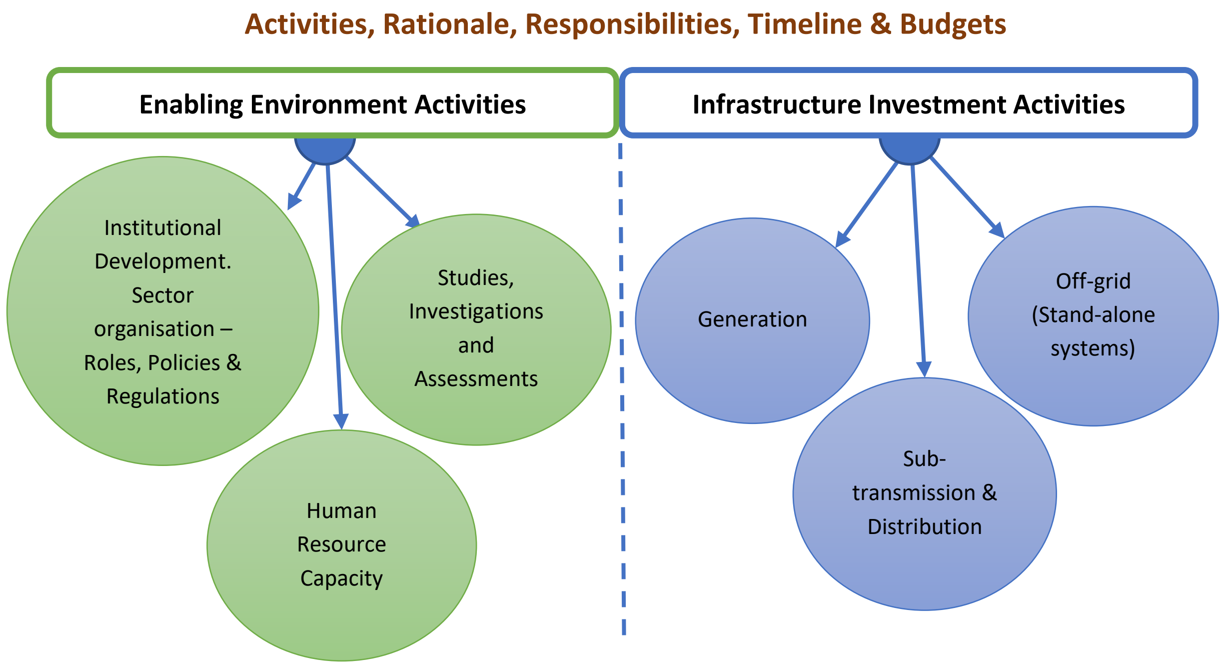
- There is insufficient generation capacity to meet the current loads;
- The current generation is not being used efficiently due to lack of investment in the equipment required to synchronise the operation of existing units as well as shortage of operations and maintenance staff trained in the use of the equipment required for synchronous operation of generating units;
- There are high technical and commercial losses in most systems for which records were available;[2]
- Significant improvements can be made to the operation of the power sector throughout the country by increased cooperation between ESPs under some supervision from one or more regulatory authorities. This is specifically in the areas of duplication of distribution investments in order to compete for customers in the same tight geographical areas (i.e. the same street) and the inability to benefit from the economies of scale in the purchase and installation of small units to serve a large market.

2. Executive Summary – Power Master Plan

This section summarises and presents the power master plan for Somaliland. It is separated into two components of (i) enabling activities, and (ii) infrastructure investments, shown in Figure 10.

[2] Anecdotal evidence suggests that the situation is as severe, if not more so in systems for which adequate records are not available.

Figure 10. Structure of the Power Master Plan



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2.1 Enabling Activities

Enabling activities applicable to the Power Sector as a whole

1. Set up institutions to promote discipline in the power sector.

US$ 0.50 million for the set-up.

Initially this would consist of (1) a Council to make recommendations to the Government on issues in the power sector, (2) associations of ESPs and others involved in the power sector to promote issues common to all participants in the power sector (this would include ESPs, and major customers) and (3) Ad-hoc committees set up to focus on s single issue needing resolution.
This would be followed by a regulator whose duties could include independent, open, objective and transparent non-discriminatory regulatory processes and practices.
This process would need to be led by the Government and have the support of the power sector stakeholders.
The specific structure, mandate and duties of the regulator could be defined through the use of an ad-hoc committee.

Immediate (2018-2019)

2018 | 2019 | 2020 | 2021 | 2022

Short term (years 2018 to 2022)

Initiated in the short term (years 2018 to 2022) but on-going

2. Implement a grid code for power sector operations.

US$ 0.50 million plus contributions of time and expertise from each ESP.

One of the early roles of the Regulator should be to develop a grid code. Two significant provisions of such a code could be:

- Safety of public and employees;
- Common set of rules for operation of systems.

This could be initiated through an ad hoc committee with representatives of the ESPs, the consumers and the government.

3. Set up rules for improving efficiency of the sector.

Covered in section 2, left. (Implement a grid code)

One of the early roles of the Regulator should be a series of rules and operating procedures aimed at improving the efficiency of the power sector. These could include:

- Promotion of cooperation between ESPs;
- Definition of service territories for each ESP (eventual).

This could be initiated through an ad hoc committee with representatives of the ESPs, the consumers and the government.

Table 2. Enabling activities applicable to the Power Sector as a whole (Costs)

#	Description	Cost
1	Initially this would consist of (1) a Council to make recommendations to the Government on issues in the power sector, (2) associations of ESPs and others involved in the power sector to promote issues common to all participants in the power sector (this would include ESPs, and major customers) and (3) Ad-hoc committees set up to focus on s single issue needing resolution. This would be followed by a regulator whose duties could include independent, open, objective and transparent non-discriminatory regulatory processes and practices. This process would need to be led by the Government and have the support of all power sector stakeholders. The specific structure, mandate and duties of the regulator could be defined through the use of an ad-hoc committee.	US$ 0.50 million for the set-up; the annual expenses of such institutions would be covered by fees from ESPs being regulated.
2	One of the early roles of the Regulator should be to develop a grid code. Two significant provisions of such a code could be: • Safety of public and employees; • Common set of rules for operation of systems. This could be initiated through an ad hoc committee with representatives of the ESPs, the consumers and the government.	US$ 0.50 million plus contributions of time and expertise from each ESP.
3	One of the early roles of the Regulator should be a series of rules and operating procedures aimed at improving the efficiency of the power sector. These could include: • Promotion of cooperation between ESPs; • Definition of service territories for each ESP (eventual). This could be initiated through an ad hoc committee with representatives of the ESPs, the consumers and the government.	Covered above.

Enabling activities applicable to the Government

Immediate (2018-2022)

US$ 0.50 million
1. More thorough survey of the energy and electricity demands for isolated rural populations.

US$ 0.50 million
2. Continue to promote and support the ongoing programme to provide mobile renewable electrical energy to the nomadic population.

US$ 0.50 million
3. Promote the installation of appropriate metering.

Ongoing (2018 and beyond)

US$ 0.50 million
4. The promotion of the use of medium speed diesel generation and simple cycle gas turbines for the major urban centres.

US$ 0.25 + US$ 0.50 million*
5. Set up a programme to update the power master plan on a regular basis, including the collection and analysis of relevant power sector data.

2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

Medium Term (2022-2027)

US$ 1.00 million
6. Study the possible implementation of electricity and energy generation from urban solid waste for the major urban centres.

US$ 1.00 million
7. Study the implementation of a transmission grid to connect the major urban centres and the power sectors of neighbouring states (Djibouti, Ethiopia and Puntland).

US$ 0.50 million
8. Consider covering any exposed water reservoirs with grid-tied or standalone solar PV "floatovoltaics" to eliminate 90% of fresh water evaporation from reservoirs.

* US$ 0.25 million per year for the data collection plus another US$ 0.50 million every three to five years for the update to the power master plan.

Table 3. Enabling activities applicable to the Government

#	Description	Cost
1	These regions support pastoralist communities and their commercial activities and lifestyles, which require electrical generation solutions that improve their quality of mobile life and commercial productivity.	US$0.50 million
2	Such a programme would include small installations of solar panels and batteries large enough to supply minimal needs of a single family or a cluster of a few families.	US$ 0.50 million for promotion only; the sale of such devices would be left in the private sector.
3	This will permit all ESPs to monitor the loading on each feeder (and each phase of the feeder) and compare those loadings to the sales of energy to customers served in order to identify, locate and quantify losses.	US$ 0.50 million for promotion only.
4	The major urban centres of Somaliland (Hargeysa and Berbera in particular) can be expected to require generation units in the 2,000 to 5,000 kW range in the near future. The use of a combination of both MSD generators and gas turbines can result in significant savings to the power sector in investment and annual costs and these savings can be shared between the ESPs and the customers. Some incentives may be required to persuade the ESPs to migrate towards this type of conventional generation.	US$ 0.50 million.
5	Any power master plan is only valid for as long as the assumptions used to derive it remain valid. Two activities are urgent: • Monitor the Somaliland economy as a whole to assess major changes that are occurring; • Build up a reliable and complete database. The government, using its own resources, should update the power master plan every year for the first three to five years. After that period, it should engage the services of an international consultant to completely redo the power master plan using a fresh approach.	US$ 0.25 million per year for the data collection plus another $0.50 million every three to five years for the update to the power master plan.

6	This would be done through the use of gasification and pyrolysis on urban solid waste at the major urban dumpsites and this would apply particularly to Hargeysa. The size, location, type of plant type of waste, waste collection approach, cost estimates and economic and financial feasibility all need to be studied.	US$ 1.00 million for the feasibility study, which should include the estimated investment cost for the implementation of the plant.
7	This would permit Somaliland to benefit from (1) economies of scale in the construction of large power plants that can be shared between ESPs, (2) permit the construction of large hydro plants, (3) take advantage of the possibility of importing fuels not currently in use in Somaliland such as Liquefied Natural Gas from Yemen and other Middle-Eastern sources and (4) increase reliability of service to major load centres.	US$ 1.00 million for a feasibility study plus cooperation from each neighbouring countries.
8	This will also produce electricity for local loads and preserve important water reserves for urban and agricultural activities. The implementation of such a project should take account of environmental and health issues. Such installations would benefit the water sector as well as the electricity sector.	US$ 0.50 million for the study to identify suitable locations and the feasibility of covering selected reservoir as a pilot project.

Enabling activities applicable to the Electricity Supply Providers

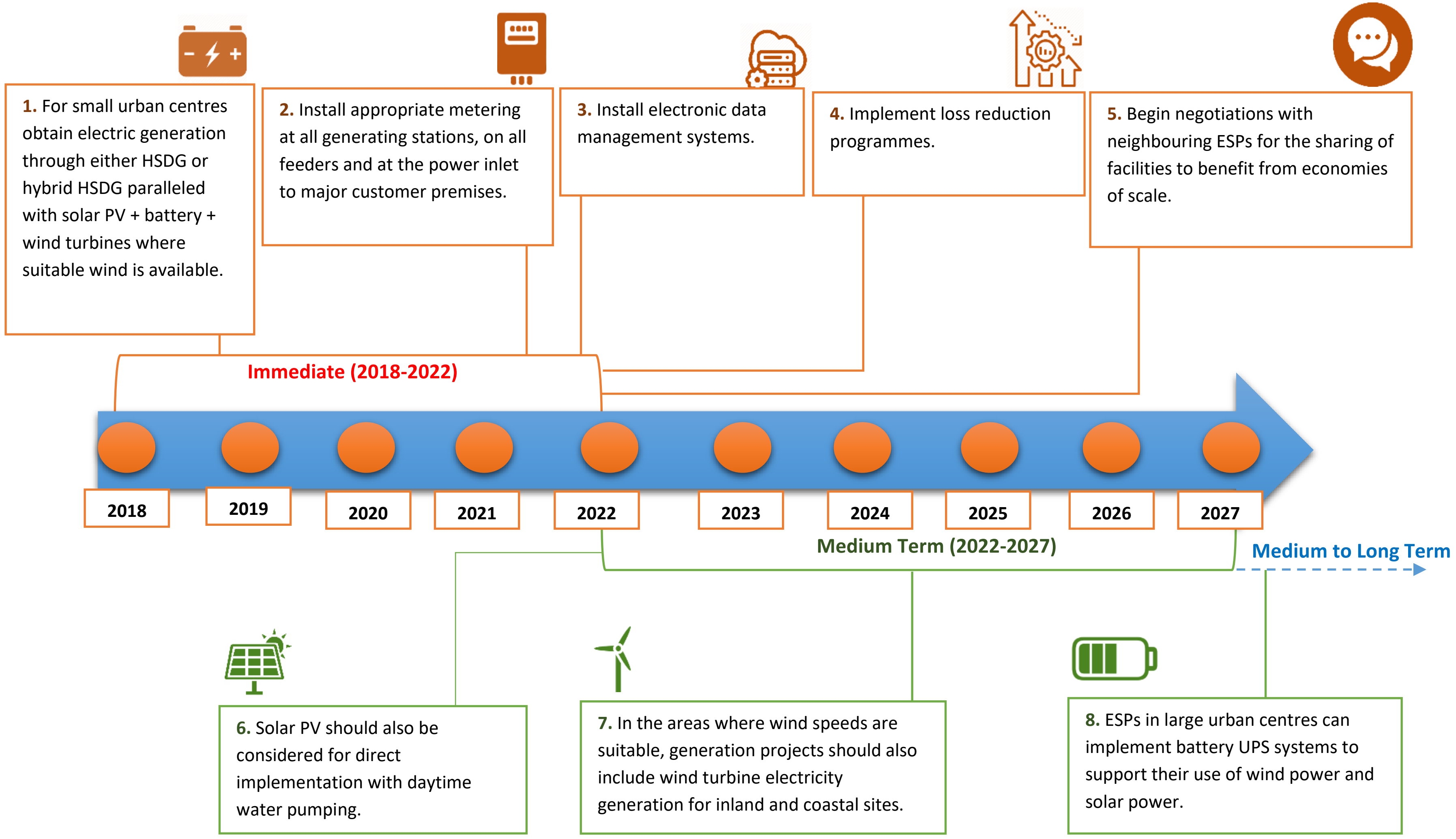


Table 4. Enabling activities applicable to the Electricity Supply Providers

#	Description	Cost
1	This will require input from the automation and synchronisation competences. It will also necessitate in-country and on site ongoing technical trainings and technical school curricula to ensure that the national technical and entrepreneurial pool for creating and implementing small urban electricity generation competencies grows.	Included in the infrastructure investment section.
2	This will permit all ESPs to monitor the loading on each feeder (and each phase of the feeder) and compare those loadings to the sales of energy to customers served in order to identify, locate and quantify losses.	Included as part of ESP normal operating expenses.
3	This will permit all ESPs to maintain, as examples: • accurate asset records in terms of locations, costs, years of installation and replacement; • generation, sales and losses. Such systems facilitate updating files and also permit the easy retrieval of files.	US$ 50 to 100 thousand per ESP depending upon the size of the ESP and commercial arrangements with suppliers of appropriate software.
4	Such programmes should be separated into three sets of activities: • A metering programme, as recommended above to identify the quantity and location of losses; • A structured plan of investments to strengthen the sub-transmission lines and feeders to reduce technical losses; • A structured plan of increased monitoring, public awareness and discipline in operations to reduce non-technical losses and theft.	Depends upon the size of the ESP and the level of commitment to the reduction in losses.
5	This applies to all ESPs in load centres with multiple ESPs. Economies of scale can be obtained by: • Sharing ownership of generating units that are too large to be used by only one of them;	None required

#	Description	Cost
	• Sharing ownership of distribution feeders; • Consolidating service territories to improve operational efficiency. Such sharing of infrastructure is facilitated by a strong regulator operating in an independent and fair manner to ensure that all appropriate rules regarding such sharing are followed.	
6	This will free up diesel fuel costs and permit these HSDGs to be re-tasked to electricity generation for other commercial or urban loads.	Part of normal expansion of the ESPs to meet the loads identified in their service territory
7	Wind power generation will require not only the construction and implementation of the wind power turbines, there will also need to be a systematic programme of training technical capability and entrepreneurial capability. This must include the building of local competence and establishing technical relationships with the OEMs to assure wind turbine commissioning and operations, plus the CMS and maintenance programmes.	Included in the infrastructure investment section
8	This will enhance the penetration of further renewable electricity generation into the electrical network and reduce diesel fuel expenses.	Included in the infrastructure investment section.

2.2 Infrastructure Investments

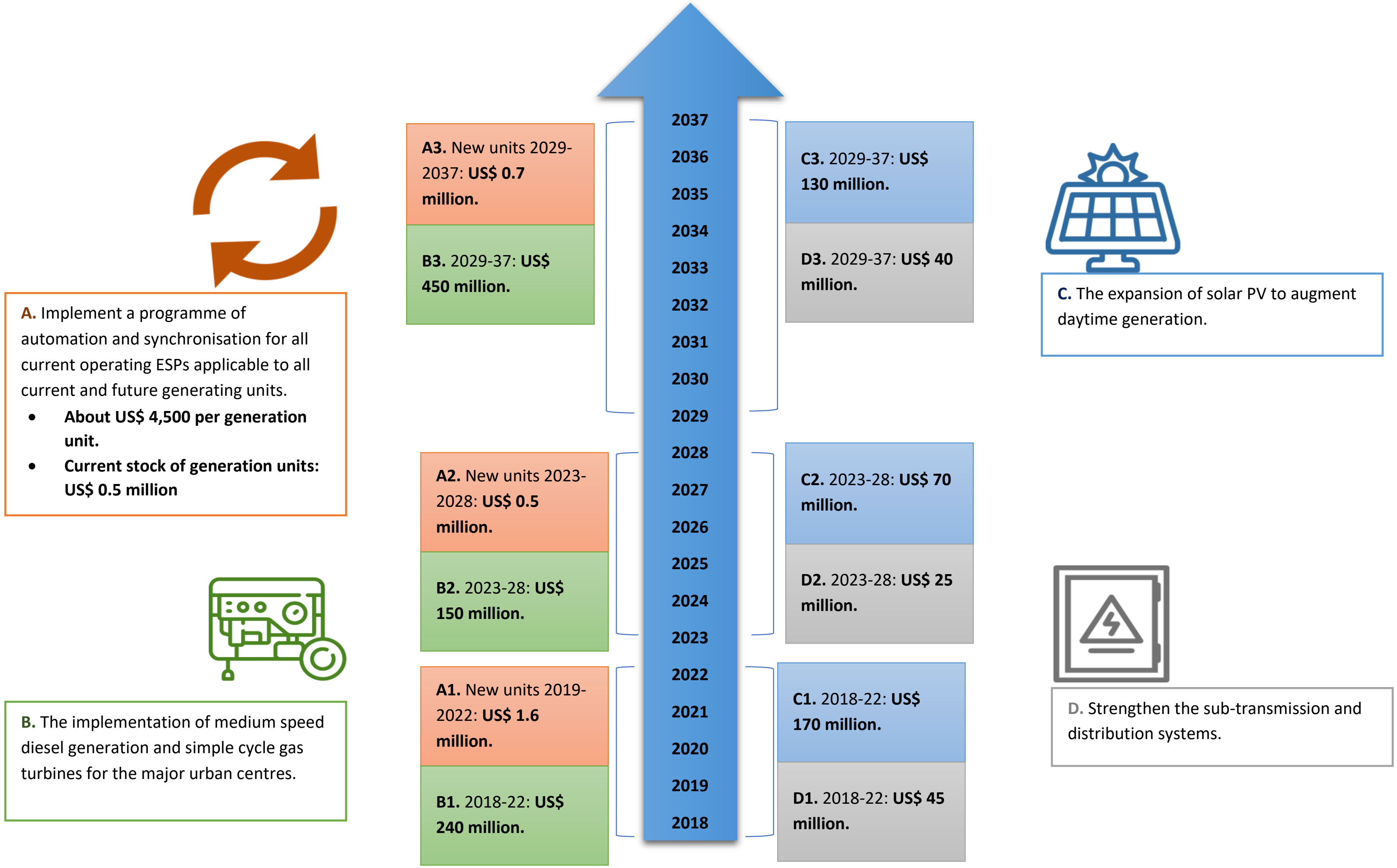
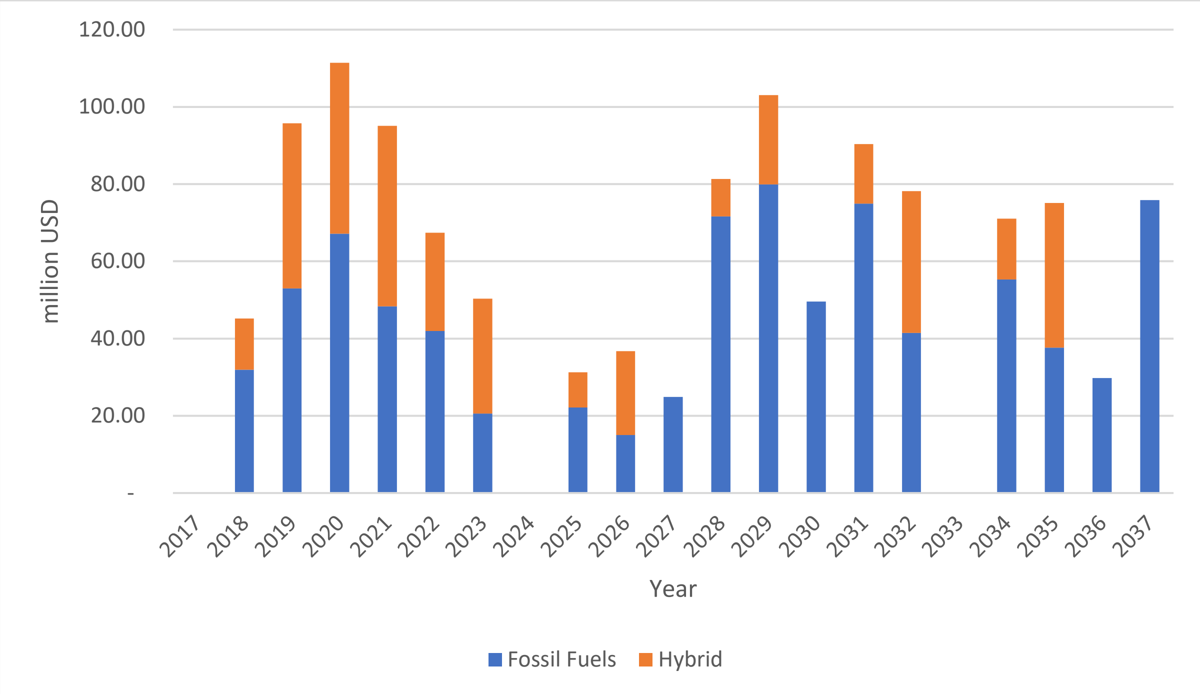


Table 5. Infrastructure investment activities

#	Description	Cost
A	The outcome from this engagement will result in: • Improved efficiencies in the use of diesel fuelled generators and their fuel consumption; • Enhance maintenance, and lifespans of diesel generators; • This will also result in the monitoring of actual generation at site for each ESP, so that this when compared to customer use loads; a proper determination of electrical losses by each ESP can be properly determined; • ESPs will be able to quickly respond to growing demands with more generation, within the confines of the current radial distribution networks carrying capacity. To affect this there will need to be technical training and assistance for ESP technical staff.	About US $4,500 per generation unit. • Current stock of generation units: US$ 0.5 million; • New units 2019 – 2022: US $1.6 million; • New units 2023 – 2028: US $0.5 million; • • New units 2029 – 2037: US $0.7 million.
B	The major urban centres of Somalia (particularly Mogadishu, Hargeysa, Boosaaso) can be expected to require generation units in the 2,000 to 5,000 kW range in the near future. Both MSD generators and gas turbines can be obtained in this size range. The combination of the two types of generation, particularly if combined with the automation and synchronisation equipment, provide the most efficient and cost-effective means of supplying the load to those centres.	• 2018/22: US$240 million; • 2023/28: US $150 million; • 2029/37: US $450 million.
C	Grid-tied solar PV should be added to both reduce diesel fuel expenses and increase daytime generation for manufacturing, commercial and institutional customers. This can only be done when the HSDG are operated in their efficient zone of 80-100%. The level of penetration of grid tied solar PV should attain 20-25% of daytime generation/penetration.	• 2012/22: US $170 million; • 2023/28: US $70 million; • 2029/37: US $130 million;
D	These investments are required to cover the following activities: • Evacuation of power from new generation plants that consolidate generation in new larger plants; • Interconnection of distribution facilities of individual ESPs with their neighbours; • Building sub-transmission rings (22 kV) in smaller communities and transmission rings (132 kV) in larger communities; • Building bus-bars to permit the generation from several generating units to be combined; • Rationalisation of sub-transmission and distribution feeders to provide more efficient supply of power to customers.	• 2018/22: US $45 million; • 2023/28: US $25 million; • 2029/37: US $40 million.

The infrastructure investments presented above represent very large investments and cover the entire country. Figure 11 below illustrates the investments required for, respectively, the fossil-fuelled plants needed to meet the load plus losses with an adequate level of reliability and the photovoltaic systems that could be added.

Figure 11. Investments in Somaliland generation – US $ millions including inflation



Source: Unicon

They are treated separately as different decision processes are required when considering each. The minimum investment cost would be to install only the fossil-fuelled generation but, in such cases, the annual operating fuel costs would result in higher lifetime costs than the hybrid systems. On the other hand, the lifetime cost of the alternative including the solar installations would reduce significantly the annual fuel costs such that the present value of the capital, operating, maintenance and fuels costs over the forecast period would be minimised. Note that the graph only presents the investment costs; the impact on lifetime costs is not shown.

The following Table 6 presents this information in tabular form for the short-term, the medium term and the long term.

Table 6. Summary of Investments in generation

2018 – 2022 (USD million)	2023 – 2028 (USD million)	2029 – 2337 (USD million)	Total (USD million)
Fossil fuelled generation units			
242	154	445	841

2018 – 2022 (USD million)	2023 – 2028 (USD million)	2029 – 2337 (USD million)	Total (USD million)
Hybrid units only – to be added to Fossil generation investments			
172	70	128	370

Source: Unicon

Note that the fossil fuelled generation is a mix of high-speed generation for smaller centres and a combination of medium-speed diesel generating units and combustion turbines using diesel as a fuel. It is recognised that these amounts represent a heavy burden on the ESPs and it is assumed that these investments will be a combination of private equity financing, private borrowings and possibly support from international donors; no attempt has been made to ascertain the precise source of any financing.

These estimates do not include any sub transmission costs. Depending upon the configuration of the generation and the dispersion of the loads in each load centre, such costs could amount to 10% to 25% of the investment costs in fossil-fuelled generation.

It is also noted that this report recommends significant departures from the norm for ESPs in Somaliland. This includes:

- synchronisation of generation to provide more efficient use of existing and new generation;
- with synchronisation of generating units, the supply of power can be made more effective with the ability to connect more customers to the generation plant via sub-transmission networks;
- the introduction of new (for Somaliland) technologies for generation such as:
  - medium-speed reciprocating engines (or diesel engines – MSDG);
  - combustion turbines (or Gas Turbines using diesel as a fuel – GT); and
  - Generation from municipal waste.
- mobile hybrid (photovoltaic plus batteries) for nomadic populations.

These departures may require technical assistance from international development partners to assist the sector in absorbing these changes effectively. The Table 7 below provides a tentative timeline for such support. It is important to note that a master plan study is, by design, a "road map" for development over the medium to long term and not a source of precise investment packages. Therefore, each investment package should be further investigated by means of a Project Preparatory Technical Assistance.[3]

In addition, as can be seen from Table 7 below, over US $70 million would be required to provide minimal electric power to the nomadic population over the forecast period.

[3] *Additionally, the city development plan for Hargeysa designed in parallel with this document provides a roadmap of identified and preliminarily costed projects on the city scale for a 5-year horizon.*

Table 7. Investments required for mobile power systems

2018 – 2022 (USD million)	2023 – 2028 (USD million)	2029 – 2337 (USD million)	Total (USD million)
Annual Investment in Mobile units for nomadic populations			
15	15	46	76

Source: Unicon

3. Overview of the Current Energy Situation in Somaliland

3.1 Introduction

As part of producing this Somaliland Power Master Plan, an assessment of the potential energy resources for producing and supplying electrical and heat energy was crucial. This is to assist the energy authorities, energy infrastructure investors and sector stakeholders in establishing modern, cost effective and reliable electricity systems for a 20-year horizon, which is key for national and regional development.

An assessment of natural energy resources fills gaps for the energy authorities and stakeholders, such that they can better develop and implement strategies along with building technological and institutional capability. In addition, this provides a basis for supporting integration and development within the energy and interconnected sectors, along with, enabling the inclusion of support from donors and Public Private Partnerships into these processes.

The resources currently mobilised for energy consumption fall into two prime categories. One category is energy resources intended for the generation of electricity and its subsequent utilisation and the other category is for the generation of heat:

- current primary sources for providing heat are sunlight, biomass, bottled kerosene, compressed LP gas and electricity;
- primary sources for providing electricity are currently high-speed diesel generation sets (HSDGs) with limited use of grid-tied solar photovoltaic (PV) and very limited use of grid-tied asynchronous wind power turbines; and
- there is also a quite significant interest to and utilisation of Pico PV and Small Home Solar (SHS) PV electricity systems for residential lighting in both urban and remote areas.

Furthermore, the addition of sizeable grid-tied solar PV generation to the HSDG based systems of some of the various electricity service provider's (ESPs) electricity generation and distribution networks has resulted in some synchronised hybrid diesel-solar PV electricity generation systems across Somaliland.

3.2 Country Overview

The initiatives shown by the Government of Somaliland in the recent years along with the overall improvement of the economic situation and business environment suggest that an appropriate course has been chosen by the country and that the current leadership is perceived as able to address the many challenges that require immediate action to stimulate further growth and development.

The main challenges the Government has to deal with on a daily basis are strategic ones like poverty, hunger, drought, and limited access to healthcare and education, as well as severely underdeveloped infrastructure. It is widely recognised that such challenges do not have a simple overnight solution, and the Government, together with the international community, are taking measures to combine efforts that produce short-term tangible effects with those that bring longer-term structural improvement in key sectors.

At the same time, Somaliland possesses substantial natural resources that could help improve the country's current economic and social reality. This, however, requires investment, which, in turn, requires a climate that fosters investment – Fortunately, this seems to be already on the Government's agenda and important steps are being taken toward that end (e.g., taxation regime clarification, customs regulations, etc.).

In 2012, the country showed an estimated per capita GDP of US $347,[4] and over US $600 if the informal economy is considered – levels which by themselves indicate that poverty is high (about 50% of the population according to various studies, including ones by the World Bank). The average monthly household income level ranges from US $132 for rural households to US $223 for urban households.[5]

In many areas, the country operates based on de-facto rules and guidelines, which are mostly beneficial to the businesses. This situation may mean that it will be challenging to bring some aspects of the country's daily life under a single regulatory framework.

This process is proving to be quite slow, requiring extensive consultations between the various official bodies (Government, local authorities, international community etc.) and it demands substantial involvement of the private sector itself because it has set the current rules of operation in most areas.

3.3 Energy Access

[4] *http://www.worldbank.org/en/news/press-release/2014/01/29/new-world-bank-gdp-and-poverty-estimates-for-somaliland*
[5] *Source: ADRA SET Baseline Survey 2015*

In addressing the many urgent needs of the Somaliland people, energy access in general and electricity access in particular will play a major role as these are widely recognised as major drivers of economic growth. At present, although significant improvements have been made in recent years, Somaliland still faces a situation where energy access is severely limited for the majority of the population. This includes both access to electricity and other sources of energy like biomass and fossil fuels.

In this regard, energy suppliers have struggled to meet growth in established demand in recent decades. Through the years of instability, the energy sector has been unable to meet latent demand and provide for stable and affordable access for most of the population, which has contributed to inadequate social indicators and hindered economic growth.

Considering the growing deficit of and high prices for firewood and charcoal – traditional energy sources for vast majority of the Somaliland people[6] – electricity will need to become more accessible and more affordable in order to sustain further economic growth and improvement in the quality of life.

3.4 Grids, Mini-Grids, Off-grid and On-grid

3.4.1 The National Grid

Electricity grids are physical networks interconnecting all the electrical energy between the source generators and the user loads. This grid is classified as the network connecting the electrical infrastructure of a region or country. Consequently, it can be a regional or national grid.

Currently in Somaliland there is no physical national grid. Electrical energy delivery to users in the country comprises a network of isolated distribution grids comprising of island networks with isolated generation providers.

These island networks are anchored to specific urban centres with dedicated Electricity Supply Providers (ESPs). The ESPs are private enterprises, each of which are vertically integrated autonomous parallel electricity providers. Each ESP owns and operates their complete generation-distribution-customer and revenue chain using a radial distribution island network. Generation is primarily, if not 100%, by high-speed diesel fuel powered generators (>1,000 rpm).

An island network is defined as an electrical energy network capable of and actually operating independently of another electrical energy network and grid. Within the cities and larger urban centres of Somaliland, there are often multiple ESPs operating. In the smaller urban centres, there is usually only one ESP, if at all, or an ensemble of small independent "entrepreneurial" electricity providers (IEP). These small IEPs have been created by expanding from their own captive generation, and are the model by which most, if not all current ESPs began.

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[6] *On average, 90% of the energy consumption, with almost 100% in rural areas. Various sources, including JNA*

All of the ESP's operate independently and, as a consequence, there is significant duplication of generation, distribution, technical,[7] maintenance and human capability infrastructure. This duplication severely limits the scaling up of electricity generation and even more, hampers delivery and servicing for larger customer loads. Duplication is especially acute for ESPs within the cities having multiple ESPs. These include Hargeysa (6xESPs), Burao (2xESP), Laascaanod (2xESPs), Boorama (2xESPs).[8]

Another consequence of these multiple entrepreneurial vertically integrated ESPs has been that there are significant electrical losses, reportedly up to 50%, within the urban island radial distribution networks. Moreover, there are no regulations or standards for electrical wiring done within the customer premises. A direct consequence of these lacks is that it is reported that some 60% of fires in urban communities are caused by electrical wiring faults.

Currently, no ESPs share distribution networks, and these combined ESP electricity delivery limitations within the urban parallel island networks, have resulted in large load customers opting for:

- utilising two different ESPs, in effect multiple networks supplying one customer; or
- creating their own on site, captive generation stand-alone "mini-grids".

One recent market adjustment to these duplication limitations has resulted in the consolidation of smaller ESPs and IEPs into larger ESP firms. The attendant pooling of these firms' technical and human capability infrastructure, has apparently benefited these consolidated firm's financial and technical attractiveness, but the degree is unknown.

Another consequence of these combinations of duplication and electrical energy losses is that electricity prices are generally high. Based on field data collected in 2017, the cost per kWh of electricity in Somaliland ranges from US$0.30 to 0.90 per kWh, with a weighted average of US$0.68 per kWh across all load users/consumers.

3.4.2 Mini-grids, Distribution and Transmission Grids

During discussions with government officials, the World Bank and donors have all indicated that in general they consider "mini-grids" as the relevant avenue for development in Somaliland. Unfortunately, the term "mini-grid" has become a broader and broader term used to cover different types of electricity networks that includes significant differences in key network components and utilisation.

Originally, "mini-grid" was a term used for a small local electrical grid with a single generation site, which generated electrical power for a short radial bus distribution network at low voltage, to the load

[7] Includes monitoring-measurement, evaluation, tracking, training, planning
[8] It is likely that the same situation of multiple ESPs applies in several of the other non-surveyed urban centres

sites. This low voltage generation and delivery was either as single or as three phase, without any step-up or step-down transformers being used in the network. This application was for local isolated low voltage sites, where either a regional or national electrical power grid was not available or not desired.

“Mini-grids” may also include auxiliary generation along the main distribution bus, usually longitudinal or radial wherein all electricity generation is synchronised to the alternating current (AC) bus at its level of voltage, frequency and phase. The key feature of “mini-grids” is they have no AC step-up or step-down transformers, and are consequently constrained to short distances/service areas, by the voltage losses produced by conductor resistance and high conductor costs.

Box.
Examples of “mini-grids” are electricity networks locally provided for an isolated community, a manufacturing facility needing to operate independently of a larger electricity grid and for temporary local electricity power generation in a limited area (e.g. emergencies). Many captive generation scenarios involve electrically powered mini-grids.

For the terms of this Power Master Plan, the original “mini-grid” classification is used, i.e. no AC step-up or step-down transformers being used in the network, with direct low voltage AC feeders from generation to loads.

The arrogation of clear, precise technical terms for electricity delivery, by non-technical professionals, such as by management consultants, for application to a broad and imprecise class of electricity generation and delivery does not create clear simple understanding. Instead, it creates orotund, obtuse and bewildering definitions for systems. This practice is unhelpful for what obviously requires clear if not always so succinct descriptions.

3.4.3 Off-grid and On-grid

In providing a clear definition for Off-grid and On-grid, the key word is Grid, as already discussed above. Across Somaliland, there are distinct and unique features defined by both socio-economic activities and geographic localities. These determine the kinds of useable electrification delivery. An important proportion of Somaliland populations are identified as rural, which encompasses a level of diversity that produces an electrification context that is quite complex.

For many of rural communities and particularly very rural region populations, these communities are very mobile pastoralists. These populations subsist as livestock herders, constantly seeking new fresh pastures and water for their livelihoods. Consequently, they do not have a fixed location for electrical energy to be delivered and used by them. In fact, they operate in a constant state of flux, adapting to the local climate, and at best currently have access to telephone communications and types of Pico solar devices.

For the aforementioned mobile rural communities, the only current economic and technical electricity solution is a combination of small mobile/portable electricity delivery systems, usually based on solar PV with rechargeable battery storage – in effect Pico solar and SHS plus the use of solar PV powered borehole pumped water supplies at water sources.

Clearly, these mobile rural communities are not connected to any electricity grid and are remote and Off-grid. On the other hand, the communities within the large urban centres like Hargeysa, Burao, Erigavo and others, are stationary and obtain electricity from an existing electrical energy network – a grid – and are therefore On-grid.

Based on discussions with key electricity stakeholders including the Ministry, Off-grid is the electrification of a single end point user (whether residence, commercial or industrial establishment), from an independent electrical energy source or sources. In effect, Off-grid is dispersed small or large-scale captive generation. Consequently, a stand-alone single solar water pump providing water at a location with no other loads is Off-grid.

Off-grid in the context of Somaliland covers the electrification of a single user (whether residence, commercial or industrial establishment). Because of the rapid drop in costs for modular electricity captive self-generation technologies, globally, are driving strong potentials and likelihoods for significant future implementations of Off-grid applications such as for residential generation, commercial generation, "mini-grids" and Off-grid systems, for both urban and rural levels, which will most likely start in the near, and certainly within the medium and further futures for many parts of Somaliland.

3.4.4 Multiple ESPs Servicing One Client

There is a significant limitation to the amount of electrical energy any one vertically integrated ESP can deliver when the ESP is not able to provide parallel (synchronised) interdependent generation and distribution to their user loads. This along with the impact of multiple radial island network duplication by ESPs constrains the amount of electrical energy any one ESP can deliver to load users, especially for large electricity users.

Consequently, large firms and institutions having large electricity requirements face several options:

- Contract with 2 or more separate ESPs for parallel electricity delivery by multiple separate radial feeder lines;
- Opt for their own captive HSDG electric generation;
- Upgrade by adding captive solar PV grid-tied generation to their stand-alone diesel-electric based mini-grid systems. This is an Off-grid generation solution;
- Implement a combination of utilising an ESP for powering certain selected business related tasks and utilising captive generation for other core business activities.

The purposes for making solar PV grid-tied upgrades are twofold:

- Increase the effectiveness of existing and new diesel generation by reducing fuel consumption and thereby overall operating costs;
- Increase the total captive generation and capacity during daylight hours, for utilisation by in-house user load business related activities.

Institutions and firms identified within the field surveys that either use two ESPs or are opting for ESP with are shown below:

Table 8. Firms using multiple ESPs or with captive generation

Urban Centre	Firm or Institution	First Supply	Second Supply	Captive Generation	Distributes Locally	Distribution Type	Surveyed
Hargeysa	Amaana School	SOMPOWER	Gafane	SHDG-25kVA	X	Radial 11KV	YES
	Dur Dur water bottling	SOMPOWER	X	SHDG-250kVA, 180 kVA, 200kVA	X	Radial 11KV	YES
	Geed Deebleh Water Pump	X	X	HSDG-6x500kVA	X	X	YES
	Ministry of Information	X	X	HSDG-300kVA	X	X	YES
	Ambassador Hotel			HSDG	YES	Radial LV	NO
	Moonsoor Hotel			HSDG	YES	Radial LV	NO
Burao	Burao Slaughter House	X	X	HSDG-1200kVA	X	X	YES
Shiekh	Fathoot Hospital	BEDER	X	SPV	X	Radial 11KV	YES
		BEDER	X	HSDG	X	Radial 11KV	YES

Source: Unicon

3.5 Electricity Market Overview

As described above, increased access to electricity will play a crucial role in the future of Somaliland. Investment in electricity generation, transmission, and distribution will not only have a sizeable economic multiplier effect, but also provide substantial environmental dividends by displacing fuels burned for lighting and cooking and, in the case of renewables, by displacing diesel burned in conventional generators prevalent around the country.

Supplemental social effects will also accompany extension of electricity to peri-urban and rural areas. The current situation is that virtually no rural population has access to electricity. Although efforts are being taken to introduce the rural and much of the poor urban population to solar power (lanterns to start with, for example), in many cases such an offer comes at a cost unaffordable to potential consumers.

Those currently with access to electricity are forced to pay one of the highest tariffs in the world for inadequate service. This results from high fuel cost and obsolete equipment, as well as from significant technical and non-technical losses. Many businesses have to either purchase their own generator or move to another locale in search of better and more affordable electricity. Many households have to limit themselves to certain level of consumption even at times when the supply is there, representing suppressed demand ready to surface as soon as the household can afford it.

In response to the pressing growth of demand, private business has been investing heavily in power generation around the country. This started with small, neighbourhood-level generation in the cities and villages, where the owner of the generator would drop a line to nearby households or businesses and change a fixed price based on the number of electrical points in the house. Generator operators also charge for specific services (e.g., mobile phone charging).

Over 90% of the population of the country relies on charcoal for cooking and heating needs. Electricity access, even when it is available, is only affordable for certain limited needs of the households (lighting, TV, and refrigeration for wealthier households).

Providing affordable and accessible electricity has become one of the highest priorities for the Government. This has resulted in various efforts in collaboration with the international community to support electricity sector development, including the present assignment of producing an associated 20-year power master plan for Somaliland as well as city development plan for Hargeysa.

In determining the scope and size of energy and electricity resources used, a field survey was conducted in Somaliland. Assessment of field data collected for energy consumption was divided up into classes. These classes were identified via five user types:

- Household-Residential;
- Small businesses;

- Restaurant-Hotel;
- Large Businesses; and
- Institutions.

The key class for identifying general population energy and electricity use is Household-Residential. It was also observed that large businesses tend towards using their own captive generation and only use the ESPs for limited services. The class of large captive generation is a special class, which, due to insufficient data, is not able to provide very much information for analysis and calculations.

Moreover, data for small business and restaurants/hotels was combined to a general business sector class for ease of use. The class of Institutions covered government entities, hospitals, and education facilities. The data was also analysed for different sized urban centres: medium towns (20-30,000 persons) and cities (over 100,000 persons).

Analysis was made for electricity utilisation by households, businesses, institutions, as well as, for medium towns, small cities and large cities. Additionally, an analysis was made for electricity rates for medium towns, small and large cities. Information concerning charcoal and kerosene was only collected in the region of Somaliland and was analysed for expenses made by household-residential, restaurant-hotel and institutions.

3.6 Urban Electricity Networks

As mentioned previously, the large majority of electricity currently provided and used in Somaliland is produced and delivered by independent vertically integrated ESPs, who own and control their whole generation and distribution network. All operate at nominally 50 Hz and 400/230 V.

Most ESPs are unique to particular urban centres, yet some ESP have operations established in several urban centres, notably BECO, ENEE, DAYAH, SOMPOWER and TELESOM.

3.6.1 Major Urban Centres

All the ESPs distribute electricity to their customers via LV feeders. In some cases, there are distribution lines utilising 11kV, 15V, 16kV and small amounts of 33kV, providing longer distant distribution distances, which then feed LV feeders. However, many ESPs use a significant amount of island radial LV distribution. A summary of ESPs and highest level of distribution voltage is tabled below.

Table 9. Current ESPs in major urban centres within Somaliland

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
Hargeysa	1,500,000	Sompower		No		No
		Telesom		No	Radial 11KV	Yes

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
		NEC		No	Radial 11KV	Yes
		Maansoor Hotel		No		No
		Hargeysa Electric Company		No	Radial 11KV	Yes
		Gafane		No		No
Burao[9]	700,000	BECO	HSDG, SPV	Yes	Radial 33KV, 11KV	Yes
	400,000	BEDER				No
Erigavo	250,000			No		No
Borama[10]	150,000	Telesom	HSDG	No	Radial 11KV	Yes
	400,000	ALOOG	HSDG, SPV	No	Radial 11KV	Yes
Badan	180,000	Badhan EC	HSDG, SPV	Yes	Radial 11KV	No
Laascaanod	130,000	LESCO	HSDG, SPV, Batt	Yes	Radial 11KV	Yes
		GURMAD	HSDG, SPV	Yes	Radial 11KV	Yes
Berbera	100,000	TAYO	HSDG	No		No

Source: Unicon

3.6.2 Medium Sized Towns

Table 10. Current ESPs surveyed in medium sized towns within Somaliland

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
Gabiley	30,000	SOMPOWER	HSDG, SPV	NO	Radial 11KV	YES
Wajaale	20,000	TELESOM	HSDG	NO	Radial 11KV	YES
		SOMPOWER	HSDG	NO	Radial 11KV	YES
Shiekh	20,000	BEDER	HSDG, SPV Batt,	NO	Radial 11KV	YES
Buhodle		TELESOM	HSDG, SPV, Batt	NO		NO

Source: Unicon

[9] *There are 2 sets of population data provided for Burao*
[10] *There are 2 sets of population data provided for Borama*

3.6.3 Small Towns

Findings from the modest number of Small Towns sampled, indicated that in these cases electricity generation is provided by one captive electricity generation source at a time. Even for small hybrid solar PV + Battery systems, with diesel generators, the modality is predominately one electricity source being used predominately, while the other is the backup/reserve source of electricity generation.

For example, in the case of the small town of Daca-Budhug, the 3kWp solar PV + Battery system is used as the primary stand-alone electricity source and the diesel generator provides an alternative electricity source or for backup or charging of the battery system, as needed.

There is currently no synchronisation carried out between the combined elements of small generation that are found within the small town systems sampled. Much of the electricity generation provided in small towns is originally captive generation that has been expanded to other paying load users (IEP).

Table 11. Current ESPs or stand-alone generators surveyed in small sized towns within Somaliland

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
Dilla	2,880	Mohammed Ali EC	HSDG	NO	Radial LV	YES
Daca-Budhug	3,000	Liban group	HSDG, SPV, Batt	NO	Radial LV	YES

Source: Unicon

3.6.4 Losses in the Electricity Distribution Networks

All the ESPs report that they have significant losses within their island distribution networks. Causes for these losses are both technical and commercial. Reportedly, these electricity distribution losses are the largest power (instantaneous energy) losses within any of the individual ESP island electricity networks. These electrical energy losses are within both the primary and secondary distribution lines, and comprise both technical losses and commercial (non-technical) losses.

While some losses can be easily corrected, others require equipment changes, and some are just inevitable due to the physics of electricity. Total losses simply reflect the difference between the generated kWh and the load used and billed kWh. This value is generally referred to as T&D losses (Transmission and Distribution), and is the electricity amounts not paid for by load users-customers. Nevertheless, ESP generators must account for these in order to optimise their financial soundness.

Loss estimates by ESPs in surveyed urban centres are shown in Table 12.

Table 12. Loss estimates by ESPs in surveyed urban centres within Somaliland

Urban Centre	Population	ESP	Reported Losses	Distribution Type	Surveyed
Small Town Centres					
Dilla	2,880	Mohammed Ali EC	40.0%	Radial LV	YES
Daca-Budhung	3,000	Liban Group	X	Radial LV	YES
Medium Town Centres					
Gabiley	30,000	SOMPOWER	19.0%	Radial 11KV	YES
Wajaale	20,000	TELESOM	40.0%	Radial 11KV	YES
		SOMPOWER	40.0%	Radial 11KV	YES
Shiekh	20,000	BEDER	30.0%	Radial 11KV	YES
Buhodle		TELESOM	X	Radial LV	NO
Major Urban Centres					
Hargeysa	1,500,000	SOMPOWER	X		NO
		TELESOM	25.0%	Radial 11KV	YES
		NEC	25.0%	Radial 11KV	YES
		Maansoor hotel	X		NO
		Hargeysa Electric Company	30.0%	Radial 11KV	YES
		Gafane	X		NO
Burao[11]	700,000 400,000	HECO	45.0%	Radial 33KV, 11KV	YES
		BEDER	X		NO
Erigavo	250,000				NO
Borama[12]	150,000 400,000	TELESOM	40.0%	Radial 11KV	YES
		ALOOG	40.0%	Radial 11KV	YES

[11] *There are 2 sets of population data provided for Burao*
[12] *There are 2 sets of population data provided for Borama*

Urban Centre	Population	ESP	Reported Losses	Distribution Type	Surveyed
Badan	180,000	Badhan EC	X	Radial 11KV	NO
Laascaanod	130,000	LESCO	28.0%	Radial 11KV	YES
		GURMAD	25.0%	Radial 11KV	YES
Berbera	100,000	TAYO	X		NO

Source: Unicon

3.7 Regulatory and Institutional Framework

The Ministry of Energy and Minerals has the mandate over the energy sector, including electricity. There is an Energy Policy adopted in November 2010 as well as draft Electricity Act. Some studies as well as international practice indicate a potential need for an appropriate regulatory body to be established in such circumstances. Such an institution would be particularly useful to regulate the sector and provide common standards offering a backbone for successful electricity sector development, and potentially bring stakeholders to agreement on generation, transmission, and distribution standards that could be introduced and subsequently enforced in Somaliland.

The renewable energy sector is also in need of standards. There have been cases of both governments and private businesses spending heavily on renewable technologies, which turned out to be obsolete, incomplete, or of inadequate quality. Since renewable technology is relatively expensive, further development would also include the need for standards for the renewable energy sector, covering such issues as licensing, developing and implementing policies, laws, regulation, rules, standards and incentive schemes to integrate rural electrification, tariffs and Power Purchase Agreement.

In the absence of regulation and industry standards and codes, shortages and outages have become common in the existing systems, because they often comprised of obsolete infrastructure using inadequate equipment managed by operators with limited professional capacity.

3.8 Electricity Supply and Tariffs

There recently has been a tendency across Somaliland for mergers among various power producers, especially in the larger cities. As already introduced in this report, the power industry, having started with small, neighbourhood-level generators, has been growing and consolidating. Many of the small generators are still in place and operating, but now as a part of larger entities.

Mergers and acquisitions are taking place initially at the ownership level then, gradually, at operational levels. Such mergers/acquisitions often mean that the owner of the smaller company becomes a shareholder of the larger one with a certain (negotiated) level of influence within the company depending on the size of the capital and client base he entered with.

Over time, new and larger generating units may be installed to take account of economies of scale, thus permitting the smaller units to be removed from the system. The large company then moves this equipment to more remote areas, providing for the 'spider web' effect of the grid. These companies have also been investing in renewable energy, the main benefit of which has been fuel displacement.

Large companies are also able to retain a power sector work force that is more skilled, enabling them to operate more efficiently. This, in turn, allows them to lower tariffs for businesses and the population, making electricity more affordable, which, in turn, leads to increased consumption and the need for more generation, stimulating further growth of the sector. They have also adopted a practice of importing their own fuel to further cut costs.

In addition to the power generation and sale-oriented companies described above, growing demand and inability of the power generators to meet it have created a market for power generation as a secondary business for those who purchase power generators for their own use.[13]

Examples of this are mobile telephone networks that have to power their antennas and which allow the neighbouring settlements to purchase the excess power. Another example would be a shop that also sells power to the immediate neighbourhood.

The general understanding gained from sector discussions is that power producers typically supply about 3% of their power free to schools, hospitals, and mosques, thus fulfilling a social role.

According to various assessments, about 70% of Hargeysa's capacity is generated by SomPower (which is also generating about 60% of electricity country-wide). There are four more private generators in Hargeysa. The tariff is US $0.75 per kWh with certain discounts for bulk users. The city has had a negative experience installing wind turbines. These are in place by the airport but are not operational due to faults in installation or production, which they are not able to have the supplier address.

Berbera is served by BEC (Berbera Electricity Company), which recently became entirely private after a period of private-public partnership with the country, its previous owner. Dahabshiil Bank and Tayo Energy have invested in the utility and are currently running it. At the time of their original investment, the tariff was US$1 per kWh. The investors committed to lowering the tariff to US$0.30 by 2019, on the way to which they are now at US$0.50 per kWh. They are running about 7 MW of installed capacity. One of the generators is newly installed. They have also installed three wind turbines that have yet to be commissioned.

3.9 Renewable Potential

[13] *About 44% of power produced is for own consumption (Somaliland Energy Policy)*

The combination of exacting and sophisticated electricity consumers supplemented by global trends in electricity generation is increasing the role of renewable energy sources in generating electricity. Renewable energy sources for electricity generation are already recognised as very important in providing reliable electricity (albeit expensive) for remote and isolated areas.

It is also becoming more and more pertinent to electricity generation for large electricity networks and contributing significant power to large urban and industrial centres, as well as, for national and regional electricity networks.

The key renewable resources to exploit in Somaliland are primarily solar PV, wind and energy storage. Energy storage will be more extensively covered in the section on generation, because it pertains to hybridising with other forms of electricity generation, rather than as generation in isolation.

This is further driven by the economic fact that capital costs for wind generation and solar PV generation have been continuing to drop in past years and are predicted to further drop some 15 to 35% during the next five to seven years.

The focus here is on applications of solar PV energy and wind energy for future electricity generation. Other potential renewable energy sources that may be worth considering in the future, but to date have not been properly identified within the region include; geothermal, tidal, wave and solar thermal. Anecdotal evidence is reported, concerning geothermal but the current good potentials are only known to exist in Ethiopia and Djibouti.

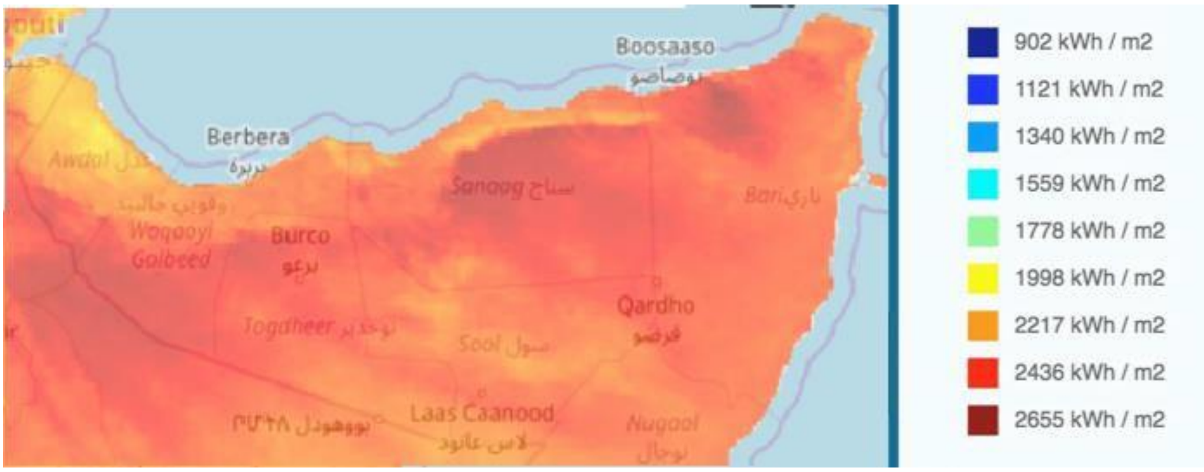
Another potential source is tidal energy, which is based on tidal variances along the coastline of Somaliland. In this area, tidal variances are only 1.8-3.0 meters, which is not very high with respect to regions of the world where tidal energy is considered sufficient to capitalise upon: > 5.0m.

In order to capitalise upon a 2-3 m variance, a significant sea water impoundment using geographical locations would need to be identified and further explored. Wave powered electricity generation is currently an area of ongoing research globally and is not relevant to the current context.

Solar Energy

The solar energy resources for electricity generation are demarked by solar energy maps, see the Figure 12 below, which show that especially in the areas of Somaliland there is excellent solar irradiation available for solar PV electricity generation. In addition to the solar irradiation, it is also crucial to know the sun path and what is the area of land required for solar PV electricity parks.

Figure 12. Somaliland solar irradiation map



Source: IRENA

In Somaliland, solar panels should be generally placed at around a 10 (8-12) degrees angle inclined to the south. Too shallow a panel angle makes array cleaning and maintenance difficult.

The surface footprint required for commercial silicon-based solar panels giving 1 kWp of solar PV electricity generation using current solar PV panels of 14-17% efficiency is 8-8.5m^2. In Somaliland it would be 8,5m^2, due to using slightly steeper panel inclinations. In effect, this is due to the shadow thrown by a panel array.

Consequently, a 1 MWp solar PV park, with 1,000x1kWp, would require 8,000 to 8,500m^2 of land, which is a square 90m x 90 m in area – less than a hectare. A 100MWp solar park would require 80-85 hectares, or 0.9km x 0.9km.

Table 13. Somaliland typical solar park footprint area

Area needed for solar PV array			
Country	**Side of Square area needed (m)**	**Area hectare**	**Generation Size (MWp)**
Somaliland	92.2	0.85	1

Note: Silicon solar PV panels: Efficiency 14-17%; Inclined at 10" South

Source: Solar shadow calculation with 0.35-0.4m spacing for inclined panels of 4 x 250Wp PV panels (dimensions 1.66m x 1m)

Wind Energy

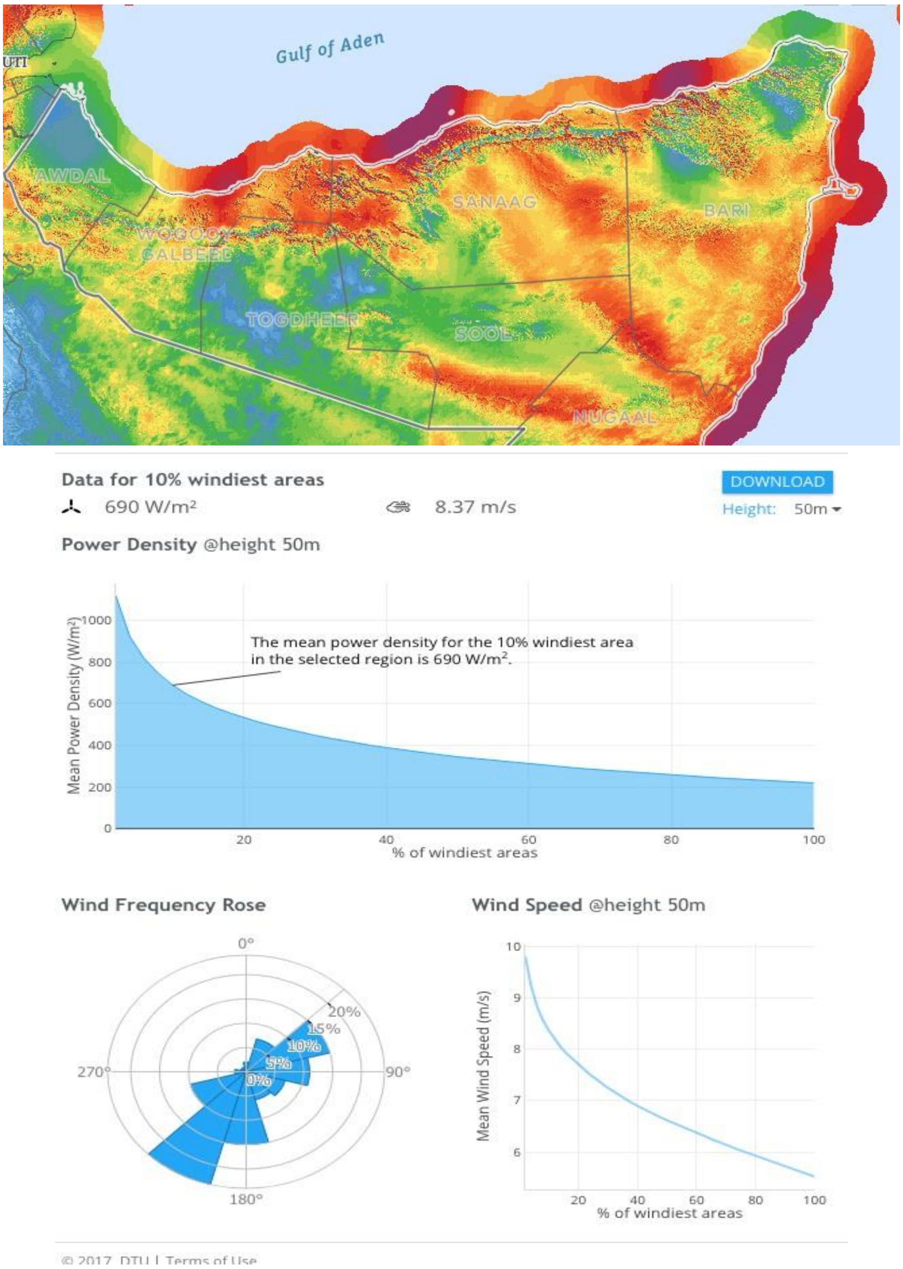
The wind energy resources for electricity generation are demarked by wind energy maps, posted below, which show that especially across Somaliland there are excellent wind speeds available for wind turbine electricity generation. In addition to the wind speed, it is also crucial to know what is the area of land required for wind farms.

Table 14. Somaliland typical wind farm footprint area

Area needed for Wind Turbine Farms							
Turbine power	**Rotor diameter (m)**	**Spacing factor (separation between)**	**Diameter required spacing (m)**	**Area required (hectare)**	**Spacing factor (separation between)**	**Diameter required spacing (m)**	**Area required (hectare)**
275 kW	30.0	5	150.0	1.77	7.0	210.0	3.46
1.5 MW	70.5	5	352.5	9.76	7.0	493.5	19.13

***Source:** Wind Power Project Site Identification and Land Requirements, Global Energy Concepts and AWS Truewind, LLC*

Figure 13. Somaliland wind map



Source: WB ESMAP DTU VORTEX Global Wind Atlas

The surface footprint required for commercial wind power is given by a spacing of 3-10 rotor diameters, with 7 being the most common recommended spacing. A 30m rotor typically used for 275kW electricity generation requires about 3.5 hectares of land that can be used for concurrent agriculture and pastoral activities also. A 1.5MW wind turbine with 70.5 m rotors requires 19.5 hectares. This spacing is to prevent wind turbines from being in a wind shadow from another turbine.

The use of renewable energy resources is largely dictated by the availability of certain specific renewable resources and their hybridisation with other energy sources to create a reliable supply. These are (i) solar irradiation, (ii) elevated and relatively continuous wind speeds, and (iii) specific geographic locations demonstrating meaningful steep changes in vertical elevation.

The predominantly used renewable resource used is solar PV with a small amount of wind power. The solar PV is being used primarily by some urban ESPs for diesel fuel replacement during daytime electricity generation, along with reductions in carbon and pollution emissions.

The scope for solar PV for urban electricity generation via grid tied (synchronised) hybrid electricity generation paralleling the existing HSDG electricity generation, is being expanded by some urban ESPs.

While the size of each current urban solar PV generation site is significant, it is still early in the solar PV process of implementation and the impact on overall generation is small. Current key players and stakeholders, include the ESPs, the ESRES project (financed by the UK's Department for International Development), the Ministry of Energy and Minerals and an international EPC firm (EPS) that has partnered with two ESPs to construct hybrid electricity generation facilities in Laascaanood.

Solar PV offers a key element in reducing significant ongoing expenses for fossil fuels, while stimulating the productive use of electricity during daylight hours. Its primary impact is on commercial, manufacturing, institutional and even political sectors, through both cheap and ecologic electricity generation during business, institutional and manufacturing hours. As grid-tied generation, it currently offers basic electricity generation in support of well-designed and operated hybrid electricity generation.

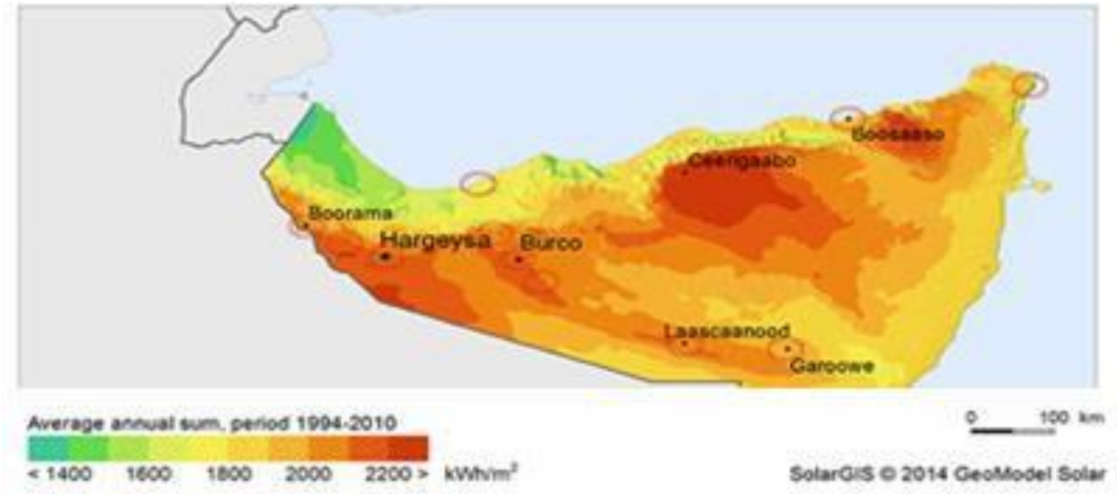
Solar PV application in remote locations offers independence from poor transport routes and significant benefits for supporting agricultural, pastoral and remote communities in water resource management, enhancing food production, employment and quality of life. Some sites sponsored by the ESRES project also use Li-ion battery storage to stabilise electricity generation from the solar PV system.

Barriers to further use of renewables are (i) the lack of technical capability for implementing wind power, and (ii) integrating renewables and thermal generation for efficient hybrid electricity generation. The capital cost for renewable generation is projected to continue to drop between 15%

and 35% during the next 7 years, and once properly commissioned – they have low operating expenses compared to fossil-fuelled HSDG thermal generation.

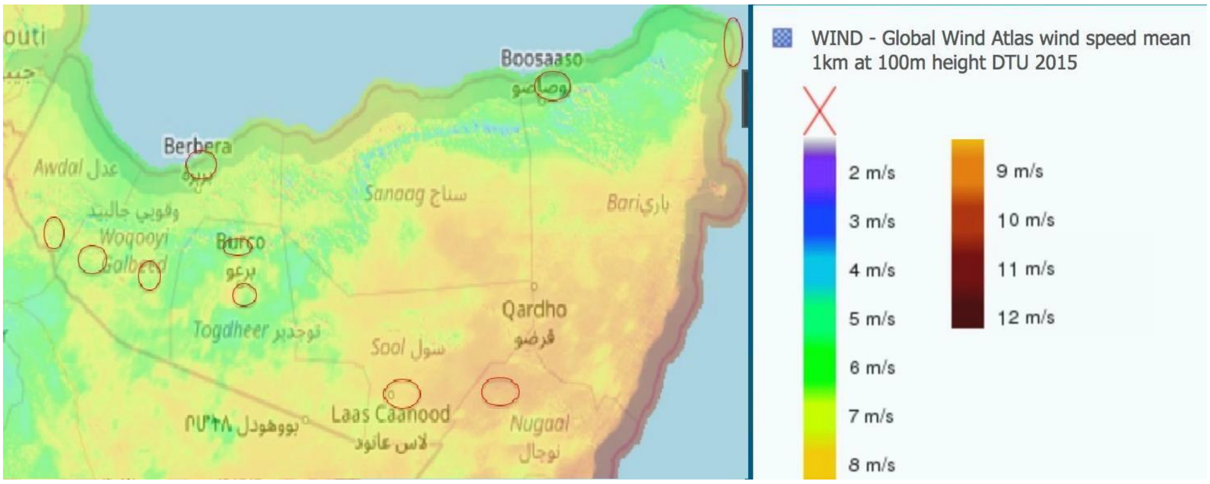
Proper, large and widespread implementation of renewables based hybrid generation is one of the long-term key elements to reliable, robust electricity generation, economic development, environmental remediation and climate resilience for Somaliland.

Figure 14. Solar resources map



Source: Solargis, Global Solar Atlas

Figure 15. Wind resources map



Note: Bountiful wind resources
Source: IRENA Global Wind Atlas

It is evident that both solar and wind resources have significant potential for electricity generation in Somaliland. While there are technical challenges to establishing distributed electric generation using solar and wind power and their integration into the electricity supply of urban centres, this has become much easier in recent years, with significant automation and the adoption of smart network management as part of electricity generation.

A significant benefit of using multiple renewable energy sources is that electricity generation is derived from diverse sources and can be situated in a distributed manner around and even between urban centres, if there is a transmission line. This contrasts with centralised thermal generation sites, requiring specific nodes for fuel delivery.

Renewable generation can also be placed closer to key demand areas within a distribution network to assure active and reactive power requirements. Consequently, if needed they can be modified more easily, based on changing load demands. Moreover, their modular nature permits very easy upgrades as well as maintenance and repair.

The integration of network UPS systems into renewable energy generation permits dual benefits:

- having both rapid Black Start and Peak response to network problems; and
- provision of Prime generation support for floating generation.

4. Development of Load Forecasts

There are, in general, three main approaches to load forecasting:

- an econometric forecast in which a statistical relationship between load and various explanatory variables is sought using historical data. Forecasts of these explanatory variables are sought and the equations derived from the historical analysis are applied to the forecast explanatory variables to calculate the resulting electricity loads. This approach requires a long period of historical statistics for the explanatory variable such as population, gross domestic consumption, per capita income, industrial production, etc. The advantage of this approach is that the impact of different growth rates of economic variables on the load can be estimated. The main disadvantage is that it requires a long historical period of consistent data;

- an extrapolation model is created in which the variables that cause the load are identified and forecast, and these drivers are then combined to derive the forecast of load. The drivers for domestic loads include the size of the population, number of people per household, percentage of households electrified, unit consumption of each household, etc. The drivers for commercial loads tend to focus on population (the more the population increases, the more shops and services that will be required). Another driver for these loads includes the wealth of the population (the richer the population the more services they can afford to use and goods to purchase). The drivers for industry tend to be the availability of resources that can be converted economically into products. In the case of Somaliland, the drivers are mainly related to population or wealth. The latter will be captured in the existing data and where it is not, it will be assumed to be common for most locations within a country. The advantage of this method is that it allows an assessment of the impact of different rates of growth in the rate of electrification. The disadvantage of this method is that it is based on a series of assumptions by the analyst;

- an end-use model is created in which the appliances used in each category of load are identified. Estimates are then made of the unit consumption of each appliance, hours of use of the appliance, and the percentages of customers with such appliances. The advantage of this method is that it allows an assessment of what is causing the load. The disadvantage of the method is that it is very data-intensive and is usually based on a series of customer usage surveys.

As recognised and noted during the inception mission, there are significant difficulties associated with attempting to apply each of these methods in Somaliland. Therefore, Unicon used a combination of these methods to generate the best possible forecast given the available historical and current information.

In addition, and in order to take into account of these uncertainties, three forecasts are derived:

- a base forecast;
- a high forecast; and
- a low forecast.

These are defined in the following sections.

4.1 Methodology and Assumptions

Unicon first developed a top-down economic-driven forecast. This involved using various benchmarks of GDP and per capita electricity consumption and comparing them to other countries in the region. These benchmarks were then later used to crosscheck and validate the results of the bottom-up load and end use analysis.

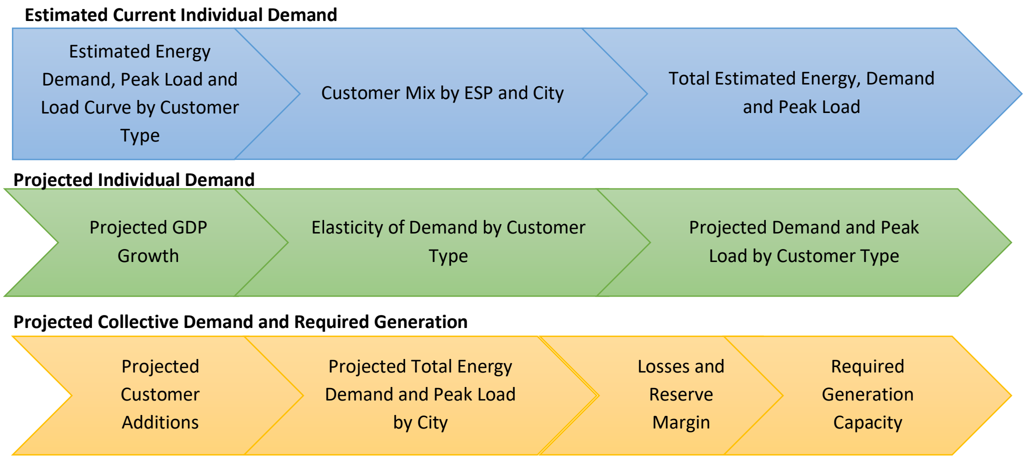
The primary forecasting approach, however, was a combination of an extrapolation model coupled with a bottom-up load and end-use analysis informed by field surveys and billing records. Unicon also assessed the sensitivity of the forecast to some of the key assumptions, which was used to refine the analysis and create several alternative scenarios to the baseline.

The three main steps in the load forecasting process were the following:

- estimate current individual demand;
- project individual demand;
- project collective demand and required generation.

These major steps, along with their sub-components, are illustrated in the following Figure 16.

Figure 16. Simplified load forecast model



Source: Unicon

4.1.1 Estimated Population

Estimates of population are a key assumption in the development of an electric power load forecast. The most recent estimate of population by state and type was the “Population Estimate Survey Somalia (PESS)”, UN Population Fund (UNFPA), October 2014. In addition, there was an overall population estimate by the World Bank for 2016. By extrapolating and combining the two sources the population estimates and assumed growth rates in population, the following forecasts of the four types of population for Somaliland were derived and are shown in the table below.

Table 15. Population estimates for Somaliland (in millions)

	2017	2027	2037
Urban	2.16	2.95	3.85
Rural	0.45	0.61	0.80
Nomads	1.38	1.89	2.46
Internally Displaced Persons	0.10	0.13	0.17
Total	***4.08***	***5.59***	***7.29***

4.1.2 Estimated Current Individual Demand

The first major step in projecting energy demand was estimating current individual demand. This process in turn had the following three sub-steps:

- estimate demand by customer type;
- identify the customer mix by ESP and city;
- calculate total estimated energy demand and peak load.

Estimating demand by customer type was the first task in the load forecasting process. Unicon approached this task from three directions. First, Unicon designed and administered an information-gathering template for the energy service providers (ESPs). Unicon sought to gather detailed information on the ESP's operations, including the number of their customers disaggregated by type and their electricity usage.

Unfortunately, in most cases, the information provided by the ESPs was either insufficient or inadequate and did not serve as a wholly reliable basis for calculating individual energy usage. The information included in the model was, therefore, based on a small sample of useable responses[14] and anecdotal evidence.

Anticipating shortcomings from the ESP data, the second approach Unicon took in parallel with gathering information from the ESPs was to design and administer an individual energy usage survey. This survey sought to gather information on energy usage directly from end users.

While this approach provided additional information and some useful insights into individual usage patterns, particularly regarding peak usage, unfortunately the level of detail that most respondents were able to provide, coupled with the small sample size, meant that the information was primarily anecdotal rather than statistically significant. The number of respondents to the survey instruments included 3 ESPs and 39 individuals.

The third approach involved gathering and analysing the billing records from the ESPs that were willing to share them.[15] This proved to be the most fruitful approach, and allowed for the analysis of the billing records of over 30,000 customers, some spanning more than a year. This information allowed for the calculation of average customer usage at least partially disaggregated by customer type. The results of this analysis are summarised in the following Table 16:

[14] In some cases, ESPs either did not have the records required to provide the data required or were not at liberty to provide it to the Consultant. Efforts by the Consultant included asking the Ministry of Energy and Minerals to intervene with the ESPs. In spite of these efforts, there are still, at the time of drafting this report, ESPs in major cities for which no data has yet been received.

[15] The field teams initially attempted to gather these electronic records during the interviews with the ESPs, but they were never provided. However, these detailed records were provided to the DFID-funded Energy Security and Resource Efficiency in Somaliland (ESRES) programme. The ESRES team kindly shared this data (with the approval of its client) with the Master Plan team, although it was aggregated to avoid disclosing commercially sensitive information.

Table 16. Average customer usage based on available billing records (kWh)

		Residential			Commercial			Industry/Other			Total		
City	ESP	Customers	Billed Monthly Usage (kWh)	Average Customer Usage (kWh)	Customers	Billed Usage (kWh)	Average Customer Usage (kWh)	Customers	Billed Usage (kWh)	Average Customer Usage (kWh)	Customers	Billed Usage (kWh)	Average Customer Usage (kWh)
Berbera	Berbera Electricity	3,318	259,691	78	712	92,377	130	102	80,755	792	4,132	432,823	105
Borama	Aloog*	7,273	158,934	22	868	31,482	36	10	2,722	272	8,151	193,138	24
Sheikh	Beder	814	14,104	17	292	9,901	34				1,106	24,005	22
Burao	HECO										14,431	543,855	38
Gabiley	Sompower*										2,926	45,042	15
Total/Weighted Average =		**11,405**	**432,729**	38	**1,872**	**133,760**	71	**112**	**83,477**	745	**30,746**	**1,238,863**	**40**

*ESP is one of two operating in the town.

Billing records not clearly disaggregated by customer type.

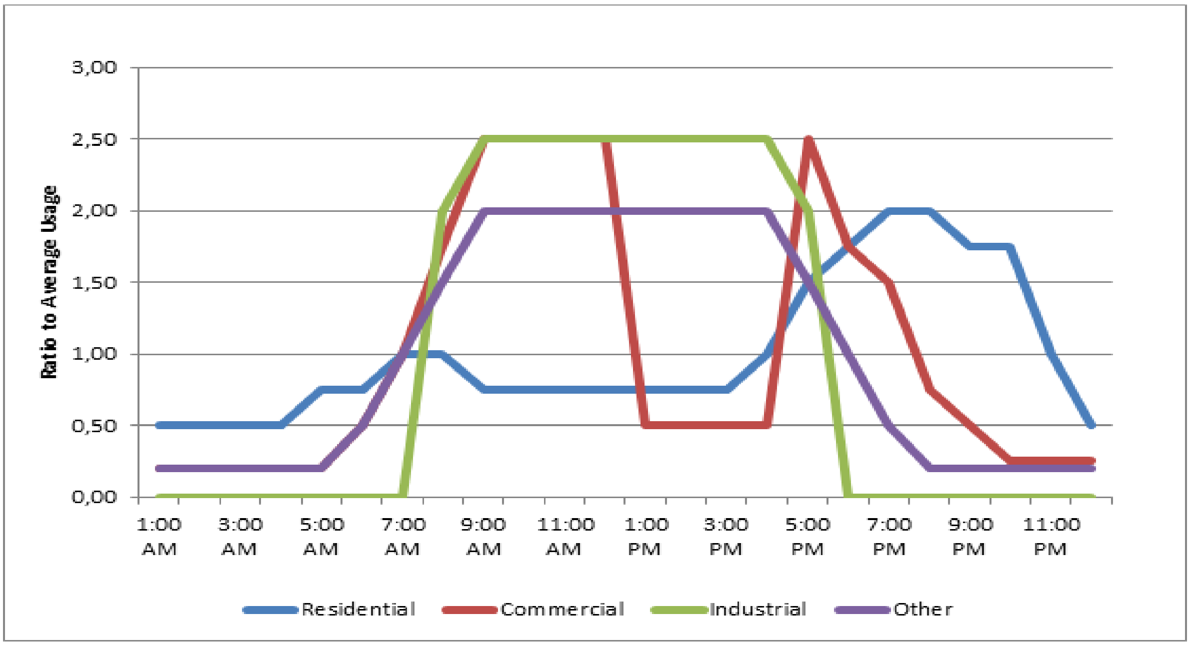
Note: Customer numbers represent latest month available, billed monthly usage is average for all data made available, and average customer usage is the average of the monthly averages.

Source: Unicon

This information proved extremely useful in estimating individual energy consumption (kWh). However, to estimate the peak load (kW), this data needed to be compiled with the individual usage surveys, generation records from the ESPs, and Unicon's field observations.

This analysis resulted in estimating the load curves by customer type (scaled as a ratio to average usage), as illustrated in the following Figure 17.

Figure 17. Estimated indicative daily load curve by tariff class



Source: Unicon

The aggregate load curve (and resulting co-incident peak load) is then a function of the mix of customers connected to the system and the relative size of their loads. Therefore, this is estimated based on the customer mix over time.

The daily load factor[16] of Somaliland was calculated as 54.6%. It is calculated by adding the loads for each costumer class hour by hour to get the total load for each hour of the day. Because the Residential, Commercial, Industrial and Other loads are grow at different rates the relative weighting of each load in any day in the future will also differ.

4.1.3 Projected Individual Demand

The second major step in the forecasting process was projecting individual electricity demand for the twenty-year forecast period. This process had the following three sub-steps:

- project GDP growth;
- estimate elasticity of demand by customer type;
- calculate projected energy demand and peak load by customer type.

The first sub-step was to project real gross domestic product (GDP) and GDP per capita. While there are clear issues and limitations to using GDP as a proxy for income, there are also no viable alternatives, particularly for a country where data is extremely limited. Even the GDP data is, at best, an approximate estimation.

The World Bank estimated a growth rate in Gross Domestic Product of 4.9% in 2016.[17] The scenarios selected for GDP growth are all based on a projection of this growth rate, as follows:

- base forecast used the recent growth for the next ten years and then half that rate for the remainder of the forecast period;
- high forecast used the recent growth for the next ten years and then one and a half that rate for the remainder of the forecast period;
- the low forecast used half the recent growth for the entire forecast period.

The GDP growth assumptions of these scenarios are illustrated in the following Table:

Table 17. Assumptions for GDP growth

Scenario	Period of forecast	
	2018-2027	2028-2037
Baseline	4.9%	2.5%
High	4.9%	7.5%
Low	2.5%	2.5%

Source: Unicon

[16] *The load factor is the ratio of the amount of usage of the system at its peak divided the average usage over the year.*
[17] *World Development Indicators, World Bank, Data Set Updated September 18, 2017, Indicator = GDP (Current US$) (NY.GDP.MKTP.CD).*

The second sub-step in the forecasting process was to translate real GDP growth into projected electricity consumption. This was done by estimating the income elasticity of demand for electricity, which is measured as the ratio of the change in electricity consumption to the change in GDP. Electricity is generally considered a necessary good, which in economic terms means that demand increases when income increases, although at a slower rate than income (income elasticity > 0 < 1.0).[18]

> e.g. if a middle-income household's income increases by 20% (say, from $5,000 to $6,000/month), then they might buy a larger TV or another electronic appliance, but their total electricity consumption would only increase by perhaps 10-15%.[19]

However, for extremely low-income households, electricity is a luxury good, which again in economic terms means that demand for it will increase at a rate greater than the increase in income (income elasticity > 1.0).[20]

> e.g. if a low-income household's income increases by 20% (say, from $200 to $240/month), then they might buy a fan or TV for the first time, which would increase electricity consumption by much more than 20% given that current consumption is likely just a few kWh from light bulbs.

The income elasticity of demand for electricity is not the same for all types of users. Unfortunately, the available literature on the subject is inconsistent and sometimes contradictory.

However, the general consensus, particularly for developing economies, is that the income elasticity of demand is highest for low-income residential customers, followed by industrial users (some of which will have extremely high income elasticities), followed by commercial users, for whom electricity is typically a less significant input to producing income.

This also makes intuitive sense. At the beginning of development, a commercial or industrial operation will typically rapidly increase its energy consumption, often as machines and equipment are used to supplement or replace labour. For example, as its income increases, a hotel might buy washing machines to replace manual washing and add dryers to make housekeeping more efficient.

As its income grows, a small manufacturing operation might add new equipment to improve efficiency or increase its ability to add value. At the early stages, much like with low-income households, in many

[18] Income elasticity of demand is calculated as the change in the quantity of demand for a good caused by a change in income. For example, if the quantity demanded of a good increase by 5% when income increases by 10%, the income elasticity of that good is calculated as 0.5 (5%/10%).

[19] While the prevailing tendency is for rising incomes to increase electricity consumption, this is at least partially offset by newer appliances being more energy efficient than the older items they replace, particularly in lighting (incandescent bulbs, to compact florescent, to LEDs), refrigeration, and even TVs (a large LED HDTV can consume less power than an older, smaller CRT unit). However, this too is subject to a rebound effect, whereby increased energy efficiency ultimately leads to increased usage-lights are left on more, additional TVs are added to other rooms, etc.

[20] See, for example, Fouquet, Roger (2014) Long run demand for energy services: income and price elasticities over two hundred years. Review of Environmental Economics and Policy, 8 (2), London School of Economics.

cases these changes are likely to increase energy demand at a greater rate than the increase in income.[21]

Finally, income elasticity of demand is not constant over time or all ranges of income. Generally, as time passes and incomes rise, elasticities tend to decline. For example, as a low-income household becomes a middle-income household, its electricity consumption (in percentage terms) will start to increase more slowly. For commercial and industrial operations, electricity becomes a smaller contributor to income growth.[22] Therefore, the estimated elasticities for each customer type are assumed to decline after the first ten years of the forecast period. These assumptions are summarised in the following Table:

Table 18. Estimated income elasticity of electricity demand

Type	2018	2028
Residential	1.10	0.90
Commercial	0.90	0.70
Industrial	1.00	0.80
Other	0.70	0.50

Source: Unicon

These same assumptions were used in all three scenarios examined.

4.1.4 Projected Collective Demand and Required Generation

The third and final major step in the forecasting process was projecting collective demand and required generation. This was done by taking the projected individual demand from the previous step and then aggregating up to total required generation through the following sub-steps:

- estimate customer additions by ESP;
- calculate total energy demand and peak load;
- estimate technical losses and required reserve margin;
- calculate the total required generation capacity.

The first sub-step in this process was to estimate the number of customers that the ESPs would connect over the forecast period. Typically, this would be done by analysing historical customer connections relative to population growth.

[21] Commercial users represent everything from tiny shops that may currently only have a few light bulbs to cell towers and offices. For the small shops income elasticity of demand for electricity is much higher (and in some cases greater than 1) than for offices, where increasing income is likely to correspond with only a minimal increase in electricity consumption. For example, if a travel agency buys an additional computer, its income might increase by 20% while its energy consumption might only increase by 2%, which equates to an income elasticity of just 0.1 (2%/20%).

[22] Based on a common example observed in Somaliland, an enterprising small shop owner might buy a chest freezer in order to offer cold drinks or better-preserved meat, which will increase the shop's electricity consumption, but may also significantly increase its income. However, adding a second freezer will not have proportionately the same effect – it will nearly double the shop's electricity consumption, but it is unlikely to also double the shop's income.

Unfortunately, there is very little reliable historical data on customer additions. Also, since Somaliland is currently significantly under-connected, rather than merely extrapolating from recent trends, it is more reasonable to make the optimistic assumption that connections and connection rates will increase at least somewhat over the forecast period.

In assessing the growth in connection rates, there are three issues that need to be addressed. The first is to start with an estimate of the population in the cities that is reasonable as that is the foundation of all customer growth. A review of the recent reports that included two recent population estimates:

- Population Estimate Survey (PESS), UN Population Fund (UNFPA), October 2014 provided a population estimate for 2014 by type of population (urban, rural, nomads and internally displaced persons);
- The World Bank provided an estimate of the total population for the years 2014, 2015 and 2016.

The following Table 19 provides an extrapolation of the 2014 population by type to 2016 using the World Bank total, the number of households and an estimate of the number of households customers:

Table 19. Extrapolation of the 2014 population by type to 2016

Type	Population	Number of households[23]	Household Customers	Share Connected
Urban	2,156,372	321,847	241,385	75.0%
Rural	447,315	73,330	36,665	50.0%
Nomads	1,376,731	193,906	N/A	N/A
IDPs	97,729	13,765	2,753	20.0%
Total	***4,078,147***	***602,847***	***280,803***	***45.6%***

Source: Unicon

Nomads, by their definition would not be customers of the ESPs although they may, and many probably do make use of electricity either on a temporary basis or through mobile sources of power such as mobile solar arrangements discussed in earlier chapters. It should be noted that the column share connected for the total is misleading since the numerator covers household customers and the denominator covers all the country population *including* nomads.

The above population and household estimates are projected to increase over the forecast period at 2.9% per year until 2027 then at 2.7% thereafter for all types of population. These rates were used in all three scenarios examined.

[23] The PESS report provided the following estimates of household sizes: 6.7 people for Urban households, 6.1 people for Rural households and 7.1 people for both Nomads and Internally Displaced Persons.

The second issue is to ensure that the differential growth rates between customers and population (and therefore households) mentioned above do not result in an estimate of customers that exceed the number of households. As can be seen from the above tabulation, this is more of a risk in the urban areas where the current number of household customers is estimated at 75% of the number of households. This issue is addressed manually in the model for each type of customer.

The third issue is the impact of the current level of social unrest. This has significantly restricted the ability of various ESPs to connect and serve customers at a rate commensurate with demand. Conceptually, there should be three periods during which the rate of customer connections will differ:

- The first period alluded to in which the connection rate is constrained or depressed. This period is assumed to cover the next five years – 2018 to 2022;
- The second period is one of recovery where there will be a growth spurt to "make up for lost time." This period is assumed to cover the following five years – 2023 to 2027;
- The third period is one that could be characterised as normal. This period is assumed to cover the last ten years of the forecast – 2028 to 2037.

Therefore, the working assumption in the baseline forecast is that the ESPs will, on average, add customers at equal to or greater than the rate of population growth.[24] This will allow for the rate of customer access to electricity to increase steadily over the forecast period. Different assumptions regarding customer additions were used for each of the three scenarios examined. The assumptions used are based on the following targets:

- for the base case forecast, customer additions would grow such that the target penetration rate was approximately midway between the penetration rates for the high and low cases, which are defined below;
- for the low forecast, customer additions keep pace with household growth; therefore, there would be no increase in the rate of electrification in the country over the entire forecast period; and
- for the high forecast, customer additions would grow at a rate equal to or higher than the growth in households in order to (a) reach a target penetration rate[25] of between 75% and 90% by the year 2037, provided that, (b) the growth rate in any of the three periods defined above never exceeded four times the growth rate in households.

The assumptions for the three scenarios are applied to each type of population in the following Table 20.

[24] The World Bank estimates Somaliland's annual population growth at 2.9% for the past several years through 2016 (World Development Indicators, SP.POP.GROW). The forecast assumes that this rate will continue for the next ten years and then slow somewhat to 2.7% as per capita income rises, following the trend of most developing countries.

[25] Penetration rate is defined for purposes of this report as the number of residential customers served by an ESP in any population group (Urban, Rural and IDP) divided by the number of households in that grouping. Nomads are excluded as it is assumed that any electricity used by them will be through off-grid supplies.

Table 20. Assumptions for customer additions (population growth multiplier)

Scenarios	Period of Forecast								
	Short-Term 2018-2022			Mid-Term 2023-2027			Long-Term 2028-2037		
	Urban	Rural	IDPs	Urban	Rural	IDPs	Urban	Rural	IDPs
Base	1.0	2.0	2.0	1.5	2.0	2.0	1.0	1.0	3.0
High	1.0	2.0	2.0	2.0	4.0	4.0	1.0	1.0	4.0
Low	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Source: Unicon

A note of explanation is required for the assumptions used in this Table. For example, for the high forecast, the growth in number of urban customers in Somaliland is assumed grow at the rate of household growth for the first five years then they would increase at the twice the rate as households during the "recovery" period then at the rate of growth of households for the remainder of the forecast period.

On the other hand, the rural customers in Somaliland are expected to grow twice as fast as the rural households for the short terms, then at four times the rate of growth of households during the recovery period then at the rate of growth of households for the remainder of the forecast period.

The customers among the Internally Displaced persons in Somaliland are assumed to grow during the three periods at the same rates as the rural customers. The rationale for these assumptions is that the degree of electrification in Somaliland (based on the limited data available) is very high in the urban areas but very low in the rural areas and even lower among the IDPs. The information available suggests that the degree of electrification for Somaliland is relatively high so the multipliers selected were lower than would be expected so as to avoid the error of connecting more customers than there are households.

Using the factors given in Table 19 above and the estimates of populations and current electrification rates, the following level of electrification for each type of population for the last year of the forecast period (2037) as well as the average point-to-point growth rate over the 20-year forecast period are calculated in Table 21.

Table 21. Customer growth and electrification rate

Scenario	Growth in Costumers 2017-2037 (%)			Electrification Rate in 2037 (%)		
	Urban	Rural	IDPs	Urban	Rural	IDPs
Base	3.2	4.2	6.9	80	66	44
High	3.5	5.6	9.7	86	84	74
Low	2.8	2.8	2.8	75	55	19

Source: Unicon

The second sub-step was to calculate the projected total energy demand and peak load over the forecast period. The energy demand is calculated as follows:

- the number of customers is estimated for each year for each of the population types of Urban, Rural and Internally Displaced Persons (Note that Nomads are excluded from this calculation for reasons explained above) taking account of:
  - the starting point of the population estimates;
  - the estimated household sizes; and
  - the rate of increase of number of customers which is a function of the population growth rate and the population growth multiplier.
- the number of customers is also broken down by customer category (Residential, Commercial, Industrial and Other);
- the unit consumption for each category and population type is then applied in the starting year and increased over the forecast period at a rate equal to the estimated growth in GDP adjusted by the assumed price elasticity of consumption;
- in each year and for each customer category and population type, the number of customers is multiplied by the appropriate number of customers to get the estimated annual energy requirement by the customers for each customer category and type of population;
- these are then aggregated to obtain the forecast of energy sales in MWh to end-user customers.

The calculation of the peak demand is carried out using the forecast of energy sales and applying a load factor. The load factor mentioned earlier in Table 18 is used as the starting point. The load factors in that Table are hourly load factors that take account of the hourly load of typical Residential, Commercial, Industrial and Other loads.

The overall load factor for a typical day was calculated appropriate weighting of customers. However, this calculation suffers from several deficiencies:

- it is calculated for a day and the factor is needed for a year;
- it is calculated for a typical work-day. The load, for example on a Friday would be expected to be much lower, particularly for the customer categories of Commercial and Other;
- it does not take account of any seasonality of load. For instance, in the hotter months the air conditioning and fan loads can be expected to be much higher;
- level of diversity found in the daily load shapes may not be representative of the diversity on an annual basis.[26]

The daily load factors for a typical day for each type of population for 2018 and for 2037 have been derived in order to provide a comparison of the relative values for population types as well as a trend over the forecast period. There is, unfortunately no data permitting a realistic and supportable

[26] The diversity factor is the reciprocal of the coincidence factor. If the shape of all loads is such that the maximum value of each category of load occurs at the same time, the coincidence is 1 and the diversity is zero. An examination of Figure 17 shows the coincidence factor for Residential would be 1.0, Commercial would be 60% Industrial would be zero and Other would be 25%.

estimate of the annual load factor for any of the above combinations. The load factor for the typical day can be used as an indicator of the maximum value for an annual load factor since the elimination of the deficiencies mentioned above would have the tendency to decrease the load factor.

Benchmarks can be considered by examining experience elsewhere, keeping in mind that each country is unique and can only be used for comparative purposes with great care. The following are examples that illustrate the variability of overall load factors:

- A small isolated region of a large African country with relatively little industry: 50-60%;
- A large African country with major industrial and other loads all connected to a main grid: 70-75%;
- Four isolated centres in the same county: 50-60%;
- An Island nation in the Caribbean off Central America with relatively small industrial loads but significant commercial loads: more than 75%.

The above suggests that there is a wide range of reasonable values that can be selected.

Another issue that needed to be addressed is the expectation that the load factor will change over time. At present, customers have a specific set of appliances, equipment and machinery, which they use as desired or as needed, constrained by the availability of the electricity supply. As time goes on, they can be expected to purchase and use additional electrical material. It is expected that much of this new equipment and appliances will tend to be operated at what is currently off-peak periods. This will have the impact of increasing the load factor.

In addition, the electricity supply is constrained by operations, budget and other issues. A major constraint in this regard is that many of the ESPs operate their units in shifts or for parts of the day only. Part of the reason for this mode of operation is that there are insufficient technical resources (materials and skills) available to operate units in a synchronised manner (this is discussed in detail in earlier chapters). Once these ESPs are able to offer their customers service on a 24-hour per day basis, the load factor would be expected to increase significantly.

For the above two reasons in particular, the Consultant has used an algorithm to gradually flatten the load curve over time such that the growth in peak demand is constrain to grow at a rate lower than the rate of growth of energy. The load forecast model, therefore includes and adjustment factor to take this issue into account. This factor is adjustable and the initial value selected was 75%; thus the load curve is flattened such that the load factor increased at a rate equal to about 75% of the growth rate in energy.

Based on the above, Unicon used the following approach to the calculation of peak demand:

- typical daily load curves presented above was used as a template for the construction of daily load curves;

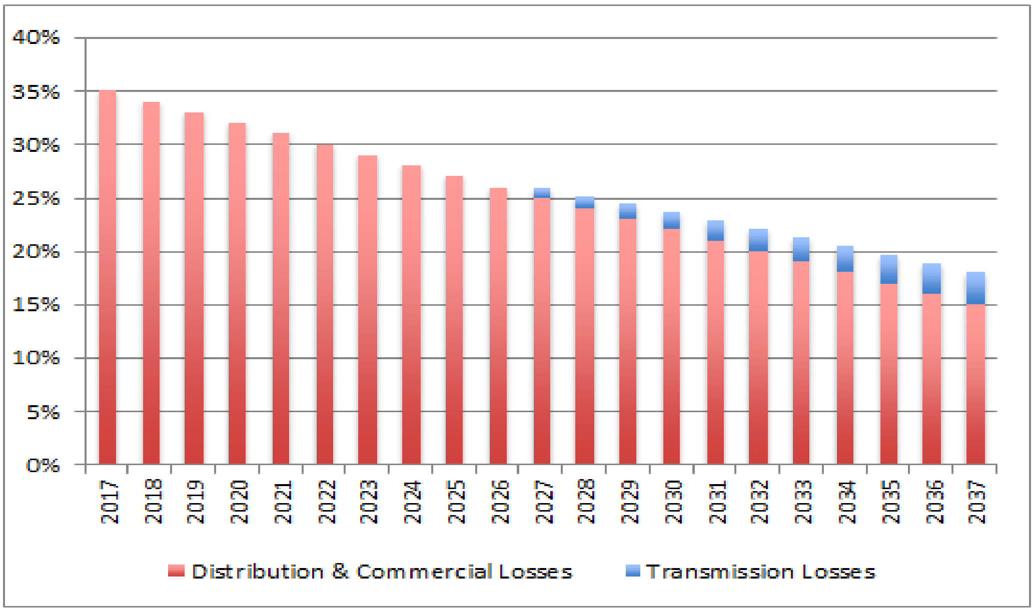
- template was modified to take account of the unit consumption and the number of customers in each category (residential, commercial, industrial and other). This resulted in the estimated load hour by hour for a typical day;
- sum of these loads hour by hour resulted in an estimated total load each hour of the day;
- as there was no better information available, this daily load factor was assumed to apply on an annual basis, beginning in 2017;
- process was repeated year-by-year for each year of the forecast period;
- resulting load factors were applied to the energy demand requirements year by year for the urban loads. These same factors were then applied to the rural and IDP loads;
- as it is assumed that nomads would use mobile solar/battery hybrid systems, the only relevant measure is the energy consumed so the derivation of load factors for this type or electricity user would not be relevant.

The application of these load factors to the appropriate energy requirements described above will yield the peak demand from the customers. However, due to technical and commercial losses and the need for a reserve margin on generation capacity, delivering this energy to end users requires both producing more power and having generation capacity in excess of the estimated end use peak load. Therefore, the third sub-step was to estimate the technical losses and required reserve margin in order to calculate the total generation and capacity required to meet demand and adequately serve the load.

Technical losses are a significant issue in Somaliland. Although they lack clear data to substantiate their claims, the ESPs interviewed typically estimated their losses (primarily technical, but to some extent commercial) as in the range of 25-45%. Empirical data from one ESP, which had reasonably consistent and reliable data on both generation and billed usage, indicated losses of 18-24%. However, their operations (as evidenced in part by having reliable data) are likely more efficient than average – and thus their losses are likely below average. Therefore, the current average system losses have been estimated at 35%.

The assumption in the baseline forecast is that distribution losses will be steadily reduced to 15% over the twenty-year forecast period. However, total losses are assumed to not decline quite so sharply, since the forecast assumes that by 2027 10% of energy will initially be transmitted over transmission lines and subject to 10% losses. The assumed trend in average energy system losses is illustrated in the following Figure 18 below.

Figure 18. Estimated and projected average energy system losses



Source: Unicon (assumptions)

The reduction in losses[27] are based on the assumption that the ESPs will make a concerted effort to reduce them over time. The reduction in technical losses usually requires significant investment to increase conductor sizes, ensure that transformers are of the appropriate size for the load (transformers that are too large engender unnecessary "no-load" losses and transformers that are too small increase load losses and risk more rapid failures due to overloading), reduction of feeder lengths, etc.

It also requires additional attention to maintenance, for instance by ensuring that all connections are correctly tensioned and by ensuring that single phase lines are connected to three-phase lines in such a way that phase loads are balanced.

Commercial losses tend to be controlled by better vigilance on the part of management and staff in order to identify anomalies in billing and correcting them as soon as noted. These can include customers stealing by disconnecting meters or current transformers attached to the meters, users connecting illegally, customers not paying their bills (with or without the complicity of staff, etc.).

The last step in the forecasting process was to calculate the required generation. This was a straightforward process of grossing up the projected end user energy demand to account for the losses. In addition, the energy required must take account of the reserve margins needed in the installation of new generation. This is to cover situations where (i) the load demanded by the customers exceeds the forecast and (ii) there is sufficient capacity in the system to permit generating units to be withdrawn from service voluntarily for maintenance or involuntarily due to outages without affecting service to customers.

[27] *A crucial element in reducing losses is the installation of a metering system on all feeders.*

This analysis assumed that systems should have a 10% reserve margin on top of peak load to arrive at the total required generation capacity. This is an aggregate margin and it is acknowledged that for operational purposes, small and relatively simple systems will ideally have reserve capacity equal to the size of the largest unit on the system, which is likely to be much greater than 10% of total capacity.

4.2 Analysis and Results

A model has been created, as described in Figure 16 that derives the energy and peak requirements for each type of load. This model consists of a single file with several sheets:

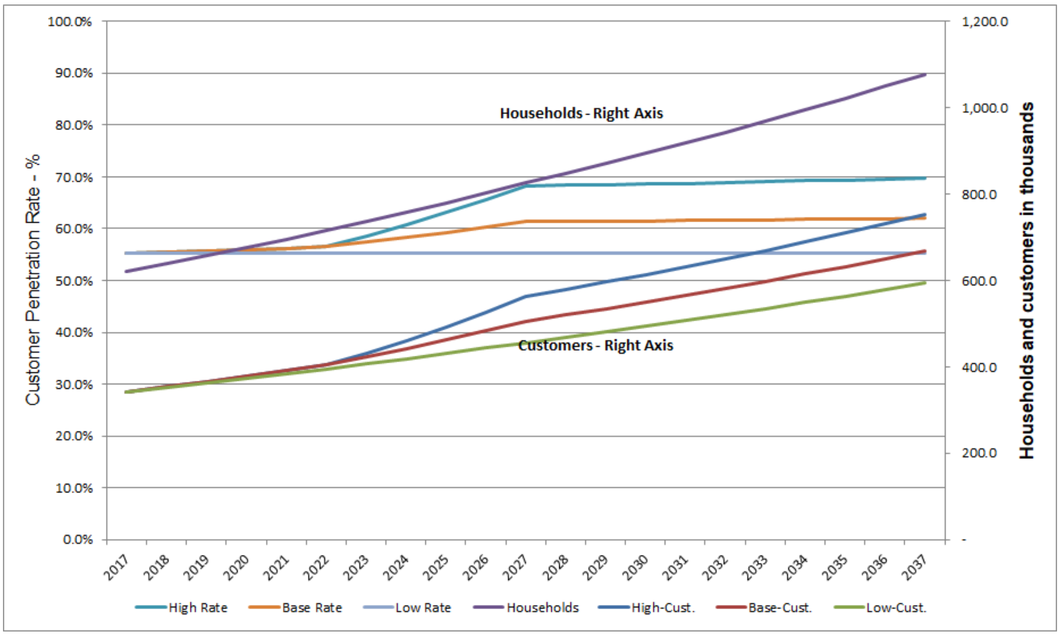
- scenario definition;
- forecast summary sheet;
- three sheets dealing with population issues;
- one sheet for demand assumptions;
- two sheets for each population type, one for the calculation of the loads (energy and peak demand) and the other dealing with load curves.

A separate model was created for each of the three scenarios examined. A summary file was then created that compared the results of the three scenarios.

4.2.1 Penetration Rate

Table 21 illustrates the penetration rate in each type of load for each of the three scenarios for the year 2037. Figure 19 illustrates the trend customer additions and resulting electrification used in the derivation of the forecast of the loads. The inflections on these curves emphasise the different assumptions used in each of the three period of the forecast.

Figure 19. Comparison of penetration rates



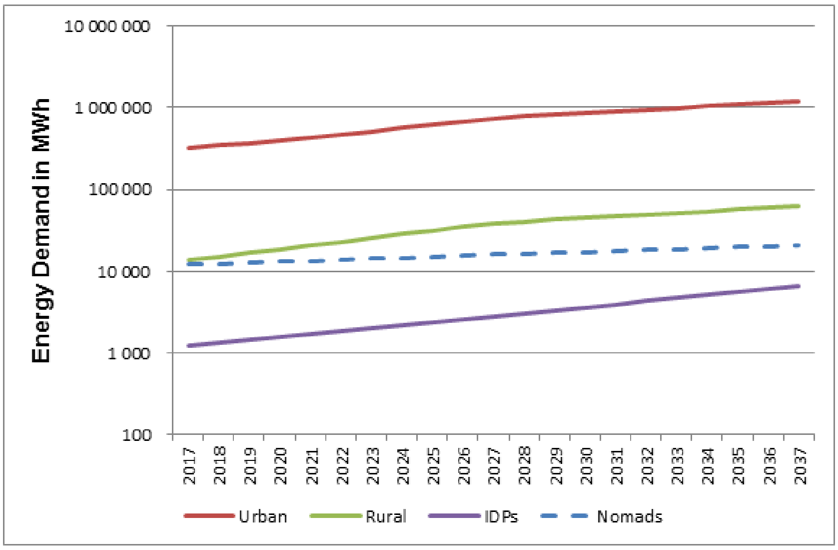
Source: Unicon

4.2.2 Forecast of Energy and Peak Requirements

Figure 20 presents the energy required for Somaliland under the base case assumptions. Included in these curves are the requirements for Urban and Rural populations as well as Internally Displaced Persons.

Nomads are not included in this figure, as it is understood that, by their nature, they will not be connected to any grid (mini or otherwise) but will satisfy their electricity requirements through mobile services.

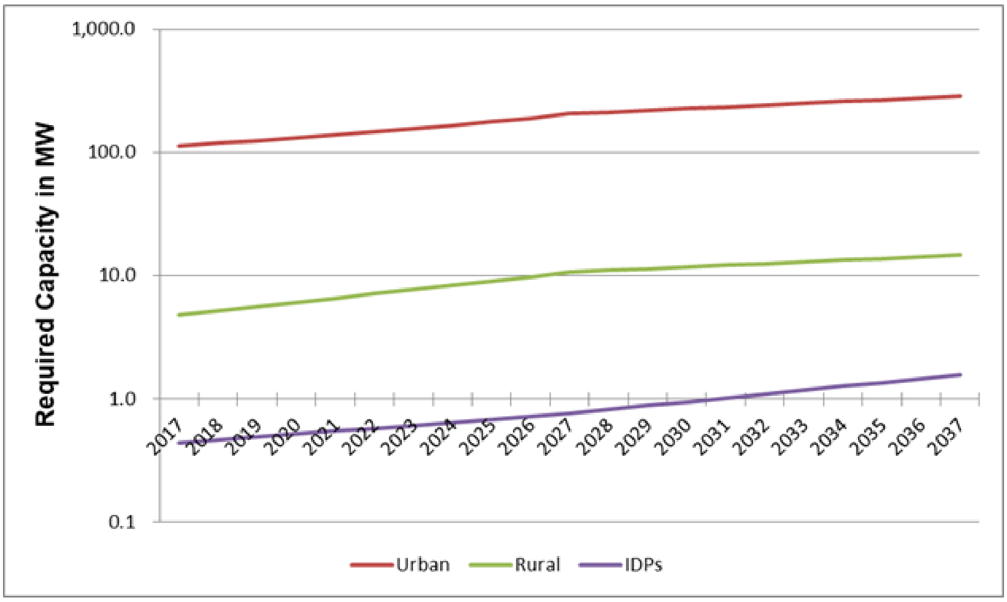
Figure 20. Energy requirements – logarithmic scale



Source: Unicon

Figure 21 presents the required generation capacity for Somaliland under the base case assumptions. Included in these curves are the requirements for Urban and Rural populations as well as Internally Displaced Persons and, again Nomads are excluded.

Figure 21. Required generation capacity by type of population



Source: Unicon

The following Table 22 presents the forecasted energy demand and generation requirements for the years 2022, 2027 and 2037, as compared to the estimated values for 2017. Also presented in the Table are point-to-point compound growth rates during the periods shown.

Table 22. Estimated energy and generation requirements for selected years

Type	2017	2022	Growth 2017 - 22	2027	Growth 2022 - 2027	2037	Growth 2027 - 37	Growth 2017 - 37
Total Estimated Energy Demand (GWh)								
Urban	318.6	471.6	8.2%	749.0	9.7%	1205.5	4.9%	6.9%
Rural	13.6	23.0	11.1%	39.0	11.1%	62.4	4.8%	7.9%
IDPs	1.3	1.9	8.7%	2.8	8.1%	6.6	9.0%	8.7%
TOTAL	***333.5***	***496.5***	***8.3%***	***790.8***	***9.8%***	***1274.5***	***4.9%***	***6.9%***
Required Generation Capacity** (MW)								
Urban	112.8	145.8	5.3%	206.0	7.2%	284.6	3.3%	4.7%
Rural	4.8	7.1	8.1%	10.7	8.5%	14.7	3.2%	5.8%
IDPs	0.4	0.6	8.4%	0.8	5.9%	1.6	7.2%	7.2%
TOTAL	***118.0***	***153.5***	***5.4%***	***217.5***	***7.2%***	***300.9***	***3.3%***	***4.8%***

**includes all allowance for losses and a reserve margin of 10% on load plus losses*

Source: Unicon

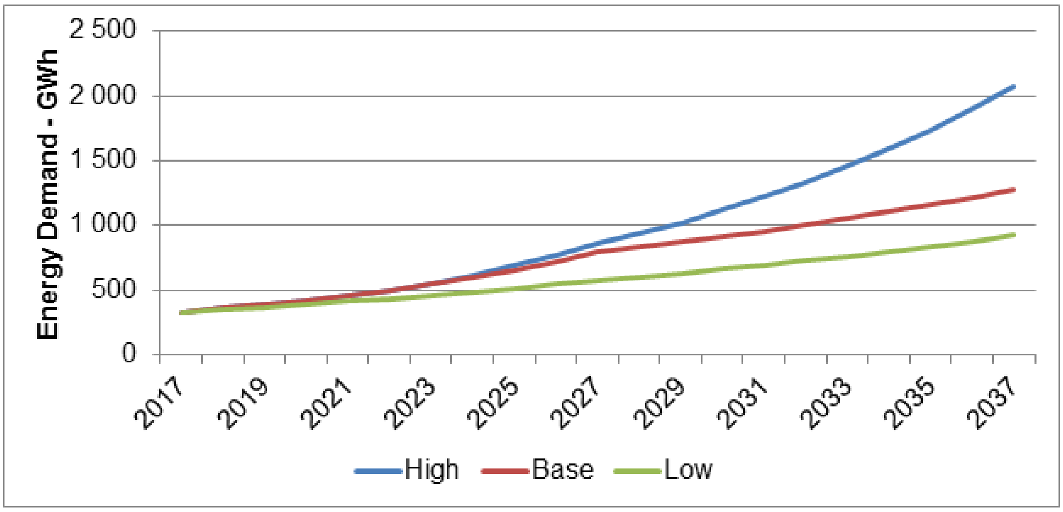
Figure 22 and Figure 23 present, respectively, a forecast of the energy demand and peak requirements for Somaliland for the three scenarios examined. The latter figure represents the generation capacity required in the systems supplied by ESPs and include losses and reserve margin.

Each line includes the estimated requirements of the urban and rural populations as well as the internally displaced persons. The latter are included as observations and indicate that such persons tend to be in built-up areas adjacent to urban or rural centres and have all the amenities of such populations, including the supply of electricity.

During the data collection phase of the mandate several major projects were mentioned as being either under construction or being actively pursued. As examples there are the expansion of the port in Berbera and the creation of a special economic zone. In both cases there could be an increase in demand on the public power systems. Although each is described as a specific project, they can be considered as an accumulation of small loads over time. For instance, the Special Economic Zone would attract a series of enterprises that would each have its own load and connection to an ESP. This understanding of these projects led to the decision to consider these projects as included in the basic assumptions used in deriving the three scenarios of the forecast. One way of considering these projects in light of the scenarios used in the forecast is as follows:

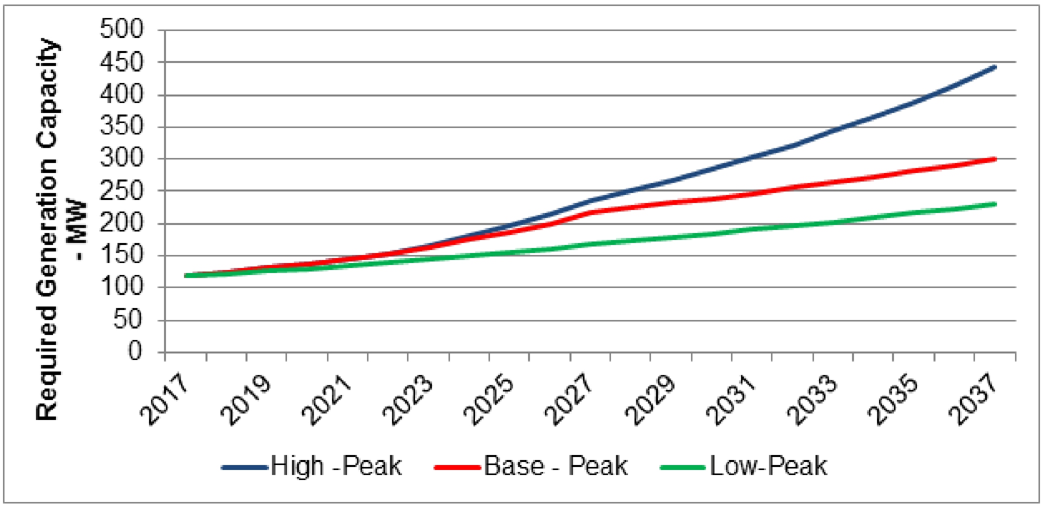
- Low forecast: neither the port expansion nor the Special Economic Zone would materialise during the period of the project;
- Baseline forecast: one of these projects would materialise in full or both partially during the period of the forecast;
- High forecast: both projects would materialise during the forecast period.

Figure 22. Forecast of energy demand by scenario



Source: Unicon

Figure 23. Forecast of generation capacity requirements by scenario



Source: Unicon

5. Generation Options

Most of the electricity produced and delivered to the businesses, institutions and the urban populations in Somaliland is provided by independent Electricity Service Providers (ESPs) and some IEPs. Nearly all of the current electricity generation in Somaliland is derived from high-speed (1,000 rpm or more) diesel fuelled generators (HSDG). Moreover, many of the larger industrial businesses and institutions utilise their own Captive Generation, which again is nearly all supplied by HSDG.

Generally, within the larger urban centres the electricity is provided by one or more ESPs using a mix of radial MV (medium voltage-11kV, 15kV & 33kV) distribution and LV (415/240V) feeder lines, all at a frequency of 5O Hz. The size of the HSDGs generally ranges from 50kVA to 2,000 kVA, with several to multiple HSDGs located at each site.

Additionally, it was observed that in the larger urban centres, with more than one ESP, there is no common shared network or cooperation in electricity distribution. In some cases, large electricity customers use multiple ESPs as service providers or opt for their own captive generation.

Annex 7 shows the size and number of HSDGs “currently surveyed” in Somaliland.

Observations from urban field data collection and discussions, indicates that until recently, the renovation or upgrading of generation sites by the ESPs, generally involved either replacements or additions, by using similar or larger HSDGs.

Most of the urban ESPs and captive generators have not implemented synchronisation and automation as part of their generation processes. As a consequence, dedicated generators are allocated to exclusive feeder lines.

It was determined that currently it is likely that many urban-based HSDGs are operating well below their expected and designed performance criteria. This kind of operation results in significant amounts of “wet stacking” (diesel fuel waste, extra pollution, performance degradation and shorter HSDG lifespans) amongst electricity producing HSDGs.

Currently there is no in-country petroleum refinery providing hydrocarbon fuels for use within Somaliland. Throughout Somaliland, all diesel fuel is transported via national road networks from port facilities to points of use.

Opportunities for upgrading current urban generation sites that could be included in the analysis include:

- introduction of synchronisation and automation for generators presently in operation;
- introduction of larger more efficient thermal generation including medium and low speed diesels using sizes of units generally available on the market;
- introduction of Gas Turbines with high efficiency thermal generation that use diesel fuel that is generally available; and
- addition of renewables based generation.

The addition of renewables based upgrades has resulted in hybrid generation opportunities. Such hybrid opportunities offer significant improvements in fuel efficiency, fuel consumption, extended HSDG lifespans, reducing greenhouse gas (GHG) emissions and combustion pollution, along with less reliance on fuel imports. Hybridised electricity generation for urban centres is the present global trend across electricity markets.

5.1 Characteristics of Current Electricity Generation

5.1.1 Current Urban Generation Capacity Implemented

As previously indicated, most electricity generation within Somaliland, is derived from urban-based HSDGs, which are owned and operated by private sector ESPs. Data was collected from the majority of ESPs operating in many of the major urban centres.

Generation Data for the major urban centres of Erigavo and Berbera could not be completely obtained. Generation data for the city of Hargeysa was incomplete, with approximately 50% of Hargeysa’s ESP’s not providing information. Some generation data was obtained for Berbera via ESRES data.

Table 23. Summary of totals from collected data for "current usable" generation

REGIONS	Type of Generation (kW) & Renewables Penetration via kWh					
	HSDG kW	Solar kW	Solar %	Wind kW	Wind %	Battery kWh
Somaliland	24,356.7	3,535.0	3.1%	118.8	0%	1,300

Source: Unicon

It must be noted that these values are not the same as for the total surveyed units. These values are for currently estimated generation sources in use and that nearly all ESPs do not currently implement synchronisation and automation of their HSDGs. Those ESPs utilising renewable generation have done so by adding it to their diesel fuel based generation, thus creating hybrid generation systems.

All the solar PV systems connected to urban distribution are grid-tied and therefore synchronised to their respective local ESP distribution network. Accordingly, these ESPs are now producing synchronised hybrid generation.

5.1.2 Fossil Fuelled Urban HSDG Operations (Diesel)

The generation data provided by the ESPs surveyed in general did not supply the actual metered electricity generated, but rather load cycles and estimated generation based on peak capacity assumptions. Monthly fuel consumption data was generally provided by the respective ESPs. The cost of diesel per litre, paid by ESPs, was systematically not provided, but the large captive HSDG generation facilities provided an average price of US$0.60/litre of diesel. A summary of operational characteristics and maintenance requirements for current surveyed operative HSDG's is shown in Annex 7.

The range of HSDGs used in Somaliland's urban areas are all under 2,000 kW in generation capacity. These systems have optimal lifespans of 3.42 years (15,000 hours) when operated 12 hours a day, at which point they must be either replaced, or a major overhaul is needed, if still viable. Apart from regular maintenance, HSDGs require major scheduled changing of filters and oil each 6 months and "Top End" overhauls each 13-14 months during a 3-4 year period.

In some ESP locations, the comparison of the level of actual fuel use against expected fuel use for HSDG electricity generation was very significant. These are low values, which usually indicate significant diesel fuel losses external to generation or theft. This is further illustrated in Annex 7.

5.1.3 Urban Electricity User Population Capitalising on Electricity Generation

Data concerning Energy use by households, small businesses, large commercial and manufacturing enterprises, and institutional users within many of the major urban centres in Somaliland, was collected.

The data collected on residential and business electricity use, showed that the population distributions concerning electricity use are asymmetric. In particular, the residential use in the surveyed urban centres is described by an exponentially declining curve, which indicates a significant proportion of the urban populations in Somaliland, do not have access to ESP generated and distributed electricity.

Data in Annex 7 illustrates the distribution of residential demand on metered electricity, as kWh/month person.

5.1.4 Renewables Generation Operations

As previously mentioned, there are ESPs within Somaliland that have commenced converting their generation systems into hybrid electricity generation. For the most part this has been via the renewable energy resource of solar PV. These solar PV systems are all grid-tied and synchronised to particular ESP’s HSDG generation systems and connected to the same ESP’s local distribution network. Data collected from the UNICON survey on current renewables-based generation is shown in Annex 7.

5.1.5 Solar PV and Battery Generation

There are six grid-tied solar PV systems located in Somaliland, which are co-sponsored by the ESRES project. As mentioned, recent implementations of grid-tied solar PV into the urban generation has been significant, grossing to 3.54MW in Somaliland.

These systems are synchronised to operate as part of solar PV-HSDG hybrid generation, with the solar component providing both extra daytime generation and diesel fuel savings. Solar PV generation data surveyed range from 3kW to 1.5MW in Somaliland.

Apart from regular maintenance, which is primarily cleaning the solar panels and generation site, grid tied solar PV systems are low cost maintenance, long lasting generators. Lifespans are considered in excess of 30 years, maybe even 60+ years and they are very easy to upgrade and repair. This is because the systems are composed of modular components that can be easily replaced.

The key vulnerability is electronics within the solar PV such as DC-AC inverters, which are intentionally modular, such that they can be easily replaced if they fail. Change out times on failed inverters are a few hours at most, and it does not prevent the rest of the modular elements of solar PV systems from continuing to generate electricity.

In the cases where there is a combination of solar PV, with rechargeable battery storage systems, these use additional grid connecting inverters and computerised battery management systems (BMS). The use of batteries reduces the impacts of low sunlight conditions (clouds) during daylight, as well as, via grid inverters, provides rapid-response peak-load generation capacity. Moreover, with a suitably large capacity, the battery systems can even permit night-time generation and peak load support. This is further discussed in Annex 7.

5.1.6 Wind Power Generation

There are currently 11 non-operational wind turbines dispersed between Hargeysa, Berbera, Borama and Erigavo. Only the five Hargeysa and three Berbera wind turbines were considered as potential generators in the survey. These are 22kW turbines mounted on 18m towers. While three of the five turbines at the Hargeysa airport are considered potentially operational, their history has created safety and liability concerns for the local ESPs who own and manage the airport distribution network. The more generic issues of wind generation are included in Annex 7.

5.1.7 Captive Generation

The small sample of large captive generation locations surveyed utilise single or multiple HSDGs on site. In addition, these were also reported to be currently not using synchronisation and automation, as part of their operational protocols.

Data from large captive generation sites can provide useful information on actual large industrial requirements for electricity, but the actual population of large businesses using captive generation is unknown, and only a limited sampling of large businesses was surveyed.

Ergo, the combination of a limited amount of data collected on large businesses, plus an even smaller sampling of large captive generation businesses constrains what reliable conclusions can be drawn concerning captive generation. It must also be annotated that historically, captive generation is the starting point for electricity generation in most societies, including how ESPs have developed in the country.

5.2 Electricity Generation Resources Available

The potential energy resources available for supplying or fuelling electricity generation in Somaliland can be divided into three classes. These are the use of:

- Biomass and waste fuels (thermal source) such as; wood, urban waste products or waste agricultural products;
- Fossil fuels (thermal source) such as coal, petroleum-based products and natural gas;
- Renewable energy, which can be grouped into solar PV, solar thermal, wind and electric.

At the present time in Somaliland, there is no national production and exploitation of nationally sourced fossil fuels such as coal, natural gas or liquid petroleum.

There are extensive resources of wind within Somaliland. In addition, there are also significant solar PV resources available in the country, both along the coasts and inland.

5.2.1 Biomass and Waste Fuels

Noting the severity of the current impact of regional climate change, a protracted drought, and significant deforestation, the presently very vulnerable natural and human environment in Somaliland does not currently offer significant opportunities for sizeable use of biomass for electricity generation. Presently there is extensive use of wood to produce charcoal for national use and significant regional targeted exports destined for use in cooking, which have severely aggravated deforestation processes.

There is a significant waste stream being produced by each of the major urban centres and there are robust and established ways in which urban waste destined for landfill can be segregated and the appropriate portions used for electricity and heat generation. Moreover, urban liquid waste efflux can be treated to provide biogas and other fuels for electricity and/or heat generation and support land regeneration.

There is also a significant livestock and local agricultural industry supplying both local consumption and, significantly, the export of live and slaughtered animals. There is significant potential for using the wastes from these industries at their collection hubs for fuel and land benefits such as in Burao and Berbera. These sites could provide biogas, other fuels and organic soil additives from their solid and liquid waste streams.

Unfortunately, it appears at this time, there are no such projects in-place to systematically examine or undertake projects to exploit these possibilities for cogeneration of electricity, waste treatment and support near urban agricultural land remediation.

5.2.2 Fossil Fuels Options

Currently there are no identified Low Speed Internal Combustion based electricity generation systems in Somaliland. Often called LSIC generators, Low Speed Diesels (LSG) or HFO (Heavy Fuel Oil) plants; these can run on either diesel or HFO, but because of the cheapness of HFO, are frequently marketed and run based on this fuel.

The adoption of either HFO or Natural gas (LNG or CNG) based electricity generation, will require the installation of specialised storage facilities for the handling and storing of these fuels both at the port and ESP sites. Moreover, the land transport of natural gas requires specialised road tankers and good roads or pipelines.

Additionally, HFO is not generally considered suitable for overland transport, as it requires continuous heating for storage and for pumped transfers. On the contrary, both fuel oil and diesel fuel are easily and safely transported by road fuel tankers over most types of roadways and share a common fuel resource with key elements of the transport infrastructure.

5.2.3 Renewables Resources

The discussion of renewable resources in this chapter is focused on its use as part of the supply of electricity to larger load centres; the use of such resources in off-grid situations was discussed at length in Annex 6.

Solar PV

Solar PV opportunities in Somaliland are primarily constrained by:

- availability of open space at the location;
- quality of solar irradiation at the location;
- number of sunlight days per year in the location; and
- need to operate in some form of hybrid configuration.

The amount of electricity that a particular solar PV location can generate for a hybrid generation network is ultimately determined by the combination of the following:

- Power rating, kWp, of the solar PV arrays;
- Solar irradiation index for that area;
- Efficiency of the inverter systems, which ranges from 0.87 to 0.97;
- The cleanliness of the panels (removal of dust); and
- Monitoring and preventative maintenance for the inverters and control panels.

The solar maps shown in Annex 7 illustrate that different locations provide unique energy irradiation characteristics throughout Somaliland. These locations are especially well suited to solar PV electric generation as part of a hybrid generation network and should be exploited in both urban and rural areas for electricity generation.

Adjunct solar PV uses

An important adjunct for expanding the utilisation of solar PV is its capacity to preserve important water resources for human, industrial and agricultural activities. Solar PV systems can be installed on water reservoirs and treatment ponds to provide evaporation protection. Floatovoltaics (floating solar PV arrays) preserve water, as well as support daytime manufacturing and institutional value-adding electricity generation. Since there are relatively few open reservoirs in Somaliland. This option, while interesting may have limited application; however, it is further discussed in Annex 7.

Batteries and electricity storage

A frequent modality for enhancing the contribution of solar PV generation in a hybrid generation network is the addition of storage. Most solar PV storage solutions are currently primarily through batteries with some kind of BMS (Battery Management Systems), with forms of climate managed environments and two-way inverters.

Such additions can significantly raise a hybrid solar PV generation system's cost and depends on the capital and operating costs for the size and type of battery technology used, plus lifespan constraints for the rechargeable battery chemistry.

An excellent technical advantage of storage-augmented solar PV systems is that they are capable of generating independently to a distribution network without HSDGs or other base-load generation. They can also be combined with other renewable electricity generation that together provides a variable generation input, plus potential for rapid response to peak demands.

Another form of energy storage available for Hybrid systems is through the use of Compressed air. This technology offers very long lifespans, modular and containerised units, temperature insensitivity and rapid peak electricity delivery, if required. Unfortunately, it is only beginning to enter the commercial marketplace, and reliability is unknown.

Wind power

Wind opportunities in Somaliland are primarily constrained by:

- availability of open space at the location;
- speeds and reliability of winds at the location;
- number of windy days per year in the location; and
- need to operate in some form of hybrid configuration.

The actual wind power systems currently installed in Somaliland are of the types generally installed globally, which comprise of wind turbine nacelles fixed on top of masts or towers, spaced apart and situated on open ground.

Key elements within wind turbines apart from the rotor blades, are the nacelle, which contains an electromechanical transmission, asynchronous generator, power electronics equipment, a wind orienting mechanism, cabling, controller, lightning and surge protection, rotor break mechanism and access ports to service the nacelle's components. At the base of the tower/mast there are usually control electronics and switches for safety and servicing. This is further discussed in Annex 7.

Hydroelectricity

Hydroelectric opportunities in Somaliland are primarily constrained by:

- availability of significant and reliable water resources;
- presence of either significant and reliable volumes of water or heads of water; and
- electricity infrastructure needed to deliver the generation to consumers and or urban centres.

Unfortunately, traditional hydroelectric dams for generation are very vulnerable to rainfall seasonality in their catchment basins and also competing needs for water by agriculture and urban populations.

No hydroelectric power generation systems have been constructed in Somaliland.

More recent alternative approaches towards hydroelectricity generation has been through the use of pumped hydro storage and generation. This necessitates the application of hybrid generation methodologies and the advantages of the rapid and peak response of power produced by hydroelectric generation. Again, like all renewable generation approaches, geographic factors determine where pumped hydro storage and generation can be implemented. This is further discussed in Annex 7.

5.3 Characteristics of Potential Electric Power Plants (including upgrades)

As has already been indicated, the majority of urban electricity generated derives from the use of high speed (>1,000rpm) diesel-powered generators (HSDG), owned and operated by ESPs. These HSDGs utilise the same diesel that is used for road transport vehicles, and can be easily modified to use fuel oil also. They range in size from <10 kW up to 2,000kW, and are often mounted on skids, and similar such more specialised units can reach sizes of 5MW. While HSDG ratings are often by kVA, for consistency sake within the document kW or MW are used for generation power ratings, based on a power factor of 0.9.

Recently, collaborations between some ESPs and international assistance, have introduced grid tied solar PV and wind power generation to provide hybrid urban electricity generation that is integrated with the ESPs current HSDGs. Current solar PV generation systems range in size from 40kW to 1.5MW, and utilise grid tied inverters synchronised to the particular ESP's HSDG generation network.

Analysis of HSDG operations in the country has indicated that a number of improvements can be made to operational features of current generation. These should be implemented before further augmentation of electricity generation is introduced. One clear phenomenon identified is the occurrence of wet stacking of HSDG electricity generation.

HSDGs perform most effectively in their 50 to 100% generating capacity zone, where they combust and use the least fuel for the maximum amount of electricity output. Below 50%, the HSDGs begin to underperform, where fuel is wasted as a result of non-combusted fuel exiting the exhaust stack, solid deposits build up in the combustion and exhaust chambers and contaminants enter the oil lubricating reservoirs.

Another major feature observed concerning HSDGs was that a significant proportion of HSDGs are currently not being operated effectively through automation and synchronisation procedures. The use of automation and synchronisation with multiple HSDGs permits the optimisation of electricity generation. This occurs because synchronisation enables the parallel operation of electric generation from a combination of generators, in unison, so that each HSDG is operating in its optimal performance zone. The use of automation makes it easy for particular HSDGs to be brought online or offline easily and smoothly. This is discussed at some length in Annex 7.

In summary, observations indicate that the crucial investments in HSDG electricity generation made by the diverse ESPs across Somaliland are being seriously compromised in performance and suffering significant losses. These impairments include losses to generated power, life expectancy and maintenance, through practices that result in wet stacking.

Further, the absence of automation and synchronisation technology for the HSDGs, prevents the ESPs from utilising parallel generation to assure optimal HSDG performance and improve dynamic reactivity to electricity load variations.

5.3.1 Upgrade Benefits

The application of automation and synchronisation to the current HSDG generation in Somaliland, will result in several things:

- significant augmentation in generation capacity and competency in synchronising generation;
- eliminate wet stacking;
- improve diesel fuel economies for electricity generation; and
- reduce maintenance and unit replacement costs.

This will enable lower electricity rates for residential, institutional and commercial customers and/or improved return on investments to the owners of the ESPs.

Tables of expected outcomes from implementing effective Automation and Synchronisation within Somaliland are shown in Annex 7.

5.3.2 Potential Power Plants

The field survey evaluation of electricity generation within Somaliland was conducted primarily on the larger and some small urban centres. As has been mentioned, significant proportions of the electricity generated within urban centres is provided by local ESPs via HSDGs.

Thermal electricity generation plants

Waste Power: Waste and Biomass based generation derives thermal energy from the ongoing and already accumulated domestic waste produced by large urban centres.

Internal Combustion Engines: The internal combustion engines can have either a 2 cycle or 4 cycle stroke for the combustion process. Four-stroke, diesel fuelled combustion ignition (CI) engines are considered the workhorse of the world, and are widely adopted. Medium and high speed diesels are usually rated in 3 modes:

- Standby (less than 2hrs/day);
- Prime for varying power generation with up to 10% overload; and
- Continuous for base load continuous rated operation with up to 10% overload.

Diesel fuelled CI engines are considered the most efficient simple-cycle thermal power generation available. They also have very favourable partial loadings between 50-100% load, but below this performance drops steeply. Emissions from CIs are a function of fuel contaminants, and inefficient load operations. When properly operated the main concern is CO and NOx emissions, both of which can be reduced by 90% with catalytic systems.

Throughout Somaliland, urban ESPs currently make extensive use of HSDGs in the 70-700kW range for prime power generation. As mentioned earlier, significant increases in generation from the current existing HSDG systems can be achieved by implementing automation and synchronisation of the existing installations.

Currently there are no medium speed (MSD) or low speed (LSD) CI powered electricity generators in Somaliland. Many MSD and LSD engine systems are modular in design, such that components can be easily replaced, and in some cases the number of cylinders operating can be modified. MSD generators ranging in 2-5MW are also skid mounted and somewhat easier to mobilise. For 5MW and larger generators, dedicated structures are required.

From a current logistical perspective, either HFO, or natural gas as fuels can only be used in urban centres located at ports. For the large inland urban centres diesel, fuel oil and possibly syngas, are the only viable thermal fuel choice going into the near future.

Furthermore, the movement, storage and utilisation of HFO require specialised (heated) port handling and generation facilities. HFO fuel contains significant levels of contaminants and stricter emission controls are being applied globally, which is making this cheap fuel less and less advantageous and attractive for urban port power generation and commercial shipping. There are large supplies of HFO being produced in the Middle East. The characteristics of the different forms of internal combustion engine are shown in Annex 7.

Gas Turbines (SGT & CCGT): The key feature of all these devices is that they are a versatile axial turbo-machine. They bring together air that is compressed by its compressor module, plus atomised or gaseous fuel which are then ignited and the expanding gases pass through exhaust turbines. Like reciprocating engines, they require initiation by a starter unit. As applied to electricity generation the gas turbine shaft usually drives a gearbox, driving the electricity generator.

Simple cycle gas turbines (SGT) are usually considered less efficient than Diesel fuelled, CI engines, and more frequently destined for larger generation systems to obtain the best efficiencies.

Gas turbines are well suited for peak generation as they have fast start up times, whereas CCGT are operated as base-load generators due to the ongoing steam generation. The advantage of multi shaft CCGT systems is certain GT units can be targeted for peak generation whilst others can be for CCGT.

Currently there are no SGT or CCGT powered electricity generators in Somaliland. An important criterion to consider, when contemplating the installation of SGT or CCGT is *whether there is the technical and logistical capability within current and future ESPs to master and carry out the new type of maintenance tasks required for these engines*.

Renewables electricity generation plants

Solar PV: The key feature of solar PV is that amongst all the electricity generation modalities, it does not require moving components or electro-mechanical (rotating) generators. It can be mounted to track the sun or, as is more common, mounted on fixed arrays oriented at the optimal position in the sky to capture sunlight through a daylight cycle.

Solar PV generation is very well suited to size scaling from small standalone user generation to solar PV farms. As a consequence, it is applicable as a power source for powering and charging small devices in isolated locations (lights, pumps or telephone) through to a large electricity power plant, or solar PV park/farm.

Panels are robust and lifespans are now considered close to 100 years if kept clean.

Solar PV is also implemented with electricity storage. The most common form of storage associated with solar PV is electrochemical batteries in combination with two-way battery charger/inverters. The purpose of the batteries or storage is to store excess generation and provide electrical energy when there is insufficient solar PV irradiation or other generation to power the load demand.

Wind: A key feature of wind power is a modular electromechanical generator that can be implemented singularly or in arrays to form wind farms. It is scalable and once properly commissioned is a reliable continuous electricity generation source, albeit changeable due to wind variability. It tracks changes in wind direction, and commercial installations are placed more than 30 metres above the ground to obtain more reliable wind and avoid most windblown dust and sand.

Key components of wind power electricity generation are the rotors, nacelle, nacelle components, the mast, power control and communications box, plus the foundation and MV transformer grid connection.

Wind farms tend to complement solar PV, as high meteorological pressure brings clear skies and low wind, while low pressures bring winds and clouds. With numerous dispersed wind turbines, the variable output from a single turbine due to local wind speeds is cancelled out by the dispersed generation, which becomes less variable and more predictable.

Currently there are no operational grid tied wind generation sites in Somaliland. There are two non-operational grid tied wind generation sites with 3x22kW rated wind turbines potentially available.

The necessary technical expertise to install and operate and maintain widespread commercial wind turbine generation has not been established in Somaliland. This is an important criterion to consider when contemplating the installation of wind power. The characteristics of wind generation units are shown in Annex 7.

Hydroelectric Power: a review of the hydro potential did not indicate any possibilities for the development of hydroelectric plants in Somaliland.

Hybrid electricity generation plants

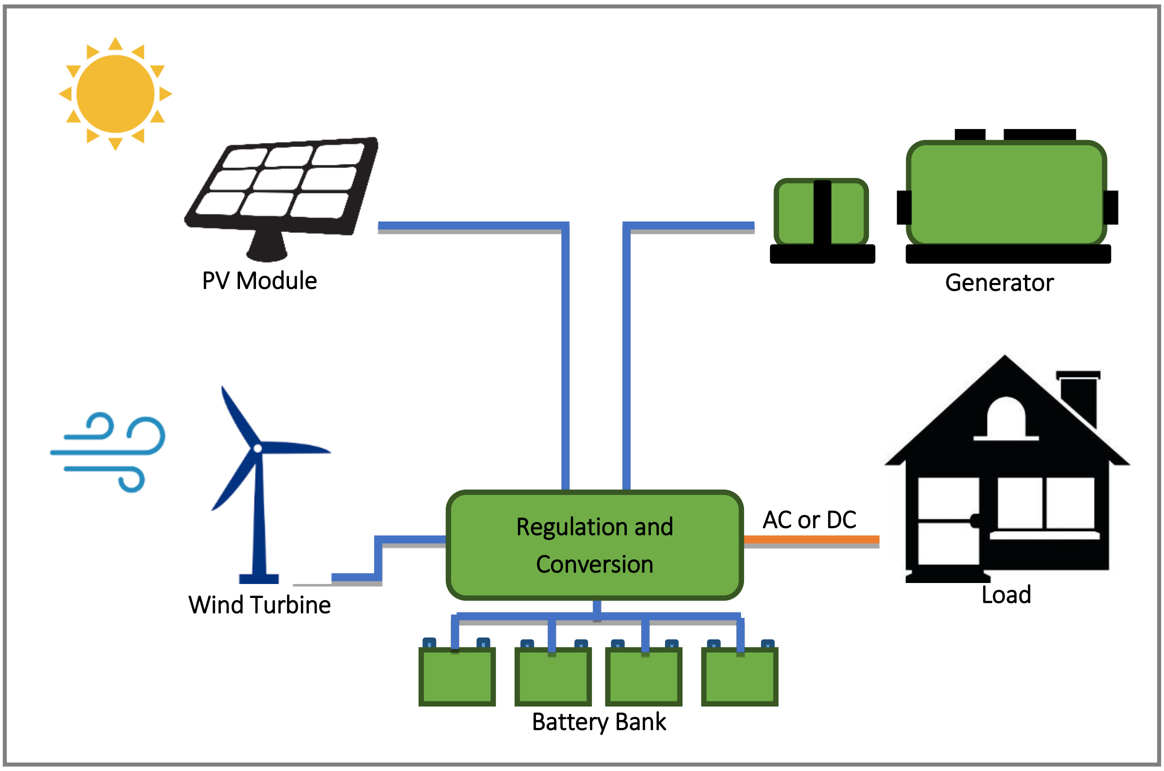
The principal goal of hybrid electricity generation systems is to create a collective of electricity generation systems that are complementary.

In terms of renewables based electricity generation, hybrid electricity generation is where two or more energy sources are combined to provide daily and seasonal generation complementarity. The combination should also provide for diversity and redundancy in reducing power outage risks. It also permits load sharing and incremental increases in generation capacity and future additions, due to modular components and designs.

As a concept, hybrid generation is well suited to both standalone captive generation and the integration of different synchronised generation sources into a common distribution grid/network. It is essential that any hybrid system:

- incorporates the coordination and prioritisation of the different energy sources through the management of AC and DC electricity generation;
- accepts electricity from the different generating units;
- monitors and updates the status of energy/electricity storage;
- prevents over storage and shunts excess electricity to suitable loads or arrests generation.

Figure 24. Hybrid thermal + renewables electricity power generation schematic



Source: Unicon-reconstructed

5.3.3 Electricity Import/Export

The prospects for enhancing national and regional economic development through establishing significant imports and exports of electricity are conceptually attractive. This is beyond the local exchange of electricity across the frontier because of collective cooperation by homologous communities with common interests. This will require the engagements of the main political and electricity generating institutions of the respective countries and the stakeholders in such endeavours.

The current electrical infrastructure of Somaliland currently does not have any transmission lines, nor collectively operated electricity distribution in any of the urban centres. The modality by which electricity generation has developed has been through distributed generation and dispersed distribution driven by small private enterprises.

This contrasts with the electricity generation modality in Ethiopia and Kenya, which is one of a centralised national plan. The interests of Ethiopia and Kenya in bringing transmission lines into Somaliland would be for the purposes of exporting their electricity and enhancing their electrical infrastructure. Moreover, such infrastructure must serve their socio-economic interests within and traversing another country, which could benefit the region as a whole if effective socio-economic reciprocity occurs.

In order for the urban centres of Somaliland to connect to and benefit from international transmission lines each urban centre requires a coordinated collective urban electricity network. Such a network must possess a distribution ring or nodes that can collectively handle the introduction of electricity generation from multiple suppliers.

If Somaliland wishes to participate in the reciprocal exchange of electricity with its neighbours, it has to create the electricity generation resources and capabilities to do so, such that they are economically competitive with their neighbours. Otherwise, they will become the recipients of the generation decisions and problems of distal generators, while ignoring a key necessity of having urban and local electricity generation infrastructure that provides for local resilience and adaptability to local conditions.

5.4 Conclusions Related to Generation Options

Based on the analysis in this chapter the generation options retained for meeting future load requirements are as follows:

- Improve the efficiency of existing generation by automation and synchronisation of generation units thereby reducing 'wet stacking';
- Convert existing generation to hybrid systems using solar photovoltaic installations;
- Consider the use of wind generation in zones with high wind potential:
    - Ensure that the implementation of such systems includes appropriate training to avoid repeating the mistakes made with earlier installations.
- New generation options retained include:
    - High speed diesel generators in size ranges from those existing in each system up to 2,000 kW;
    - Medium speed diesel generation in the common size ranges of 1,000 kW to 10,000 kW;
    - Simple gas turbines burning diesel fuel in size ranges of 1,000 to 10,000 kW;
    - Solar photovoltaic systems to be added to the fossil fuel generation;
    - Wind generation to be considered in high potential areas.

6. Development of Expansion Plans

6.1 Methodology for Least-cost Generation Planning

The existing power systems in Somaliland supply individual population centres in an isolated manner. The sizes of the generation units used to supply these loads can be very small – less than one megawatt. For these loads, the generation options are restricted to either diesel units, renewable plants such as photovoltaic solar systems or hybrid systems. The previous chapter showed that the pure photovoltaic systems were not economical. The only practical and cost-effective solutions are either straight diesel units or hybrid diesel-solar systems.

The data collected from the field programmes show that the existing generation in each community surveyed only supplies the load to a small percentage of the population in the community.

These observations have led to the selection of three major guiding principles for the least cost generation planning:

- The load to be satisfied is the *unconstrained* demand in the community. This is the load that would permit all residents of the community to enjoy fully the benefits of electrification;
- The starting point for the expansion plan will be the existing generation system;
- The analysis does not differentiate between ESPs in any location but examines the community as a whole.

These three principles imply that the amount of generation in the community is inadequate to meet the unconstrained load and rapid expansion will be required before the generation is adequate to meet the unconstrained load with an allowance for a reserve margin.

With these issues in mind a series of generation expansion models were prepared for the country. The model consists of a folder with a separate file for each population centre plus a summary file for Somaliland as a whole. The file for each population centre contains the following sheets:

- The load forecast data for country as well as the number of customers in each population centre and the energy consumption and coincident peak demand by customer type;
- A load data sheet that interpolates the load to the specific community being analysed in that file;
- A generation sheet that lists all the generation units in each community by size and by ESP;
- An expansion plan sheet that shows:
  - the estimated load year-by-year from 2017 to 2037 in terms of energy in GWh and peak demand, allowance for losses and allowance for reserve margin all in MW;
  - the existing generation in MW;
  - assumed additions to the generation system to reach the estimated load plus reserve margin over the study period.
- A costs sheet that shows:
  - existing and new generation additions in MW;
  - estimated capital costs of generation.

6.2 Approach

The approach used is to select several expansion scenarios that represent different types of generation and to prepare an expansion plan for each scenario that meets the forecast load with the defined reserve margin. These scenarios are then compared on the basis of the net present value (NPV) of the capital and operating costs using a selected discount rate.

In order to ensure that the generation options with significantly different service lives are compared fairly, the analysis covers the load forecast period of 2018 to 2040 and, in addition, the load and annual costs in the last year of the forecast period are continued for another twenty-five years. The present value of costs over the full period (2018 to 2065) are then compared.[28]

6.3 Assumptions and Criteria

6.3.1 Fuel Sources and Prices

Future thermal generation options include new thermal using imported fuels. There are no proven petroleum resources in Somaliland. Fossil fuel is assumed to be purchased from international sources.

All estimated fuel prices to be used in the generation plan will be exclusive of taxes that may be applicable in Somaliland.

The variable cost of thermal generation is referenced to an offshore crude oil price of US$ 60/bbl, and delivery via local port. Reference costs for alternative fuel grades are shown below.

Table 24. Reference costs for alternative fuel grades

Fuel type	**Factor**	**US$/bbl**	**US$/Mt**
Heavy fuel oil (No. 6)	0.85	51.00	329
Industrial Diesel (No. 2)	1.35	81.00	604

Source: Unicon

"Factor" is a historical average conversion to be applied to the price of on shore crude oil.

Price delivered to port includes US$ 5.50/bbl for transport, handling, terminal charges, insurance and losses.

Costs of fuel delivered to the population centres being studied are derived as cost delivered to the port, plus appropriate transport charges. A road transport cost of US$ 0.10/Mt/km, is used. It should be noted that this is an economic price; it excludes, taxes, subsidies.

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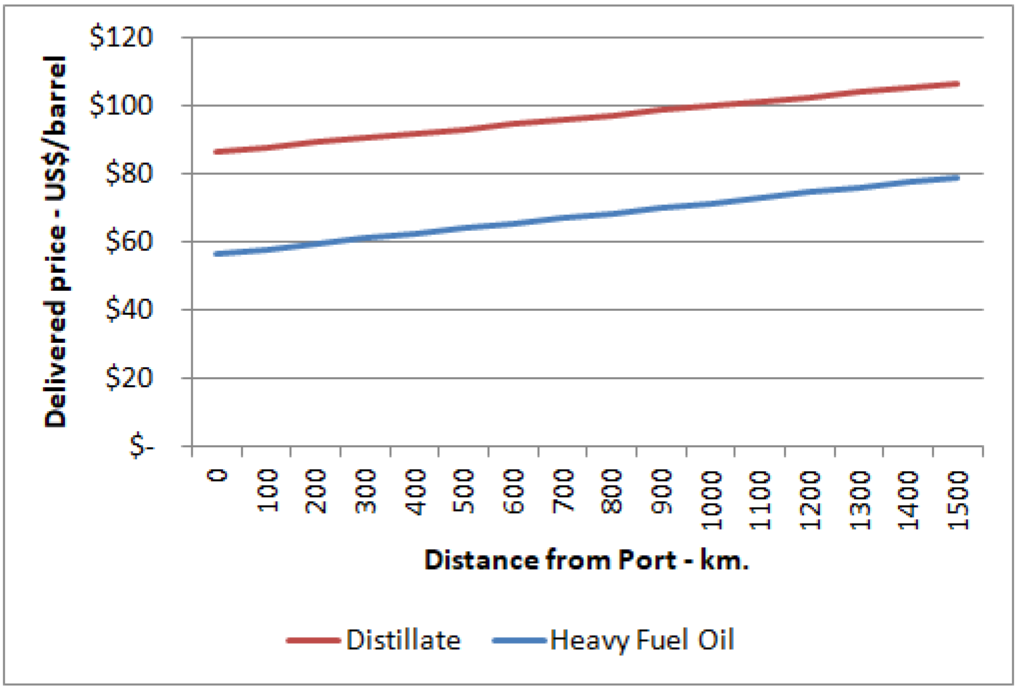
[28] This is a common approach in the economic analysis of electric power expansion planning. This approach ensures that the benefits of any large investments made toward the end of the study period are fully appreciated in such an analysis the assumption is made that all generating projects would be replaced at the end of their economic lives. The load to be met in the period after the study period is kept constant at the level of the forecast load in the last year of the study period and the generation plants are also kept at that same level. The rationale for this approach is that the period is sufficiently long the present value of any costs at the end of the extended period will have very little impact on the comparison.

The following Figure 25 illustrates the derivation of the price of fuel delivered based on the distance from the port of delivery. The price is calculated as follows:

- No. 2 oil (distillate): Crude oil at $60.00/bbl X factor of 1.35 + port handling charges of $5.50/bbl + Transportation charges of $0.100/km/Mt X 7.46 barrels/metric tonne;
- No. 6 (heavy fuel oil): Crude oil at $60.00/bbl X factor of 0.85 + port handling charges of $5.50/bbl + Transportation charges of $0.100/km/Mt X 6.66 barrels/metric tonne.

Figure 25. Derivation of the cost of fuel



Source: Unicon

6.3.2 Other Assumptions

The following assumptions and criteria are also used in the analysis:

- ***Reference year for discounting:*** All costs are to be expressed in terms of 2017 costs. No further escalation is applied to capital costs or operating costs;
- ***Study period:*** The identification and assessment of new power options to meet the forecast load growth covers the period 2018 to 2040. In the system planning studies, the simulations of system operations and production costs will include an additional evaluation period to 2065 (i.e. 40 years total) to allow the different service lives of the various technologies to be taken into account;
- ***Discount rate:*** The discount rate may be considered as the time value of money, and is used to calculate the present value of a series of future costs. A real discount rate of 10% (i.e. excluding inflation) is used in determining equivalent annual costs of investments and in present value calculations;

- ***Escalation:*** All economic analyses are carried out in constant price levels; hence, no inflation estimates need to be applied;
- ***Reserve margins:*** For thermal plants, a reserve margin on installed capacity is assumed as equal to the size of the largest unit;
- ***Plant service lives:*** The following service lives will be used:

Generation type	Normal service life - years
Combustion turbines	30
High speed reciprocating engines	9 (but with a complete overhaul every 3 years)
Medium speed reciprocating engines	10
Photovoltaic cells	20

Source: Unicon

- ***Operation and maintenance and other costs:*** Unit generation costs include allowances for operation and maintenance, interim replacement, and insurance. The following allowances will be used:

Plant type	Fixed O&M % of capital	Variable O&M US$/MWh
Combustion turbine	2.70	3.48
High speed reciprocating engines	1.4*	3.50
Medium speed reciprocating engines	1.1	1.99
Photovoltaic cells	1.3	0

*Plus a complete overhaul every 3 years at 50% of the capital cost *Source: Unicon*

- ***Interest during construction:*** Interest during construction is added to the direct project costs to provide a more realistic approximation of the total cost of the project, to be used in calculating unit generation costs, for the initial screening or ranking of alternatives. Total IDC is calculated using a discount rate of 10%;
- ***Installation rate:*** because the unconstrained demand is so much higher than the existing generation capability, the rate of installation of new generation has been restrained to practical limits. The limit chosen is to ensure that new generation in any year does not exceed the existing total installed capacity up to that point;[29]
- ***Sizes of new units:*** In the derivation of an expansion plan for a service area, three criteria were used:

[29] *For instance, if a community has an installed capacity of 2.0 MW and an unconstrained demand including losses and reserve margin of 20 MW, the assumption is that 2.0 MW would be installed in year 1 (bringing the total to 4.0 MW at the end of the year), 4.0 MW in year 2 (bringing the total to 8.0 MW at the end of the year), 8.0 MW in year 3 (bringing the total to 16.0 MW at the end of the year) and 4.0 MW in year 4 (bringing the total to the required 20.0 MW at the end of the year).*

  - new units would be between 100% and 150% of the size of the largest unit already in the system;
  - the maximum size of unit would not exceed 10% of the expected total load in the system (i.e. if a community is expected to have a load of 8 MW in any year, the maximum size of unit installed in that year would be 800 kW);
  - when a unit is proposed that is larger than any units currently in the system, a minimum of two such units would be installed.
- ***Treatment of communities with multiple service providers:*** in communities served by two or more electricity service providers, the sizes of new units would be restricted to the above criteria applied to the size of service area assumed available for each service provider (i.e. if there are three service providers in a community, it is assumed that each service provider would be responsible for one third of the load in the community and the new units would be sized accordingly).

6.4 Comparison of Options

6.4.1 New Supply Options Considered

The supply options considered in the expansion plans for Somaliland need to take into consideration at least the following aspects:

- size and type of generation units currently in use;
- availability of fuel;
- current and expected size of each separate system (or combined system for any systems that could be expected to merge);
- relative cost of each competing technology; and
- maximum single load on the distribution system.

The size of the units currently in use and the current and expected size of each separate unit have already been taken into account in the development of expansion plans in Section 6.3.

Conventional generating units currently in use consist exclusively of reciprocating engines using fossil fuels, primarily diesel fuel. All of the identified generating units of this type have been high speed units, although it is understood that some medium-speed units are being planned by some ESPs.

Fossil fuels other than diesel and heavy fuel oil such as natural gas (compressed or liquefied) require significant infrastructure costs and have therefore been excluded from further consideration.

When considering the addition of new generation, the type of technology selected must be appropriate to the size required. The following Table 25 indicates for the technologies considered, the size range that technology is available for and the number of communities falling within that size range of the 36 surveyed:

Table 25. Size ranges of various technologies and applicability to Somaliland

Technology considered	Size range - kW	Communities
High-speed diesel	0 – 1,000	31
Medium-speed diesels	1,000 – 10,000	5
Low-speed diesels	3,000 – 80,000	3 (eventually)
Simple cycle gas turbine	1,000 – 10,000	5
Combined cycle gas turbine	50,000 – 500,000	0

Source: Unicon

For practical reasons, the ***conventional generation units*** being considered in the expansion plans in this report are restricted to:

- high speed reciprocating units using diesel fuel;
- medium speed reciprocating units using heavy fuel oil; and
- simple cycle combustion turbines using diesel fuel.

In terms of renewable energy, there have been sporadic and largely unsuccessful implementations of wind energy conversion systems, which is non-operational. Although there is significant wind energy available in many locations throughout the country, most of the existing installations have failed through one of two reasons:

- inappropriate technology was provided; and/or
- there were insufficient skilled maintenance personnel available to ensure their viable operation.

As far as hydroelectric power is concerned, this option is site-specific and tends to be large with respect to the demand that can be supplied from such plants. In addition, there are no sites identified for which adequate studies have been carried out to permit an adequate assessment of their potential. On the other hand, photovoltaic systems are modular and are in widespread use and have been operating successfully.

For the above reasons, the ***renewable generation*** units being considered in the expansion plans in this report are ***restricted to photovoltaic systems***.[30] Because electricity storage systems associated with solar photovoltaic systems are expensive and have short useful lives, the use of photovoltaic systems alone has not been pursued; these systems are considered only in the context of fuel displacement and the reduction in use of conventional thermal during daylight hours.

6.4.2 Analysis of Conventional Units

[30] *It is expected that wind can make a significant contribution; however, based on this analysis, the selection of wind generation in a specific site would need to be compared in an economic analysis with the proposed generation (Fossil fuel alone or with Photovoltaic) to assess the most economic option*

The selection of the appropriate technology to be installed in any community depends upon the size of unit and the lifetime cost of installing and operating the units. Such an analysis takes account of the differences between the technologies considered in terms of useful lives, capital cost, operating costs and the cost of fuels used.

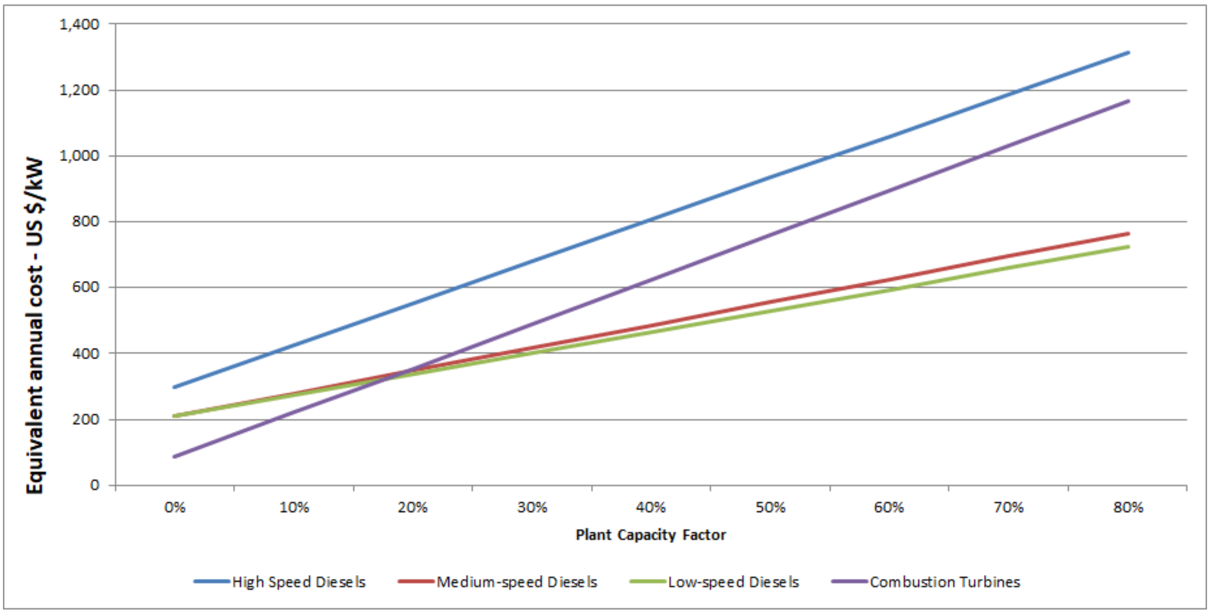
The screening curves in Figure 26 show the relative annual cost of each of the technologies at different plant factors. The costs are calculated on the basis of equivalent annual cost per kilowatt and are made up of the following components:

- annuity of the capital cost using the investment cost per kilowatt, the useful life of the plant and a discount rate of 10%;
- fixed annual operating and maintenance cost as a percentage of the initial investment cost;
- for the high speed diesel plants, the equivalent annual cost to a major overhaul every three years;
- variable operating and maintenance costs based on a typical cost per kilowatt hour for the technology and the number of hours of use of the plant in a year;
- fuel cost based on the fuel used, the heat content of the fuel, the purchase price of the fuel, the efficiency of the plant and the number of hours of use of the plant in a year.

Figure 26 suggest the following:

- high speed diesels are always more expensive than any other technology regardless of their mode of operation (i.e. over the full range of plant factors);
- there is virtually no difference in cost between medium speed and low speed diesels; however, the medium speed diesels are available in smaller sizes, which are more appropriate to Somaliland;
- simple cycle combustion turbines are the lowest cost technology at plant factors of less than about 20%;
- at plant factors above 20% either medium speed or low speed diesels are least expensive.

Figure 26. Screening curve for conventional generation units



Source: Unicon

Based on the above, the following algorithm is used for selecting new *conventional* generation units in any community:

- for communities with loads of less than 1,000 kW, use high-speed diesels (the only option available);
- for larger loads the first two units should be medium-speed diesels;
- next two units should be simple cycle combustion turbines;
- sizes of new units should be equal to or larger than the size of earlier units;
- size of new units should be increased once the number of units of the largest size reaches four to six to take account of economies of scale and to minimise the land area required.

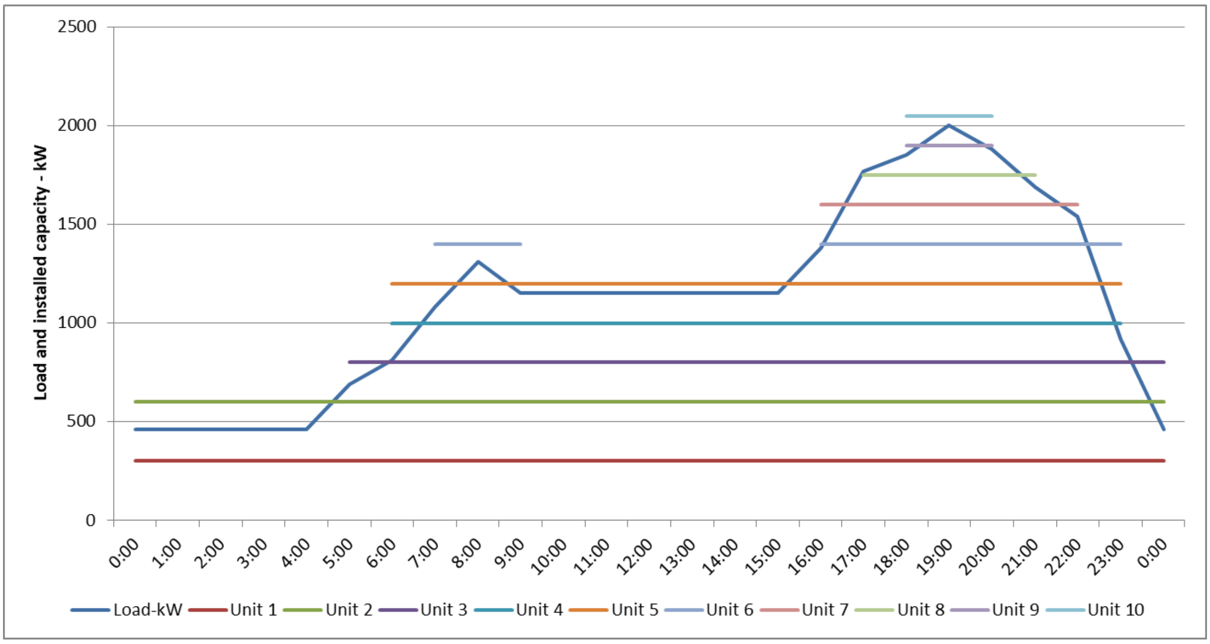
6.4.3 Analysis of Hybrid Systems

In order to assess the benefits of hybrid systems, two generation options were considered in the supply of a hypothetical generation system, whose daily load curve is shown in Figure 27.

This hypothetical load of 2,000 kW (plus a reserve margin of 10%) is assumed to be satisfied initially by the following diesel installations:

- 4 units of 150 kW each;
- 5 units at 200 kW each; and
- 2 units at 300 kW each.

Figure 27. Load curve for a hypothetical 2,000 kW load in a conventional system



Source: Unicon

This figure shows a daily load factor of about 57%. The figure also shows the need for each reciprocating engine unit during each hour of the day. As can be seen, units 1 and 2 are required 24 hours per day while units 9 and 10 are required only for two hours during the day.

The other units are required for varying periods during the day. It should be noted that this is a simplistic analysis; in practical terms, the target operating range for each unit would normally be about 80% of their nominal capacity in order to allow the units some flexibility in following the load.

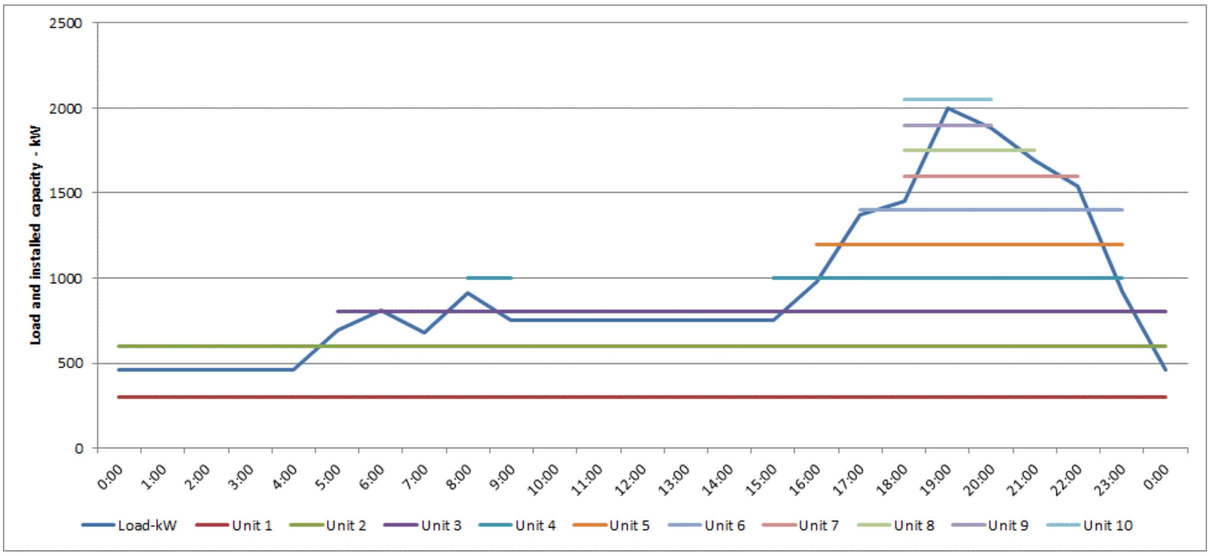
The alternative generation system uses the same diesel installations but includes a grid tied solar PV system of 400 kWp (20%) from 07:00 to 18:00 – this would be equivalent to between 20% and 40% of the hourly load during daylight hours.

This is shown in Figure 28 below. Note that the load curve shown in this figure is the load to be met from conventional means only. Solar energy requirements are represented by the difference between the load shown in this figure and the load in the previous figure.

In this case, it is assumed that the equivalent of two reciprocating engine units would remain on full load during the full 24 hours but many of the remaining units would be shut down during the hours of daylight.

Using this hypothetical arrangement, solar energy could replace 18% of the total energy requirements in the hypothetical day represented by these figures.

Figure 28. Thermal load curve for a 2,000 kW load in a hybrid system



Source: Unicon

6.4.4 Economic Benefit of Hybrid Systems

The economic benefit of the hybrid system defined above was calculated as follows:

- The conventional installations mentioned above are assumed to operate for 18 years:
  - Each unit would be operated for 9 years then replaced with identical units;
  - In years 3, 6, 12 and 15 there would be a complete overhaul of each of the units (in practical terms these overhauls would be spread out over time but is simplified herein);
  - There would be fixed operating and maintenance charges annually on the installations that are over and above the complete overhauls;
  - There would be variable operating and maintenance costs based on the energy generated by the conventional plants;
  - There would be fuel charges based on the amount of energy generated (the unit cost of fuel is assumed dependent upon international prices of crude oil, off-loading charges at the nearest port and transportation charges inland);
  - The assumptions applicable to the conventional units used for the economic analysis are as follows:

> - Energy is generated at 57% load factor;
> - Size of load: 2,000 kW and 9.99 GWh;
> - Size of installation, including reserve margin: 2,200 kW;
> - Unit cost of units: $800 per kW;
> - Useful life of plant: 9 years (with complete overhauls as required);
> - Operation and maintenance costs:
>   - ✓ Fixed annual costs: 1.4% of the investment cost;

- ✓ Complete overhaul: every 3 years at 50% of investment cost;
- ✓ Variable costs: $3.50/MWh.
- Fuel cost (based on price of $60/bbl of crude oil on the international market plus port handling charges plus transportation inland where applicable): $0.141/kWh.

- The photovoltaic installations mentioned above are assumed to also operate for 18 years:
  - Each unit would be operated for 18 years then scrapped when the second set of conventional units are retired (although these units have a theoretical life of 20 years, it would not be worthwhile to retain them for two additional years after the plant with which they are associated is removed);
  - There would be fixed operating and maintenance charges annually on the installations;
  - There would be no variable operating and maintenance costs based on the energy generated by the conventional plants;
  - There would be no fuel charges;
  - The assumptions applicable to the solar component of the system used for the economic analysis are as follows:

- Size of installation: 400 kW;
- Share of energy generation:
  - ✓ Diesel generation: 8.23 GWh/year;
  - ✓ Solar generation: 1.76 GWh/year (18% of total generation).
- Unit cost of solar units: $1900 per kW;
- Useful life of plant: 20 years;
- Operation and maintenance costs:
  - ✓ Fixed annual costs: 1.3% of the investment cost;
  - ✓ Variable costs: none for the solar units;
  - ✓ Fuel cost: none for the solar units.

Table 26 illustrates the present value of the estimated costs for the hypothetical system described above. The figures apply to coastal installations; thus as these installations are moved inland, the advantage of the hybrid system increases.

Table 26. Comparison of costs – conventional versus hybrid systems

Present value of costs in 2018 for example shown	Present values of annual costs over 18 years (US$ millions)		Present values of annual costs over 18 years expressed in US $/kWh	
	Conventional	Hybrid	Conventional	Hybrid
Capital cost	3.34	4.13	0.041	0.050
Fixed O&M – regular	0.20	0.28	0.002	0.003
Complete overhaul	2.69	2.69	0.033	0.033

Present value of costs in 2018 for example shown	Present values of annual costs over 18 years (US$ millions)		Present values of annual costs over 18 years expressed in US $/kWh	
	Conventional	Hybrid	Conventional	Hybrid
Sub TOTAL	***6.23***	***7.09***	***0.076***	***0.087***
Variable O&M	0.29	0.24	0.004	0.003
Fuel cost – coast	11.57	9.54	0.141	0.116
Sub TOTAL	***11.86***	***9.77***	***0.145***	***0.119***
TOTAL COST	***18.09***	***16.87***	***0.221***	***0.206***
Percent of conventional		93.2%		93.2%
Benefit – cost ratio		1.07		1.07
Total Energy Generated (GWh)	81.90	81.90		

Source: Unicon

In addition to these quantified economic advantages, there are two practical and/or non-quantified benefits of the hybrid system:

- The use of solar reduces the operating hours of most of the diesel units in the system, thereby improving the life of the units;
- The economic life of the photovoltaic system used in the analysis was 18 years although the literature suggests that 20 years could be used.

This analysis and the conclusions arising therefrom are only valid in systems where generation units can be operated in a synchronised manner to ensure that the diesel units are run in an efficient operating range of 80% ± 20% of plant capacity.

6.5 Proposed Expansion Plans

As mentioned in earlier sections of the report, the data available was often incomplete and in some cases appears to be in error. As a result, it is the *Consultant's opinion that, while the results for each community examined can be subject to significant error, the summation of the results to the country level is sufficiently accurate to provide a useful planning tool*. For this reason, the results presented below are shown only in graphical form (without detailed numerical results).

The largest cities of Somaliland are: Hargeysa, Borama, Berbera and Burao.

Unicon visited the following population centres in Somaliland:

Table 27. Visited population centres in Somaliland

Community	Population	Electricity Supplier
Borama	150,000	Aloog Electric Company-Borama
		Telesom Electric Company - Borama
Dilla	13,000	Mohamed Ali
Laascaanod	130,000	Gurmad
		Lesco
Gabiley		SomPower
Sheikh	5,000-6,000	Beder
Wajaale	15,000	Sompower
Jawaale	20,000	Telesom Electric Company - Wajaale
Burao	600,000-700,000	Horn Electricity Company
Hargeysa	1,500,000-2,000,000	Hargeysa Energy Company
		Telesom Electric Company
		National Electric Power

Source: Unicon

The above tabulation suggests a population of identified electrified communities in Somaliland of between 2.4 million and 3.0 million. The sizes of the existing generation units vary from 40 kW in Dilla to 1,800 kW in Burao.

The Table also illustrates a situation common to Somaliland in that two or more electricity suppliers may be competing in the same municipality. In this analysis, no attempt is made to determine which ESP will provide the increased capacity nor indeed if any will. This analysis is carried out from the perspective of the needs of the country; whether the required generation is actually installed will depend upon management priorities of the ESPs in each of the communities.

There are severe constraints on the data availability in Somaliland. Some examples include:

- In Hargeysa, generation and customer data from reputedly the largest ESP was not made available. In addition, two other ESPs are known to exist although no data was forthcoming from them;
- Generation and customer data from Berbera were not available;
- Gabiley is known to have two ESPs but data were made available for only one of them; and
- Recent population data were not available.

Because of the data limitations, expansion plans could not be prepared for each of the above communities using the criteria discussed earlier. Instead, expansion plans were prepared for each type of population (Urban, Rural, IDPs and Nomads) on a country basis.

Based on the results of the work carried out earlier in this chapter as well as in Chapters 5 and Annex 6, the following assumptions were used concerning the type of generation considered for each population type:

- ***Urban populations:***
  - These are defined for purposes of this analysis as cities known to have at least one generation unit in excess of 1,000 kW or being served by more than one ESP;
  - Current generation is by high-speed diesel units (or, more properly reciprocating engines using Diesel fuel);
  - All new generation would be by a combination of medium speed diesels and simple cycle gas turbines;
  - Generation additions to replace retiring existing units would be by medium speed diesels;
  - Generation to meet the expected increase in loads would be met equally by the two types of generation.

- ***Rural populations:***
  - These are defined for purposes of this analysis as communities known to have installed generation less than 1,000 kW in 2016;
  - Current generation is by high-speed diesel units;
  - All new generation would be by a continuation of high-speed diesel units; this would apply to both, generation to replace retiring units as well as to generation required to meet increases in expected load.

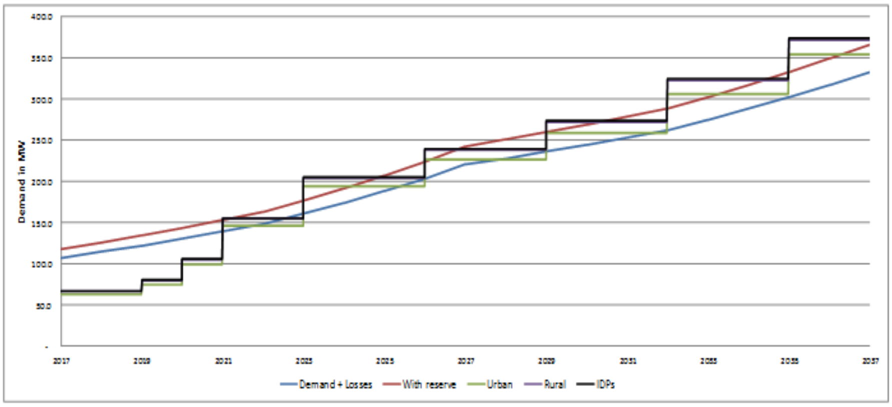
- ***Internally Displaced Persons:***
  - Observations by Unicon suggest that such persons gather into communities adjacent to rural communities and require the same services as the rural communities they are adjacent to;
  - For purposes of this analysis, it is assumed that the ESP(s) serving the rural community will also serve the adjacent IDP community;
  - Thus, any expansion plan for the rural population will include service to the IDPs.

- ***Pastoralist Nomads:***
  - By definition, they have no fixed address that can be electrified by extension of a community's distribution system. They are therefore not considered as ESP customers;
  - Their electricity needs are assumed to be provided through a hybrid system of solar photovoltaic systems supplemented by rechargeable batteries. These would be provided by the country directly, possibly with support from international lending agencies;
  - Unicon could not obtain information on the current extent of implementation of any programme to provide such equipment to the pastoralist nomads. For purposes of this report, it is assumed that the programme is just beginning;
  - Growth in the programme is based on the following algorithm:

- ✓ Pastoralist nomad populations would be served either by solar PV/battery combination units sized for single families of six members or groups of families with a total population of 30 to 36 people;
- ✓ The populations would be split evenly between the two groups;
- ✓ The number of units provided to each group would increase linearly from zero to 25% of the population in each group be the end of year 2023;
- ✓ Thereafter the number of units provided to each group would increase at four times the rate of growth of the population of the group.

The following Figure 29 presents the peak requirements with and without reserve margin for the country as well as the generation additions for the three types of communities served by ESPs.

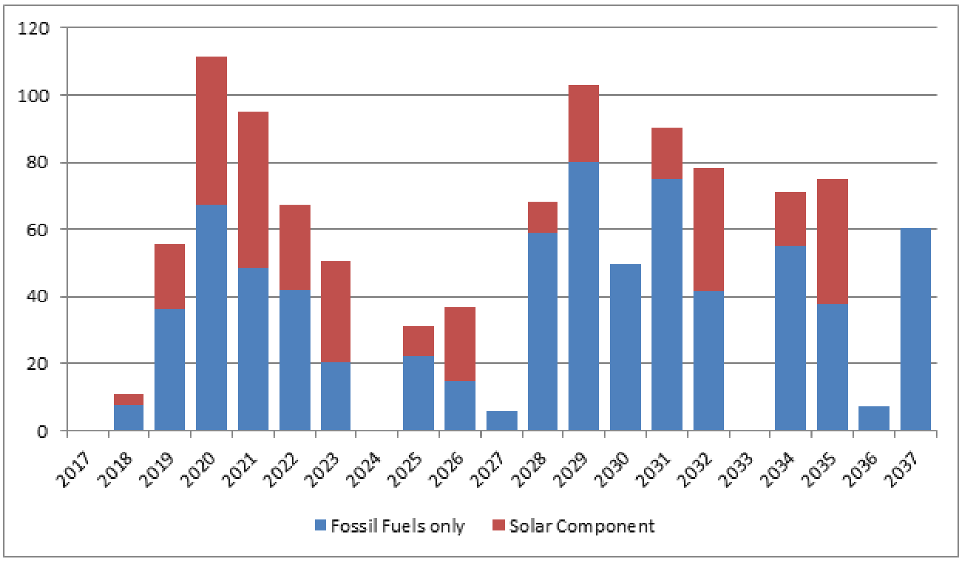
Figure 29. Cumulative generation expansion – Somaliland



Source: Unicon

The investments required to satisfy the installations suggested above are shown in Figure 30.

Figure 30. Investments in Somaliland generation - US$ millions - including inflation



Source: Unicon

6.5.1 Nomadic Population

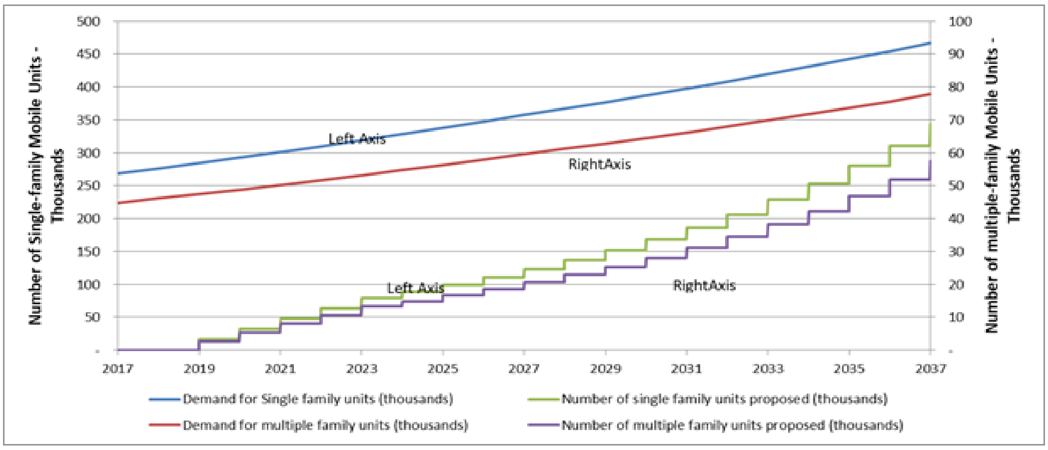
As mentioned in the previous sections, the expansion plans for Somaliland does not include service to the nomadic populations. These populations represent 34% of the total Somaliland populations (1,376,700 out of a total 4,078,100).

As mentioned before, service to these populations require off-grid equipment. A review of the types of generation available as shown in Annex 6 suggests that the appropriate supply for this type of use is a remote mobile off-grid system with solar photovoltaic installation plus Lithium-Ion battery storage operated at low voltages such as 12 to 24-volt direct current, which can run LED lights and small devices. These systems would have a useful life of five to eight years and do not require any maintenance except cleaning the panels, monitoring the cables and keeping the power unit free of dust.

Figure 31 presents an estimate of the market for off-grid mobile generation units and a scenario for the provision of such units to the nomadic population. To derive these estimates several assumptions were required:

- Two sizes of the types of equipment mentioned above are included in the estimate; one at 25 Watts per uit to satisfy single families of an average of about six people and a second sized at 200 Watts per unit to meet the needs of a group of six families or an extended family consisting of about 30 people;
- Half the nomadic population would be supplied with units sized for single families and half would be supplied with units sized for multiple families or an extended family;
- In each case, the rate of penetration was assumed at 25% of the population during the next five years;
- Thereafter the number of units to be supplied would increase at four times the estimated growth in population.

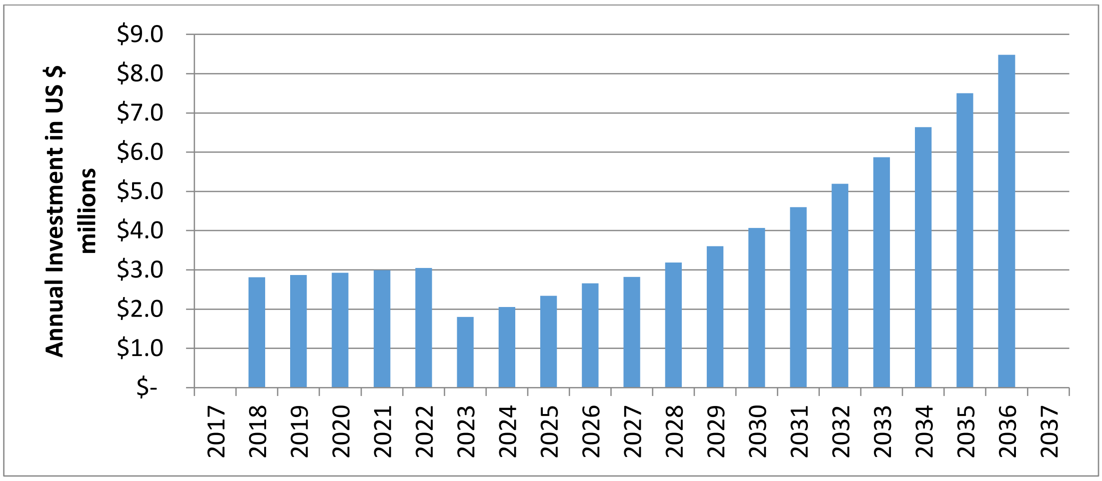
Figure 31. Estimated Market for Off-grid Mobile Generation



Source: Unicon

Figure 32 provides an estimate of the cost of providing these units in Somaliland. As can be seen from the figure, the above assumptions would require slightly under 3 million dollars per year for the first five years to meet this demand (the figure shows a slight increase year by year to account for inflation).

Figure 32. Estimated cost of mobile generation

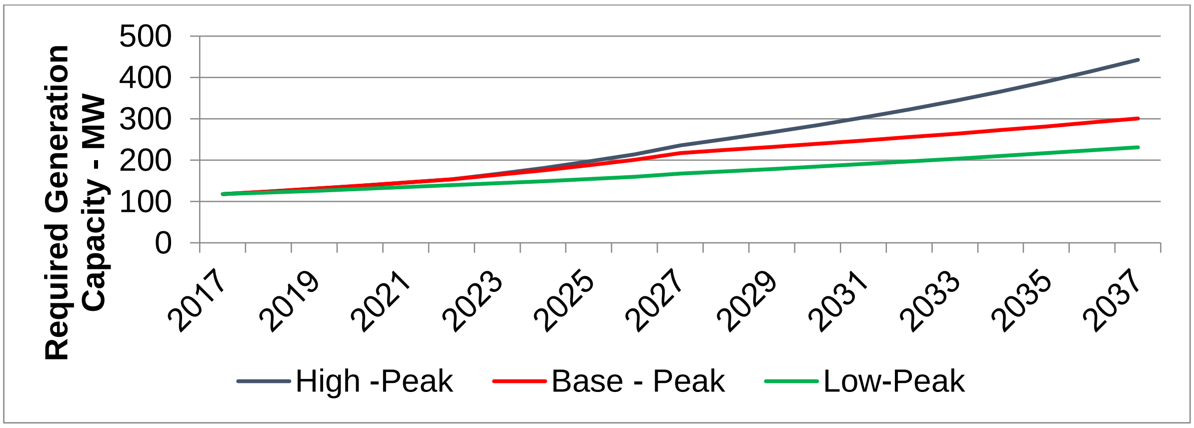


Source: Unicon

6.5.2 Analysis of Scenarios

Figure 33 presents the forecast capacity requirements under the three load-growth scenarios considered in Chapter 4. The preceding sections examined the most practical and cost-effective means of satisfying the demand for the Base Case Scenario. In this Base Case Scenario, the amount of generating capacity required to satisfy the load, including losses and an allowance for reserves, was estimated at about 300 MW in 2037.

Figure 33. Required generation capacity under three load scenarios



Source: Unicon

If the load grows at a rate equal to the High Scenario, the amount of generation in the first ten years (up to about 2027) would be very similar to that required in the Base Case Scenario. Thereafter the requirements under the High Scenario would grow more quickly such that all the capacity installations identified as being needed after 2027 would need to be advanced such that the total generation investment programme thereafter would need to be installed by 2031, or six years earlier.

In the analyses of the Base Case Scenario, several uncertainties were highlighted; these same uncertainties would remain and be accentuated under the High Scenario. These uncertainties include:

- The merging or otherwise of ESPs serving the same cities;
- Availability of financing and technical assistance resources;
- The selection of new generation types, such as wind energy conversions systems (there are issues with the operation and maintenance of existing systems), pumped storage, power from waste, etc.

Based on the analyses carried our earlier in this chapter, the most economic generation units remain robust over a wide range. Thus, High-speed diesels would remain the most economic generation for small power systems and a combination of medium speed diesels and gas turbines would remain economic for the larger systems.

Because of regulatory, commercial and geographic issues, there is little incentive for the interconnection of communities.

If the load grows at a rate equal to the Low Scenario, the amount of generation in the full forecast period to 2037 would require the amount of generation derived for the first ten years under the Base Case Scenario. Again, the uncertainties mentioned above would also apply but, because of slower growth there would be more time available for the power sector to overcome them.

6.6 Transmission Expansion

The current and expected development of the power sector of Somaliland suggests that all currently electrified communities are isolated from each other and are likely to remain so throughout the period of analysis. In addition, the load forecasts for these communities suggests that growth will continue through a combination of increasing the density of the loads within each community as well as gradual expansion of the built-up areas around the communities.

Another issue particular to Somaliland is that the electricity supply providers tend to be independent. In some cases, there are two or three (or more) providers in one community and in some cases (particularly those associated with cellular telephone communications) the same corporate owner may supply power to several communities.

Where electricity supply providers are associated with cellular communications, the main focus of their business is the communications aspects and electric power tends to be of lower priority. Therefore, there is very little incentive to interconnect neighbouring communities.

The main need for a transmission system is to evacuate power from local generating stations in each community to the surrounding load. With this in mind, two options are examined:

- for smaller communities, the load is expected to be met from central generation stations via a network of distribution feeders constructed as a radial system;
- for larger communities, it is assumed that power will be evacuated from the generation stations to a ring system that surrounds the community. The individual distribution loads would then be supplied by feeders from both the generating stations and from step-down transformers located on the sub-transmission ring.

There are no transmission implications for the first option so it need not be discussed any further. The concept for the second option is illustrated in the Hargeysa City Development Plan that accompany this report.

6.6.1 Interconnections with Neighbouring Countries

An interconnection with neighbouring countries could include Djibouti, and Ethiopia. As such interconnections imply long lines, they would need to be of high voltage in order to keep technical losses in the system to a minimum. It also implies that substantial loads would need to be served to make the arrangement commercially attractive. Such loads would also need to be concentrated and this implies only the major cities of Hargeysa and Berbera could be considered as candidates for service from neighbouring countries. However, there are logistical and technical issues that render such connections unlikely in the near to medium term:

- The loads in any of these systems is too low to justify a connection to other power systems outside the country;
- There are currently no national standards in place;
- Several of these cities are served by more than one ESP which would complicate and contractual efforts to use such lines;
- The investment in the lines would be heavy since new infrastructure would be needed in each city, which would include high-voltage substations, the construction of the line and the connection to the appropriate substation in the neighbouring country;
- There is social instability along the routes that such lines would take if built.

As a result of the above, no major interconnections with neighbouring countries have been considered in this report.

6.6.2 Connection of Remote Generation to Loads

A possible need for transmission lines is if a major plant such as pumped storage hydro or wind farms are installed at some distance from a major city such as Hargeysa or Berbera.

Again, there are logistical and technical issues that render such a plant and therefore the need for transmission unlikely in the near to medium term:

- The city is served by more than one ESP which would complicate and contractual efforts to use such lines;
- The investment would be heavy since new infrastructure would be needed in the city, which would include high-voltage substations, the construction of the line and the construction of the hydro plant;
- Depending upon the location of such a plant, there could be social instability along the routes that such lines would take if built.

As a result of the above, no opportunities for the construction of any transmission lines were identified.

6.7 Summarised Description of Power Master Plan

The following tabulation presents a summary of the generation requirements to meet the expected load in Somaliland over the period 2018 to 2037:

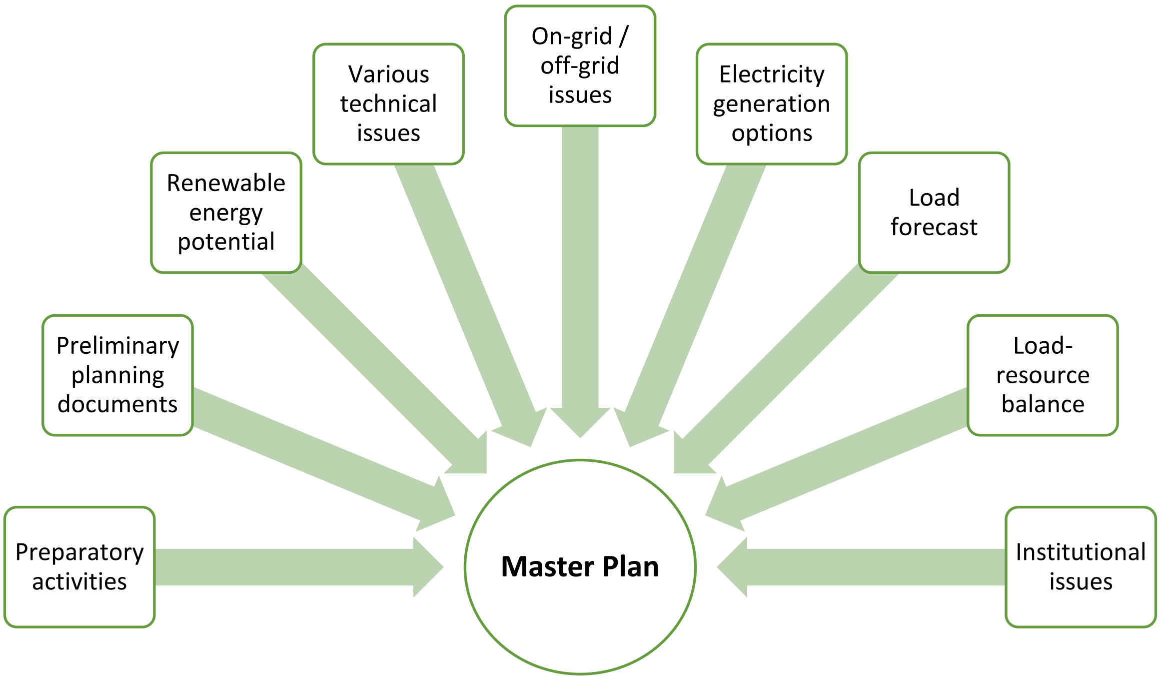
- The population is expected to grow from an estimated 4.2 million in 2017 to 7.3 million in 2037, made up of 3.9 million urban, 0.8 million rural, 0.2 million IDPs and 2.5 million nomads;
- The expected number of customers in 2037 would reach 668.3 thousand made up of:
  - 541.7 thousand urban;
  - 107.6 thousand rural; and
  - 19.0 thousand internally displaced persons.
- The degree of penetration by 2037 is expected to reach 80% for urban loads, 66% for rural loads and 44% for IDPs;
- The total energy required by those customers would reach 1,274.6 GWh made up of:
  - 1,205.5 GWh for urban customers;
  - 62.4 GWh for rural customers; and
  - 6.6 GWh for internally displaced persons.
- The energy requirements of the nomads forecast to increase to over 20 GWh;
- The total installed capacity required to meet the load in Somaliland in 2037, including an allowance for reserve margin is 300.9 MW of which almost 95% would be required in urban areas and the remainder for total and internally displace persons;
- This load would be met by a combination of medium speed diesel generating units and simple cycle gas turbines in roughly equal amounts for the urban loads and by high-speed diesel units for the rural and IDP loads;
- The requirements of the nomads would be met by mobile hybrid solar PV/battery combinations; the level of penetration would depend upon the policies of the Government and the availability of funds. The assumptions used in this report lead to a rate of service to

the nomadic population of about 74% by 2037 and a total investment over that period of about US $75 million.

7. Conclusions and Recommendations

The elements presented and discussed in the earlier chapters, as well as the earlier reports on institutional issues[31] can be considered as inputs to the power master plan, as shown in the Figure 34 below.

Figure 34. Preliminary activities



Source: Unicon

This chapter presents the proposed power master plan for the electric power sector of Somaliland. It is separated into three components: the conclusions drawn from the input activities, the enabling activities and infrastructure investments, with the latter two shown in Figure 35.

7.1 Conclusions

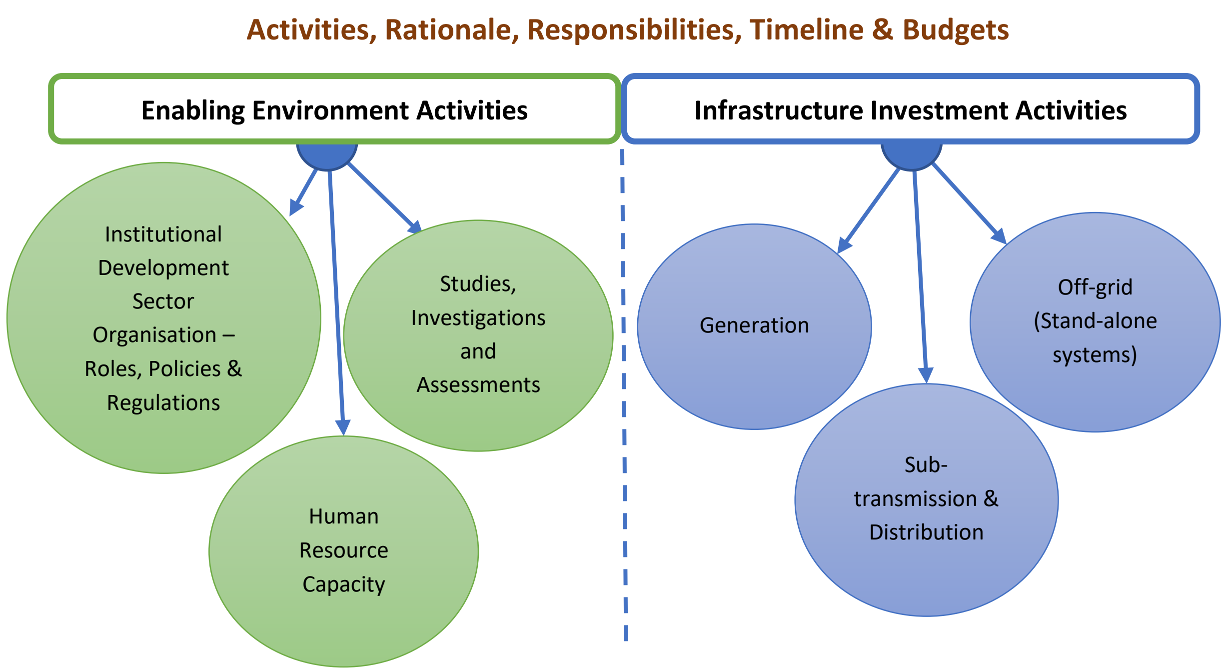
The main conclusions drawn from the analyses are:

- The databases available for this type of analyses need to be expanded – this includes within the relevant ministries as well as all ESPs;

[31] *See Annex 2 – Human Resource Development Plan, Annex 3 – Power Sector Institutions, Regulations and Laws, and Annex 3 – Distribution Standards and Voltage Levels*

- There is insufficient generation capacity to meet the current loads;
- Current generation is not being used efficiently in most of the ESPs surveyed due to lack of investment in the equipment required to synchronise the operation of existing units nor the availability of operations and maintenance staff trained in the use of the equipment required for synchronous operation of generating units (anecdotal evidence suggests that this situation extends also to many ESPs not part of the survey);
- There are high technical and commercial losses in most systems for which records were available. Anecdotal evidence suggests that the situation is as severe, if not more so in systems for which adequate records are not available;
- Significant improvements can be made to the operation of the power sector throughout the country by increased cooperation between ESPs under some supervision from one or more regulatory authorities. This is specifically in the areas of duplication of distribution investments in order to compete for customers in the same tight geographical areas (i.e. the same street) and the inability to benefit from the economies of scale in the purchase and installation of small units to serve a large market.

Figure 35. Structure of the Power Master Plan



Source: Unicon

7.2 Enabling Activities

In order for the investments required in the power sector to be fully effective, certain activities have been identified as being required to set a proper foundation for such investments. These “enabling” activities have been split into three groups:

- Activities that need to be carried out jointly by all parties involved in the power sector (ministries, regulator, committee, associations, ESPs, etc.);
- Activities that need to be carried out by the relevant government ministries; and
- Activities that need to be carried out by the ESPs themselves.

All such activities need to be monitored during their implementation and then evaluated for effectiveness upon completion.

7.2.1 Enabling Activities Applicable to the Power Sector as a whole

This grouping of recommendations would impact the government and the ESPs and would imply strong cooperation between the parties involved at a national level.

✓ **Enabling activity – Sector 1: Set up institutions to promote discipline in the power sector.**

Time frame: Immediate (years 2018 to 2019).

Budget required: US$ 0.50 million for the set-up; the annual expenses of such institutions would be covered by fees from ESPs being regulated.

Initially this would consist of:

- a Council to make recommendations to the Government on issues in the power sector;
- associations of ESPs and others involved in the power sector to promote issues common to all participants in the power sector (this would include ESPs, and major customers);
- ad-hoc committees set up to focus on single issue needing resolution.

This would be followed by a regulator whose duties could include:

1. Independent, open, objective and transparent regulation;
2. Non-discriminatory regulatory processes and practices;
3. Assurance of equitable competition among service providers;
4. Assurance of low regulatory risk for infrastructure investments;
5. Enhancement of the ease of private-sector participation;
6. Improvement or maintenance of the quality of electricity service;
7. Protection of customer interests;
8. Acceleration of installation of electricity services and networks;
9. Acceleration of the development of electricity services and networks.

This process would need to be led by the Government and have the support of all the power sector stakeholders.

The specific Structure, mandate and duties of the regulator could be defined through the use of an ad-hoc committee.

✓ **Enabling activity – Sector 2: Implement a grid code for power sector operations.**

Time frame: Short term (years 2018 to 2022).

Budget required: US$ 0.50 million plus contributions of time and expertise from each ESP.

One of the early roles of the Regulator should be to develop a grid code. It could take as a starting point the grid codes already in use in neighbouring countries (Ethiopia, for example). Two significant provisions of such a code could be:

- Safety of public and employees;
- Common set of rules for operation of systems.

This could be initiated through an ad hoc committee with representatives of the ESPs, the consumers and the government.

✓ **Enabling activity – Sector 3: Set up rules for improving efficiency of the sector.**

Time frame: Initiated in the short term (years 2018 to 2022) but on-going.

Budget required: Covered above in the first activity.

One of the early roles of the Regulator should be a series of rules and operating procedures aimed at improving the efficiency of the power sector. These could include:

- Promotion of cooperation between ESPs:
  - Rules for joint ownership of generating facilities (management, sharing of operating and maintenance costs, procedures for when the plant is on planned maintenance or forced outages, sharing of plant output, price of power when sold to its plant partner, etc.) distribution;
  - Rules for assisting an ESP if it requires emergency purchases to continue to meet its load;
  - Rules to ensure fair treatment of consumers (tariffs, connection costs, delays in connections and reestablishment of connections, etc.).
- Definition of service territories for each ESP (eventual):
  - The purpose would be to remove pockets or islands of customers of one ESP that are surrounded by another ESP;
  - This could involve the voluntary trading of customers or service areas under the monitoring of the Regulator.

This could be initiated through an ad hoc committee with representatives of the ESPs, the consumers and the government.

7.2.2 Enabling Activities Applicable to the Government

✓ **Enabling activity – Gov. 1: The promotion of the use of medium speed diesel generation and simple cycle gas turbines for the major urban centres.**

Time frame: Starting immediately and continuing throughout the short term.

Budget required: US$ 0.50 million.

The major urban centres of Somaliland (Hargeysa and Berbera in particular) can be expected to require generation units in the 2,000 to 5,000 kW range in the near future. The use of a combination of both MSD generators and gas turbines can result in significant savings to the power sector in investment and annual costs and these savings can be shared between the ESPs and the customers. Some incentives may be required to persuade the ESPs to migrate towards this type of conventional generation. The budget shown is for coordination with ESPs and perhaps the provision of a short consultancy to convince a nucleus of ESPs of the benefits that would accrue to the sector of the use of such generation plants.

✓ **Enabling activity – Gov. 2: Study the possible implementation of electricity and energy generation from urban solid waste for the major urban centres.**

Time frame: Medium term (years 2022 to 2027) with preliminary work carried out in the short term.

Budget required: US$ 1.00 million for the feasibility study, which should include the estimated investment cost for the implementation of the plant.

This would be done through the use of gasification and pyrolysis on urban solid waste at the major urban dumpsites and this would apply particularly to Hargeysa and perhaps to other major centres. This will provide fuels for electricity generation, energy to carry out the pyrolysis, reduce landfill, create biochars for landfill and agricultural remediation, create both skilled and unskilled employment and also process sludge from municipal liquid waste treatment, whilst improving urban waste management and disposal.

The fuels produced are syngas and fuel oil, which can be used in HSDG, MSD and Gas turbines. It is advisable that newer high efficiency modular 400-450kW gas turbines are used for syngas. This permits greater mobility in generation units, while captivating on the synchronisation and paralleling expertise being developed nationally. This will also reduce expenses on importing fossils fuels.

The size, location, type of plant type of waste, waste collection approach, cost estimates and economic and financial feasibility all need to be studied.

✓ **Enabling activity – Gov. 3: Continue to promote and support the ongoing programme to provide mobile renewable electrical energy to the nomadic population.**

Time frame: Immediate (years 2018 to 2022).

Budget required: US$ 0.50 million for promotion only; the sale of such devices would be left in the private sector.

Such a programme would include small installations of solar panels and batteries large enough to supply minimal needs of a single family or a cluster of a few families.

✓ **Enabling activity – Gov. 4: Promote and provide incentives (financial or otherwise) to the ESPs to install appropriate metering at all generating stations, on all feeders and at the power inlet to major customer premises.**

Time frame: Immediate (years 2018 to 2022).

Budget required: US$ 0.50 million for promotion only.

This will permit all ESPs to monitor the loading on each feeder (and each phase of the feeder) and compare those loadings to the sales of energy to customers served in order to identify, locate and quantify losses.

✓ **Enabling activity – Gov. 5: Study the implementation of a transmission grid to connect the major urban centres and the power sectors of neighbouring countries of Djibouti and Ethiopia.**

Time frame: Medium term (years 2022 to 2027).

Budget required: US$ 1.00 million for a feasibility study plus cooperation from its neighbours.

This would permit the country to benefit from (1) economies of scale in the construction of large power plants that can be shared between ESPs, (2) take advantage of the possibility of importing fuels not currently in use in Somaliland such as Liquefied Natural Gas and (3) increase reliability of service to major load centres.

✓ **Enabling activity – Gov. 6: Consider covering any exposed water reservoirs with grid-tied or standalone solar PV "floatovoltaics" to eliminate 90% of fresh water evaporation from reservoirs.**

Time frame: Medium term (years 2022 to 2027).

Budget required: US$ 0.50 million for the study to identify suitable locations and the feasibility of covering selected reservoir as a pilot project.

This will also produce electricity for local loads and preserve important water reserves for urban and agricultural activities. The implementation of such a project should take account of environmental and health issues.

Such installations would benefit the water sector as well as the electricity sector. It may be expeditious for the Government to make the appropriate investments in such facilities as a 'de facto' ESP and to sell the output to the private sector ESPs or distribution companies (if the sector were to disaggregate to that extent).

✓ **Enabling activity – Gov. 7: More thorough survey of the energy and electricity demands for isolated rural populations should be conducted to determine electricity generation needs and solutions for the rural regions.**

Time frame: Immediate (years 2018 to 2022).

Budget required: US$ 0.50 million.

These areas support pastoralist communities and their commercial activities and lifestyles, which require electrical generation solutions that improve their quality of mobile life and commercial productivity. Examples of mobile electricity generation technologies, suitable for pastoralists, were discussed in Annex 6.

✓ **Enabling activity – Gov. 8: set up a programme to update the power master plan on a regular basis, including the collection and analysis of relevant power sector data.**

Time frame: Immediate and on-going (years 2018 and beyond).

Budget required: US$ 0.25 million per year for the data collection plus another $0.50 million every three to five years for the update to the power master plan.

Any power master plan is only valid for as long as the assumptions used to derive it remain valid. Two activities are urgent:

- Monitor the Somaliland economy as a whole to assess major changes that are occurring:
  - The construction of a major load or project such as a port;
  - The importation of fuels cheaper than diesel (liquefied natural gas);
  - The discovery and exploitation of natural gas or crude oil.
- Build up a reliable and complete database, including:

- Installed capacity by type of generation and by ESP;
- Generation by type and ESP;
- Sales by ESP by customer type;
- Peak demand;
- Costs of generation;
- Revenues by ESP by type of customer.

The government, using its own resources, should review the power master plan every year for the first three to five years to assess the changes to the power sector during that period and the possible impact those changes could have on the implementation of the recommendations made in the plan. After that period, it should engage the services of an international consultant to completely redo the power master plan using updated data and any changes in approach that those updates may suggest.

7.2.3 Enabling Activities Applicable to the Electricity Supply Providers

✓ **Enabling activity – ESP 1: Other applications of solar PV should also be considered for direct implementation with daytime water pumping for urban and agricultural water supplies, as solar PV can be used to directly drive water pumps without batteries or grid tied operation.**

Time frame: Medium term (years 2022 to 2027).

Budget required: Part of normal expansion of the ESPs to meet the loads identified in their service territory.

This will free up diesel fuel costs and permit these HSDGs to be re-tasked to electricity generation for other commercial or urban loads.

✓ **Enabling activity – ESP 2: In the areas where wind speeds are suitable, generation projects should also include wind turbine electricity generation for inland and coastal sites.**

Time frame: Medium term (years 2022 to 2027).

Budget required: Included in the infrastructure investment section.

Here the thermal generation operation component should always be kept in the 75-80% load zone to avoid fuel waste and wet stacking. Wind power generation will require not only the construction and implementation of the wind power turbines. There will need to be a systematic programme of training technical capability and entrepreneurial capability.

This must include the building of local competence and establishing technical relationships with the OEMs to assure wind turbine commissioning and operations, plus the CMS and maintenance programmes.

✓ **Enabling activity – ESP 3: For small urban centres obtain electric generation through either HSDG or hybrid HSDG paralleled with solar PV + battery + wind turbines where suitable wind is available.**

Time frame: Immediate (years 2018 to 2022).

Budget required: Included in the infrastructure investment section.

This will require input from the automation and synchronisation competences. It will also necessitate in-country and on site ongoing technical trainings and technical school curricula to ensure that the national technical and entrepreneurial pool for creating and implementing small urban electricity generation competencies grows.

✓ **Enabling activity – ESP 4: ESPs in large urban centres can implement battery UPS systems to support their use of wind power and solar power.**

Time frame: Medium to long term (years 2022 to 2027 and beyond).

Budget required: Included in the infrastructure investment section.

This will enhance the penetration of further renewable electricity generation into the electrical network and reduce diesel fuel expenses.

✓ **Enabling activity – ESP 5: Install appropriate metering at all generating stations, on all feeders and at the power inlet to major customer premises.**

Time frame: Immediate (years 2018 to 2022).

Budget required: Included as part of ESP normal operating expenses.

This will permit all ESPs to monitor the loading on each feeder (and each phase of the feeder) and compare those loadings to the sales of energy to customers served in order to identify, locate and quantify losses.

✓ **Enabling activity – ESP 6: Install electronic data management systems.**

Time frame: Immediate (years 2018 to 2022).

Budget required: US$ 50 to 100 thousand per ESP depending upon the size of the ESP and commercial arrangements with suppliers of appropriate software.

This will permit all ESPs to maintain, as examples:

- accurate asset records in terms of locations, costs, years of installation and replacement;
- generation, sales and losses.

Such systems facilitate updating files and also permit the easy retrieval of files.

✓ **Enabling activity – ESP 7: Implement loss reduction programmes.**

Time frame: Immediate (years 2018 to 2022).

Budget required: Depends upon the size of the ESP and the level of commitment to the reduction in losses. Increases in investments and operating expenses would be compensated by reduced fuel costs and increased sales of energy.

Such programmes should be separated into three sets of activities:

- A metering programme, as recommended above to identify the quantity and location of losses;
- A structured plan of investments to strengthen the sub-transmission lines and feeders to reduce technical losses;
- A structured plan of increased monitoring, public awareness and discipline in operations to reduce non-technical losses and theft.

✓ **Enabling activity – ESP 8: Begin negotiations with neighbouring ESPs for the sharing of facilities to benefit from economies of scale.**

Time frame: Immediate (years 2018 to 2022).

Budget required: None required.

This applies to all ESPs in load centres with multiple ESPs. As expressed elsewhere in this report, there is significant waste of resources by adhering to current practices of small generating units linked to a small number of customers. Economies of scale can be obtained by sharing facilities such as:

- Sharing ownership of generating units that are too large to be used by only one of them – contractual agreements can easily be set up defining costs, share of output, sales and purchase of portions of the plant output, management of the facility, etc.;
- Sharing ownership of distribution feeders with similar agreements;
- Consolidating service territories to improve operational efficiency.

Such sharing of infrastructure is facilitated by a strong regulator operating in an independent and fair manner to ensure that all appropriate rules regarding such sharing are followed.

7.3 Infrastructure Investment Activities

All of the infrastructure activities are considered the responsibility of the ESPs.

✓ **Infrastructure activity 1: Implement a programme of automation and synchronisation for all current operating ESPs applicable to all current and future generating units.**

Time frame: Immediate (years 2018 to 2022).

Budget required: About US$ 4,500 per generation unit.

- Current stock of generation units: US$ 0.4 million;
- New units 2019-2022: US$ 1.6 million;
- New units 2023-2028: US$ 0.5 million;
- New units 2029-2037: US$ 0.7 million.

The outcome from this engagement will result in:

- Improved efficiencies in the use of diesel fuelled generators and their fuel consumption;
  - A more than doubling of electricity that can be generated for existing surveyed ESPs electricity customers
  - It will allow the redistribution of existing high speed diesel electric generators within each of the ESPs, so that electricity generation can be optimised to satisfy the needs of varying loads and peak loads;
  - This while also maintaining the best fuel efficiency on each HSDG;
  - Eliminate in large part, Wet Stacking of generators as part of current electricity generation;
- Enhance maintenance, and lifespans of diesel generators;
- It will allow for further expansion of electricity generation;
- This will also result in the monitoring of actual generation at site for each ESP, so that this when compared to customer use loads; a proper determination of electrical losses by each ESP can be properly determined;
- ESPs will be able to quickly respond to growing demands with more generation, within the confines of the current radial distribution networks carrying capacity.

To affect this there will need to be projects that involve technical training and assistance for ESP technical staff, and technical school staff to develop expertise to identify, purchase and install the necessary equipment for automation and synchronisation. Thereafter there would be the necessary competence to supervise and operate both automated synchronisation and carry out manual synchronisations where and when needed for the respective ESPs.

This project will enable further enhancements to electricity generation when other thermal and renewable energy source generation is added in future.

It should be noted that the synchronisation hardware has a useful life estimated at significantly longer than the high speed diesels to which they are attached and similar to solar photovoltaic; such equipment attached to the diesels would need to be reused when the diesels are replaced.

✓ **Infrastructure activity 2: The implementation of medium speed diesel generation and simple cycle gas turbines for the major urban centres.**

Time frame: Starting immediately and continuing throughout the forecast period.

Budget required to cover all new conventional thermal plants:

- 2018-2022: US$ 240 million;
- 2023-2028: US$ 150 million;
- 2029-2037: US$ 445 million.

The major urban centres of Somaliland (particularly Hargeysa and Berbera) can be expected to require generation units in the 2,000 to 5,000 kW range in the near future. Both MSD generators and gas turbines can be obtained in this size range mounted on skids. Such skids will facilitate relocations when needed. These MSD can provide for electricity base-load demands with good fuel efficiencies within their 50% to 100% load range. The gas turbines can follow the load much more readily than the medium speed diesels. The combination of the two types of load, particularly if combined with the automation and synchronisation equipment, provide the most efficient and cost-effective means of supplying the load to those centres.

✓ **Infrastructure activity 3: The expansion of solar PV to augment daytime generation.**

Time frame: Starting immediately and continuing throughout the forecast period.

Budget required to cover all new photovoltaic plants:

- 2018-2022: US$ 170 million;
- 2023-2028: US$ 70 million;
- 2029-2037: US$ 130 million.

Grid-tied solar PV should be added to both reduce diesel fuel expenses and increase daytime generation for manufacturing, commercial and institutional customers. This can only be done when the HSDG are operated in their efficient zone of 80-100%. The level of penetration of grid tied solar PV should attain 20-25% of daytime generation/penetration.

✓ **Infrastructure activity 4: Strengthen the sub-transmission and distribution systems.**

Time frame: Starting immediately and continuing throughout the forecast period.

Budget required to cover strengthening of all sub-transmission and distribution systems:

- 2018-2022: US$ 45 million;
- 2023-2028: US$ 25 million;
- 2029-2037: US$ 45 million.

These investments are required to cover the following activities:

- Evacuation of power from new generation plants that consolidate generation in new larger plants;
- Interconnection of distribution facilities of individual ESPs with their neighbours;
- Building sub-transmission rings (22 kV) in smaller communities and transmission rings (132 kV) in larger communities;
- Building bus-bars to permit the generation from several generating units to be combined
- Rationalisation of sub-transmission and distribution feeders to provide more efficient supply of power to customers.

Annex 1: Terms of Reference

The following terms of reference were received from the World Bank and the Unicon proposal was based on these terms.

Power Master Plans

The current situation is that all electricity provision is best characterised as being delivered in isolated grids. The Consultant is expected to present and outline how best to increase electrification through on-grid and off-grid methodologies and also to present and outline principles and methodologies for when and how to transition from off-grid to on-grid.

The expectation of the Client is that the Consultant will employ a “Least-Cost Power Development Plan (LCPDP)” methodology that fully cover both off- and on-grid solutions.

Task 1: Assessment of current situation of the power sector in Somaliland

The following topics should be addressed under this task:

- Historical background;
- Institutional framework and associated challenges of the power sector”;
- Current status of the power sector including and any imminent reforms;
- Electricity supply:
  - description of the systems (including current standards and voltage levels employed);
  - sources of energy in Somaliland;
  - committed generation projects;
  - transmission systems;
  - distribution networks.
- Electricity demand:
  - characteristics of customers (including willingness to pay);
  - electricity prices charged to end users.
- Electricity balance;
- Loss of load expectation (LOLE).

Task 2: Assessment of natural energy resources

It should comprise:

- Resources currently mobilised for energy consumption;
- energy supply;
- sectorial end-use energy consumption;

- energy balance; and
- energy sales prices.
- Energy resources available for future power supply:
    - renewable energy;
    - fossil fuels (domestic and imports); and
    - electricity imports and exports.

Task 3: Define off-grid and on-grid for the power master plans

The future structure of the electricity industry / sector. Thus:

- Envisaged transition over the 20 year planning horizon from isolated grids towards integration;
- Criteria for deciding between "off-grid" and "on-grid".

Task 4: Local load (demand) forecasts

The following should be evaluated under this task:

- Overview of the domestic economy:
    - (estimates of) current GDP growth;
    - current performance of the electricity sector;
    - Future economic outlook: the 20 year vision.
- Demand forecasting methodology:
    - energy forecast methodology;
    - peak load forecast methodology.
- Assumptions and hypothesis used for the projections:
    - energy demand forecast;
    - losses adjustments and supply forecast;
    - load factor assumptions.
- Resulting energy and peak load forecast(s):[32]
    - energy load forecast;
    - peak load forecast; and
    - suppressed demand.

Task 5: Power generation projects for supply

It should comprise:

- Technical characteristics of power plants:

[32] *Aggregated and disaggregated for distinct supply system*

  - using renewable energy; and
  - using fossil fuels;
  - Assumptions for fuel costs: price forecast for crude oil, oil products, coal, liquefied natural gas;
  - Assumptions on discount rate for net present value calculations.
- Assessment of renewable energy resources and identification of generation projects:
  - wind;
  - biomass;
  - solar; and
  - others.
- Assumptions on electricity imports and exports:
  - high-voltage interconnectors; and
  - low-voltage cross-border electrification possibilities along the borders with Djibouti and Ethiopia.
- Modelling of the expansion and screening of candidate projects:
  - screening criteria and procedures; and
  - ranking of candidate projects.

Task 6: Methodology for least-cost generation planning

The methodology to be proposed should address Short run marginal cost (SRMC) and long run marginal cost (LRMC). Components to be considered for least-cost calculations:

- Basic assumptions and key parameters:
  - economic parameters;
  - operation criteria and reliability constraints;
  - modelling of the existing generating system;
  - implementation constraints for candidate projects.
- Results of the analysis:
  - Base Case (medium load growth scenario);
  - Low Load forecast scenario;
  - High Load forecast scenario.
- Capex costs of the respective growth scenarios;
- Sensitivity analyses:
  - sensitivity to low fuel costs;
  - sensitivity to high fuel costs;
  - sensitivity to changes in discount rate;
  - sensitivity to changes in financing costs;
  - sensitivity to changes in availability and prices of imported energy.

Task 7: Transmission expansion – Definition of target network projects

Under this task the Consultant should assess:

- Methodology;
- Planning assumptions and criteria and database of transmission equipment;
- Generation and load data use;
- Definition of target network candidate projects:
  - identification;
  - development;
  - optimisation.

Task 8: Optimisation of the future transmission system

This task should comprise:

- Methodology employed;
- Development of sequence of investments;
- Comparison of investment strategies;
- 20 years Power Transmission System Development Plan with time sequences for investments in:
  - transmission lines;
  - substations;
  - reactive compensation facilities.

Task 9: Conclusions: summarised description of the 20 year Least-Cost Power Master Plans

In this section the Consultant should present:

- Load forecasting (aggregated and disaggregated for distinct systems);
- Least-Cost Generation and Transmission plan and time sequences: (i) short term (5 years); medium –long term (20 years).

Detailed City Development Plan

On the basis of the above 20 years power master plans the Consultant will produce four detailed city electricity development plans. The targeted city is Hargeysa.

The city plan will have a horizon of 5 years and in effect for the four selected cities will constitute the first five years of the 20 year power master plan.

In addition, the Consultant will identify, describe (including producing drawings where relevant) and cost to the level of pre-feasibility priority projects for the city.

In designing and identifying the priority projects for the four cities the Consultant will, but is not necessarily restricted to:

- Assess technical assistance (TA) needs of city utilities and develop 1 prioritised TA project in city;
- Develop, design and provide cost estimates for priority distribution and sub-transmission (backbone-type) grid investment projects in city;
- Develop, design and provide cost estimates for priority investments in generation in city;
- Develop, design and provide cost estimates for priority investments in electricity for the supply of water and sanitation.

All projects shall have a degree of detail that will allow the World Bank and/or other donors to fund and develop programmes and projects around the findings and proposals of the Consultant.

Gap analysis of regulations and laws

On the basis of its work in the sector the Consultant will perform a gap analysis outlining what regulations and laws exist and are required for the implementation of the 20-year power master plans.

One essential missing piece has already been identified namely the lack of engineering standards for safety related issues, distribution, transmission and generation.

Draft terms of reference and summary recommendation note on distribution standards and voltage levels

The Consultant will provide a short note (maximum 10 pages) explaining the engineering, cost and safety advantages of standardisation of distribution designs, voltage levels, interconnection regulations, and so forth in construction and rehabilitation of electrical networks. The note will form the basis for terms of reference (also developed by the Consultant) for the development of national standards that can support electrification.

Outlines of institutional development needs

On the basis of the work conducted above the Consultant will produce a proposal for institutional development in support of the 20 year master plans. This entails but is not necessarily restricted to:

- Assess, analyse and make proposals concerning the need for new public institutions:
  - Regulatory institutions;
  - Distribution, transmission and generation companies.

Human resource development needs

On the basis of the work conducted above the Consultant will produce a proposal for human resource development needs in support of the 20 year master plans. This entails but is not necessarily restricted to:

Assess, analyse and make proposals concerning the need for human resource development need in the private and public sectors. Proposals will be organised around:

- Immediate needs;
- Intermediate needs (5 years);
- Longer term needs (5 – 20 years).

Other on-going activities

The Consultant will with the help of the World Bank staff and recipient Ministries stay abreast of other projects being implemented by the utilities, government authorities and donors.

At the time of producing the ToR the following donor projects are known:

- The World Bank is introducing a Lighting Africa project;[33]
- The World Bank also support capacity building in the oil and gas sector;
- DFID is supporting a green mini-grid project;
- The EU has a PV solar home system project under implementation;
- USAID has an economic growth programme under which some activities related to energy have been and are planned to be funded. USAID has, inter alia, assisted with producing a draft energy law for Somaliland;
- The African Development Bank has completed an assessment of where it sees it should focus in infrastructure and the expectation is that a programme for energy will be developed;

In support of this project the World Bank is planning to take advantage of an on-going partnership with the European Space Agency (ESA).

ESA has committed itself to provide to the project free satellite image services. Preliminarily, the agreement between ESA and World Bank entails that ESA's free services will be targeted the development of the four selected cities.

Due to limited resources for delivery of free images the Consultant in his proposal should provide a prioritised list of what image services from ESA would in his opinion be the most useful.

[33] *https://www.lightingafrica.org*

Annex 2: Human Resources Development Plan

Box.
This Annex was separately submitted earlier as a stand-alone deliverable/report for the project and added to this Power Master Plan report as a supplementary annex to highlight findings and recommendations of Unicon on this matter. Terms 'report' and similar in this annex are related to this Annex only.

Introduction to the Report

The Project's Terms of Reference (TOR) require the Consultant, concurrently to developing the power and city master plans, to outline institutional development needs and human resource needs. The reports' scope is to outline a framework that would serve as the basis for future fully fledged institutional and sectorial human resource development (HRD) plans to be developed beyond this project for both, public and private actors. The responsibility of the Consultant in these reports, in accordance with TOR, is restricted to providing an outline of the general needs.

However, to an extent possible, and where information was available, the Consultant went beyond the scope outlined above and provided more insight that would be useful and helpful for the Government, as well as to the World Bank and other parties involved.

This Report contains:

- an overview of national undertakings that are relevant to human resources;
- general approach to inter-ministerial cooperation that could be expanded in the future by those preparing detailed human resource development plans;
- design and proposal for institutional human resources;
- ministerial tasks and hierarchy;
- training needs for the short-, medium-, and long-term;
- necessary positions for the Ministry/Agency; and
- private sector support.

Background

At a relatively recent past, most of Somaliland's power and electricity infrastructure has been destroyed or left to deteriorate to a severely poor state of repair. The current electricity infrastructure is owned and operated by the private sector or public-private partnerships (PPPs). These companies operate within a commercial environment with little-to-no private or public oversight.

Under normal conditions, an absence of the government oversight function would be unusual. Power supply and electricity are accepted widely as essential services that improve the quality-of-life of Somaliland's resident population, and therefore, a suitable candidate for government oversight.

However, Somaliland's political establishment is undergoing a process of evolution and development, which has the potential to take Somaliland to a stable political and macro-economic environment. As a result, the Government of Somaliland is focused on re-establishing the efficiency of priority economic sectors and the effectiveness of the Executive, Legislative and Judicial branches.

Engaging in and completing such tasks require a massive effort that leaves little room for quasi-judicial government entities such as an independent Electricity Regulation Commission(ERC).[34] In the case of Somaliland, it would be more correct to discuss in the direction of regulatory commission, because it has become a part of the proposed pieces of legislation.

As of preparing this report, Somaliland has neither a law nor a bill[35] in place that addresses the structure and operation of Somaliland's electricity sector or the establishment of an independent ERC. In the absence of any objectified plans to establish an independent ERC, treating an independent ERC as a suitable item when discussing a human resource development (HRD) plan would be non-productive.

This assertion is not as unconventional or controversial as it may seem at first.[36] In another report written for this project, it was shown that an independent ERC is not a prerequisite for the efficient and effective regulation of an electricity sector. Instances exist throughout the world where efficient and effective regulation of an electricity sector is performed by a ministry.

Choosing to exclude a discussion of an independent ERC assumes that the full responsibility for performing the regulatory functions required to support Somaliland's Power Master Plan falls on Somaliland's Ministry of Energy and Minerals. This assumption also conforms to the reality supported by the fact that Government of Somaliland, to date, has not passed legislation or introduced a legislative bill establishing an independent ERC. This is understandable in the environment, where private electricity producers have built significant influence, especially in larger towns, and the government hesitates to allow such an independent authority realising the risk of it being in fact steered by the private sector.

Thus, as of today, the Ministry of Energy and Minerals does not have any options when it comes to the regulation of the electricity sector. It must accept the responsibilities, duties and tasks of an

[34] In this report, ERC is a generic term for a regulatory entity that may be an agency, commission, board or authority. An ERC cannot be a Ministry or a directorate or department within a Ministry. This distinction enables us to refer to the Ministry as the regulator or the electricity sector, which implies unambiguously that the regulator is not independent in any sense of the term.

[35] By absence of law in this report we mean that there are no laws and/or electricity bills officially approved by all relevant authorities in Government. In Somaliland, the electricity bill and act are still waiting for their approval. The Energy Policy is about to undergo a revision effort after 2017 and up to 2021.

[36] The controversy within the assertion comes in the form of a question.

economic regulator, or there would not be any economic regulation at all.[37] It is this inescapable reality that led us to conclude virtually nothing is lost by excluding an independent ERC and including a shadow ERC.

The physical presence of a shadow ERC already exists within Ministry as a directorate staffed with about 10 people (with some additional regional representatives). The directorate actively exercises the responsibilities that an ERC would normally be responsible for, and which are already part of the draft Electricity Bill – permissions for wiring, approvals for new private generators, work toward issuing licenses, handling disputes and complaints, etc.

To give an international example – in Iraq, these tasks are performed by a department within the Directorate of Planning and Studies. Its leadership and staff are employees of the Ministry. It does not have its own budget. It does not have a commission or board at its head. Its leadership and staff are paid out of the Ministry's budget. The leadership reports according to the chain of command.[38]

The Ministry is free to bring in non-government actors to assist it with its institutional support of a twenty-year Power Master Plan. These actors may be Somaliland organisations such as professional or commercial organisations. They may be donor institutions involved in foreign developmental aid. They may be individuals who contract directly with government. Their missions fall into two categories:

- capacity building and training; and
- advisory services especially with respect to policymaking and recommended solutions to specific and well-defined problems.

Institutional Success for the Somaliland Power Master Plan

The success of any Power Master Plan is dependent on the presence of two distinct sets of labour – (i) the workers who construct the infrastructure and other facilities that are required pursuant to the Power Master Plan; and (ii) the workers who support it at the institutional level. This report focuses on the institutional workers who support Power Master Plan. However, it is not beyond the scope of this report to comment briefly on the characteristics and attributes of construction workers.

Actualising a Power Master Plan, which is the next step after planning, employs personnel that construct physical infrastructure and facilities. A sampling of these workers yields project managers, on-site foremen, designers, engineers, accountants, charters, graph-makers, unskilled labour, and the very important skilled trade labour. In other words, what is required is the labour needed on a site to build facilities and infrastructure over a period of twenty years.

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[37] In a prior report submitted by Unicon in early December 2017, it was argued that an association of energy service providers (ESPs) is not a suitable candidate for performing self-regulation beyond ethical considerations.

[38] A dependent ERC in Somaliland would report directly to the President bypassing the Parliament. Its head is a single person who is nominated by the President and confirmed by Parliament. The Executive provides guidance, and the President provides direction. It is not part of the President's staff. It is a stand-alone entity with its own physical infrastructure, staff and budget.

As the Master Plan is implemented, the firms populating Somaliland's electric sector will encounter an increased need for operations and maintenance workers. The capability to generate electric power is very exposed to the ill-effects of poor operation and maintenance. These adverse effects also occur when the operation and maintenance of transmission and distribution facilities occur poorly. Therefore, the private sector should take action and work with the public sector to assure to the extent practicable that a pool of skilled operation and maintenance workers grows over time to meet the needs of an expanding electric sector.

To avoid confusion, as stated above, this report deals with the institutional human resources needed to support Somaliland's Power Master Plan, which is under development. The absence or presence of specific laws, bills and regulations, which are highlighted in the previously submitted report, is useful insight in this regard.

Somaliland does not have an officially approved energy development plan as of today. However, the need for developing the electricity sector is mentioned in the existing Energy Policy[39] and the National Development Plan II (NDP-II)[40] that outlined further development of the policy throughout NDP-II (2017-2021). Unfortunately, the Government of Somaliland, recognising that certain key goals of the NDP-I[41] were not achieved for various reasons, launched NDP-II that indicates the need to revise the existing Energy Policy that will guide the overall sector, including the electricity. The new energy policy, as well as its shape and focus are unclear at the moment.

We expect that the new Energy Policy to be developed under the framework of NDP-II will set boundaries and create expectations for a successful ERC. An energy development plan is the official framework for the role, duties and responsibilities of Somaliland's energy sector. An electricity bill or electricity law establishing an ERC would describe roles, responsibilities and duties of ERC in more depth than the energy development plan. Therefore, in the near term at least, it is the Ministry of Energy and Minerals that will be the best candidate to implement human resource development proposal.

The Ministry already has the necessary jurisdiction over energy infrastructure, facilities and services. As outlined in our Somaliland's Power Sector Institutions, Regulations, and Laws Report,[42] the Ministry, among other things, has the task of dealing with disputes and complaints.

Other ongoing tasks include advising the President, Prime Minister and Parliament on energy matters and assisting other ministries when they encounter energy-related issues. Although this is not an official duty, the Ministry possesses the implied power to issue rules and promulgate regulations for

[39] Somaliland Energy Policy No. 01/419/08/03/2010, approved by the Council of Ministers on 3 March 2010
[40] National Development Plan II (2017-2021), July 2017
[41] Somaliland National Development Plan (NDP) 2012-2016
[42] Submitted by Unicon in December 2017

the governance of the energy sector. In short, the Ministry can be structured to fill institutional gaps temporarily or permanently. This is the approach taken in this report.

Segment Needs

Following the Terms of Reference (TOR) for this task, the expected life of Somaliland's Power Master Plan for electricity sector is divided into three unequal segments. Each segment has different institutional human-resource needs, which are determined by the immediacy of the tasks within each segment. Immediacy, in general, is essential for the first segment. It dims from essential to necessary in the second segment. Immediacy does not exist in the third segment.

Core services characterise essential immediacy. Hiring staff to provide institutional core services and commencing their training cannot be deferred or suspended. These human resource assets, while not necessarily highly educated, are essential for introducing order into the expansion of the energy sector, which of course is the primary objective of a Power Master Plan.

Non-core services characterise necessary immediacy. These services, in general, complement the core services. However, not all non-core services are equally important with respect to the support of a Power Master Plan. This attribute enables us to assert two classifications for non-core services, thereby providing us with the flexibility to defer some of the staffing and training for personnel providing non-core services. The personnel performing non-core services with a low potential for deferral fall to the first classification, whereas the personnel performing non-core services with a high potential for deferral fall into the second classification. This sequencing of non-core services adds a great deal of structure to the report.

This report contains proposal for the electricity sector. Developing a Power Master Plan for the electricity sector is an exercise in integrated generation, transmission and distribution planning. Each of the three functional domains is associated with different relations among other ministries.[43]

Transmission availability and access, for example, are important when negotiating an inter-country electricity trade or when choosing the location of a generation facility. In the former instance, foreign relations and trade ministries are expecting consultations with the energy ministry. In the latter instance, ministries with developmental or environmental jurisdictions will be sought out by the energy ministry before any decision is reached.

Approach to Inter-Ministerial Relationships Supporting Power Master Plans

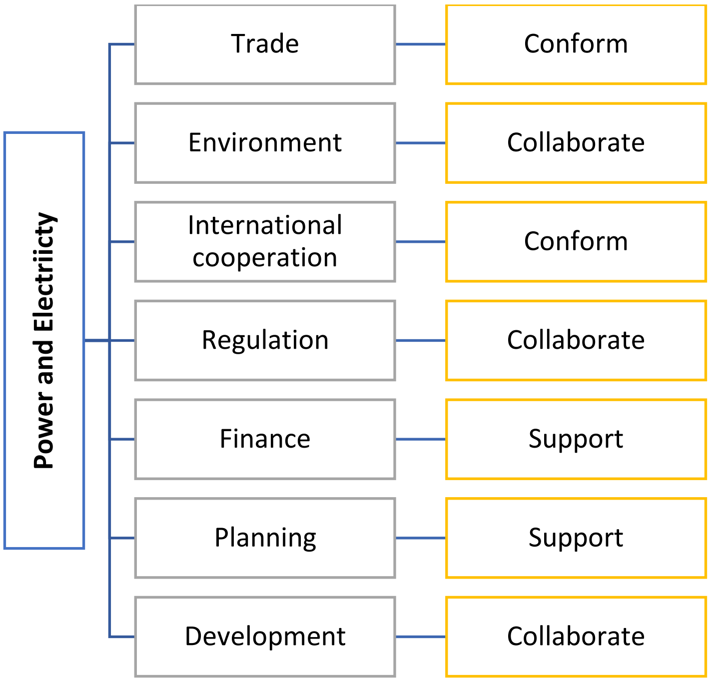
Supporting a Power Master Plan for supplying essential services such as electricity goes across ministries with distinctly different responsibilities. A Ministry of Finance, for example, would be naturally in the centre of the sector development. Other ministries include those responsible for

[43] *A Power Master Plan for the supply of electricity affects ESP, generators, co-generators, transmission entities, consumers, non-government organisations (NGOs), donors and the Government of Somaliland.*

environmental protection, trade enhancement, regional and international cooperation and/or overall planning and development of priority sectors.

Figure 36 is a general display of cross-cutting institutional functions expected to support the Power Master Plan to expand Somaliland's electricity sector. In an ideal world, the associated cross-cutting ministries would cooperate, collaborate and coordinate with each other during the performance of these functions. The cause of such an ideal world is the absence of the bureaucratic boundaries that create protection issues. The real world, however, does have boundaries. This fact establishes that expecting the realisation of the currently popular "three 'C's" (Collaboration, Conformance, Cooperation) is unduly optimistic. Less optimism is a better choice in our case.

Figure 36. Collaboration, conformance and support among government functions



Source: Unicon

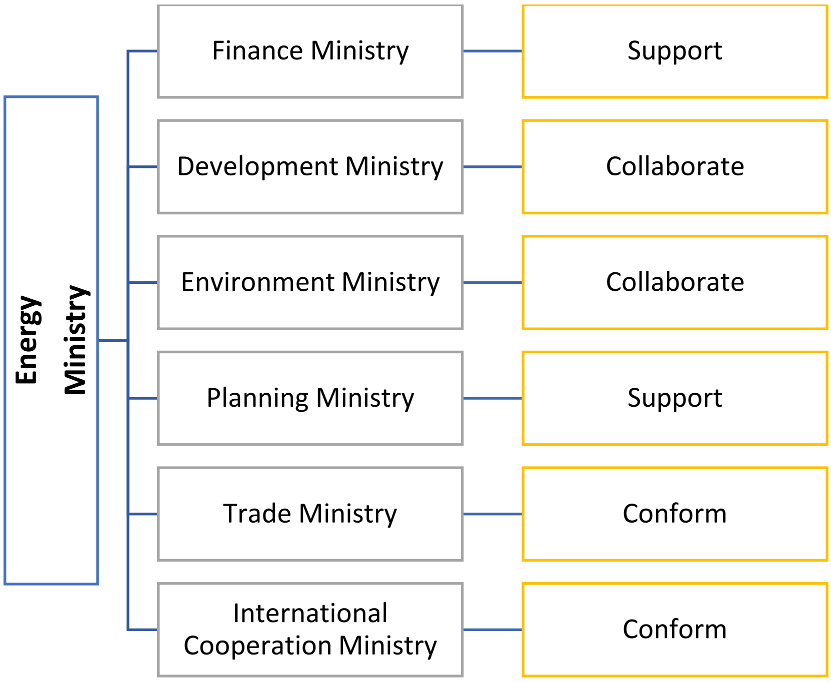
Support is substituted for coordination in Figure 36 while conformance is substituted for cooperation. Collaboration is retained because it is believed to be viable within Government of Somaliland political apparatus. Support does not demand coordination. Support only demands the recognition of the needs of other ministries. Conformance is a lesser standard than cooperation. Conformance with official government documents is mandatory. Cooperation among ministries is voluntary although desirable.

As depicted in Figure 36, environmental, developmental and energy ministries at the functional level cannot avoid collaborating with each because of an electricity sector's characteristics. Using fossil fuel to generate power often pollutes air and may pollute groundwater. Resolving pollution issues typically increases the cost of generating power. Developing a national economy is difficult to impossible to achieve without developing the electricity sector. Thus, the energy and development ministries find it useful to collaborate with each other with respect to timing issues involving multiple priority sectors.

An energy ministry cannot avoid conforming to the policies, frameworks and guidelines of trade and international cooperation ministries. Such official documents are supported by domestic laws and regional or inter-country treaties. That is, laws and treaties are binding government documents, and therefore, an energy ministry's policies, frameworks, guidelines, rules and regulations cannot be in opposition to them.

Figure 37, below, is a general representation of government ministries (general, not actual, for visual purposes) that will interact on a regular or quasi-regular basis with Ministry of Energy and Minerals.[44] Following the same layout as Figure 36, the nature of the energy ministry's interactions with other ministries is included in Figure 37. It is useful to point out that Figure 37 does not use arrows to show the direction of the interaction.

Figure 37. Collaboration, conformance and support among influential Ministries



Source: Unicon

[44] The Ministry of Education and Higher Education has not been included in Figure 37 for the following reasons. The inter-ministerial focal point of this Report is the identification of the necessary interactions among GoSL Ministries in support of the economic regulation with respect to the governance of Somaliland's electric sector. However, its exclusion does not suggest that the Ministry of Education and Higher Education does not have an important role to play with respect to the implementation of the Master Plan. To play its role effectively, the Ministry of Education and Higher Education will benefit from an assessment of the capabilities of Somaliland's technical training institutes to create a sufficient pool of skilled workers to operate and maintain the generation, transmission and distribution facilities that will be put into service as the Master Plan is implemented. The private sector will benefit as well when it acts as the catalyst for this in-house assessment by the Ministry of Education and Higher Education. Stated briefly, the private sector and the Ministry of Education and Higher Education will benefit from beginning their collaboration as soon as possible to assist with ensuring the successful implementation of the Master Plan.

This shortcoming is addressed at this time using an explicit comment on the interactions between the energy ministry and ministries that have jurisdiction over trade and international cooperation. These interactions are one-way going from the energy ministry to the trade and international cooperation ministries. The cause is that the energy ministry cannot make decisions or take action that does not conform to trade agreements and international treaties.

A planning ministry is responsible for preparing a national development plan, and the energy sector always is included in it. The planning ministry could choose to prepare its own plans for the energy sector, or it could choose to enlist the assistance of the energy ministry. Although the NDP II is silent on this choice it is better that the planning ministry seeks out and uses the expertise and experience of an energy ministry in support of its efforts to prepare a NDP II.

A finance ministry collects and redistributes taxes. It prepares financial reports capturing Somaliland's financial strength. It approves the budgets of each ministry within the Somaliland Government. In other words, the finance ministry has an essential role in support of an energy ministry at the planning and implementation levels.

Figure 37 suggests how heavily the Ministry of Energy and Minerals can rely on other ministries during the performance of its duties and the meeting of its responsibilities. The Ministry can expect complementary activities from the environmental and development ministries. It can expect information-seeking activity from a planning ministry on the one hand, and on the other hand, it can expect monitoring in addition to information-seeking from a finance ministry.

Meanwhile, the Ministry of Energy and Minerals can expect governance activities from trade and international cooperation ministries. At the same time, it could also expect regulatory guidance and assistance from an ERC if there is one.

Design and Proposal for the Human Resource Development

Pursuant to the argument provided in the immediately prior section of this report, examples of organisational charts for an independent ERC would not have much value. Moreover, such chart would be made part of the piece of legislation allowing for formation of an ERC. For example, the draft Electricity Bill already contains such a chart. Since the Government of Somaliland has not shown interest in independent regulation, hierarchy charts take the place of organisational charts as a result.

Hierarchy charts reflect the required collaboration among ministries and non-government actors. They also identify the primary government and/or non-government actor. Hierarchy charts include actors from the public and private sector. These charts differ from the chart found in the way-forward section of the Institutional and Gap Report.[45] That chart shows an independent ERC with the following characteristic. While it has sole jurisdiction over regulatory issues and problems its solutions are

[45] *World Bank, Development of a Power Master Plan for Somaliland: Power Sector Institutions, Regulations and Laws, November, 2017*

subject to review and approval by the Ministry of Energy and Minerals. However, any direction or guidance offered to the independent ERC may be rejected.

In this report, there are two primary actors. One is a government actor, and the other is a non-government actor. The Ministry of Energy and Minerals with primary jurisdiction of over the electricity sector is the primary government actor.

The primary non-government actor changes over time. An ad hoc committee is the primary non-government actor during the first period, that is, one-to-three (1-3) years from the 1st day implementation of this plan is commenced by the Ministry of Energy and Minerals. Its mission is to provide the Ministry and shadow ERC with recommended solutions to pressing problems. At this first mention of the ad hoc committee, it is important to explain its ownership and membership. Although the ad hoc committee will receive direction from the Ministry one topic, problem or issue at a time it is first and foremost a private-sector organisation with voluntary membership.[46] Consequently, it is primarily the responsibility of the private sector to populate the committee with its experts. Moreover, no member of the ad hoc committee is permanent; that is, the membership follows the expertise that is required to discuss the assigned topic, solve the assigned problem or resolve the assigned issue. Thus, providing job descriptions is impractical.

The Ministry and the shadow ERC are on uncharted ground, and consequently, both need to rely on the expertise, knowledge, data and experience of the private sector and perhaps an experienced advisor funded by a donor.

Primary status shifts to an association during the second period that is, four-to-seven (4-7) years from the 1st day of the next month after implementation of the HR plan has commenced – the medium term. Its mission is to provide advice and guidance to the Ministry and as appropriate the shadow ERC.[47] The second period is the time when policymaking and policy support share the status of being one of the Ministry's important activities.

The Ministry and the shadow ERC have reached full strength by the beginning of third period, that is, eight-to-twenty (8-20) years from the 1st day of the next month after implementation of the HR plan has commenced – the long term. They have formalised their services and tasks. Their need for private sector expertise and experience has diminished significantly. However, both remain dependent on the private sector when it comes to the revelation of an incipient regulatory issue or a beneficial change in regulatory direction.

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[46] *The primary sources from which the members (i.e. experts) will be drawn are private-sector firms, domestic organisations, domestic academic institutions and perhaps donors.*

[47] *The **association** is a private-sector organisation that may or may not have government representation depending on the decision made by the Ministry. Ideally, the **association** consists of independent power producers, energy service providers, electric and electrical equipment manufacturers, consumer groups and social service groups. The essential members, however, are independent power producers, energy service providers and consumer groups. In either instance, the private sector chooses the representatives, and it would be beyond the power of the Ministry to appoint these representatives implying that including job descriptions for association members would be impractical.*

As a result, the council is the primary non-government actor.[48] Its mission is to discuss regulatory issues and commercial problems in an open and transparent way that includes the participation of the government, academics, donors, consumers, generators, transmitters, distributors and ESPs. The recommendations that emerge from these discussions have the potential to improve the governance of the electricity sector and enhance the quality-of-life.

Table 28. Timeline for Establishing Communications Links with the Private Sector

Private Sector Actor	Communications Link Established	Year of Actor's critical mass
Ad Hoc Commission	Year 0 of the short term (1-3 years)	Year 1 of the short term (1-3 years)
The Association	Year 1 of the short term (1-3 years)	Year 1 of the medium term (4-7 years)
The Council	Year 3 of the short term (1-3 years)	Year 4 of the medium term (4-7 years)

Source: Unicon

Table 28, above, contains the timeline for establishing strong communications links between the public sector (i.e. the Ministry and the shadow ERC) and the private sector, which is the dominant producer and supplier of electricity in Somaliland. The interpretation of the second column of Table 28 is the year by which the private sector actor should be established. It is not the year by which the private sector organisation should be nearly full functional. That year is indicated in the third column of Table 28.

When reviewing Table 28, it is important to note that the Ad Hoc Committee needs to be formed and operationalised immediately. It is the Ad Hoc Committee that serves as the source for the beginning of public dialogue on the problems and issues affecting Somaliland's electricity sector.

The Association needs to be in place before the beginning of the second year of the short term. The Association, for all intents and purposes, is an early warning system that identifies problems and issues in need of immediate attention.

The Council should be in place no later than the beginning of the medium term, that is, the Council needs to be formed by end of the third year of the short term. The Council's formation may be deferred for three (3) years because the Ministry and the shadow ERC need of history of successes with the Ad Hoc Committee and the Association before they willingly process the advice and guidance offered by the Council.

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[48] *The **council is** a private-sector organisation that will not have government representation. It consists of executives drawn from Somaliland's electric sector. The Ministry may recommend council members, but it would counterproductive in the context of the intent of the **council's** formation for the Ministry to appoint any or all of them. Consequently, providing job descriptions for council members would be impractical.*

Figure 38, below, mimics a phase change diagram. The communications activities in each phase are dominated by one of the three private sector actors. The primary and dominant private sector actor occupies the first rank. There are rank boundaries within each phase. The first, second and third rank have clear boundaries during Phase 1. The Council is not established until the last year of the short term, and the Association has not established a history of success with respect to bringing issues and problems to the negotiation table.

Figure 38. Changing Status of Private Actor Communications Links

Source: Unicon

The rank boundaries during Phase 2 are relatively firm. The Council is starting to communicate with the public sector, and therefore, the Council is not yet sufficiently prepared to occupy the second rank and displace the Ad Hoc Committee in the communications chain. The rank boundaries for Phase 3 are not firm at all. Each private sector actor has a history of success; however, the Council should be the private sector organisation that the Ministry and the shadow ERC will reach out to for assistance.

A phase change represents a shift in the status of each private sector actor. For example, the change from Phase 1 to Phase 2 has the Association replacing the Ad Hoc Committee as the primary and dominant actor with respect to communications with the Ministry and shadow ERC. This change in status is not dramatic by any measure. The status of the Ad Hoc Committee does not fall to the bottom. Instead, the Ad Hoc Committee falls to second rank with the Council remaining in the position of third rank.

A dramatic event, however, does occur during the change from Phase 2 to Phase 3. At this point, the Council becomes the primary and dominant private sector actor, and in doing so, it jumps over the Ad Hoc Committee and the Association. Another dramatic event is that the Association occupies the second rank position, and the Ad Hoc Committee falls to third rank. While dramatic, the characteristics of the second phase change are rational and reasonable.

The work of the Ad Hoc Committee has become more routine and predictable although no less important and immediate. The character of the Association has been established, and its capability to identify and bring important issues and problems to the negotiation table has been tested and proven to one degree or another. But, additionally, the Association is the source of the raw material from which the Council fashions the advice and guidance that it offers to the Ministry and the shadow ERC.

Path Forward for Institutional Human Resource Development in support of the Power Master Plan

The path forward with respect to the development of human resources requires explicit attention to the time periods identified in the TOR.[49] Additionally, the path forward requires a separation of duties. Policymaking, planning and plans and supporting the implementation of policies are the primary activities of the Ministry throughout the 20-year Power Master Plan period. The shadow ERC's primary activity is implementing policies, which involves issuing rules and promulgating regulations to the extent practicable.

The Ad Hoc Committee's primary activities are leading the formation of standards, codes and procedures and recommending solutions to pressing problems. The Council's primary activity is to assist the Ministry and shadow ERC with developing guidelines and making policies. The Association's primary activity is addressing unassigned electricity issues and problems including but not limited to regulatory issues and problems.

Determining staff levels and salaries for the Ad Hoc Committee, the Council and the Association does not necessarily depend on the content of the Power Master Plan. Staffing these three private sector organisations depends on unforced decisions by the private sector companies and organisations. The contents of the Power Master Plan do not have any influence whatsoever over these voluntary decisions.

Salaries associated with private sector representatives participating in the activities of these private sector organisations are equally unaffected by the Power Master Plan. Once again, private sector participation in these organisation is achieved by imposing a new responsibility and duty on an existing employee.

Guiding Principle for the Institutional Human Resource Development Proposal

The Ministry of Energy and Minerals is expected to always be involved in the management and regulation of Somaliland's electricity sector. The cause is not too difficult to discern. This Ministry will be impacted by the successes and failures of the country's electricity sector from the beginning of time to the end of time. Power and electricity are essential services in modern times.

An ERC becomes involved only after it is decided that a Ministry cannot regulate electricity sector efficiently and effectively. But, it is important to take into consideration that an independent ERC is

49 It is assumed for the purposes of this report that the split of the 20-year Power Master Plan into three periods is somewhat flexible. This report division the 20-year period as follows: Immediate Term = 0 years, Short Term = 1 to 3 years, Medium Term = 4 to 7 years, Long Term = 8 to 20 years. Other divisions may be used as well. For example, a more collapsed division is: Immediate = 0 years, Shorter Term = 1 to 5 years, Longer Term = 6 to 20 years.

expected to perform adequately as soon as it is established while a Ministry typically is given more time to become comfortable with the tasks, responsibilities and duties of regulation albeit economic, social or environmental.

Another fact that cannot be ignored comfortably is that a Ministry is required to accept and take on the tasks, duties and responsibilities of an independent ERC whenever an independent ERC has not been established, but only after the Government has concluded that regulation of the Ministry's jurisdiction is required.

Development of Institutional Staff

Our proposal for HRD in support of the Somaliland Power Master Plan is sequential covering the entire twenty years. The first stage, that is, the 0 to 3 years after implementation of the HR plan has commenced, dedicates HRD efforts to securely establishing the essential staff to perform core tasks and to provide core services by the Ministry of Energy and Minerals.

The second stage, which is 4 to 7 years after implementation of the HR plan has commenced, is characterised by steady growth in the size and capacity of the institutional staff at the Ministry. The training and capacity-building conducted during this stage foretell that some parts of the Ministry's human-resource infrastructure will reach maturity before other parts.

The third stage, which is 8 to 20 years after implementation of the HR plan has commenced, addresses the financial and other issues encountered during the Ministry's efforts to reach full staff and maximum proficiency with respect to the performance of tasks and the fulfilment of duties and responsibilities. Continuous training and capacity-building occur throughout the three stages.

Despite this requirement, it is important to emphasise the training and capacity-building need to continue without a substantial reduction in effort and resources during the third stage. Additionally, the Ministry formalises the performance of tasks and the provision of services by restructuring the Ministry and creating new and permanent directorates and departments.

Years 0-3

The Ministry's primary HRD objective is to develop the institutional staff capable of performing core tasks and providing core services. It is at this time that segments of the Ministry's staff are handed the responsibility of providing regulatory services and performing regulatory tasks.[50]

At the top of its list of secondary objectives, the Ministry sets out to create communications channels ensuring the decisions are compatible with the decisions of other ministries to which it is connected.

[50] *A point of clarification is needed. The minimally sufficient set of core services established by Ministry is the same minimally sufficient set that an independent ERC would establish.*

Developing the institutional hierarchy that supports the core services and tasks is another important secondary objective. An optional objective is for the Ministry to take on important non-core services to the extent practicable.

Years 4-7

The Ministry improves the performance of core tasks to maximum proficiency and increases the supply of core services to maximum production. It also improves the performance of non-core tasks taken on during the first stage and adds new non-core tasks and services to reach the full set.

Years 8-20

The Ministry formalises all core and non-core tasks by creating guidelines and procedures to the extent practicable. It is fully staffed and adequately trained at the beginning of the eighth year of HRD proposal.

It provides advanced training and capacity-building throughout the eighth through twentieth year of the HRD proposal. Training and capacity-building become more formal. Less reliance is placed on on-the-job training, and more reliance is placed on on-site capacity building provided by experienced personnel presumably from the outside of the country.

Ministry Tasks and Hierarchy

Regardless of the regulatory environment, the Ministry of Energy and Minerals will always have responsibilities covering multiple areas of governance and technical support that are associated with the supply of electricity. That is, it will have policy, legal and technical responsibilities in areas of generation, transmission, distribution, import of electricity and fuel supplies. The Ministry will also have promotional responsibilities covering environmental practices, energy technologies, energy research and development among other things.

The regulatory environment for electricity is currently still ill-defined. Government of Somaliland has not introduced a legislative bill that establishes a federal power and electricity regulator. This omission automatically transfers all regulatory responsibilities, duties and tasks to the Ministry.

As a result, the Ministry becomes involved deeply in inspections, certifications, regulations, final rules, administrative procedures, dispute resolution, standards and codes. These additions require an expansion of the Ministry's hierarchical chart, which, in turn, foretells of staff expansions and budget increases.

Somaliland's Power Master Plan may be broken down into short-, medium- and long-term activities as follows, that is, broken down into the three stages described above. This design feature suggests that this institutional HRD proposal also should conform to these stages. This suggestion is taken on board.

The tasks are categorised by immediacy and essentiality. A core task is essential and immediate. A first-tier, non-core task is essential but not immediate. A second-tier, non-core task is neither essential nor immediate. These categories conform closely to the three stages described above, and consequently, they enable us to restrict the distribution of the core and non-core tasks to the first and second stages.[51]

Tasks for Years 0-3 (immediate and short-term)

The suggested core tasks cover the areas of promotion, inspection, collaboration, administration, promulgation, policymaking, planning, codes, electrical specifications, docket management, document accessibility, economic analysis, recruitment, training, capacity-building and monitoring and evaluation.

The set of suggested core tasks, therefore, is undeniably large, which portends of staff expansion and budget increases. The two implications cannot be avoided because the Power Master Plan has an integrative scale that spans the generation and transmission of power and the distribution and retail sales of electricity.[52] The only areas not affected by the Power Master Plan are the characteristics and attributes of the generation, transmission, distribution and sales markets, the industrial organisation of the electricity industry as a whole and the structures of generation, transmission and distribution industries.

Table 29, below, contains core tasks for Ministry of Energy and Minerals. A hierarchy identifier also is included in Table 29. An organisational chart and a hierarchical chart are two sides of the same coin. The former provides a schematic of the organisation down to the section level along with staff identifiers for each office (directorate), department and section. The latter goes down as far as an office (directorate). As a result, staff identifiers become meaningless.

Table 29. Suggested Core Tasks for the Power Master Plan's Short-term

Activity	Office (directorate)
Promote the international cooperation, private-sector investments, development of renewable energy sources and use of advanced fossil-fuel technologies	Office of the Minister
Provide recommendations to import bulk electricity	Office of Energy
Inspect electrical installation at all public facilities	Office of Energy
Provide cost-benefit analysis for imported electricity	Office of Energy

[51] *As indicated earlier in this proposal, none of the second-tier, non-core tasks can be deferred for a period-of-time that would place the task within the long-term.*

[52] *The areas not affected by this Power Master Plan are the characteristics and attributes of electricity markets, the organisation of the electric industry and structures of the generation, transmission and distribution industries. This separation is beneficial because planning in this area is determined by government policies that are largely economic in nature.*

Activity	Office (directorate)
Monitor and evaluate efficiency and performance of ESPs	Office of Energy
Serve as the official representative of the Ministry and distribute the Ad Hoc Committee's recommendations and advice and guidance from the Council	Office of General Counsel
Administer Notices of Proposed Rulemaking, Notices of Inquiry, hearings and other regulatory proceedings	Office of Legal Services
Issue final rules and promulgate regulations	Office of Regulation
Promulgate national standards for power and electricity	Office of Regulation
Develop guidelines for operation of the electricity sector	Office of Regulation
Conduct open, objective, transparent, and non-discriminatory regulation especially for tariff making	Office of Regulation
Prepare policies and plans for the development of power and electricity	Office of Policy, Planning and Studies
Develop codes and specifications for energy equipment, works and systems	Office of Policy, Planning and Studies
Establish consultative committees, as necessary	Office of Policy, Planning and Studies
Maintain documents, decisions, orders, rules and evidentiary records associated with proceedings in accordance with administrative procedures	Office of Registrar and Clerk
Provide public availability to all legal documents and records in accordance with administrative procedures except for redacted portions due confidential information or trade secrets	Office of Registrar and Clerk
Promote the international cooperation, private-sector investments, development of renewable energy sources and use of advanced fossil-fuel technologies	Office of the Minister
Provide training and skill building	Office of Human Resources

Source: Unicon

None of the suggested core tasks goes outside the boundaries of the power and electricity industries. What causes the large number is the fact that Government of Somaliland has not introduced a legislative bill establishing an independent ERC. If such a bill had been introduced, then the core tasks assigned to the Office of Legal Services, Office of Regulation and Office of Registrar and Clerk would not be included in Table 29. Instead, they would be classified as core tasks for the ERC.

A large set of core tasks has been posited as being needed to fulfil the Ministry's responsibilities. However, the size of this set cannot be used to defer consideration of the entire set of first-tier non-core tasks to the second stage. Still, entries within Table 29 may be prioritised based on the current circumstances characterising Somaliland's electric industry. One recommendable prioritisation of the top four (4) core tasks contains in recommended order:

- Inspection of electrical installations at all public facilities;
- Issuance of final rules and promulgate regulations applying to licensing, standards, codes and to the extent practicable tariffs;
- Promulgation of national standards for power and electricity; and
- Development of guidelines for operation of the electricity sector.

One of the first-tier non-core tasks included in Table 30, below, is the promotion of equitable competition by the Office of the Minister. It is an essential activity. Although this promotion should occur immediately, the reality is that the government entity that would oversee this promotion does not exist. A functioning Office of Regulation may not exist within the Ministry during the first stage.

However, the Ministry should not wait until a functioning Office of Regulation does exist to support this promotional activity. If the Office of the Minster has the time, it should begin this promotion as soon as possible. The same reasoning applies even more strongly to the task of balancing the protection of consumers with the need for full-cost-recovery tariff.

Even if a functioning Office of Regulation does emerge during the first stage of the HRD proposal the likelihood is in the range of fifty-fifty that it will not have the capacity to collect the data and perform the analysis that are required to achieve this desired outcome.

Still, this task is essential. Therefore, a guiding principle for the Office of Regulation is to make every effort to act in this manner even though it may be considering an electricity tariff in an ad hoc manner.

Table 30. Suggested First-tier Non-Core Tasks for the Power Master Plan's Short-term

Activity	Office (directorate)
Promote equitable competition and an electricity sector that realises equitable economic returns	Office of the Minister
Provide technical and energy economics support to Somaliland Ministries	Office of the Minister
Promote the opportunity to choose an ESP offering reasonable prices and reliable services	Office of Regulation
Balance the protection of consumers with the need for full-cost recovery tariffs	Office of Regulation
Formulate strategies to implement policies and plans	Office of Policy, Panning and Studies
Maintain registers of electricity operators and service providers in accordance with administrative procedures	Office of Registrar and Clerk

Source: Unicon

The first-tier, non-core tasks shown in Table 30 play to inherent strengths of Ministry of Energy and Minerals. Two tasks are purely promotional on two different fronts. The first promotion focuses on equity, and the second promotion emphasises the opportunity to choose a service provider.

One task is purely strategic, but it is tied very securely to policies and plans. This tie is the fact that moves this first-tier, non-core task into the first stage of the HRD proposal. One task is purely administrative, but very doable time permitting. Time is a limited resource.

Tasks for Years 4 – 7

The fourth through seventh year of the Power Master Plan is where the first-tier and second-tier non-core tasks are taken up by the Ministry. The entire set of second-tier, non-core tasks is contained within the second stage of the HRD proposal as well as the remainder of the set of first-tier, non-core tasks.

The division of the first-tier, non-core tasks may not be accepted by everyone. This outcome, if it occurs, is not surprising. Any division of this sort involves judgment for the most part and a trace of arbitrariness. In other words, it is not unusual when different analysts make different judgmental decisions.

Table 31, below, contains fourteen (14) first-tier, non-core tasks that should be initiated and completed within the confines of the second stage of the HRD proposal. Harnessing opportunities to engage in carbon-credit trading has been deferred because setting up a carbon-trading mechanism and organisational structure takes several years.

Inspecting and enforcing standards, of course, requires their prior existence. Enforcing regulations and codes has the same characteristic. There is nothing to enforce if they do not exist. Thus, again, the promulgation of standards regulations, issuing of standards and the creation of codes are delegated to first stage of the HRD proposal while the inspection and enforcement of the standards and codes are deferred to the second stage.

Charging the Ministry with formulating a strategy for energy research might be considered by some as a first-tier, non-core task with enough urgency to be placed for completion within the first stage of the HRD proposal. This option was rejected. While robust research is an important driver for the development of natural resources and the extraction of fossil fuels it is less important with respect to power and electricity.

Research in renewable energy is looking at advanced technologies, and Somaliland may not have the capacity to conduct such research. Therefore, developing a strategy for research in renewable energy was judged to lack sufficient urgency to include it in the first stage of the HRD proposal.

Table 31. Suggested first-tier non-core tasks for the Power Master Plan's medium-term

Activity	Office (directorate)
Harness opportunities for carbon credit trading	Office of the Minister
Inspection and enforcement of electricity standards	Office of Energy
Enforce regulations, codes and directives	Office of Energy
Provide a framework to enable advanced fossil-fuel technologies and renewable-energy technologies	Office of Energy
Conduct assessments of the forecasts of the supply and demand for electricity	Office of Energy
Conduct assessments of the availability and reliability of electricity	Office of Energy
Collect information and statistics on generation and transmission entities	Office of Energy
Collect information and statistics on ESPs and distribution entities	Office of Energy
Ensure decisions and orders are supported by oral and written testimony and data and information submitted in accordance with administrative procedures	Office of Legal Services
Convene inquiries to ensure equitable competition, economic returns, freedom of choice and use of sound environmental practices	Office of Regulation
Prepare feasibility studies and environmental impact assessments	Office of Policy, Planning and Studies
Formulate a national strategy for energy research	Office of Policy, Planning and Studies
Provide compliance statements for policies and plans	Office of Policy, Planning and Studies
Assist with the development of local capacity to manufacture, install, maintain and operate basic power technology	Office of Public Awareness

Source: Unicon

The first-tier, non-core tasks delegated to the second stage of the HRD proposal in Table 31, above, lack the urgency of the first-tier, non-core tasks that were delegated to the first stage of the HRD proposal for performance and completion. Each of second-stage has prerequisites, which, by definition, reduces the urgency of performing the task. Core tasks do not have this characteristic.

For example, requiring the Ministry's decisions to be based on oral and/or written testimony implies that sufficient administrative procedures for the proper handling of oral or written testimony already exist. The urgency of collecting information and statistics applicable to generation, and transmission arises after Government of Somaliland has passed laws dealing with the industrial organisation of the electricity sector and the structures of the generation and transmission markets.

The prerequisite for preparing a feasibility study is a large-scale generation or transmission project or a generation project in a remote area. Dedicating time to build a framework that enables the deployment of renewable-energy technologies presumes that a renewable-energy policy and plan already are in place.

Table 32. Suggested second-tier non-core tasks for the Power Master Plan's medium-term

Activity	Office (directorate)
Review innovations, inventions, technology transfer, and dissemination of energy technologies	Office of Energy
Review and monitor efficiency and performance of generation and transmission entities	Office of Energy
Support reforms in the structure and operations of the distributors of electricity	Office of Energy
Update standards for power and electricity	Office of Regulation
Maintain registers of assessments, innovations, inventions, technology transfers in accordance with administrative procedures	Office of Registrar and Clerk

Source: Unicon

Table 32, above, contains entries that have been judged to be second-tier, non-core tasks for the Ministry. Additional explanation of the meaning of second-tier, non-core tasks will help to achieve a good understanding of this institutional HRD proposal. Second-tier does not mean that these tasks and the responsibilities and duties that they are tied to are not essential for the success of the Power Master Plan. They are essential.

The Ministry, as it matures, cannot turn a blind eye to innovations, inventions and opportunities to transfer proven and effective power and electricity technologies. It is the immediacy of these activities that place them in the second tier. Somaliland's electricity sector needs to be established securely at the basic and foundational levels before it can take advantage of innovations and inventions.[53]

Updating standards, of course, is essential, but Somaliland does not have any electricity standards to update. Once again, a similar argument applies to maintaining registers of assessments, innovations, inventions and technology transfers.

None of the entries in Table 32 is linked to the Offices of the Minister, General Counsel, Legal Services and Communications and Media. Their omission establishes the position that these offices have only core and first-tier, non-core responsibilities and duties. Furthermore, this position causes the front-loading of the core and non-core tasks.

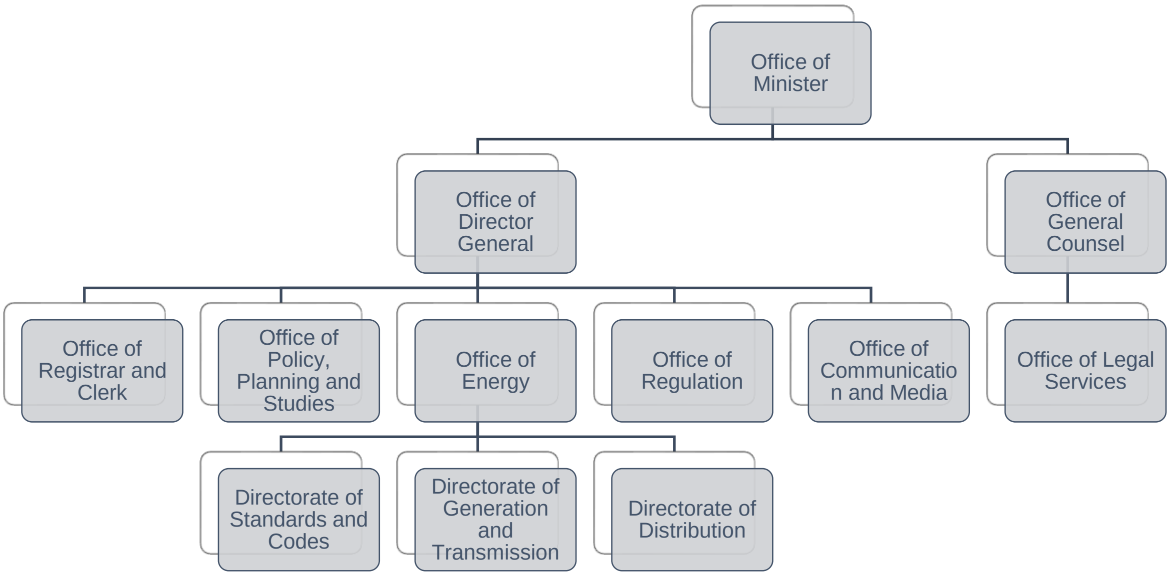
[53] There, however, is one case where the Ministry should embrace an invention or innovation as soon as possible. This is the case of a disruptive technology. Embracing this class of new technology would put Government of Somaliland ahead of the curve. Unfortunately, it is very difficult for any struggling electricity sector to accomplish this feat.

Twenty-four (24) tasks are initiated in the first stage of the HRD proposal. Nineteen (19) tasks are initiated in the second stage of the Proposal. Not one task is initiated during the eighth through twentieth year of the Power Master Plan.

Hierarchy for the Ministry of Energy and Minerals

Figure 39, below, is a schematic representation of the proposed hierarchy for the Ministry of Energy and Minerals.[54] It has four levels of hierarchy. The first and second levels are executive. The third level is upper management. The fourth level is middle management. Offices populate the first, second and third levels of the proposed hierarchy. Departments populate the fourth level.

Figure 39. Proposed Hierarchy for the Ministry with focus on electricity



Source: Unicon

This structure can become a part of the larger Ministry structure, where the ministerial position will be held by the corresponding officer/director general in charge of electricity and report to the overarching ministerial position.

A proposed organisation hierarchy never is the only possible hierarchy or the only reasonable hierarchy or the only rational hierarchy. Alternative organisational hierarchy surely do exist. The distinguishing feature is a consolidation of the higher levels of management and the substitution of managers for directors. However, neither the total number of staff nor the required capabilities change. Annex C contains the depiction of the suggested alternate organisational hierarchy for the

[54] *It does not contain an Office of Environment and Social Safeguards for the following reason. Practicing environmental regulation differs significantly from the practice of economic regulation, and therefore, including this Office as proposed would be impractical. There is limited merit associated with inserting a social-safeguards function in the Ministry's hierarchy if and only if it is related to the production and consumption of electric power or electricity. An option in this regard is to place the social-safeguard function within the Office of Communications and Media.*

Ministry of Energy and Minerals with a focus on electricity. Also included are revised Tables showing the new management positions and hierarchical identifiers.

Management Level and Composition of Staff

First Level

The Office of the Minister is the public face of the Ministry. Its main responsibilities, therefore, are to govern the Ministry's operations, manage the Ministry's image and promote power and electricity policies.[55] The Minister, of course, is an executive.

Staff are administrative and secretarial. Administrative staff is responsible for scheduling the Minister's meetings and managing the Minister's daily, weekly and monthly calendars. The role of the secretarial staff includes, among others, processing letters over the Minister's signature and controlling access to the Minister.

Second Level

The Offices of the Director General and the General Counsel constitute the second level of the hierarchy. Management is at executive level. Staff are administrative and secretarial. Administrative staff are at the assistant level. The responsibilities of the secretarial staffs are identical to the responsibilities of the secretarial staff within the Office of the Minister. An office manager will become an asset when the Director General's responsibilities extend beyond the Ministry's physical confines.

General Counsel is charged with two duties. The first is to provide legal advice or opinions to the Minister. The second is to represent the Ministry in courts, respecting externally imposed time lines and deadlines is the chief attribute of administrative staff. Skill-wise, staff will assist with the preparation of legal briefs.

Whenever and for whatever reasons the only responsibility of the General Counsel is to defend the decisions of the Ministry's shadow regulator in court, then the Office of the General Counsel may be eliminated from the Ministry's hierarchical chart with any loss of functionality or generality. Government's Attorney General is the logical choice thereby avoiding any duplication of duties. However, the circumstances change considerably when the Ministry desires an on-site advisor that is charged with keeping the shadow regulator out of court. The issue is whether the Attorney General or the legal advisor to the Government has the specific human capital that is required to advise the Ministry on legal/regulatory matters. When the resolution of this issue yields an affirmative answer to the immediately preceding issue, then the position and Office of General Counsel may be eliminated. But, the Office of Legal Services cannot be eliminated because the Ministry's shadow regulator is conducting regulatory-like hearings, which must reflect a sufficient amount of administrative due process.

[55] *The image dimension establishes the essentiality of an Office of Communications and Media.*

The Director General is the chief operations officer. The primary responsibility is managerial. On the one hand, the Director General is responsible for managing day-to-day activities. On the other hand, the Director General is responsible for the execution of policies and plans. Staff are administrative and secretarial. Administrative staff are responsible for coordinating meetings; secretarial staff are responsible for performing the duties of a receptionist.

Third Level

The third level of the hierarchy consists of five (5) Offices. They are:

- Office of Energy;
- Office of Regulation;
- Office of Registrar and Clerk;
- Office of Communications and Media; and
- Office of Policy, Planning and Studies.

Upper management is the status of the leaders of each of these Offices.

These leaders are required to have managerial and professional expertise. Each leader manages professional staff to a greater or lesser extent. Staff for each Office are a mixture of professional, technical, secretarial and administrative personnel. Administrative staff concentrate their efforts on record keeping, archiving and document management.

The efforts of the secretarial staff shift between report preparation, keeping personnel records and controlling access to professional and technical staff. The efforts of the professional staff are consonant with their respective expertise and education. The efforts of technical staff focus on keeping the Office running efficiently.

Fourth Level

A fourth level of hierarchy does not exist for (i) the Office of Regulation, (ii) the Office of Registrar and Clerk, (iii) the Office of Communications and Media, and (iv) the Office of Policy, Planning and Studies. However, a fourth level does exist for the Office of Energy. The fourth level consists of three departments. They are:

- Department of Standards and Codes;
- Department of Generation and Transmission; and
- Department of Distribution.

Middle management is the status of the leaders of these departments. Although some management skill will be necessary their prime capacity will be professional skills. Staff are secretarial and professional.

Conforming to the Level 3 hierarchy, professional staff work within their education and expertise. Secretarial staff divide their time between keeping departmental records and controlling access to the professional staff including the leader of the department.

Training Needs for the Ministry of Energy and Minerals

Training needs in support of the Power Master Plan will conform to the introduction of new institutional tasks over the next twenty years. The TOR appear to require that these training needs be divided into three (3) different time segments. To fulfil this requirement and to achieve a much-needed preliminary programmatic objective, the chosen approach is to partition the training needs according to immediacy.

After the partitioning is complete, the most immediate training needs are assigned to the first stage of the HRD proposal. Adhering to this procedure, the next most immediate training needs are assigned to the second stage of the HRD proposal. Finally, the least immediate training needs are assigned to the third and final stage of the HRD proposal.

Training Needs for Years 0-3

The most immediate training needs involve preparing staff to:

- produce policy and plans for Somaliland's electricity sector;
- improve the efficiency of the competing distribution systems;
- set health and safety standards for workers and consumers within Somaliland's electricity sector;
- establish electrical wiring and installation codes;
- prepare Notices of Proposed Rulemaking (NOPR);
- conduct tariff hearings;
- promulgate tariffing and licensing regulations;
- file, archive and provide public access to official documents; and
- initiate public awareness programmes.

The set of most immediate training needs is not small. There are nine (9) such needs. Completing each of the training tasks needs to occur within the first stage of the HRD proposal.

The Offices that receive this training are:

- Office of Policy, Planning and Studies;

- Office of Energy;
- Office of Regulation;
- Office of Registrar and Clerk; and
- Office of Communications and Media.

Each of these Offices has different training needs. Training for the Office of Policy, Planning and Studies will focus on performing background research, analytical methods, consultative meetings and writing of policy and plans.

The training needs for the Office of Energy exist in two areas – (i) distribution; and (ii) standards. The training needs with respect to distribution are instruction in distribution planning, charting the distributions system, acceptance of intermittent power and deployment of low-cost but efficient distribution technologies. The training needs with respect to standards are conducting background research on health and safety standards elsewhere in the world, consultative meetings and collaborative approaches to developing standards.

The training needs for the Office of Regulation are background research and instruction in the use of administrative procedures, handling of intervener comments, testimony, data and information, writing of rules and promulgation of regulations. The Office of Legal Services is expected to assist with this instruction.

The training needs for the Office of Registrar and Clerk are instruction on the handling of official documents, docket management, public access to official documents, control over confidential information and trade secrets and filing methods and procedures. The training needs for the Office of Communications and Media are instruction to help ensure good and productive interactions with journalists, visitors and worker, industry and consumer representatives.

Training Needs for Years 4-7

The attributes of the next lower ranking of immediate training needs are somewhat different from the attributions of the highest ranking of immediate training needs. These training needs involve preparing staff to:

- set infrastructure standards;
- establish electrical codes;
- conduct cost-benefit analysis;
- analyse imports of electricity;
- conduct generation and transmission planning;
- collect and store of technical data;
- grant licenses;
- docket regulatory proceedings;
- perform document management; and

- professionally publish policies and plans.

The performance of these tasks signals the beginning of the economic rationalisation of Somaliland's electricity sector, and therefore, training to perform these tasks cannot be deferred beyond the second stage of the HRD proposal.

The Offices requiring additional training and instruction are:

- Office of Energy;
- Office of Regulation;
- Office of Legal Services;
- Office of Registrar and Clerk; and
- Office of Communications and Media.

The training needs for the Office of Energy and Office of Regulation are more substantial than previously. It will need instruction in the setting of standards and codes that meet international best practices, training and instruction in macro-economics and cost-benefit analysis, instruction in the methods and procedures for granting a license.

The training needs of the Office of Legal Services may be instruction in the issue of licenses and will be instruction in the administration of dockets. Docket management and maintenance will be added to the training needs of the Office of Registrar and Clerk. Instruction in the professional publication of policies and plans will be added to the training needs of the Office of Communications and Media.

Training Needs for Years 8-20

The objective of the final stage of meeting training needs, which is the third stage of the HRD proposal, is the attainment of full functionality in electricity governance. It is at this point that the training needs are advanced and become more intensive in time and effort. The training needs in the forefront are to enable staff to:

- promulgate the full set of necessary regulations;
- support national policies and plans;
- integrate generation, transmission and distribution planning;
- conduct feasibility studies;
- establish a grid code and codes for the construction of generation, transmission and distribution facilities;
- form policies for competition, investment, industrial organisation and market structure for Somaliland's electricity sector;
- record and publish licenses and tariffs;
- explain policies and plans; and
- resolve disputes and customer complaints.

The Offices experiencing the need for training in new areas are:

- Office of Regulation;
- Office of Energy;
- Office of Policy, Planning and Studies;
- Office of Registrar and Clerk;
- Office of Communications and Media; and
- Office of Legal Services.

The Office of Regulation would benefit from instruction on how to support a policy or plan without issuing a rule or promulgating a regulation. Thus, instruction in the art of developing frameworks and guidelines is necessary but can be deferred into a relatively distant future.

The Office of Energy would benefit from additional instruction and training in more advanced economic and financial methods and engineering/economic/demographic forecasting and modelling. Its efforts in related areas would be more productive after the Office of Energy receives training and instruction with respect to supplying assistance during the development of building and construction codes.

The responsibilities of the Office of Policy, Planning and Studies broaden significantly. Thus far, the Office of Policy, Planning and Studies would have received training and instruction in the areas of performing background research, analytical methods, consultative meetings and writing of policy and plans. It now would benefit from training and instruction on the formation of policies that go beyond the production and consumption of power and electricity. Specifically, training and instruction are needed with respect to forming competition, investment, industrial organisation and market structure policies that are suitable for Somaliland's electricity sector.

The Office of Registrar and Clerk would benefit from training and instruction in creation of an archive for published but outdated tariffs and licenses. The Office of Communications and Media would benefit from training and instruction in the areas of writing and using published public announcements to explain the Ministry's policies and plans or the Ministry's actions in support of national policies and plans.

Thus far, the Office of Legal Services would have received training and instruction in the areas of issuing licenses and administering dockets and hearings. It now is time to go beyond receiving training and instruction in administrative procedures and move on to forming dispute-resolution policy and procedures and procedures for the handling of complaints.

The character of staffing also will change when the Ministry completes the first three years of the Power Master Plan. Staffing will be difficult during the first three years of the Power Master Plan, and it will be extremely difficult during the fourth through seventh years. The causes are changes in the number of required staff and changes in the staff member's required education. Consequently, recruitment will become harder and more time consuming during the transition.

Necessary Positions to Support the Power Master Plan

At least two approaches exist for this section. The approach selected is to propose a set of workers for each Office shown in the hierarchical chart. Each set includes the total number of workers and the job classification for each worker (e.g. engineer or lawyer). The text consists of annotations when deemed necessary.

The declined approach is to put together a list of the executive, managerial, professional, technical, administrative and secretarial personnel. The objective is to provide the composition of the required work force. Afterwards, a set of job descriptions is provided for each functional area.

The declined approach was not selected because it would compete with Somaliland's existing civil service system. For example, a job description proposed in this report as necessary to perform the required tasks already may exist within the existing civil service system. If the job description does not exist, then the HRD proposal may be erecting its own barriers to its successful implementation.

However, samples of job descriptions for personnel presumed necessary to provide institutional support for the Power Master Plan are provided in annexes to HRD Plan report. The sample of public sector job descriptions private sector job descriptions are found in annex to HRD Plan report.

The set of workers for each office are shown in Tables below. As stated above, an annotation is provided when one is deemed to be necessary to improve the understanding of the intent of the table. It must be asserted in advance that the proposed number of workers and the proposed composition of an office's work force rest on a mixture of experience and judgment. As a result, Government of Somaliland is free to make substitutions.

Office of the Minister					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Appointee	Provided in text	Immediate	None
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	Immediate	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Office of the General Counsel					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Lawyer	Provided in text	Immediate	None
Administrative	1	Assistant	Support the General Counsel function	Immediate	None
Secretarial	1	Multi-task	Receptionist and secretarial tasks with telephone call handling responsibilities	Immediate	None

Office of the Legal Services					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Lawyer	Provided in text	Immediate	None
Professional	1	Lawyer	Staff lawyer, supports Director of Legal Services	Immediate	None
Technical	1	Investigator	Works in the areas of customer complaints, commercial disputes, health and safety violations and accidents	0 to 3 years	2 to 3 by end of seventh year
Technical	1	Legal Assistant	Legal assistance to support the Legal Services function.	0 to 3 years	2 by end of seventh year
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Office of Director General					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Director General	Provided in text with expertise in operations management and coordination is desirable but not necessary	Immediate	None
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	Immediate	None

Office of Director General					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Office of Energy					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Director	Preferred profession: engineer	Immediate	None
Managerial	1	Manager	Preferred profession: engineer	0 to 3 years	None
Professional	1	Engineer	experience in generation, specialisation: electrical, mechanical or civil	0 to 3 years	None
Professional	1	Engineer	Experience in transmission specialisation: electrical, mechanical or civil	4 to 7 years	None
Professional	1	Engineer	Experience in distribution specialisation: electrical, mechanical or civil	Immediate	None
Technician	1	Information Technology	Experience with the set-up, operation and maintenance of local area network is desirable.	0 to 3 years	1 in 4 through seventh year
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	Immediate	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	1 in 0 through 3 years
Student	3	Intern	Engineering students preferred	0 to 3 years	None

Office of Policy, Planning and Studies					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Director	Preferred profession: Engineer or Economist	Immediate	None

Office of Policy, Planning and Studies					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Professional	1	Engineer	Desired experience: planning specialist	Immediate	1 in 0 through 3 years and 1 in 4 through seven years
Professional	1	Analyst	Preferred specialisation: Economic	0 through 3 years	Environmental specialisation, 1 in 0 through 3 years
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	0 through 3 years	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None
Student	1	Intern	No strong preference for major	0 through 3 years	None

Office of Regulation					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Director	Preferred profession: Economist, Engineer or Social Scientist	Immediate	None
Professional	1	Engineer	Preferred specialisation: Renewable energy or advanced fossil-fuel technology	Immediate	None
Professional	1	Accountant	Experience in tariff-making is desired	0 through 3 years	None
Professional	1	Analyst	Preferred specialisation: Economic	0 through 3 years	Environmental specialisation, in 4 through 7 years
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	0 through 3 years	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Office of Regulation					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Student	1	Intern	No strong preference for major	0 through 3 years	None

Office of Registrar and Clerk					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Director	Preferred profession: Librarian	Immediate	None
Administrative	1	Assistant	Preferred specialisation: library	0 through 3 years	1 in 4 through seven years
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial tasks	Immediate	None
Student	1	Intern	No strong preference for major	0 through 3 years	None

Office of Communications and Media					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth**
Executive	1	Director	Preferred profession: Journalist	Immediate	None
Technician	1	Photographer		0 through 3 years	1 in four through seven years
Technician	1	Information Technology		0 through 3 years	None
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	0 through 3 years	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None
Student	1	Intern	Journalism or communications major	0 through 3 years	None

This section may be interpreted as arguing that supporting the Power Master Plan at the institutional level will not be an inexpensive or easy endeavour. The skill of the executives will be a significant determinant of the success of the Power Master Plan. Special care, therefore, should be taken when Government of Somaliland chooses to fill these positions.

The number of proposed professionals and their skill levels are not insignificant. This institutional HRD proposal asks for fourteen (14) professionals in addition to the Directors. The technical skill levels are less challenging. The proposal argues for two (2) information technology technicians, one (1) photographer and one (1) investigator.

The administrative and secretarial requirements, however, should be manageable with proper screening of applicants. This institutional HRD proposal also includes seven (7) interns. It is important that students become aware of the opportunities within government. On-the-job experience, therefore, is an excellent way to achieve this objective.

Regional Support

Very little is gained descriptively or otherwise by extending the HRD proposal to the regional level. Regional staffing, in large measure, is dependent on the specific activities that the Ministry of Energy and Minerals will be looking to conduct away from Hargeysa. The best way to handle this omission is to ensure that the HRD proposal for the national level is scalable.

This insurance was taken through the spreading of the national staffing needs over seven years. By distributing staffing needs in this manner, the HRD proposal is made scalable. As a result, each region may choose to adopt the federal staffing needs in whole, conclude a larger scale is required or conclude a smaller scale is required.

Private Sector Institutional Support for the Power Master Plan

The state-of-affairs throughout Somaliland is that the private sector is the dominant and almost exclusive generator and distributor of electricity. Furthermore, legislative bills have not been proposed or laws have not been passed that would cause the Government of Somaliland to gain the dominant positions with respect to the generation, transmission and distribution of electricity.

It is the array of government institutions that the private sector needs to recognise and seek to influence to assure that the subsequent implementation of the Power Master Plan will proceed as smoothly as possible.

Fortunately, the way forward in this regard already has been determined, implemented and found to be successful. It is that each generator, transmitter, distributor or retail electricity provider (REP) creates and staffs a Government Affairs Office. The role and responsibility of this Office is to interact with the Government and to provide the Government with well-constructed arguments in support of its commercial and policy beliefs.

The duty also is well-defined. The Government Affairs Office is to provide the Government with the information and data that assist the Government in reaching just policies and making fair and equitable decisions.

While the necessary technical expertise will be company-specific (the key positions are covered in Annex B, three is the minimum number of staff for a Government Affairs Office. Either a director-level or manager-level position is at the head of this Office. The staff consists of one (1) legislative/regulatory assistant and one (1) secretarial position.

Conclusions

Developing an institutional HRD proposal in support of the Power Master Plan requires an examination of the relationships among ministries. Supporting the Power Master Plan for the supply of essential services cuts across ministries with distinctly different responsibilities. In an ideal world, it can be assumed that cross-cutting ministries would cooperate, collaborate and coordinate with each other.

It is concluded, however, that this scenario will not be present in the real world. Instead, it is concluded that the cross-cutting ministries will collaborate with each other. It is concluded that the collaboration will be two-way in most instances with exceptions for the collaboration between the Ministry of Energy and Minerals and the ministries responsible for trade and international cooperation.

Certain assumptions are required to design the institutional HRD Proposal in support of the Power Master Plan. It is assumed that government does not establish an independent ERC before initiating the Power Master Plan. The consequence flowing out from this assumption is that the Ministry is responsible for meeting all regulatory responsibilities and performing all regulatory tasks.

It is concluded, therefore, that the institutional HRD Proposal should include a shadow ERC in the form of an Office of Regulation. Lastly, it is concluded that the Ministry and the shadow ERC will reach full strength by the beginning of the third and final stage of the HRD proposal.

The path forward with respect to the development of human resources requires explicit attention to the time periods partitioning the Power Master Plan. It also requires the separation or joining of responsibilities and tasks. It is concluded, therefore, that the best course of action is to join responsibilities and tasks until government establishes an independent ERC.

Determining the staffing levels and job descriptions supporting institutional HRD proposal do not depend on the content of the Power Master Plan. Institutional support for the Power Master Plan is functional in nature. The important prescriptive factors are education and skills. Experience is a secondary prescriptive factor because of the newness of the needed institutional support. A high-quality staff member can substitute for one or two lower quality staff members. It, therefore, is concluded that samples of general job descriptions are the appropriate response. These samples are found in Annex A and Annex B.

If a law establishing an independent ERC had existed, Ministry of Energy and Minerals would not have any regulatory responsibilities. However, such law does not exist, and consequently, all regulatory responsibilities, duties and tasks are transferred to the Ministry. To recognise this reality and to account for the complexity of the Power Master Plan, the Ministry's tasks are categorised as core, first-tier non-core and second-tier non-core tasks.

These categories enable us to restrict the distribution of the core and non-core tasks to the first and second stages of the HRD proposal. Twenty-four (24) tasks are initiated in the first stage of the Proposal. Many of these tasks are performed by the Ministry of Energy and Minerals because of the absence of an independent ERC. Nineteen (19) tasks are initiated in the second stage of the Proposal, and some of these tasks also are associated with the economic regulation of Somaliland's electricity sector. No task is initiated during the third and final stage of the HRD proposal.

The absence of an independent ERC has affected a number of core tasks to be performed by the Ministry and the timing of the performance of these tasks. With respect to timing, it is concluded that the performance of tasks in support of the Power Master Plan has to be frontloaded into the first stage of the Proposal.

Several levels of hierarchy are needed for the institutional support:

- first level of the hierarchy is responsible for governing the operations of the Ministry, managing its image and promoting the electricity policies of Somaliland Government;
- second level is responsible for providing legal advice or opinions to the Minister, representing the Ministry in court, directing the Ministry's operations including but not limited to electricity policies and plans;
- third level is responsible for executing government policies and plans and performing the core and non-core tasks that support the Power Master Plan; and
- fourth level exist at the functional level involving the setting of standards, issuing of codes and the operation and maintenance of generation, transmission and distribution facilities.

Training needs in support of the Power Master Plan at the task level have been partitioned according to immediacy. The most immediate category contains nine (9) tasks that are performed by four (4) different proposed Offices for the Ministry.

The next most immediate category contains ten (10) tasks that are performed by five (5) different Offices. The least immediate category contains nine (9) tasks that are performed by six (6) different Offices. These numbers and the description of the training needs provided above establish that training and capacity building needs to continue through all three periods.

The number and capabilities of the human resources needed to provide adequate institutional support of the Power Master Plan are a significant challenge. Due care shall be given to identification, trainings, and retaining of required staff.

HRD Plan | Annex A: Sample Job Descriptions

The sample of job descriptions provided in this annex is meant to inform the Government of Somaliland on the responsibilities and tasks of key Ministry and/or shadow ERC professional and non-professional staff supporting the Power Master Plan. Executive job descriptions are excluded to focus on the execution of regulatory responsibilities and duties regardless of whether they are mandated by law.

The content of the six (6) sample job descriptions alerts the executive staff as to what should be expected from the personnel hired into their Offices, Directorates or Departments. Furthermore, the content of this annex, as a result, is not meant to cover the administrative and secretarial positions identified in Tables found within the body of the Report.

With this caveat in mind, the sample job description prepared for the Annex A tables below should be informative and helpful as the government staffs-up the Ministry or staffs the shadow ERC that will be established within the Ministry with proper jurisdiction over the government affairs arising from public and private sector activity affecting electricity sector.

Staff Engineer, Office of Regulation	
Responsibilities and Duties	Explanatory Comments
Review, provide commentary on and recommended approval or rejection, if required by laws and regulations, with respect to operating policies, procedures, budgets, annual plans, power contracts, power rates and standing operating procedures.	Because the private sector is responsible for the production and supply of power and electricity the staff engineer at the Office of Energy cannot be involved directly in the development and implementation of operating and maintenance policies, procedures, budgets etc. The duties of the staff engineer are to review and provide commentary, and if required by law or regulation, recommend approval.
Review, provide commentary on and recommend approval or rejection, if required by law and regulations, with respect to the quarterly monitoring and evaluation reports addressing power purchase agreements, good utility practices and conformance to all applicable laws and regulations.	To have the opportunity to perform these duties, a rule or regulation is needed that requires the regulated company to submit a monitoring and evaluation reports to the shadow ERC on a quarterly basis.
Review, provide commentary and recommend approval or rejection, if required by laws and regulations, with respect to the quarterly	A staff engineer is not required to formulate new maintenance goals, however, the staff engineer can be assigned the duty of evaluating maintenance goals.

Staff Engineer, Office of Regulation	
Responsibilities and Duties	Explanatory Comments
monitoring and evaluation report covering all aspects of operations and maintenance.	
Review, provide commentary on and recommend approval or rejection, if required by law and regulations, with respect to the quarterly monitoring and evaluation report covering testing, inspections and operation and maintenance of the facilities.	The monitoring and evaluation requirements placed are a function of what is permitted by law and the interests of the shadow ERC.
Observe on a random basis maintenance performed, daily reading made and the inspection of the facilities and provide commentary on these observations.	Performing or supervising activities in these areas are not duties of a staff engineer. A staff engineer, however, may “observe” on a random basis.
Review and provide commentary on a quarterly monitoring and evaluation report covering power house operating parameters and conditions, and analyse the parameters and conditions when submitted in support of docketed regulatory proceeding.	A staff engineer can analyse operating parameters only if mandated by law or during a docketed proceeding. What a staff engineer can do without the cover of docketed proceeding is review and provide commentary on parameters and conditions that are reported in M&E reports.

Staff Engineer, Office of Regulation Education/Experience	
Education and Experience	Explanatory Comments
Bachelor Degree in Electrical Engineering or Electromechanical Engineering	Standard education requirement
One to Three (1 to 3) years of experience	The conventional wisdom within Somaliland appears to be that three years of experience is the maximum that private sector and the public sector can expect to witness.

Information Technology Specialist, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
Develop and implement a system for the management and safe custody and retrieval of records and information routed to and from the	The area of expertise is information technology (IT) with an understanding of administrative procedures. The task calls for the setting up and managing a local area network with good to

Information Technology Specialist, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
Director's Office in line with the administrative guidelines and procedures.	excellent file (document) sorting and retrieval capabilities. These responsibilities are virtually identical to those that are found in the regulator's Office of the Registrar and Clerk.
Execute technical duties not included in the job description as they are delegated.	This is the safety net clause. It has become a HR convention.
Represent the Office, Directorate or Department in technical meetings, seminars and other fora as and when delegated by the head of the Office, Directorate or Department.	This convenience clause is included in the job description to protect the Director from being expected to attend meetings discussing minor or inconsequential issues or problems. However, this clause also ensures that the Director will be expected to attend technical meetings dealing with major or consequential problems and issues.
Schedule internal & external customer appointments and providing feed back to the specific stakeholders in line with organisation procedures.	The assignment of this responsibility is appropriate for IT personnel working in the Office of the Registrar and Clerk because this Office interacts on a regular basis with the public and other Offices.

Information Technology Specialist, Office of Registrar and Clerk, Education/Experience	
Education and Experience	Explanatory Comments
Bachelor Degree in Information Science	Standard education requirement
Alternative: Technical Diploma in Information Technology with 2+ years of experience in administrative or legal procedures.	Bachelor Degree in Information Science may be in short supply.

Registrar, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
Evaluate records for preservation and retention – some may be fragile and need careful handling.	Filing and archiving at library standards is the proper measure of capacity for the Office of the Registrar and Clerk. This Office is responsible for the handling, preservation, systematic filing and archiving of official government documents that

Registrar, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
	can be accessed upon request by the public and other interested parties also known as interveners in regulatory circles.
Arrange the acquisition and retrieval of documents and records.	Some regulatory authorities require the interveners to deliver minimum filing requirements to the Office of the Registrar and Clerk prior to the beginning of scheduled regulatory hearings to expedite the hearing process.
Develop and implement detailed record-keeping systems and procedures for retention or destruction of documents and records for all docketed and undocketed proceedings. Develop and implement a separate system for researching archived records and documents.	This is an important responsibility that is assigned to the Office of the Registrar and Clerk. An excellent record-keeping system is very important, and procedures for the retention and destruction of documents and records are almost as important. Although archival research does happen at Offices of the Registrar and Clerk such activity is not commonplace, therefore, this task can be put in a place of lower priority.
Catalogue separately the collection of docketed proceedings and the collection of undocketed proceedings and manage the information, data, documents, records and testimony therein.	The Office of the Registrar and Clerk has two collections – docketed proceedings and undocketed proceedings. All data, information, written testimony, recorded testimony, workshop documents and presentations and *ex parte* communications fall into one of these collections.
Facilitate on-site access by maintaining user-friendly, computer-aided search systems.	Access should be provided at terminals within the Office of the Registrar and Clerk if it is permitted at all.
Identify ways of protecting and preserving collections.	This is a catch-all task.

Registrar, Office of Registrar and Clerk, Education and Experience	
Responsibilities and Duties	Explanatory Comments
Diploma in Library and Information Science with at least three years of experience in records management.	This is the preferred choice for the education and experience that is needed to a Registrar/Clerk at a regulatory authority. However, it is recognised that such candidates will be in short supply.
Alternative: A University degree in Office Administration or Business Management with a proven experience of three years.	The alternative is the most likely outcome. The preference is a candidate with an Administration Management degree.

Staff Lawyer, Office of Legal Services	
Responsibilities and Duties	Explanatory Comments
Review, analyse and write an opinion as to whether vendor contracts and confidentially agreements comply with regulations. On an as needed basis and when requested by the contractual parties, provide mediation services for a contractual disagreement involving solely the interpretation of policies, rules and regulations.	When a contractual agreement is reached, the draft contract forwarded to a staff lawyer for review to ensure that it conforms with policies, rules and regulations. The staff lawyer writes an opinion for the record and informs parties as to its conformance with policies, rules and regulations.
Review, analyse and provide commentary on whether the contract through risk shifting imposes an unacceptable economic cost on consumers.	A staff lawyer is rightly concerned about commercial and transactional risks that affect consumers because the economic regulator has a responsibility to protect consumers in a balanced manner. To fulfil this responsibility, a staff lawyer may make the parties aware of areas of concern that suggest to the staff lawyer that the contract shifts too much risk to the consumers and way from the contract's parties.
Lead in the implementation of legal policies adopted by management. Lead in the implementation of administrative policies, process and procedures that conform strictly to administrative law and in the absence of administrative law conform to international best practices.	It is a grey area as to whether regulator can choose legal policies that further its strategic objectives because this choice implies that the regulator is anticipating legal challenges to its decisions. It is not a grey area when the topic is administrative procedures. Regulator is required to be objective, transparent and fair.

Staff Lawyer, Office of Legal Services	
Responsibilities and Duties	Explanatory Comments
Update legal policies in accordance with changes in the applicable law, and update administrative policies practices and procedures in accordance with changes in administrative law and alter administrative practices and procedures accordingly.	Regulator always is required to conform to changes in administrative law, and therefore, a staff lawyer must update practices and procedures to reflect these change in administrative law.

Staff Lawyer, Office of Legal Services, Education and Experience	
Responsibilities and Duties	Explanatory Comments
Bachelor's Degree in Law and a professional qualification in law	Standard education qualification
3+ years of experience in contract or administrative law	Standard experience requirement

Occupational Safety Specialist, Office of Regulation	
Responsibility and Duties	Explanatory Comments
Contribute to the issue of safety rules and to the promulgation of safety regulations.	This is a basic duty of an occupational safety specialist employed with the Office of Regulation.
Monitor and evaluate the operational records of regulated companies with respect to worker and consumer safety and to provide commentary on issues and problems that have been identified.	This is a basic duty of an occupational safety specialist employed in the Office of Regulation.
Review, digest and provide commentary on the monthly safety reports as input for the possible updating or modification of existing safety regulations or to propose a new safety regulation.	It is a responsibility of an occupation safety specialists working at the Office of Regulation to review, digest and provide commentary on the monthly safety reports as input for the possible updating or modification of existing safety regulations or to propose a new safety regulation.
Investigate, report and if deemed necessary contribute to securing the resolution of all safety-related and health-related events. Manage the data base of the resolutions of safety-related and health-related events.	A basic responsibility of an occupational safety specialist is to manage the data base of the resolutions of safety-related events. Investigation, however, is the grey area unless there is *not* an occupational health and safety

Occupational Safety Specialist, Office of Regulation	
Responsibility and Duties	Explanatory Comments
	regulator and if the municipalities fire departments do *not* have the resources to investigate the causes of safety related events and contribute to their resolution.
Conduct random inspections to ensure that the processes and procedures are compliant with the pertinent regulations, rules and guidelines. Conduct random inspections at work sites to assure that work in progress conforms to designs, charts, etc.	If a report is not submitted on a routine basis that affirms that the regulations, rules and guidelines have been complied with, then an occupational safety specialist working at the Office of Regulation only route to ensuring compliance is routine and random inspection.
Possess a sufficient level of understanding of all health and safety regulations applicable the electricity sector up to and including the capacity to make initial assessments of compliance or non-compliance with existing regulations.	A basic tenet of employment is that a specialist should have good understanding of the regulations to the level of making an initial assessment of compliance or non-compliance.
Create a health and safety awareness campaign to assist the public in becoming more health and safety conscious when it uses electricity daily.	While it is the responsibility of the company to train its staff and build the capacity It is the responsibility of an occupational safety specialist working at the Office Regulation to make the public aware of the importance of being health and safety conscious when using electricity.
Develop an information-dissemination plan that assures the disclosure to the public of the basic dangers of consuming electricity and what can be done to avoid or mitigate them. Create a bare-bone programme for the dissemination of this information to the public using the most persuasive means available.	Establishing a culture of using electricity safely is not the sole responsibility of an occupational safety specialist working at the Office of Regulation. The public must do its part to ensure its safety and health. However, the dangers of electricity are not well known. For this reason, an occupational safety specialist working at the Office Regulation is responsible for establishing programme to alert the public of the basic dangers of electricity and how to avoid them or at least mitigate them.

Occupational Safety Specialist, Office of Regulation, Education and Experience	
Education and Experience	Explanatory Comments
Knowledgeable of all applicable health and safety guideline and well-versed in the applicable health and safety standards.	An occupational safety specialist must be well-versed in safety regulations and procedures.
Knowledge of the safety and health threats and risks that exist when using and consuming electricity for various essential purposes.	An occupational safety specialist working at the Office of Regulation must be knowledgeable of safety risks encountered when consuming electricity.
Three (3) years of experience in promoting and assuring the health and safety of the public.	An occupational safety specialist working at the Office of Regulation must have experience in assuring the health and safety of the public as the public uses electricity.
Operation Health and Safety (OHS) Certification is desirable.	Such a certification is desirable because of the responsibility to review, digest, monitor and evaluate safety incidents.

Wage and Salary Compensation Specialist, Office of Director General	
Responsibilities and Duties	Explanatory Comments
Develop and supervise the implementation of a performance-management system within the Ministry and the shadow ERC with a goal of establishing a performance related pay framework for adoption by the Somaliland Civil Service.	While wage and salary levels are established by Somaliland's Civil Service, the Director General is responsible for staff performance. Developing this system may be costly and may encounter technical problems with respect to the protection of wage and salary data. Whatever technology is chosen to measure performance its configuration will have to respect local norms. With these challenges in mind fulfilling this responsibility may be deferred.
Develop and manage an employee recognition framework and recommend a list of employee recognition awards.	An effective awards system has the potential to build morale and reduce costs. In a new organisation with unfamiliar tasks and responsibilities morale building is extremely important.

Wage and Salary Compensation Specialist, Office of Director General	
Responsibilities and Duties	Explanatory Comments
Develop performance measures that track the efficiency and effectiveness to establish a history of employee activity.	It is premature to develop a performance-management system before measures of performance have been proposed, vetted and agreed upon.
Coordinate departmental performance-management cycles to avoid congestion at the end of the fiscal year. Consolidate performance appraisals before the end of the fiscal year.	This is execution extending beyond development and implementation. Thus, development and implementation of the coordination process should not begin until performance measures have been proposed, vetted and agreed upon.
Develop a human resource development proposal, design a plan and create a programme to execute the plan.	The Director General is charged with multi-part task because it the Director General's responsibility to support staff development.

Wage and Salary Compensation Specialist, Office of Director General. Education and Experience	
Education and Experience	Explanatory Comments
Bachelor's Degree in Human Resource Management or Business Administration with 2+ years of experience with human-resource operations.	These are standard education and experience requirements.
Alternative: Master's degree in Human Resource Management and 1+ years of experience with human-resource operations.	The higher level of education has the potential to reduce the number of years of experience in human-resource operations.

HRD Plan | Annex B: Public vs. Private Sector Job Descriptions

The comparison of public sector and private sector job descriptions provided in this annex is meant to inform Government of Somaliland on the noticeable differences in the responsibilities and duties of a public-sector employee versus a private-sector employee with the same job classification. The result is stark.

The private-sector employee is involved with the production of a good or service. The public-sector employee is involved with monitoring and evaluating the production of a product or service. Therefore, the number and type of responsibilities and duties are different for the private-sector and public-sector employees.

The private-sector employee tends to have more duties than the public-sector employees while the public-sector employee tends to have more responsibilities than the private-sector employee. However, it has been established that duties involving production require more experience and education than responsibilities of off-site monitoring and off-site evaluation.

Staff Engineer, Office of Regulation	
Responsibilities and Duties	Explanatory Comments
Review, provide commentary on and recommended approval or rejection, if required by laws and regulations, with respect to operating policies, procedures, budgets, annual plans, power contracts, power rates and standing operating procedures.	Because the private sector is responsible for the production and supply of power and electricity the staff engineer at the Office of Energy cannot be involved directly in the development and implementation of operating and maintenance policies, procedures, budgets etc. The duties of the staff engineer are to review and provide commentary, and if required by law or regulation, recommend approval.
Review, provide commentary on and recommend approval or rejection, if required by law and regulations, with respect to the quarterly monitoring and evaluation reports addressing power purchase agreements, good utility practices and conformance to all applicable laws and regulations.	To have the opportunity to perform these duties, a rule or regulation is needed that requires the regulated company to submit a monitoring and evaluation reports to the shadow ERC on a quarterly basis.
Review, provide commentary and recommend approval or rejection, if required by laws and regulations, with respect to the quarterly monitoring and evaluation report covering all aspects of operations and maintenance.	A staff engineer is not required to formulate new maintenance goals, however, the staff engineer can be assigned the duty of evaluating maintenance goals.

Staff Engineer, Office of Regulation	
Responsibilities and Duties	Explanatory Comments
Review, provide commentary on and recommend approval or rejection, if required by law and regulations, with respect to the quarterly monitoring and evaluation report covering testing, inspections and operation and maintenance of the facilities.	The monitoring and evaluation requirements placed are a function of what is permitted by law and the interests of the shadow ERC.
Observe on a random basis maintenance performed, daily reading made and the inspection of the facilities and provide commentary on these observations.	Performing or supervising activities in these areas are not duties of a staff engineer. A staff engineer, however, may "observe" on a random basis.
Review and provide commentary on a quarterly monitoring and evaluation report covering power house operating parameters and conditions, and analyse the parameters and conditions when submitted in support of docketed regulatory proceeding.	A staff engineer can analyse operating parameters only if mandated by law or during a docketed proceeding. What a staff engineer can do without the cover of docketed proceeding is review and provide commentary on parameters and conditions that are reported in M&E reports.

Staff Engineer, Office of Regulation Education/Experience	
Education and Experience	Explanatory Comments
Bachelor Degree in Electrical Engineering or Electromechanical Engineering	Standard education requirement
One to Three (1 to 3) years of experience	The conventional wisdom within Somaliland appears to be that three years of experience is the maximum that private sector and the public sector can expect to witness.

Information Technology Specialist, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
Develop and implement a system for the management and safe custody and retrieval of records and information routed to and from the Director's Office in line with the administrative guidelines and procedures.	The area of expertise is information technology (IT) with an understanding of administrative procedures. The task calls for the setting up and managing a local area network with good to excellent file (document) sorting and retrieval capabilities. These responsibilities are virtually

Information Technology Specialist, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
	identical to those that are found in the regulator's Office of the Registrar and Clerk.
Execute technical duties not included in the job description as they are delegated.	This is the safety net clause. It has become a HR convention.
Represent the Office, Directorate or Department in technical meetings, seminars and other fora as and when delegated by the head of the Office, Directorate or Department.	This convenience clause is included in the job description to protect the Director from being expected to attend meetings discussing minor or inconsequential issues or problems. However, this clause also ensures that the Director will be expected to attend technical meetings dealing with major or consequential problems and issues.
Schedule internal & external customer appointments and providing feed back to the specific stakeholders in line with organisation procedures.	The assignment of this responsibility is appropriate for IT personnel working in the Office of the Registrar and Clerk because this Office interacts on a regular basis with the public and other Offices.

Information Technology Specialist, Office of Registrar and Clerk, Education/Experience	
Education and Experience	Explanatory Comments
Bachelor Degree in Information Science	Standard education requirement
Alternative: Technical Diploma in Information Technology with 2+ years of experience in administrative or legal procedures.	Bachelor Degree in Information Science may be in short supply.

Registrar, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
Evaluate records for preservation and retention – some may be fragile and need careful handling.	Filing and archiving at library standards is the proper measure of capacity for the Office of the Registrar and Clerk. This Office is responsible for the handling, preservation, systematic filing and archiving of official government documents that can be accessed upon request by the public and other interested parties also known as interveners in regulatory circles.

Registrar, Office of Registrar and Clerk	
Responsibilities and Duties	Explanatory Comments
Arrange the acquisition and retrieval of documents and records.	Some regulatory authorities require the interveners to deliver minimum filing requirements to the Office of the Registrar and Clerk prior to the beginning of scheduled regulatory hearings to expedite the hearing process.
Develop and implement detailed record-keeping systems and procedures for retention or destruction of documents and records for all docketed and undocketed proceedings. Develop and implement a separate system for researching archived records and documents.	This is an important responsibility that is assigned to the Office of the Registrar and Clerk. An excellent record-keeping system is very important, and procedures for the retention and destruction of documents and records are almost as important. Although archival research does happen at Offices of the Registrar and Clerk such activity is not commonplace, therefore, this task can be put in a place of lower priority.
Catalogue separately the collection of docketed proceedings and the collection of undocketed proceedings and manage the information, data, documents, records and testimony therein.	The Office of the Registrar and Clerk has two collections – docketed proceedings and undocketed proceedings. All data, information, written testimony, recorded testimony, workshop documents and presentations and *ex parte* communications fall into one of these collections.
Facilitate on-site access by maintaining user-friendly, computer-aided search systems.	Access should be provided at terminals within the Office of the Registrar and Clerk if it is permitted at all.
Identify ways of protecting and preserving collections.	This is a catch-all task.

Registrar, Office of Registrar and Clerk, Education and Experience	
Responsibilities and Duties	Explanatory Comments
Diploma in Library and Information Science with at least three years of experience in records management.	This is the preferred choice for the education and experience that is needed to a Registrar/Clerk at a regulatory authority.

Registrar, Office of Registrar and Clerk, Education and Experience	
Responsibilities and Duties	Explanatory Comments
	However, it is recognised that such candidates will be in short supply.
Alternative: A University degree in Office Administration or Business Management with a proven experience of three years.	The alternative is the most likely outcome. The preference is a candidate with an Administration Management degree.

Staff Lawyer, Office of Legal Services	
Responsibilities and Duties	Explanatory Comments
Review, analyse and write an opinion as to whether vendor contracts and confidentially agreements comply with regulations. On an as needed basis and when requested by the contractual parties, provide mediation services for a contractual disagreement involving solely the interpretation of policies, rules and regulations.	When a contractual agreement is reached, the draft contract forwarded to a staff lawyer for review to ensure that it conforms with policies, rules and regulations. The staff lawyer writes an opinion for the record and informs parties as to its conformance with policies, rules and regulations.
Review, analyse and provide commentary on whether the contract through risk shifting imposes an unacceptable economic cost on consumers.	A staff lawyer is rightly concerned about commercial and transactional risks that affect consumers because the economic regulator has a responsibility to protect consumers in a balanced manner. To fulfil this responsibility, a staff lawyer may make the parties aware of areas of concern that suggest to the staff lawyer that the contract shifts too much risk to the consumers and way from the contract's parties.
Lead in the implementation of legal policies adopted by management. Lead in the implementation of administrative policies, process and procedures that conform strictly to administrative law and in the absence of administrative law conform to international best practices.	It is a grey area as to whether regulator can choose legal policies that further its strategic objectives because this choice implies that the regulator is anticipating legal challenges to its decisions. It is not a grey area when the topic is administrative procedures. Regulator is required to be objective, transparent and fair.
Update legal policies in accordance with changes in the applicable law, and update administrative policies practices and procedures in accordance	Regulator always is required to conform to changes in administrative law, and therefore, a staff lawyer must update practices and

Staff Lawyer, Office of Legal Services	
Responsibilities and Duties	Explanatory Comments
with changes in administrative law and alter administrative practices and procedures accordingly.	procedures to reflect these change in administrative law.

Staff Lawyer, Office of Legal Services, Education and Experience	
Responsibilities and Duties	Explanatory Comments
Bachelor's Degree in Law and a professional qualification in law	Standard education qualification
3+ years of experience in contract or administrative law	Standard experience requirement

Occupational Safety Specialist, Office of Regulation	
Responsibility and Duties	Explanatory Comments
Contribute to the issue of safety rules and to the promulgation of safety regulations.	This is a basic duty of an occupational safety specialist employed with the Office of Regulation.
Monitor and evaluate the operational records of regulated companies with respect to worker and consumer safety and to provide commentary on issues and problems that have been identified.	This is a basic duty of an occupational safety specialist employed in the Office of Regulation.
Review, digest and provide commentary on the monthly safety reports as input for the possible updating or modification of existing safety regulations or to propose a new safety regulation.	It is a responsibility of an occupation safety specialists working at the Office of Regulation to review, digest and provide commentary on the monthly safety reports as input for the possible updating or modification of existing safety regulations or to propose a new safety regulation.
Investigate, report and if deemed necessary contribute to securing the resolution of all safety-related and health-related events. Manage the data base of the resolutions of safety-related and health-related events.	A basic responsibility of an occupational safety specialist is to manage the data base of the resolutions of safety-related events. Investigation, however, is the grey area unless there is *not* an occupational health and safety regulator and if the municipalities fire departments do *not* have the resources to

Occupational Safety Specialist, Office of Regulation	
Responsibility and Duties	Explanatory Comments
	investigate the causes of safety related events and contribute to their resolution.
Conduct random inspections to ensure that the processes and procedures are compliant with the pertinent regulations, rules and guidelines. Conduct random inspections at work sites to assure that work in progress conforms to designs, charts, etc.	If a report is not submitted on a routine basis that affirms that the regulations, rules and guidelines have been complied with, then an occupational safety specialist working at the Office of Regulation only route to ensuring compliance is routine and random inspection.
Possess a sufficient level of understanding of all health and safety regulations applicable the electricity sector up to and including the capacity to make initial assessments of compliance or non-compliance with existing regulations.	A basic tenet of employment is that a specialist should have good understanding of the regulations to the level of making an initial assessment of compliance or non-compliance.
Create a health and safety awareness campaign to assist the public in becoming more health and safety conscious when it uses electricity daily.	While it is the responsibility of the company to train its staff and build the capacity It is the responsibility of an occupational safety specialist working at the Office Regulation to make the public aware of the importance of being health and safety conscious when using electricity.
Develop an information-dissemination plan that assures the disclosure to the public of the basic dangers of consuming electricity and what can be done to avoid or mitigate them. Create a bare-bone programme for the dissemination of this information to the public using the most persuasive means available.	Establishing a culture of using electricity safely is not the sole responsibility of an occupational safety specialist working at the Office of Regulation. The public must do its part to ensure its safety and health. However, the dangers of electricity are not well known. For this reason, an occupational safety specialist working at the Office Regulation is responsible for establishing programme to alert the public of the basic dangers of electricity and how to avoid them or at least mitigate them.

Occupational Safety Specialist, Office of Regulation, Education and Experience	
Education and Experience	Explanatory Comments
Knowledgeable of all applicable health and safety guideline and well-versed in the applicable health and safety standards.	An occupational safety specialist must be well-versed in safety regulations and procedures.
Knowledge of the safety and health threats and risks that exist when using and consuming electricity for various essential purposes.	An occupational safety specialist working at the Office of Regulation must be knowledgeable of safety risks encountered when consuming electricity.
Three (3) years of experience in promoting and assuring the health and safety of the public.	An occupational safety specialist working at the Office of Regulation must have experience in assuring the health and safety of the public as the public uses electricity.
Operation Health and Safety (OHS) Certification is desirable.	Such a certification is desirable because of the responsibility to review, digest, monitor and evaluate safety incidents.

Wage and Salary Compensation Specialist, Office of Director General	
Responsibilities and Duties	Explanatory Comments
Develop and supervise the implementation of a performance-management system within the Ministry and the shadow ERC with a goal of establishing a performance related pay framework for adoption by the Somaliland Civil Service.	While wage and salary levels are established by Somaliland's Civil Service, the Director General is responsible for staff performance. Developing this system may be costly and may encounter technical problems with respect to the protection of wage and salary data. Whatever technology is chosen to measure performance its configuration will have to respect local norms. With these challenges in mind fulfilling this responsibility may be deferred.
Develop and manage an employee recognition framework and recommend a list of employee recognition awards.	An effective awards system has the potential to build morale and reduce costs. In a new organisation with unfamiliar tasks and responsibilities morale building is extremely important.

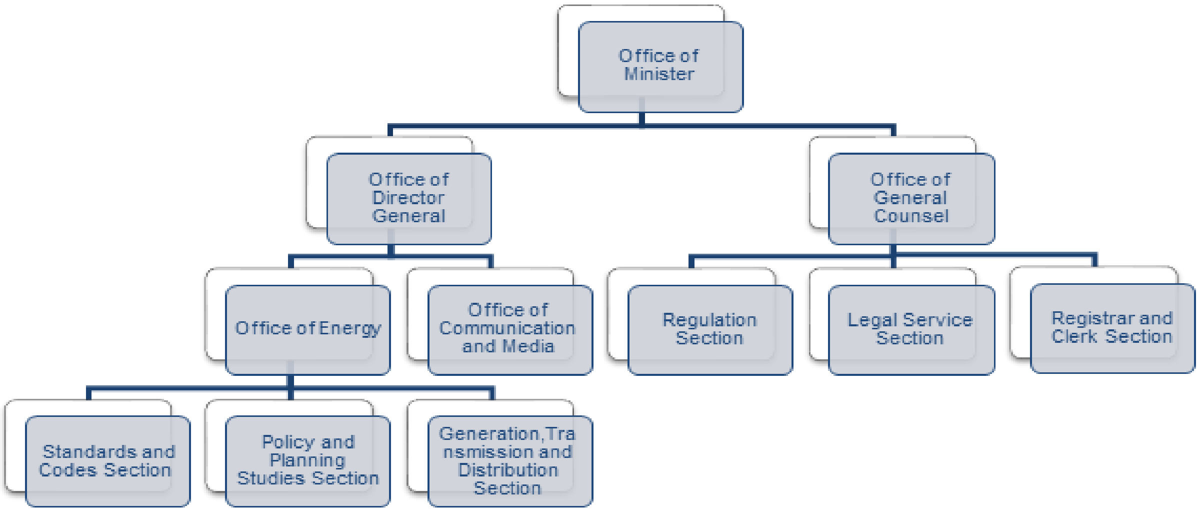
Wage and Salary Compensation Specialist, Office of Director General	
Responsibilities and Duties	Explanatory Comments
Develop performance measures that track the efficiency and effectiveness to establish a history of employee activity.	It is premature to develop a performance-management system before measures of performance have been proposed, vetted and agreed upon.
Coordinate departmental performance-management cycles to avoid congestion at the end of the fiscal year. Consolidate performance appraisals before the end of the fiscal year.	This is execution extending beyond development and implementation. Thus, development and implementation of the coordination process should not begin until performance measures have been proposed, vetted and agreed upon.
Develop a human resource development proposal, design a plan and create a programme to execute the plan.	The Director General is charged with multi-part task because it the Director General's responsibility to support staff development.

Wage and Salary Compensation Specialist, Office of Director General. Education and Experience	
Education and Experience	Explanatory Comments
Bachelor's Degree in Human Resource Management or Business Administration with 2+ years of experience with human-resource operations.	These are standard education and experience requirements.
Alternative: Master's degree in Human Resource Management and 1+ years of experience with human-resource operations.	The higher level of education has the potential to reduce the number of years of experience in human-resource operations.

HRD Plan | Annex C: Alternate Hierarchy for the Ministry

The distinguishing feature of the alternate hierarchy for the Ministry with a focus on electricity is the consolidation of higher levels of management and the substitution of managers for directors. However, neither the total number of staff nor the required capabilities are altered.

Figure 40. Alternate Proposed Hierarchy for the Ministry with focus on electricity



Source: Unicon

Office of the Minister					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Executive	1	Appointee	Provided in text	Immediate	None
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	Immediate	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Office of the General Counsel					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Executive	1	Lawyer	Provided in text	Immediate	None
Administrative	1	Assistant	Support the General Counsel function	Immediate	None

Office of the General Counsel					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Secretarial	1	Multi-task	Receptionist and secretarial tasks with telephone call handling responsibilities	Immediate	None

Legal Services Section					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Manager	1	Lawyer	Provided in text	Immediate	None
Professional	1	Lawyer	Staff lawyer, supports Director of Legal Services	Immediate	None
Technical	1	Investigator	Works in the areas of customer complaints, commercial disputes, health and safety violations and accidents	0 to 3 years	2 to 3 by end of seventh year
Technical	1	Legal Assistant	Legal assistance to support the Legal Services function.	0 to 3 years	2 by end of seventh year
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Regulation Section					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Professional	1	Manager	Preferred profession: Economist, Engineer or Social Scientist	Immediate	None
Professional	1	Engineer	Preferred specialisation: Renewable energy or advanced fossil-fuel technology	Immediate	None
Professional	1	Accountant	Experience in tariff-making is desired	0 through 3 years	None
Professional	1	Analyst	Preferred specialisation: Economic	0 through 3 years	Environ-mental, in 4 through 7 years

Regulation Section					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	0 through 3 years	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None
Student	1	Intern	No strong preference for major	0 through 3 years	None

Registrar and Clerk Section					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Professional	1	Manager	Preferred profession: Librarian	Immediate	None
Administrative	1	Assistant	Preferred specialisation: library	0 through 3 years	1 in 4 through seven years
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial tasks	Immediate	None
Student	1	Intern	No strong preference for major	0 through 3 years	None

Office of Director General					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Executive	1	Director General	Provided in text with expertise in operations management and coordination is desirable but not necessary	Immediate	None
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	Immediate	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None

Office of Energy					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Executive	1	Director	Preferred profession: engineer	Immediate	None
Managerial	1	Manager	Preferred profession: engineer	0 to 3 years	None
Professional	1	Engineer	experience in generation, specialisation: electrical, mechanical or civil	0 to 3 years	None
Professional	1	Engineer	Experience in transmission specialisation: electrical, mechanical or civil	4 to 7 years	None
Professional	1	Engineer	Experience in distribution specialisation: electrical, mechanical or civil	Immediate	None
Technician	1	Information Technology	Experience with the set-up, operation and maintenance of local area network is desirable.	0 to 3 years	1 in 4 through seventh year
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	Immediate	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	1 in 0 through 3 years
Student	3	Intern	Engineering students preferred	0 to 3 years	None

Policy, Planning and Studies Section					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Professional	1	Manager	Preferred profession: Engineer or Economist	Immediate	None
Professional	1	Engineer	Desired experience: planning specialist	Immediate	1 in 0 through 3 years and 1 in four through seven years
Professional	1	Analyst	Preferred specialisation: Economic	0 through 3 years	Environmental specialisation, 1 in 0 through 3 years

Policy, Planning and Studies Section					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	0 through 3 years	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None
Student	1	Intern	No strong preference for major	0 through 3 years	None

Office of Communications and Media					
Classification	**Nr**	**Type**	**Task Description**	**Hiring Urgency**	**Growth in staff**
Executive	1	Director	Preferred profession: Journalist	Immediate	None
Technician	1	Photographer		0 through 3 years	1 in four through seven years
Technician	1	Information Technology		0 through 3 years	None
Administrative	1	Assistant	Calendar management, scheduling and meeting coordination	0 through 3 years	None
Secretarial	1	Multi-task	Receptionist, initial telephone contact and secretarial responsibilities	Immediate	None
Student	1	Intern	Journalism or communications major	0 through 3 years	None

Annex 3: Power Sector Institutions, Regulations and Laws

Box.
This Annex was separately submitted earlier as a stand-alone deliverable/report for the project and added to this Power Master Plan report as a supplementary annex to highlight findings and recommendations of Unicon on this matter. Terms 'report' and similar in this annex are related to this Annex only.

Background

Terms of Reference (TOR) for this component of the project requires that the Consultant provides an outline of the institutional development needs that enable the Government of Somaliland (GoSL) to govern its electric sector and perform a gap analysis outlining the laws and regulations that exist for the governance of Somaliland's electric sectors and laws and regulations that need to exist for the implementation of the 20-year power master plans.

According to the TOR, one essential missing piece has already been identified; namely the lack of engineering standards for distribution, transmission, and generation facilities and safety-related issues. This is addressed in another deliverable, which is a note on distribution standards and voltage levels.

A second already identified essential missing piece is a regulation that requires an as-of-yet unidentified entity to conduct an integrated generation, transmission, and distribution planning exercise on a periodic basis with a time horizon of less than 20 years. This missing piece is examined in the context of the absence of the prerequisites for the promulgation of this regulation and for that matter any other regulation dealing with Somaliland's electric sector.

The absence of the prerequisites for the promulgation of a regulation can be examined from two different perspectives, and the TOR for this project leaves it to the Consultant to choose the perspective that assists best with the implementation of Somaliland's master plans.

The first perspective is to identify the prerequisites that do exist and then list and explain the necessity of the prerequisites that do not exist. The second perspective is to identity the prerequisites that do exist and then list the prerequisites that do not exist, then to qualitatively estimate the likelihood that they will exist before the master plans are completed and then choose between explaining why the prerequisites are necessary or finding sustainable alternatives to the non-existent perquisites. The Consultant chose the second perspective. The insertion of alternatives in the form of non-government institutions (i.e. actors) is the best approach to implement the Power Master Plan when it is completed at the end of this project.

During the Inception Mission, the Consultant learned that little legislative efforts have been made in the recent past, but the GoSL released the National Development Plan II (NDP II), and desires and intentions were revealed throughout this official document that Somaliland is in dire need of legislation and regulations to improve the governance an operation of its basic and essential sectors and priority industries.[56]

The Consultant sought out and reviewed the work that has already been completed concerning the institutional, legal and regulatory status in Somaliland's electric sector to establish the initial conditions for further work. The Consultant made full use to the extent practicable of the prior work by experts. Their findings and conclusions assisted in assuring that the Consultant's recommendations provided in this report would correspond to the overall spirit of the Power Master Plan and international best practice.

This Report

This report discusses the details of the appropriate and transparent institutional and regulatory reform models in short-range and long-range terms, including explicit consideration of the following issues:

- the purpose of proposed/revised laws and regulations, to govern and establish a framework for the supply of electric-power and the principles of the law, including operations in the power-supply industry and activities of licensees in the provision of electricity services; establishment of favourable conditions for investments in, and commercial operation of, the electric power industry; regulation of the supply of electric power; promotion of the rights of consumers to receive reliable and adequate power services at reasonable cost; establishment of competition; granting of rights and obligations; the possible establishment of an Electricity Regulation Commission (ERC);[57] establishment of a rural electrification agency, if needed, or suggest other appropriate structures to promote electrification and regulate third-party access to the power sector; contractual arrangements between the government and enterprises; environmental and social considerations; and the use of land;
- the framework for electric-power supply and services, including the designation of an authority for policy making; the use of primary energy sources; the regulatory responsibilities

[56] *Government of Somaliland, National Development Plan II (NDP II) for Somaliland 2017-2021.*

[57] *Knowledge of bureaucratic terminology is a useful trait when investigating the proper governance of an electric sector. The key pieces of bureaucratic terminology in this instance are agency, commission and authority. Each of these institutions would be housed in the GoSL's Executive. Each has different internal governance, and power differentials exist among them. An agency is headed by a single individual, and it often reports directly the President. Therefore, an agency is the most powerful institution of the three. A commission has a group of men and women at the top, and one of them is a chairperson that often is nominated by the President. The chairperson does not head the commission, but rather, the chairperson assigns responsibilities to commission members, sets the commission's agenda and schedules meetings and hearings. A commission does not report to the President, but the chairperson may report directly to the President. A commission is less powerful than an agency as a result. An authority is the least powerful of the three institutions. It is headed by a board, and it behaves more akin to a commercial operation than as a regulator. This is not to say that an authority does not have regulatory power because it does have this authority. What is being said is that a Board decides how the regulatory authority is wielded by the chief executive officer of the authority. It is the powerful differentials that make an authority the proper choice because there is not any enabling legislation, which establishes the regulator of an electric sector.*

of the ERC; the operational responsibilities of the other structures involved in the sector, and any licensed Independent Power Producer (IPP); the overall basis for power conservation; and policy and regulation of the supply of electric-power services throughout Somaliland, including project cities; and

- institutional arrangements necessary for undertaking electricity operations and the roles and responsibilities between the central government and local authorities, as applicable.

The report then provides recommendations for improvements in various areas of legislation for and regulation of the electric-power sector.

Purposes of Laws and Regulations

The purpose of a law in abstract terms is to fulfil the desires and intentions of the voting population as expressed through the actions and decisions of its Government. A law must be constitutional. It is the nation's Constitution that prevents its laws from impinging on the rights of its inhabitants. A law may be narrowly or broadly defined depending on desires, intentions and current circumstances. Some examples of proposed laws, that is, legislative bills, are provided below.

Essential, Non-Essential and Avoided Features of Electric-Power and Electricity Bills

However, before turning to these examples, it is imperative that the nature of an electric-power bill is comprehended in the sense of what it must address and may address. An electric-power bill must address:

- framework for the electric-power market;
- commercial operation of the electric-power industry as to licensing, granting of rights and obligations to the participants in the power market;
- accessibility of the power market to third parties; and
- the use of land. If these are not considered explicitly in the bill, then a foundation is not present for the promulgation of regulations in these areas.
- An electric-power bill may address:
- establishment of competition;
- establishment of favourable conditions for investment in the power market;
- general characteristics and attributes of contractual arrangements between the GoSL and private-sector enterprises;
- promotion of electrification; and
- consideration of environmental and social issues.

If these issues are not confronted in an electric-power bill, then each is confronted properly in a separate bill. In fact, it is a good practice to consider each of these issues in separate bills. By doing so, ancillary issues do not cast shade over the creation of an electric-power market.

What is normally not included in an electric-power bill is:

- operations and regulation of the power-supply industry;
- regulation of third-party access to the power sector
- establishment of a regulatory authority; and
- establishment of a rural electrification agency.

Each issue has nothing to do with the electric-power market. Consequently, they are grouped together appropriately and addressed in bills that are separate from the electric-power bill. This separation is necessary to avoid deflection and diversion during parliamentary deliberations.

The same format should be followed during the statutory construction of an electricity bill, but with two additions. They are:

- activities of licensees in the provision of electricity services;
- promotion of the rights of consumers to receive reliable and adequate power services at reasonable cost.

An electricity bill without them de-fangs a regulatory authority when it addresses the availability of electricity to consumes and the affordability of electricity to residential, commercial and industrial users.

Examples of Electricity Laws

An electricity law might establish a governing framework for supplying electric power to electricity service providers (ESPs). Alternatively, it might:

- establish an ERC that among other mandated tasks sets electric-power and electricity tariffs and issues licenses to ESPs, transmission providers, generators or fully integrated electricity companies;
- structure the supply of electric power in a manner that creates favourable conditions for investment in the electric sector and achieving rural electrification that benefits consumers;
- establish competitive markets for electricity that promote the rights of consumers to receive high-quality electricity at an affordable cost.

Each of these bills would support a Master Plan for Somaliland, and each of these bills would articulate substantive polices that would affect its electric sector. The purpose of a legislative bill then is to formalise the government policies that reflect the desires and intentions of the voting populace.

Narrowly Defined Electricity Law

Electricity laws, at times, are narrowly defined to assure government officials that their implementation will move forward quickly and smoothly. An example of a narrowly defined electricity law could be to constrain its statutory construction to the formalisation of the interaction between the Ministries in Somaliland with responsibilities in electric power and electricity and the duties and powers of Somaliland's ERC.

A narrowly defined law subject to this constraint would contain pre-specified procedures. For example, the law could delve into the details concerning the nomination of potential regulators, appointment of regulators, human resource needs of the ERC and the funding of the ERC in the short run and the long run.

Such a bill, however, can do more than establish the modes and means of collaboration between a Ministry and an ERC. Narrow statutory construction has the capability to control a new ERC that might overstep its boundaries by issuing orders and promulgating regulations that stand in conflict with existing laws, national policies and national plans. Often, a new ERC is unaware of the strict linkages among policies, laws, rules and regulations, and therefore, it is not unusual that a new ERC on occasion to overstep its boundaries.

Broadly Defined Electricity Laws

An electricity law also can be defined broadly. Table 33 below summarises the history of broadly defined draft laws for Iraq's electric sector. The Table demonstrates draft laws are defined broadly when it is believed that economic and political circumstances will change over time. Significant amounts of flexibility and latitude, as a result, are common characteristics of a broadly defined law.

Table 33. History of legislative bills for the electric sector of Iraq

Year	Legislative Bill	Description of the Legislative Bill
2005	Electricity Bill	Altered responsibilities of the Ministry of Electricity; established an ERC; mandated corporatisation of state-owned integrated monopolistic companies.
2009	Electricity Bill revision 1	Unbundled state-owned generation companies; encouraged private-sector investment in generation; mandated a slow transition to an (undefined) liberalised electric sector; added regulation and licensing to the Ministry of Electricity's responsibilities; removed the establishment of an ERC.
2012	Electricity Bill revision 2	Continued restructuring of the electric sector; added distribution as a candidate for market liberalisation; permitted provincial governments to participate in policy-making and decision-making, encouraged the addition of renewable energy to the generation mix.

Source: Unicon

An electricity bill, written circa 2005 by consultants and experts, established an ERC and revised the responsibilities of the Iraq Ministry of Electricity (IMOE). It also sought to return to the corporatisation of electricity companies using state-owned enterprises (SOE) as the vehicle. This bill did not receive substantial support from the IMOE; however, it did induce the creation of SOEs that were structured consistent with the principles of corporatisation.

A second bill, also written by consultants and experts circa 2009, altered the industrial organisation of the Iraq electricity sector; promoted a role for the private sector; encouraged private investment in the electricity sector; mandated a slow and managed transition to a liberalised electricity sector; realigned the IMOE's responsibilities toward regulation and licensing; reformed the electric-power market by permitting the entry of IPPs.[58] Notably, this bill did not contain articles that would establish an independent ERC and instead positioned major regulatory functions of contract oversight, tariffs and consumer protection within the IMOE. That is, economic regulation of the Iraq electricity sector would be the responsibility of the IMOE.

This bill was placed on the parliamentary agenda.[59] Although it received support from the IMOE because it complemented a recent large purchase of combined-cycle gas turbines this purchase was not sufficient to push the bill through the Iraqi Parliament. Opposition to reform and restructuring remained substantial throughout Iraq.[60]

A third electricity bill, which also restructured Iraq's electricity sector, was drafted a few years later. This bill added the distribution sub-sector as a candidate for private-sector entry while decentralising the electric sector through more participation by the provincial government in policy and decision-making. Also, the bill encouraged the addition of renewable energy to the generation mix. Independent regulation was not mentioned. This bill also has not been passed into law.

Missing Essential Laws in Somaliland

Essential laws are missing in Somaliland:

- law that establishes a regulatory authority for the electric sector;
- law that mandates the structures of the electric-power and electricity industries and markets;
- law that establishes competition in the electric-power and electricity markets and establishes favourable conditions for investment;

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[58] "Iraq's Power Crisis and the Need to Re-Engage the Private Sector - Smartly," Middle East Economic Survey, 6 February 2011, http://www.taylor-dejongh.com/wp-content/uploads/2012/02/Iraqs-Power-Crisis.pdf

[59] Luay Al-Khatteeb and Harry Istepanian, TURN A LIGHT ON: ELECTRICITY SECTOR REFORM IN IRAQ, Policy Briefing, Brooking Institute, March 2015, referencing Bertelsmann Stiftung, BTI 2012 - Iraq Country Report (Gütersloh: Bertelsmann Stiftung, 2012).

[60] Luay Al-Khatteeb and Harry Istepanian, "Iraq Draft Electricity Law: What's Right, What's Wrong," Petroleum Economist, 14 April 2014, http://www.brookings.edu/research/papers/2014/04/15-iraq-electricity-law-alkhatteeb-istepanian

- law that outlines the general characteristics and attributes of contractual arrangements between the GoSL and private-sector enterprises;
- law that promotes the electrification of Somaliland and considers environmental and social issues;
- law that mandates the activities of licensees in the provision of electricity services and promotes the rights of consumers to receive reliable and adequate power services at a reasonable cost;
- law that establishes the administrative procedures that govern decision-making by an ERC.

Purpose of Regulations

Regulations have different purposes than laws. Regulations formalise the implementation of a law. A regulation cannot be promulgated without an enabling law, and the content of an enabling law relies on the content of underlying policies. Because regulations are so closely tied to its enabling legislation it has the effect of a law.

The purpose of a regulation, however, is more than the simple implementation of the enabling law. It also supports the creation of procedures that are designed to assure the efficiency and safety of the electric system and protect the health and safety of consumers and workers. These procedures take the form of:

- Grid Codes;
- protocols for distribution network planning;
- codes for electrical installations;
- standards for electric equipment, high-voltage wiring and low-voltage and low-voltage wiring; and
- procedures for the operation and maintenance (O&M) of generation, transmission and distribution facilities.

Promulgation of a Regulation

Generally, a very precise sequence of events leads to a regulation:

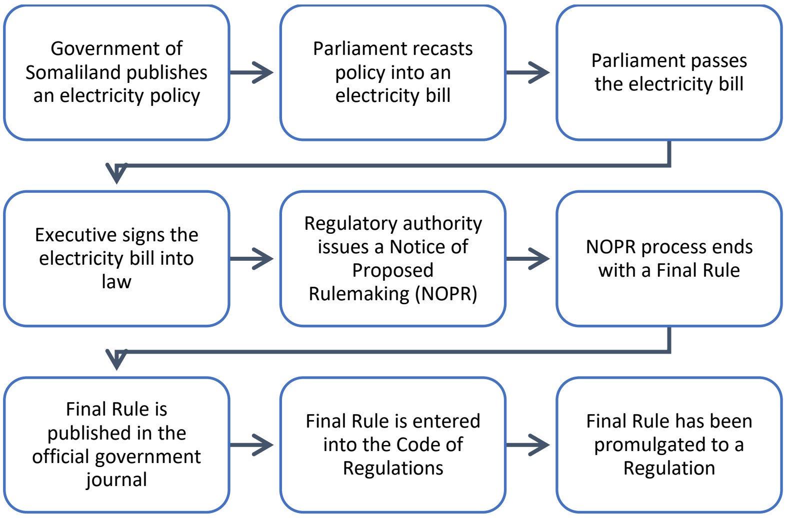
- GoSL develops and publishes a national electric policy;
- GoSL recasts the policy into legislative bills;
- Parliament passes the bill, and the President signs the bill into law;
- if the law is challenged on constitutional grounds, the courts investigate to ensure its constitutionally;
- the ERC issues a Notice of Proposed Rulemaking (NOPR);[61]

[61] *The NOPR initiates the rulemaking process.*

- the NOPR process ends with a final rule. This is the point where policy, law and rule making come together and sets the stage for the promulgation of a regulation;
- the final rule is placed in the official government notification journal;
- the final rule is entered into a Code of Regulations (COR) after the passage of a pre-determined amount of time; it is at this point that a regulation is promulgated and has the force of law.

This process is represented in Figure 41 below.

Figure 41. Promulgation of a regulation



Source: Unicon

Absent Regulations for the Electric Sector in Somaliland

Regulations cannot exist without laws to enable and support them. Somaliland, at present, has draft electricity law that has not been approved at the moment, and therefore, it properly does not have regulations in this area.[62] It is after the essential electric-power and electricity bills are written, deliberated upon and passed into laws that the absent regulations materialise through the work of an ERC.

As noted in the background discussion, a regulation is required to govern the preparation of an integrated generation, transmission and distribution plan. In addition, regulations are required to approve standards and codes and to install safety measures and technologies to protect workers and consumers. And lastly, regulations are required to implement the essential laws in the manner desired by GoSL.

[62] *The people of Somaliland have elected a new President who will be inaugurated in mid-December of 2017. The Parliament of Somaliland also is expected to be in session as well. After the new President decides on his choice for the Minister of Energy and Minerals the consultant has been informed that the Ministry intends to act immediately and launch an effort to pass the draft electricity bill establishing an ERC and subsequently begin work a licensing regulation.*

The purposes of laws and regulations are many and faceted. Their presence is a major cause of an electric sector expanding in a rational and orderly manner. Laws and regulations, in general, do not detract from productive economic activity; they, in general, prevent non-productive economic activity.

Framework for electric power supply and services

The framework for electric-power supply and the provision of electricity services includes among other things:

- designation of government authorities for making electric-power and electricity policy;
- duties and powers of the government authorities charged with implementing the policies and any laws and plans that are associated with them;
- government policy applicable to the supply of electric-power and electricity services; and
- regulation of the supply of electric-power and electricity services.

Policymaking Authority

Policymaking is a collaborative process that brings into play the personnel and expertise of different parts of the GoSL.[63] The Executive possesses the authority to make policy, which it exercises through the issuance of a government document with the seal of the appropriate government office.

During the development of a policy, the Executive keeps the leadership of the Legislature informed about the work in progress. The Executive may reach out to the private sector and public advocates to assist it with the making of policy.

Electricity policy often is made by the Office of the President and an ERC. The Office of the President is responsible for making national electric policy, which guides the planning and development of the electric sector.[64] ERC makes policies that are needed to support its regulations.

For a typical electricity licensing regulation, which has the effect of law, a prospective electricity licensee must submit data that describes its financial resources and capacities. ERC would make policy in areas of evaluation and verification of the submitted data.

Duties and Powers of an Implementation Authority

[63] Coordination among the Government's different parts is essential for making policy. Cooperation is preferred among the different part, but it cannot be assured or mandated. Government policies rarely have universal acceptance within the different parts of a large Government.

[64] The written version of national electric policy either may be a separate, stand-alone government document or a section of National Energy Policy.

Either a Ministry with electricity responsibilities or an ERC is charged with implementing electric policy and any laws that are associated with it. As noted above, either an ERC or a Ministry can make subordinate policy that assists with the implementation of policies and laws.

Debate continues over the proper choice of whether a Ministry or an ERC governs the electric sector. Supporters of the selection of a Ministry argue that a well-trained and independent government bureaucracy is ample protection from secret legislative, private or public influence. That is, an Administrative Procedures Law (APL) is not required to assure this protection. Supporters of the selection of an ERC argue that government bureaucracy is incapable of withstanding these destructive influences, and therefore, the proper choice is an independent administrative agency staffed with vetted members and supported by an APL.

The duties and powers of the implementation authority remain the same notwithstanding the selection of a Ministry or an ERC. Their duties are mandated in the enabling legislation. The purpose of their inclusion in an enabling law is to ensure that either a Ministry or an ERC respects and follows the desires and intentions of the GoSL Legislature and Executive. Table 34 below lists duties that commonly are included in an enabling law.

Table 34. Commonly included duties of an electricity regulator

Number	Description
1	Independent, open, objective and transparent regulation
2	Non-discriminatory regulatory processes and practices
3	Assurance of equitable competition among service providers
4	Assurance of low regulatory risk for infrastructure investments
5	Enhancement of the ease of private-sector participation
6	Improvement or maintenance of the quality of electricity service
7	Protection of customer interests
8	Acceleration of installation of electricity services and networks
9	Acceleration of the development of electricity services and networks

Source: Unicon

Each duty points a Ministry or an ERC in a general direction. Administrative decisions, for example, always should be objective and transparent with an evidentiary foundation achieved through open administrative processes and procedures. Non-discrimination assists with the elimination of any claims or assertions of conflict of interest. Assurances concerning the operations of electric-power and electricity markets ease the concerns of investors and the private sector in general. Maintaining and improving electricity networks and power grids are essential general functions of a Ministry or an ERC as either exercises its powers over the private sector. Protecting customer interests is a universally accepted regulatory duty.

However, there may be instances where enabling laws place specific duties on a Ministry or an ERC. Three examples are contained in Table below. Each specific duty implies a course of action that is taken by a Ministry or an ERC.

Table 35. Sample of specific duties for an electricity regulator

Number	Description
1	Acceleration of the development of electricity networks,
2	Acceleration of the installation of electricity services
3	Enhancement of the ease of private-sector participation in an electricity sector

Source: Unicon

An enabling law necessarily contains a list of tasks that assists with the fulfilment of the duties of a Ministry or an ERC. Some essential tasks are listed in Table below. Each task is tied securely to the implementation of an enabling law or to preparation for the implementation of an enabling law.

Table 36. Sample of essential tasks for an electricity regulator

Number	Description
1	Implementation of electricity policies and regulations
2	Enforcement of electricity policies and regulations
3	Assurance of compliance with electrical codes, procedures and directives

Source: Unicon

Although not typically the case, an enabling law could contain a list of mandated behaviours on the part of a Ministry or an ERC. Each behaviour would establish the tenor of regulatory activity. Table below provides a list of regulatory behaviours that might be included in an enabling law to push the members of an ERC in the legislators' desired direction.

Table 37. Sample of mandated behaviours

Number	Description
1	Ensure compliance of regulation with national electricity policy
2	Integrate full-cost recovery of costs with protection of customers
3	Consult with public and stakeholders when applying regulations

Source: Unicon

Each mandated behaviour implies that a Ministry or an ERC does not function in isolation from the general population, stakeholders and Parliament. As a result, it is best to interact with the external environment. For example, consider the protection of customers versus the full recovery of the costs incurred by the providers of electric-power and electricity services.

On the one hand, a Ministry or an ERC should not drive an energy-service provider (ESP) into financial ruin.[65] On the other hand, neither should they make decisions that ensure electricity services are unaffordable. One of the most difficult decisions in this context is to accept or reject the policy that cross-subsidisation is an option for balancing the interests of consumers and ESPs.

An enabling law that establishes an ERC often provides a list of mandated regulations. Table below suggests the contents of such a list. The suggested list addresses the day-to-day activities of an ERC.

Table 38. Sample of mandated regulations

Number	Description
1	Procedure for approving an application for a license to provide electricity services
2	Establishment of license application fees and annual license fees
3	Procedures for setting and approving tariffs and tariff schedules
4	Procedure for addressing and resolving disputes
5	Procedure for auditing certified technicians, suppliers and service providers
6	Procedures for monitoring code and standards enforcement

Source: Unicon

Regulations addressing the day-to-day activities of ESPs are essential for the efficient and safe operation of an electricity network and the generation of electric power. This is the major reason why regulations are the primary means for achieving the implementation of electric policies and electric-power and electricity laws.

Electricity Policy

Several avenues are open for the making of electric policy. The Office of the President, the Legislature, a Ministry with jurisdiction over the electricity sector and an ERC makes electric policy. The Office of the President typically has the authority to issue Executive Orders with the effect of law. The Legislature has the authority to clarify and expand the policy presented in an Executive Order through the passage of laws. A Ministry with jurisdiction typically makes electric policy by developing and issuing a recommended policy that is subject to approval by the Council of Ministers or the Legislature. An ERC makes electric policy in the context of rulemaking.

The electric policy that emerges at the end of each avenue tends to differ in scope and generality. A Ministry makes the broadest and most general electric policy. The Legislature makes less general and more focused electric policy as it clarifies a national electricity or electric-power policy or expands an Executive Order. The Office of the President makes the least general electricity policy because it usually addresses a single electricity issue. An ERC makes electricity policy with the most specificity because it promulgates regulations. Table below contains some examples for an ERC.

[65] *Balancing the needs of consumers and ESPs does not rule out less-than-full-cost recovery tariffs, but such tariffs can be in place only for a limited time. Moreover, there is an unavoidable precondition. A financial mechanism should be in place that ensures that service providers are made financially whole.*

Table 39. Sample of policymaking by an electricity regulator

Number	Description
1	Selection the appropriate tariff-making methodology
2	Deployment of community-level renewable energy
3	Assistance with bringing electricity services to rural areas
4	Evaluation of alternative ways to deliver electricity services

Source: Unicon

Regulation of the Supply of Electric-Power Services

The regulation of the supply of electric-power and electricity services depends on the existing electric policies and laws. The existing laws and policies may be old, new or a mixture of old and new laws and policies. Still, for the most part, the existing configuration of policies and laws is driven by the existing circumstances and resulting needs and desires of the lawmakers.

On the one hand, the development of rules and regulations is focused on market entry and the prevention of anti-competitive behaviour whenever the dominant electric policy addresses the restructuring of the electric sector and the reform of electricity and electric-power markets. A secondary regulation in this regard is the licensing of incumbents and new entrants, and secondary rules are the procedures for issuing Requests for Proposals (RFPs) for new electric infrastructure and the procedures for accepting a proposal, evaluating it and issuing or not issuing a tender based on the results of the evaluation.

On the other hand, the development of rules and regulations focuses on technical issues whenever electric policy deals with reducing technical inefficiencies and improving the safety profiles of ESPs and the health profiles of electricity consumers. The most noticeable regulatory activities in this regard are initiatives with respect to standards, grid codes, certifications and inspections. For example, a regulation might be promulgated that approves standards that apply to the health and safety of consumers and employees of ESPs. Or perhaps, a regulation would be promulgated for the approval of quality-of-service standards and the associated certification procedures. Or, a regulation may be promulgated that ensures the issuance of certificates that certify compliance with these standards.

Current Setup – Somaliland

Institutional Environment

Most of the distribution and generation facilities are owned and operated by the private sector with minimal to no oversight by GoSL. Many ESPs may be characterised as self-generators. The remainder may be characterised as utilities. As a result, the electric sector is fragmented at the local level and decentralised at the national level. However, some of the ESPs within the sector have decided to abandon fragmentation and to consolidate their facilities.

Consolidation recognises the benefits of economies of scale, but it threatens competition. This threat is manageable if GoSL, the private sector and consumer and worker groups assure each other of falling prices and rising availability of more reliable and available electricity. Collaboration is the cleanest and fastest way to obtain these two ends when certain realities are taken under advisement.

Urban communities have more access to electricity than rural communities. The financially better-off members of the urban population can afford the electricity that they can access. The financially worse-off members of this community cannot. The capitalism practiced by the private sector does not yield affordable electricity prices for everyone. But fortunately, collaboration resolves some of these issues immediately and the remainder over time.

Governance

Governance within Somaliland occurs at the national and local levels. Government is parliamentary in character. Somaliland political governance system does not raise issue or questions about forming, codifying, implementing and executing national electric policy. The Constitution makes it clear that GoSL can form and enforce policy for Somaliland's electric sector.

Existing Institutional Arrangements for the Production and Delivery of Electricity

Government-owned generators provided electric power in major towns and cities in the past. However, even when they did exist they were not interconnected using a transmission network as a spine. Instead, each generation source was attached to an islanded distribution network.

Presently, generation infrastructure is owned and operated by private companies and NGOs. They also have isolated distribution networks. These networks are very rudimentary in comparison to the past distribution networks.

Single wires are the predominant form of connection between a generation source and a consumer. The effects are predictable. The electricity quality is low; that is, frequency fluctuations are common. Substandard O&M are common due to the makeshift nature of the current provider-specific distribution networks, and non-technical as well as technical losses are high.

The current generation infrastructure suffers similar problems. The reliability is low because each generation asset is a stand-alone facility. Capacity factors are low because of fuel scarcities. Consequently, electric power often is unavailable when needed or desired by consumers.

Larger and more profitable commercial enterprises in Somaliland own, operate and maintain generation assets to meet their own electricity needs first and sell their excess electricity directly to consumers. Their registered generation facilities were licensed by the Ministry of Public Works, which did provide some assurances concerning consumer and worker safety. However, these licenses have since expired.

Prior Work in Institutional Arrangements

MoEM drafted Energy Policy of Somaliland, which was approved by Council of Ministries in 2010, after four-year formulation process. This policy establishes regulatory framework for the Energy Sector of Somaliland with core objective to make a strong base for future developments within energy subsectors. Over the period of the first NDP of Somaliland, the MoEM worked with stakeholders to finalise the Somaliland Electricity Act; currently it is being presented to the Council of Ministries.

The Consultant has been informed by the Ministry officials that immediately following the presidential election of November 2017, work on the Electricity Bill would become the Ministry's top priority.

De-facto Procedures

In addition, the Ministry has succeeded greatly in implementing order in Somaliland electricity sector. There are factual procedures followed by the players in the sector, including power generators, consumers and the Government.

In the absence of formal regulation, the Ministry is running an informal system of permissions, standards and licenses, which, although basic, provides a solid foundation for the work being done toward formalising the rules of the electricity market.

For instance, there is a common practice at present, where no new power provider is able to install distribution equipment/wiring in the cities without a permission by the Ministry. An approval given by the Ministry is based on an inspection/audit conducted by the officers, who make sure that the are certain minimal standards followed by the power producers (such standards, however, are not documented formally).

Shortly after the election, the Ministry is planning to implement the concept of interim licenses that will be given to power providers. Such licenses will be paid by the providers through the Ministry of Finance directly to the country budget. The procedure of licensing will be accompanied by power provider audits conducted by Ministry representatives.

Exact arrangements (license fees, license terms etc.) are currently being finalised by the Ministry.

Gaps in Institutional Arrangements

Growth in electric infrastructure over time is desirable and beneficial virtually everywhere on the globe, but the technical rationalisation and repair of this infrastructure are immediate and essential needs for Somaliland's well-being. Electric policies rationalise the growth potential of the electric sector.[66] Electricity and electric-power laws and institutions provide the framework for an accessible electric sector. Regulations and technical procedures assist with the transition to efficient electric markets.

One example is formal procurement procedures that help to assure the availability of parts for the repair of the electric infrastructure.[67] Another example is a grid code that governs the interconnection of generation assets. As a group then, policies, laws, institutions, regulations and procedures provide the tools that would enable GoSL to expand the electric sector and meet consumer needs.

It has been well documented by the body of prior reports that a central authority is not involved in licensing of ESPs, setting of electricity standards and monitoring of the activities of ESPs in the areas of generation, transmission and distribution. Similarly, a central authority is not involved in the creation of codes and guidelines that refer to O&M of the electric infrastructure, appliances and inside wiring.

An often-pursued solution for closing institutional gaps within the electric sector involves passage of electricity and electric-power laws, introduction of new institutions and the initiation of new processes and practices. The widely-agreed upon full-blown approach to pursuing this solution involves a specific set of government and private-sector actions that may occur in any order. GoSL approves a national electric policy and passes a national electricity and electric-power laws.[68] If the national electricity and electric-power laws establish an ERC, then GoSL “stands-up” an ERC with an adequate staff to fulfil its legislative mandates.[69]

The private sector, meanwhile, contributes to the development of a transmission code and a transmission grid. It also, if possible, provides staff and expertise for the development of electricity and electric-power standards. It further agrees to follow guidelines for the conduct of distribution-network planning and a distribution code when feasible to do so. A long timeframe from beginning to end is associated with this solution, and as well, it typically is characterised by missteps. The challenges encountered during the pursuit of this solution have led to its temporary abandonment in a few instances.[70] For Somaliland, a suggestion has been made that self-regulation in the form of an Association should be substituted for conventional regulation for the short and immediate terms.

Master Plan and Institutional Arrangements

[66] *Policies are government documents that do not have the force of law, but they do possess the stamp of approval from the Executive and Legislative branches of Government.*

[67] *Many procedures are relied upon to install transmission and distribution lines properly. Similarly, numerous procedures are called upon during the installation and commissioning of a generator.*

[68] *A national electric policy is a framework, and a national electric law is a means to realise the government’s desires and to fulfill the government’s intentions.*

[69] *An Energy Regulatory Commission among other things promulgates regulations that implement the national electric policy in a manner that conforms to the national electric law.*

[70] *Temporary abandonment has occurred in Iraq and Kurdistan.*

Work is in progress on a Power Master Plan for the electric sector. While a Power Master Plan is not an official policy document per se it is a government-approved infrastructure-development plan that should respect existing polices, laws and regulations. Respect in this context is defined as compliance with laws and regulations and conformance with policies. If policies, laws and regulations are not present, then alternative preconditions are considered during the development of a Power Master Plan. One of these preconditions is whether the existence of pertinent policies, laws and regulations is a prerequisite for the execution of a Power Master Plan.

Practically speaking, the question of whether the existence of laws and regulations is a valid precondition for a Power Master Plan is rhetorical. Electric-power or electricity infrastructure has been constructed and commissioned without their benefits. However, the location and timing of the expansion of an electric sector is difficult to achieve without guidance provided through an institutional arrangement. Legislatures, ministries, commissions, corporations, donors and lenders and NGOs are examples. What follows is a summary of the more prominent ones throughout Somaliland.

International Best Practices

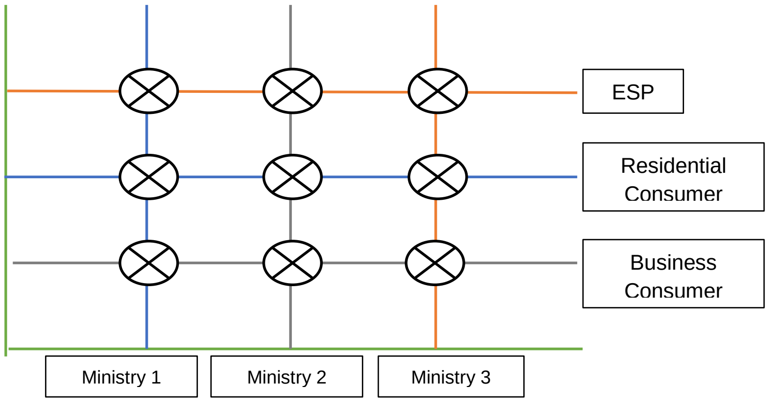
Past efforts to restructure an industry or reform a market have revealed that new institutions are not perfect at their inception. Unfortunately, this information was discovered after the institutions had been put in place. Monitoring and evaluation (M&E) techniques were developed to shorten the time between inception and the discovery of unexpected adverse side effects. But, the question is whether an ERC is the only government institution that can be equipped to perform these tasks, or can other institutions perform them as well.

Different governments answered this question differently. The United States chose the Regional Transmission Organisation (RTO) to monitor and evaluate industry restructuring and market reform. A RTO is a private company that works closely with the federal and state regulatory commissions. Iraq, Japan and Pakistan chose different paths.

Path Taken by the Government of Iraq

To begin, the private sector is absent with respect to Iraq's electric sector. The effect on the public is that it does not experience the benefits of corporate responsibility, instead, the public leans heavily on government responsibility. That is, presently, the public's concerns over the availability and reliability of electric power and quality of electricity service are voiced to the Government of Iraq (GOI) and no one else. GOI, for its part, redirects these concerns to government institutions for action or inaction. The map for this communication channel, shown in Figure 42 is a two-dimensional plane. The horizontal axis contains Ministries in Iraq.

Figure 42. Two-dimensional communication between Ministry and others



Source: Unicon-constructed

Each Ministry is represented as a vertical line at a specific location on the horizontal axis. Although there surely are more than three Ministries in Iraq. Figure 42 shows only three of them. The vertical axis contains the electricity consuming businesses, the electricity consuming residences and ESPs. They are represented by horizontal line at a specific location on the vertical axis. Figure 42 shows three of them. Each circle with an X inside of it represents a communication between a business, a residential user or an ESP with a Ministry.

Nine individual lines of communication are shown in Figure 42. As an example, consider the vertical line that represents Ministry 1. The bottom circle with X represents and individual communication between a single business customer and Ministry 1. The circle in the middle represents a single communication between a residential customer and Ministry 1. The top circle represents a communication between Ministry 1 and an ESP.

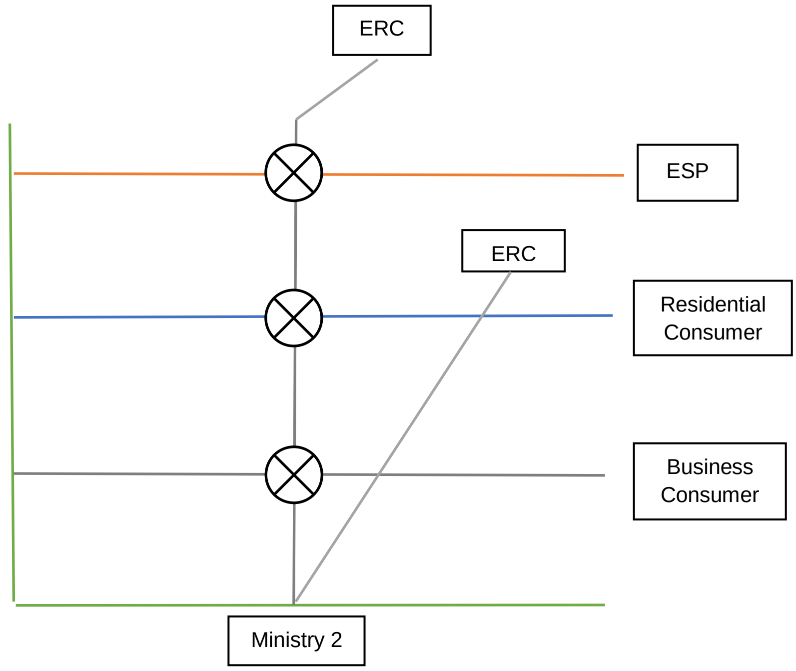
Figure 42 captures the concept that an institution does not exist that enables all three groups to communicate with any Ministry at the same time, in the same venue and under the same rules. In the absence of such an institution, a business customer might have a stronger and more accessible line of communication with a Ministry than say a residential customer or an ESP. It also captures the notion that an ESP does not know what a business or residential customer is talking about to the Ministry, and identically, a residential customer does not know what an ESP and business customer are talking about to the Ministry, and so on.

Figure 43 below adds an institution to Figure 42 in the form of a third dimension. This institution is open, transparent and accessible to everyone and anyone who wishes to communicate with a Ministry as a group.[71] Furthermore, this institution extends the same benefits to an individual who wishes to communicate directly with a Ministry. Note, however, that an individual communication is not subject to same rules that would apply when communications with a Ministry are run through another government institution that is sanctioned by a law.

[71] *In regulatory terms, an intervenor represents the entire group usually through a lawyer.*

This institution selected for representation in Figure 43 is an ERC. For the sake of clarity, it is assumed that ESPs, residential electricity users and business electricity users only communicate with Ministry-2. Also for the sake clarity it is assumed that the black horizontal line represents the entire group if business customers. The blue horizontal line represents the entire group of residential customers, and the red horizontal line represents the entire group of ESPs. The black vertical line represents Ministry-2, and the two green oblique lines represent the upper and lower edges of plane that denotes an ERC that captures the entire groups of ESPs, residential users and business users.

Figure 43. Three-dimensional communication including the regulatory authority



Source: Unicon-constructed

The description of what is occurring in Figure 43 differs significantly from the description of what was occurring in Figure 42. The green plane in Figure 43 is a unifying force in the form of a universal line of communication that is available to Ministry-2 and the parties that are affected by actions taken by Ministry-2. This universal line of communication is named an ERC, and opening lines of communication is exactly what a regulatory authority does in addition to promulgating regulations, issuing final rules and creating policies that assist with the implementation of a law. But this is not all that a third dimension does. The green plane also opens lines of communication among the ESPs, residential users and business users that are filtered through an ERC, which is subject to specific regulations that govern these communications.

The proper interpretation of the three circles with an X within them is as follows. Each line of communication always is open and transparent. Each line of communication may be active simultaneously, or each line of communication may be active while the others are inactive. Or, two lines of communications may be active while the remaining line is inactive. Ideally speaking, an ERC is the champion of open and transparent communications that lead to fair, just and reasonable decisions. The decisions that generally come to mind are rules, regulations, guidelines and frameworks.

To this date, it has been difficult for GOI to attract non-local companies to enter the electric sector and improve or expand its infrastructure. Several causes have been given that range from government obstructionism to unacceptable economic or institutional risks. Table 40 summarises the progression of causes in this regard. The first cause was the lack of will on the part of GOI to mandate the entry of the private sector into a reformed generation market via a law. The second cause was a grouping of unacceptable institutional risks. For example, GOI had not established by law and stood up an ERC for the electric sector and furthermore had not clarified the legal framework for contracts with GOI. The third cause was and continues to be a grouping of unacceptable fuel-supply and payment risks even though regulatory risks have been diminished with respect to Request for Proposals (RFP), their evaluation and recommendation.[72]

Table 40. Progression of causes for poor private sector performance

Phase of Time	Description of Causes
Period 1	Lack of government will to mandate private-sector entry in the electricity sector.
Period 2	Failure to establish and stand up an ERC to assist in the governance of the electricity sector
Period 3	Failure to reduce economic risks to levels acceptable to private-sector companies

Source: Unicon

Repeated efforts have been made to reverse the dominant failure occurring during the second period. Each attempt has failed in one degree or another; however, each failure has pushed GOI closer to a functioning regulatory capability. It has been asserted in the context of independent research on the status of economic regulation in Iraq that the regulatory Department within the IMOE performs its tasks conscientiously and adequately. The justification is that it has been documented that Iraqi staff is competent and trained sufficiently to complete the required regulatory work.[73]

The first effort occurred in 2004-2005. It failed because it proved to be impossible to dismantle decision-making by the individual within the Executive of GOI. The draft electricity law did not protect the Executive's interests sufficiently. An important lesson was learned. Establishing an ERC cannot be achieved without being sensitive to the balance-of-power between an Executive and an ERC. As an example, the draft law did not state clearly that the Executive and an ERC would be partners. Furthermore, it did not identify where senior-partnership status is transferred between them during

[72] *Bilal A. Wahab, Iraq and KRG Energy Policies: Actors, Challenges and Opportunities, Institute of Regional and International Studies, The American University of Iraq, May 2014*

[73] *Bilal A. Wahab, Iraq and KRG Energy Policies: Actors, Challenges and Opportunities, Institute of Regional and International Studies, The American University of Iraq, May 2014*

the governance of the electric sector. And lastly, it proved to be too difficult to convince the Executive that an ERC would collaborate with it.

Still, Iraq needed more generation facilities to meet the demand for electric power. As a result, a new direction was taken to establish regulatory capacity. As an alternative, GOI decided to pursue “regulation by contract”; that is, a contractual relationship between GOI and the private sector such that a private-sector company builds, owns and operates generation facilities.[74]

Challenging issues were encountered immediately. Each contract is unique even though there are standardised parts. Each contract has different transactions costs. Each contract addresses the risks differently. Each contract is dependent on the existing laws, and how the laws are interpreted and enforced. And lastly, each contract is subject to a re-negotiation risk. GOI was unfamiliar with these issues, and the Iraq Ministry of Energy (IMOE) did not have the regulatory or legal capacity to deal with them effectively. Iraq’s legal and regulatory institutions had been in decline before 2004.[75]

Neither the failed economic regulator nor the failed “regulation by contract” altered the fact that Iraq needed more generation facilities to meet the demand for electric power. This reality led IMOE to purchase numerous generation assets from a non-local producer/supplier. The new generation facilities had to be installed and commissioned before they could reduce the pressures on IMOE and GOI. The proper tool for this purpose is an engineering-procurement-construction (EPC) contract wherein a private company builds the new electricity infrastructure and hands it over to IMOE for O&M. This course of action produced a beneficial ancillary outcome. Data were compiled, and procedures were developed that would guide the construction of new infrastructure in the future.[76]

In 2010, GOI ruled that the private sector should have a role in repairing and expanding the infrastructure serving the electric sector. A second law was drafted as a result. It mandated a slow progression of private-sector participation (PSP) in the electric sector, and it mainly limited IMOE’s roles to establishing licensing prerequisites, defining consumer obligations, protecting consumer rights, encouraging private-sector investment, performing M&E and making regulatory policies.[77]

Following form, the second draft law was not passed by Parliament. However, what is important is that this second bill made it to Parliament for its consideration. Also important is that the continuing difficulties in passing this draft law revealed deep-seated concerns among the elected officials. A

[74] *Such a company is called a BOO (Build Own and Operate). Another option was that the private company would build, own, operate the generation facilities for a pre-determined time, and subsequently, the generation facilities are transferred to the Government of Iraq. This type of company is called a BOOT.*
[75] *Bethsheba Crocker, “Restructuring Iraq’s Economy”, The Washington Quarterly 27 No. 4 (2004) 73-93*
[76] *Robust procedural capacity was built within the IMOE in operations, maintenance and inventory management. This capacity was embedded among a small and committed cadre of engineers and operations and maintenance personnel.*
[77] *World Bank, Doing Business 2009: Country Profile for Iraq - Comparing Regulation in 181 Economies (Washington, DC: World Bank, 2008); John Sachs, Shamshek Asad, and Hussain Qaragholi, “Iraq’s Power Crisis and the Need to Re-Engage the Private Sector -Smartly,” Middle East Economic Survey*

blocking coalition had risen that championed the protection of national assets, or fears additional strife, or opposition to the privatisation of the electricity sector.[78]

Time Line for Building Regulatory Capacity within the IMOE

The course of events leading to the authorisation of a Regulatory Department within the IMOE is summarised in Table 41. This Table supports a few important conclusions. The building of regulatory capacity requires focused effort over a long period of time. Moreover, new tactical approaches dictated by country-specific concerns need to be developed and applied to overcome the objections of several different blocking coalitions.

Table 41. Authorisation of a regulatory department within the Iraq Ministry of Electricity

Year	Summary of Events Leading to Authorisation
2004	Face-to-face discussion with a single senior ministry official. Regulatory buy-in not established. A buy-in on formalised tariff-making was obtained
2005	Discussions with the Deputy Minister of Electricity and the Director General of Planning. The core topic was creation of an economic regulator within the IMOE. Regulatory capacity building continued at the staff level using workshops and lectures as the vehicles.
2006 -2008	A hiatus was imposed on regulatory capacity building
2008	Regulatory capacity building was re-initiated and accelerated at the staff level. Capacity-building vehicles continued to be workshops and lectures. Capacity-building staff was expanded to include short-term experts.
2009	An educational effort was begun to convince the Minister of Electricity that a Regulatory Directorate was the best way to incorporate regulatory capacity within the IMOE. Capacity building continued among staff.
2010	The effort to create a Regulatory Directorate failed, but the establishment of a Regulatory Department succeeded. New RFPs electricity infrastructure were responded to by regional and local private-sector companies.

Source: Unicon

An effort to start building regulatory capacity within the IMOE was initiated in 2004 through several face-to-face discussions with a single senior ministry official. These discussions were used to explain in detail the opportunities that economic regulation created for the expansion of the electric infrastructure. For example, it was explained how the inflow of financial capital would lessen constraints on the national and IMOE's budgets. These discussions did not result in a regulatory buy-in, but a door was opened to interact closely with staff charged with tariff-making.[79]

[78] Luay Al-Khatteeb and Harry Istepanian, "Iraq Draft Electricity Law: What's Right, What's Wrong," Petroleum Economist, 14 April 2014, http://www.brookings.edu/research/papers/2014/04/15-iraq-electricity-law-alkhatteeb-istepaniaean
[79] Face-to-face discussions with staff focused on the mechanics of estimating the revenue requirement for the electric sector.

At the same time, a framework and plan were developed to stand up an independent, external economic regulator. The framework consisted of an organisational chart for the regulator, and the plan consisted of a catalogue of needed equipment and operating materials and a cost estimate for standing up the regulator. The framework and plan were not put into practice.

The effort continued in 2005, but a different approach was taken to build regulatory capacity within Iraq. It consisted of discussions with the Deputy Minister of Electricity and the Director General of Planning that reiterated the benefits and opportunities associated with the implementation of economic regulation. However, it also was explained that some of the benefits and opportunities would be lost if the economic regulator was located within the Ministry, but on net it would be advantageous to establish an internal regulatory authority.

This discussion was well received, and the process was started to establish this authority; however, it ground to a halt when the Minister of Electricity was removed, and no replacement was imminent. At the same time, discussions on capacity building continued at the staff level. The topics addressed were the principles of cost-of-service regulation and the elements of the revenue-requirements equation which is essential for effective cost-of-service regulation. The capacity building was more formalised than previously using workshops and lectures along with detailed hand-outs. Building regulatory capacity was put on hold from 2006 to 2008.[80]

Regulatory capacity building began again in 2008. This effort focused on how adopting and using regulatory principles and procedures would rationalise the electricity tariff and contribute to the attraction of private capital. It was offered in response to the then current interest in “regulation by contract”, which is rooted heavily in the rule of law, transparency, openness and non-discrimination. The capacity building vehicles, as previously, were workshops and lectures, but the capacity-building cadre was increased to include short-term experts who were brought in to conduct the workshops and provide the lectures.

At the organisational level, a programme was initiated to convince the Director General of Planning and the Minister that a Regulatory Directorate would be the best vehicle for an internal economic regulator.[81] Following prior form, the formation of a Regulatory Directorate within the IMOE was blocked by opposition to a new Directorate and the parliamentary procedures that had to be followed to establish a new Directorate in any Ministry. To overcome these obstacles, it was argued that a Regulatory Department within an existing Directorate was the next best option although some independence was lost. This change in tactics proved to be fruitful, and a Regulatory Department was created prior to 2014.[82]

[80] *Regulatory capacity building was replaced with renewed emphasis on passing the 2005 draft electricity law.*

[81] *The face to face discussions with staff focused on the mechanics of estimating the revenue requirement for the electricity sector.*

[82] *Email to author indicating that the Minister of Electricity had signed an order establishing the Regulatory Department, February 2014.*

In 2010-2011, IMOE conducted a tender for four (4) electric infrastructure projects. Some IMOE's generation assets would be sold to the winning bidders, thereby creating an IPP tender. The depth and breadth of bidders was reduced by IMOE's refusal to accept all the risk of the failure of the Iraq Ministry of Oil (IMO) to deliver fuel to the generation sites. Only local companies (with some international participation in consortiums) bid. These bids were analysed IMOE's IPP team that included staff from the Regulatory Department. The bids were rejected, and EPC contracts were substituted to meet the demand for electric power.

In 2013, the Cabinet of Iraq without the support of an electricity and electric-power laws instructed the IMOE to restart the IPP programme with the order to begin negotiations with three independent Iraqi companies. Several months later in 2014, the Cabinet passed Resolution 90 of 2014, enabling IMOE to sign PPAs with these companies only. Subsequently, two Iraqi IPPs entered into PPAs with IMOE and the National Investment Commission (NIC) that would result in the use of combined-cycle gas turbine plants to generate electric power. The PPAs were followed by the execution of power purchase contracts (PPC). However, other issues beyond the control of the IMOE and the Regulatory Department have slowed down the IPPs efforts to build new generation facilities.[83]

Path Taken by the Government of Japan

A lifetime of study may be needed to grasp the responsibilities and accountabilities of bureaucracy in Japan. This study may very well rival the study of the bureaucracy that famously characterised the Byzantine Empire. But notwithstanding the difficulty of these studies, two facts are well known to the public. The Byzantine and Japanese bureaucracies are extraordinarily structured, and they are immensely powerful. The Byzantine and Japanese bureaucracies are institutions, and they make policy and issue orders, ordinances, regulations and above all government decisions. The individuals within these bureaucracies share the responsibilities and accountabilities.

From this vantage point, it is perceived clearly why the economic regulation of Japan's electric sector took root so quickly and without strong opposition from any coalition of affected parties. Economic regulation simply has been perceived as another aspect of bureaucracy that had not been appreciated previously. The catalyst leading to this new appreciation was the influence that was wielded by a foreign government after the end of World War II.

Japan always has suffered noticeable limitations on the availability of the fossil fuels that are used to generate electric power. The persistence of this difficulty obligated the Government of Japan (GOJ) to be involved in the generation of electric power and its transmission as well as the delivery of electricity to consumers. The persistence of the natural-resource limitations also obligated Japan's bureaucracy to proceed cautiously as it performed its task of re-establishing the electric sector after the end of World War II.

[83] One issue is the transfer of land to the IPPs. Another issue is the Iraq Ministry of Finance's (IMOF) reluctance to issue payment guarantees. Potential issues are the Transmission Grid Code and the licensing process have not been fully tested.

Decision-making by Japan's bureaucracy in this area was coloured by accepting two influential conventional wisdoms that were offered to it at the end of World War II. The first was that the private sector is the most suitable economic institution for repairing and expanding the electric infrastructure and for supplying electric-power and electricity to users. The second was that electric power and electricity are two essential services that could not be left to the vagaries and volatilities of market forces.[84] Consequently, Japan's bureaucracy agreed that economic regulation is a necessary element of the effective governance of the electric sector.

However, there were bumps on the road to the general adoption of the two conventional wisdoms. The first bump on the road was that the electric sector had to receive direct financial assistance from GOJ and others to rebuild the electric infrastructure. The second bump was that economic regulation of the sector had to be performed by Japan's bureaucracy. That is, bureaucratic control of the electric sector is superior to the control provided by an independent ERC even with the protections of an APL.[85]

The Structure of Electric Sector Regulation in Japan

The regulation of the electric sector in Japan is experiencing a change in direction. It is transitioning from a focus-on-form to a focus-on-function. That is, policy, laws and regulations are transitioning from the industrial organisation of the electric sector prior to the regulation of generation, transmission and distribution.[86] However, the structure of the regulatory process has not changed. Figure 44 captures the depth and breadth of regulatory influences on the electric sector of Japan.

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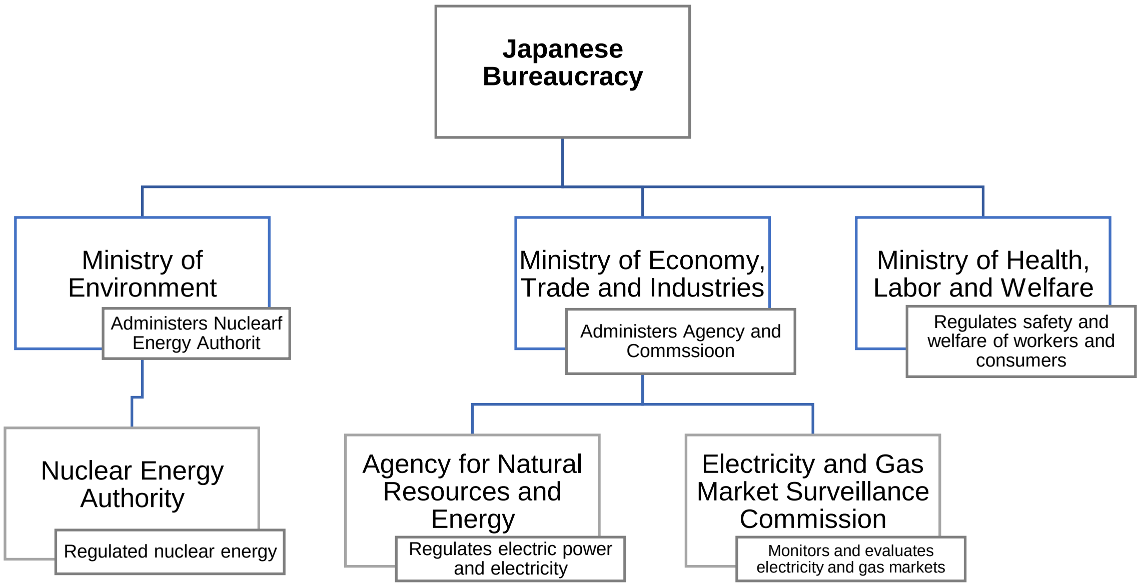
[84] The theory supporting these beliefs was that a monopoly with a franchised service territory is the most efficient industrial organisation of an economic sector that produces essential services using production and deliver processes that require a quasi-guaranteed stream of revenue to support them. The availability of natural gas and the introduction of the combined-cycle gas turbine changed this thinking. The modular nature of the combined-cycle gas turbine was believed to be sufficient to open the generation market to the forces of competition, and the cost and technological improvements in renewable energy have opened the door for competition with respect to the delivery and supply of retail electricity. Of course, these two modern beliefs irrevocably change the characteristics of the transmitting electric power and the distributing electricity.

[85] An administrative procedures law governs the actions taken and the decisions made by an ERC and any other administrative body that is a government entity.

[86] Japan – The Energy Regulation and Market Review, edition 5 – Reiji Takahashi, Norifumi Takeuchi. Wataru Higuchi, Kunihuro Yokoi, Kunitaro Yabuki

Figure 44. Reporting hierarchy of Japanese economic and safety regulation



Source: Unicon-constructed

Table 42. Institutional arrangement providing oversight within the Japanese bureaucracy

Type	Accountability	Responsibilities
Ministry	Economy, Trade and Industry	Grant of licenses to general transmission and distribution operators as well as transmitters; administration of (a) registration of retail electricity providers, (b)filings of power generators, (c) security of electricity facilities, (d) security of electricity infrastructure construction, (e) environmental assessment for the development of new power plants (Authorisation is the EBA.)
Ministry	Environment	Countermeasures against global warming; opinions from an environmental perspective with respect to the construction of new power plants (Authorisation is the EIAA).
Ministry	Health, Labour and Welfare	Safety of workers (Authorisation is the ISHL)

Source: Electricity Regulation in Japan: Overview, Takahiro Kobayashi

Table 42, above, summarises the responsibilities and accountabilities of three of GOJ's Ministries. Each of them has specific responsibilities and accountabilities with respect to the regulation of the electric sector.

The regulation of the electric sector by the GOJ goes deeper than the three Ministries described above. Specifically, METI is the home of an agency and a commission with regulatory responsibilities and accountabilities. Moreover, the agency and the commission report to METI. Following the format chosen above, Table 43 summarises their responsibilities and accountabilities.

Table 43. Institutional srrangements of electricity regulation in Japan

Type	Accountability	Responsibilities
Agency	Natural Resources and Energy	Implementing of electricity-related policies; Drafting of Energy Basic Plan; Drafting of the Energy Mix Plan; Securing a stable, nationwide supply of electricity; Securing a stable supply of fuel and other resources for the generation of electric power; Promoting the installation of renewable-energy generation; Designing and administrating the regulatory systems for the electricity and gas markets; Considering nuclear-energy policies (Authorisation is being an affiliated agency of the METI).
Commission	Electricity and Gas Market Surveillance	Ensuring the integrity of the electricity, gas and heat-supply markets; Ensuring the neutrality of the network divisions; Overseeing the electricity, gas and heat-supply markets using audits of the utilities business and accounting processes and procedures; Issuing adjurations for business improvement and regulated retail prices; Requesting reports from the utilities and retail suppliers, Conducting inspections of the retail providers; Providing suggestions to the METI Minister with respect to the approval of wheeling charges or the registration of retail providers (Authorisation is reports only to the METI Minister).

Source: Electricity Regulation in Japan: Overview, Takahiro Kobayashi

The same approach is followed for the regulation of nuclear energy. The Nuclear Energy Authority (NRA) is an affiliate of Japan's Ministry of Environment (JMOE). Consequently, JMOE oversees this source of economic regulation within the Japanese bureaucracy. Following the format chosen above, Table 44 summarises its responsibilities and accountabilities.

Table 44. Institutional arrangement providing regulation of nuclear energy

Type	Accountability	Responsibilities
Authority	Nuclear regulation	Monitors and regulates nuclear facilities (authorisation is being an affiliated agency of the Ministry of Environment).

Source: Electricity Regulation in Japan: Overview, Takahiro Kobayashi

However, the regulation of Japan's electric sector is not restricted completely to the bureaucracy. The change in regulatory focus from form to function has necessitated the introduction of a non-government actor into the regulatory mix. The Organisation of Cross-Regional Control of Transmission Operators (OCCTO) is a not-for-profit, private-sector entity. Once again, following format, Table 45 below summarises its duties and responsibilities.

Table 45. Institutional arrangement providing regulation of transmission operators

Type	Accountability	Responsibilities
Private-sector Organisation	Cross-regional Coordination of Transmission Operators	Operation of the national transmission grid; Coordination of the nationwide supply and demand of electric power; Promotion of the construction of electric infrastructure for cross-regional transmission (Authorisation is the EBA).

Source: Electricity Regulation in Japan: Overview, Takahiro Kobayashi

<u>*Time Line Leading to the Current Regulatory Bureaucracy*</u>

As noted previously, two catastrophic events changed the regulatory direction taken by GOJ and its bureaucracy. They are the Great East Japan Earthquake and the nuclear accident at Fukushima Daiichi. What follows is Table 46, which describes the path over time to the current bureaucracy that regulates the electric sector. This time line omits the regulatory arrangements.

Prior to 2012, the primary regulatory bureaucracy for Japan's electric sector consisted of the Ministry of Economy, Trade and Industries (METI) and the Agency of Natural Resources and Energy (ANRE). The enabling legislation that supported this regulatory institutional arrangement consisted of the Electricity Business Act (EBA) and the Ministry of Economy, Trade and Industries Establishment Act (METI Establishment Act). The EBA directs the bureaucracy to regulate any business that is involved in the generation, transmission and distribution of electric power and the sale of electricity to consumers. The METI Establishment Act provides this Ministry with the authority to make comprehensive energy and mineral-resources policies that are constructed to secure the stable and efficient provision of electric power.[87] Other legal vehicles supporting the operation of METI and ANRE include enforcement orders and ordinances.

Table 46. Time line to new electric regulation bureaucracy in Japan

Year	Event	New Institutional Arrangement	Enabling Legislation
2012	Electricity System Reform Program	Feed-in tariffs to assist with the procurement of renewable energy technologies	Act on Special Measures Concerning Procurement of Renewable Energy Sourced by Electric Utilities

[87] *Japan – The Energy Regulation and Market Review, edition 5 – Reiji Takahashi, Norifumi Takeuchi. Wataru Higuchi, Kunihuro Yokoi, Kunitaro Yabuki*

Year	Event	New Institutional Arrangement	Enabling Legislation
2015	Liberalise retail electricity market	Organisation for Cross-Regional Coordination of Transmission Operators	Enabling legislation is not required because the OCCTO is not a government institution
2015	Monitor retail electricity market	Electricity Market Surveillance Commission	Electricity Business Act
2016	Monitor retail gas market	Electricity and Gas Market Surveillance Commission	Revised Electricity Business Act

Source: Unicon

The Electricity System Reform Programme (ESRP) was initiated in 2012 by GOJ with the passage of the Act on Special Measures Concerning Procurement of Renewable Energy Sourced by Electric Utilities (Renewable Energy Act). This legislation was passed in response to the Great East Earthquake and the accident at Fukushima Daiichi. The objective was to accelerate the procurement of renewable-energy technologies to provide Japan's consumers with a new source of electric power. Feed-in tariffs were approved in the same year to assist with the implementation of this first-stage of the ESRP.[88]

The OCCTO was established and started operation in April of 2015. It primary responsibilities are to monitor the supply of electricity, the balance of the demand for electric power and the electric system's frequencies. The purpose is to coordinate electricity markets. The membership of OCCTO, which are private-sector companies, must provide specific information and data to OCCTO on a continuous basis. The real-time analysis of these data and information enables OCCTO to compel its members to supply electric power to other member to continue the balance of the electric system. Its secondary responsibility is to instruct or recommend to a member that it is required to ensure a stable supply of electricity.

The Electricity Market Surveillance Commission (EMSC) was established in September 2015.[89] Its responsibility is to monitor the liberalised retail electricity market.[90] The full liberalisation of this market is supported by revisions to the EBA, which occurred in 2016. Hence, EMSC was established prior to the liberalisation of the retail-electricity market, and therefore, it was a preparatory action. It complemented the change in focus from the industrial organisation of the electric sector to the functions of the generation, transmission and distribution markets.[91]

Path Taken by the Government of Pakistan

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[88] Japan's feed-in tariff has been revised continuously to deal with rapid entry into the renewable-energy market. See, Japan - The Energy Regulation and Market Review - edition 5, Reiji Takahashi, Norifumi Takeuchi. Wataru Higuchi, Kunihu ro Yokoi, Kunitaro Yabuki

[89] Monitoring the liberalised gas market was assigned to the Electricity Market Surveillance Commission (EMSC) in 2016, and the Commission's name was changed to the Electricity and Gas Market Surveillance Commission (EGMSC).

[90] The retail-electricity market is restricted to the sale of electricity to industrial, commercial and residential customers. A retail-electricity provider is not involved in the generation or transmission of electric power or the distribution of electricity.

[91] Revisions to EBA are the cause of the change in focus that occurred in 2016.

Table 47 below traces the legislative path to the economic regulation of Pakistan's electric sector. Eight-seven (87) passed between the passage of the Electricity Law of 1919 (EL1910) and the Regulation of Generation, Transmission and Distribution of Electric Power Act of 1997 (RA). During the interim the Water and Power Development Authority (WAPDA) and the Ministry of Water and Power (MOWP) shared the responsibility of governing the electric sector.[92]

Table 47. Legislation related to the economic regulation of the Pakistan electric sector

Year	Act	Comments
1910	Electricity Act	This law addressed the powers and responsibilities of the federal, provincial and local governments. It also placed the governance of hydro-electric power within the domain of the federal government.
1994	Private-Sector Power Act	This law altered the industrial organisation of the electric sector. It fashioned entry points for independent power producers (IPPs). It also fashioned an entry point for the transition of a government-owned electricity provider to an investor-owned electricity provider without the privatisation of the electric sector. Lastly, electricity providers allowed to purchase power from the IPPs.
1997	Regulation of Generation, Transmission and Distribution of Electric Power Act	This law created the economic regulator and codified its primary responsibility of regulating the transition of a monopolistic, government-owned electric sector to a competitive and privatised electric sector.

Source: Unicon

While not included in Table 47, another significant law was passed in 2002.[93] Like the Private Sector Power Act (PSPA) it addressed structural issues associated with the transition of a government-owned and operated electric sector to an industrial organisation that included private-sector companies and other ancillary participants.

Each of the laws contained in Table 47 were passed without the benefit of an electric-power or electricity policy. As a result, these laws did not reflect the full intent of the Government of Pakistan (GOP). Instead, they were written to resolve short-term, pressing issues that were affecting the electric sector adversely. This omission was corrected after the passage of the Power Act of 2002.

Table 48 below contains major electric-power and electricity policies that were adopted after the passage of the Power Act of 2002. The first policy addressed the GOP's desires with respect to the role of renewable energy in the electric sector. The second policy was adopted in reaction to the unexpected outcomes that occurred after IPPs entered the electric sector.[94] This policy revealed the

92 MOWP benefitted by having access to the technical and administrative capabilities of WAPDA.
93 The law is The Power Act.
94 If for whatever reason the government-owned electricity provider or the GOP did not pay IPPs in a timely manner, then IPPs

GOP's desire to substitute public private partnerships (PPPs) for IPPs.[95] This policy was revised in 2010. The third major policy was the National Power Policy (NPP). A draft policy, not included in Table 48, reveals the desires of the GOP with respect to furthering energy conservation.

Table 48. Major electric power and electricity policies for Pakistan

Year	Policy
2006	Policy for the Development of Renewable Energy for Power Generation
2007	Public Private Partnership Policy
2010	Public Private Partnership Policy (revised)
2013	National Power Policy

Source: Unicon

Table 49. Legislative bills after 2002 in Pakistan

Year	Legislative Bills
2016	Public Private Partnership Act
2016	Pakistan Council for Renewable Energy Technologies Act

Source: Unicon

These policies resulted in the emergence of two legislative bills that may or may not become law in Pakistan. They are listed in Table 49 above. The first bill seeks to codify the legal framework for PPPs in Pakistan.[96] Presumably, the purpose is to enable GOP to regulate PPPs within its electric sector. The second bill seeks to create the Pakistan Council for Renewable Energy Technologies (PCRET). Presumably, the Council will be authorised to promulgate regulations and approve standards that apply to renewable-energy technologies.[97]

Closure of Gaps

Policies, laws, regulations, rules, standards, codes, guidelines and procedures are the hands-on tools that are used to fill gaps in electric infrastructure, plant O&M and worker/consumer safety. Various institutional arrangements are used throughout the world to develop policies, pass laws, promulgate regulations, make rules, set standards, create codes, present guidelines and implement procedures. The availability of different institutional arrangements is required because each country has different initial conditions even though each country has the same overall objective of a sufficient supply of reliable and affordable electric power and electricity services.

Status of Gaps

stopped supplying electric power.

95 This document also contains a regulatory framework for PPPs.

96 This bill is meant to codify international best practices in this area.

97 If these powers were not granted to this Council, then a law would not be necessary to create it.

Although gaps often are numerous and large, they are not insurmountable. Two avenues are available for GoSL to travel to fill the institutional gaps that exist in Somaliland electric sector. GoSL may choose to rely on a Ministry to make policy and to rely on Parliament to draft a bill and pass it into law to formalise policy. GoSL also may choose to rely on Parliament to pass a law that establishes an ERC and thereby initiating the process leading to rule-making, promulgation of regulations, setting of standards, creation of codes and presentation of guidelines; all of which affect the operations of the ESPs.

Alternatively, the GoSL may choose to form councils that have the capability to recommend policies and work with a Ministry and an Association to implement them. Also, GoSL may choose to convene an ad hoc committee that is charged with recommending solutions to pressing electric infrastructure problems.[98] These options are workable and effective precursors to an ERC.

Road Maps for the Closure of Gaps

A clear road map for the closure of gaps is a desirable outcome. This section addresses this issue from three perspectives. Each perspective has different characteristics.

Figure 45 below describes the conventional road map for the closure of institutional gaps. Sound electric policy drives the contents of electricity, electric power and regulatory laws. Hence, sound policymaking is the first milestone. Electricity, electric power and regulatory laws address industry and market structures, level of competition and governance of the electric sector. Their passage is the second milestone.

It is important to note at this point that establishing an ERC does not have to occur simultaneously with the passage of electricity and electric power laws.[99] Staffing, training and building capacity within an ERC is the third milestone. Completing these three tasks consumes a significant amount of time and requires the dedication of significant amounts of effort. Issuing of rules, promulgating regulations, setting standards, devising codes, determining tariffs, recommending guidelines and approving quality-of-service targets are the fourth milestone.

The time line associated with the conventional road map for the closing institutional gaps in the electric sector is largely indeterminate. This emergence of the National Electric Power Regulatory Authority (NEPRA) occurred eighty-seven years after the passage of the first electricity law. On the other hand, NEPRA was established just prior to the passage of the second major law, which restructured the electric sector. The convention wisdom is that the quick turnaround occurred because GOP was signalling an intention to attract foreign investment to Pakistan.

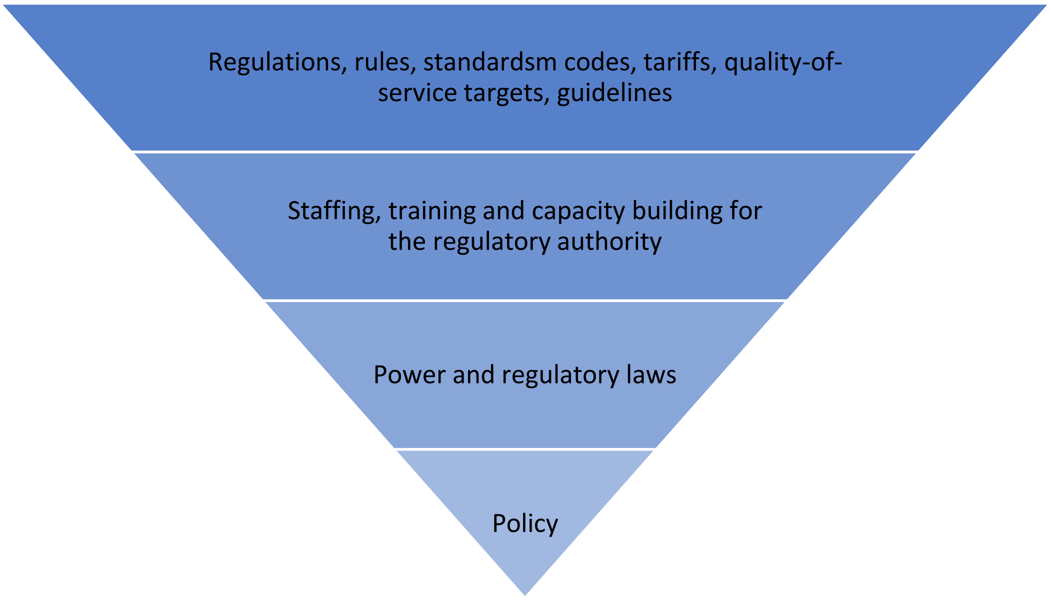
[98] *An Association can sign Memorandums of Understanding (MOUs) that serve as a foundation for participating in the governance of the electric sector.*

[99] *It is noted at this point that the situation in Somaliland suggests strongly that a law establishing an ERC should precede the passage of an electricity law involving industrial organisation, industry structure and market reform.*

The quick turnaround had a downside. Only recently NEPRA had significant limitations in the areas of procedures, capacity and methodology after ten years of operation. Thus, an optimistic time line for the establishment of a fully functional regulatory authority is:

- one-to-two years for the development of a national electric policy, passage of the first major electricity and electric power laws and the passage of law that establishes an ERC for the governance of the electric sector; and
- three-to-five years for an ERC to train and build capacity through on-the-job training and text-book education.

Figure 45. High-level road map for the closure of institutional gaps



Source: Unicon

Figure 46 below is the unconventional road map for closing institutional gaps. This road map places an ERC under the administrative jurisdiction of a Ministry. However, this placement requires a great deal of preparatory discussion within Somaliland's political apparatus. The first milestone, therefore, is completing discussions pertaining to the type of an ERC that will govern the electric sector.

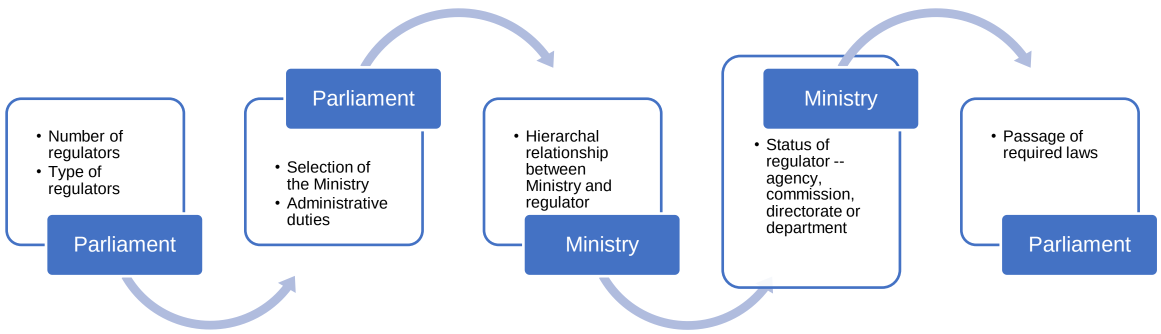
The second milestone is completing discussions involving the selection of the Ministry that will house, administer and oversee an ERC. Making this selection requires the engagement of Somaliland's entire political apparatus. The next stage starts with discussions within the selected Ministry that concern the hierarchal relationship between an ERC and the selected Ministry. Completing these discussions is the third milestone. The next groups of discussions within the selected Ministry address the status of an ERC. The candidates are:

- an agency;
- a commission;

- a directorate;
- a department; and
- an authority.

Completing these discussions denotes the fourth milestone. The last stage and fifth milestone is passing a law that establishes an ERC.

Figure 46. Road map for the creation of a regulatory authority within a Ministry



Source: Unicon

Process starts at Parliament, moves to the Ministry, returns to Parliament and circles back to the Ministry. Parliament makes general decisions, and the selected Ministry makes detailed decisions.

The time line associated with this unconventional road map is indeterminate. The first set of discussions within the Parliament will end quickly because they would not begin unless GoSL has committed to establishing an ERC for the electric sector. The second set of discussion, however, will not end quickly as Parliament makes its cases for the selection of a Ministry.

The first set of discussions at the Ministry will last a short period of time. Parliament has provided the selected Ministry with benchmarks for determining the hierarchal relationship between it and an ERC that it administers and oversees. However, the next set of discussions will take a longer time. These discussions have a high probability of being contentious.

An agency tends to be more powerful and more independent than a commission, it usually has a larger staff and is charged with more responsibilities than a commission. Both are independent to the extent practicable. Meanwhile, a directorate is less independent with a smaller staff as compared to a commission. A department has the least amount of independence and the smallest staff. And lastly, the internal governance of an authority is the most fluid.

The passage of required laws will occur very quickly after the status of an ERC has been determined by the selected Ministry. Staffing, training and building capacity within an ERC occurs subsequently.

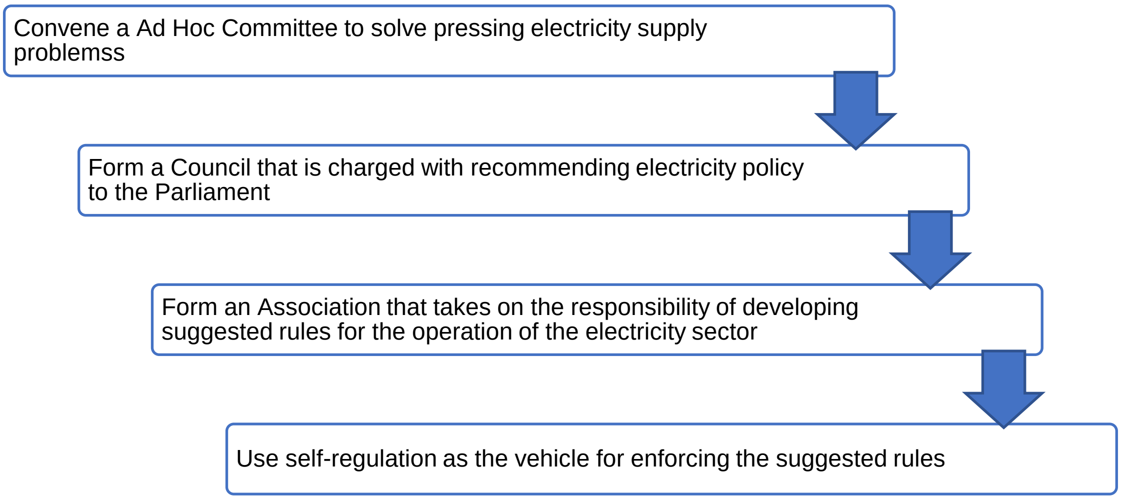
Recommending guidelines, defining quality-of-service targets, setting standards, issuing rules, promulgating regulations, determining tariffs, approving codes, occur thereafter.

An optimistic time line for establishing an ERC within a Ministry is:

- less than one year for determining an ERC's type;
- one year for selecting the Ministry that will house, administer and oversee an ERC;
- less than a year to establish the hierarchal relationship between the Ministry and an ERC;
- up to two years to agree on the status of an ERC relative to the Ministry; and
- up to a year to pass required laws.

Figure 47, below, is the outline of a road map for preparing to close institutional gaps in Somaliland. This outline is examined in detail in the sub-sections that follow.

Figure 47. Communications road map for the establishment of a regulatory authority



Source: Unicon

The first step is convening an ad hoc committee to recommend solutions to pressing electricity infrastructure problems. The second step is forming a Council, which is responsible for recommending policy and submitting it to Parliament for review and consideration. The third step is forming an Association that will suggest rules benefitting the operation of the electric sector. It is suggested that the Association uses Memorandums of Understanding (MOUs) for this purpose. The fourth step is to use self-regulation as the vehicle for enforcing these rules. When completed these four steps create a sustainable foundation to establish an ERC for Somaliland's electric sector.

The time line for Figure 47 is not long. An ad hoc committee can be convened in a matter of days. Recommendations for solving pressing electric problems are apt to be provided in up two months after the first meeting of the committee. If recommendations bear fruit, then the Council and the Association are likely to be formed one-to-three months later.

Role of Government

GoSL does have a role to play even with the absence of laws and the lack of capability and infrastructure to promulgate regulations. GoSL through a Ministry might initiate a collaborative process that ends with a rule that has been adopted voluntarily.[100] In Pakistan, as an example, the MOWP, which is responsible for developing water and power resources, makes policy and resolves certain types of issues that are related to the generation and transmission of electric power and the distribution and pricing of electricity.[101]

GoSL also might create a Board and appoint its Chairperson.[102] The Board could promote a course of action that has been ordered by GoSL and supported by stakeholders. Typically, the course of action, in this instance, would assist with the management of an electric programme.[103] An electric programme, however, needs an electric policy, and an electric policy does not exist presently. Therefore, creating a Board is not recommended.

Instead, GoSL and stakeholders might put together a Council that recommends policy that deals with the industrial organisation of an electric sector. In Pakistan, the National Economic Council (NEC) is responsible approving the National Energy Plan (NEP), approving the portions of the NEP related to electric power and electricity and approving the policies that apply to the development of the electric-power and electricity markets.[104] Clearly, NEC has power beyond providing advice on the transition of the electric sector. Perhaps, a better example for Somaliland is the Executive Committee of the National Economic Council (ECNEC). It supervises the implementation of energy policy.

Council and Association

Advice and Guidance Council

Members of an advice and guidance council are appointees that represent the affected parties. Membership is voluntary. Its responsibility is to make recommendations supported by research and data collection.[105] Committees might support the Council. A minimal staff is required to arrange meetings, pay travel expenses and oversee data collection and research.

Association

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[100] *GoSL can put the monitoring function within the domain of the Ministry or local government by passing an ordinance.*
[101] *It is important to note that MOWP – Pakistan does have any direct regulatory authority.*
[102] *The membership of the Board will be filled from the ranks of the stakeholders with standing.*
[103] *The GOP, for example, created the Alternate Energy Development Board (AEDB) and the Private Power and Infrastructure Board (PPIB). The role of the AEDB is to promote the entry of IPPs into the renewable- energy market. The role of the PPIB is to supply administrative management to Pakistan's IPP Programme.*
[104] *The National Economic Council (NEC) was created in 1962 pursuant to Article 145 of the Constitution of Pakistan.*
[105] *The authority of such a Council does not extend to decision-making.*

An Association is a well-known vehicle for self-regulation. It is well placed for this task when its members are professionals that provide services that directly affect the lives of others. An Association sets ethical standards for the profession and a code of behaviour for the professionals. In principle, membership in an Association is voluntary. However, in practice, membership is a necessity. After an Association sets ethical standards for the entire profession, the reality is that non-members as well as members are compelled to abide by them.

The same expectations would apply to any rules that might be issued by an Association. Thus, at the inception of an Association, it might be best to deny it the power to issue rules to avoid conflict among the members. As an alternative, it might be better to focus attention on improving the quality-of-life of the members and serving the public interest. A prime activity in this regard may be to improve the membership's safety records.

What is needed then is an Association that supports the economic interests of its private members and the public interest of its public members. Some of the first-tier responsibilities for such an Association are arranging the research desired by the public or private members, assisting with the allocation and distribution of funds, and scheduling the meeting for committees that have been formed by the Association.

An Association also would have additional responsibilities. It would reject or accept recommendations made its committees or an ad hoc committee. After a recommendation is accepted the members would be responsible for working toward its implementation. Once a recommendation has been vetted and adopted the Association's members would be expected to voluntarily abide by it.

An Association's staffing requirements while not substantial are nonetheless precise. Its staff would not be members of the Association. Furthermore, its staff would not be responsible for approving data collection and research efforts. The Association's committees or the Ad Hoc Committee would have this responsibility.[106]

Funding an Association

An Association is self-funding in most instances. Its members pay fees and levies in return for the services that are provided to them by the administrative and management staff of an Association. Usually, fees and levies paid to an Association are not used to pay the members' travel, meal and lodging expenses. These costs are covered by the members themselves. However, covering these costs will place a burden on many of the ESPs operating in Somaliland, and the cost burden may be so great that many of them will not join the Association. As a result, other sources of funding will be needed to finance it.

Standard practice is to use only verifiable and auditable sources of funding. In-kind contributions from the members of an Association are at the top of the list. Membership fees and levies follow. Levies

[106] *An Association's membership would staff the committees.*

and fees, however, may not be sustainable sources of funding. Free ridership is a real problem during the time in which the value of an Association is being proven to the base of potential members. Furthermore, it may the case that benefits provided by an Association are public goods that can be accessed and used by non-members.

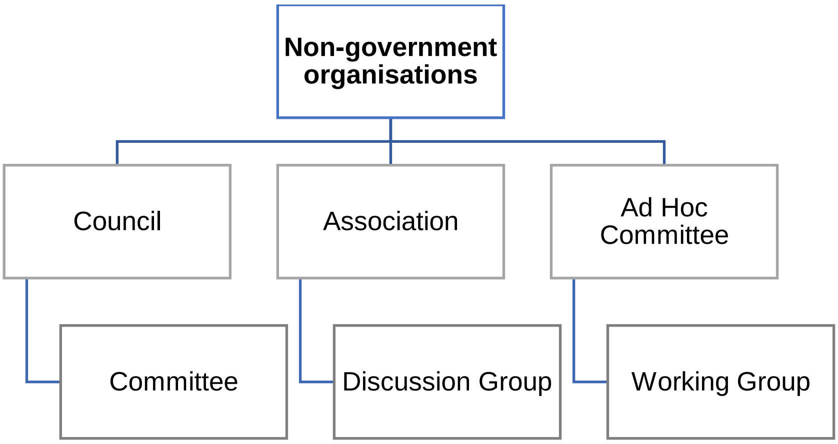
Other possible sources are loans from an international lender and grants from the donor community. Some possibilities in this regard are WB and AfDB. Country-specific donors tend to be poor candidates because of suspicions with respect to special interests. The International Monetary Fund (IMF) also is questionable source of funds because it tends to be more aggressive in terms of the preconditions that it places on the recipient of a loan. For example, the IMF might require an Association to initiate a voluntary licensing regime within a pre-determined span of time. NGOs are another questionable source of funding. They might have agendas that are at odds with some or all parts of an Association.[107]

Organisational Charts for the Council and the Association

What follows in Figure 48 below is the skeleton of a non-governmental institutional arrangement that performs preparatory regulatory activities. The Council provides advice and guidance on the selection of policies. A committee assists the Council in these efforts.

An Association provides a forum among ESPs, consumers and the GoSL for discussing rules and procedures. Discussions occur at the group level. The Association chooses discussion topics and sets the number of discussion groups. An ad hoc committee deals with assigned issues or problems at the recommendation level. A working group collects and analyses data that assist the ad hoc committee with completing its tasks.

Figure 48. Skeleton of institutional arrangements for preparation of regulatory activities



Source: Unicon

Figure 49 below is the organisational chart for an inclusive Association such that any affected party may join it. Each group represented within the Association will elect one member to represent it on

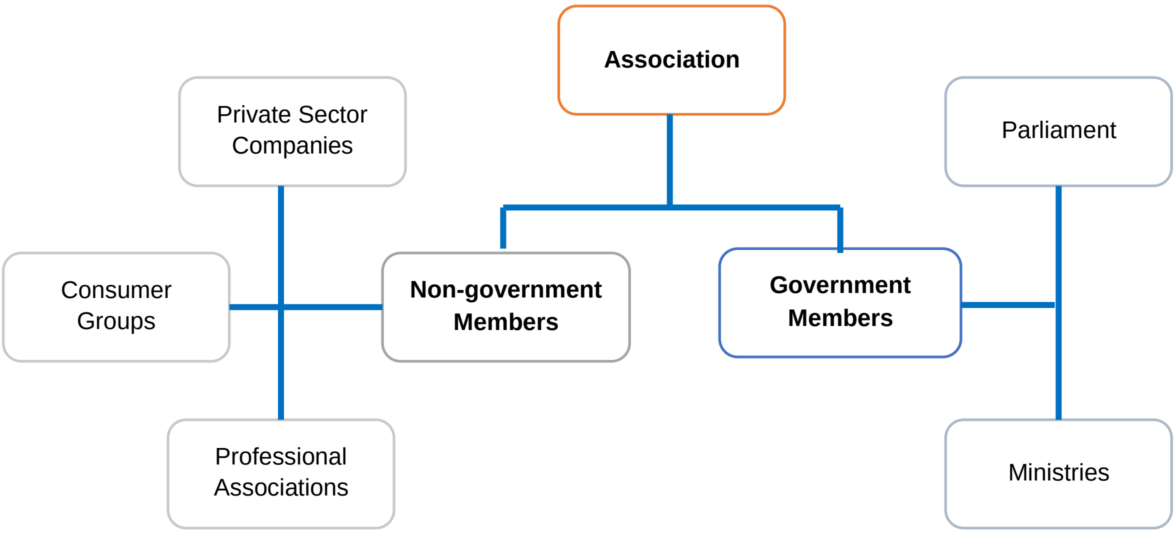
[107] *Donations from the wealthier members of the Association are frowned upon because they raise concerns that special interests want to control the work and services provided by the Association.*

the Council. The voting method such as majority rule or unanimity will be chosen by the group. Membership consists of government and non-government representatives. Discussion groups are formed ad hoc, and participation is voluntary. Access to a discussion group is open to the entire membership.

Discussion topics will be tied to closing institutional, regulatory, operational and maintenance gaps that exist within the electric sector. Participants share their thoughts, opinions and data with the other participants when discussion groups are in session. They also may share their observations and conclusions with the entire membership. A discussion group, as a whole, is authorised to make recommendations if it chooses to do so.

Recommendations deal with solving technical or non-technical problems adversely affecting the electric sector. But, for the most part, discussion groups are expected to make recommendations that solve non-technical problems. After a discussion group makes a recommendation on how to close a gap; it is expected to transmit it to the entire membership. After review and discussion of the recommendation by the membership the Association, as a whole, may choose to deliver it to the Council for review and perhaps submission to a Ministry, an ERC or both for further consideration.

Figure 49. Organisational chart for the association



Source: Unicon

The Council and Association are domestic, not-for-profit, NGOs that are national in scope. The acceptance of an appointment to the Council is voluntary. Representatives of GoSL, private companies and other "legal persons" are eligible for an appointment to the Council for a pre-determined duration. A decision to join the Association for an indefinite term is voluntary. It recommended that GoSL joins the Association or to provide a government perspective.

Ad Hoc Committee

An ad hoc committee is a well-worn administrative tool for dealing with unique and compelling problems. This type of committee does not want for members for several reasons. Membership is not permanent. Demonstrated expertise and verifiable experience in solving problems are the bases for selection. Seniority does not affect the selection because membership is not permanent.

A committee meeting is scheduled to address the contents of a detailed agenda. Matters pertaining to the specific problem at hand are the only entries on the agenda. The handling of procedural issues is done by the chairperson at least a week prior to the meeting. Consequently, the objective of each meeting is to make progress toward a recommended solution for the assigned problem.

The Committee's success depends on each member behaving as follows throughout each meeting. Appointees treat each other as equals. They agree in advance that "protecting turf" hinders the committee's efforts to find a solution for the assigned problem. Furthermore, they agree in advance that sharing of opinions and thoughts is proper because they contribute to a better understanding the problem under discussion.

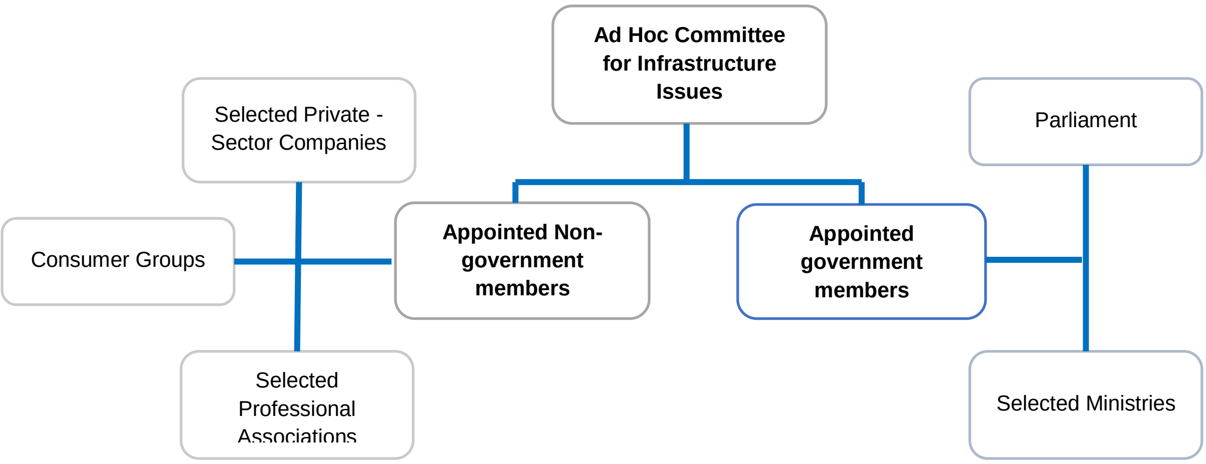
An ad hoc committee performs more effectively when it deals with one problem at time. However, it is not possible to guarantee that other pressing problems will not be identified as the Committee moves toward a recommended solution for the assigned problem. Whenever related problems are identified the appointees should make every effort to put them aside and take them up at later date. But, of course, there will be instances when the appointees will be compelled to add newly identified problems to their agenda.

Each session of the Committee has a definite beginning and end. The session begins when a compelling problem is assigned to it by a Ministry. It ends when the appointees recommend a solution for consideration by the Ministry and/or an ERC.[108] Meetings occur in between. After a session has ended, the Committee is suspended, and the appointees are thanked for their service. Its operation is restarted when another compelling problem requiring an immediate solution is assigned to it.

Organisational Chart for Ad Hoc Committee

[108] *The Committee also provides the Association with the recommended solution for its consideration. The Association, after giving the recommended solution due consideration, might forward to it to the Council for its consideration. The Council will decide whether the recommended solution will help with making effective electric policy.*

Figure 50. Organisational chart for the Ad hoc committee for infrastructure issues



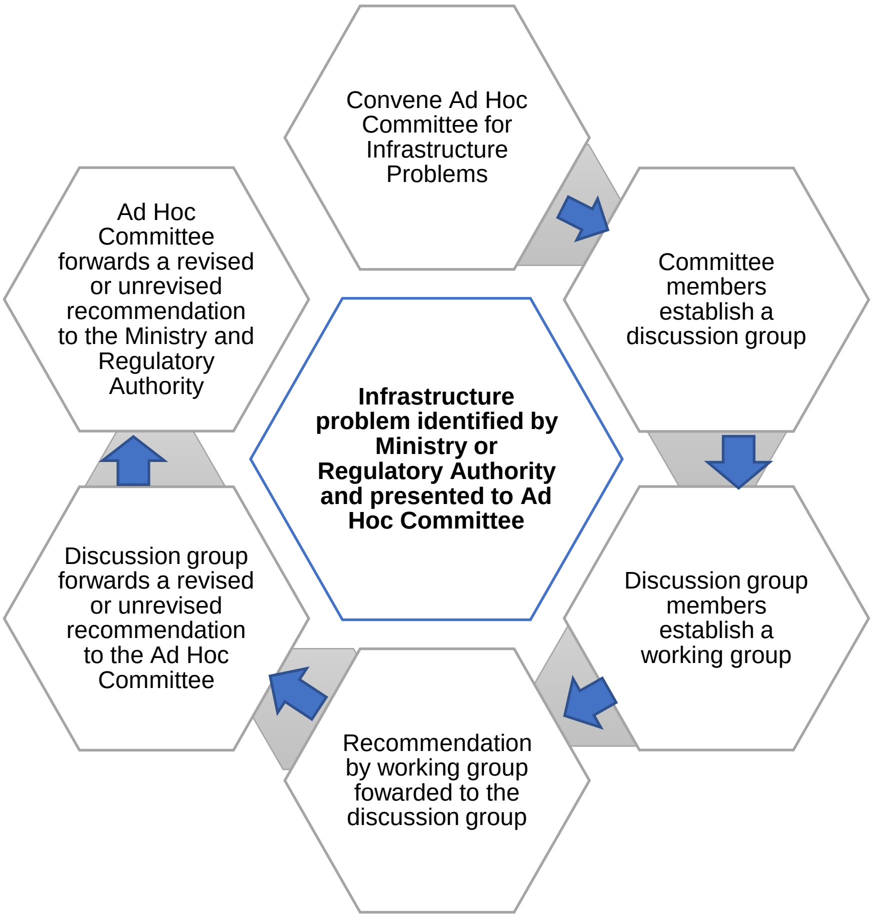
Source: Unicon

The Ad Hoc Committee will be independent of and separate from the Association and the Council. It will deal exclusively with electric problems that need solutions in the short term. The Ad Hoc Committee will discuss one problem at a time. At the closure of the discussion, it will issue a recommendation, which is received for processing by the Association. The Ad Hoc Committee, being a subset of the entire Association, does not communicate with Ministries directly. Communication with Ministries occurs through the Ministry's representatives that have been appointed to the committee. Another constraint on the Ad Hoc Committee is that the pertinent Ministry will not bring a new problem or issue to it until a recommendation is forwarded to the Ministry and/or an ERC. This recommendation will be consensual.

Organisational chart for Ad Hoc Committee is provided in Figure 50. An important feature of this chart is that Parliament, Ministries and private sector are equal members of the Committee. Equal status is provided to the ESPs, residential users and business users of electricity as well.

The Council and/or the Association can nominate candidates for appointment to the Ad Hoc Committee; however, the Ministry that forwarded the problem to the Committee makes the appointments. Being an ad hoc committee, it does not remain operative indefinitely. Instead, its operation is suspended and reconvened as necessary.

Figure 51. Description of work process for the Ad hoc committee



Source: Unicon

Figure 51 above describes the "working" of the Ad Hoc Committee. It starts to work when a problem has been brought before it by a Ministry. The Committee is convened or reconvened at this point. After convening or re-convening the Committee the Ministry responsible for forwarding the problem to the Committee makes appointments.[109] The appointments are expected to maximise the probability that the assigned problem will be solved swiftly. The Committee members establish a smaller working group. The Ad Hoc Committee's "work" ends when a recommendation is provided to the pertinent Ministry and forwarded to the membership of the Association. The Committee is suspended at this point until a new problem is brought to it. At that time, the Ad Hoc Committee is reconvened with the expectation of new appointments. Given this process, the Ad Hoc Committee has considerable value before after an ERC is established.

The Ad Hoc Committee is responsible for recommending solutions for pressing electricity problems on an expedited basis. The logic supporting its creation is that it will work against the public interest and the smooth implementation of the Master Plan when pressing problems are left unattended. Consequently, the proper course is to balance the limited available time between solving pressing

[109] *The Ministry assigns the problem to the Ad Hoc Committee and charges it to provide a recommended solution to it and/or an ERC. The Committee is decommissioned after the charge is met, and it is re-commissioned when a new problem is handed over to it for solution.*

problems created by the absences of guidelines and procedures and establishing an ERC and making it fully functional.[110]

Governing an Electricity Sector

As stated several times above, regulation is one of the elements of the traditional approach to governing an electric sector. Other elements are laws, ordinances, guidelines, policies and a Constitution. GOP selected the traditional approach, and as is common, a significant amount of time had to pass before regulation entered the governance regime. This outcome should not be surprising. Anyone who is unfamiliar with regulation initially has many suspicions. Regulation is not a simple matter, and its implementation is not simple as well.

Role of the Regulatory Authority

An ERC necessarily is a government entity. Among other things, it investigates regulatory issues, writes orders, issues rules and promulgates regulations. An ERC in Somaliland can be established by GoSL. The regulations it promulgates have the effect of law, but they are not laws.[111] The purpose for each regulation is to implement the supporting law in a manner that improves economic efficiency and serves the public interest.

Specific groundwork is completed by an ERC before it promulgates a regulation. The following procedure represents a well-worn path for laying the groundwork. Briefly stated, the procedure begins with identifying an issue requiring a regulation before it can be resolved in accordance with the supporting law. An ERC may or may hold a public hearing to discuss this issue before it initiates a rule-making proceeding. Regardless of the decision to hold or not hold public hearings to discuss the issue an ERC issues a NOPR thereby opening a rule-making proceeding. The rule-making proceeding ends with an order written by the ERC. This order also is the final rule. The final rule sets the precedent for the regulation. In fact, the final rule contains the regulation that will be promulgated by including it in a COR.

What follows is Table 50, which traces the progress to the resolution of two regulatory issues in Pakistan. The issues pertain to practical problems that affect transmission planning and cost allocation by transmission-owning and operating public utilities. In this case, their resolution did not result in two regulations. Instead, two final rules were issued because a supporting law was not put in place. The most important points made in this Table are: 1) a rule-making process always ends with a rule and 2) it does not have to end with a regulation.

[110] *Delaying consideration of standards and codes is not as damaging as it appears. Transmission grids and distribution networks can be "retrofitted" with standards and codes to formalise and extend the protections provided by guidelines and procedures.*
[111] *Laws cannot be passed by a government agency. Only GoSL can pass laws.*

Table 50. Trace of the Pakistan – regulatory orders leading to a regulatory rule

Date	Docket Number	Issue	Document
June 17, 2010	RM 10-23-000	Transmission Planning and Cost Allocation	Notice of Proposed Rulemaking
July 21, 2011	RM 10-23-000	Transmission Planning and Cost Allocation	Order No. 1000 (Final Rule)
Post July 21, 2011	RM 10-23-001	Transmission Planning and Cost Allocation	Notice of Proposed Rulemaking
May 17, 2012	RM 10-23-001	Transmission Planning and Cost Allocation	Order No. 1000-1 (Final Rule)

Source: Unicon

Conversion of a Final Rule into a Regulation

A rule promulgates to a regulation when a rule issued by an ERC is inserted a COR.[112] However, insertion into a COR is permissible only when there is a supporting law. This subtlety creates the widely experienced confusion between a regulation and a rule.[113] It, therefore, is not surprising that Somaliland unfamiliar with economic regulation has many institutional gaps to fill. This problem is extremely pressing when regulations are preconditions for international aid, lending or investment.

Rules do more than influence the behaviour of participants in an electric sector; they also assure the realisation of policies that have been written to guide transitions within and between electric markets.[114] However, they do not have the force of law. Regulations do have the force of law. Hence, they are better suited for guiding the expansion of an electric sector. Still, it cannot be forgotten that regulations cannot exist without precedent law.[115]

Summary

Options for developmental progress within an electric sector are present in Somaliland despite the absence of laws and regulations. Policies, rules, technical codes and procedures are viable options. It is not that they replace laws and regulations. Replacement is not possible because rules are in a very

[112] *Rules are not codified, buy they should be noticed and archived at a central location for references by affected parties.*

[113] *After this subtlety is revealed and explained, economic regulation is de-mystified becoming more understandable and simple. As a result, over time, new laws will be passed that are not as detailed as the first one, and then the regulatory process becomes more sequential and less daunting.*

[114] *Important and fundamental differences exist between economic markets within the economic sector and the economic sector itself. Markets capture the interactions between producers, consumers and the Government. A sector exhibits the industrial organisation of the markets, thereby establishing the interrelations among the markets as to competitive, non-competitive and monopolistic.*

[115] *Two examples are useful for illustrative purpose. Regulations do not exist concerning the licensing of electric-power or electricity providers because a law has not passed that codifies that an electric-power or electricity provider must have a license. Regulations do not govern the procurement of electric machinery and do not exist because there are not laws that codify specific procurement policies and processes.*

real sense voluntary. In short, rules can be ignored or violated at any instant even if they are outcomes of a collaborative process.[116]

Way Forward

Somaliland's NDPII continues a process for building a foundation for governing the electric sector. Passage of laws and the creation of new institutions are elements of this process. Once this process ends GoSL will begin staffing, training and building the capacity of an ERC. The case studies presented in this report suggest that it will take a considerable amount of time to complete the process.

A theme found in this report is that the existing lines of communication between the Ministries, ESPs and the users of electric power and electricity users do not provide the depth and breadth that is required for the effective governance of an electric sector. Pairwise communication currently is the norm, but this norm is most suitable for the airing of complaints. Unfortunately, it is less suitable for the resolution of complaints. What is required are open and transparent lines of communication. They hasten the solution of pressing electricity problems that affect the welfare of electric power and electricity users and ESPs. But, open and transparent lines of communication do not occur naturally. The lines of communication that do emerge are closed and isolated.

Institutions are effective means for creating open and transparent lines of communication. Institutions, in principle, are charged with establishing and maintaining lines of communication with these two attributes. Meanwhile, GoSL, in principle, is charged with ensuring that the lines of communications are fair, just, non-preferential, non-discriminatory. GoSL also in principle is charged with passing legislation that governs the flow of information and data among the Ministries, an ERC, ESPs and electric power and electricity consumers.

Case studies of Iraq and Pakistan showed that it takes time to establish a functional ERC. They also suggested that a major difficulty with respect to establishing an ERC is that the capacity of groups to communicate peacefully with each other was lacking. Instead, group communication took the form of protests and court cases. As a result, it will be concluded in this report that effective lines of group communication are needed to prepare for the establishment of an ERC.

Universal agreement has been reached that polices are more powerful than rules and procedures. But also, policies are less prescriptive than rules, and rules are less prescriptive than procedures.[117] Universal agreement also has been reached that the Constitution is more powerful than laws and regulations. These facts cannot be ignored. When they are ignored establishing an ERC becomes bogged down in details. For example, a regulation cannot be promulgated without a supporting law. Hence, a demand for regulations often is counter-productive when an enabling law is not already present.

[116] Procedures have the same characteristics and attributes of rules. They are voluntary. Codes, however, can be voluntary or mandatory. Of course, a code that is mandatory requires an ordinance at the very least.
[117] A rule can be passed before a law has been passed if the rule is presented in the form of a recommendation.

Preconditions

An approach for opening group lines of communication in preparation for establishing an ERC has been explained in the preceding chapter. It consists of forming a Council and Ad Hoc Committee and supporting an Association. However, there are preconditions. First, GoSL has to be committed to open and transparent communications with respect to electric matters, problems and issues. Second, disguised barriers cannot be erected by anyone to thwart these group communications. Third, the GoSL is the champion for implementing the approach.

After these preconditions are fulfilled and the lines of group communication have been opened and are working, it is a straightforward matter for affected parties to participate meaningfully in the passage of laws that establish an ERC. After becoming prepared and passage of these laws affected parties will be able to act as interveners in the process of issuing of rules, determining tariffs, setting standards and approving codes.

Government Role

One or more of the Ministries can initiate a collaborative process to develop a recommended policy. GoSL can participate in an Association and a Council. GoSL can convene an Ad Hoc Committee. It needs to be emphasised at this point in the Report that the Council, Association and Ad Hoc Committee are private-sector organisations with government representatives acting as either observers or participating as an equal during the meetings. Therefore, it would be counterproductive for any Ministry or agency of the GoSL to assert jurisdiction and authority over the discussions that occur during meetings. However, it would be appropriate to a Ministry or agency to assert jurisdiction over the topics, problems and issues assigned to the Ad Hoc Committee of Experts for resolution. In effect, the GoSL would be providing general and non-specific direction to the Ad Hoc Committee, but it would not direct the course of the work occurring within the Committee in any substantive manner.

Associations have been used to self-regulate professionals. In principle, membership is voluntary. In practice, membership is a necessity. Associations have passed and enforced rules that address unacceptable behaviour. But, the worth of these rules had to be proven before they are enforced effectively. Thus, in the beginning, the stated purpose of an Association should be to improve the livelihood of its members and the public in general. Membership should be all inclusive with the criterion for inclusion being designation of an affected party. These objectives are best achieved by assuring that any recommended rules are predated with data collection research and the rationalisation of Association funding.

A strong and effective Association is self-funding. But, strength and effectiveness grow over time. As a result, it cannot be asserted that fees and levies are sustainable sources of funding for a new Association. Consequently, the largesse of donors and lenders is needed to some extent to assure the survival of an Association. This largesse, however, cannot be assured. Hence, an Association's expectations must be realistic and achievable.

An active Ad Hoc Committee requires GoSL support and input from the Ministries. GoSL and Ministries have the capability and capacity to prioritise pressing electricity issues and problems. They also have the power to motivate affected parties using the means deemed appropriate in the context of the problem assigned to the Committee.

The ideal group membership of the Association would consist of Independent Power Producers, if any, Electricity Service Providers, electric and electrical equipment manufacturers, consumer groups and social-services groups. Whereas the staffing needs of the Association are administrative and secretarial those fulfilling these needs would not require any donor support. The next question is donor support needed to fund the Association's membership to wit the answer is only in two limited circumstances. IPPs. ESPs and equipment manufacturers would not need any external financial support to join the Association. Only, the consumer and social-service groups would need some financial support which can be shared between the GoSL and donors. Moreover, the essential members of this Association are the IPPs, ESPs and consumer groups. Therefore, if donor support is scant, the social-service groups can be excluded. Hence funding the Association is not a deal-breaking issue. This conclusion is even stronger for the Council because it would be comprised of executives from firms operating within the electric sector. None of them would need financial assistance to join the Council voluntarily. The Ad Hoc Committee, which would be comprised of experts, would needs daily stipends to participate in the meeting when they are drawn from domestic organisations and academic institutions, and foreign experts desired by donors would quite naturally be funded by the donors.

Future Structure and Roadmap

The proposed future structure for governing Somaliland's electric sector occurs in stages. The first stage is preparatory. The second stage is enabling in the sense that GoSL determines the hierarchy for the governance of the electric sector. The third stage is the establishment of an ERC.

The first stage ends with GoSL forming and establishing a Council and an Ad Hoc Committee and supporting an Association. These three new institutions survive through the second stage and become permanent with the completion of the third stage. And importantly, they remain public-private organisations that place GoSL and the affected parties on equal footing.

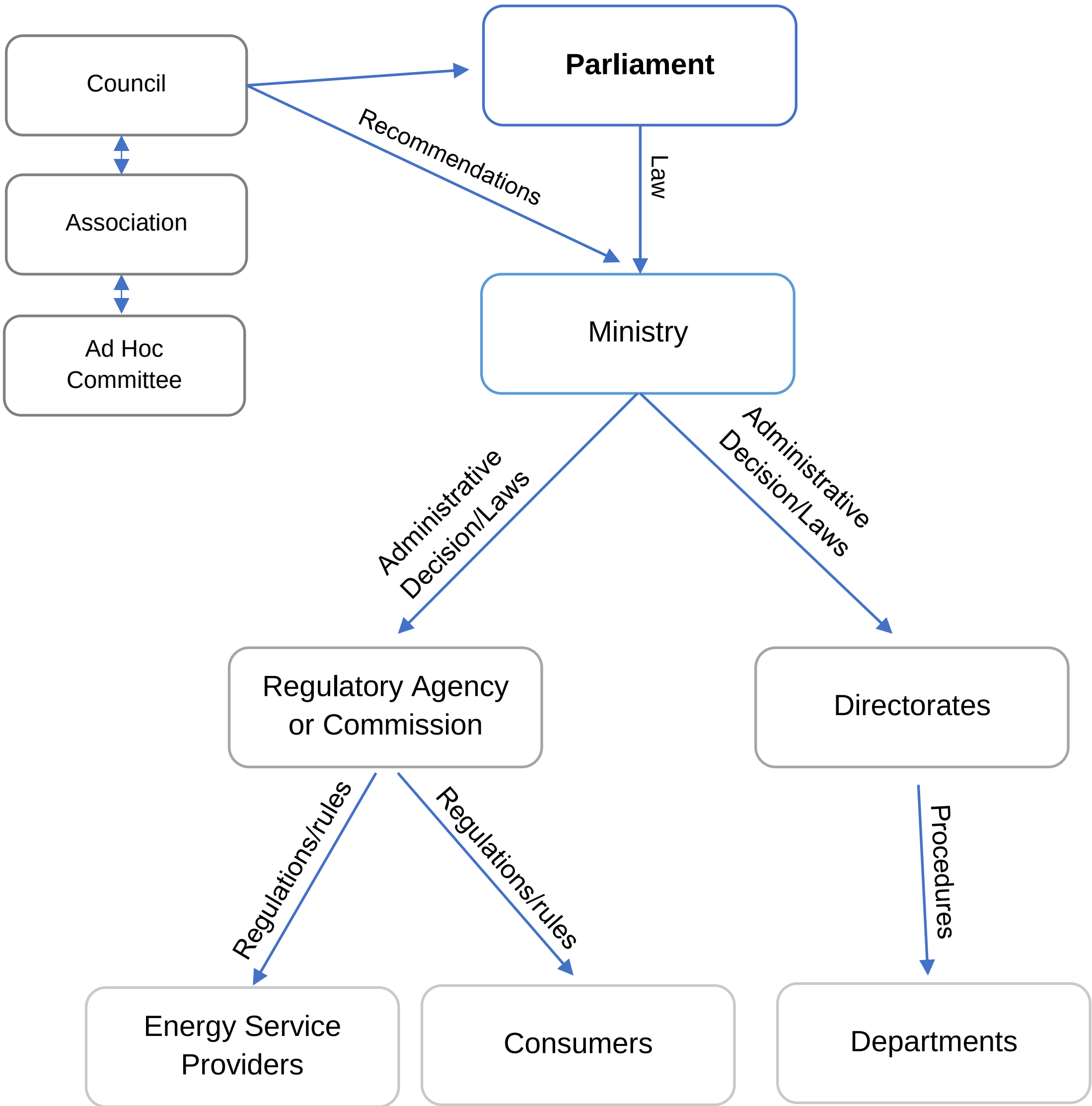
The second stage ends with the passage of laws that establish an ERC for Somaliland's electric sector. Parliament and Ministries are the driving entities. Working interactively, they determine the location of an ERC, the hierarchal relationships affecting the operations, independence and the status an ERC. None of these actions requires the passage of laws. They are administrative in nature. However, the impacts of these actions will be included in the laws that establish an ERC.

The third stage ends with the issue of policies, regulations, rules, standards, codes, tariffs, quality-of-service targets and guidelines. These activities will begin as soon as ERC's members are appointed by GoSL, and ERC's core staff is selected, hired and begin to work. However, the third stage does not end until the regulations, rules, tariffs, targets, guidelines, standards and codes meet or approach international best practices. This goal is achieved through training and building the capacity of an ERC.

Figure 52 below depicts the proposed future structure of the GoSL hierarchy for the governance of Somaliland's electric sector. The future ERC is an independent agency, commission or authority having its own budget, its own staff and its own building; however, it reports to a Ministry, which performs its administrative tasks and oversees its activities. The Ministry reports to Parliament on regulatory matters and informs the Executive.

The future ERC is structurally separate from the Ministry's directorates and is not a department of the Ministry. Meanwhile, the Ministry's departments report to the Directorate, while consumers and EPSs interact with the ERC. The Council provides recommendations to the Ministries and/or the ERC. The Association discusses policy, regulatory and commercial issue and informs the Council. The Association also reviews the Ad Hoc Committee's recommended solutions and informs the Ministries and/or the ERC. The Ad Hoc Electricity Committee recommends solutions for the problems assigned to it by a Ministry. The recommended solutions are given to the Ministries and the ERC.

Figure 52. Future structure for the governance of Somaliland's electricity sector



Source: Unicon

Table 51 below is the timeline for the path forward to establish an ERC. The timeline does not contain exact quantities in several instances. Hence, an assumption is needed to provide an expected minimum and an expected maximum number of years to the full establishment of an ERC. The assumption is that the minimum number of months for an inexact quantity of less than one year is three (3) months. Thus, the minimum number of years to an ERC is estimated to be 6 years and 3 months, and the maximum number of years to an ERC is estimated to be 10 years. These estimates are rather distressing, but the case studies presented in this report demonstrate that they are not unreasonable.

Table 51. Timeline for the path forward on establishing the ERC

Milestone	New Institution	Time to Completion
1	Establish the Ad Hoc Committee	Less than one year
2	Establish the Association	Less than one year

Milestone	New Institution	Time to Completion
3	Establish the Council	Less than one year
4	Select the location of the ERC	Up to one year
5	Select the status of the ERC	One year
6	Pass a law that establishes the ERC	One-to-two years
7	Appoint the members of the ERC	Up to one year
8	Staff, train and the build the capacity of the ERC	Three-to-five years

Source: Unicon

Conformance with Somaliland's National Development Plan

The Somaliland National Development Plan II (2017-2021) is a cohesive official government document describing the intentions, desires and expectations of GoSL with respect to pillars for development, civil service and infrastructure investment. The document recognises the fact that the electricity access, affordability and quality are in need of urgent improvement.[118]

The energy-and-extractives-sector was made a major part of the 'economic development' pillar and focuses, among others, on the priority of 'ensuring access to affordable, reliable, sustainable and modern energy for all'.[119] An important issue in this regard is the difficulty that consumers are experiencing as they seek to attain access affordable electricity.

The document talks, among other things, about the importance of development in the areas of (i) electricity transmission and distribution, (ii) wind energy, (iii) solar energy, and (iv) wave and tidal power.

Several themes are present in NDPII that are applicable to this report. To set the context, this report is a description and analysis on the current institutional situation in Somaliland electric sector and the gaps that exist within it. As with every report of this type, there is a baseline from which the analysis is begun. In this instance, the baseline was very scant. Also, the Plan not only looks at introducing new arrangements like ERC, but also recognises the need for review and revision of the existing document, (i.e. the Energy Policy of 2010 is scheduled to be revisited and revised by the year 2021.)[120]

There are numerous institutions, that is, Ministries, with roles to play in governing Somaliland's electric sector, but beyond that, as documented in the preceding paragraph, there is little. There are not any laws that refer to industry and market structures or inclusion of competitiveness behaviour and exclusion of anti-competitive behaviour. Not unexpectedly, NDPII follows on with the notation that policies applicable to the electric sector do not exist as well. In short, the entire internal structure that supports the roles, duties and responsibilities of an ERC is absent.

[118] *National Development Plan II (2017), page 62*
[119] *National Development Plan II (2017), page 67*
[120] *Somaliland National Development Plan II, page 73*

In line with the above, the National Development Plan II, among the needed reforms in legal and institutional framework, lists to:

- Develop a Power Master Plan;
- Undertake reform in order to strengthen the Sector's institutional and financial positions;
- Develop and enforce electricity provisions, regulations and guidelines;
- Strengthen health and safety rules and regulations;
- Improve guidelines for customer services and relations;
- Unbundle the power sector to power generation, transmission and distribution;
- Consolidate private power generating companies.[121]

Finally, and most importantly, the National Development Plan II specifies that, by 2021:

- a national framework will have motivated electricity trader business transactions with an annual net worth by US $1million;
- 100% of electrical workers and contractors will be licensed and certified;
- the approved and endorsed legal and regulatory framework will attract US $100 million business investment and financing commitments for industry.

All of the above confirms the necessary political will to implement change, and building the proper legal/institutional framework is correctly recognised and an important prerequisite.

Conclusions

This report contributes to the implementation of a Power Master Plan for Somaliland's electric sector. Several objectives have been achieved in this regard.

The first is an examination and analysis of the current institutions within Somaliland that are involved with the regulation of the electricity and electric-power industries. The findings are:

- Somaliland does not have electricity and electric-power laws;
- Somaliland does not have government institutions charged with the regulation of these industries;
- Somaliland has not promulgated any regulations that govern the operation of the electricity and electric-power markets or address the safety of these markets.

The **second objective was to devise an approach that would compensate for the absences of laws, regulations and a regulatory authority**. In this regard, analysis has been conducted to show that three well-tested institutions mimic to the extent practicable the activities of an ERC established by a law. These institutions are:

[121] *Somaliland National Development Plan II, page 65*

- Council;
- Association; and
- Ad Hoc Committee.

The **third objective was to conduct case studies that demonstrate the need for these institutions**. The first case study revealed that agreeing upon the status of an ERC and its location are not simple decisions that are made quickly before passing a law establishing the ERC. The second case study reveals that training and building the capacity of staff is a long and continuous process. The third case study documents the passage of the significant amount of time that was foreseen in the second case study. Thus, each of these case studies demonstrates that something had to be done to compensate for the absence of a fully functional ERC.

The **fourth objective was to provide a compelling defence of the recommendation to form a Council, an Association and an Ad Hoc Committee** while waiting for the passage of a law establishing an ERC. The defence's central feature is that not pursuing immediate solutions to pressing problems is not in the public interest or in the interests of the electricity and electric-power industries. Other features of the defence are the implementation of the Master Plan suffers when these new institutions have not been created to compensate for the absence of an ERC; these institutions and the benefits that they provide survive the establishment of an ERC; membership in these institutions is voluntary; the interrelated actions of these institutions provide a well-tested mechanism that provides GoSL with recommendations that lead to polices and solutions for pressing problems; these institutions do not replace an ERC; these institutions complement an ERC.

The **fifth objective was to integrate the results and findings described above into a path forward for the filling of institutional gaps**. This objective is met herein by first recalling the objective to be met by preparing a Master Plan. That objective is the preparation of a least-cost, integrated plan for the deployment of generation, transmission and distribution assets over the next twenty years. It was recalled that preparing a Master Plan requires verified data or efficient estimates of the values of many quantitative and qualitative variables, and furthermore, it was recalled that planners are confronted by a continuum of "all possible worlds".

The attributes of the best of all possible worlds are not difficult to imagine when creating a Master Plan for an electric sector. A national electricity and electric-power policy has been fully vetted, conscientiously revised and assiduously articulated, thereby providing an extremely solid foundation for the Master Plan. Robust, efficient and unbiased forecasts of electric power and electricity have been prepared and published. The full spectrum of different types of generation assets are available to the planner, and all proven transmission and distribution technologies are accessible by the planner and can be deployed as planned. However, it is unlikely that the best of all possible worlds will exist in the real world. Instead, planners are compelled to choose from the available good and not-so-good possible worlds.

Planners would benefit greatly if a proven transmission grid and efficient distribution networks were present in Somaliland. Planners also would appreciate the availability of the full set of generation options. But, planners cannot rely on either in Somaliland. As a result, the possible world for Somaliland is not-so-good.

Waiting for laws and regulations delays progress that could have been made without them. The Master Plan suffers as a result. Specifically, it becomes stuck in the political or bureaucratic apparatus. The best way to avoid such an outcome is to open lines of communication between GoSL, the private sector, the users of electricity and electric power and interested parties in general. Free and frequent communications are essential to the integrated planning of an electric sector that is immature and unruly.

Opening lines of communication, however, often requires the creation of new institutions. This is the situation in Somaliland. The conclusion reached in this regard is **to form a Council, an Association and an Ad Hoc Committee**. Membership in each of these institutions is voluntary and open to all affected and interested parties. Preferred status does not exist in any these institutions, and therefore, every member is treated equally.

Councils appointed elsewhere have made sound recommendation efficiently, and therefore, they contribute regularly to the formation of policies at all levels of government. But, making recommendations is not the only thing that a Council does. Council members offer their expertise and experience. In this instance, they would review the comments, opinions and analyses given to them by the Association as whole and individual members of the Association as they prepare for making a recommendation to a Ministry and/or an ERC. In other words, the Council does not make its recommendation in isolation from the work of others.

An Association in other contexts writes rules, implements them and enforces them. But, these powers should not be exercised in Somaliland. Instead, an Association should exercise its authority to sign MOUs with GoSL. MOUs are useful for a country with a fledging private electric sector that does not have a strong foundation of policies and laws. They also are excellent vehicles for opening lines of communication while the country is in the process of establishing governance institutions that serve the private and public interests. And importantly, an Association will survive the establishment of an ERC.

Associations in existence elsewhere have been shown to self-regulate professionals effectively. Although membership is voluntary in principle membership is mandatory in practice. Associations have passed and enforced behavioural rules. But, such power is a by-product of the Association having proven its worth to the members. Thus, the recommended conclusion in this report to form an Association does not rest on a precondition that the Association must have the power to issue and enforce rules. Instead, the conclusion presented in this section rests on the capability of the Association to open lines of communication among its members.

The conclusion also rests on the fact that open and accessible lines of communication yield a unified front when its members interact with GoSL, an ERC and affected parties. A unified front is not easy to come by when problems are pressing. Largely for this reason, it is concluded that the Association should not have the power to issue and enforce behavioural rules. Instead, it is concluded it should use its newly opened and accessible lines of communication to improve the livelihood of its members and the public in general. This objective is best achieved when its members charge the Association with discussion, data collection and focused research tasks.

While a strong Association is self-funding strength grows over time. As a result, it cannot be concluded that fees and levies are sustainable sources of funding for the recommended Association. Consequently, the conclusion is that the largesse of donors and lenders is needed to assure the survival of the Association. To obtain this largesse, it is concluded that the Association's expectations and identified tasks and purposes must be realistic and achievable.

It is concluded that an Ad Hoc Committee is an extremely effective means for solving problems when the industry and market structures are ill-defined. The justification is the characteristics and nature of an Ad Hoc Committee. The first and foremost characteristic is that it is in session only when a problem or issue has been brought before it by a Ministry for a recommended solution. The next characteristic is that it stays in session until the requested recommendation is provided to the Ministry that assigned the problem and shared with others. The final characteristic is that only pressing problems are brought before it by Ministries. As for its nature, the Ad Hoc Committee always has high levels of expertise and experience in the context of the problem that has been assigned to it. Hence, appointment to the Committee is not permanent. Instead, appointment varies with the problem.

It is concluded that the Council, an Association and the Ad Hoc Committee are essential for the following reasons. Although there is universal agreement that the electricity and electric-power industries do not function smoothly without policies, laws, rules, regulations and an ERC universal agreement also is being approached that an ERC is not fully functional as soon as a law is passed establishing an ERC. Neither is full functionality achieved by promulgating regulations. An ERC with insufficient capacity does not always promulgate regulations without significant technical errors. The interaction and relationships among the Council, the Association and the Ad Hoc Committee are buffers against the eventuality of technical errors being made during the construction of a regulation. The comments, opinions and recommendations provided by the Council, the Association and the Ad Hoc Committee are additional information that would not necessarily be available to an ERC.

Each of the above reasons for forming a Council, an Association and an Ad Hoc Committee is buttressed by the case studies presented in this report. The first case study revealed the difficulties encountered in selecting a location for an ERC and agreeing upon its status within the government hierarchy. The original proposal was an independent ERC that was not overseen by a Ministry, and therefore, the ERC performed its own administrative functions. The actual location and status are a Department within a Directorate within a Ministry. The causes for this outcome were bureaucratic and legal barriers. The fact is that not all government cultures are the same.

The second case study examined the progression of the maturation of an ERC. It revealed that establishing a smoothly functioning ERC takes a significant amount of time even when it is independent in the sense that it is not overseen by a Ministry. The primary cause was a failure to become fully versed in regulatory processes and procedures.

The third case study examined the importance of the Government's mind-set during training and building the capacity of an ERC. It was revealed that a best practice is that training and capacity building occur throughout the tenure of the staff. It also was presented that regulatory staff should be permanent in the sense that it is not subject to mandatory rotation to other parts of the bureaucracy. This form of permanency ensured a solid institutional memory, which is an essential element of a smoothly functioning ERC. And lastly, the case study proved that an ERC can perform efficiently and effectively when it reports to a Ministry.

However, none of these case studies addressed the attributes and characteristics of the processes and procedures used to make regulatory decisions. Therefore, it was necessary to include an institutional gap that generally is not mentioned. This gap is the absence of a law dealing with administrative procedure. Relying on the experience of a country with a mature regulatory apparatus it is concluded that such a law does not have to pass contemporaneously with the passage of a law establishing an ERC. Although the presence of this law serves to install confidence that an ERC will not overstep its boundaries it also is concluded that an ERC without the constraints of an administrative procedures law is able to complete its work effectively by limiting its initial decisions and regulations to the approval of standards, codes and safety measures.

The path forward picks and chooses among the options presented in the report. It contains the Council, the Association and the Ad Hoc Committee. They are included because each one survives the establishment of an ERC. Once an ERC is established the internal discussions that the Council, the Association and the Ad Hoc Committee are engaged in outside of the regulatory process will yield recommendations that will shorten the regulatory proceedings.

The path forward includes an independent ERC with the status of an agency, commission or authority. It is concluded that the status of an ERC is too low when it is a Directorate within a Ministry or a Department within a Directorate. Furthermore, it is concluded that the newness of an ERC requires oversight by a Ministry. It also is concluded that the Ministry should perform an ERC's administrative functions, which frees an ERC to work exclusively on regulatory issues and problems.

There is no doubt that the path forward is blocked partially by an absence of a law establishing an ERC. It is a fact that regulations cannot be promulgated before an ERC has been established. Similarly, a government-sanctioned rule cannot be issued until an ERC has been established. It has been concluded that accomplishing either of these two tasks requires that several preconditions are in force. First, the ERC is aware of an unresolved regulatory issue. Second, it decides to hold public hearings. Third, it issues a NOPR. Therefore, it is concluded that the best course of action is for GoSL to confront this obstacle head on and re-route the path forward. The formation of the Council, the Association and the Ad Hoc Committee is the re-routing of the path forward.

GoSL has an important role to play when the proposed re-routing of the path forward is accepted. A Ministry is made responsible for initiating a collaborative process to solve a pressing problem. The Ministry chooses the problem that is assigned to the Ad Hoc Committee for prescriptive action. The Ministry appoints the members of the Ad Hoc Committee only with expertise and experience in the context of assigned problem. The Ministry participates in the deliberations of this Committee as an equal member. The Ministry participates in developing a recommendation that subsequently will be provided to it and/or an ERC. However, the Ministry does not have the power to block a recommendation.

Forming the Council, the Association and the Ad Hoc Committee opens accessible lines of communication that benefit Somaliland and its electric sector. These lines of communication provide GoSL with an opportunity to experience the benefits of listening to the concerns and demands of affected parties in neutral environments. These institutions help GoSL and affected parties to grasp the importance of putting their concerns and demands in writing. They inform GoSL and affected parties of the benefits of several meetings on the same topic and making time available for reflection. And lastly, they are the sources of records that support GoSL's decisions before an ERC is established. Each of these benefits assists GoSL's efforts to become well-versed in the regulatory process.

Annex 4: Note on Distribution Standards and Voltage Levels

Box.
This Annex was separately submitted earlier as a stand-alone deliverable/report for the project and added to this Power Master Plan report as a supplementary annex to highlight findings and recommendations of Unicon on this matter. Terms 'report' and similar in this annex are related to this Annex only.

Objectives

The objective of the task is to recommend engineering standards for safety related issues and technical standards and guidelines for harmonisation in areas of planning and design, system operation, and maintenance for local utilities and national level agencies.

There is a noticeable lack of standards of any kind in the electricity sector. There have been curtailed attempts by the authorities to introduce change, but very limited and not structural. Significant improvement is necessary in bringing the distribution standards and voltage levels to a unified base, which will serve as a foundation for further development.

This note discusses Standards and voltage levels under three main headings: Data management, High Voltage Transmission, MV and LV Distribution.

Data Management

The creation, update, maintenance and general management of electricity transmission and distribution network in terms of spatial and non-spatial data is critical toward efficient operation.

The voluminous nature of data involved for proper record keeping is indeed cumbersome, and cannot effectively be handled by traditional system of record keeping. The outdated analogue system means acceptance of inflexibility resulting from data storage in fixed forms and formats. The system becomes less useful for many purposes and are rarely updated because of cost implications. The maps are easily displaced or destroyed because many different people at different locations use them.

An alternative approach of maintaining a database in a scientific and efficient manner by use of information technology is therefore, required. Hence, there will be improvements in planning, implementation and operation of the electricity sector through provision of timely, reliable, accurate data which will facilitate its decision making activities. In order for mapping for proper utility design and maintenance to be satisfactorily achieved, the more sophisticated a data management system must be embraced.

When any new transmission or distribution system is designed, positional data (Latitude, Longitude) is a minimum requirement for electrical design. Mechanical design has an additional minimum requirement for elevation data (Z).

Status in Somaliland

Although Somaliland does not have its own dedicated positional database for electrical transmission or distribution, the technology evolution now provides some useful tools and data sets, which are readily available, and can be easily used to contribute toward Somaliland's data management needs.

There is a SRTM30 dataset (CGIAR-SRTM data aggregated to 30 seconds).[122] This data is freely available from the U.S. Department of the Interior U.S. Geological Survey, and is a valuable design tool which can be used. A meshed topographical map can now be created for preliminary design of overhead transmission and distribution lines. Detailed satellite imagery is available in some major cities which can also be used as a base layer for detailed final design of transmission, sub-transmission lines, and distribution lines.

Status of Land Surveying in Somaliland

Land surveying and land management is a fundamental and integral part of electrical transmission and distribution systems. Without proper surveying and cadastral maps, management is not possible. Countries differ on what tools or technologies used for surveying. With the advent of new technologies such as Lidar, total stations, RTK GPS, the surveying tasks have become more accurate, far simpler, and manageable. Most countries opted to bring state-of-the-art technology in their Surveying departments to take benefit of the new developments. In Somaliland, however, the contrary is evident, and this technology is not used.

Synopsis and proposed scope of Data Management

Data management is still largely paper-based in Somaliland. There has to be a fundamental change in mind-set for all local stakeholders regarding Data Management. The biggest obstacle to change acceptance is for stakeholders to understand the benefits of new technology. The best way to provide this understanding, is for the stakeholders "to feel the consequences" of not having a modern data management system.

High Voltage Transmission

Status of Regional High Voltage Transmission Master Plans

[122] *The Shuttle Radar Topography Mission (SRTM) is an international research effort that obtained digital elevation models on a near-global scale. The data (referred to as SRTM), is readily available.*

There are several regional role players who have master plans in place either in final or in amended draft form. These reports and master plans all are all in general agreement with one another, but are lacking detail when considering interconnection of Somaliland.

Common Market for Eastern and Southern Africa (COMESA) has embarked on an Energy Programme whose main thrust is to promote regional cooperation in energy development, trade and capacity building. The COMESA adopted in November 2007, the COMESA Model Energy Policy Framework. In the area of Renewable energy, a baseline renewable energy database was developed for COMESA region.

The Eastern Africa Power Pool (EAPP) was established in 2005 and adopted in November 2006 as a COMESA specialised institution for the enhancement of energy interconnectivity in the region and the rest of Africa. The EAPP adopted the 2025 strategic road map and the regional market design. A regional power master plan and grid code were also developed as well as the establishment of an Independent Regulatory Body.

The East African Power Pool (EAPP), published their first high voltage master plan in 2011. This was then updated to incorporate scope to include Libya, the entire DRC and South Sudan Master Plan. There is however, no detailed interconnection plan to Somaliland.[123]

The International Renewable Energy Agency (IRENA) is an inter-governmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation. In their study 'Analysis of Infrastructure for Renewable Power in Eastern and Southern Africa', they incorporate Somaliland into the EAPP grid connection plan by means of northern and southern 230kV transmission lines from Ethiopia.

Conclusion: Regional transmission expansion masterplans all largely ignored detailed interconnection plans for Somaliland. There is however, a common generalised and vague reference to possible future interconnection.

Current Status of Regional HV Transmission Grid Codes

The Ethiopian National Transmission Grid Code (ENTGC) follows exactly the East African Power Pool Interconnection code (EAPP IC), as well as the COMESA Model Energy Policy Framework. Ethiopia would therefore be the most technically and economically viable point of interconnection to Somaliland. This section therefore, addresses the status of grid codes specifically in Ethiopia.

The ENTGC is based on the grid codes of several other countries. These include The South African Grid Code (2012), The South African Grid Code for Renewable Power Plants (2012), The Namibian Grid Code (2005), The Indian Electricity Grid Code (2010, The Rwanda Grid Code (2012, The Ethiopian

[123] *EAPP Regional System Masterplan Published Dec 2014*

Energy Agency (EEA)'s Draft Interface codes for Generation, Interconnection, Distribution, and the Kenyan Grid Code (2015).

The ENTGC specifies grid compliance criteria under 4 main headings: Planning, Connections, Renewables and Operations.

Conclusion: If Somaliland wished to interconnect with Ethiopia, it would need to comply with the technical requirements laid down by EAPP IC and ENTG codes, as well as the COMESA Model Energy Policy Framework. These requirements are well developed and clearly defined, based on internationally accepted IEC standards. It would clearly not be economically or technically viable for Somaliland to create a new grid code, or deviate from an existing grid code for cross border interconnection.

Status of HV Regional Transmission Standards

The Ethiopian Standards Agency (ESA) is the authority representing Ethiopia. The National Electro-technical Committee of Ethiopia, (NECE), was established in November 2012 under ESA. Ethiopia is an affiliate member of International Electro-technical Commission (IEC). It has adopted 246 IEC specifications. There are Technical Committees (TC) within the framework of the IEC affiliate programme. These TC's fall under the control of NECE. The most relevant TC's to the transmission industry are TC62 and TC63.

TC 62 covers electrical power supply systems and machines, rotating machinery and components, transformers, solar cells, batteries, household electrical appliances and equipment, power transmission, distribution networks; and Rectifiers, converters, stabilised power supply. TC 63 covers electrical materials and conductors, electrical materials and conductors in general such as cables, bus bars, wires, magnetic materials, semi conducting materials, and insulation materials, etc.

Ethiopian Conformity Assessment Enterprise (ECAE) is the conformity assessment organisation in Ethiopia. ECAE provides testing and accreditation services based on standards such as ES, IEC, ISO and others national standards or specifications.

ECAE has a well-developed Electrical Test laboratory where different electro technology products are tested according to Ethiopian standards adopted from IEC International Standard test methods and requirements. ECAE's Electrical laboratory has six main laboratories for testing Cables, Insulators, Protection Devices, photo-metrics, batteries, power analysis, and a new PV test lab.

Conclusion: There is a well-developed regional set of standards and local laboratories, which conform to and incorporate IEC international standards. Ethiopia appears to lead the field in terms of enforcement and implementation of standards, within the auspices of COMESA and the EAPP.

Synopsis and Proposed scope for High Voltage Transmission

There are no power master plans within Somaliland. There are, however, well-defined regional power master plans, but with vague, yet common reference to possible 230kV interconnectors from Ethiopia. It is most improbable, given the complexity of negotiations, and policy making, and lack of any HV infrastructure, that any form of interconnection with Somaliland could materialise in the short term.

There are no methods and standards within Somaliland, but there are well-developed international interconnection and transmission standards in place in Ethiopia, and in the neighbouring EAPP countries.

In the context of Somaliland's future HV transmission planning strategy, it would be imprudent for Somaliland to develop new or different transmission grid codes, or standards, if they wish to connect to Ethiopia or any of the EAPP countries at some unknown future point in time.

The most expensive component of a transmission grid is transformers and substations. The purchase of non-standard plant can have disastrous cost implications later. [124] [125] It would be of utmost long-term importance that Somaliland, during its gradual network expansion, adopt and adhere strictly to IEC international standards for any planned HV transmission lines and substations.

Significant technical augmentation could be achieved by joining the IEC as an affiliate country (like Ethiopia), and by direct cooperation with ESA. The primary benefit would be training and development of technical work groups within the IEC framework.

The absence of fixed interconnection plans, or a national grid code does not prevent Somaliland from developing a corridor route selection plan for the future 230kV interconnectors. All this can be done in advance of any negotiations with neighbouring countries. This exercise is also not affected by electrical grid codes of neighbouring countries. The line route options, and even preliminary design and costing options, can all be done by making use of currently available SRTM data and satellite imagery utilising industry standard line design software.[126] Having a preliminary line design, costing and route options available would provide a significant advantage when negotiating with neighbouring countries, and when requesting funds from international donors.

It would therefore be a very viable proposal, to carry out preliminary line design and corridor route selection for the possible 230kV interconnector. The benefits for training local engineers in survey, GIS and line design techniques, using industry standard design software, would be immense.[127]

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[124] *Case study 1:- In South Africa during the apartheid era sanctions period, non-standard transformers were purchased from non- reputable sources. These have to be replaced later at huge cost.*

[125] *Case Study 2:- Afghanistan, interconnection between HV grids is not possible unless a back- to- back DC substation is built at h cost.*

[126] *Power Line Systems software (PLS Cadd) is the industry standard design programme for the design of overhead electric power transmission, distribution, lines and their structures. https://www.powline.com/*

[127] *The training component would only be possible if Somaliland provided an engineer and purchased PLS Cadd software for its own use.*

MV and LV Distribution

Cost of Distribution and effects of low consumption

By comparison to other developing countries, Somaliland has a very low After Diversity Maximum Demand (ADMD). All past reports researched, estimate ADMD to be in the range of 500-600W per connection.[128] This is less than half that of similar strife torn countries like Afghanistan. This low figure is a direct result of the consumer not being able to afford the cost of electricity.

In order to fully appreciate the simplicity of problem, one has to look at it from the perspective of the private electricity supplier. In order to receive the same return on investment, with only half the demand, the private generator has no option but to double the price to consumers.[129] This is precisely what happened in Somaliland. This strategy clearly did not work, as customers simply cannot afford the high prices.

Latest figures indicate that the initial high prices are dropping from in excess of US $1/kWh to less than 60 cents. The only other option left to the generators to improve profits is to cut the cost of the infrastructure. The direct disastrous effects of this on the distribution network are clearly evident (no standards, 'spaghetti' wiring, overloaded wires, brown outs, volt drop, sub-standard equipment, fierce competition between private generators).

In the context of the private generators having to operate in this harsh environment, the last item on their agenda is methods and standards. The financial losses resulting from having no methods and standards are huge.

An even worse financial outlook faces the companies in years to come. As the economy of Somaliland continues developing, the consumption will increase, and the sub-standard infrastructure installed in previous years will become overloaded, fail, and have to be replaced.

A grid as a means of achieving self-regulation, and compliance with minimum acceptable methods and standards

Any grid no matter how small or large, is inherently self-regulatory. It is not tolerant of current, voltage or frequency violations. If any of these criteria are violated, the load or generator is simply disconnected from the grid in order for the grid to function optimally. These technical constraints force technical compliance by members, if they wish to stay connected to the grid. This in turn forces all grid operators (generators and consumers), to accept and maintain minimum acceptable methods and standards, if they wish to remain connected.

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[128] *Energy Sector Needs Assessment and Action/Investment Programme Draft Final Report: June 2015 Federal Government of Somaliland and African Development Bank*

[129] *The rate of $10 month (more or less a traditional price by now) for a 50 watt bulb (in use, say, 6 hours a day) is equivalent to more than US$ 1/kWh. For comparison, tariffs in other similar countries were: 10-12 us cents/kWh in Burundi, 50-55 us cents in Liberia (Monrovia), 18 us cents in Kenya, and about 40 us cents/kWh in Uganda.24*

Example: A generator operating autonomously does not care if his generator voltage drops to 150V under heavy load. He is not affected by the consumer's volt drop problems, and losses. If however his plant is connected to a grid, his paying consumers would be disconnected from the grid automatically when the voltage falls below 5%. This would force him to purchase a larger generator to adequately match the demand. It also forces him to implement demand management.

Protective devices as a means of achieving self-regulation, and compliance with minimum acceptable methods and standards

Resellers of electricity having a LV networks see no reason or benefit for using protective devices under the current conditions. As a result of cost cutting, 'spaghetti' wiring, direct connections without circuit breakers, overloaded conductors, and low voltage, are the order of the day. Resellers do not care about the consumer's voltage problems, neither do they understand the benefits provided by protective grading.

Example: If, however, the reseller were connected to a grid, he would have his entire network summarily disconnected from the grid if a fault or overload condition occurs (instead of only a small section of affected line). The associated loss of income forces him to recognise the need to start using protective devices in order to sectionalise faults and manage load.

Renewables as a means of achieving self-regulation, and compliance with minimum acceptable methods and standards

A modern grid-tie inverter has a fixed unity power factor, which means its output voltage and current are perfectly lined up, and its phase angle is within 1 degree of the AC power grid. The inverter has a pre-set on-board computer which senses the current AC grid waveform, and outputs a voltage to correspond with the grid. Grid-tie inverters are also designed to quickly disconnect from the grid if the utility grid goes down. This is an international safety requirement that ensures that in the event of a blackout, the grid tie inverter will shut down to prevent the energy it transfers from harming any line workers. Grid-tied inverters dislike even minor voltage or frequency disturbance. This results in automatic disconnection of the inverter from the grid.

The intentions of renewable solar or wind generation (without expensive batteries), will not be achievable if the grid voltage waveform and frequency are unstable, as the inverter will be disconnected from the grid most of the time.

This therefore forces the grid members to ensure that their grid frequency, waveform, and voltage (all set by, by the primary generating diesel generating plant) meet international standards in order to optimally import power from renewables.

The Cost Premium for Badly Designed Overhead Lines

The cost of an overhead line is directly proportional to the structural loading of the structures. The placement of structures and the ground elevation profile determine the optimum positioning of structures. In theory, a perfectly designed line will have all structures loaded to 100% of capacity (in the real world 80-95% is achieved for a well-designed line).

A badly designed line is one that has been "designed" without determining the structural loading of each structure. It will (based on a simple statistical rule of 50/50) have 50% of the structures overloaded and 50% under-utilised. The cost premium for a "no-design" line is at best 65% more expensive when taking into account the wasted material for under-utilised structures, and the rework related to overloaded structures which have to be replaced later.

In the context of Somaliland, it can be said with certainty that most lines are costing at least 65% more than they should, purely as a result of "no-design". This expensive reality, should prompt developers to realise the need for proper design rules relating to the correct placement of structures.

The Cost Premium for Using the Incorrect Technology for Overhead Lines

In developing countries, the incorrect selection of wood, steel, or concrete for overhead lines, can result in significantly inflated costs. Developed countries often take for granted the availability of materials, and the state of roads and transport.

Example: The use of spun-concrete poles, becomes a very expensive exercise if there is not a manufacturer near to the proposed installation. The transport and import costs become excessive, and there are often breakages, due to transporting poles over across bad terrain.

Localised distribution line design technologies need to be developed. An example would be from South Africa, which is one of the few countries that applies all three technologies (wood, steel, concrete) to their most suitable application, based on terrain, cost and availability.[130]

Localised distribution line design technologies and standards can easily be developed in parallel with pilot projects, while remaining within the electrical constraints of IEC. A set of pre-defined set/s of structure family types with a simple set of design usage rules could be implemented for use in possible future HV lines.

The Cost Premium for Using Incorrect MV voltage

The development of insulator technology, line hardware, and cables, and IEC clearances, means that MV overhead line structures can now be standardised for all medium voltages up to 33kV. An example of this would be in Malawi, where the entire MV grid is being rebuilt at 33kV.

[130] *Eskom provides a Technology Web site which allows secure access to equipment Design and Manufacturing specifications, http://www.eskom.co.za/Whatweredoing/Pages/Technical_Specifications_And_Standards.aspx*

Fortunately, Somaliland has very few 15kV lines and only one 33 kV line. These 15 kV lines are a relic from the pre-war days, and should not be further extended

Synopsis and Proposed scope for Distribution

There have been many need assessment reports published, all referencing the same problems, but no tangible action has been implemented. This delay has resulted in private generators taking the initiative into their own hands, and the situation of maverick private generation is worsening the situation day by day. There is no technical or regulatory reason why Somaliland should not be able to immediately start implementing distribution design standards, provided that they all fall within the constraints of IEC. The main obstacle to implementation is “buy-in” from the private sector and local authorities.

Recommendations

Selection of Medium voltage System

The merits of 33kV and 20/22kV were evaluated based on geographic layout, load densities, and using 240mm 2 ACSR conductor. (largest size conductor that can be used).

For the high load density 36 consumers / hectare, and streets typically 3-5m wide, 33kV structures are not feasible, or constructible, as twin pole H structures would be required, which would encroach onto the road, and / or encroach into private properties. Therefore, 20kV is recommended for these load areas, where most of the 20/22kV structures would be single pole type.

For lower load densities and wider roads, and in rural areas, 33kV lines could be used, however the merits of standardisation for operational purposes, also need to be considered. Therefore 20/22kV in all areas may be a more feasible option for the sake of standardisation of structures, and interchangeability of pole mounted transformers and compact stations.

Technical Assistance

This note suggests that there are two areas where assistance could be provided to the power sector by lending agencies:

- the proposal of a pilot project to illustrate the need for geographic information systems; and
- the development of national standards.

Data Management Systems

The Government could approach a selected Energy Supply Provider to offer to convert its paper-based record system to electronic systems. The terms of reference for such a system would include:

- Review of readily available systems;
- Prepare a 'white paper' (i.e. a short high-level report) on the advantages and disadvantages to the Somaliland ESP of each such system. For the purposes of this project the objective would be to set up a rudimentary but functional GIS/Mapping database system[131] to be run in parallel with any pilot project, and to provide much needed local training;[132]
- After agreement with the ESP and the funding agency, purchase for the ESP the selected software package;
- Install the selected system in the main office of the ESP;
- Train a team of personnel within the ESP to enter the paper-based data into the system;
- Jointly with the ESP, prepare a user's manual for the system as applicable to the ESP;
- Assist the ESP with the use of the system on a jointly selected (consultant – ESP) pilot project;
- Prepare a report for the funding agency on the benefits observed of the newly-installed data management system;
- The level of effort required for this mandate would depend upon the size and complexity of the ESP selected.

Development of national standards

As mentioned above, there are national standards and grid codes in place for neighbouring countries. National standards should be prepared for Somaliland that would be consistent with those documents. The terms of reference for such a system would include:

- Obtain and review electric power network standards from Ethiopia;
- Select one of these sets of documents to act as a starting point for the development of national standards;
- Propose a draft set of documents for Somaliland with the intention that the document would permit the implementation of sub-transmission and, eventually, transmission systems that would be compatible with the neighbouring countries;
- Revise the draft taking into account comments received and send copies to the government.

[131] *A good inexpensive mapping software such as Global Mapper®™ or equivalent is recommended.*
[132] *Past experience in Afghanistan shows that three young local engineers, can after 18-24 months of expat training can take ownership of electrification projects of in excess of 20,000 connections.*

Annex 5: Energy Situation in Somaliland

Introduction

As part of producing this Somaliland Power Master Plan, an assessment of the potential energy resources for producing and supplying electrical and heat energy was crucial. This is to assist the energy authorities, energy infrastructure investors and sector stakeholders in establishing modern, cost effective and reliable electricity systems for a 20-year horizon, which is key for national and regional development.

An assessment of natural energy resources fills gaps for the energy authorities and stakeholders, such that they can better develop and implement strategies along with building technological and institutional capability. In addition, this provides a basis for supporting integration and development within the energy and interconnected sectors, along with, enabling the inclusion of support from donors and Public Private Partnerships into these processes.

The resources currently mobilised for energy consumption fall into two prime categories. One category is energy resources intended for the generation of electricity and its subsequent utilisation and the other category is for the generation of heat:

- current primary sources for providing heat are sunlight, biomass, bottled kerosene, compressed LP gas and electricity;
- primary sources for providing electricity are currently high-speed diesel generation sets (HSDGs) with limited use of grid-tied solar photovoltaic (PV) and very limited use of grid-tied asynchronous wind power turbines; and
- there is also a quite significant interest to and utilisation of Pico PV and Small Home Solar (SHS) PV electricity systems for residential lighting in both urban and remote areas.

Furthermore, the addition of sizeable grid-tied solar PV generation to the HSDG based systems of some of the various electricity service provider's (ESPs) electricity generation and distribution networks has resulted in some synchronised hybrid diesel-solar PV electricity generation systems across Somaliland.

Assessment of Current Resources

The current energy resources being used in Somaliland can be classed into three groups. Two are chemical energy stored fuels – biomass based energy resources and fossil fuel energy resources. The third is renewable energy resources.

The most significant energy resource currently used Somaliland is biomass – use of wood and charcoal to provide both heat for food and export revenues. Table 52 provides some quick facts on the use of biomass and fossil fuels for heating and lighting.

Table 52. Quick facts on biomass and fossil fuel direct use for heating and light

Energy Source	Cooking/ Heating SSMP*	Lighting SSMP
Charcoal National BM		
Urban resident BM	US$1.06/month cap	
Commercial BM	US$2.84/month empl	
Institution BM	US$3.64/month empl	
Kerosene FF		
Urban resident BM		US$2.35/ month cap
Commercial BM		US$10.37/ month empl
Urban households of 6 people expend on average US$20.46/month on Charcoal and Kerosene		

* SSMP – Somaliland Survey PMP 2017

Source: SSMP

Wood & Charcoal

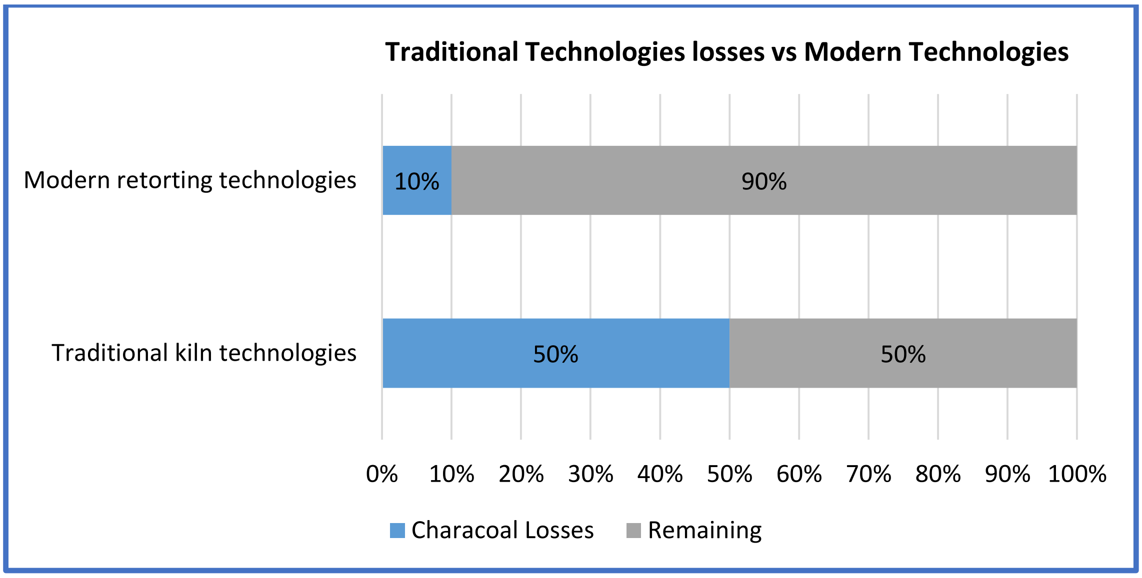
Both wood and charcoal are used primarily for heating. They are also a source of significant revenue for numerous commercial activities. Unfortunately, while trees are renewable resources, the current practices of wood and charcoal exploitation is almost 100% dominated by extractive practices carried out on slow growth primary forests that are not being replanted. This process has caused both profound deforestation and environmental degradation across many areas.

Significant quantities of wood are converted/manufactured into charcoal. This is then transported across the country to both urban centres and ports for export.

Charcoal is manufactured by slow pyrolysis of wood, through either traditional kiln technologies, or modern retorting technologies. The traditional kiln technologies are known to be inefficient with manufactured charcoal fuel losses in excess of 50%, while modern retorting technologies are markedly more efficient, with manufactured charcoal fuel attaining yields of 90%.

Box.
It is estimated that approximately 80% of the manufactured charcoal is exported to the Middle-East Gulf Areas for cooking practices in those countries.

Figure 53. Comparison of traditional vs modern technology losses



Source: Unicon

The advantages of charcoal over wood are numerous:

- low smoke and odours;
- stable heat source without flames and burns at a higher temperature;
- charcoal produces almost twice the heat produced by dry wood;
- charcoal is 60% of the volume and ¼ the weight of dry wood;
- charcoal resists humidity and is easier to store and transport than wood; and
- it is a value adding activity that provides employment and revenues for those involved in its manufacture and distribution.

The scope and size of the wood and charcoal industry is both broad and large, with key stakeholders, including transport companies, urban and rural communities, local venders, climate refugees, marginalised pastoralists, other marginalised communities.

It has direct impacts in the residential, commercial, manufacturing, institutional and even political sectors. Notwithstanding the harsh impact it has had on the ecology and environment of Somaliland, it is a key priority in the lives of the majority of citizens of Somaliland.

Barriers to change in the use of wood and charcoal within the energy economy of biomass are a combination of a lack of integrated sociological, employment, economic and climate-ecologic and technical solutions.

Fossil Fuel

The fossil fuels used in Somaliland include diesel, gasoline, kerosene, aviation fuels and small quantities of natural gas. These are used for diverse energy related activities:

- kerosene is largely used for both heating and lighting;
- natural gas, as either compressed gas or liquefied gas, is used for cooking and some commercial purposes;
- the scope of gasoline is primarily in the transport sector powering small and medium motor vehicles. Gasoline is also the primary fuel used in powering small household electricity generators, and for mini captive generation and minor isolated communities;
- aviation fuel is specifically used for the airline industry that serves the major urban centres such as Berbera and Hargeysa.

Diesel is the predominant fossil fuel. This fossil fuel is a significant imported product, and powers nearly all the large machines. It extensively powers large transport vehicles, such as trucks hauling and delivering materials, including that of diesel, gasoline, kerosene, natural gas bottles and even charcoal. Diesel also fuels all the High Speed Diesel electricity Generators (HSDGs). Furthermore, this is the primary fuel powering the national and domestic fishing fleets.

Consequently, the scope and size of the diesel fuel use industry is also broad and large with key stakeholders including transport companies, urban/rural/agricultural communities, fuel storage and port authorities, and local venders. Additionally, it is essential to the electricity generating companies.

It is a key element to the stability and economic survival of Somaliland as it directly impacts the residential, commercial, manufacturing, institutional and even political sectors, through both electricity generation and the transport of essential goods for trade and commerce.

Amongst the key players in the delivery and transport of fossil fuels are the ports of Berbera, where there are notable fuel storage and distribution facilities. Thereafter all these fossil fuels are distributed nationally via diverse local agents and vendors. The delivery of fossil fuels is prioritised to major urban centres.

Barriers to further use of fossil fuel for electricity generation, notably diesel, include, at least, the following:

- Economic and ecologic cost of liquid fossil fuels are expected to rise globally;
- Poor quality roads for fuel deliveries and transport;
- Inefficient use of existing diesel generation leading to “wet stacking”.

Box.

Fossil fuel deliveries to remote or isolated locations are hindered by the quality and distance of the roads reaching these locations and consequently result in higher costs for fuel deliveries.

Renewables

The use of renewable energy resources is largely dictated by the availability of certain specific renewable resources and their hybridisation with other energy sources to create a reliable supply. These are (i) solar irradiation, (ii) elevated and relatively continuous wind speeds, and (iii) specific geographic locations demonstrating meaningful steep changes in vertical elevation.

The predominantly used renewable resource used is solar PV with a small amount of wind power. The solar PV is being used primarily by some urban ESPs for diesel fuel replacement during daytime electricity generation, along with reductions in carbon and pollution emissions.

The scope for solar PV for urban electricity generation via grid tied (synchronised) hybrid electricity generation paralleling the existing HSDG electricity generation, is being expanded by some urban ESPs.

While the size of each current urban solar PV generation site is significant, it is still early in the solar PV process of implementation and the impact on overall generation is small. Current key players and stakeholders, include the ESPs, the ESRES project (financed by the UK's Department for International Development), the Ministry of Energy and Minerals and an international EPC firm (EPS) that has partnered with two ESPs to construct hybrid electricity generation facilities in Laascaanood.

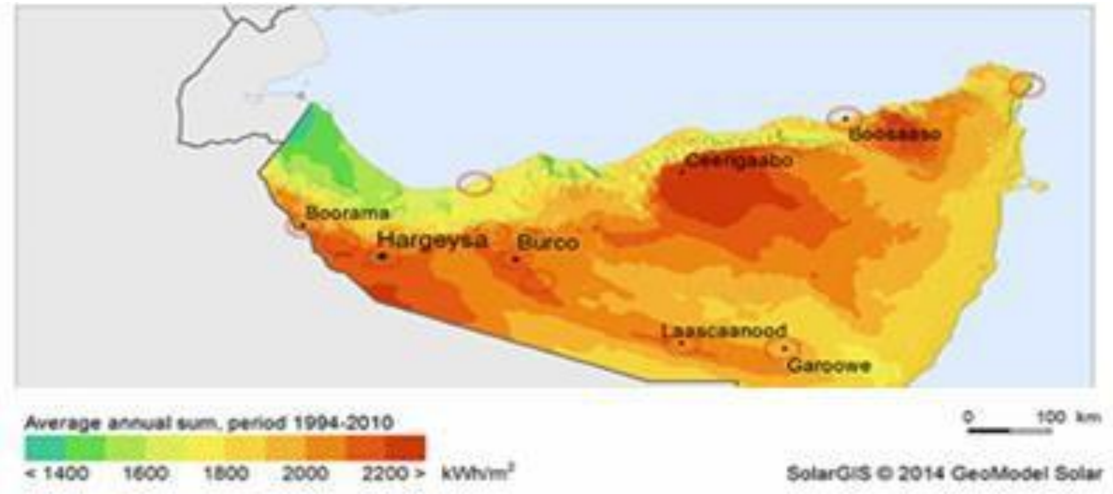
Solar PV offers a key element in reducing significant ongoing expenses for fossil fuels, while stimulating the productive use of electricity during daylight hours. Its primary impact is on commercial, manufacturing, institutional and even political sectors, through both cheap and ecologic electricity generation during business, institutional and manufacturing hours. As grid-tied generation, it currently offers basic electricity generation in support of well-designed and operated hybrid electricity generation.

Solar PV application in remote locations offers independence from poor transport routes and significant benefits for supporting agricultural, pastoral and remote communities in water resource management, enhancing food production, employment and quality of life. Some sites sponsored by the ESRES project also use Li-ion battery storage to stabilise electricity generation from the solar PV system.

Barriers to further use of renewables are (i) the lack of technical capability for implementing wind power, and (ii) integrating renewables and thermal generation for efficient hybrid electricity generation. The capital cost for renewable generation is projected to continue to drop between 15% and 35% during the next 7 years, and once properly commissioned – they have low operating expenses compared to fossil-fuelled HSDG thermal generation.

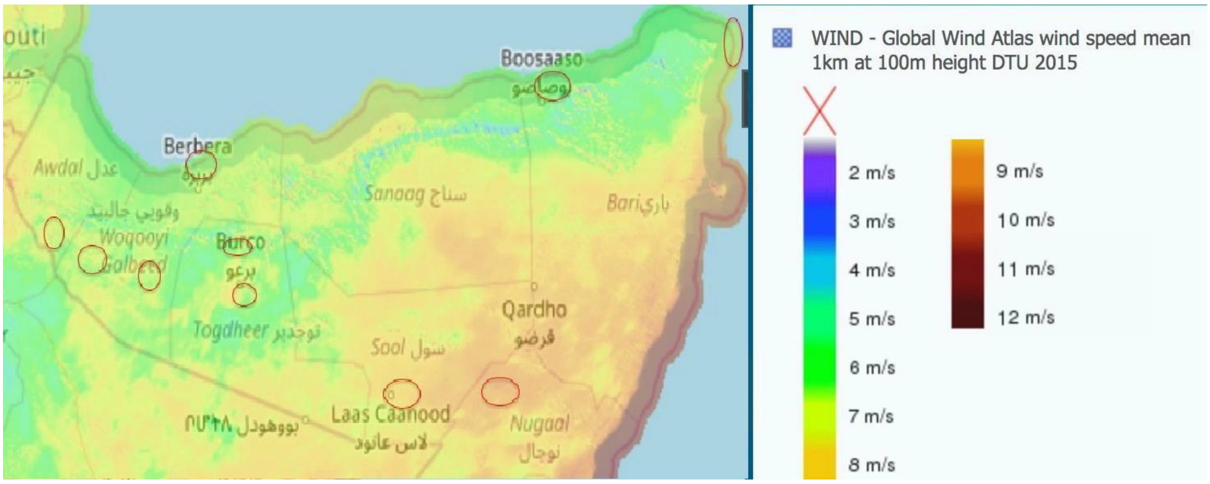
Proper, large and widespread implementation of renewables based hybrid generation is one of the long-term key elements to reliable, robust electricity generation, economic development, environmental remediation and climate resilience for Somaliland.

Figure 54. Solar resources map



Source: Solargis, Global Solar Atlas

Figure 55. Wind resources map



Note: Bountiful wind resources
Source: IRENA Global Wind Atlas

Institutional Framework for Developing Energy Resources

Technologies

The technologies currently available in the commercial marketplace for developing the energy resources of Somaliland are primarily based on using fossil fuel thermal generation, solar PV, wind turbines, traditional hydroelectricity and waste energy generation. The future of electricity generation and energy utilisation Somaliland will greatly benefit from the philosophies and union of hybrid electricity generation and energy utilisation.

This means that these technologies and their implementation should be coordinated with applications that are also beneficial to other key sectors necessary for socio-economic development. These include the water resources sector, agricultural sector, employment sector, waste treatment sector, regional and national security, transport sector, education sector, physical infrastructure sector, entrepreneurial and commercial sectors.

Barriers

Barriers to implementing the projects reside in financial support, wherein two main modalities are available. One is investments for commercial sector oriented projects, based on sound business practices and partnership creation within local and international actors and investors. The alternative is aid programmes, which offer support for investment practices that optimise results for successful operational infrastructure.

The lack of quality road transport infrastructure for the distribution of fossil fuels for electricity generation is problematic and ongoing. Furthermore, climate change is causing a major burden on the region's population and their environment, which is aggravated by the population's predisposition for traditional agricultural and extractive practices.

Opportunities

Opportunities for developing energy resources are best framed as encouraging the interests of investors and creating effective reciprocal partnerships between national and international firms to develop the necessary human and technical infrastructure to implement, operate and maintain the electricity infrastructure.

These can also create effective mechanisms of technical and economic reciprocity between areas in the country and with neighbouring countries, and also with foreign investment agents. Aid/development agencies should be encouraging the creation of real reciprocity in commercial, financial and technical activities.

Bottlenecks

Bottlenecks to the effective development of energy resources include the current lack of physical infrastructure that facilitates and supports the implementation and maintenance of distributed and decentralised electricity generation. The current lack of technical capability also limits the current and future operation and maintenance of decentralised distributed hybrid electricity generation and energy utilisation.

There must be effective mechanisms for creating and ensuring that explicit planning and implementation of projects occurs with proper tracking and linkages to other projects for validation and collaboration. The current issues of political recognition and financial clarity and openness must be addressed in creating the needed partnerships that create the necessary electrical infrastructure and generation.

There is also a lack of clear regulations and standards for the electricity sector, which makes it very difficult to create the crucial financial investments and partnerships required for the expansion of electrical generation because the liabilities are unknown and discouraging.

Sectorial End-use Energy Consumption Classification

In determining the scope and size of energy and electricity resources used, a field survey was conducted in Somaliland. Examination of this limited data set provided useful information concerning the utilisation of electricity, wood, charcoal and kerosene.

Consumption Classes

Assessment of field data collected for energy consumption was divided up into classes. These classes were identified via five user types:

- Household-Residential;
- Small businesses;
- Restaurant-Hotel;
- Large Businesses; and
- Institutions.

The key class for identifying general population energy and electricity use is Household-Residential. It was also observed that large businesses tend towards using their own captive generation and only use the ESPs for limited services. The class of large captive generation is a special class, which, due to insufficient data, is not able to provide very much information for analysis and calculations.

Moreover, data for small business and restaurants/hotels was combined to a general business sector class for ease of use. The class of Institutions covered government entities, hospitals, and education facilities. The data was also analysed for different sized urban centres: medium towns (20-30k persons) and cities (over 100k persons).

Analysis was made for electricity utilisation by households, businesses, institutions, as well as, for medium towns, small cities and large cities. Additionally, an analysis was made for electricity rates for medium towns, small and large cities. Information concerning charcoal and kerosene was collected in and analysed for expenses made by household-residential, restaurant-hotel and institutions.

Energy Resources Available for Future Power Supply

Hybrid Electricity Generation

A growing global trend, within electricity generation and delivery is the utilisation of hybrid electricity generation resources. This modality derives from combinations of fossil or biomass fuelled thermal electricity generation and renewable energy electricity generation. The blending of the strengths and vulnerabilities of the different sources of electricity generation along with advances in integrating isolated electricity generation has resulted in reliable, resilient, cleaner and more responsive electricity power networks.

Additionally, this trend is being further advanced and benefiting from a category of technologies referred to as ‘smart grids’. Strategies for implementing smart grids are applicable to either isolated small urban island distribution networks, or as part of large urban island distribution networks, or multi urban distribution and transmission networks sharing electricity generation across a region.

These new technologies for hybrid electricity generation and delivery include Black Start and Rapid Peak response electricity generation (high-speed responses of 3-4 millisecond) using renewables based UPS (Uninterrupted Power Supply) systems. These systems are designed to support whole electricity networks that are relying on distributed sources of electricity generation.

As a result of legacy thermal and hydroelectric based electricity generation in many developed economies, electricity generation has become a blend of centralised electricity generation and distributed electricity generation.

The future electricity generation for Somaliland should follow a sequence of evolving electricity generation and delivery integration and complexity to fully capitalise on hybrid electricity generation. The initial stages must involve (i) the creation of effective and efficient urban electricity generation, and (ii) island distribution networks for each of the urban centres.

These hybrid resources must then utilise both increasingly intelligent and automated management of electricity generation and distribution; combined with radial and ring distribution networks. These steps will lead to creating the economic conditions for connecting multiple and distal urban centres via transmission lines, which will in turn, provide a regional electricity transmission bus.

Such steps of competent local electricity generation and distribution will enable sound economic arguments for reciprocal electricity exchanges, such as, via electricity exports and imports, with the neighbouring countries of Ethiopia and Djibouti.

Renewable Energy Resources

The combination of exacting and sophisticated electricity consumers supplemented by global trends in electricity generation is increasing the role of renewable energy sources in generating electricity. Renewable energy sources for electricity generation are already recognised as very important in providing reliable electricity (albeit expensive) for remote and isolated areas.

It is also becoming more and more pertinent to electricity generation for large electricity networks and contributing significant power to large urban and industrial centres, as well as, for national and regional electricity networks.

The key renewable resources to exploit in Somaliland are primarily solar PV, wind and energy storage. Energy storage will be more extensively covered in the section on generation, because it pertains to hybridising with other forms of electricity generation, rather than as generation in isolation.

This is further driven by the economic fact that capital costs for wind generation and solar PV generation have been continuing to drop in past years and are predicted to further drop some 15 to 35% during the next five to seven years.

The focus here is on applications of solar PV energy and wind energy for future electricity generation. Other potential renewable energy sources that may be worth considering in the future, but to date have not been properly identified within the region include; geothermal, tidal, wave and solar thermal. Anecdotal evidence is reported, concerning geothermal but the current good potentials are only known to exist in Ethiopia and Djibouti.

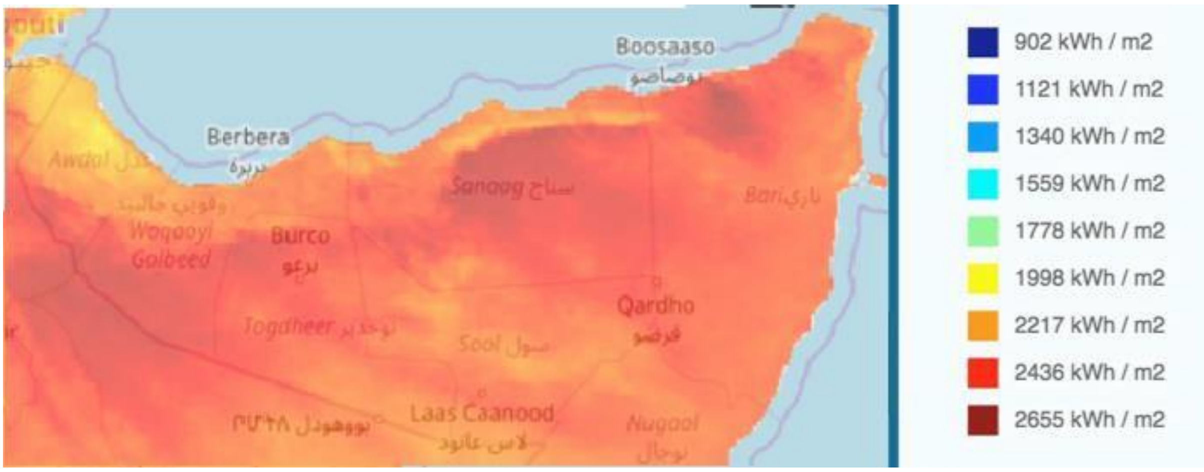
Another potential source is tidal energy, which is based on tidal variances along the coastline of Somaliland. In this area, tidal variances are only 1.8-3.0 meters, which is not very high with respect to regions of the world where tidal energy is considered sufficient to capitalise upon: > 5.0m.

In order to capitalise upon a 2-3 m variance, a significant sea water impoundment using geographical locations would need to be identified and further explored. Wave powered electricity generation is currently an area of ongoing research globally and is not relevant to the current context.

Solar Energy

The solar energy resources for electricity generation are demarked by solar energy maps, see the Figure 56 below, which show that especially in the areas of Somaliland there is excellent solar irradiation available for solar PV electricity generation. In addition to the solar irradiation, it is also crucial to know the sun path and what is the area of land required for solar PV electricity parks.

Figure 56. Somaliland solar irradiation map



Source: IRENA

In Somaliland, solar panels should be generally placed at around a 10 (8-12) degrees angle inclined to the south. Too shallow a panel angle makes array cleaning and maintenance difficult.

The surface footprint required for commercial silicon-based solar panels giving 1 kWp of solar PV electricity generation using current solar PV panels of 14-17% efficiency is 8-8.5m^2. In Somaliland it would be 8,5m^2, due to using slightly steeper panel inclinations. In effect, this is due to the shadow thrown by a panel array.

Consequently, a 1 MWp solar PV park, with 1,000x1kWp, would require 8,000 to 8,500m^2 of land, which is a square 90m x 90 m in area – less than a hectare. A 100MWp solar park would require 80-85 hectares, or 0.9km x 0.9km.

Table 53. Somaliland typical solar park footprint area

Area needed for solar PV array			
Country	**Side of Square area needed (m)**	**Area hectare**	**Generation Size (MWp)**
Somaliland	92.2	0.85	1

Note: Silicon solar PV panels: Efficiency 14-17%; Inclined at 10" South
Source: Solar shadow calculation with 0.35-0.4m spacing for inclined panels of 4 x 250Wp PV panels (dimensions 1.66m x 1m)

Wind Energy

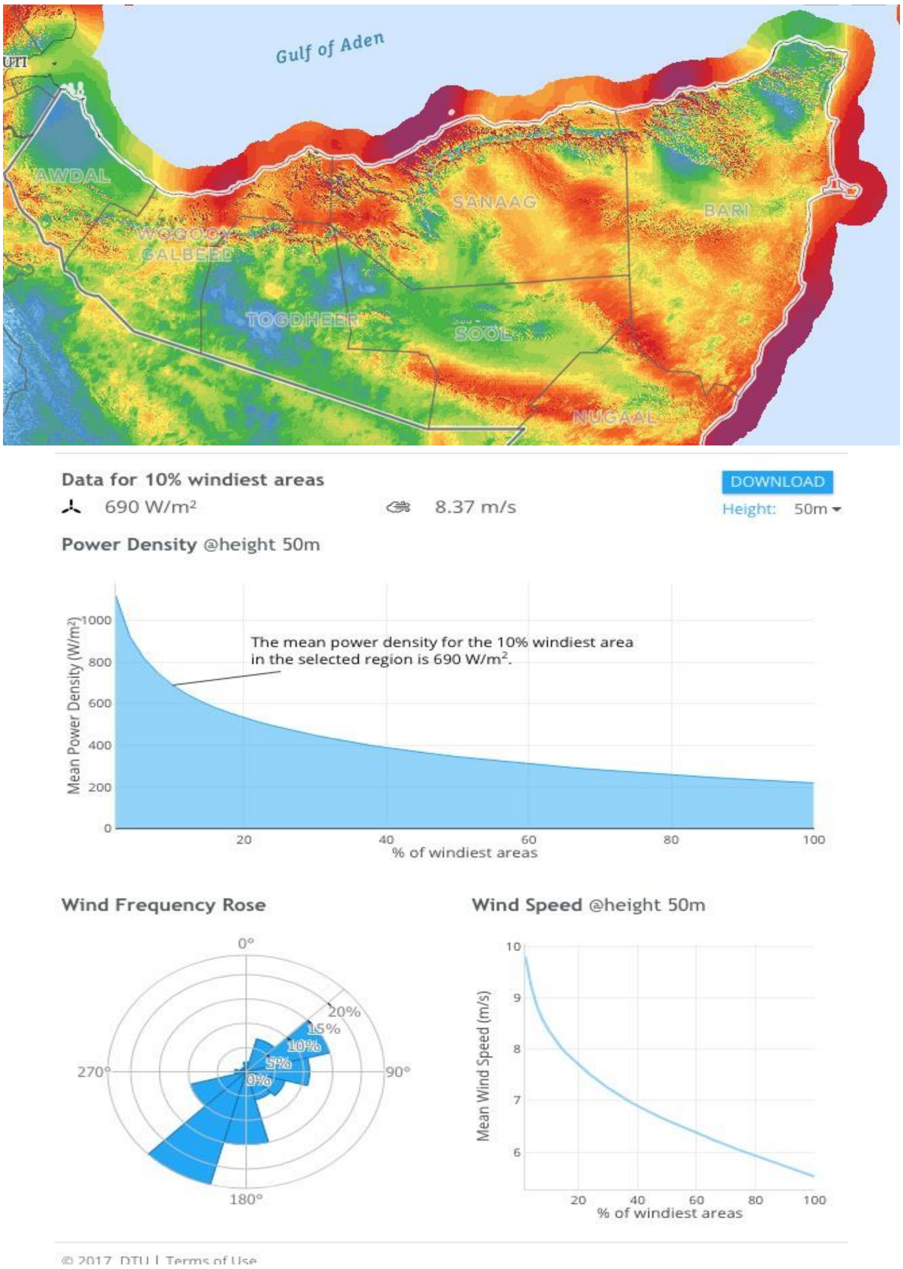
The wind energy resources for electricity generation are demarked by wind energy maps, posted below, which show that especially across Somaliland there are excellent wind speeds available for wind turbine electricity generation. In addition to the wind speed, it is also crucial to know what is the area of land required for wind farms.

Table 54. Somaliland typical wind farm footprint area

Area needed for Wind Turbine Farms							
Turbine power	**Rotor diameter (m)**	**Spacing factor (separation between)**	**Diameter required spacing (m)**	**Area required (hectare)**	**Spacing factor (separation between)**	**Diameter required spacing (m)**	**Area required (hectare)**
275 kW	30.0	5	150.0	1.77	7.0	210.0	3.46
1.5 MW	70.5	5	352.5	9.76	7.0	493.5	19.13

Source: *Wind Power Project Site Identification and Land Requirements, Global Energy Concepts and AWS Truewind, LLC*

Figure 57. Somaliland wind map



Source: WB ESMAP DTU VORTEX Global Wind Atlas

The surface footprint required for commercial wind power is given by a spacing of 3-10 rotor diameters, with 7 being the most common recommended spacing. A 30m rotor typically used for 275kW electricity generation requires about 3.5 hectares of land that can be used for concurrent agriculture and pastoral activities also. A 1.5MW wind turbine with 70.5 m rotors requires 19.5 hectares. This spacing is to prevent wind turbines from being in a wind shadow from another turbine.

Conclusion

It is evident that both solar and wind resources have significant potential for electricity generation in Somaliland. While there are technical challenges to establishing distributed electric generation using solar and wind power and their integration into the electricity supply of urban centres, this has become much easier in recent years, with significant automation and the adoption of smart network management as part of electricity generation.

A significant benefit of using multiple renewable energy sources is that electricity generation is derived from diverse sources and can be situated in a distributed manner around and even between urban centres, if there is a transmission line. This contrasts with centralised thermal generation sites, requiring specific nodes for fuel delivery.

Renewable generation can also be placed closer to key demand areas within a distribution network to assure active and reactive power requirements. Consequently, if needed they can be modified more easily, based on changing load demands. Moreover, their modular nature permits very easy upgrades as well as maintenance and repair.

The integration of network UPS systems into renewable energy generation permits dual benefits:

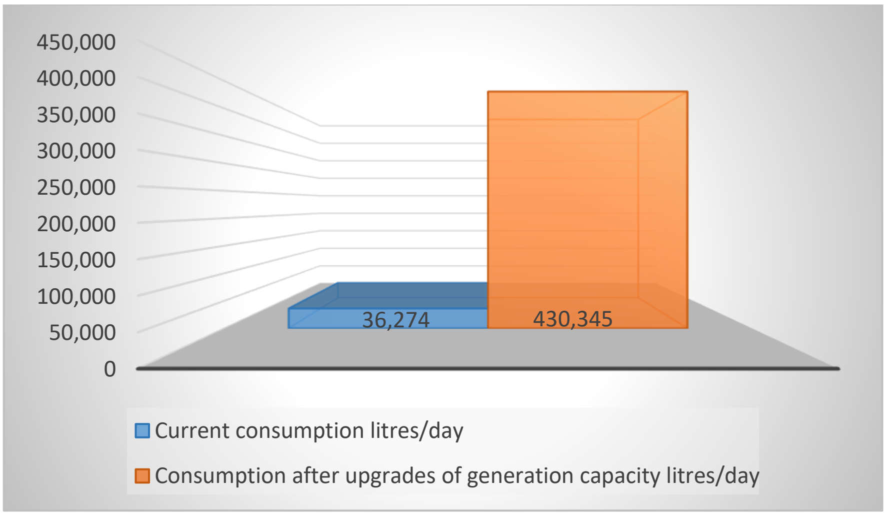
- having both rapid Black Start and Peak response to network problems; and
- provision of Prime generation support for floating generation.

Concentrated solar thermal is currently an evolving technology, but it may have excellent potential in Somaliland.

Waste and Fossil Fuels Resources

Based on data collected by the field surveys, Somaliland consumes diesel fuel in excess of 36,000 litres/day. Much of this is occurring in suboptimal and wasteful conditions of wet stacking. With future upgrades to current generation capacity, major improvements in performance of electricity demands. It is expected that the daily consumption of diesel fuel for electricity generation will increase significantly. This process of development will require significant expenses by the ESPs and their consumers.

Figure 58. Consumption of diesel (liters/day) in Somaliland – Currently reported consumption and expected consumption after upgrade of generation capacity



Source: Unicon

Clearly, hydrocarbon fuels are essential to electricity generation. Consequently, any other sources for such fuels, apart from imports, should be considered very valuable. An alternate source for much needed hydrocarbon fuels, necessary for electricity generation can be the waste energy processing of major urban dump sites of solid wastes.

The pyrolysis of urban dumpsite solid waste and urban sludge from wastewater treatment produces fuel that can be used to power gas turbines, and fuel oil powered HSDG and MSD (medium speed diesels) electricity generation. This processing will reduce fossil fuel imports and is also carbon negative, as well as producing a biochar for agriculture and market garden soil enhancements.

Fossil Fuels

Domestic sources of fossil fuels do not currently exist, but there is a long history of oil and gas exploration in the region. In recent years, upsurges in exploration for gas and oil reservoirs in perspective hydrocarbon basins, associated with the East African coastal basins, have been productive.

Annex 6: On-grid / Off-grid Issues

Criterion for Grids, Mini-Grids, Off-grid and On-grid

The National Grid

Electricity grids are physical networks interconnecting all the electrical energy between the source generators and the user loads. This grid is classified as the network connecting the electrical infrastructure of a country. Consequently, it can be a national grid.

Currently in Somaliland there is no physical national grid. Electrical energy delivery to users in the country comprises a network of isolated distribution grids comprising of island networks with isolated generation providers.

These island networks are anchored to specific urban centres with dedicated Electricity Supply Providers (ESPs). The ESPs are private enterprises, each of which are vertically integrated autonomous parallel electricity providers. Each ESP owns and operates their complete generation-distribution-customer and revenue chain using a radial distribution island network. Generation is primarily, if not 100%, by high-speed diesel fuel powered generators (>1,000 rpm).

An island network is defined as an electrical energy network capable of and actually operating independently of another electrical energy network and grid. Within the cities and larger urban centres of Somaliland, there are often multiple ESPs operating. In the smaller urban centres, there is usually only one ESP, if at all, or an ensemble of small independent "entrepreneurial" electricity providers (IEP). These small IEPs have been created by expanding from their own captive generation, and are the model by which most, if not all, current ESPs began.

All of the ESPs operate independently and as a consequence, there is significant duplication of generation, distribution, technical,[133] maintenance and human capability infrastructure. This duplication severely limits the scaling up of electricity generation and even more, hampers delivery and servicing for larger customer loads. Duplication is especially acute for ESPs within the cities having multiple ESPs. These include Hargeysa (6xESP), Burao (2xESP), Laascaanood (2xESP), Boorama (2xESP).[134]

Another unfortunate consequence of these multiple entrepreneurial vertically integrated ESPs has been that there are significant electrical losses, reportedly up to 50%, within the urban island radial distribution networks. Moreover, there are no regulations or standards for electrical wiring done within the customer premises. A direct consequence of these lacks is that it is reported that some 60% of fires in urban communities are caused by electrical wiring faults.

[133] *Includes monitoring-measurement, evaluation, tracking, training, planning.*
[134] *It is likely that the same situation of multiple ESPs applies in several of the other non surveyed urban centres.*

Currently, no ESPs share distribution networks, and these combined ESP electricity delivery limitations within the urban parallel island networks, have resulted in large load customers (LLC) opting for:

- utilising two different ESPs, in effect multiple networks supplying one customer; or
- creating their own on site, captive generation stand-alone “mini-grids”.

One recent market adjustment to these duplication limitations has resulted in the consolidation of smaller ESPs and IEPs into larger ESP firms. The attendant pooling of these firms’ technical and human capability infrastructure, has apparently benefited these consolidated firm’s financial and technical bottom lines, but the degree is unknown.

Another consequence of these combinations of duplication and electrical energy losses is that electricity prices are generally high. Based on field data collected in 2017, in Somaliland, the cost per kWh of electricity ranges from US $0.30 to 0.90 per kWh, with a weighted average of US $0.68 per kWh across all load users/consumers.

<u>Mini-grids, Distribution and Transmission Grids</u>

Discussions with both central and regional governments, the World Bank and donors have all indicated that in general they consider “mini-grids” as the relevant avenue for development in Somaliland. Unfortunately, the term “mini-grid” has become a broader and broader term used to cover different types of electricity networks that includes significant differences in key network components and utilisation.

Originally, “mini-grid” was a term used for a small local electrical grid with a single generation site, which generated electrical power for a short radial bus distribution network at low voltage (LV), to the load sites. This low voltage generation and delivery was either as single or as three phase, without any step-up or step-down transformers being used in the network. This application was for local isolated low voltage sites, where either a regional or national electrical power grid was not available or not desired.

> **Box.**
> Examples of “mini-grids” are electricity networks locally provided for an isolated community, a manufacturing facility needing to operate independently of a larger electricity grid and for temporary local electricity power generation in a limited area (e.g. emergencies). Many captive generation scenarios involve electrically powered mini-grids.

“Mini-grids” may also include auxiliary generation along the main distribution bus, usually longitudinal or radial wherein all electricity generation is synchronised to the AC bus at the level of voltage, frequency and phase. The key feature of "mini-grids" is they have no AC step-up or step-down transformers, and are consequently constrained to short distances/service areas, by the voltage losses produced by conductor resistance and high conductor costs.

For the terms of this Power Master Plan, the original "mini-grid" classification is used, i.e. no AC step-up or step-down transformers being used in the network, with direct low voltage AC feeders from generation to loads.

The arrogation of clear, precise technical terms for electricity delivery, by non-technical professionals, such as by management consultants, for application to a broad and imprecise class of electricity generation and delivery does not create clear simple understanding. Instead, it creates orotund, obtuse and bewildering definitions for systems. This practice is unhelpful for what obviously requires clear if not always so succinct descriptions.

Off-grid and On-grid

In providing a clear definition for Off-grid and On-grid, the key word is Grid, as already discussed above. Across Somaliland, there are distinct and unique features defined by both socio-economic activities and geographic localities. These determine the kinds of useable electrification delivery. An important proportion of Somaliland populations are identified as rural, which encompasses a level of diversity that produces an electrification context that is quite complex.

For many of rural communities and particularly very rural area populations, these communities are very mobile pastoralists. These populations subsist as livestock herders, constantly seeking new fresh pastures and water for their livelihoods. Consequently, they do not have a fixed location for electrical energy to be delivered and used by them. In fact, they operate in a constant state of flux, adapting to the local climate, and at best currently have access to telephone communications and types of Pico solar devices.

For the aforementioned mobile rural communities, the only current economic and technical electricity solution is a combination of small mobile/portable electricity delivery systems, usually based on solar PV with rechargeable battery storage – in effect Pico solar and SHS plus the use of solar PV powered borehole pumped water supplies at water sources.

Clearly, these mobile rural communities are not connected to any electricity grid and are remote and Off-grid. On the other hand, the communities within the large urban centres like Hargeysa, Burao, Erigavo and others, are stationary and obtain electricity from an existing electrical energy network – a grid – and are therefore On-grid.

Based on discussions with key electricity stakeholders including the Ministry of Energy, Off-grid is the electrification of a single end point user (whether residence, commercial or industrial establishment), from an independent electrical energy source or sources. In effect, Off-grid is dispersed small or large-scale captive generation. Consequently, a stand-alone single solar water pump providing water at a location with no other loads is Off-grid.

Off-grid in the context of Somaliland covers the electrification of a single user (whether residence, commercial or industrial establishment). Because of the rapid drop in costs for modular electricity captive self-generation technologies, globally, are driving strong potentials and likelihoods for significant future implementations of Off-grid applications such as for residential generation, commercial generation, “mini-grids” and Off-grid systems, for both urban and rural levels, which will most likely start in the near, and certainly within the medium and further futures for many parts of Somaliland.

Urban Electricity Networks

As mentioned previously, the large majority of electricity currently provided and used in Somaliland is produced and delivered by independent vertically integrated ESPs, who own and control their whole generation and distribution network. All operate at nominally 50 Hz and 400/230 V.

Most ESPs are unique to particular urban centres, yet some ESP have operations established in several urban centres, notably SOMPOWER and TELESOM.

Major Urban Centres

All the ESPs distribute electricity to their customers via LV feeders. In some cases, there are distribution lines utilising 11kV, 15V, 16kV and small amounts of 33kV, providing longer distant distribution distances, which then feed LV feeders. However, many ESPs use a significant amount of island radial LV distribution. A summary of ESPs and highest level of distribution voltage is tabled below.

Table 55. Current ESPs in major urban centres within Somaliland

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
Hargeysa	1,500,000	Sompower		No		No
		Telesom		No	Radial 11KV	Yes
		NEC		No	Radial 11KV	Yes
		Maansoor Hotel		No		No
		Hargeysa Electric Company		No	Radial 11KV	Yes
		Gafane		No		No
Burao[135]	700,000	BECO	HSDG, SPV	Yes		Yes

[135] *There are 2 sets of population data provided for Burao*

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
	400,000	BEDER			Radial 33KV, 11KV	No
Erigavo	250,000			No		No
Borama[136]	150,000	Telesom	HSDG	No	Radial 11KV	Yes
	400,000	ALOOG	HSDG, SPV	No	Radial 11KV	Yes
Badan	180,000	Badhan EC	HSDG, SPV	Yes	Radial 11KV	No
Laascaanod	130,000	LESCO	HSDG, SPV, Batt	Yes	Radial 11KV	Yes
		GURMAD	HSDG, SPV	Yes	Radial 11KV	Yes
Berbera	100,000	TAYO	HSDG	No		No

Source: Unicon

Medium Sized Towns

Table 56. Current ESPs surveyed in medium sized towns within Somaliland

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
Gabiley	30,000	SOMPOWER	HSDG, SPV	NO	Radial 11KV	YES
Wajaale	20,000	TELESOM	HSDG	NO	Radial 11KV	YES
		SOMPOWER	HSDG	NO	Radial 11KV	YES
Shiekh	20,000	BEDER	HSDG, SPV Batt,	NO	Radial 11KV	YES
Buhodle		TELESOM	HSDG, SPV, Batt	NO		NO

Source: Unicon

Small Towns

Findings from the modest number of Small Towns sampled, indicated that in these cases electricity generation is provided by one captive electricity generation source at a time. Even for small hybrid solar PV + Battery systems, with diesel generators, the modality is predominately one electricity source being used predominately, while the other is the backup/reserve source of electricity generation.

[136] *There are 2 sets of population data provided for Borama*

For example, in the case of the small town of Daca-Budhug, the 3kWp solar PV + Battery system is used as the primary stand-alone electricity source and the diesel generator provides an alternative electricity source or for backup or charging of the battery system, as needed.

There is currently no synchronisation carried out between the combined elements of small generation that are found within the small town systems sampled. Much of the electricity generation provided in small towns is originally captive generation that has been expanded to other paying load users (IEP).

Table 57. Current ESPs or stand-alone generators surveyed in small sized towns within Somaliland

Urban Centre	Population	ESP	Generation Type	Synchro	Distribution Type	Surveyed
Dilla	2,880	Mohammed Ali EC	HSDG	NO	Radial LV	YES
Daca-Budhug	3,000	Liban group	HSDG, SPV, Batt	NO	Radial LV	YES

Source: Unicon

Network Technical Issues

Wiring Practices

All urban centres and small towns visited revealed that distribution is primarily by overhead wiring, with varying degrees of order and disorderliness. Wiring within distribution, residential and business structures is currently carried out in a legal free environment. Although it appears there are some basic standards being practiced, based on professional and client criteria.

In so much as there are no current national standards, regulations or codes in place, nor are any codes being presently enforced, all electrical wiring safety and quality and assurance (Q&A) for distribution and buildings is self-regulated and only evaluated by the installer and customer. Within the vertically integrated autonomous parallel electricity providers, the ESPs, all electrical wiring safety and Quality and Assurance (Q&A) for distribution is self-regulated and not independently evaluated.

Losses in the Electricity Distribution Networks

All the ESPs report that they have significant losses within their island distribution networks. Causes for these losses are both technical and commercial. Reportedly, these electricity distribution losses are the largest power (instantaneous energy) losses within any of the individual ESP island electricity networks. These electrical energy losses are within both the primary and secondary distribution lines, and comprise both technical losses and commercial (non-technical) losses.

While some losses can be easily corrected, others require equipment changes, and some are just inevitable due to the physics of electricity. Total losses simply reflect the difference between the generated kWh and the load used and billed kWh. This value is generally referred to as T&D losses (Transmission and Distribution), and is the electricity amounts not paid for by load users-customers. Nevertheless, ESP generators must account for these in order to optimise their financial soundness.

Technical losses

Technical power losses occur because of energy dissipated by equipment and conductors within the distribution line network. The electro-physical characteristics of the network and its mode of operation determine these losses. Two classes of technical power losses occur:

- Fixed technical losses; and
- Variable technical losses.

Fixed technical losses

These losses are usually present as heat and noise arising from transformer energising. They are not influenced by load currents, but rather by leakage current losses, open-circuit losses, measurement and control losses, Corona losses and dielectric losses. These are most often the least easily rectified losses, and derive from network equipment and fixed elements. Typically, fixed losses comprise 1/4-1/3 of the total technical losses.

Variable technical losses

These losses are proportional to the square of the load user currents and usually account for a significant proportion of losses in a distribution system. These variable losses are due to:

- Line impedances;
- Contact resistances; and
- Joule (resistance) heating.

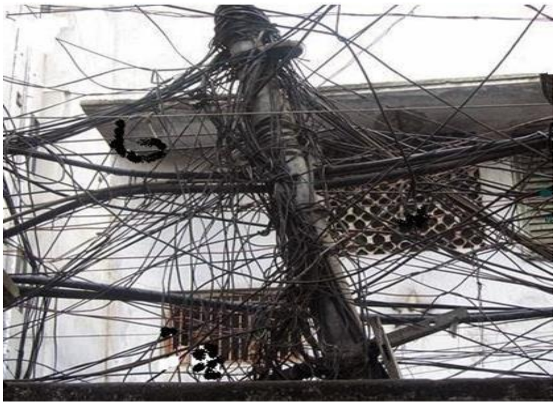
Variable losses usually comprise 2/3-3/4 of technical losses. Causes of variable technical losses include:

- Inadequate size of conductors in the distribution lines;
- Long distribution lines;
- Load imbalance between phases;
- Low power factor coefficient in the network;
- Overloading of lines;
- Transformers distal from load centres;
- Haphazard installation of distribution systems to cope with demands to new areas.

Also of particular note is the impact of bad workmanship within a distribution network: this contributes significantly to elevated variable technical losses. Corollary to these are electrical joints, which are a source of energy losses and must be kept to a minimum by using proper jointing techniques in securing all connections.

A common example of bad workmanship in distribution wiring is 'Spaghetti wiring' as shown in Figure 59 below. This is a generic example taken from elsewhere but recognised as one of the challenges local authorities and their experts face in improving electrical services.

Figure 59. Example of bad workmanship in distribution wiring (Spaghetti Wiring)



Source: General example (engineering.electrical-equipment.org)

Moreover, network operations using a low Load Factor causes losses, due to the higher peak losses. This can be reduced by levelling daily loads, through the use of "time of use" loading practices, and thereby raise the network Load Factor.

Commercial losses

Commercial losses, are losses unaccounted for within energy use bills, and they relate to:

- Unmetered supplies;
- Incorrect billing;
- Wrong tariffs;
- Defective electricity meters; and
- Electricity thefts.

In Somaliland, both the ESPs and government officials collectively assert, that load users tamper with their electricity meters to lower the measured electricity consumption. Moreover, electricity theft and illegal connections are reported frequently.

An examination of the data collected from the ESPs concerning losses, indicates that there is no systematic or effective form of monitoring and measuring the actual ESP electricity losses. It can be argued that while all the ESPs consider their electricity losses significant, there are no systematic incentives or attempts being made to better determine and remedy these losses in the current ESP based marketplace.

The combination of captive urban clientele, limited technical resources and ill-determined technical and commercial losses is a script for urban load users bearing the brunt of the costs caused by distribution system and ESP inefficiencies.

Table 58. Loss estimates by ESPs in surveyed urban centres within Somaliland

Urban Centre	Population	ESP	Reported Losses	Distribution Type	Surveyed
Small Town Centres					
Dilla	2,880	Mohammed Ali EC	40.0%	Radial LV	YES
Daca-Budhung	3,000	Liban Group	X	Radial LV	YES
Medium Town Centres					
Gabiley	30,000	SOMPOWER	19.0%	Radial 11KV	YES
Wajaale	20,000	TELESOM	40.0%	Radial 11KV	YES
		SOMPOWER	40.0%	Radial 11KV	YES
Shiekh	20,000	BEDER	30.0%	Radial 11KV	YES
Buhodle		TELESOM	X	Radial LV	NO
Major Urban Centres					
Hargeysa	1,500,000	SOMPOWER	X		NO
		TELESOM	25.0%	Radial 11KV	YES
		NEC	25.0%	Radial 11KV	YES
		Maansoor hotel	X		NO
		Hargeysa Electric Company	30.0%	Radial 11KV	YES
		Gafane	X		NO
	700,000 400,000	HECO	45.0%	Radial 33KV, 11KV	YES

Urban Centre	Population	ESP	Reported Losses	Distribution Type	Surveyed
Burao[137]		BEDER	X		NO
Erigavo	250,000				NO
Borama[138]	150,000 400,000	TELESOM	40.0%	Radial 11KV	YES
		ALOOG	40.0%	Radial 11KV	YES
Badan	180,000	Badhan EC	X	Radial 11KV	NO
Laascaanod	130,000	LESCO	28.0%	Radial 11KV	YES
		GURMAD	25.0%	Radial 11KV	YES
Berbera	100,000	TAYO	X		NO

Source: Unicon

Quantification and control of losses

During the survey carried out by the Consultant, many of the ESPs could not quantify the level of their losses let alone characterise them as technical or non-technical. A good metering system throughout the system is essential to identify the location of losses (i.e. which feeders) are subject to high losses and the level of those losses.

Once remedial work is carried out to reduce the identified losses, the metering system allows the improvement to be monitored.

Multiple ESPs Servicing One Client

There is a significant limitation to the amount of electrical energy any one vertically integrated ESP can deliver when the ESP is not able to provide parallel (synchronised) interdependent generation and distribution to their user loads. This along with the impact of multiple radial island network duplication by ESPs constrains the amount of electrical energy any one ESP can deliver to load users, especially for large electricity users.

Consequently, large firms and institutions having large electricity requirements face several options:

- Contract with 2 or more separate ESPs for parallel electricity delivery by multiple separate radial feeder lines;

137 There are 2 sets of population data provided for Burao
138 There are 2 sets of population data provided for Borama

- Opt for their own captive HSDG electric generation;
- Upgrade by adding captive solar PV grid-tied generation to their stand-alone diesel-electric based mini-grid systems. This is an Off-grid generation solution;
- Implement a combination of utilising an ESP for powering certain selected business related tasks and utilising captive generation for other core business activities.

The purposes for making solar PV grid-tied upgrades are twofold:

- Increase the effectiveness of existing and new diesel generation by reducing fuel consumption and thereby overall operating costs;
- Increase the total captive generation and capacity during daylight hours, for utilisation by in-house user load business related activities.

Institutions and firms identified within the field surveys that either use two ESPs or are opting for ESP with are shown below:

Table 59. Firms using multiple ESPs or with captive generation

<table>
<tr><th>Urban Centre</th><th>Firm or Institution</th><th>First Supply</th><th>Second Supply</th><th>Captive Generation</th><th>Distributes Locally</th><th>Distribution Type</th><th>Surveyed</th></tr>
<tr><td rowspan="6">Hargeysa</td><td>Amaana School</td><td>SOMPOWER</td><td>Gafane</td><td>SHDG-25kVA</td><td>X</td><td>Radial 11KV</td><td>YES</td></tr>
<tr><td>Dur Dur water bottling</td><td>SOMPOWER</td><td>X</td><td>SHDG-250kVA, 180 kVA, 200kVA</td><td>X</td><td>Radial 11KV</td><td>YES</td></tr>
<tr><td>Geed Deebleh Water Pump</td><td>X</td><td>X</td><td>HSDG-6x500kVA</td><td>X</td><td>X</td><td>YES</td></tr>
<tr><td>Ministry of Information</td><td>X</td><td>X</td><td>HSDG-300kVA</td><td>X</td><td>X</td><td>YES</td></tr>
<tr><td>Ambassador Hotel</td><td></td><td></td><td>HSDG</td><td>YES</td><td>Radial LV</td><td>NO</td></tr>
<tr><td>Moonsoor Hotel</td><td></td><td></td><td>HSDG</td><td>YES</td><td>Radial LV</td><td>NO</td></tr>
<tr><td>Burao</td><td>Burao Slaughter House</td><td>X</td><td>X</td><td>HSDG-1200kVA</td><td>X</td><td>X</td><td>YES</td></tr>
<tr><td rowspan="2">Shiekh</td><td rowspan="2">Fathoot Hospital</td><td>BEDER</td><td>X</td><td>SPV</td><td>X</td><td>Radial 11KV</td><td>YES</td></tr>
<tr><td>BEDER</td><td>X</td><td>HSDG</td><td>X</td><td>Radial 11KV</td><td>YES</td></tr>
</table>

Source: Unicon

Operations and Maintenance Challenges

One observed consequence of the current ESP size limitations combined with their obligation to create duplicate radial distribution networks is that duplicating ESP firms cannot establish the sufficiently large technical and financial resources needed to engage in the cost-benefit activities of effective maintenance programmes in support of the divergent demands of dispersed and focused distribution as against targeted generation operations.

This is evidenced in numerous ESPs reporting multiple generators in poor condition, or inoperative, plus their reporting of significant technical and commercial losses in their captive radial distribution networks.

Consolidation of ESPs and Infrastructure Responsibilities

SOMPOWER, within Somaliland, which has become the largest ESP in Hargeysa, was created from recent consolidations of multiple smaller ESPs and IEPs. This in principle should have resulted in increased technical staffing efficiencies and revenues, along with increased potential generating capacity.

However, it also inherited very disparate island networks and sundry technical faults. Moreover, coincident to the consolidation, there have been complaints by some clients of unacceptable reductions in electricity customer services.

Concurrently, a combination of high levels of electricity induced fires in Hargeysa, plus the wider responsibilities delivered by consolidation, resulted in several of the senior executives for Hargeysa's largest ESP, SOMPOWER, being arrested and imprisoned as part of investigations into the death of a family resulting from a household electrical fire.

This matter reflects a potentially disquieting narrative that should be relentlessly neutralised. Specifically, infrastructure business strategies that remunerate non-delivery and insufficiencies in implementing, adding and operating network generation resources should be discouraged. These essential resources are necessary to support and improve stability in electricity generation and distribution and socio-economic growth.

Bothersome examples of this is the positioning of five non-operational small 20-22kW asynchronous wind power turbines at the Hargeysa International Airport. Additionally, three similar non-operational small 20-22kW asynchronous wind power turbines were also positioned in Berbera, 1 wind power turbine was delivered but not installed in Borama and two wind power turbines were delivered but never installed in Erigavo.

None of these 11 electromechanical asynchronous wind power turbines is in operation to produce electricity for their respective urban ESP networks. Reports from the project GEEL (Growth, Enterprise, Employment and Livelihoods) in Hargeysa and the Somaliland Ministry of Energy and Minerals indicate that two of the Hargeysa turbines are inoperative, while three are reportedly capable of operation. Nonetheless, the in situ deficiencies in technical competency skills, along with a complete lack of construction and commissioning, documentation prevents these turbines from being connected either to SOMPOWER's Hargeysa airport distribution network or TAYO's Berbera distribution network or any other ESPs in the other locations.

Furthermore, there are reports of serial failures and subsequent repairs to the five Hargeysa wind power turbines since installation in 2013, which have plagued all attempts to generate electricity. The historical sequence of events bespeaks to significant O&M failings: a 40-73% failure rate. Exacerbation of these grave O&M failures are amplified by non-existent commissioning and operation reports. Moreover, requests for assistance from the original installers, has been systematically unproductive.

In point of recognition to these on-going O&M failures, it is practical to envisage the Hargeysa Airport and Berbera wind turbines will be eventually tasked to providing technical training and capability training for future wind power turbine opportunities in Somaliland.

Benchmarks for Transitioning Electricity Grids

Planning and Monitoring

The process of transitioning Somaliland's electricity grids into larger scales of integration and better mixes of electricity implementation and utilisation will require a mix of planning and monitoring and, in particular, national skill set advancement and institutional entities. Some of their goals should be to support electrification and faster growth in human development through:

- energy efficiency;
- optimising socio-economic growth;
- economies of scale;
- adoption of evolving innovations in the power and energy sector; and
- shouldering the challenge of harmonising collective and independent electricity infrastructure.

Reaching these goals will require targeting and attaining certain touchstones in social, technical and institutional capability. All of this will need to take place within a background of regional climate and environmental challenges and changes, which are identified as part of the current global warming trends.

Regulations, Standards and Technical Capability

Further development of Somaliland's electricity networks towards larger integration will require the effective enactment of appropriate regulations, standards, safety and technical performance requirements.

These standards will require all ESPs to improve technically and provide better operations within a levelled and regulated market place. Key stakeholders for this should include Ministries responsible for Energy, Education, Finance, Commerce and Environment plus the ESP firms, their business associations, their suppliers and funding agencies.

Sampling, Surveying Loads and Generation

Larger integration and development of electricity distribution and generation will require better and regular inputs derived from the effective sampling of energy utilisation across the various classes of urban centres. Regular sampling via limited energy census should include the involvement of the urban high school systems, colleges, Universities and even the chambers of commerce.

Another consequence of improved monitoring and planning will be that further enhancements and openly available information will be available towards constructing larger urban centre infrastructure with more flexibility to evolving developmental needs. Monitoring and planning will also facilitate the construction of urban distribution rings based on reality based user load projections versus population based load predictions.

Distribution Network Regulator and Operator

Improvements towards better and regular monitoring and projecting of load demands and generation planning will require the active participation of stakeholder associations, working committees and commerce associations. These tasks are an essential element to economic development and sustainable distributed electricity infrastructure.

Furthermore, acknowledging that most, if not all, urban centres in Somaliland operate as island distribution networks; there is a need for an Independent Distribution Network Regulator and Operator (IDNO) to be created in each major urban centre. Such an entity will speed the creation of urban distribution ring networks for each major urban centre. This is an upcoming necessary evolution from the current independent parallel radial island distribution networks towards dedicated shared collective urban distribution networks, with empowered generators and users.

The proper administration of the distributed infrastructure of the collective urban distribution networks will allow the current ESPs to specialise towards generation or distribution and speed the creation of urban distribution ring networks for each major urban centre within Somaliland. This shared network process should not hamper further consolidation processes by ESPs into larger firms with concomitant greater financial and technical resources for Generation growth and better long term O&M.

City/Port Development Plans

The determination of specific development zones such as port and major urban centres should be paralleled with an effective energy and electricity load generation plan. Such a plan should identify site focused renewable, thermal and storage energy sources that would be effective in optimising electricity generation and drive the creation of urban distribution rings for industrial, manufacturing and residential loads within the port or city.

Such plans should also be paralleled with clearly identified strategies for integrated urban and regional development targets and zones. Ports are currently key elements in the energy, electricity and transport networks. Their generation potential can be both derived from fossil fuel imports like heavy fuel oil (HFO), Coal, Natural Gas or Diesel supplemented by renewable options such as solar PV, wind power and energy storage.

Moreover, the ease of delivery of wind turbine technology to a port, and strong local winds along much of the coastal areas makes a strong argument for selecting port as the initial location for pilot cases. These would entail installing significant hybrid generation that includes wind power generation in combination with hybrid thermal fossil fuel and solar PV and eventually electricity storage.

Hybrid Pumped Hydroelectric Generation

The development of effective renewable and hybrid-energy electricity generation and load management, monitoring and planning will require the creation of nationally based technical capability. This expertise will then permit the development of the potential for using multiple renewables energy based storage via hybrid simultaneous pumped hydroelectric (SPH) generation for selected and centralised sites within Somaliland.

This technology requires the availability of large vertical drops in elevation, reliable local renewable energy sources such as wind and solar PV and leadership in sound water resource administration via reservoirs. The reservoirs only need be filled during heavy rain seasons and topped up with small additions to replace small reservoir evaporation losses.

Import and Export of Electricity Generation

The potential for exporting/importing electricity with Ethiopia and Djibouti should be explored. In the interests of reciprocity, treaties for this must resolve how the electricity will be managed. Comprehensive studies should be made on what will be the strengths, weaknesses, opportunities and threats of such electricity imports, to the frontier communities and the ESPs, citizens and government of Somaliland. Equally important is when these reciprocal interests will mature.

Ethiopia and UAE have clear economic interests in developing Berbera as a port, in part to ease the increasing congestion in Djibouti. In addition, in the case of Ethiopia, it could expand its electricity network into Somaliland and acquire clientele within its neighbour via the Wajaale – Hargeysa – Berbera corridor. How will this be owned and managed, what will be the commercial and socio-economic benefit of such electricity imports, to the ESPs, citizens and Government of Somaliland would need to be studied.

Ultimately, this will require the engagement of the main political institutions and impacted stakeholders and the negotiation of treaties. These arrangements will need negotiations with the respective governments of Ethiopia, Djibouti, local regional leaders, as well as, commercial stakeholders and the impacted populations.

Innovations Impacting Generation and Transmission

There are currently major and significant changes in the electricity power generation and distribution sector, which are projected to both continue and evolve into distributed generation and storage that is harmonised with centralised storage. Time lines for such changes, certainly covers a 20-year scope like this Power Master plan.

The large-scale global adoption of solar PV and wind power turbines, the enhancement of flexible base-load management schemes and the utilisation of network UPS storage along with the progressive adoption of extensive automation and monitoring for power networks, all testify to existing changes in electricity delivery.

The key barrier often cited for further adoption of renewables into electricity generation and distribution is high quality, low cost, long-lived and ideally modular energy storage. Somaliland has significant resources for renewables based electricity generation. Moreover, certain geographic areas confer significant opportunities for high quality, low cost, long-lived energy storage, which could warrant the creation of regional and national transmission lines, based on centralised generation sources.

Evolution of Electricity Generation and Delivery

The transition of Somaliland's electrical energy utilisation during a 20 year planning horizon must take into account the transition from isolated radial island distribution networks/grids towards integrated urban distribution ring networks and the integration of pertinent new innovations in renewables and storage generation as needed. This must all take place in partnership with a concurrent expansion of electricity load demands in both urban and rural areas.

The primary basis for evaluating the relative benefits of interconnecting major urban centres can be made either by a case-by-case economic analysis, concerning generation expansion and the creation of transmission infrastructure, or for political, strategic and economic motives. In either case, the integration of urban centres will require satisfying actual or planned loads from optimally placed generation and distribution infrastructure that must be ultimately economically sustainable.

Based on current infrastructure any consequential integration must be via current 11kV & 15kV radial distribution within urban centres, or better with upgrades to 33 KV as part of the creation of urban distribution ring networks for urban centres.

Historically, applying a standard infrastructure development model to remote and low population density regions is usually inappropriate. Mini-grids and island distribution networks and their clientele in remote or isolated urban centres do not necessarily benefit from integration. Consequently, any deterministic criteria for specifying integration is unreliable; even more so at present due to the dynamic of widespread implementation of reliable decentralised renewable energy generation.

Rural and Remote Electricity Networks

Criteria for Electricity Generation in Isolated and Frontier Communities

In general, the frontier areas are isolated and not heavily populated. Communities located there face the challenges of isolation, the demands imposed by national security, and the need to maintain effective reciprocal relationships with their trans-frontier neighbours.

The long frontier areas of Somaliland are quite isolated and communities associated with these areas face the combined challenge of limited access to and poor delivery from outside resources. As a consequence, diesel fuel availability for diesel electric generation is constrained by both poor roads and by distance.

Essential to the survival of these isolated communities is their ability to produce value added products, attain a quality of life, be resilient to climate changes, maintain effective communications regionally and participate in trans-frontier commerce. Common reports indicate that electric generation and distribution within such communities often involves small scale trans-frontier commerce, such as two-way small scale electricity transfers across the frontiers of Somaliland, Ethiopia, and Djibouti.

Four criteria have been identified for determining the load and generation required to facilitate community development. In particular, these communities need electricity support for loads that:

- create and operate via commercial value adding activities;
- assure country services;
- support commercial trade and communications activities; and
- assure residential load demand satisfaction.

Data necessary to assess this should be derived from field data for remote communities, which would be used to make generic projections concerning load demands and generation requirements. Such field data should be gathered by the Ministry responsible for Energy in partnership with national and regional partners.

This data will permit specific load demand and generation planning to be modelled. This will in turn enhance government statistics, and facilitate the utilisation of effective sampling and planning for further field data collection across the nation, especially for remote areas.

Another important challenge faced by remote communities including those on the frontiers is capability and communications. Both technical capability and communication networks need to be created to support the creation and management of all the electric generation and distribution networks implemented into these communities. Approximately 80% of technical challenges in rural electrification can be resolved locally if there is adequate technical competence.

Furthermore, the government authorities also need to engage with their neighbouring countries to establish pertinent treaties concerning electricity generation and delivery for future growing user loads in the frontier areas.

Establishing Mini-grids and Small Distribution Networks

A direct consequence of on-going tracking and planning of loads and generation will be an enabling of optimal planning for any targeted rural economic development zones. As part of this economic planning, implementing mechanisms for establishing hybrid HSDG-solar PV-Battery-wind power mini-grids and small island distribution networks within small urban centres must be created.

These implementing mechanisms must include effective revenue collection and technical capability supports for the long term O&M of these hybrid mini-grids and small island distribution networks. In addition, these mechanisms must include on-going effective sampling of energy utilisation within this subclass of urban centres, for future load and generation growth.

Types of Off-grid and Small Isolated Generation Networks

The key feature of classic off-grid generation systems is that they are stand-alone units. In remote applications, they are often called Remote Area Power Supplies (RAPS) or SPS (Standalone Power Systems). RAPS can range in size from simple lights or devices, through to units that incorporate devices and machines that enable people to do value-adding work. They can be compact and mobile or fixed to a site.

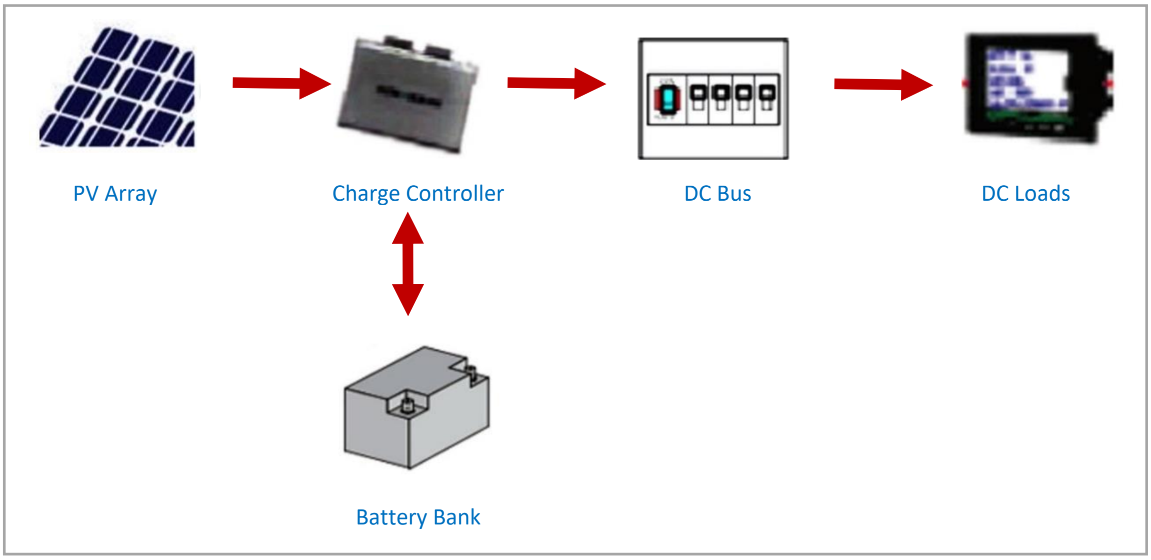
These systems are generally destined for isolated communities and locations and therefore must obtain electricity from local sources like solar PV and wind power. They can be either DC or AC biased (coupled) depending on the population and activities being served. For optimal operation, the solar panels should be cleaned once per month or performance losses of 10-30% will occur due to dust or mould (humid climates) build-up.

Fixed DC-biased RAPS

The primary source of energy in isolated locations is solar energy and sometimes wind energy. These units are usually supplemented by electrochemical battery storage. The battery permits nocturnal use of devices and machines and supports daylight load uses, especially during heavy cloud cover or rain. Consequently, RAPS goals can range from improving the quality of life to enabling small-scale manufacturing and cottage industries. They are also used to power remote water pumps and communications and monitoring relays.

The essential elements of these RAPS are solar PV Panels and their supports – cabling and a maximum power point (MPPT) Charge Controller converts the solar PV DC voltage to battery storage voltage plus a Battery. Thereafter the electrical energy stored from the electrochemical battery, powers a 6, 12 or 24-volt DC bus, which is usually also controlled by the charge controller, along with safety breakers, control switches and connection points for DC powered devices. Figure 60 illustrates a basic small fixed or mobile DC-coupled off-grid solar PV system.

Figure 60. Basic DC coupled (biased) Off-grid solar PV systems



Source: Unicon

In geographically suitable fixed locations with good wind speed, a small DC wind turbine on a mast can also be incorporated to charge the battery and power the DC bus via another charge controller. Additionally, for fixed system configurations, a DC to AC Inverter can be added to the DC bus, which converts the DC bus power supplied by the battery into LV (230V/50Hz) AC single phase (or even 3 phase) power to operate a small AC bus connected to small machines and devices.

The most vulnerable components in these systems are the inverters, the batteries and connections. The inverters, as low impedance devices, are very vulnerable to voltage surges, short circuits, corrosion, overheating, insects, pests and mistreatment, including inappropriate loads being connected to them.

The second most vulnerable element of these systems is the battery. Typically, the batteries are either lead acid battery (PbA) usually in a gel format (VRLA) for ease of maintenance and handling or Lithium-ion batteries in circumstances of small compact mobile devices. PbA batteries are cheap and 100% recyclable, but do not tolerate greater than 50% DoD (depth of discharge) treatments well, and are heavy and vulnerable to high ambient temperatures, which degrades their performance.

Lithium-ion batteries are less vulnerable to temperature, are much lighter (33%) and four times higher energy density, tolerate a 80% DoD, but are two and a half to three times more expensive, they poorly tolerate heating during charging, are not recyclable and can explosively decompose. Mobile lithium-ion battery based systems tend to be lower in total energy capacity as they are lightweight, compact and mobile. The 80% DoD of Li-ion systems can result in situations of unavailable electricity reserves. Each technology, in practice, has similar lifespans.

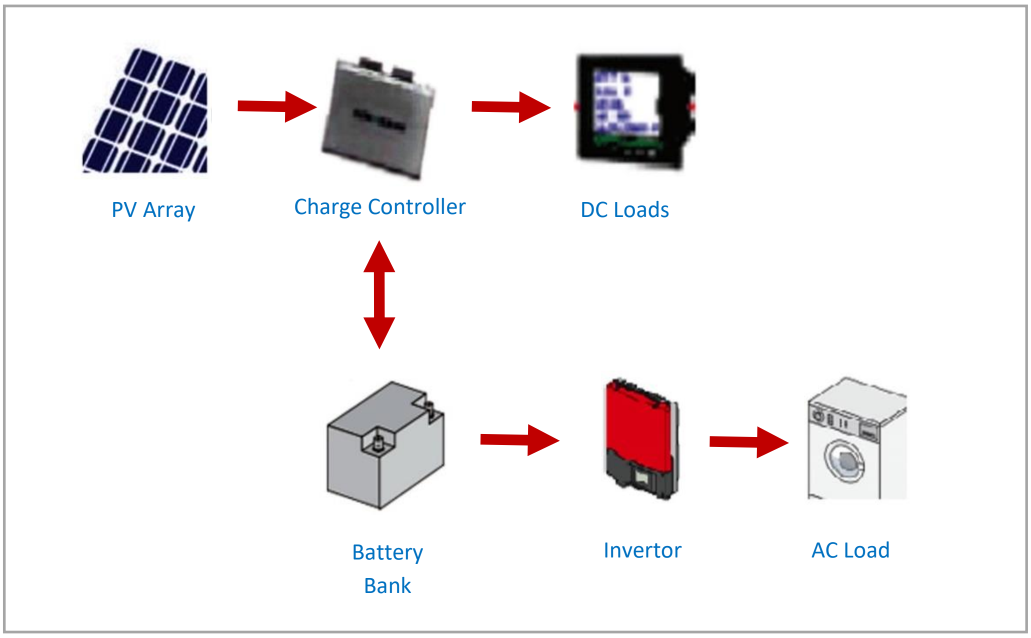
On the other hand, charge controllers and solar PV panels are generally robust devices that provide reliable charging voltage to the batteries, but the panels must be kept clean on a regular basis. The key goals are to operate essential and long service devices via the DC bus to assure reliable operations and nonessential higher power short-duration devices using the AC bus.

An important feature in setting up remote isolated off-grid systems is to minimise liabilities due to system faults. Consequently, essential and long running items operate on the DC bus circuit. Depending on their size, either mobile or fixed off-grid systems provide for different aspects of quality of life, which can include lighting, refrigeration/freezer, telephone charging, radio, communications devices, Internet access devices, laptop computer, battery charging and small ventilation devices.

The lighting components for these systems are generally long life (11year) robust low power consuming LEDs (light emitting diodes), which operate from a 6, 12, 24 or even 48-volt DC bus. Mobile systems nearly always run on a 6VDC bus using Li-ion batteries, while fixed systems run with a 12, 24 or 48-volt DC bus with mostly PbA and sometimes Li-ion batteries.

For the fixed single site units, ancillary devices used for value-adding and recreational activities, or high current short term operations can be run off a small inverter, sized to one and a half times the expected loads. These small inverters can power devices such as TV, DVD players, computers, sewing machines, simple food processors, handheld power tools and normal ventilators. Figure 61 illustrates a DC-coupled off-grid solar PV with AC options for fixed single sites.

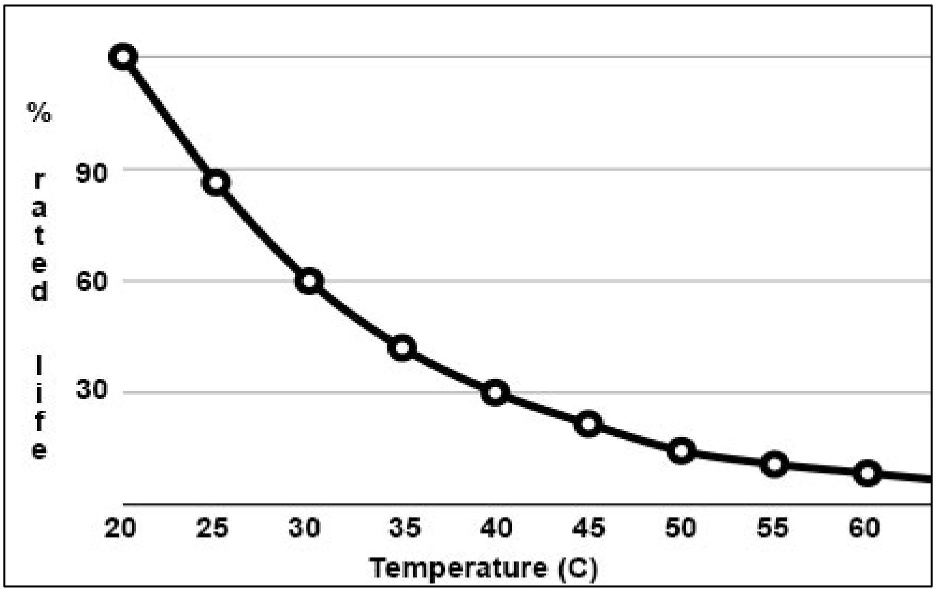
Figure 61. DC coupled (biased) Off-grid solar PV with AC option systems



Source: Unicon

The temperature vulnerability of PbA batteries in fixed systems, can be markedly reduced, as is shown below in Figure 62. Consequently, to extend battery useable lifespans, simple procedures can be effected. It involves placing the batteries in ventilated boxes, which are put in a shaded lined excavated pit 50cm deep, which is one and a half times the length and width of the battery, and covered with a secure, insulating, but well ventilated cover, for outgassing H2 emissions.

Figure 62. Lifespan impact due to elevated temperature in PbA batteries



Source: Unicon

A PbA battery is rated to operate at 20-25°C, and an increase of 8.3°C to 33.3°C, results in its lifespan halved – from 10 to 5 years. Locating a battery in a pit also prevents tampering and reduces terminal corrosion with batteries. Additionally, there must also be good ventilation for the charge controllers and inverters so as to protect them from overheating.

The sizing of the systems and batteries is usually done to provide power for the combined use of basic devices and illumination for 4-6 hours of nocturnal use. Operation of machines from the Inverter should include a time control. Systems powering refrigeration/freezers should be run via the DC bus, such as high efficiency DC freezer/fridges. Unfortunately, many of these devices are developed from political and opportunistic interests, rather than technical and economic priorities and are noted for their poor performance.

Variations on RAPS can power single households, small single building/institutional sites such as small health clinics, police and security stations, administrative centres, border posts, communications sites, small single building schools, small religious and community buildings and even small commercial enterprises such as shops that sell food, drinks and technical services like internet access, phone and device charging, computer services, electronic banking and communications services.

Another crucial use for single use sites is solar PV powered water pumping. These systems do not require battery storage and operate during daylight hours, preferably with water reservoir levels controlling the level of pumping. Water resources are crucial to pastoralists and should be integrated into their existing and evolving communications and livestock movement networks.

Mobile DC biased RAPS

Systems intended for pastoralists must be mobile and compact. Solar PV panel sizes and configurations should be compact and potentially expandable. Their tasking needs to prioritise quality of life and productivity value adding activities, examples being illumination, portable battery charging, communications and small refrigeration, all on a DC bus. Batteries for such systems should be lightweight, high-density lithium-ion types.

Due to the higher cost of lithium-ion energy storage and mobile components, pastoralist destined units must be properly aligned in performance to contribute to value-adding socio-economic activities that are currently or can be carried out by pastoralists.

For example, systems that are allocated via family units should be joinable together as either parallel or series configured units. This would permit powering larger devices such as, radios, communications, small DC power TVs, DVD players, computers and even small power tools when multiple family units gather.

Moreover, these units can be used to provide information, education and social integration of pastoralists into national, climatic, resource, frontier and security information resources. These devices should be a nexus for pastoralists to collectively gather and create local innovations to improving their quality of life and productivity.

Small mobile off-grid systems for pastoralists should have a clear vision and mechanisms for assisting the pastoralists to further evolve in their quality of life, enhance their value-adding activities and empower their integration into the regional and national society.

Small multi-family isolated Off-grid mini-grid AC biased systems

In the case of small multi or extended family isolated communities the optimal solution is to create a hybrid community generation system utilising solar PV and batteries, with AC wind power added if available, which creates a collective coupled AC bus.

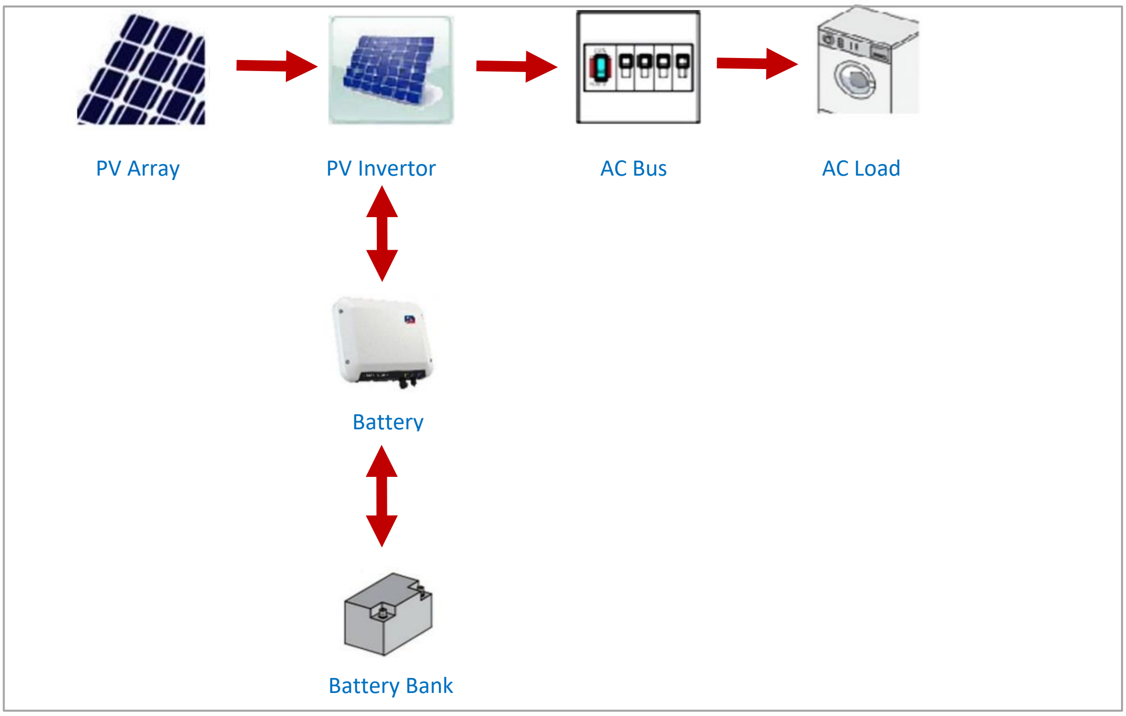
This in turn provides community LV AC electricity during daylight and portions of the nocturnal cycle, for manufacturing and institutional uses, as well as households. Such systems can be also hybridised and synchronised with either small HSDG or Stirling engine generators.

These are small mini-grids operating with a radial LV distribution network, focused on the dual targets of improving quality of life and stimulating cottage manufacturing/value adding activities. In these systems, the key vulnerabilities are the battery electricity storage and O&M of the electricity generation infrastructure.

The solar PV is arranged as a ground mounted array, with solar and battery inverters creating an AC bus. The vulnerability of the batteries is collectivised into a battery bank that must be protected and optimised to maximise life span. The simplest least-risk approach to maximise battery bank performance is to place the bank in an easily accessible rectangular or square lined excavated pit, 2m deep, which is both covered and well ventilated, and then capped with a building so that it remains at earth cooled 20-25°C.

The electricity generation and LV distribution is placed at ground level in the same building within five metres but not in the path of vertical ventilation. The system requires a basic technician/operator, for both basic O&M plus 80% of problems in mini-grids can be remedied locally. The inverters must be properly ventilated and cleaned, and protected with effective earthing, surge protection and high speed main load breakers for load faults, as well as multi-layered building breaker protections.

Figure 63. AC coupled (biased) Off-grid solar PV small LV mini-grid for multiple buildings



Source: Unicon

The battery systems for such situations are PbA based, with either VRLA gel format or Fluid filled (flooded) format. The PbA VRLA batteries are lower maintenance and will provide lifespans of 7-10 years. PbA Fluid filled batteries will provide lifespans of 13-17 years, and require more regular basic maintenance and a viable source of distilled or deionised water. Both types of PbA require equalisation cycles once every 3 months. The price for VRLA can be 25-50% higher than Fluid filled batteries, so generally not recommended in this context.

These systems are easy to integrate or expand into other LV AC distribution networks, and incorporate larger generation sources as circumstances and daylight value adding activities evolve. These systems are ready for integration into synchronised HSDG hybrid systems and larger urban electricity distribution networks.

In fact, they could be the basis for multiple distributed generation networks sharing a common urban distribution grid. This is a halfway point between centralised urban generation and residential grid tied Solar PV generation, which is now a significant source of the growing practice of distributed electricity generation in many developed economies.

Characteristics of Sample Off-grid and Small Isolated Generation

Remote Mobile Off-grid Systems with solar PV + Storage

Mobile solar PV systems based on Li-ion batteries are offered in a wide range, but nevertheless at significant prices for each watt-hour (Wh) of energy. Systems are usually being marketed with either a small 5Wp or 20Wp solar PV panel. Battery capacities vary from 16Wh to 100Wh and the power anywhere from 2-4 LED lights of 1-5W rating.

The 20W systems capacity based prices are in the order of US$1,400/kWh, while the 5W systems capacity based prices are in the order of US$2,800/kWh. Over the lifespan of the battery (80% DoD) these prices reduce to US$1.63 and 3.53/kWh respectively.

These devices all have ports for charging USB powered devices like mobile telephones, radios, games, speakers and music players. The operation time on a full charge ranges from 4 hours for all lights to 24+ hours with one light and the DoD is 80%.

Realistic lifespan expectancy for the battery is usually 5 years, though some vendors claim up to 8 years. In fact, like all battery types, there are good and bad quality Li-ion batteries, which is reflected in shorter lifespans and lower pricing.

When considering a small fixed system using Li-ion batteries a 100-200Wp solar PV panel is a common size. Such a system usually comes with 800-900 Wh battery capacity and 3-4 5-watt lights. These again have USB charging ports for operating small low power portable devices. 100Wp systems can be priced in the order of US$500/kW with claims of 5-year lifespans. Over the lifespan of the battery (80% DoD) the electricity price reduces to US$0.60/kWh.

<u>Remote Fixed Off-grid Systems with solar PV + Storage Stand-alone</u>

Examples of remote fixed off grid systems (RAPS) with solar PV and PbA battery storage in a standalone configuration are described and modelled below as 3 scenarios. The modelling is then displayed in Figures 66 through 77. These 3 scenarios encompass the major immobile type situations encountered:

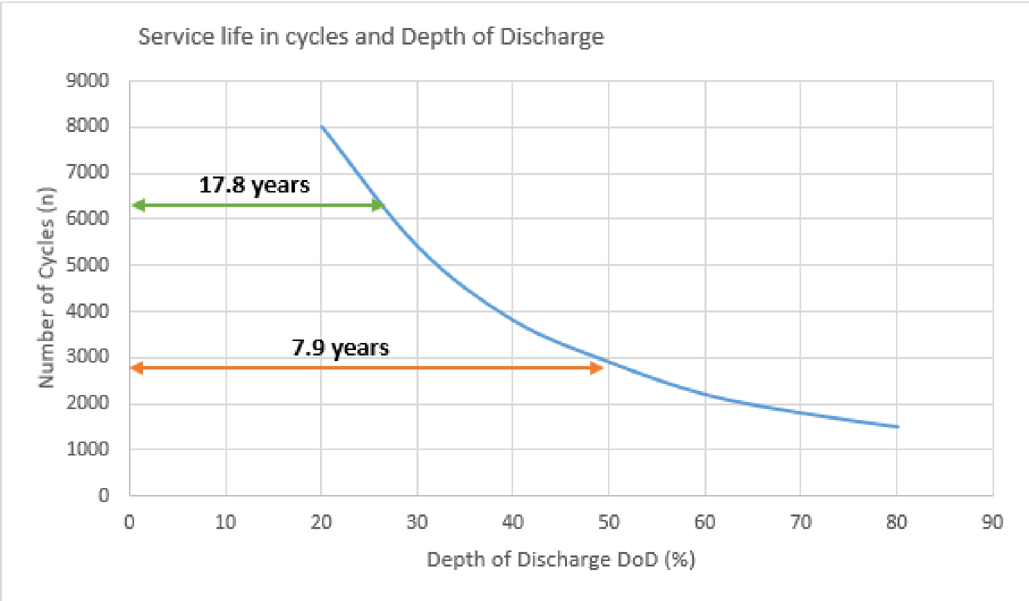
Examples:

- A single home/household with a family in an isolated location that could engage in some small cottage type value-adding activity;
- A five-family household community cluster or unit that represents an isolated small community of five families, totalling about 30 people. This includes that they collectively engage in a value adding-activity for both their own benefit and to generate revenues;
- The context of a standalone situation powering a small one building institutional facility, such as a police station, health clinic or border post.

In all the exampled cases, PbA batteries are used because of they are fixed, much cheaper, and if properly installed for temperature considerations and mostly operated with a DoD of 25%, the Gel VRLA will last 5-6 years, while the Fluid Filled PbA will last 13-17 years. Moreover, they also provide another 55% of reserve electricity in emergencies. Figures 64 & 65, below, illustrate the variable lifespans that can be expected from PbA batteries when sequentially subjected to different depths of discharge (DoD).

As can be seen in Figure 64, a Fluid filled or Flooded acid PbA battery, kept at 20-25C, and habitually subjected to a DoD of 25% discharge, before being recharged back to full, will last approximately 17.8 years; while if it is habitually discharged by 50%, it will only last 7.9 years.

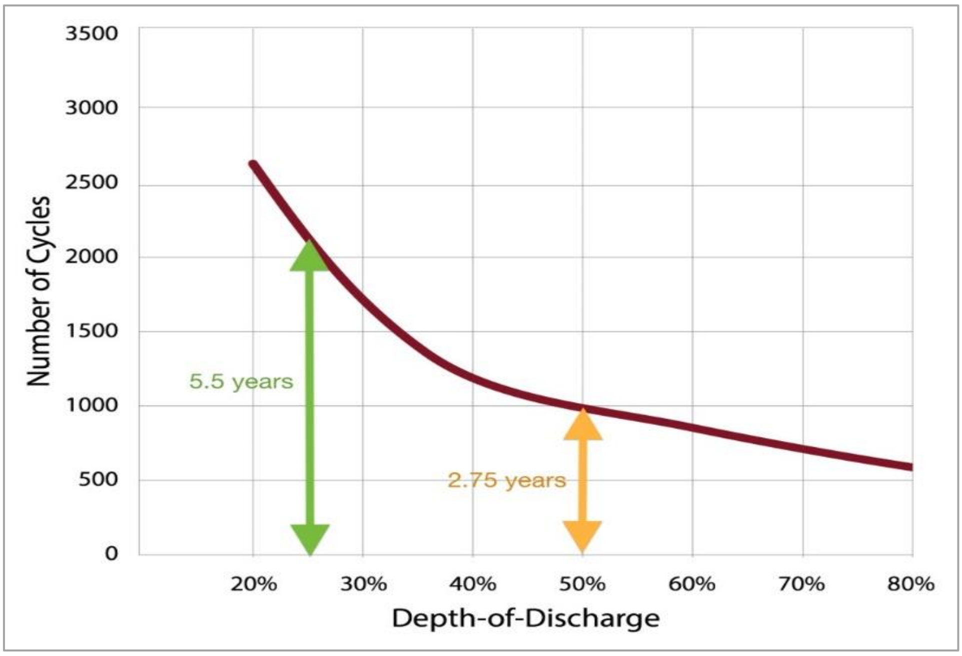
Figure 64. Lifespan of good Fluid Filled PbA batteries at 20-25°C



Source: HOPPECKE Batteries Flooded Lead Acid (LA) Specifications Sheet

Similarly if a Gel VRLA PbA battery, kept at 20-25C; as shown below in Figure 65; is subjected to a DoD of 25% discharge, or a 50% discharge, before being recharged back to full, it will respectively last either 5.5 or 2.75 years.

Figure 65. Lifespan of good VRLA PbA batteries at 20-25°C



Source: TROJAN Batteries Gel VRLA Specifications Sheet

Example 1: Single Isolated Home (6 persons) Scenario with Solar PV DC Coupled with AC

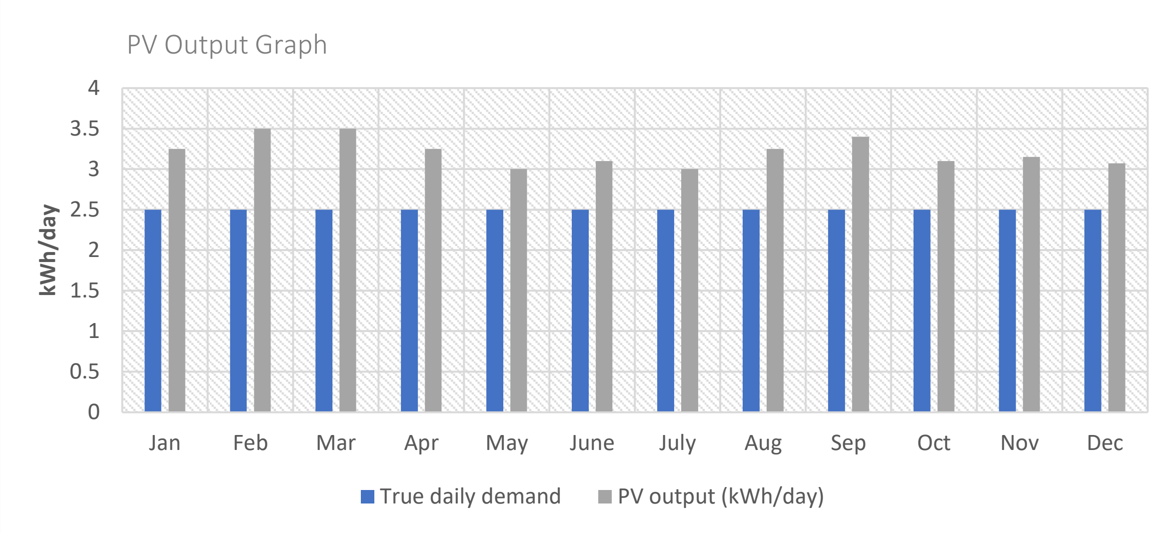
This generic single home system has a combination of 305W of AC loads and 294W of DC loads matched to a daily demand of 1.89 kWh/d. Solar PV generation utilising 0.57 kWp of solar panels provides an average of 2.89 kWh/d for this family of 6 persons, which is combined with PbA Battery storage. The PbA VRLA batteries, are rated to 300Ah x 24V (2 banks of 2x12V (150Ah) batteries), and operated at a 25% DoD with a spare day to 50% DoD. As shown in Figure 65 a typical PbA VRLA, maintained at 20-25C and operated this way should have a lifespan of 5.5 years, with up to 7 years for top quality.

Consequently this typical household's electricity use is 0.48kWh/d capita = 176kWh/an cap; => HDI (Human Development Index) of 0.54.

Figure 66, below, shows the modelled Solar PV battery system generation (grey bars) against household load demand (blue bars) on a monthly basis, over a 1 year period.

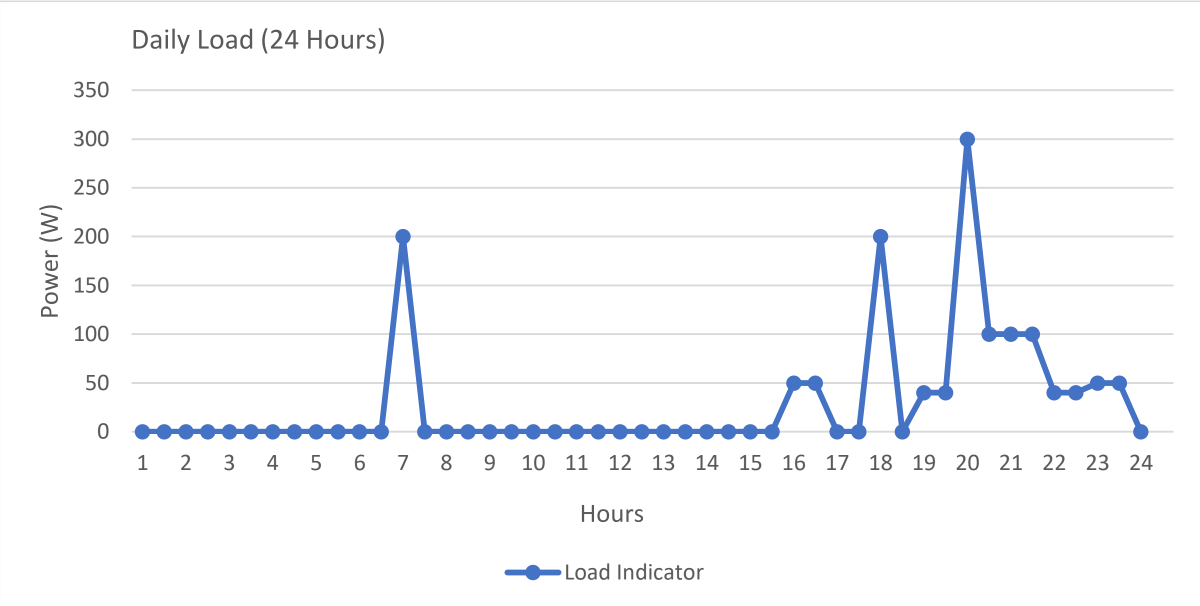
Figures 67 through 69 illustrate, respectively, the typical daily DC load demand (Figure 67), the AC load demand (Figure 68) and the combined AC+DC load demand (Figure 69) for the modelled typified single/standalone 6 person family home in Somaliland.

Figure 66. Single home solar PV monthly power generation against load demand



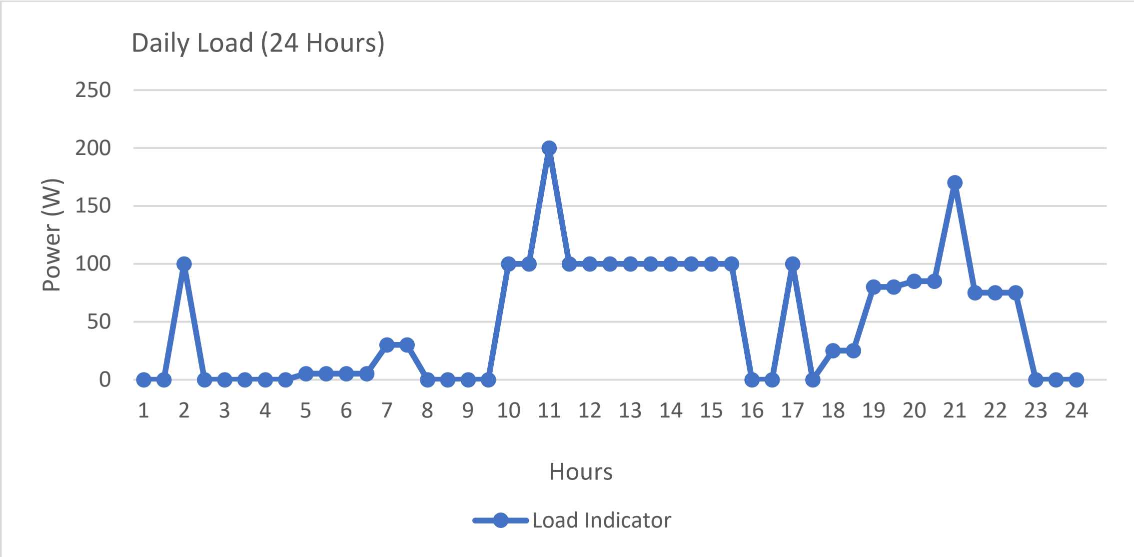
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 67. Single home DC coupled system value added with AC loads: Peak Load 300W



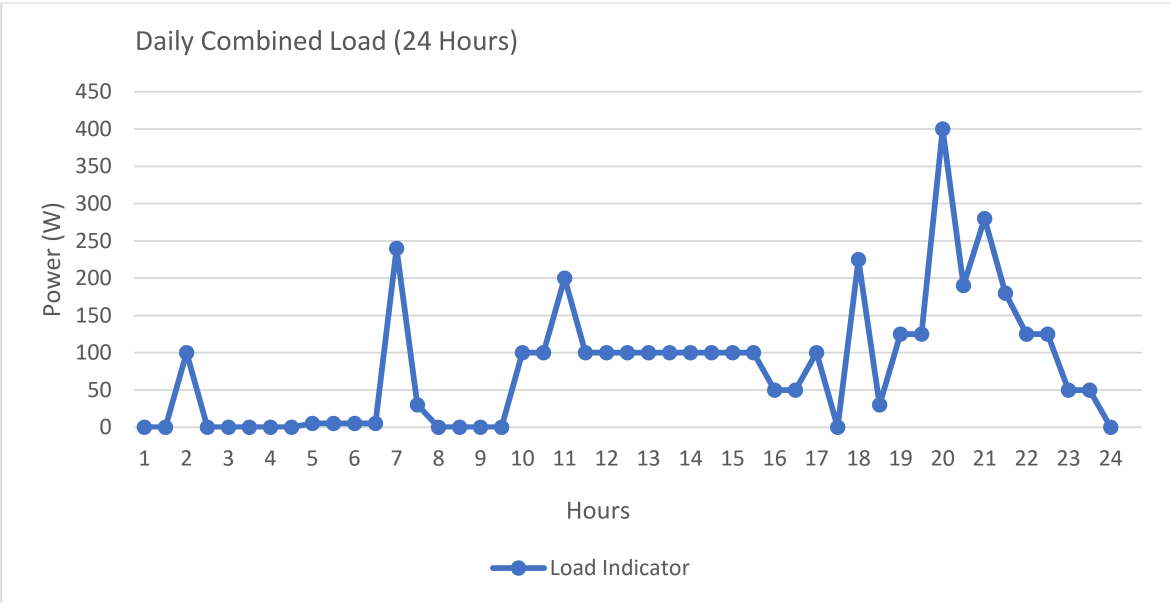
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 68. Single home DC coupled system essential DC loads: Peak Load 200W



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 69. Single home DC coupled system combined Loads: Peak Load 400W



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Example 2: Five Household (6 person/home) Small Community System

This generic five household small community system includes a Solar PV and Battery system that is AC coupled to provide electricity for value adding activities. It has a combination of 3.5kW of AC loads and 1.7kW of DC loads matched to a daily demand of 22.38 kWh/d. Solar PV generation utilising 6.75

kWp of solar panels provides an average of 34.22 kWh/d for this community of 30 persons, which is combined with PbA Battery storage.

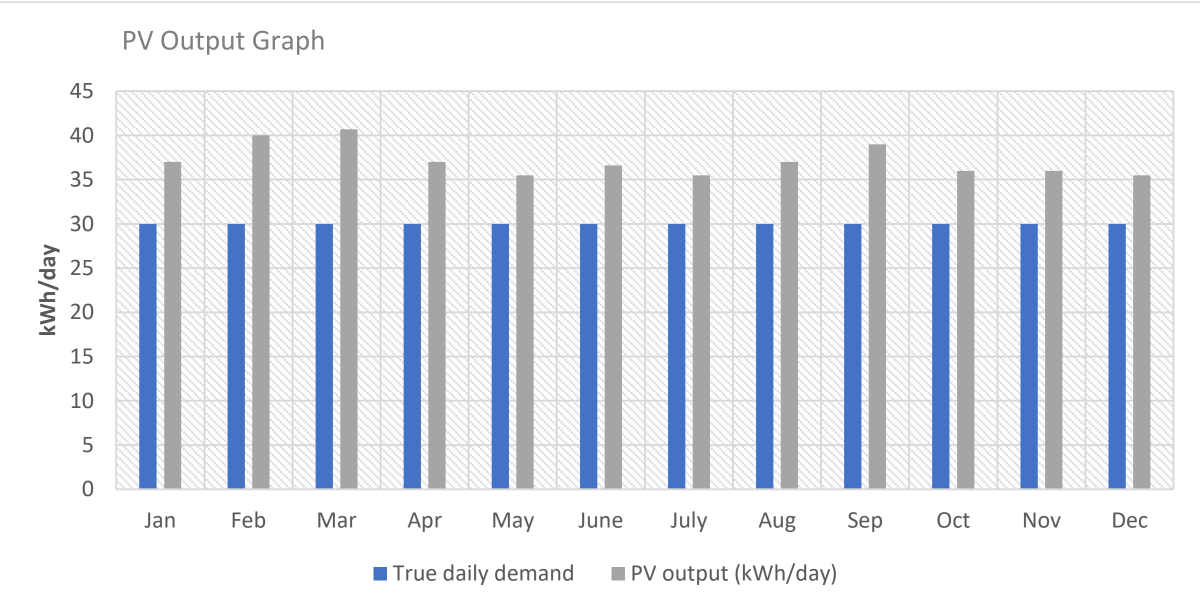
Here PbA fluid filled batteries are used, and rated to 1,840Ah X 48V (2 banks of 24x2V (920Ah) batteries). They are operated at a 25% DoD with a spare day to 50% DoD. As was shown in Figure 64, a typical PbA fluid filled battery bank, maintained at 20-25C and operated this way, should have a lifespan of 17.8 years, or at least 15 years, when accounting for some early battery failures.

Consequently this typical small isolated community electricity use is 1.14kWh/d capita = 416kWh/an cap; => HDI (Human Development Index) of 0.62.

Figure 70, below, shows the modelled Solar PV battery system generation (grey bars) against community load demand (blue bars) on a monthly basis across a 1 year period.

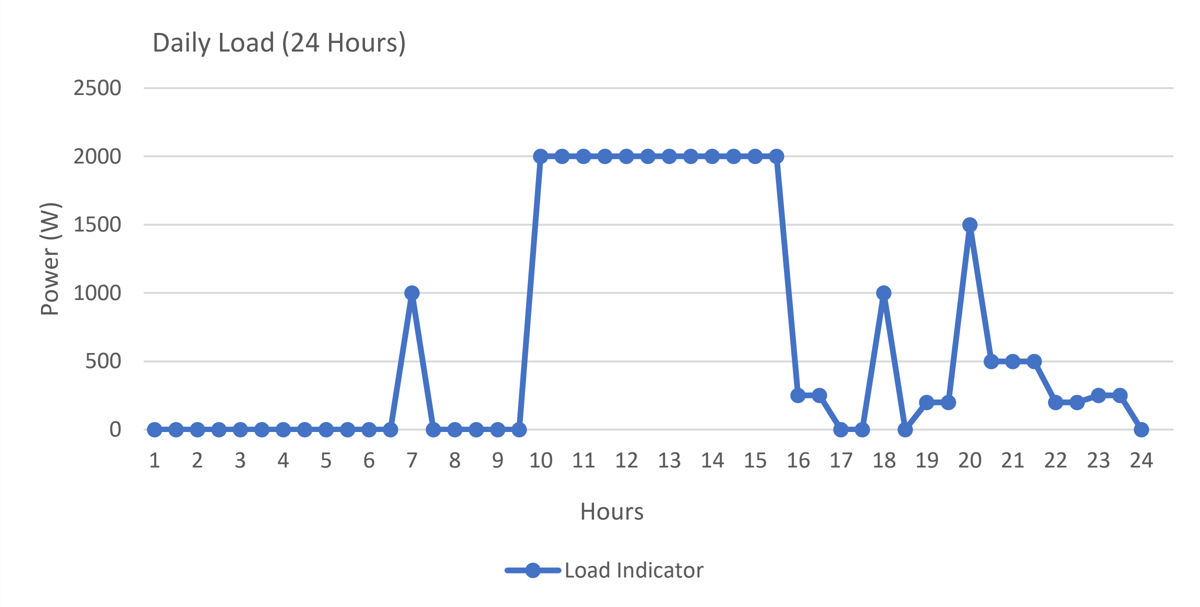
Figures 71 through 73 illustrate, respectively, the typical daily DC load demand (Figure 71), the AC load demand (Figure 72) and the combined AC+DC load demand (Figure 73) for the modelled typified isolated 30 person community in Somaliland.

Figure 70. Five-home solar PV monthly power generation against load demand



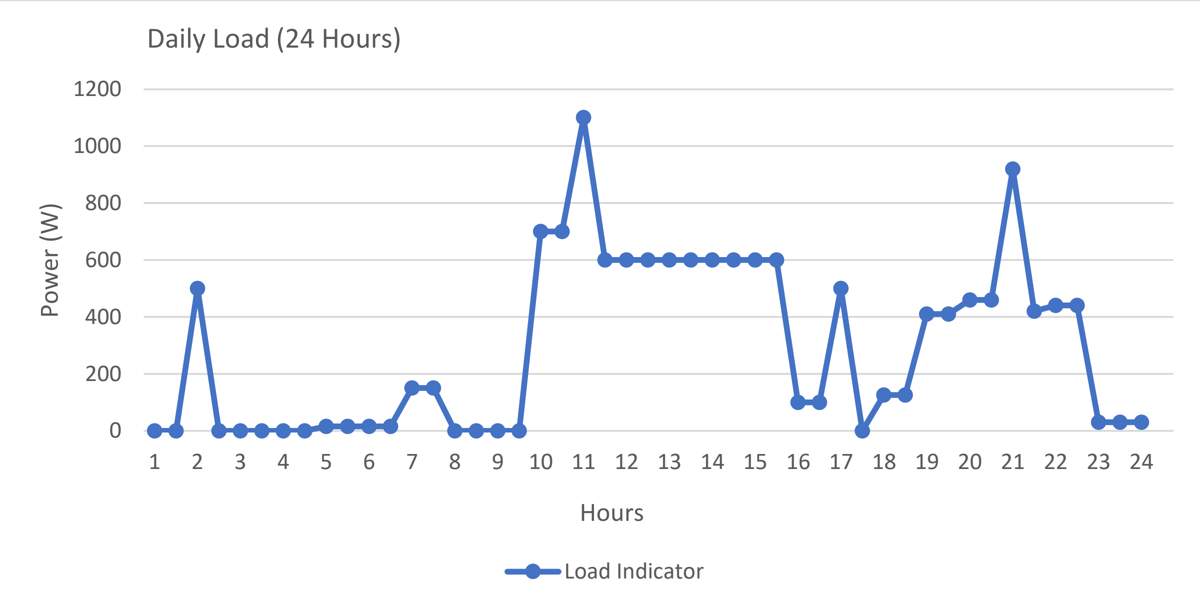
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 71. Five household community system with value add AC loads: peak AC load 2kW



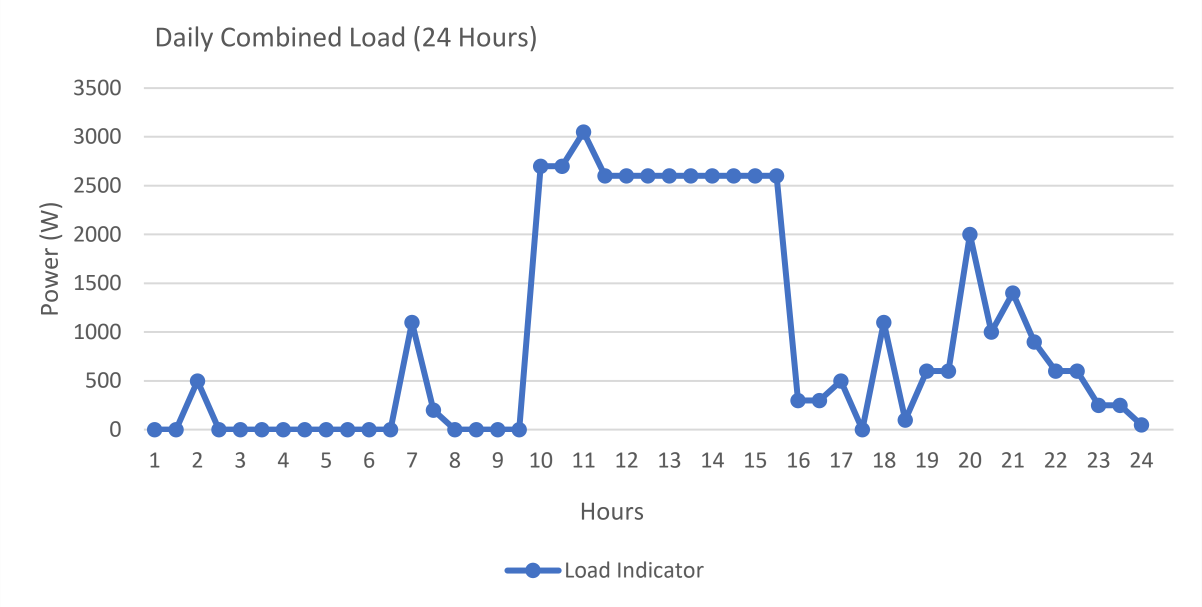
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 72. Five household community system, quality of life domestic loads: peak load 1.1kW



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 73. Five household community system; combined Loads: peak load 3.1kW



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Example 3: Single Isolated Institution Building with 12 staff

This generic isolated Institution Building system with 12 staff engaged includes a Solar PV and Battery system that is AC coupled to provide electricity for value adding activities. It has a combination of 1.2kW of AC loads and 1.0kW of DC loads matched to a daily demand of 12.56 kWh/d. Solar PV generation utilising 3.75 kWp of solar panels provides an average of 19.0 kWh/d for this isolated Institution Building, which is combined with PbA Battery storage.

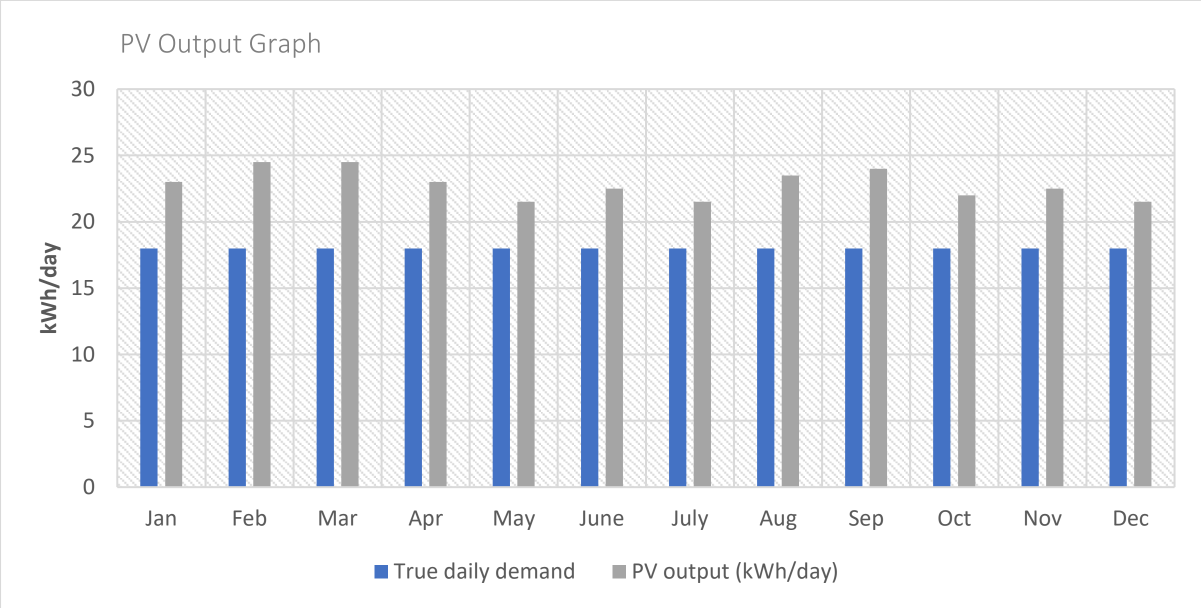
Here PbA fluid filled batteries are used, and rated to 2,000Ah X 24V (2 banks of 2x12V (1,000Ah) batteries). They are operated at a 25% DoD with a spare day to 50% DoD. As was shown in Figure 64, a typical PbA fluid filled battery bank, maintained at 20-25C and operated this way, and should have a lifespan of at least 15 years, like for example 2 above.

Accordingly, this typical isolated Institution Building electricity use is 1.58kWh/d capita = 578kWh/an cap; => HDI (Human Development Index) of 0.65.

Figure 74, below, shows the modelled Solar PV battery system generation (grey bars) against Institution Building load demand (blue bars) on a monthly basis across a 1-year period.

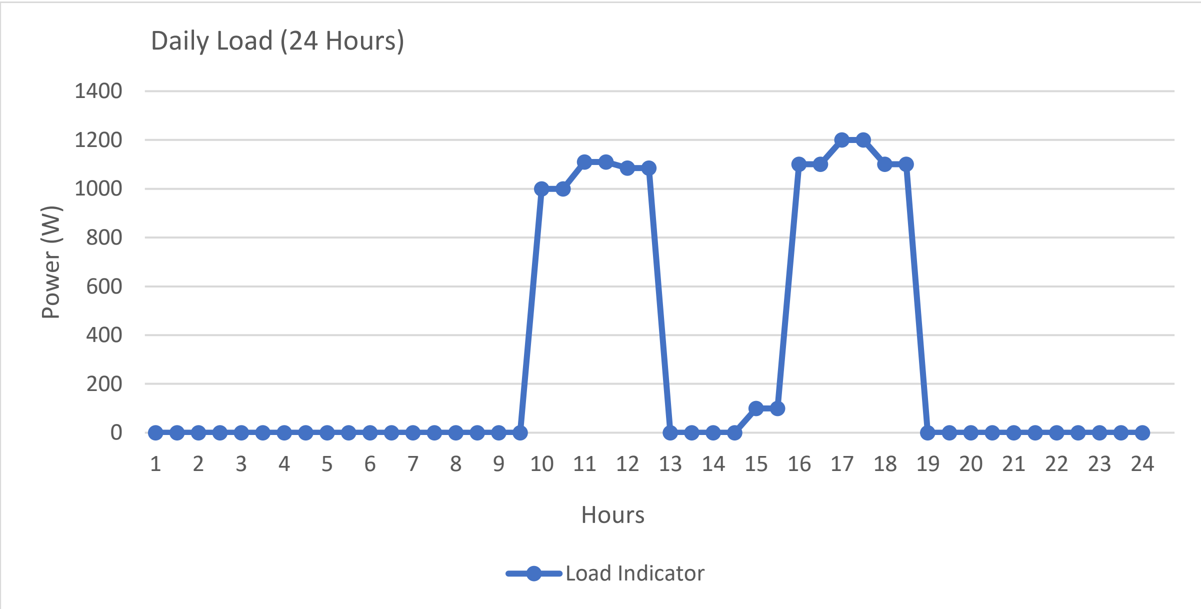
Figures 75 through 77 illustrate, respectively, the typical daily DC load demand (Figure 75), the AC load demand (Figure 76) and the combined AC+DC load demand (Figure 77) for the modelled typified isolated Institution Building in Somaliland.

Figure 74. Single isolated institution solar PV monthly power generation against load



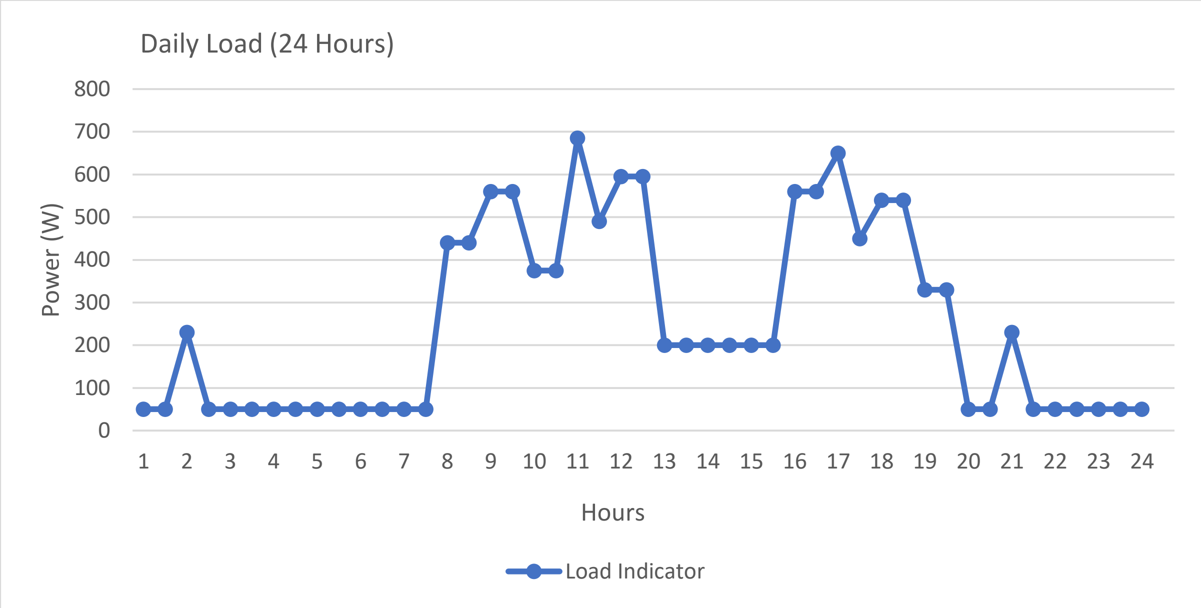
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 75. Single isolated institution DC coupled system Value Add AC inverter loads: peak load 1.2kW



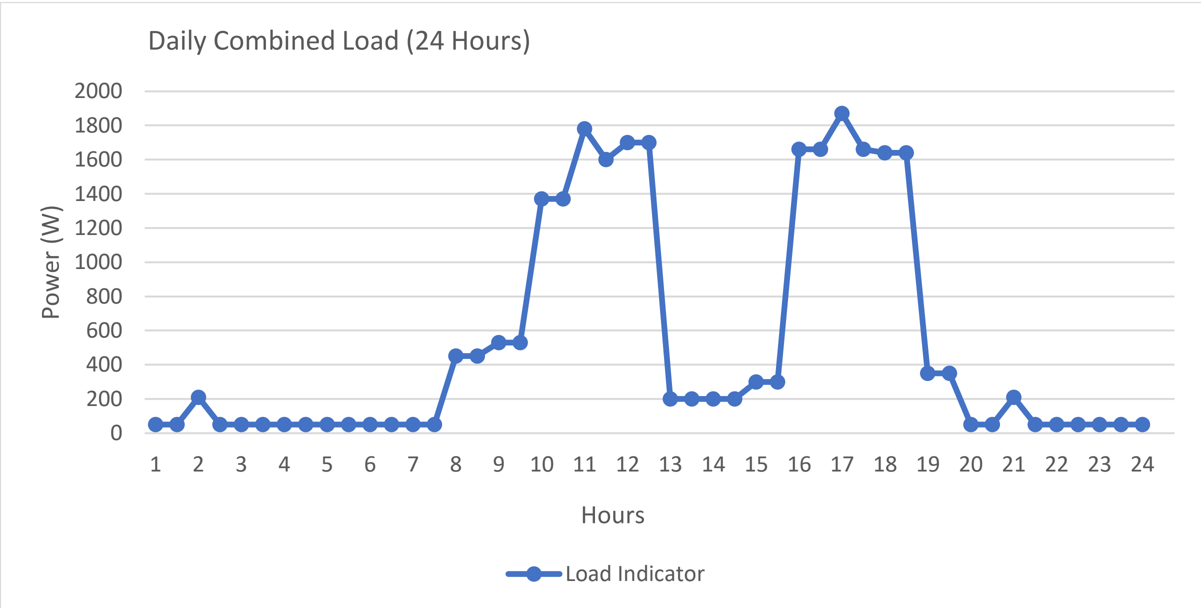
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 76. Single isolated institution DC coupled system DC loads: peak load 0.7kW



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 77. Single isolated institution DC coupled system Combined loads: peak load 1.9kW



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

It is evident there will be a significant investment in battery storage when sizing a solar PV + battery stand-alone system. In fact, for good quality PbA battery systems, the batteries are approximately 50%

of the price of the system. While for a good quality Li-ion battery based system the battery systems are 2/3 of the total system cost.

Tabled below are estimated costs for Off-grid standalone solar PV with battery systems and characteristic costs for elements in such systems.

Table 60. Estimates of cost for stand alone Off-grid solar PV + Battery systems

Stand Alone Solar PV + Battery Systems				
Calculate for system with PbA 25% DoD				**OG Solar system**
Size, kW	0.60	6.75	3.75	1
Battery, kWh	7.20	81.00	45.00	12.00
Battery price, US$	1,728	19,440	10,800	2,880
System cost estimate, US$	3,456	38,880	21,600	5,760
System Price, US$/kWh	480	480	480	480
Calculate for system with Li-ion 80% DoD				**OG Solar system**
Size, kW	0.60	6.75	3.75	1
Battery kWh	4.80	54.00	30.00	8.00
Battery price, US$	3,360	37,800	21,000	5,600
System cost estimate, US$	5,088	57,240	31,800	8,480
System Price, US$/kWh	1,060	1,060	1,060	1,060

Source: Unicon

Table 61. Characteristics of Off-grid solar PV + Battery generation

Solar PV Off-Grid + Battery Small system Characteristics									
Type	**Description**	**Solar PV array**	**BUS Coupling**	**DC Bus V**	**AC Bus V**	**Solar Inverter**	**Charge controller**	**Battery Inverter**	**Unit price $/Wh**
Mobile Solar PV	Size range W	5	DC	6		X	integral	X	3.53
		100		12		X	integral	X	0.60
Fixed Solar PV	Size range kW	0.200	AC or DC	24	220	1	1	2	
		100		96	240	20	5	10	
	PbA Battery capacity/Solar PV ratio kWh/kW	13	11						
	Li-ion Battery capacity/Solar PV ratio	9	8						

Solar PV Off-Grid + Battery Small system Characteristics									
Type	**Description**	**Solar PV array**	**BUS Coupling**	**DC Bus V**	**AC Bus V**	**Solar Inverter**	**Charge controller**	**Battery Inverter**	**Unit price $/Wh**
	Lifespan	30+	8hrs / day			20	20	20	
Solar PV Prices	CAPEX $/kW range	$610	$400			$800	$600	$800	
	Construc'n time months	0.5	2			0.5	0.5	0.5	
		CAPEX $/kW	DoD 25% Lifespan years	DoD 50% Lifespan years	DoD 80% Lifespan years	Assembly time months	Battery Manage't System BMS/kWh		
Battery PbA small systems	VRLA $/kWh	$450	6	3	1.5	1	$150		
	Fluid Filled -Flooded $/kWh	$240	17	8	4	1	$150		
Li-ion small systems	$/kWh	$700	10	10	10	1	$700		
Mode	Prime-Continuous floating	✓							
	Peak	✓							
	Standby	✓							
	Blackstart	✓							
	STOR	✓							
O&M Battery $/kW yr	PbA Fluid filled/VRLA	$27.50							
	Li-ion	$60.00							
O&M Solar PV	O&M fixed $/kW yr	$23.40				in the PV	in the PV	in the PV	
Service	Clean cycle years	0.1				0.1			
	Main mainten. yrs	1				0.5			
	Full overhaul cycle yrs	30+				20			
	Scheduled downtime days/year per unit	2				2			

Solar PV Off-Grid + Battery Small system Characteristics									
Type	**Description**	**Solar PV array**	**BUS Coupling**	**DC Bus V**	**AC Bus V**	**Solar Inverter**	**Charge controller**	**Battery Inverter**	**Unit price $/Wh**
	Replace't time year	0.1	1			0.1			
	Emissions Carbon cost $/tonne	0				0			

Source: Unicon

Conclusions Related to On-grid/Off-grid Issues

This annex provides a definition and an analysis of the grids, mini-grids and off-grid renewable and provides an example of remote stand-alone fixed off-grid Systems with solar PV plus storage.

These systems encompass the major scenarios that can be encountered:

- a single home with a family in an isolated location that could engage in some small cottage type value-adding activity;
- a five-family home cluster or unit that represents an isolated small community of five families, totalling about 30 people. This includes that they collectively engage in a value adding-activity for both their own benefit and to generate revenues; and
- the context of a standalone situation powering a small one building institutional facility like a police station, health clinic or border post as mentioned above.

Annex 7: Discussion of Generation Issues

Overview of Generation

Generation Context and In-house Upgrades for Urban Centres

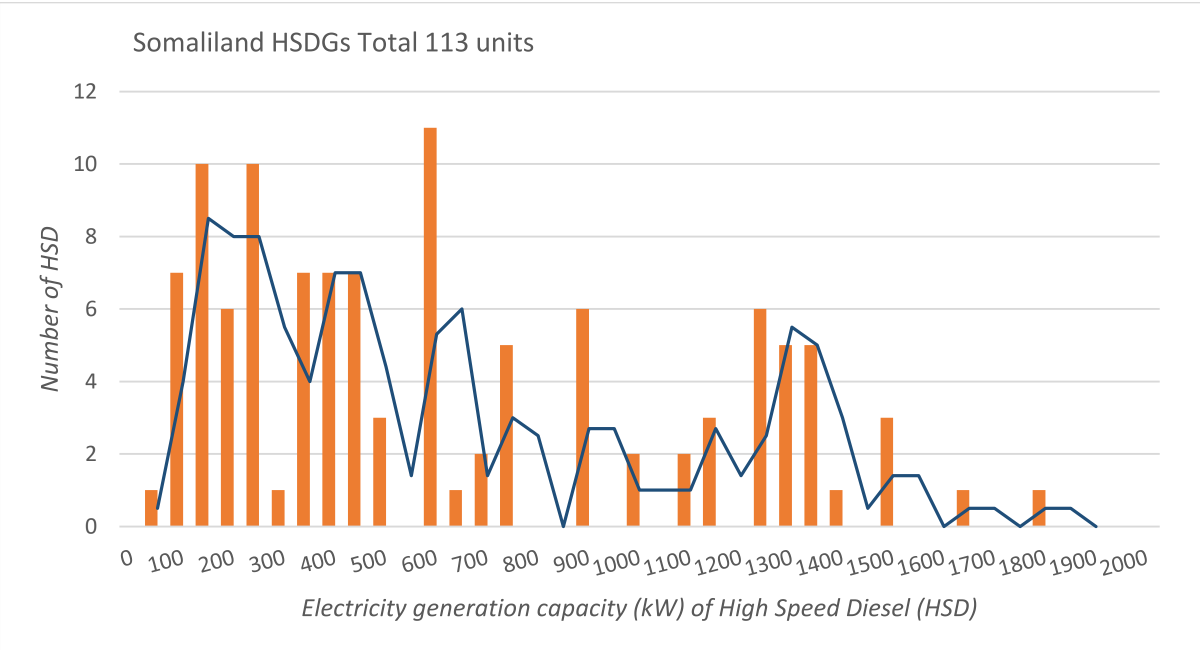
Most of the electricity produced and delivered to the businesses, institutions and the urban populations in Somaliland is provided by independent Electricity Service Providers (ESPs) and some IEPs. Nearly all of the current electricity generation in Somaliland is derived from high-speed (1,000 rpm or more) diesel fuelled generators (HSDG). Moreover, many of the larger industrial businesses and institutions utilise their own Captive Generation, which again is nearly all supplied by HSDG.

Generally, within the larger urban centres the electricity is provided by one or more ESPs using a mix of radial MV (medium voltage-11kV, 15kV & 33kV) distribution and LV (415/240V) feeder lines, all at a frequency of 5O Hz. The size of the HSDGs generally ranges from 50kVA to 2,000 kVA, with several to multiple HSDGs located at each site.

Additionally, it was observed that in the larger urban centres, with more than one ESP, there is no common shared network or cooperation in electricity distribution. In some cases, large electricity customers use multiple ESPs as service providers or opt for their own captive generation.

Figure 78 shows the size and number of HSDGs "currently surveyed" in Somaliland.

Figure 78. Somaliland – number and sizes of High Speed Diesel Generators, Median = 495 kW



Source: Unicon

Observations from urban field data collection and discussions, indicates that until recently, the renovation or upgrading of generation sites by the ESPs, generally involved either replacements or additions, by using similar or larger HSDGs.

Most of the urban ESPs and captive generators have not implemented synchronisation and automation as part of their generation processes. As a consequence, dedicated generators are allocated to exclusive feeder lines.

It was determined that currently it is likely that many urban-based HSDGs are operating well below their expected and designed performance criteria. This kind of operation results in significant amounts of "wet stacking" (diesel fuel waste, extra pollution, performance degradation and shorter HSDG lifespans) amongst electricity producing HSDGs.

Currently there is no in-country petroleum refinery providing hydrocarbon fuels for use within Somaliland. Throughout Somaliland, all diesel fuel is transported via national road networks from port facilities to points of use.

Opportunities for upgrading current urban generation sites that could be included in the analysis include:

- introduction of synchronisation and automation for generators presently in operation;
- introduction of larger more efficient thermal generation including medium and low speed diesels using sizes of units generally available on the market;
- introduction of Gas Turbines with high efficiency thermal generation that use diesel fuel that is generally available; and
- addition of renewables based generation.

The addition of renewables based upgrades has resulted in hybrid generation opportunities. Such hybrid opportunities offer significant improvements in fuel efficiency, fuel consumption, extended HSDG lifespans, reducing greenhouse gas (GHG) emissions and combustion pollution, along with less reliance on fuel imports. Hybridised electricity generation for urban centres is the present global trend across electricity markets.

Implementation of Renewables

Over the years there have been assorted attempts to introduce renewable energy based generation to Somaliland electricity marketplaces. These endeavours have been via solar PV, wind power and limited Hydro-electric generation – all with mixed results. This has been driven by a combination of well-meaning technology parachuting and the combined facts that:

- significant amounts of solar radiation are incident upon Somaliland;
- the area is endowed with significant and reliable wind activity;

- these technologies are modular and scalable and theoretically amenable to small and large systems.

Solar PV

Solar PV with rechargeable batteries (Pb gel and Li-Ion gel types) has a broad regional acceptance for applications in rural and decentralised areas. They are easily adopted in rural areas as a source of energy for small home and mobile devices; such as lighting, phone chargers, radios and low energy use devices.

These devices are usually classed under the category Small Home Systems (SHS) and in practice generally provide for a better quality of life. But SHS systems are limited in providing sufficient energy for direct value-adding work. In optimum conditions, their lifespans are 2-3 years and they are mostly limited by battery lifespans, maintenance and component failures, all requiring a replacement infrastructure that rarely functions. While SHS has spawned an industry, its enhancement of rural productivity is questionable.

More recently there has been the adoption of larger solar PV systems within some urban centres in Somaliland for commercial, residential and institutional applications. These systems comprise of either:

- standalone solar PV + Battery for captive mini-grid or isolated island distribution for dedicated uses; or
- solar PV grid tied generation; synchronised and attached to an existing ESP generation infrastructure.

The primary benefits of these systems are that they:

- permit reductions in diesel fuel costs for a thermal (HSDG) based system;
- have key elements with long lifespans of 15 - 25 + years, except for batteries;
- have low O&M complexity and cost;
- are modular easily replaced components;
- are easily upgraded;
- automatically synchronise to the local electrical energy supply;
- offset the need to purchase another HSDG;
- provide peak electrical energy during the daytime peak demand period;
- have capital cost that are low and continuing to drop significantly, likely by 35% over the next 6-8 years (except for batteries).

These observations suggest that solar PV has been quite effective, albeit limited by the weaknesses in O&M infrastructure (batteries and solar panels) for SHS, and limitations concerning battery utilisation.

Wind power

Contrary to Solar PV, wind power generation while modular and scalable, comprises electro-mechanical devices plus power electronics, all requiring higher quality and integrated O&M. Therefore, while it is scalable, broad scale implementation of small isolated wind power generation providing for the level of applications use, such as SHS, is not economical. Historically, wind power has been used in Somaliland for pumping water for rural purposes.

More recently there have been attempts in Somaliland to implement wind power generation for medium scale (5-100kW) captive generation and grid-tied applications. These systems comprise of either:

- Standalone wind turbines with Battery for captive mini-grid generation for dedicated uses; or
- Wind power turbines intended for grid tied generation – synchronised and attached to an existing ESP generation infrastructure.

These systems have been for the most part failures.

Cross-border and Remote Electricity. Import/Export of Electricity

Pastoralist communities

Land frontier areas and broad spans of land within Somaliland bordering the neighbouring countries of Ethiopia and Djibouti are generally sparsely populated, with sporadic frontier urban centres and significant tracts of land being utilised by pastoralist communities.

Nevertheless, despite the remoteness of much of these generally poorly serviced areas, the combination of the significant length of the land frontiers, with a significant synthesis of trans-frontier pastoralist communities all result in an important and underserved population within the trans-frontier areas.

A direct consequence of the general pastoralist community commercial activities and lifestyles, already mentioned in Annex 6, is that they require mobile electrical generation directed at either, or both, improving their quality of life and/or their commercial productivity. The alternative is that these communities must become sedentary, and abandon their lifestyles and their sources of revenue and sustenance, and risk entering absolute poverty.

Unfortunately, this situation is already prescient, due to the current extended drought impacting significant parts of Somaliland. This drought has resulted in significant numbers of climate refugees needing to establish bivouacs and camps proximal to large urban centres and seek charitable assistance.

Import/Export of Electricity

The prospect of establishing significant imports and exports of electricity, beyond small local synergistic generation and supply across the borders of Somaliland's various frontier areas, is important. This was discussed in Annex 6.

Characteristics of Current Electricity Generation

Current Urban Generation Capacity Implemented

As previously indicated, most electricity generation within Somaliland, is derived from urban-based HSDGs, which are owned and operated by private sector ESPs. Data was collected from the majority of ESPs operating in many of the major urban centres.

Generation Data for the major urban centres of Erigavo and Berbera could not be completely obtained. Generation data for the city of Hargeysa was incomplete, with approximately 50% of Hargeysa's ESP's not providing information. Some generation data was obtained for Berbera via ESRES data.

Table 62. Summary of totals from collected data for "current usable" generation

REGIONS	Type of Generation (kW) & Renewables Penetration via kWh					
	HSDG kW	Solar kW	Solar %	Wind kW	Wind %	Battery kWh
Somaliland	24,356.7	3,535.0	3.1%	118.8	0%	1,300

Source: Unicon

It must be noted that these values are not the same as for the total surveyed units. These values are for currently estimated generation sources in use and that nearly all ESPs do not currently implement synchronisation and automation of their HSDGs. Those ESPs utilising renewable generation have done so by adding it to their diesel fuel based generation, thus creating hybrid generation systems.

All the solar PV systems connected to urban distribution are grid-tied and therefore synchronised to their respective local ESP distribution network. Accordingly, these ESPs are now producing synchronised hybrid generation.

Fossil Fuelled Urban HSDG Operations (Diesel)

The generation data provided by the ESPs surveyed in general did not supply the actual metered electricity generated, but rather load cycles and estimated generation based on peak capacity assumptions. Monthly fuel consumption data was generally provided by the respective ESPs. The cost of diesel per litre, paid by ESPs, was systematically not provided, but the large captive HSDG generation facilities provided an average price of US$0.60/litre of diesel. A summary of operational characteristics and maintenance requirements for current surveyed operative HSDG's is tabled below in Table 63.

Table 63. Summary of O&M characteristics and requirements for current surveyed urban HSDG generation

Description	HSDG Specifications and Requirements			Fuel price US$/Litre	
	Value	Fuel	Motor RPM		Current values and expenses for surveyed ESPs in Somaliland
Systems Size kW	100 - 2,700	Diesel	1500	0.6	
Median HSDG Size kW					495
Number HSDG Generators					113
Generation	**Combined current estimated Generation capacity kW**				24,356.70
	Combined current Electricity Estimated Generation kWh/day				581,728.70
	Combined current Electricity estimated Generation kWh/year				212,330,981.80
Capex US$/kW, US$	**779**				**$18,973,869**
Fuel	Estimated Fuel use based on 3.75 kWh/Litre (0.267 Lt/kWh) Litres/day				155,128
	Estimated Fuel cost US $/day				$93,077
	Estimated Fuel cost US$/year				$33,972,9 57
	Reported fuel use Lt/day				*36,279*

Description	HSDG Specifications and Requirements				Fuel price US$/Litre	Current values and expenses for surveyed ESPs in Somaliland
	Value	Fuel		Motor RPM		
O&M	O&M Fixed US$/kW yr - US$	10.93				$266,219
	O&M Variable US $/MWh (year) - US$	3.48				$738,912
	Annual O&M estimate - US$					$1,005,13 1
	Annual O&M/kWh estimate - US$					$0.0047
Annual O&M + Fuel						**$34,978,0 88**
Annual O&M + Fuel/kWh estimate - US$						**$0.1647**
Generation Lifecycle	**Lifespan 12hrs/day generation lifecycle - years**	3.42				
	O&M costs per generation lifecycle - US$					$3,442,22 7.90
	Estimated Fuel cost US $/generation lifecycle - US$					$116,345, 743
	Total estimated Generation costs per lifecycle - US$					$138,761,840.65
	Proportion of O&M + Fuel costs to Capex during lifecycle					631.30%
	Lifespan Simple cost O&M + Fuel + Capex					$0.191

Description	HSDG Specifications and Requirements				Fuel price US$/Litre	Current values and expenses for surveyed ESPs in Somaliland
	Value	Fuel		Motor RPM		
	/kWh					
Oil & FC per Generator	Period Maintenance Oil & Filter Change cycle period - years	0.5				
	Down Time Oil & Filter Change Time/event - days	1				
	Number of Oil & Filter Changes / Lifespan	7				
	Number of days of O&FC / Lifespan - days	7				
Top Overhaul per Generator	Period Maintenance Top Overhaul cycle period - years	1				
	Down Time Top Overhaul Time/event - days	3				
	Number of Top Overhauls / Lifespan	3				
	Number of Top Overhaul days / Lifespan - days	9				
Full Overhaul per Generator	Period Maintenance Full Overhaul cycle period - years	3.42				

Description	HSDG Specifications and Requirements				Fuel price US$/Litre	
	Value	Fuel		Motor RPM		Current values and expenses for surveyed ESPs in Somaliland
	Down Time Full Overhaul Time/event - days	5				
	Number of Full Overhaul days / Lifespan - days	5				
Scheduled down time work for	Generator replacement time - year	0.1				
Generators	Scheduled Down time during a lifespan with replacement - days	54				6,087
	Scheduled Down time during a lifespan with Full overhaul - days	21				2,356
New Site Assembly time - year	0.25					

Source: Unicon

The range of HSDGs used in Somaliland's urban areas are all under 2,000 kW in generation capacity. These systems have optimal lifespans of 3.42 years (15,000 hours) when operated 12 hours a day, at which point they must be either replaced, or a major overhaul is needed, if still viable. Apart from regular maintenance, HSDGs require major scheduled changing of filters and oil each 6 months and "Top End" overhauls each 13-14 months during a 3-4 year period.

Calculations are made using current estimated generation and that each HSDG operates for a 12-hour cycle. Costings for capital cost of systems and O&M (Operations and Maintenance) are based on international and regional data sources.

The combined costs of O&M and fuel over the expected lifespan for the HSDGs ranges from four times to six times the Capital cost needed for installing the HSDG generation. Further, the scheduled labour and down time associated with a successful complete overhaul of well-maintained HSDGs is about 39% of the scheduled labour and down time associated with the full replacement of poorly maintained HSDGs.

In addition, there is an increase in unscheduled downtime and labour when HSDGs are run in Wet Stacking modes along with poor maintenance and service.

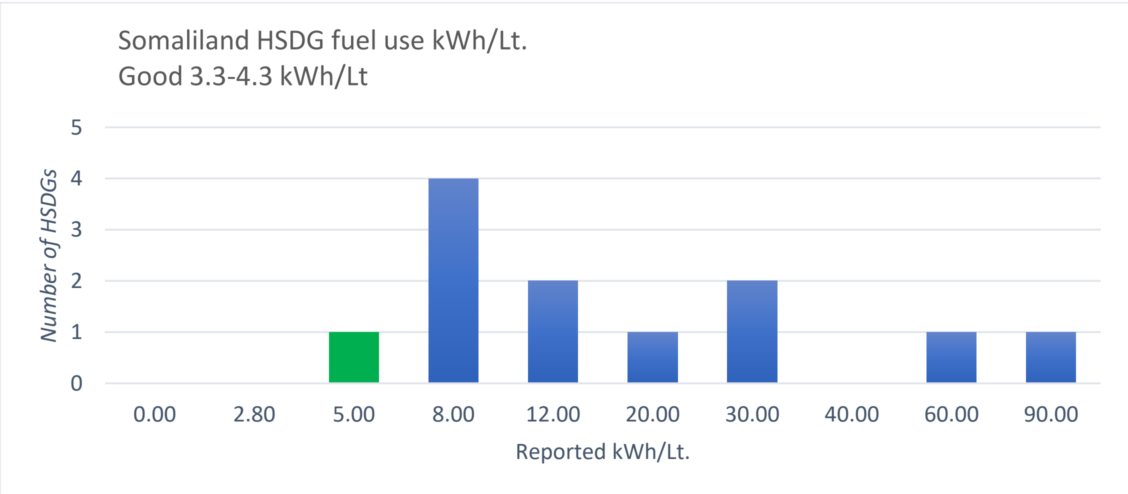
A deeper analysis of monthly fuel use and estimated generation from peak capacities and load cycles of the HSDGs for each ESP surveyed provided fuel use estimates for generation in kWh/lt. Well operated HSDGs generally operate in the range of 3.3 to 4.3 kWh of electricity per litre of Diesel used, with an average of 3.7-3.8 kWh/Lt as reference (GREEN zone in the following Figure 79).

Comparison of the expected electricity generation versus the estimated electricity generation using load cycles and peak capacity assumptions, indicates that many ESPs are operating HSDGs significantly below their optimal rated performance. A direct consequence of running light loads is insufficient operating temperatures, resulting in unburned diesel fuel emissions, elevated pollution and contaminated lubrication.

This aforementioned wasteful process is "Wet Stacking" (BLUE zone), which results in fouled engines, scarred internal surfaces and contaminated lubricants. These all combine to reduce maximum generation power, reduce lifespans of the generator engines and elevate maintenance costs and unscheduled generation downtime.

Distribution histograms of fuel use for generation, displaying the kWh/Lt distribution are shown below, along with colours identifying the relevant HSDG fuel use performance.

Figure 79. Somaliland – summary of generators fuel use against expected generation

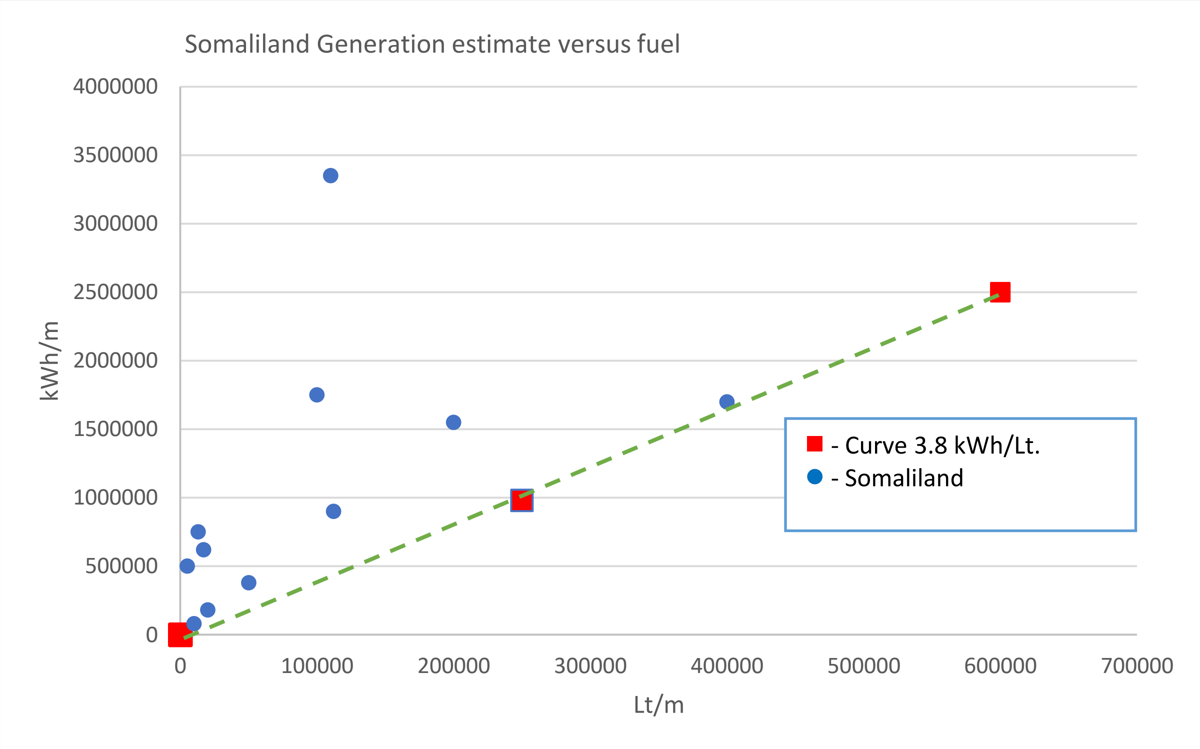


Source: Unicon

As can be seen, the majority (BLUE zone) of HSDGs throughout the mandated areas, based on fuel use and projected generation, are very likely engaging in different degrees of Wet Stacking operations. Losses due to Wet stacking practices produce significantly higher overall operation costs, which in turn, the electricity consumers must pay for: via higher electricity rates. The green zone illustrates that a minority of ESPs are actually operating their HSDGs in optimum generation conditions.

To further illustrate the scale of segmentation in performance of HSDG generation within Somaliland, the estimated generation against fuel use, compared to the optimal fuel use curve is shown below in Figure 80.

Figure 80. Somaliland estimated generation versus fuel use. Wet stacking above best generation line, non-generation losses are below the line



Source: Unicon

It is observed that for estimated ESP electricity generation for Somaliland shows some wet stacking (above the line), some good operations near the line. This indicates fuel consumptions issues are more severe in Somaliland. In general, wet stacking is a significant operations issue in many ESPs.

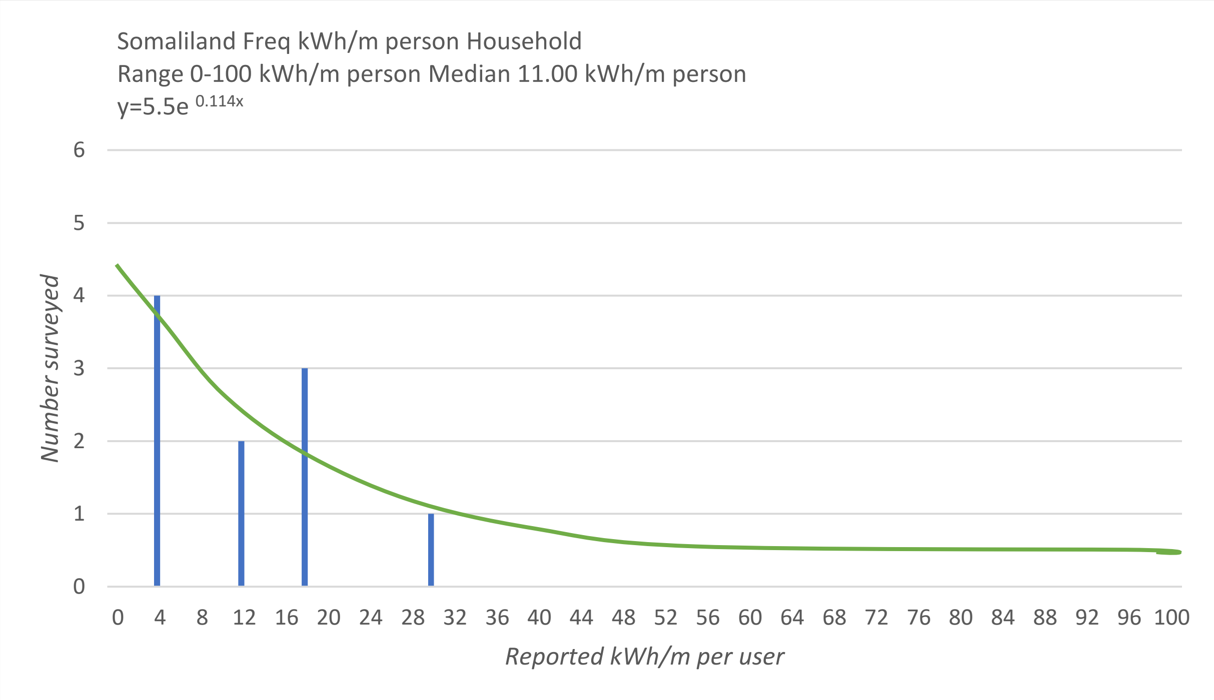
Urban Electricity User Population Capitalising on Electricity Generation

As mentioned in Annex 5, data concerning Energy use by households, small businesses, large commercial and manufacturing enterprises, and institutional users within many of the major urban centres in Somaliland, was collected.

The data collected on residential and business electricity use, showed that the population distributions concerning electricity use are asymmetric. In particular, the residential use in the surveyed urban centres is described by an exponentially declining curve, which indicates a significant proportion of the urban populations in Somaliland, do not have access to ESP generated and distributed electricity.

Figure 81, below, illustrates the distribution of residential demand on metered electricity, as kWh/month person, within Somaliland. These all exhibit declining curves, starting from a large base of non-users of ESP generated electricity.

Figure 81. Residential kWh/m person demand: Somaliland



Source: Unicon

In fact, this should be expected given that there is a significant base of electricity distribution nonusers within Somaliland, in part due to common small scale captive generation.

The analysis of the energy use data surveyed, is again provided as in Annex 5 for Somaliland, which is tabled below, in Table 64.

Table 64. Electricity consumption by classes kWh/month person

Monthly Electricity Use and Urban Electricity Rates								
Criterion	Residential metered Use (median) kWh/m cap	General Business metered Use (average) kWh/m worker	Medium towns metered Use (average) (20-30K) kWh/m cap	Medium towns electricity Rate (average) (20-30K) US$/kWh	Large cities metered Use (average) (>500K) kWh/m cap	Large cities electricity Rate (average) (>500K) US $/kWh	Considered population in survey	Total population reference
Somaliland	11.10	62.57	16.28	$0.76	10.39	$0.69	2,665,880	3,500,000

Source: Unicon

Proportion of Urban Electricity Generation Users

Further examination of the data extracted from electricity usage and generation data and then their combination provides for a current estimate to determine the number of urban residents who are not utilising the electricity resources provided by the respective ESPs.

As identified, the median monthly per capita electricity consumption determined for Somaliland is 11.1 kWh/month person. When this value, derived from median, is applied to the considered or assessed populations that were sampled, they provide a calculated demand, which when compared to the actual estimated electricity generation provides an estimate of the served population. This is tabled below, in Table 65.

Table 65. Estimated proportion of assessed urban populations currently, using ESPs or not

Region	Estimated urban Generation kWh/day	Median kWh/month capita electricity consumption	Assessed urban population	Estimated Demand kWh /day	% of ESP users in assessed population	% non-ESP and/or non users of Electricity in assessed population	Number of Electricity or ESP Non-users
Somaliland (3 ESPs Hargeysa)	581,728.7	11.10	2,665,880	986,376	59.0%	41%	1,093,011
Somaliland (est 6 ESP Hargeysa)	700,000	11.10	2,665,880	986,376	71.0%	29%	773,105

Source: Unicon

The consequence of these values indicates that there is a significant proportion of the population in each mandated area, that is either not obtaining electricity from the surveyed ESPs or do not have access to electricity. This corroborates with Annex 5 population distributions concerning urban electricity use, which are asymmetric and described by an exponentially declining curve, and signify sizeable electricity or ESP non-use.

Unfortunately, values obtained for Somaliland are actually understated, because only three of the six ESPs in Hargeysa provided estimated generation data. A revised estimation based on doubling the current generation in Hargeysa is also tabled, which proposes a lower current level of non ESP and / or electricity users (NESP).

In any case, increasing electricity generation will have to provide for increases in two classes of electricity consumption: consumption increases by current urban electricity users or by additional

NESP users entering the electricity market. It is logical to expect the user distributions will remain asymmetric into the near future.

Renewables Generation Operations

As previously mentioned, there are ESPs within Somaliland that have commenced converting their generation systems into hybrid electricity generation. For the most part this has been via the renewable energy resource of solar PV. These solar PV systems are all grid-tied and synchronised to particular ESP's HSDG generation systems and connected to the same ESP's local distribution network.

While there are some wind power generators installed in Somaliland, all of these, bar one, currently do not provide electricity to their local ESP distribution network.

Table 66. Current renewables in Somaliland

Region	Location	ESP	Source	Solar PV kW	Grid tied inverter kW	Battery Inverter kW	Battery kWh/d	PV factor	Solar Battery kWh/d	Wind Power kW	Wind power kWh/d	Average Wind speed m/s	In Operation
WOQOOYI GALBEED MAROODI- JEEH	Hargeysa	Airport	Wind power							19.8	0		NO
										19.8	0		NO
										19.8	0		NO
										19.8	0		BROKEN
										19.8	0		BROKEN
TOGDHEER	Burao	HECO	Solar PV	1,500	1,500			5.03	7,545				
	Shiekh	BEDER	Solar PV	130				5.04	655				
SOOL	Laascaanod	GURMAD	Solar PV	402	500			5.07	2,038				
		LESCO	Solar PV	500	500			5.07	2,535				
						250	1,300		1,300				
AWDAL	Borama	ALOOG EC	Solar PV	700	700			5.33	3,731				
GABILEY MAROODI- JEEH	Gabiley	SOMPOW ER	Solar PV	300	300			5.33	1,599				
SAHIL	Daca-Budhug	LIBAN Group	Solar PV	3	3	3	???	???	???				
SAHIL	Berbera	TAYO PC	Wind power							19.8	0		NO
	Berbera	TAYO PC	Wind power							19.8	0		NO
										19.8	0		NO
TOTALS				**Solar PV kW**			**Battery kWh/d**		**Solar Battery kWh/d**	**Wind Power kW**	**Wind power kWh/d**	**Potential Wind power kWh/d**	**Current Total Renewables kWh/d**
Somaliland				3,535			1,300		19,403	119	0	2,851	19,403

Source: Unicon

A summary of operational characteristics and maintenance requirements for current surveyed operating solar PV, battery and wind power generation systems in Table below.

Table 67. Summary of O&M characteristics and requirements for current surveyed operating solar PV, battery and wind power generator

Description	Indicators	HSDG Specifications and Requirements			Vulnerability	Current values and expenses for surveyed ESPs in Somaliland
		Value	Source	Period		
Solar PV Systems Size kW		1 - 200,000	Sun	Daylight	Clouds	
Windpower Systems Size kW		1-2,000,000	Wind	24 hours	Variability	
Capacity	Solar PV Size kW					3,535
	Number Solar PV sites					7
	Windpower Size kW					119
	Number Wind turbines					8
	Combined Renewables Generation capacity kW					3,654
Generation	Solar PV Generation kWh/day					18,103
	Windpower usable Generation kWh/day					0
	Windpower possible Generation kWh/day					2,851
	PbA Battery storage Generation kWh/day					1,300
	Li-Ion Battery storage Generation kWh/day					0
	Combined Renewables Generation kWh/day					19,403
	Combined Renewables Generation kWh/year					7,082,168

Description	Indicators	HSDG Specifications and Requirements			Vulnerability	Current values and expenses for surveyed ESPs in Somaliland
		Value	Source	Period		
CAPEX	**Solar PV 2018 US$/kW - US$**	$1,810				$6,398,350
	Solar PV 2025 US$/kW - US$	$790				$2,792,650
	Wind 2018 US$/kW - US$	$1,560				$185,328
	Wind 2025 US$/kW - US$	$1,370				$162,756
	PbA Battery US$/kWh - US$	$550				$715,000
	Li-Ion Battery US$/kWh - US$	$2,000				$0
O&M	Solar PV O&M Fixed US$/kW yr - US$	23.4				$82,719
	Windpower O&M Fixed US$/kW yr - US$	46.71				$5,549
	Solar PV O&M Variable US$/MWh (year) - US$	0				$0
	Windpower O&M Variable US$/MWh (year) - US$	0				$0
	Solar PV Annual O&M estimate - US$					$82,719
	Windpower Annual O&M estimate – US$					$5,549
	Renewables Annual O&M - US$					$88,268
	PbA Batt US$/kWh yr - US$	$27.50				$35,750
	Li-Ion Batt US$/kWh yr- US$	$60.00				$0
	Annual Renewables + Batt O&M - US$					$124,018
	Annual Renewable + Batt O&M/kWh estimate - US$					$0.0175
	Lifespan Solar PV - years	30.00				

Description	Indicators	HSDG Specifications and Requirements			Vulnerability	Current values and expenses for surveyed ESPs in Somaliland
		Value	Source	Period		
Generation Lifecycle	**Lifespan Wind Turbine - years**	25.00				
	Lifespan Battery PbA - years	10.00				
	Lifespan Li-Ion - years	10.00				
	Solar PV O&M costs per generation lifecycle - US$	30yrs				2,481,570
	Solar PV+Batt O&M costs per generation lifecycle - US$	10yrs				1,184,690
	Wind power O&M costs per generation lifecycle - US$	25yrs				138,729
	Total Solar PV Generation costs per lifecycle - US$	30yrs				8,879,920
	Total Solar PV + Batt Generation costs per lifecycle - US$	10yrs				8,298,040
	Total Wind power Generation costs per lifecycle - US$	25yrs				324,057
	Renewables 10yr Simple cost O&M + Capex /kWh	10yrs				$0.1155
Solar PV maintenance per system	Period Maintenance cleaning cycle period - years	0.1				
	Down Time cleaning - days	0				
	Annual Maintenance cycle period - years	1				
	Down Time Annual Maintenance - days	2				

Description	Indicators	HSDG Specifications and Requirements			Vulnerability	Current values and expenses for surveyed ESPs in Somaliland
		Value	Source	Period		
Battery maintenance per system	Period Maintenance Monitoring cycle period - years	0.25				
	Down Time Monitoring - days	0				
	Annual Maintenance Equalising cycle period - years	0.5				
	Down Time Equalising - days	1				
Wind Turbine Maintenance per turbine	Period Maintenance Service cycle period - years	0.50				
	Down Time Full Overhaul Time/event - days	2				
	Statistical downtime/year - days	6.2				
Scheduled down time Renewable Generators	Solar PV annual Downtime days/year	2				14
	Solar PV + Battery annual Downtime days/year	4				4
	Wind power annual Down time days/year	10.2				81
	New Site Assembly time - year	0.25				

Source: Unicon

Solar PV and Battery Generation

There are six grid-tied solar PV systems located in Somaliland, which are co-sponsored by the ESRES project. As mentioned, recent implementations of grid-tied solar PV into the urban generation has been significant, grossing to 3.54MW in Somaliland.

These systems are synchronised to operate as part of solar PV-HSDG hybrid generation, with the solar component providing both extra daytime generation and diesel fuel savings. Solar PV generation data surveyed range from 3kW to 1.5MW in Somaliland.

Apart from regular maintenance, which is primarily cleaning the solar panels and generation site, grid tied solar PV systems are low cost maintenance, long lasting generators. Lifespans are considered in excess of 30 years, maybe even 60+ years and they are very easy to upgrade and repair. This is because the systems are composed of modular components that can be easily replaced.

The key vulnerability is electronics within the solar PV such as DC-AC inverters, which are intentionally modular, such that they can be easily replaced if they fail. Change out times on failed inverters are a few hours at most, and it does not prevent the rest of the modular elements of solar PV systems from continuing to generate electricity.

In the cases where there is a combination of solar PV, with rechargeable battery storage systems, these use additional grid connecting inverters and computerised battery management systems (BMS). The use of batteries reduces the impacts of low sunlight conditions (clouds) during daylight, as well as, via grid inverters, provides rapid-response peak-load generation capacity. Moreover, with a suitably large capacity, the battery systems can even permit night-time generation and peak load support.

Estimations of expected solar PV electricity generation are usually made using 22-year based average daytime solar irradiation for each site, which is geographically determined, along with the peak rated real power (W) generation of the solar PV system. Solar PV inverter systems are automated and can be programmed to also provide different levels of reactive power support as part of a generating network (VAR).

The utilisation of rechargeable battery storage systems, with BMS, currently proposes the replacement of the battery systems after 10 years of operations. This occurs because the capacity to store electrical energy of these rechargeable batteries is significantly reduced after 10 years of continued use, unless very well managed. The erosion of battery performance is a direct result of irreversible chemical changes within the batteries.

Two types of rechargeable Battery technologies are being used in the mandated areas. As per industry practice, the larger storage capacity systems are lead acid (PbA) based technologies, while smaller storage capacities utilise lithium-Ion (Li) based technologies. The PbA systems are ¼ the cost, easily recycled, well known, heavy, temperature sensitive, bulkier, safe if well ventilated and require basic climate control to perform optimally.

The Li systems are four times more expensive, are frequently operated on an 80% DoD cycle, 1/3 the weight, more compact, less vulnerable to temperature, but require well regulated climate control for optimal performance, are a newer technology, are currently not recyclable and are capable of explosive decomposition if mistreated.

One ESP in Somaliland, located in the urban centre of Laascaanood, LESCO, has implemented a solar PV-Battery-HSDG hybrid generation system. LESCO has executed an automated and synchronised hybrid generation system with the extensive technical assistance of an expert foreign hybrid electricity EPC (Engineering Procurement Construction) firm, EPS (Electro Power Systems S.A).

Their information website indicates their generation is from 500kW of solar PV, 1,300 kW of battery storage in PbA technology with a BMS, a 250 kW battery inverter and 1,900 kVA of diesel generation. Their use of hybrid generation has permitted them to reduce their diesel consumption by 53%, and CO2 emissions have been reduced by 131 tons/annum.

Estimates for capital costs and O&M practices are according to international and regional data sources and practices.

Wind Power Generation

Wind power turbines are electro-mechanical devices that require a certain level of technical capability and infrastructure to do the construction, commissioning and operations, which, to the present time, has not in large part been available in Somaliland. Nevertheless, it is well known there are significant good quality wind generation opportunities in Somaliland.

As mentioned in Annex 6, within Somaliland there are currently 11 non-operational wind turbines dispersed between Hargeysa, Berbera, Borama and Erigavo. Only the five Hargeysa and three Berbera wind turbines were considered as potential generators in the survey. These are 22kW turbines mounted on 18m towers. While three of the five turbines at the Hargeysa airport are considered potentially operational, their history has created safety and liability concerns for the local ESPs who own and manage the airport distribution network.

The biggest challenges in operating wind power systems derive from both electrical and mechanical issues. They are most vulnerable to mechanical problems, and to a lesser degree electrical, soon after installation and commissioning. When these problems are well managed and resolved they will then become much more regular and reliable in their standalone operation. They are expected to last in excess of 25 years.

Regular maintenance for wind turbines is usually done every six months, which involves a thorough inspection of the nacelle complex, comprising of the rotors, the gearbox, the generators, power electronics and controllers necessary for normal operations and orientation of the wind turbine. Following the wide scale implementation of wind power in developed economies, there has been a growing interest in and development of SCADA and remote tools for optimising the O&M aspects of wind power generation.

This enhancing of O&M performance involves the use of real time CSM (Condition Monitoring Systems), which provides near instantaneous telemetry monitoring of turbine component performance throughout its operational life. This permits remote monitoring, to optimise operations and enhance preventative maintenance scheduling. This reduces unscheduled downtimes, shutdowns and faults.

Many of the wind power installations in the world are now linked to real time monitoring for this purpose and CMS is a potent tool for facilitating technology transfer and integration, between poorer and wealthier economies.

Small Urban, Rural and Isolated Mini-grid Generation

A few small urban isolated locations were sampled. Here it was found that either fossil fuelled generation, and/or solar PV + battery generation systems were each operated independently and if present together, coexisted as stand-alone generation, and were not synchronised. These types of separate generation modalities are classed as unsynchronised hybrid generation. The absence of synchronisation between the generation modalities provides for simpler less technically demanding operations and maintenance and provides for redundancy in electricity generation.

These types of coexisting unsynchronised hybrid generation systems are often utilised with small stand-alone mini-grids. Implementation of such separated generation operations is also done to service different demand periods. In these cases, the use of either solar PV and/or small wind power turbines + battery and/or fossil fuelled generation is largely dependent on local user demands and daily incident solar irradiation (seasonality) for the solar PV component and wind reliability for small wind power generation.

Any isolated and/or remote electricity generation is by definition a form of captive generation targeting a specific class of users and tasks. Consequently, as mentioned in Annex 6, it is very likely off-grid and standalone generation needs to be conceptualised as part of an electricity infrastructure designed for remote and even pastoralist communities.

Captive Generation

Large captive generation sites are necessary amongst large businesses and institutions throughout Somaliland. This phenomenon is a result of:

- limited generation capacity of ESPs;
- unreliable generation and delivery from ESPs;
- variability in quality of electricity delivered vis-à-vis voltage and frequency stability;
- high cost of electricity generated by the ESPs;
- economies of scale within the business or institutions operations;
- obtaining electricity from multiple ESPs requires separate distribution lines from each ESP.

The small sample of large captive generation locations surveyed utilise single or multiple HSDGs on site. In addition, these were also reported to be currently not using synchronisation and automation, as part of their operational protocols.

Data from large captive generation sites can provide useful information on actual large industrial requirements for electricity, but the actual population of large businesses using captive generation is unknown, and only a limited sampling of large businesses was surveyed.

Ergo, the combination of a limited amount of data collected on large businesses, plus an even smaller sampling of large captive generation businesses constrains what reliable conclusions can be drawn concerning captive generation. It must also be annotated that historically, captive generation is the starting point for electricity generation in most societies, including how ESPs have developed in the country.

Electricity Generation Resources Available

The potential energy resources available for supplying or fuelling electricity generation in Somaliland can be divided into three classes. These are the use of:

- Biomass and waste fuels (thermal source) such as; wood, urban waste products or waste agricultural products;
- Fossil fuels (thermal source) such as coal, petroleum-based products and natural gas;
- Renewable energy, which can be grouped into solar PV, solar thermal, wind and electric.

In a certain context biomass can be considered a form of renewable when it is applied to regenerative practices that ensure carbon neutrality, such as the cyclic use of tree forestry and plant farming to produce biomass crops. Currently this is not the case for biomass fuels in Somaliland.

At the present time in Somaliland, there is no national production and exploitation of nationally sourced fossil fuels such as coal, natural gas or liquid petroleum.

There is a key distinction between the thermal energy sources and the other energy sources mentioned above when used for electricity generation. Storage for thermal sources utilises the chemical energy stored in the fuel itself to produce heat to drive turbines, and is dependent upon the control, stockpiling and regular supply of fuel from distant sources.

On the other hand, the renewable forms of wind and hydro energy rely on the transfer of mechanical energy produced from the movement of air and water. Solar PV relies upon the transfer of energy from selected electromagnetic radiation (sunlight-blue light) to electrons within specific photoelectric materials. As a consequence, these modalities are very dependent on local and regional climate and geography, and the subject of storage is fixed to addressing variability in supply or demand at the locus of generation, and is not dependent on distal energy sources.

There are extensive resources of wind within Somaliland. In addition, there are also significant solar PV resources available in the country, both along the coasts and inland.

Biomass and Waste Fuels

Noting the severity of the current impact of regional climate change, a protracted drought, and significant deforestation, the presently very vulnerable natural and human environment in Somaliland does not currently offer significant opportunities for sizeable use of biomass for electricity generation. Presently there is extensive use of wood to produce charcoal for national use and significant regional targeted exports destined for use in cooking, which have severely aggravated deforestation processes.

There is a significant waste stream being produced by each of the major urban centres and there are robust and established ways in which urban waste destined for landfill can be segregated and the appropriate portions used for electricity and heat generation. Moreover, urban liquid waste efflux can be treated to provide biogas and other fuels for electricity and/or heat generation and support land regeneration.

There is also a significant livestock and local agricultural industry supplying both local consumption and, significantly, the export of live and slaughtered animals. There is significant potential for using the wastes from these industries at their collection hubs for fuel and land benefits such as in Burao and Berbera. These sites could provide biogas, other fuels and organic soil additives from their solid and liquid waste streams.

There would be separation of clinical, building and ceramic wastes from carbon rich waste. It would produce heat, syngas, fuel oil and biochars as outputs. It is quite feasible that similar facilities could be implemented at all of the other major urban centres also, such as Hargeysa, Burao, Erigavo and even for smaller cities like Borama, Berbera, Laascaanood.

Unfortunately, it appears at this time, there are no such projects in-place to systematically examine or undertake projects to exploit these possibilities for cogeneration of electricity, waste treatment and support near urban agricultural land remediation.

Fossil Fuels

Coal deposits have been historically recorded and identified, but as discussed in Annex 5 they are not considered commercial.

Consequently, all fossil fuels used in Somaliland, must be imported through national seaport or possibly delivered by road from Ethiopia. For practical purposes, currently all of the fossil fuels are imported through seaport. The current key seaport for fossil fuel imports is Berbera.

From this port there are established road routes, of variable quality, connecting through much of the rest of the country for fuel delivery. It also has storage facilities for these fossil fuel imports, although capacities are unknown. Clearly, the cost of storing, transporting and further storing diesel for its various uses, including that used by the ESPs is passed onto consumers. Consequently, long and/or poor transport routes also contribute to higher diesel fuel costs.

As previously mentioned, nearly all urban electricity generation is produced by ESPs operating HSDGs, including for the large urban centres. Anecdotal evidence indicates that many of the small sized fossil fuelled generators used in small-scale standalone captive generation, that service small businesses, isolated homes and small isolated communities, tend to be small gasoline driven generators.

As mentioned in Annex 5, other fossil liquid fuel imports include aviation and jet fuels, intended for aircraft using the major airports and lastly Kerosene; a fuel used primarily in lighting and cooking activities. There is also importation of LNG (liquefied natural gas), which is primarily used for cooking tasks. All these imported fuels are sourced from foreign suppliers and refineries; mostly venders located in the Middle East.

Field surveys confirmed that nearly all the major urban electricity generation is currently provided by HSDGs and that some of these have recently been hybrid-augmented by solar PV, and in limited cases also with battery storage, and in one case wind power. Consequently, diesel fuel for HSDGs is “de rigueur” for the majority of electrical energy in Somaliland.

Also mentioned in Annex 5, the large vehicle transport sector uses significant diesel fuel as well as being responsible for the delivery of diesel fuel from the seaport centre to inland urban centres. Moreover, the fishing industries are another major diesel and fossil fuels consumer.

Table 68. Reported monthly diesel fuel use for HSDG generation (wet stacking likely common)

Region	Estimated kWh/m	Reported fuel Lt/m	kWh/Lt	Comments
Somaliland	12,008,916	1,088,206	11.04	Very likely extensive under-loaded operation and Wet Stacking, overestimated generation

Source: Unicon

Fossil Options

Currently there are no identified Low Speed Internal Combustion based electricity generation systems in Somaliland. Often called LSIC generators, Low Speed Diesels (LSG) or HFO (Heavy Fuel Oil) plants; these can run on either diesel or HFO, but because of the cheapness of HFO, are frequently marketed and run based on this fuel.

The adoption of either HFO or Natural gas (LNG or CNG) based electricity generation, will require the installation of specialised storage facilities for the handling and storing of these fuels both at the port and ESP sites. Moreover, the land transport of natural gas requires specialised road tankers and good roads or pipelines.

Additionally, HFO is not generally considered suitable for overland transport, as it requires continuous heating for storage and for pumped transfers. On the contrary, both fuel oil and diesel fuel are easily and safely transported by road fuel tankers over most types of roadways and share a common fuel resource with key elements of the transport infrastructure.

Renewables Resources

The discussion of renewable resources in this chapter is focused on its use as part of the supply of electricity to larger load centres; the use of such resources in off-grid situations was discussed at length in Annex 6.

Solar PV

Solar PV opportunities in Somaliland are primarily constrained by:

- availability of open space at the location;
- quality of solar irradiation at the location;
- number of sunlight days per year in the location; and
- need to operate in some form of hybrid configuration.

The actual solar PV systems installed comprise of solar PV panels fixed on mounting arrays, whether situated on open ground or on structures like buildings. The panel arrays are oriented in a fixed manner to either:

- obtain the maximum amount of solar radiation throughout the year for generation; or
- obtain the optimum utilisation of solar radiation throughout the year for standalone balanced loads.

The first of these two approaches fixes the PV panel array orientations for maximum total solar energy received during a calendar year. The second fixes the panel array orientations such that the delivery of energy throughout the year is more constant or seasonally targeted.

Solar PV for hybrid grid-tied generation applications generally follows the first methodology, unless there are specific seasonal requirements. On the other hand, solar PV systems for hybrid standalone situations, such as providing for storage and off-grid captive generation or isolated communities; are configured for clearly structured and balanced loads: methodology two.

Other key elements within hybrid solar PV systems are the inverter systems and control panels. These comprise of modular Inverters, which are electronic devices that convert the solar PV DC energy, or stored electricity into AC electricity and synchronise it to an electrical network. They automatically inject synchronised AC into the local distribution lines, while also providing anti-island protection (fast safe disconnections), to prevent unsafe energising of local island or even regional distribution lines. Their high level of automation allows for easy remote monitoring.

The amount of electricity that a particular solar PV location can generate for a hybrid generation network is ultimately determined by the combination of the following:

- Power rating, kWp, of the solar PV arrays;
- Solar irradiation index for that area;
- Efficiency of the inverter systems, which ranges from 0.87 to 0.97;
- The cleanliness of the panels (removal of dust); and
- Monitoring and preventative maintenance for the inverters and control panels.

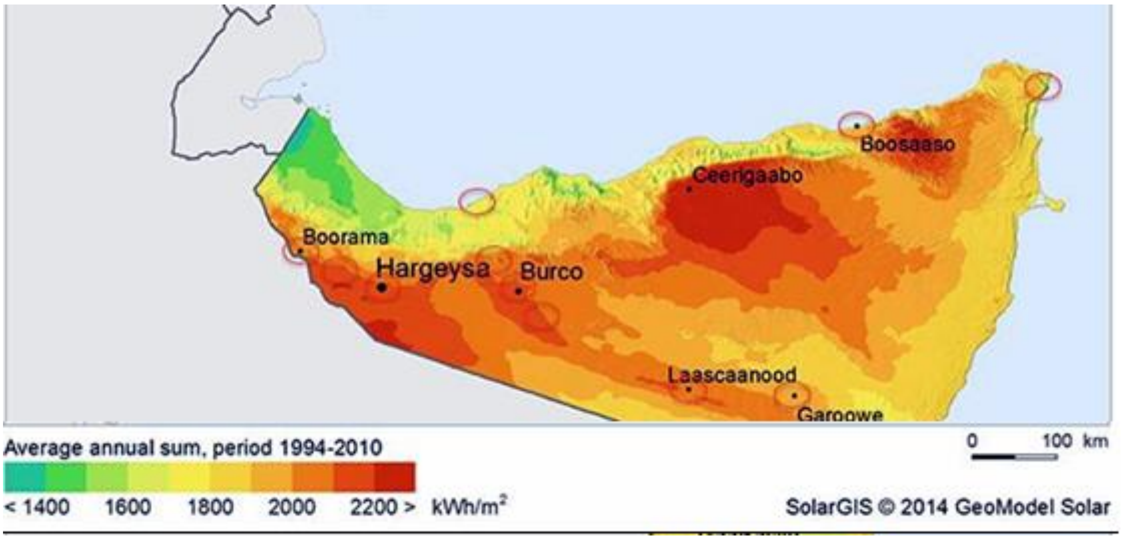
The modular nature of the inverter systems can allow for simple quick replacement of failed or faulty electronic components while the unaffected portion of the system can continue to generate.

The solar maps shown below and in, Annex 5 illustrate that different locations provide unique energy irradiation characteristics throughout Somaliland.

These locations are especially well suited to solar PV electric generation as part of a hybrid generation network and should be exploited in both urban and rural areas for electricity generation.

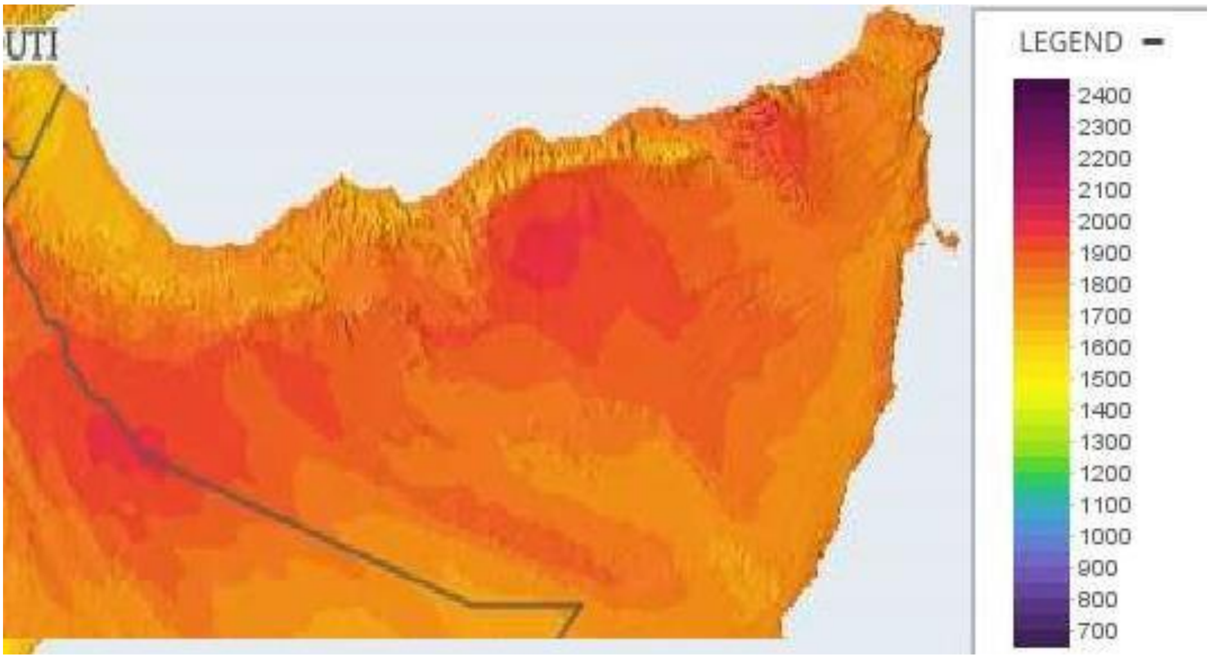
As seen in the maps below, different location possesses different levels of solar irradiation and so a solar PV array output will be different. Consequently, examples are provided below of what electricity generation will be obtained at different locations from a 1kW solar PV during an average day.

Figure 82. Solar map and solar DNI (Direct Normal Irradiation)



Source: SOLARGIS Global Solar Atlas

Figure 83. Solar DNI map

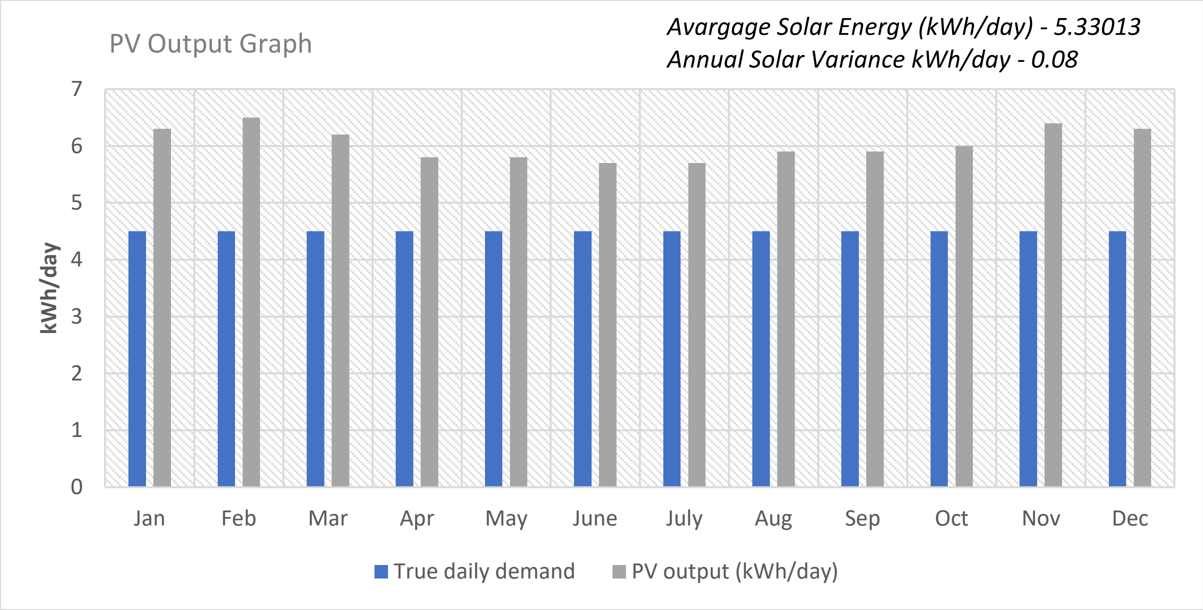


Source: IRENA

Examples of Solar PV Generation Output from a 1kW solar PV array

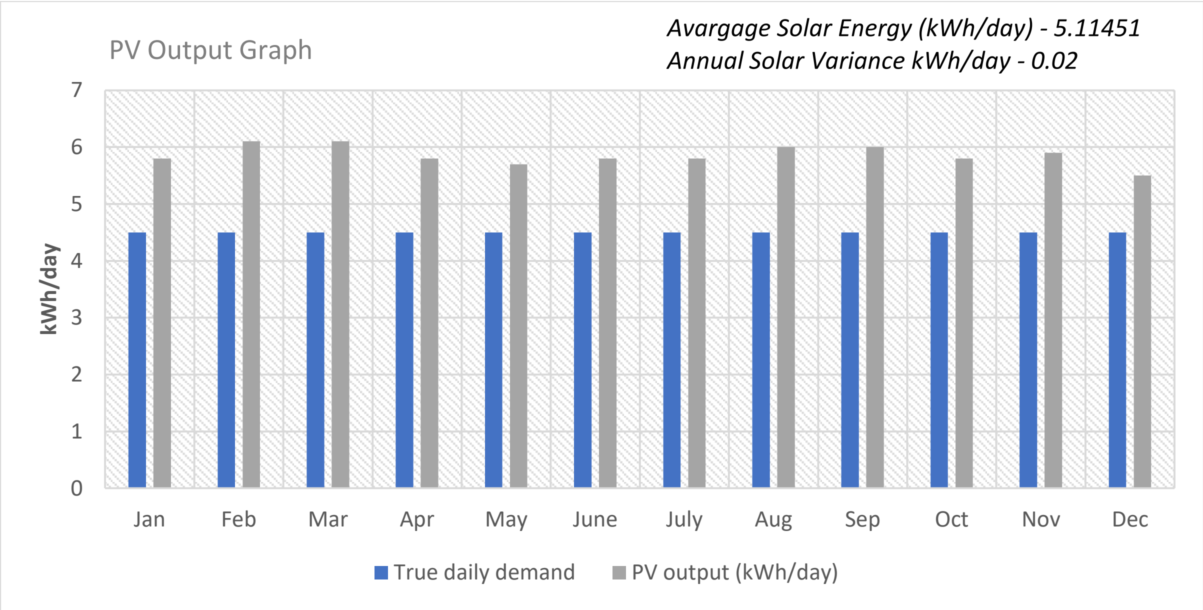
In figures below, the array is inclined for optimum performance within selected different urban centres (data is based on 22 year NASA Surface meteorology and solar energy data). Each location graph shows Solar PV battery system generation (grey bars) against household load demand (blue bars) monthly, over 1 year.

Figure 84. Boroma 1kW 18 Degrees inclined South => Average 5.33 kWh/d per 1kWp installed



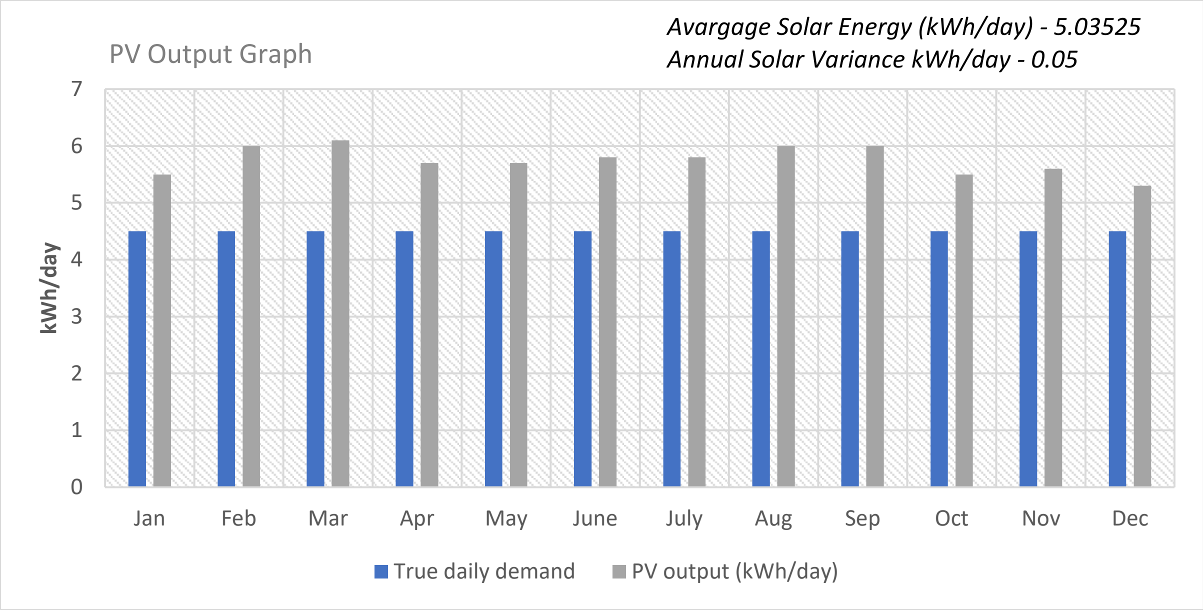
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 85. Hargeysa 1kW 11 Degrees inclined South => Average 5.11 kWh/d per 1kWp installed



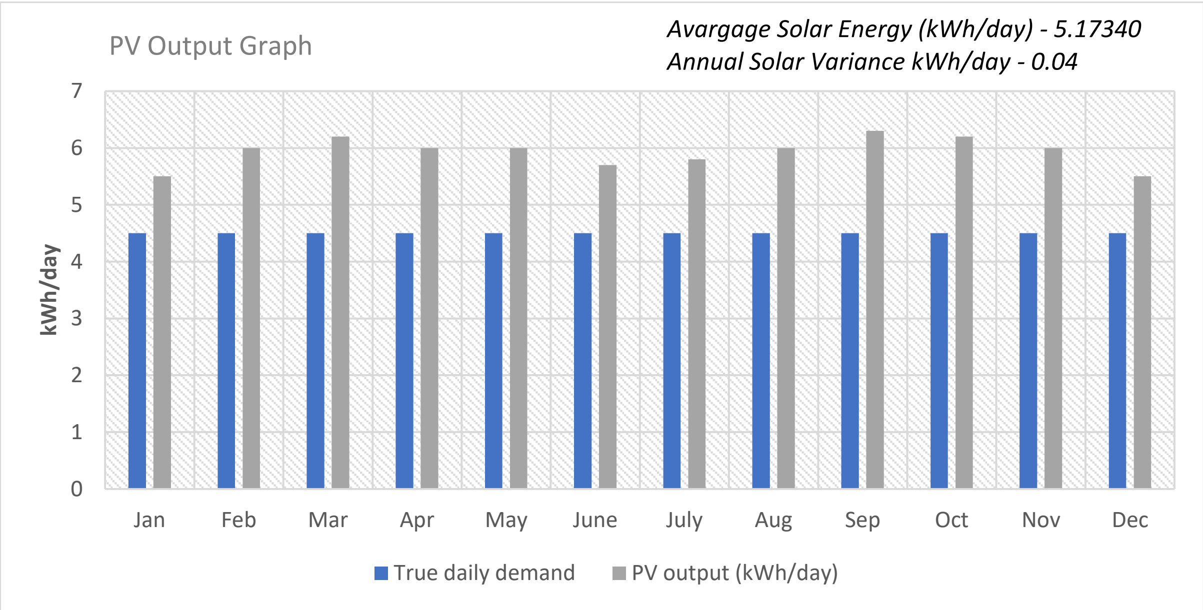
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 86. Burao 1kW 8 Degrees inclined South => Average 5.03 kWh/d per 1kWp installed



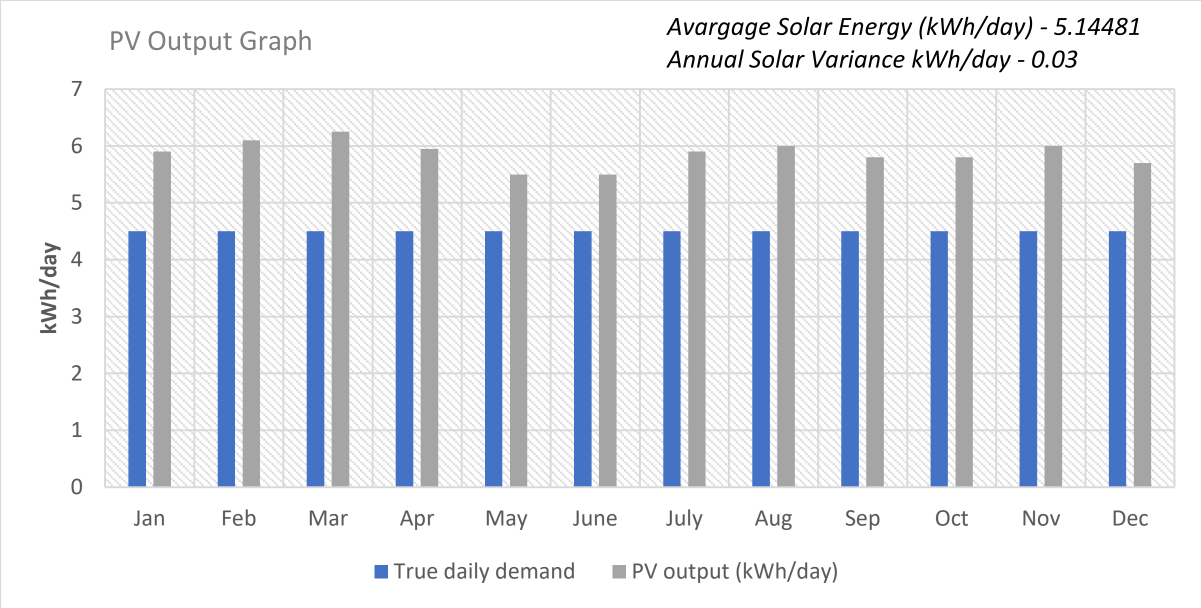
Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 87. Berbera 1kW 12 Degrees inclined South => Average 5.17 kWh/d per 1kWp installed



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Figure 88. Erigavo 1kW 12 Degrees inclined South => Average 5.14 kWh/d per 1kWp installed



Source: Output from Unicon software using multiyear data "obtained from the NASA Langley Research Centre (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Programme"

Adjunct solar PV uses

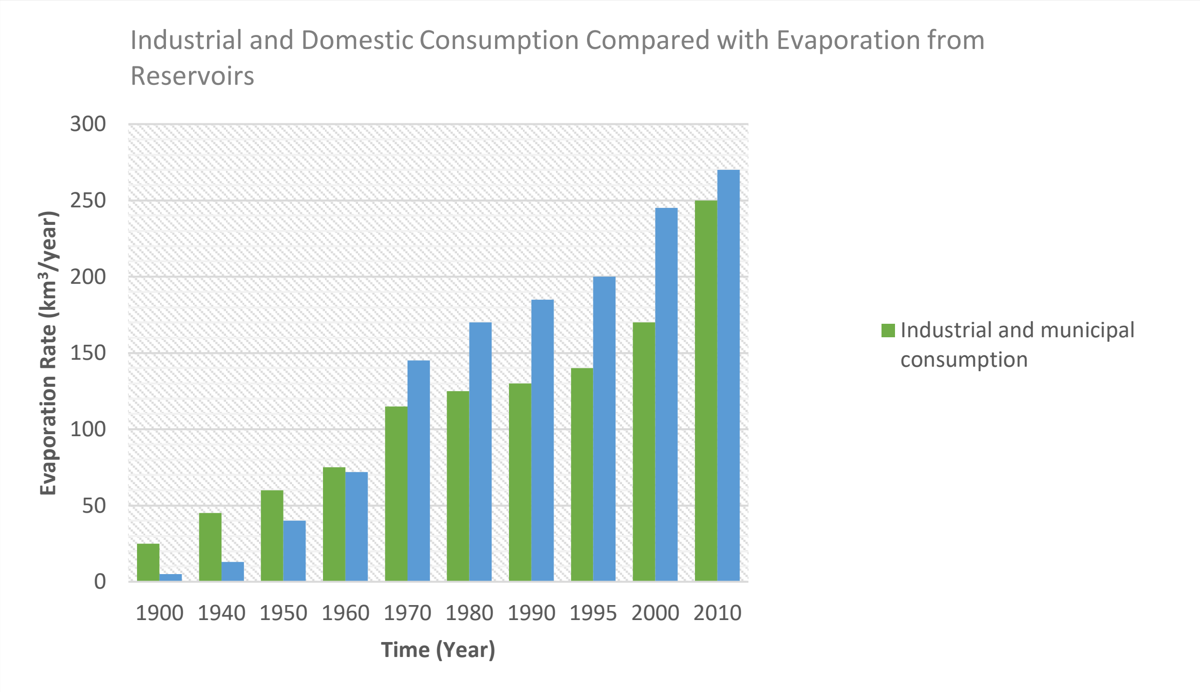
An important adjunct for expanding the utilisation of solar PV is its capacity to preserve important water resources for human, industrial and agricultural activities. Solar PV systems can be installed on water reservoirs and treatment ponds to provide evaporation protection. Floatovoltaics (floating solar PV arrays) preserve water, as well as support daytime manufacturing and institutional value-adding electricity generation.

An important study of global water trends, for 1900-2010, conducted by UNESCO indicated that evaporation from reservoirs exceeds domestic and industrial consumption of water from reservoirs. This trend in greater evaporation losses versus municipal water use up to 2010 is shown in Figure 89, below. From a physics of evaporation perspective, more water is evaporated from shallower versus deeper water reservoirs.

Moreover, recent studies from Australia and other hot climates indicates that physical evaporation methods like “floatovoltaics” prevents evaporation by 70-100% from water reservoirs, plus preserves water quality and enhances solar PV performance due to the passive cooling of the arrays by the reservoir. Such systems are already implemented and growing in use on water reservoirs and dams across countries like Australia, USA, Brazil, Japan, Europe and Korea for example.

The preservation of surface collection of rainwater reserves is crucial in hot climates. A 2009 Australian study found up to 95% of rainwater is re-evaporated without significant runoff, and that over 50% of storage in reservoirs is evaporated in dry climates. Using the 2010 global values from Figure 89, it is observed that for a total of 510 km3 of reservoir water, some, 240 km3 was used by municipalities, whilst 270 km3 was lost to evaporation. Therefore, approximately, at least 52.9% is lost by evaporation, whilst 47.1% is utilised, or alternatively; of the water volume used, another 112.5% of water is lost, i.e. of 2.125 volumes of water delivered into open reservoirs, only 1 volume is actually used by municipalities.

Figure 89. Evaporation of water from open reservoirs exceeds industrial & domestic water consumption

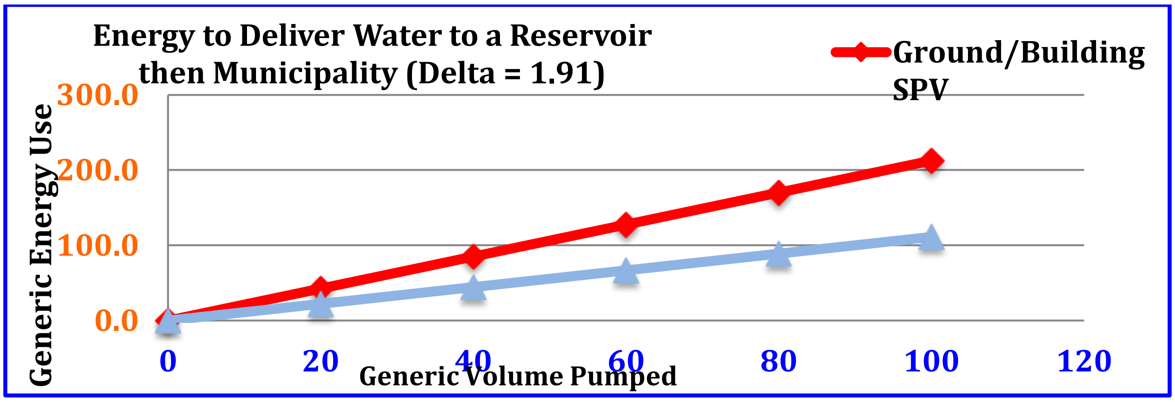


Source: Trends in water consumption and evaporation
Joint Report, Hydrological Institute, UNESCO, Paris, France

The covering of reservoir surfaces with "Floatovoltaics" is observed to reduce the annual evaporation by 90%. Consequently, Floatovoltaics permits the storage of 1 and 1/9 times the desired water to provide the needed water supply. A graph of the proportional difference between water supplied to an open water reservoir, versus to a Floatovoltaics covered reservoir is shown in Figure 90, below, where it is apparent that annually, 2.125 volumes more of water must be placed in an open reservoir, as compared to 1.1111 volumes of water that must be placed in a "Floatovoltaics" covered reservoir over the same period. This results in a water (Energy use) delivery differential of 191%. (2.125/1.1111)

Moreover, it is well known Solar PV panels distinctly diminish in electricity performance as their temperature rises above 25C. Field measurements indicate that in many hot dry climates, especially for high solar irradiation, PV panels become distinctly hot during power generation hours. In fact, panel temperatures exceed 80C, giving major output degradation. Generically many Solar PV panels have a Power Temperature Coefficient (PTC) of -0.5 %/K or C; with the negative indicating, as temperatures rise above 25C, PV panels loose power output by the %/C.

Figure 90. Water delivery (ergo energy needed) to an open reservoir, thereafter to municipality; without and with, floatovoltaics based solar panels

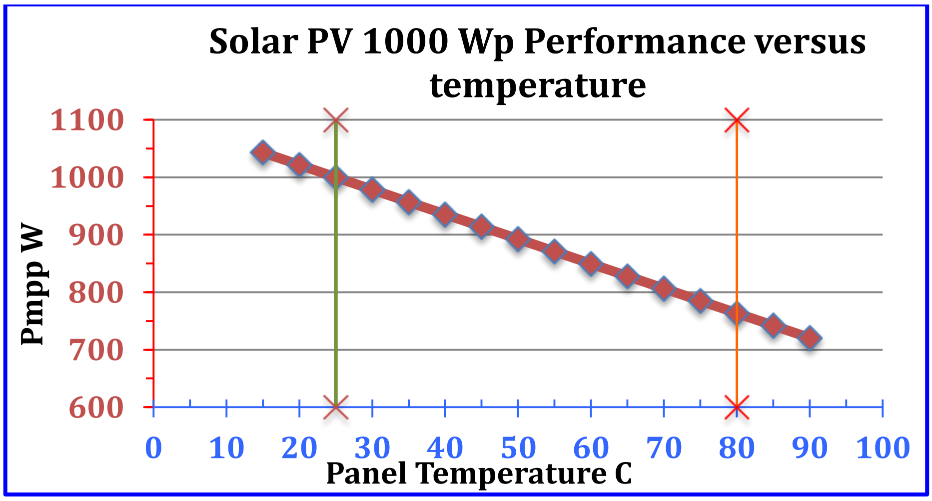


Source: Unicon

While some modern high performance (21% efficiency) Solar PV panels PTCs are -0.3/K, (SunPower X21-345) for our calculations, we use a common good quality German manufactured (15.2% efficiency) 250Wp panel as reference (Centrosolar S250P60) with a PTC of -0.43 %/K, weighing 20kg each.

Figure 91 below, graphs the performance of 4 such PV Panels (1,000Wp) against temperature. It is clearly observable that at 80C, these panels only deliver 763Wp versus 1,000Wp. This mean's 31% more panels must be installed to provide the ticketed electric power generation, whenever installed on a building or even the ground in hot dry climates.

Figure 91. Graph of solar PV panel electricity generation performance versus temperature

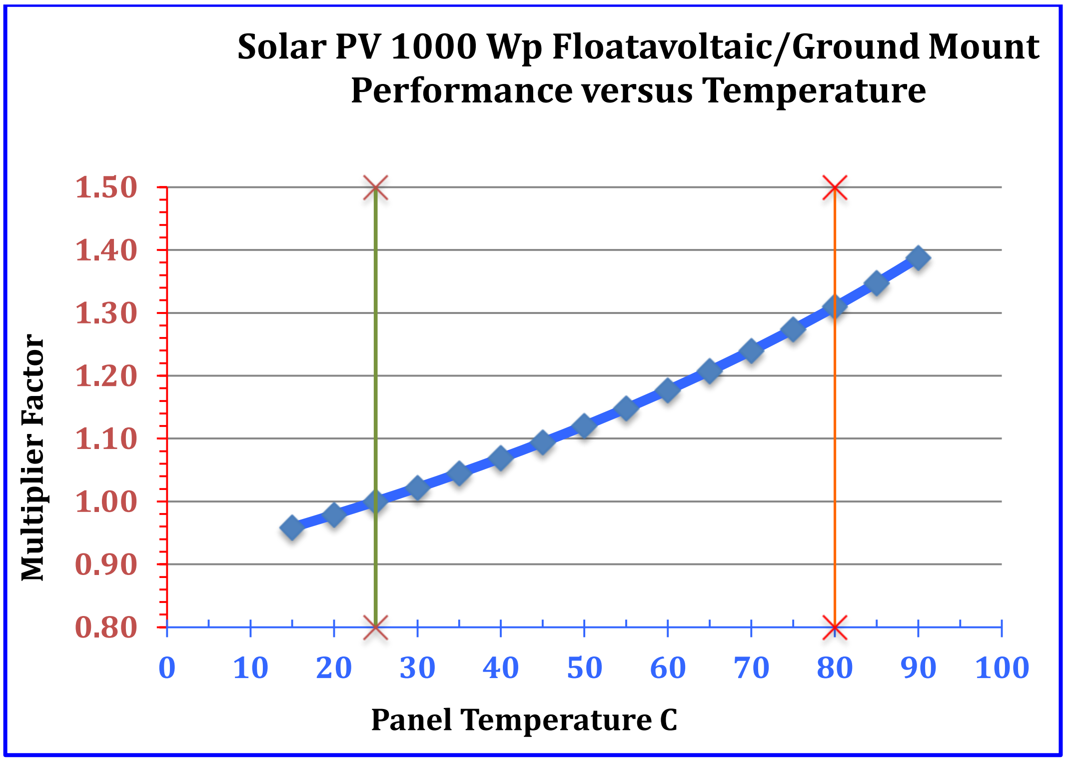


Source: Unicon

Contrarily, field measurements of Floatovoltaics indicate that the PV panels, remain at or below 25C, due to the cooling effect of the water body and rear surface humidity. Ergo Floatovoltaics provide at least 31% more electricity for an equal surface coverage compared to ground or building mounted

Solar PV arrays, which is illustrated in Figure 92, below. In some cases, it is indicated 50% more can be recovered.

Figure 92. Graph of solar PV floatovoltaics electricity generation advantage versus temperature



Source: Unicon

The ramifications of combining the phenomena of PV panel thermal derating and controlling large water losses due to evaporation, plus preserving water quality and quantities in reservoirs for municipal utilisation is a strong stimulus for implementing comprehensive Floatovoltaics in hot dry climatic regions were Solar PV generation is advantageous and water resource management is crucial.

Table 69 is a summary of the benefits and potentials for Floatovoltaics implementations.

Table 69. Summary of "floatovoltaics" benefits and potentials

Option	Consequence
Floatovoltaics covering any water reservoir will deliver more Electricity than an equal surface of ground or building mounted solar Panels	31% more Solar PV Electricity generated and Solar PV panels less likely to fail due to thermal stressing
Floatovoltaics require some more water stored to provide the cooling benefits and deliver the expected water during annual period.	11% more water annually must be stored to provide 31% more Electricity

Option	Consequence
For municipalities much more water must be placed in an open reservoir, compared to a Floatovoltaics covered reservoir over an annual period.	212.5% more water than needed must be placed in open reservoirs as compared to 11.1% more water in a Floatovoltaics reservoir. This results in 191% more Water and 251% more Electricity to fill and utilise an open reservoir compared to using a Floatovoltaics reservoir.
For waste treatment ponds; the use of Floatovoltaics permits significant pond water retention for secondary water uses.	900% more pond water is retained over an annual period, for secondary water uses, plus 31% more electricity is produced, as compared to using an equal ground or building surface.
There are Energetic, Water and Economic development arguments for Floatovoltaics.	Using water tanks in place of Floatovoltaics saves 11.1% water yet spends 31% more on any Solar PV energy, Floatovoltaics supports the effective management of large urban water reservoirs as well as Berkads, with respect to water resource preservation, water distribution, simple and effective use of Solar PV electricity generation, distributed generation and reducing diesel fuel expenses for pumping. It would also support a waste energy programme as well.

Source: Unicon

<u>Batteries and electricity storage</u>

A frequent modality for enhancing the contribution of solar PV generation in a hybrid generation network is the addition of storage. Most solar PV storage solutions are currently primarily through batteries with some kind of BMS (Battery Management Systems), with forms of climate managed environments and two-way inverters.

Such additions can significantly raise a hybrid solar PV generation system's cost and depends on the capital and operating costs for the size and type of battery technology used, plus lifespan constraints for the rechargeable battery chemistry.

An excellent technical advantage of storage-augmented solar PV systems is that they are capable of generating independently to a distribution network without HSDGs or other base-load generation. They can also be combined with other renewable electricity generation that together provides a variable generation input, plus potential for rapid response to peak demands.

Another form of energy storage available for Hybrid systems is through the use of Compressed air. This technology offers very long lifespans, modular and containerised units, temperature insensitivity and rapid peak electricity delivery, if required. Unfortunately, it is only beginning to enter the commercial marketplace, and reliability is unknown.

Wind power

Wind opportunities in Somaliland are primarily constrained by:

- availability of open space at the location;
- speeds and reliability of winds at the location;
- number of windy days per year in the location; and
- need to operate in some form of hybrid configuration.

The actual wind power systems currently installed in Somaliland are of the types generally installed globally, which comprise of wind turbine nacelles fixed on top of masts or towers, spaced apart and situated on open ground.

Key elements within wind turbines apart from the rotor blades, are the nacelle, which contains an electromechanical transmission, asynchronous generator, power electronics equipment, a wind orienting mechanism, cabling, controller, lightning and surge protection, rotor break mechanism and access ports to service the nacelle's components. At the base of the tower/mast there are usually control electronics and switches for safety and servicing.

Larger wind turbines of 275kW (i.e. 30m mast, with 15m radius rotors) and higher power ratings use towers of heights of 30m, 50m and higher. At these heights such systems are supplied by more reliable wind speeds and are usually well above the turbulent layers of wind that carry sand and dust. Like all electromechanical devices, they are vulnerable to strong dust storms, and require maintenance servicing if subjected to such storms.

Commercial generation turbines are usually rated to operate to a maximum sustained wind speed of 25m/s. The maximum sustained 10 min gust speeds are usually above 35m/s; a maximum value often cited is 60m/s or 216km/h.

On the contrary, turbines set below 20m are much more vulnerable to sand and dust laden winds, in addition to being subjected to ground effect turbulence and less regular wind speeds. While there are some exceptions, wind turbine towers are generally fixed structures that require the use of a high lift crane or a small ladder inside the large tower, for maintenance and repairs access.

For areas where there are poor roads and access and/or extreme wind storms such as cyclones and typhoons, there are wind turbine designs that can be mechanically lowered for both protection from extreme wind speeds as well as for maintenance and repairs on the nacelles. Such mast designs are well suited for Somaliland, as part of introducing and developing the necessary technical and logistical capabilities and infrastructure that is required for the implementation of significant wind-farm power generation.

The successful implementation of wind power generation is made easier by the use of real time remote CSM (condition monitoring systems), which provides near instantaneous telemetry monitoring of turbine component performance throughout its operational life. CMS also permits the optimisation of regular scheduled maintenance servicing, which is usually biannually, to minimise unscheduled downtime, shutdowns and faults.

As electromechanical devices, wind turbines are vulnerable to cascading mechanical faults, which if properly monitored can be prevented with CMS determined interventions upon detecting the first mechanical or electrical fault.

The amount of electricity that a particular wind turbine can generate for a hybrid generation network is ultimately determined by the combination of the following:

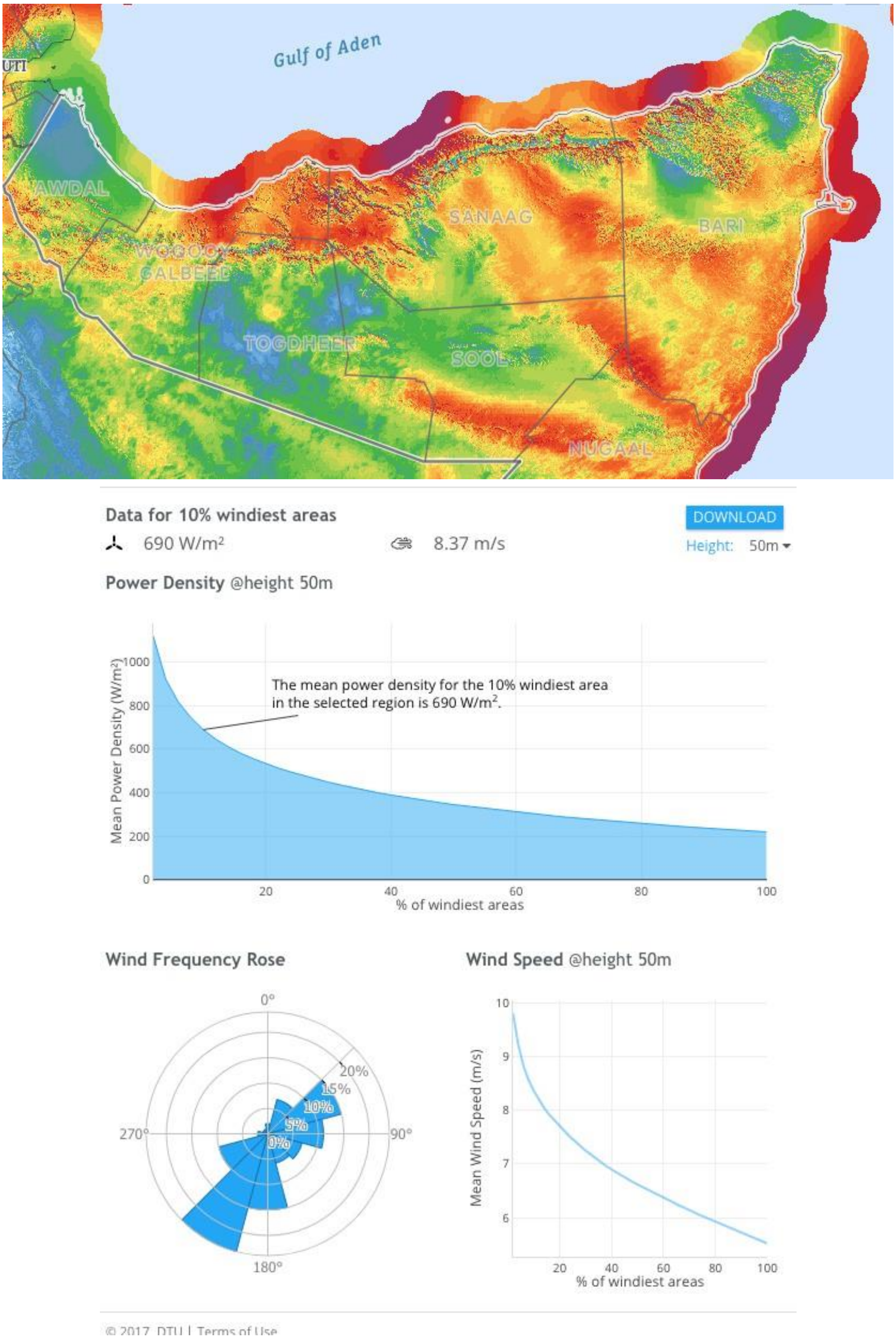
- Power rating, kW, of the generator driven by the rotors;
- The actual average wind speed that is turning the rotors;
- The effectiveness of CMS operations in monitoring and enabling effective preventative maintenance and avoiding unscheduled shutdowns.

The wind speed maps shown below and in Annex 5, show that different locations provide unique wind energy opportunities throughout the country. It is most noticeable that parts of the coastline of Somaliland possess significant levels of consistent strong winds, which are well suited to hybrid based wind power grids.

Many of the current locations surveyed are not in optimal wind generation areas but some are. It should also be restated that wind speeds are generally stronger and more reliable with higher towers/masts as well as for elevated areas or coastal areas.

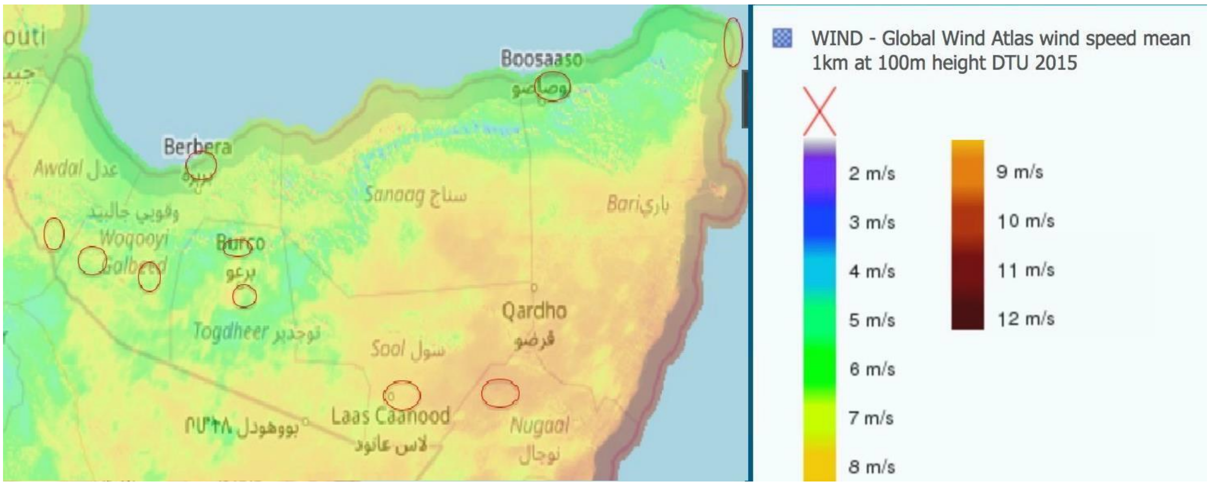
As seen on the maps below, different locations possess different levels of wind and so wind turbine output will be different. Further below are more detailed examples of some areas for wind during an average day.

Figure 93. Wind Map (50m height) for northern areas showing strong winds in coastal and mountainous areas



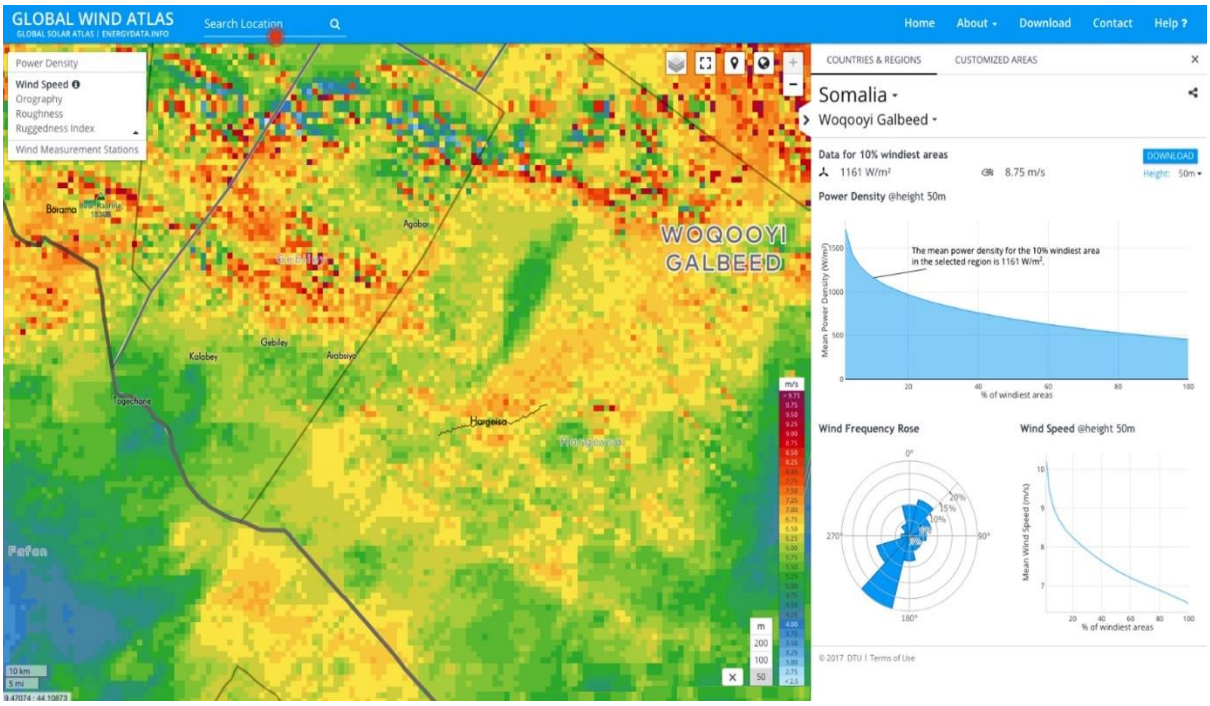
Source: WB ESMAP DTU VORTEX Global Wind Atlas

Figure 94. Wind map (100m height) showing locations. Strong winds in coastal and elevated areas



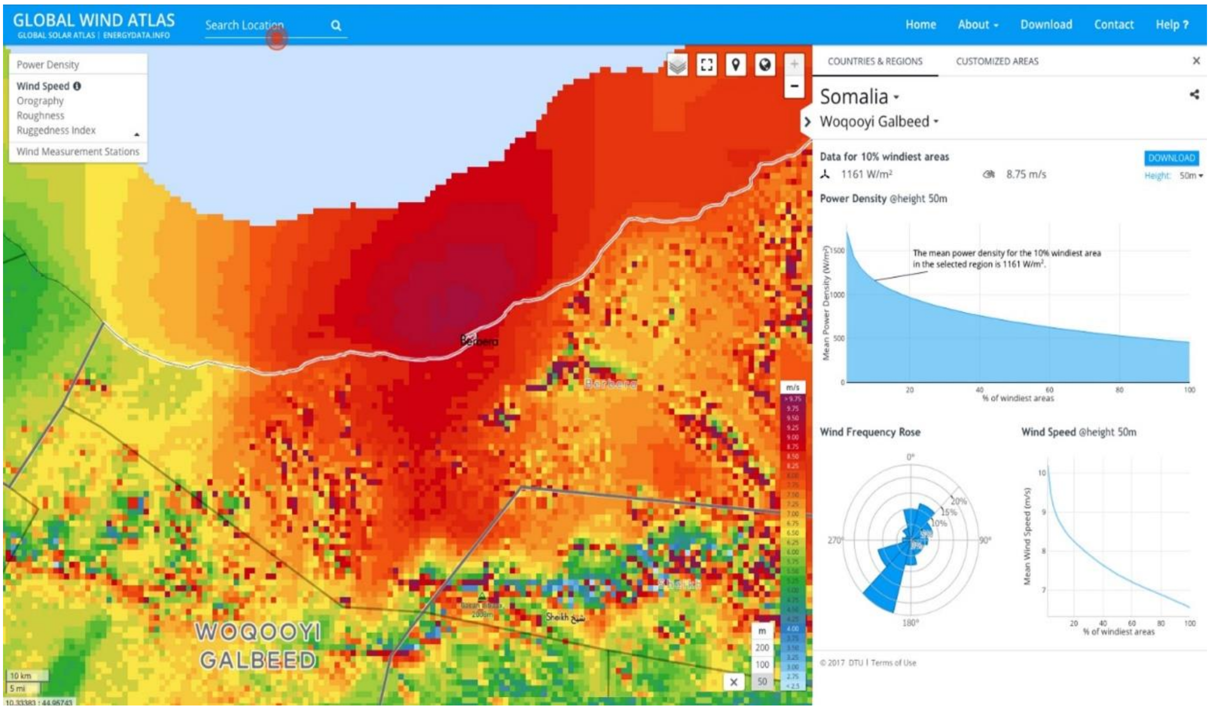
Source: IRENA Global Wind Atlas. Note Bountiful Wind resources

Figure 95. Wind map (50m) for Hargeysa



Source: DTU, Global Wind Atlas
Note: Winds mostly SW then NE

Figure 96. Wind map (50m) for Berbera



Source: DTU, Global Wind Atlas

Note: Winds mostly SW then NE

Hydroelectricity

Hydroelectric opportunities in Somaliland are primarily constrained by:

- availability of significant and reliable water resources;
- presence of either significant and reliable volumes of water or heads of water; and
- electricity infrastructure needed to deliver the generation to consumers and or urban centres.

Unfortunately, traditional hydroelectric dams for generation are very vulnerable to rainfall seasonality in their catchment basins and also competing needs for water by agriculture and urban populations.

More recent alternative approaches towards hydroelectricity generation has been through the use of pumped hydro storage and generation. This necessitates the application of hybrid generation methodologies and the advantages of the rapid and peak response of power produced by hydroelectric generation. Again, like all renewable generation approaches, geographic factors determine where pumped hydro storage and generation can be implemented.

Traditional pumped hydro storage is a tried-and-tested technology that has been doing the energy storage job for well over a century. First employed in the 1890s, pumped hydro makes up 97 per cent of energy storage worldwide, with around 168GW currently installed. There are potential sites for significant possibilities for a new type of pumped hydroelectric generation, SPH and SMPH, in Somaliland, in areas associated with the Northern coastline areas.

The amount of electricity that a particular pumped hydroelectric turbine can generate for a hybrid generation network is ultimately determined by the combination of the following:

- power rating, kW, of the generator driven by the mechanical energy in the water;
- actual elevation drops and volume of water providing the mechanical energy;
- volume of water placed in storage that is used for providing hydroelectric electricity; and
- availability of water for storage along with the replacement of evaporation losses.

Characteristics of Potential Electric Power Plants (including upgrades)

In identifying potential electric power generation plants for the future development of the electricity sectors in Somaliland, it is important to reflect upon the current situation; what works, what is problematic and how this may be improved, should be addressed before introducing more of similar or different electricity generation technologies.

As has already been indicated, the majority of urban electricity generated derives from the use of high speed (>1,000rpm) diesel-powered generators (HSDG), owned and operated by ESPs. These HSDGs utilise the same diesel that is used for road transport vehicles, and can be easily modified to use fuel oil also. They range in size from <10 kW up to 2,000kW, and are often mounted on skids, and similar such more specialised units can reach sizes of 5MW. While HSDG ratings are often by kVA, for consistency sake within the document kW or MW are used for generation power ratings, based on a power factor of 0.9.

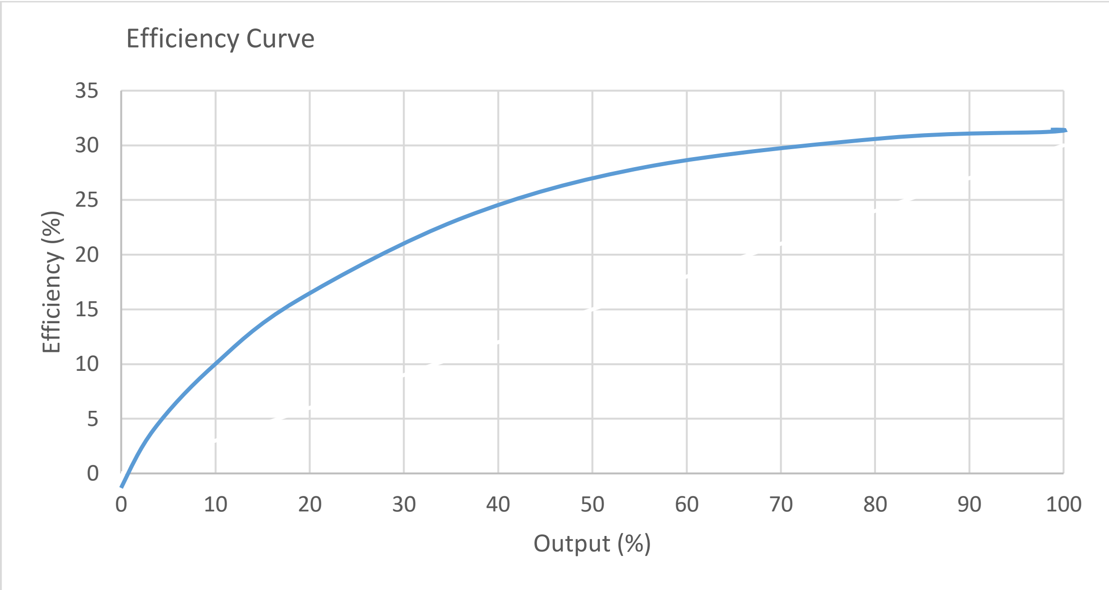
Recently, collaborations between some ESPs and international assistance, have introduced grid tied solar PV and wind power generation to provide hybrid urban electricity generation that is integrated with the ESPs current HSDGs. Current solar PV generation systems range in size from 40kW to 1.5MW, and utilise grid tied inverters synchronised to the particular ESP's HSDG generation network.

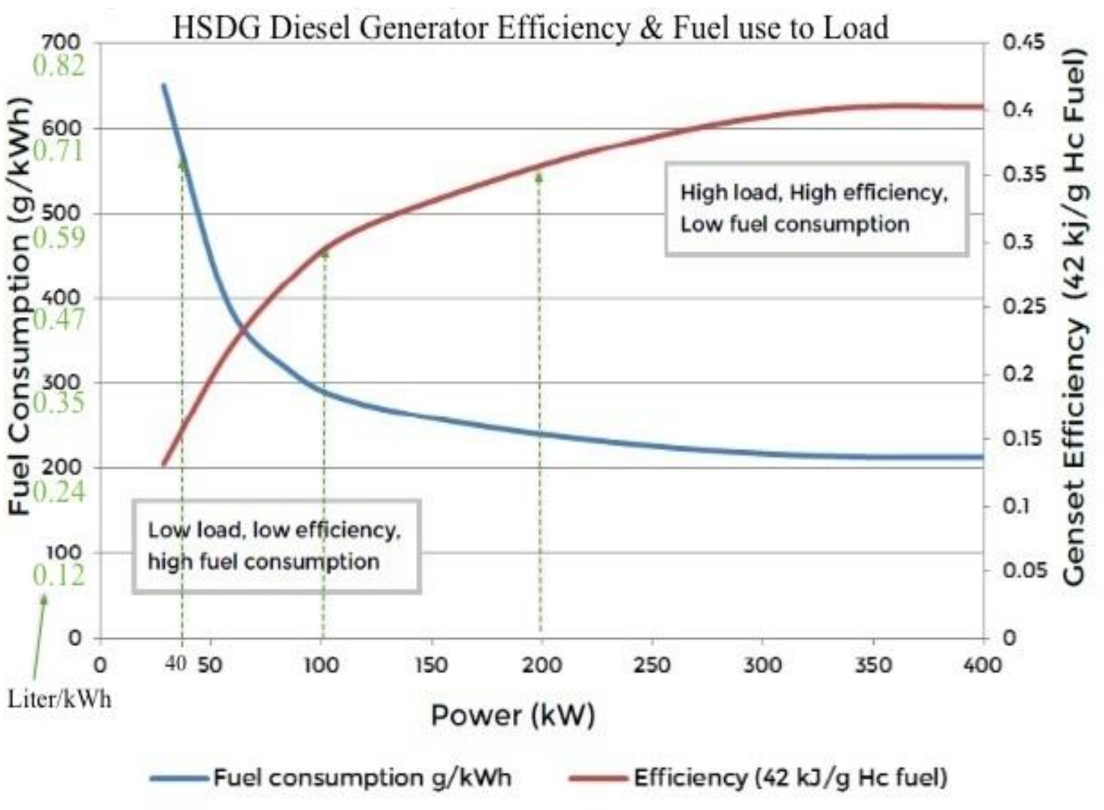
The wind power generation units comprise rotors and turbines ranging in size from 22kW to 275kW and are mounted on masts/towers 18m-33m high. Regrettably, the wind turbine generators have not been successfully placed in operational mode.

Analysis of HSDG operations in the country has indicated that a number of improvements can be made to operational features of current generation. These should be implemented before further augmentation of electricity generation is introduced. One clear phenomenon identified is the occurrence of wet stacking of HSDG electricity generation. As mentioned earlier, Wet Stacking occurs when HSDGs are operated well below their optimum power generation performance.

HSDGs perform most effectively in their 50 to 100% generating capacity zone, where they combust and use the least fuel for the maximum amount of electricity output. Below 50%, the HSDGs begin to underperform, where fuel is wasted as a result of non-combusted fuel exiting the exhaust stack, solid deposits build up in the combustion and exhaust chambers and contaminants enter the oil lubricating reservoirs.

Figure 97. Typical performance efficiency and fuel use to load curves for HSDG





Source: Unicon

As can be seen in the graph above, Figure 97, generation below 50% of rated output, results in quick performance drops, moreover when loads are of the order of 10%: fuel consumption per kWh of generation can reach three times that of optimal generation.

Furthermore, wet stacking results in greater wear within the engines, higher fuel consumption, pollution, reduced power output, more unexpected downtimes and longer scheduled overhaul times. It also results in more frequent replacement of HSDGs that cannot be repaired or overhauled.

Another major feature observed concerning HSDGs was that a significant proportion of HSDGs are currently not being operated effectively through automation and synchronisation procedures. The use of automation and synchronisation with multiple HSDGs permits the optimisation of electricity generation. This occurs because synchronisation enables the parallel operation of electric generation from a combination of generators, in unison, so that each HSDG is operating in its optimal performance zone. The use of automation makes it easy for particular HSDGs to be brought online or offline easily and smoothly.

In summary, observations indicate that the crucial investments in HSDG electricity generation made by the diverse ESPs across Somaliland are being seriously compromised in performance and suffering significant losses. These impairments include losses to generated power, life expectancy and maintenance, through practices that result in wet stacking.

Further, the absence of automation and synchronisation technology for the HSDGs, prevents the ESPs from utilising parallel generation to assure optimal HSDG performance and improve dynamic reactivity to electricity load variations.

Wet Stacking and Remedies

The optimum performance of an internal combustion motor requires the correct fuel/air ratio to be sustained, and appropriate temperatures for the combustion. When light loads are placed on the device it cannot achieve proper combustion temperatures and unused fuel is vented out the exhaust. As this continues, incomplete combustion solids deposit in the engine causing exhaust backpressure, loss of power and begins to scar internal surfaces.

Moreover, insufficient temperatures in the combustion chambers prevents proper piston ring sealing resulting in unused fuel, gasses and particles entering the oil pan and promoting lubrication failures. All these cause a number of outcomes:

- Major shortening of engine life, to well before planned replacement;
- Pollution – hydrocarbon aerosols both to generation worksite workers and surrounding urban residents;
- Deposits that prematurely reduce maximum power;
- Deposits that increase engine wear;

- A multiplication of maintenance tasks and expenses and time remedying engine problems.

Remedies to Wet Stacking

Following are the key steps in addressing wet stacking:

- Always run HSDGs with an electrical load that reaches approximately 75 percent of full load;
- Install load bank solutions, that can be either:
  - Automatic auxiliary load – for a HSDG, which is the primary source of power; that engages for light loads;
  - Manual load bank – for a HSDG where different loads are switched in and out manually;
  - Portable load bank – Used as part of a scheduled monthly planned maintenance, with the generator exercised for 2 hours on a load of 25% for 30 minutes, 50% for 30 minutes and then 75% for 60 minutes.

These procedures maintain HSDG designed operational temperatures and ensure HSDG longevity.

Automation and Synchronisation of HSDGs

The purpose of synchronising two or more electricity generators, also called paralleling generation, is to permit the electrical coupling of the generators in order to increase the total generation capacity on a network. This is done when either a load enters a network so that the loads become more than the capacity currently feeding the load or when the load has to be transferred from generator to another without interruption.

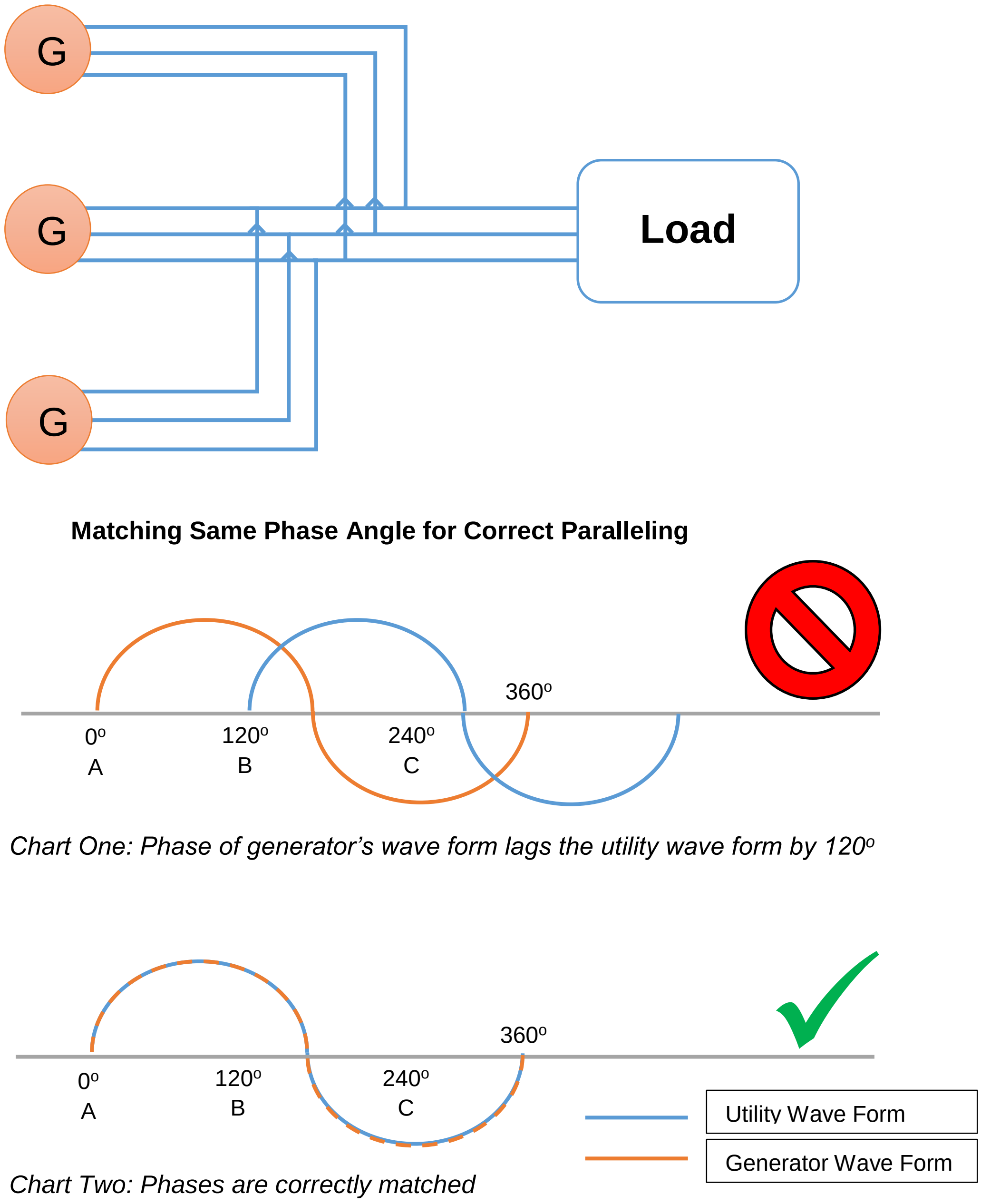
For it to be effected, two or more generators must be synchronised to the same voltage, the same frequency and the same phase on all current phases. Figure 98, below, illustrates the basic mechanical and electrical principles involved in synchronising two or more generators. Three different methods can be used to achieve generator synchronisation via a synchronising panel.

The oldest method is a manual synchronisation using extinguished lamps to indicate that the phases are aligned, and meters to match voltage and frequency. A more common manual synchronisation method utilises a synchroscope for the synchronising of phases to control the connection.

More recently, modern automatic synchronisers perform the task more effectively, by measuring the phase difference and use microprocessors to control and carry out the synchronisation connection. Consequently, the process is largely automated, with human oversight providing the possibility for manual intervention.

Automatic systems are more precise and repeatable in causing the main contacts of the breaker to close at 0°. Human operators have the advantage of better recognising abnormal conditions and errors in the synchronising indications. Systems that require both an operator and an automatic synchroniser to initiate the breaker closing take advantage of these complementary attributes.

Figure 98. Basic physical and electrical principles of parallel connected generators and matching phase angles for synchronisation



Source: Electrical Engineering Blog; engineering.electrical-equipment.org

It is evident that in order to be able to effectively synchronise or parallel two or more generators, they must share the same common load and each must be capable of modifying its rotational speed (revolutions per minute or RPMs) either manually or by an electronic governor. Controlling the RPM adjusts the frequency and ultimately the power output. It is also necessary to be able to change the voltage coming out of the alternator and so match voltage amplitudes. Once the synchronisation procedure is completed, the generators can be electrically connected and thereon provide a common generation to a common electrical network.

Consequently, an existing generation network can be supplemented by the addition of a synchronised generator. This same process permits a captive generation site, through the use of synchronisation, to add its excess local generation to a local distribution network. In such cases, export-import meters are necessary, as well as safety and reverse power breakers.

In practice, the easiest approach is to use similar generators, or at least that their alternators, motor speeds, load-sharing controls, and interfaces are compatible. If the generators are the same size they can support a higher priority load in an emergency, but if they are not then the smallest sized generator limits the maximum size priority load, unless effective protections are in place.

Ignoring such limitations can result in complex control procedures and makes manual interventions difficult. The use of auto load sharing units can ensure proper load sharing and protect against thermal drift, but it is wiser to minimise complexity with simpler designs.

Thermal drift is the drift in voltage, current and phase caused by internal heating of equipment during normal operation. It can also be due to significant changes in external ambient temperature.

Advantages to implementing automation and synchronisation of HSDGs are as follows:

- Increased reliability and redundancy for both critical and non-critical loads;
- Reduced cost of power generation because generator per kW of purchase cost, rise above 600kW, due to a more competitive market for smaller versus larger engines;
- Decreased light loading of prime mover generators, i.e. load at 30%. In such a case a prime mover is wet stacking. A smaller paralleled generator could run in its more efficient 75% to 100% zone, thereby saving fuel;
- More control and savings on generating costs as loads and generation are balanced to different circuits;
- Parallel systems can achieve major savings when all generators are operated above 75% of their rated load;
- The generation is continual, expandable and flexible to supplying a varying load without piling up costly units or spending too much on a big generator whose full capacity is rarely used;
- Generators can be added gradually as demand increases;
- It permits more efficient mixed responses to loads and enables load demand operations as part of prime power operations;
- Permits commonality and economies of smaller equipment, with respect to parts, maintenance, design and incremental generation upgrades.

The benefit of utilising a well-designed automated and synchronised generation network is that it provides both backup power and a variable output. It is essential to use correct paralleling switchgear to achieve the maximum output when the power demand is at its peak while also providing the minimum output when the load requirements are low.

There are situations where paralleling is a challenge:

- Critical loads like computers and communications equipment are better served by battery backed up UPS, (Uninterruptable Power Supply) which do not interrupt supply even for a microsecond and protect against, high voltage surges;
- The costs for power cable can be a limiting factor;
- The technical expertise required for maintaining the system is not present.

Table 70. Characteristics of automation and synchronisation

Automation - Synchronisation Characteristics									
Characteristics		**Synchronisation Panel**	**Note**	**Load Share Unit**	**Note**	**Controller (PLC)**	**Note**	**Automation**	**Note**
Description		**Hardware**		**Hardware**		**Hardware**		**HMI / SCADA**	
Lifespan years		20	24hrs / day	20	24hrs / day	20	24hrs / day	20	24hrs / day
CAPEX $/Unit		3,000	Per 3 Generators	1,500	1,000	50	500	100	500
Construction time years		0.1		0.1		0.1		0.1	
Mode	Prime-Cont'ous	✓		✓		✓		✓	
	Peak	✓		✓		✓		✓	
	Standby	✓		✓		✓		✓	
	Blackstart	✓		✓		✓		✓	
	STOR	✓		✓		✓		✓	

Source: Unicon

Equipment for synchronising major generators is made to be very reliable. For base load applications where the generator is only synchronised to the system a few times a month or year, a manual synchronising system is often the only system installed. Whereas, peaking generators that are synchronised several times a week are best done by automatic synchronising systems.

Using automatic synchronisation limits the risks for faulty synchronisation events that can cause cumulative mechanical damage in generators.

Upgrade Benefits

The application of automation and synchronisation to the current HSDG generation in Somaliland, will result in several things:

- significant augmentation in generation capacity and competency in synchronising generation;
- eliminate wet stacking;
- improve diesel fuel economies for electricity generation; and
- reduce maintenance and unit replacement costs.

This will enable lower electricity rates for residential, institutional and commercial customers and/or improved return on investments to the owners of the ESPs.

Tables of expected outcomes from implementing effective Automation and Synchronisation within Somaliland are shown below.

Table 71. Estimated increase in electricity generation from full synchronisation upgrade

Urban Centre	Estimated current generation kWh/d	Automation & Synchronisation generation kWh/d	Upgrade daily diesel fuel use expected at 3.8 kWh/Lt
Hargeysa	221,265	778,320	204,821
Burao	146,880	245,145	64,512
Laascaanod	73,798	103,192	27,156
Boroma	60,021	232,621	61,216
Wajaale	21,267	61,236	16,115
Dilla	216	864	227
Gabiley	23,328	55,167	14,518
Shiekh	4,714	14,782	3,890
Berbera	30,240	143,986	37,891
TOTAL kWh/d	885,841	2,638,577	694,362
Ratio improvement from synchronisation		2.98	

Source: Unicon

Potential Power Plants

The field survey evaluation of electricity generation within Somaliland was conducted primarily on the larger and some small urban centres. As has been mentioned, significant proportions of the electricity generated within urban centres is provided by local ESPs via HSDGs.

Potential electricity generating power plants for sizeable urban centres, due to the context and consumer mix of urban centres, permits greater flexibility, variety and sizing of generation and distribution options whereas for rural areas the options are more constrained, by population sizes, activities and lifestyles. Indeed, one can divide the rural context into small urban centres, pastoralist communities and agricultural users.

Each of these require some form of island and/or off-grid captive generation, whether it be via standalone local community mini-grids for the small urban centres and agricultural users, or dispersed off-grid standalone generation or even mobile off-grid electricity generation systems for the pastoralist communities.

Larger urban centres can incorporate the use of medium voltage urban distribution networks/grids. Potential electric power plants can be divided into three generation classes; thermal based units, renewables based units, and hybrid based units.

Thermal based units utilise chemical energy stored within fuels to power engines, which drive an electric generator/alternator. Two classes of thermal sources are available in Somaliland, at the present time. One is Waste energy generation, which uses large urban waste resources and biomass to provide heat to power electricity generation in large urban centres. These can be a useful instrument in managing and treating significant waste at urban waste dumpsites.

The other is the use of imported fossil fuels to provide heat to power electricity generation in the larger urban centres, fuel which is transported from the seaport.

The renewable energy resources currently available in Somaliland encompass solar PV and wind power turbines. Options for hybrid generation in Somaliland are both flexible and diverse and reflect growing trends in electric generation globally.

Hybrids in general mean mixed sources but within the electricity generation sector it involves the inclusion of renewables with combinations of thermal units and/or other renewables units and can even include energy storage via electrical or mechanical means. Actually, storage mechanisms by their recyclable nature are renewable energy resources but not intrinsic sources. Storage can be used for short peak generation support through to providing base-load generation support and providing immediate support for load demand operations as part of prime power operations.

Thermal electricity generation plants

Waste Power: Waste and Biomass based generation derives thermal energy from the ongoing and already accumulated domestic waste produced by large urban centres.

Dumpsites can provide energy in two ways; one by collecting landfill gases and the second is by subjecting selected carbon rich waste to pyrolysis and gasification processes. The second approach is much more energy intensive and produces significant but varying quantities of fuel for energy generation, depending on the calorific value of the dry solid waste. This dry waste fuel is obtained by separating out ceramics, metal, building waste and clinical waste from the waste stream.

The treatment of dry waste involves subjecting it to gasification and pyrolysis (thermal decomposition) to produce heat, syngas, fuel oil, CO2, methane and biochar solids and minerals. Higher pyrolysis temperatures (gasification) produce more liquid and gas fuel components. Typical outputs can be 60% bio-oil (a fuel oil), 20% biochar, and 20% syngas.

This method is considered a carbon negative operation and environmentally positive. The biochar (sequestered carbon) can be used for soil amendments or landfill. Equally well, pyrolysis and gasification approaches can be applied to sludge recovered from sewerage and biogas production, to provide liquid and gas fuels and biochars as well. Biochars are an important ingredient of terra preta soils, which are considered one of the best sources for soil amendments and enhancing intensive agriculture productivity.

Internal Combustion Engines: The key feature of all these devices is that they are reciprocating engines that operate on compression ignition (CI) or spark ignition (SI), of the fuel mixed with air (oxygen), and are also called internal combustion (IC) engines. Spark ignition is used for fuels such as natural gas, syngas, and gasoline. CI engines use fuels such as diesel oil, fuel oil or HFO (Heavy Fuel Oil), and can also operate on natural gas that is seeded by diesel as a pilot fuel (called dual fuel).

IC engines can have either a 2 cycle or 4 cycle stroke for the combustion process, and they are classed according to their speed or RPM and size for operation. There are 3 speed classes:

- High speed (HSDG): are four-stroke engines run at speeds above 1,000 rpm and range from under 10kW to 2,000kW and use diesel fuel, biofuel and sometimes fuel oil and are based on motor vehicle engines. For Somaliland, they would run at 1,500 rpm to provide 50Hz AC generation;
- Medium speed (MSD): are 4 stroke engines run at speeds between 400-1,000 rpm and range from 1-10MW, have slightly higher efficiencies than HSDGs, utilise air turbo-compressors, can use a range of fuels (diesel, crude oil, and HFO) and they are based on marine and locomotive engines. They have a higher capital cost than HSDGs. They are often used on large ships;
- Low speed (LSD): are 2 stroke engines run at speeds under 400 rpm and use HFO, have higher efficiencies compared to HSDG and medium speed engines, utilise air turbo-compressors, have the highest capital cost, and range from 3-80MW. They are often the preferred large power generation where there is a large price differential between HFO and natural gas, or where there is no natural gas available. They are also used as drive trains for large ships.

As an aside, the largest and most efficient diesel engine in the world is the 14 cylinder, Wartsila-Sulzer RTA96-C turbocharged two-stroke diesel engine. Each cylinder is 960 mm in diameter and the stroke is 2.5m. Each cylinder produces 5.8 MW, with the 14 inline cylinder version being 26.59 m long, 13.52 m high, weighs 2,300 tonnes, spins at 92-102 rpm, and produces a rated 80 MW at 102 rpm.

Four-stroke, diesel fuelled CI engines are considered the workhorse of the world, and are widely adopted. Medium and high speed diesels are usually rated in 3 modes; Standby (less than 2hrs/day), Prime for varying power generation with up to 10% overload, and Continuous for base load continuous rated operation with up to 10% overload. According to the magazine "Diesel & Gas Turbine Worldwide", approximately 90% of IC generator sets are diesel fuelled, while 8-10% are gas fuelled, that some 60% are in the 500-1,000kW range and 30% are in the 1-2MW range. Approximately 95% are high speed engines. There are numerous manufacturers of diesel, gas and dual fuel (gas + diesel) IC engines.

Table 72. List of some major diesel engine manufacturers

Manufacturer	Manufacturer	Manufacturer
Caterpillar/MAK 349 Cummins	Deutz	Waukesha
GE Jenbacher	MAN Diesel	MTU Friedrichshafen
Mitsubishi Heavy Industries	Niigata	Rolls-Royce
Wartsila	Yanmar	Cummins

Source: Unicon

Diesel fuelled CI engines are considered the most efficient simple-cycle thermal power generation available. They also have very favourable partial loadings between 50-100% load, but below this performance drops steeply. Emissions from CIs are a function of fuel contaminants, and inefficient load operations. When properly operated the main concern is CO and NOx emissions, both of which can be reduced by 90% with catalytic systems.

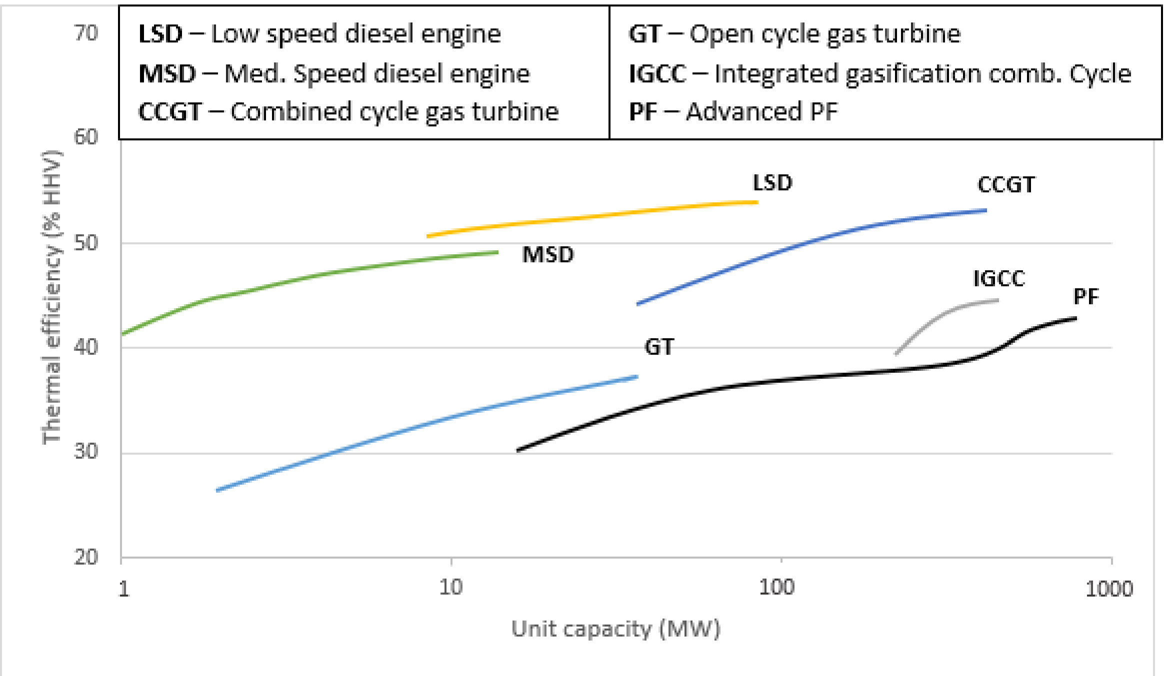
To visualise the efficiency in performance of different engines powering electric generators, many manufacturers, provide efficiency performance charts that advocate their products. Unfortunately, many efficiency performance charts comparing reciprocating engines, with other thermal generators are prepared by these same said commercial interests and favour their reciprocating engines. In point, within the data, different implicit assumptions are applied to favour reciprocating engines. Consequently, we use an independent study by the CSIRO (Australia - Commonwealth Scientific and industrial Research Organisation) as our reference and it is provided below as Figure 99. The terms IGCC and pf are terms used for coal power plants, which can be used as a reference.

One particular feature of diesel powered reciprocating engines, is that they do not exhibit economies of scale; in fact, smaller HSDGs are often cheaper – generator per kW purchase costs tend to rise above 600kW. The waste heat from CI engines is not very high in temperature, so while they are suitable for Combined Heat and Power (CHP) applications they are poorly suited for Combined Cycle (CC) for driving auxiliary steam turbines.

In some cases, the CHP can be used to drive a low maintenance Stirling engine generator, which is a key interest in the development of mini and micro CHP generation units.

Throughout Somaliland, urban ESPs currently make extensive use of HSDGs in the 70-700kW range for prime power generation. As mentioned earlier, significant increases in generation from the current existing HSDG systems can be achieved by implementing automation and synchronisation of the existing installations. The current generation market involves multiple ESPs, which from a generation perspective are Independent Power Producers (IPP).

Figure 99. Efficiency of thermal plants



Source: Unicon

A national priority in mastery and utilisation of paralleling generation will also permit incremental generation increases and effective load demand operations for all urban ESPs nationwide, whether via island radial distribution networks or urban distribution ring networks.

Currently there are no medium speed (MSD) or low speed (LSD) CI powered electricity generators in Somaliland. Many MSD and LSD engine systems are modular in design, such that components can be easily replaced, and in some cases the number of cylinders operating can be modified. MSD generators ranging in 2-5MW are also skid mounted and somewhat easier to mobilise. For 5MW and larger generators, dedicated structures are required.

An important criterion to consider when contemplating installing larger sized diesel generation such as 3-10MW MSD generators is the technical and logistical capability of current and future ESPs to provide or obtain the specialised maintenance required for these larger engines.

A HSDG can be started up and go to full load in 10-20 seconds, and so well suited for peak, as well as, prime load performance while a MSD can take several minutes for the start-up and initiating full load, and so suited for base loads and not very variable loads. MSD's and LSDs, due to a lower revolution speed require a larger engine and so are heavy and more expensive.

From a current logistical perspective, either HFO, or natural gas as fuels can only be used in urban centres located at ports. For the large inland urban centres diesel, fuel oil and possibly syngas, are the only viable thermal fuel choice going into the near future.

Furthermore, the movement, storage and utilisation of HFO requires specialised (heated) port handling and generation facilities. HFO fuel contains significant levels of contaminants and stricter emission controls are being applied globally, which is making this cheap fuel less and less advantageous and attractive for urban port power generation and commercial shipping. There are large supplies of HFO being produced in the Middle East.

Table 73. Characteristics of different forms of CI generation

Internal Combustion (IC) Reciprocating engines Characteristics							
Description	Indicator	High Speed Diesel Generator HSDG	Fuel Type Stroke 4 Diesel (Fuel Oil)	Medium Speed Diesel Generator MSD	Fuel Type Stroke 4 Diesel (Fuel Oil) HFO	Low Speed Diesel Generator LSD	Fuel Type Stroke 2 HFO (Fuel Oil) Diesel
	Speed RPM	(1,000) 1,500		400-1,000			
Size	Size range kW	10		1,000		3,000	
		2,000		10,000		80,000	
	Lifespan years	3.5	12hrs / day	9	24hrs / day	18	24hrs / day
	CAPEX $/kW	779		923	1,200	1,664	
	Construction time years	0.25		0.5	1	3	
Fuel Use	Fuel use Lt/kWh	0.25	0.29	0.25	0.29		
	Fuel use gm/kWh	210	240	210	240	180	240
	Capacity Factor	80.0%	10.0%	90.0%	70.0%	90.0%	75.0%
Mode	Prime-Continuous	✓		✓		✓	
	Peak	✓		NO		NO	
	Standby	✓		NO		NO	
	Blackstart	✓		NO		NO	
	STOR	NO		NO		NO	
Performance	Heat rate kJ/kWh	7,580	10,286	7,748	7,836	7,090	
	Heat rate Btu/kWh	7,184	9,749	7,343	7,427	6,720	
	Good-Normal Efficiency	47.5%	35.0%	46.5%	45.9%	50.8%	
O&M	O&M fixed $/kW yr	10.93		9.94		9.94	
	O&M var $/MWh	3.48		1.99		1.99	
Service	Lubrication cycle years	0.5		0.5		0.5	
	Top overhaul cycle yrs	1		3		6	
	Full overhaul cycle yrs	3.5		9		18	

Internal Combustion (IC) Reciprocating engines Characteristics							
Description	Indicator	High Speed Diesel Generator HSDG	Fuel Type Stroke 4 Diesel (Fuel Oil)	Medium Speed Diesel Generator MSD	Fuel Type Stroke 4 Diesel (Fuel Oil) HFO	Low Speed Diesel Generator LSD	Fuel Type Stroke 2 HFO (Fuel Oil) Diesel
	Scheduled downtime days/year per unit	6		6		6	
	Replacement time year	0.1		0.3		1	
Emissions Carbon cost $/tonne		30		30		30	

Source: Unicon

Table 74. Footprint of HSDG versus MSD diesel generators

Type	Engine RPM	Prime Rating	Engine Displacement	Footprint	Weight
Medium-speed	900 rpm	3,640 kW	222 litres	$26m^2$	51,000 kg
Medium-speed	900 rpm	2,775 kW	175 litres	$22m^2$	59,000 kg
High-speed	1,800 rpm	3,000 kW	95 litres	$13.5m^2$	25,000 kg

Source: Unicon

Gas Turbines (SGT & CCGT): The key feature of all these devices is that they are a versatile axial turbo-machine. They bring together air that is compressed by its compressor module, plus atomised or gaseous fuel which are then ignited and the expanding gases pass through exhaust turbines. Like reciprocating engines, they require initiation by a starter unit. As applied to electricity generation the gas turbine shaft usually drives a gearbox, driving the electricity generator.

Many gas turbines are aero-derivative, making them light weight and modular in construction. There are three key modules: compressor, combustion chamber and turbine, along with many other components, all modular in design. This enables for easy replacement of components and modifications. Gas turbines for electricity generation can range in size from 50kW to more than 200MW.

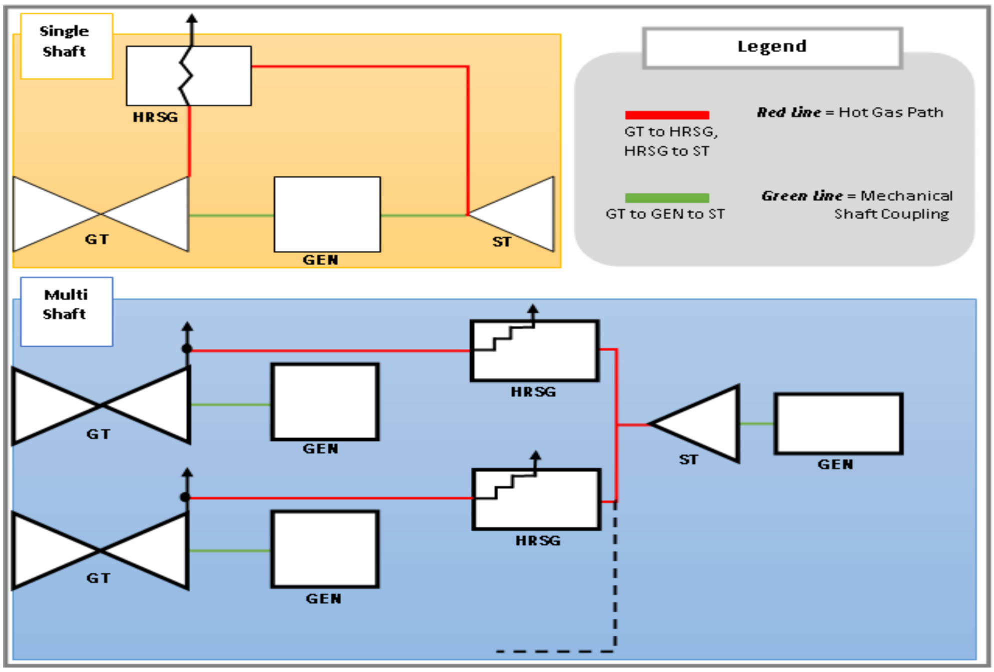
Newer designs split the compressor and turbine modules into sub-modules; a low pressure module compressor (LPC), and a high pressure module (HPC) plus equivalent high and low pressure turbine modules (LPT and HPT). The LPC/LPT operate on one long shaft at the same speed. The HPC/HPT operate on a shorter shaft that fits around and is concentric to the low pressure shaft, and runs at a higher speed than the low pressure module, or as separate shafts.

Simple cycle gas turbines (SGT) are usually considered less efficient than Diesel fuelled, CI engines, and more frequently destined for larger generation systems to obtain the best efficiencies. However, some newer gas turbines (Aurelia A 400-450) in the 400-450kW range, NgGT, are more efficient than natural gas fuelled reciprocating engines (ICs) and comparable to diesel MSDs in efficiency, with much better partial load performance. In fact they provide almost flat partial load performance efficiencies from 100% load down to 37% partial load. Figure 101, below, shows the performance characteristics of these NgGTs with respect to other gas fuelled drivers for electricity generation.

Multiple fuels can be used in gas turbines, but like MSD and LSD systems, different fuel types require customised fuel delivery systems. For example, gas turbines require varying combustor residence times. However, most original equipment manufacturers have standard fuel systems for natural gas, syngas, liquid fuel (such as LNG or diesel), dual fuel (gas or liquid) and in the case of Rolls Royce, bi-fuel (both gas and liquid at the same time). Both gases and diesel are considered excellent fuels for gas turbines.

Gas turbine hot exhausts can be used to also provide steam for steam turbines (ST) to produce Combined Cycle Gas Turbine (CCGT) generation plants, which result in higher thermal efficiencies. The steam is produced by a Heat Recovery Steam Generator (HRSG), which drives a steam turbine, as a form of cogeneration. The steam turbine can be either on the same shaft as the gas turbine or a separate shaft. Figure 100, below, illustrates the principle behind the two main classes of CCGT generation plants; single and multi-shaft turbines.

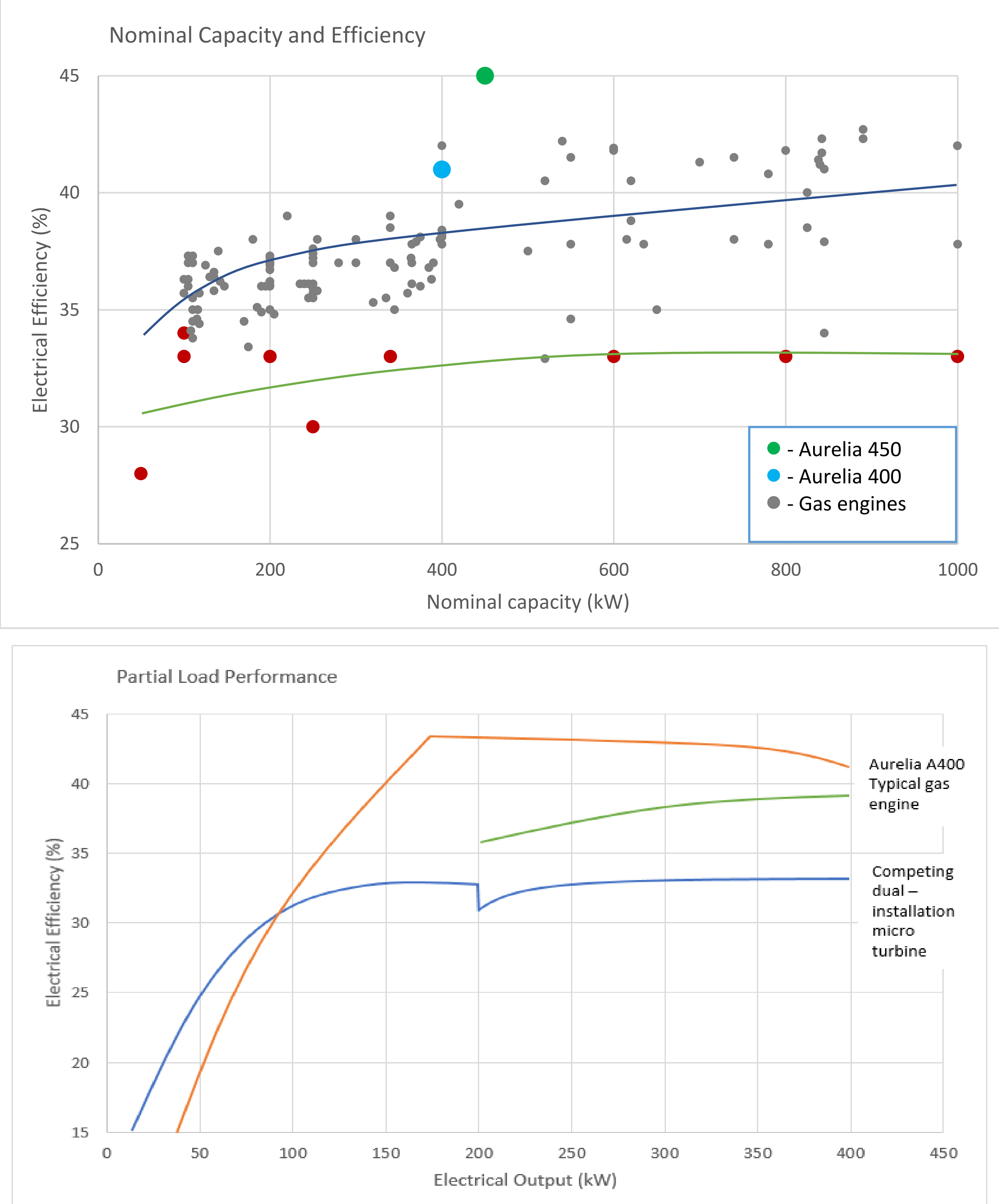
Figure 100. Single and multi-shaft physical layouts for CCGT power generation



Source: Unicon-reconstructed

HFO can also be used in gas turbines, but salts and vanadium contaminants in HFO require a combination of fuel additives, de-rated operations and that the turbine be washed every 100-120 hours. Pulverised coal can also be used but it is notably corrosive in the turbine.

Figure 101. Performance of new generation (Aurelia) dual axis gas turbines (NgGT) compared to gas IC engines and micro gas turbines



Source: Aurelia Turbines, Unicon-reconstructed

Gas turbines are well suited for peak generation as they have fast start up times, whereas CCGT are operated as base-load generators due to the ongoing steam generation. The advantage of multi shaft CCGT systems is certain GT units can be targeted for peak generation whilst others can be for CCGT.

However, some newer gas turbines (Aurelia A 400-450), NgGT, in the 400-450kW range are more efficient than natural gas fuelled reciprocating engines and comparable to diesel MSDs in efficiency.

Currently there are no SGT or CCGT powered electricity generators in Somaliland. An important criterion to consider, when contemplating the installation of SGT or CCGT is *whether there is the technical and logistical capability within current and future ESPs to master and carry out the new type of maintenance tasks required for these engines*.

From a current logistical perspective natural gas (LNG/CNG), as a fuel can only be used in urban centres located at ports. For the large inland urban centres diesel is a very viable thermal fuel choice for SGT or CCGT going into the near future, especially with new generation high efficiency gas turbines.

The movement, storage and utilisation of natural gas (LNG or CNG) require specialised port handling and storage facilities. Natural gas is the cleanest fossil fuel and there are large supplies of natural gas being produced in the Middle East.

Table 75. Characteristics of different forms of SGT and CCGT generation

Gas Turbines Characteristics							
Description	Indicator		Fuel Type / Stroke - C		Fuel Type / Stroke - C		Fuel Type / Stroke - C
		Traditional small Gas Turbine SCGT	Natural gas, Syngas (Diesel, Fuel Oil)	Combined Cycle Gas Turbine CCGT	Natural gas, Syngas (Diesel, Fuel Oil)	New class small Gas Turbine AGT	Natural gas, Syngas (Diesel, Fuel Oil)
	Speed RPM	25,500	6,000	9,000		???	
Size	**Size range kW**	1,000		50,000		400	
		10,000		500,000		450	
	Lifespan years	30	24hrs / day	30	24hrs / day	30	24hrs / day
	CAPEX $/kW	640		1,040		850	
	Construction time years	2		2	3	1	
Fuel Use	**Fuel use Lt/kWh**						
	Fuel use gm/kWh	230	331	118		172	185
	NG Btu/kg	46,053					
	Capacity Factor	90.0%	10.0%	90.0%	70.0%	90.0%	40.0%
Mode	**Prime-Continuous**	✓		✓		✓	
	Peak	✓		✓		✓	
	Standby	✓		✓		✓	
	Blackstart	NO		NO		NO	
	STOR	NO		NO		NO	

Gas Turbines Characteristics							
Description	Indicator		Fuel Type / Stroke - C		Fuel Type / Stroke - C		Fuel Type / Stroke - C
		Traditional small Gas Turbine SCGT	Natural gas, Syngas (Diesel, Fuel Oil)	Combined Cycle Gas Turbine CCGT	Natural gas, Syngas (Diesel, Fuel Oil)	New class small Gas Turbine AGT	Natural gas, Syngas (Diesel, Fuel Oil)
Performance	Heat rate kJ/kWh	11,188	16,060	5,714		8,372	9,000
	Heat rate Btu/kWh	10,605	15,222	5,416		7,935	8,530
	Good-Low Efficiency	32.2%	22.4%	63.0%		43.0%	40.0%
O&M	O&M fixed $/kW yr	17.39		6.76		17.39	
	O&M var $/MWh	3.48		10.63		3.48	
Service	Inspection cycle years	0.9		0.9		0.9	
	Turbine overhaul yrs	2.7		2.7		2.7	
	Major overhaul yrs	5.4		5.4		5.4	
	Full overhaul cycle yrs	30		30		30	
	Scheduled downtime days/year per unit	7		7		7	
	Replacement time year	0.5		1		0.25	
	Emissions Carbon cost $/tonne	30		30		30	

Source: Unicon

Renewables electricity generation plants

Solar PV: The key feature of solar PV is that amongst all the electricity generation modalities, it does not require moving components or electro-mechanical (rotating) generators. It can be mounted to track the sun or, as is more common, mounted on fixed arrays oriented at the optimal position in the sky to capture sunlight through a daylight cycle. It is a technology that utilises the largest continuous energy resource on earth and most equipment that use it are nearly always based on modular components that are easy to replace or upgrade.

Current commercial solar PV panels are mostly silicon mono-crystalline or poly-crystalline modules with sunlight conversion efficiencies ranging from 15-17%, followed by thin film CdTe solar panels ranging 13-14%. There are recent claims by PV firm solar Frontier, that they can produce a 30% efficient thin film CIGS (Copper Indium Gallium Selenide) cell.

Solar PV generation is very well suited to size scaling from small standalone user generation to solar PV farms. As a consequence, it is applicable as a power source for powering and charging small devices in isolated locations (lights, pumps or telephone) through to a large electricity power plant, or solar PV park/farm. At present the largest global solar PV plant is the 850MW (4 million panels) Longyangxia Dam Solar Park in the Tibetan Plateau of China.

Panels are robust and lifespans are now considered close to 100 years if kept clean. Solar PV performance is diminished by 0.4% per degree C rise in module temperatures above 25°C, so modules at 65°C are only 80% effective.

Applications for solar PV electricity generation target two primary sectors – geographic regions that are remote, and regions that possess reliable and high solar irradiation. Remote location use of solar PV is done without or with batteries to ensure an electricity supply for a particular service or activity. Examples of the first are solar powered water pumps, while for the second are illumination, communications and monitoring equipment.

Regions of reliable solar irradiation are used for electricity power generation through solar parks, which are added to an electricity distribution network through the use of grid-tied inverters and have no storage. These systems are grid following anti-island protected generation that provides power to the floating daytime electricity load on a network. No batteries are used. This is the most common and cheapest form of solar PV electricity generation and is utilised to provide extra generation during peak daylight hours and reduce fuel costs on thermal generation. Alone it is a non-dispatchable generation source.

Grid tied solar PV parks target primarily daylight commercial, industrial and institutional consumers, i.e. economic work and production. In highly developed economies, grid tied solar PV targets reductions in fossil fuel use and is a replacement technology, whereas in developing economies it is a key instrument for raising the electrical energy utilisation for productive work and economic growth, while reducing expenses on fossil fuels and rotating generation.

The degree of penetration that grid tied solar PV can have in a network is limited by a combination of the daylight hours and the distributions networks ability to manage variable loads and generation. It is generally considered that purely grid tied solar PV can easily provide 25% of electricity generation in a distribution network: i.e. 25% solar PV penetration during daylight hours.

Solar PV is also implemented with electricity storage. The most common form of storage associated with solar PV is electrochemical batteries in combination with two-way battery charger/inverters. The purpose of the batteries or storage is to store excess generation and provide electrical energy when there is insufficient solar PV irradiation or other generation to power the load demand.

Solar PV battery generation can occur either as supplemental generation via battery inverters during daylight hours for peak or varying load demands or to power nocturnal electricity load demands. This is the basis for off-grid–standalone-captive generation solar PV generation. Such systems are well suited for remote 24/7 electricity generation. Currently there are several large grid tied solar PV powered electricity generators in Somaliland. These are owned and operated by several ESPs that also own HSDG generation sites. Solar PV systems are modular and their operational and economic success locally has provoked other ESPs to plan their own grid tied solar PV generation sites.

The modular nature of solar PV makes implementation and construction quite easy and quick, and requires les maintenance and operation than HSDGs. The technical and logistical capability within current and future ESPs to learn and carry out the maintenance tasks required for solar PV generators is growing and succeeding.

Table 76. Characteristics of grid tied solar PV generation

Description	Indicator	Solar PV array	Fuel Type/ Stroke - Solar Day	Grid Inverter	Fuel Type/ Stroke - Solar Day
			Sunlight on Solar Panels		DC from Panels
Size	Size range kW	1		1	
		100,000		500	
	Lifespan years	30+	8hrs / day	20	8hrs / day
	CAPEX $/kW range	610	400	1,200	390
	Construction time years	0.2	2	0.1	0.33
Fuel Use	Fuel use Lt/kWh	0		0	
	Fuel use gm/kWh	0		0	
	Capacity Factor	30.0%	15.0%		
Mode	Prime-Continuous floating	✓		✓	
	Peak	NO		NO	
	Standby	NO		NO	
	Blackstart	NO		NO	
	STOR	NO		NO	
Performance	Good-Low Efficiency	21.0%	14.0%	97.0%	85.0%
O&M	O&M fixed $/kW yr	23.4		in the PV	
	O&M var $/MWh	0			
Service	Clean cycle years	0.1		0.1	
	Main maintenance yrs	1		0.5	
	Full overhaul cycle yrs	30+		20	
	Scheduled downtime days/year per unit	2		2	
	Replacement time year	0.1	1	0.1	

Description	Indicator	Solar PV array	Fuel Type/ Stroke - Solar Day Sunlight on Solar Panels	Grid Inverter	Fuel Type/ Stroke - Solar Day DC from Panels
	Emissions Carbon cost $/tonne	0		0	

Source: Unicon

Wind: A key feature of wind power is a modular electromechanical generator that can be implemented singularly or in arrays to form wind farms. It is scalable and once properly commissioned is a reliable 24/7 electricity generation source, albeit changeable due to wind variability. It tracks changes in wind direction, and commercial installations are placed 30+m above the ground to obtain more reliable wind and avoid most windblown dust and sand.

It is a technology that utilises one of the largest renewable energy resources on earth (wind) and much of the equipment is based on modular components that are easy to replace. It directly converts wind kinetic energy (wind speed cubed) into electricity and most systems are horizontal axis nacelle mounted on propeller type rotors.

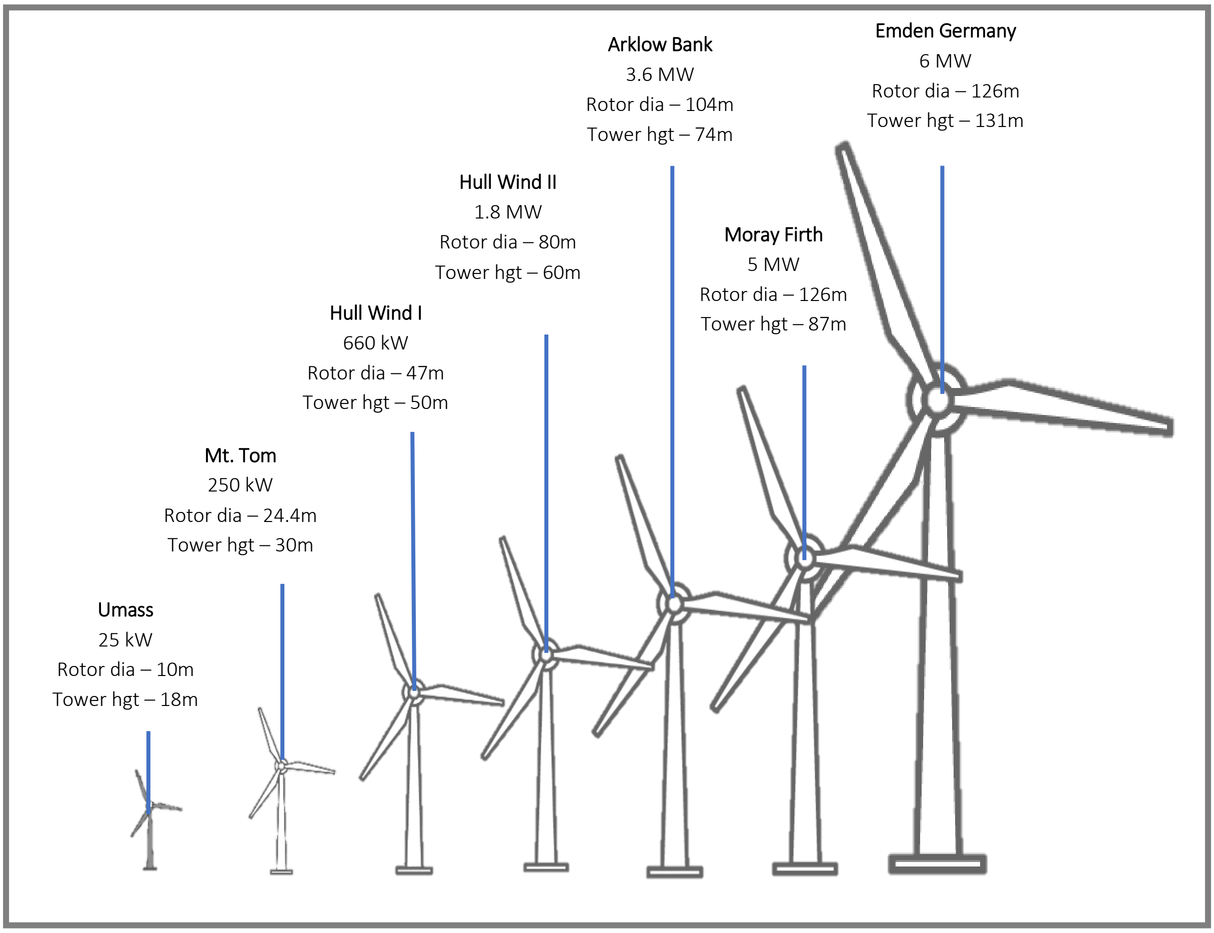
Small standalone systems can range from 3+m diameter rotors on 8-15m masts for small uses up to 50kW to commercial applications that include both onshore and offshore wind farms which utilise rotors and generators mounted on nacelles, 30 to 130m above the ground or sea, that generate from 100kW to 6,000kW each. Figure 102, below, illustrates the physical scale of different sized wind turbines used within the wind power generation industry. Within Somaliland, the current wind turbines installed are similar in size to 25kW turbines, 18m high with 10m diameter rotors (UMass) and 275kW turbines, that are 30m high with 25m diameter rotors (Mt Tom).

Within the Horn of Africa region, current Wind power farms, such as placed in Ethiopia, already include 500kW/50m towers and 1.5MW/60m towers. In point of fact, Ethiopia has undertaken plans to implement 5.2GW of wind power generation by the end of 2020; of which 324MW is already in operation, and another 700MW is currently under development.

Key components of wind power electricity generation are the rotors, nacelle, nacelle components, the mast, power control and communications box, plus the foundation and MV transformer grid connection. Images of the sizes, comparisons and siting of components in a wind turbine generator are shown below.

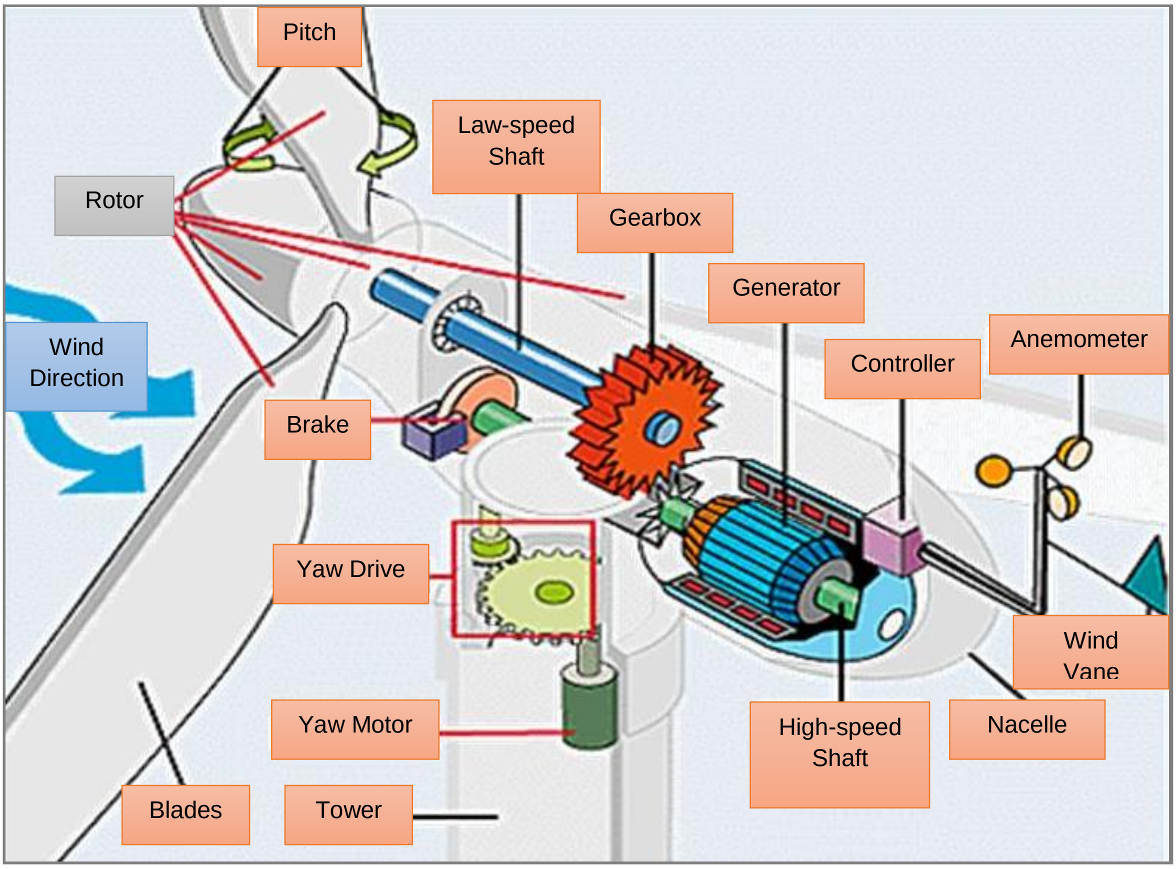
Wind resources are often characterised by power density classes, which range from 1-7, with 4-7 considered economic. Classes are also linked to height above ground, as proximity to the ground reduces wind speeds and constancy. Much of the cost of wind power (some 80%) is in the actual machinery, versus site preparation. The site can be concurrently used for animal grazing and even ground level agriculture if well managed.

Figure 102. Wind turbines size comparisons (Somaliland systems = 22kW)



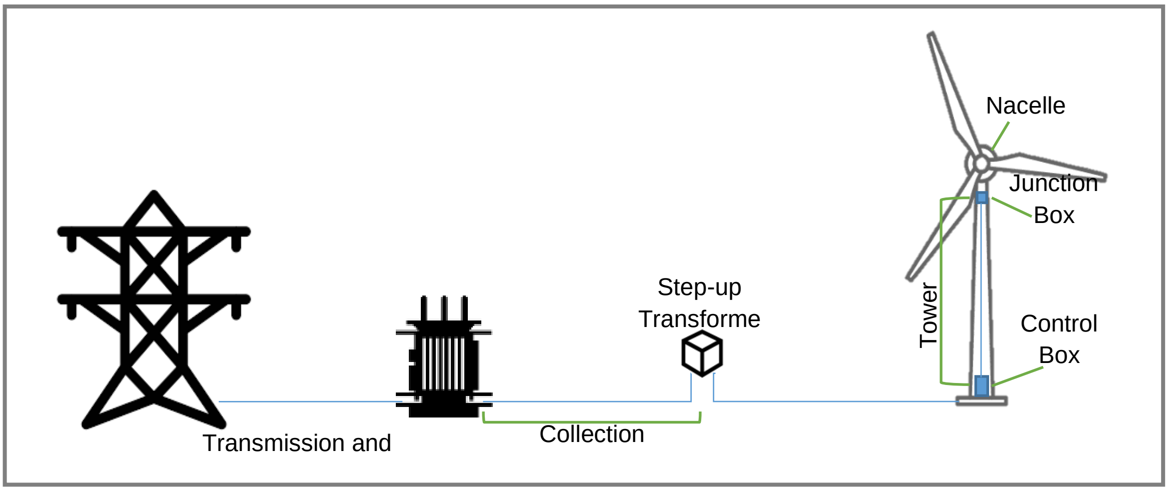
Source: Unicon-reconstructed

Figure 103. Wind Turbine traditional nacelle and site components



Source: Unicon-reconstructed

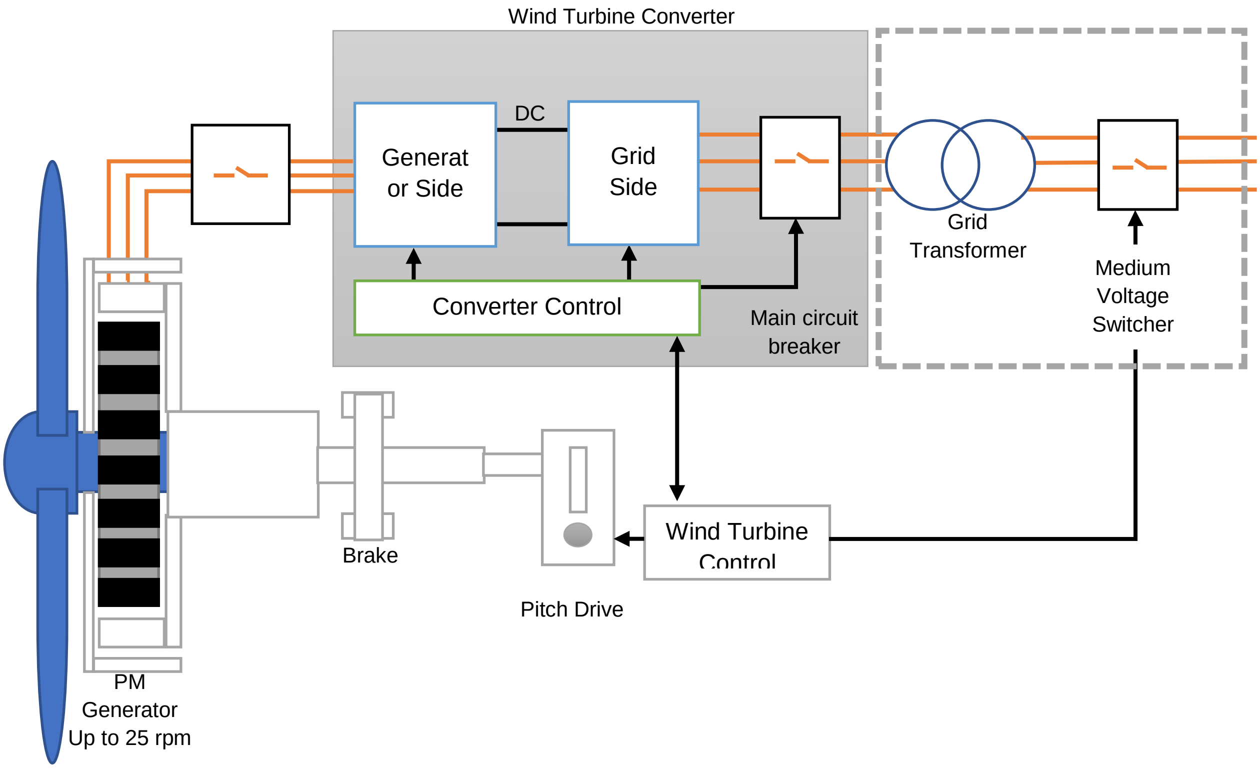
Products Used:	*Fiber Optic Cables*	*Signal Cables*	*Control Cables*	*Low-Voltage Power Cables*	*Medium -Voltage Power Cables*	*Grounding Wires*	*Bare Overhead Conductors*	*Underground Transmission Cables*	*Submarine Power Cables*	*Cable Assemblies*
Nacelle	✓	✓	✓	✓	✓	✓				✓
Tower	✓	✓	✓	✓	✓	✓				✓
Collection System	✓			✓	✓	✓			✓	
Substation & Transmission	✓		✓	✓	✓		✓	✓	✓	
Grounding & SCADA Systems	✓					✓				



Source: Unicon-reconstructed

Two types of rotor transmissions are used; the traditional uses a gearbox requiring oiling and biannual maintenance and the newer approach of direct drive, which has no gearbox and has much simpler mechanical maintenance, lower speeds and longer lifespans. This latter approach uses more elaborate electronics to produce a stable power output from a varying turbine speed rather than a gearbox.

Figure 104. Wind Turbine newer type direct drive components



Source: Unicon-reconstructed

Table 77. Wind classes for wind power (values of class 4 and plus are considered economically good)

Wind Class	Height above ground					
	10 m (33 ft)		30 m (98 ft)		50 m (164 ft)	
	Wind power density (W/m2)	Speed m/s (mph)	Wind power density (W/m2)	Speed m/s (mph)	Wind power density (W/m2)	Speed m/s (mph)
1	0 - 100	0 - 4.4	0 - 160	0 - 5.1	0 - 200	0 - 5.6
		(0 - 9.8)		(0 - 11.4)		(0 - 12.5)
2	100 - 150	4.4 - 5.1	160 - 240	5.1 - 5.9	200 - 300	5.6 - 6.4
		(9.8 - 11.5)		(11.4 - 13.2)		(12.5 - 14.3)
3	150 - 200	5.1 - 5.6	240 - 320	5.9 - 6.5	300 - 400	6.4 - 7.0
		(11.5 - 12.5)		(13.2 - 14.6)		(14.3 - 15.7)
4	200 - 250	5.6 - 6.0	320 - 400	6.5 - 7.0	400 - 500	7.0 - 7.5
		(12.5 - 13.4)		(14.6 - 15.7)		(15.7 - 16.8)
5	250 - 300	6.0 - 6.4	400 - 480	7.0 - 7.4	500 - 600	7.5 - 8.0
		(13.4 - 14.3)		(15.7 - 16.6)		(16.8 - 17.9)
6	300 - 400	6.4 - 7.0	480 - 640	7.4 - 8.2	600 - 800	8.0 - 8.8
		(14.3 - 15.7)		(16.6 - 18.3)		(17.9 - 19.7)
7	400 – 1,000	7.0 - 9.4	640 - 1600	8.2 - 11.0	800 – 2,000	8.8 - 11.9
		(15.7 - 21.1)		(18.3 - 24.7)		(19.7 - 26.6

Source: Unicon

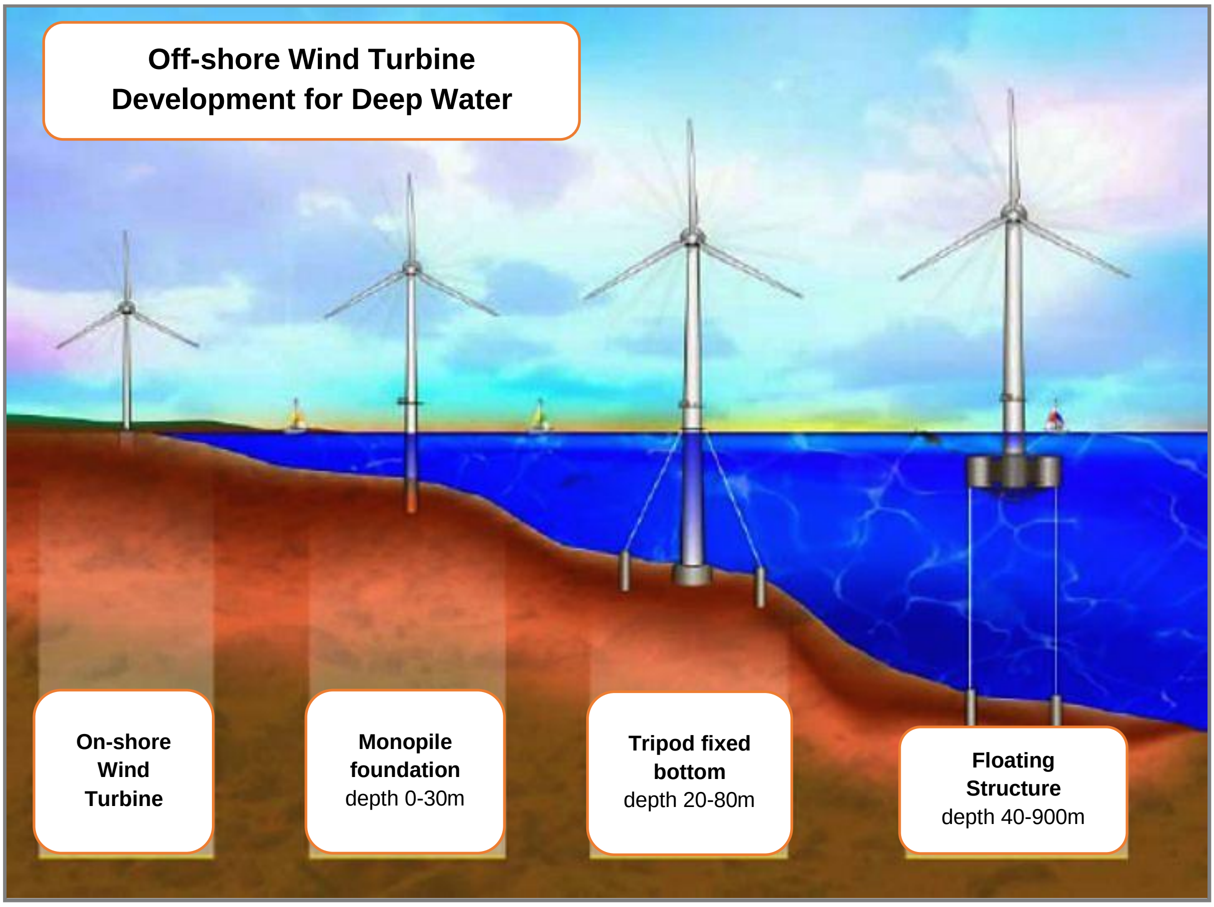
Applications for wind power electricity generation target two primary sectors: geographic regions that are remote that have reliable wind, and regions that possess reliable and high wind speeds for wind farms. Remote location use of wind power is usually done with battery storage to ensure an electricity supply for a particular service or activity. Examples are wind powered electric water pumps and isolated mini-grids for machinery and equipment.

Regions of reliable strong wind are also used for electricity power generation wind farms, which are added to an electricity distribution network through the use of transformers and have no storage. These systems are anti-islanding protected grid generation that provides power to the floating daytime electricity load on a network. Alone it is a non-dispatchable generation source.

The performance of a wind turbine is also a function of its efficiency number, which varies with wind speed and consequently has a "design point" where its peak efficiency is set to a wind speed for which the system is designed. Operations in wind speeds above and below the design speed mean efficiency will be the same or less.

Wind farms are the most common of the new renewables generating electricity for power grids and its capacity to penetrate a power grid is limited by a network’s ability to manage variable loads and generation. Denmark in 2015 obtained 40% of its national electricity from wind power, while Europe-wide 11.4% of electricity came from wind. Wind turbines can be installed on land, many times on elevated terrain, but as much of the excellent wind prospects are on shorelines and the sea, more and more installations are being installed offshore.

Figure 105. Wind power configurations (onshore and offshore)



Source: Unicon-reconstructed

Wind farms generate 24/7 and tend to complement solar PV, as high meteorological pressure brings clear skies and low wind, while low pressures bring winds and clouds. With numerous dispersed wind turbines, the variable output from a single turbine due to local wind speeds is cancelled out by the dispersed generation, which becomes less variable and more predictable.

Consequently, wind farm power like solar PV hardly ever suffers major technical failures, since the failure of an individual wind turbine has hardly any effect in dispersed overall power, whereas conventional centralised generator units, while far less variable, can suffer major unpredictable outages.

Wind power complements greater technical integration and decentralisation in electricity generation. It targets quality of life and econo-technical integration. In highly developed economies, wind power targets reductions in fossil fuel use and is a replacement technology, whereas in developing economies it is a key instrument for raising the electrical energy utilisation for quality of life, econo-technical integration and economic growth, while reducing expenses on fossil fuels and rotating generation.

Wind power applications can also be implemented with electricity storage (hybrid). Two approaches have been proposed: one being proposed by some OEMs involves the implementation of shared battery storage for several wind turbines near the masts (local hybrid). The other is the creation of larger central UPS that store excess generation from a network and provides distribution network level fast peak response and automated load demand management (hybrid network).

At a small single unit level, wind-battery hybrid generation uses a supplemental generation via battery inverters during operations to support variable wind generation and varying load demands. Such systems are well suited as part of hybrid generation for remote electricity delivery in windy areas.

Currently there are two non-operational grid tied wind generation sites, in Somaliland, with 3x22kW rated wind turbines potentially available.

The necessary technical expertise to install and operate and maintain widespread commercial wind turbine generation has not been established in Somaliland. This is an important criterion to consider when contemplating the installation of wind power.

Table 78. Characteristics of wind generation

Description	Indicator		Fuel Type / Stroke 24hrs		Fuel Type / Stroke 24hrs
		Land Wind Turbine	Regular 6+ m/s strong wind	Marine Wind Turbine	Regular 6+ m/s strong wind
Size	Size range kW	10		500	
		3,000		6,000	
	Lifespan years	25	24hrs / day	25	24hrs / day
	CAPEX $/kW	1,560	1,370	4,650	3,950
	Construction time years	0.25	0.5	0.25	1
Fuel Use	Fuel use Lt/kWh	0		0	
	Fuel use gm/kWh	0		0	
	Capacity Factor	50.0%	30.0%	60.0%	45.0%
Mode	Prime-Continuous floating	✓		✓	
	Peak	NO		NO	
	Standby	NO		NO	
	Blackstart	NO		NO	
	STOR	NO		NO	
Performance	Good-Low Efficiency	40.0%	30.0%	40.0%	30.0%
O&M	O&M fixed $/kW yr	46.71		100	

Description	Indicator	Land Wind Turbine	Fuel Type / Stroke 24hrs Regular 6+ m/s strong wind	Marine Wind Turbine	Fuel Type / Stroke 24hrs Regular 6+ m/s strong wind
	O&M var $/MWh	0		0	
	Main maintenance yrs	0.5		0.5	
	Full overhaul cycle yrs	25		25	
	Scheduled downtime days/year per unit	10		10	
	Replacement time year	0.25	0.5	0.25	0.5
	Emissions Carbon cost $/tonne	0		0	

Source: Unicon

Storage: a key feature of storage is that it can provide highly effective variable dispatchable sources of electricity for load demands. It is often very scalable and can be based on either electrochemical, capacitive, thermal or mechanical storage mechanisms. Storage systems do not operate in isolation but rather are adjunct to hybrid systems. The primary use of storage is to provide dispatchable and scalable energy that can be converted into electricity.

Electrochemical and super-capacitive storage is modular, transportable, scalable and usually assembled into banks of storage cells. Such banks are used widely in electricity applications and more frequently in electric power generation applications as their lifespans and capacities have risen, whilst their costs dropped.

Super-capacitive storage does not offer significant storage capacities, but it does offer rapid short-term responsiveness for large surge loads, long lifespans, low maintenance and good resilience to temperature variations.

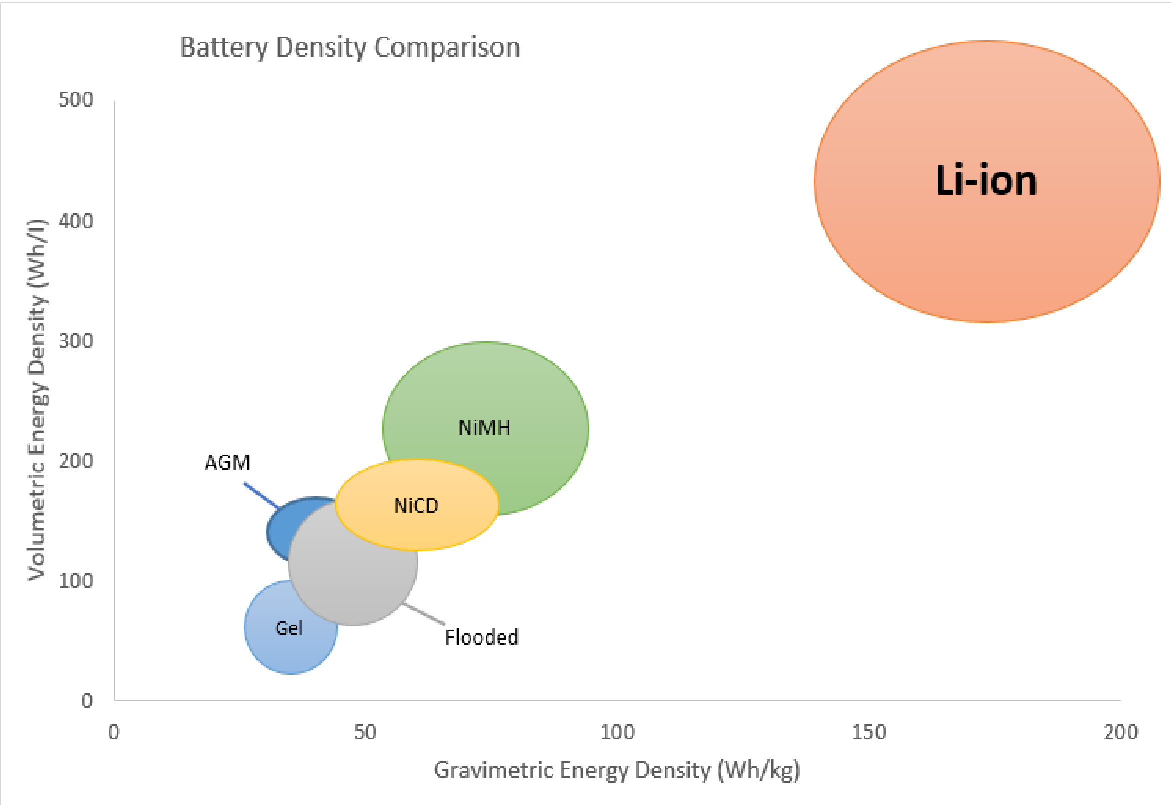
Electrochemical storage (batteries) provides much improved electricity storage compared to super-capacitors and are more economic in cost. As part of electric power generation, battery bank lifespans depend on their composition, load/charge cycling, the stability of operating temperatures and how well they are reconditioned and maintained for discharging and charging throughout their service life. Both PbA and Li based battery banks in most real life operations offer lifespans in the order of 10 years but can be better.

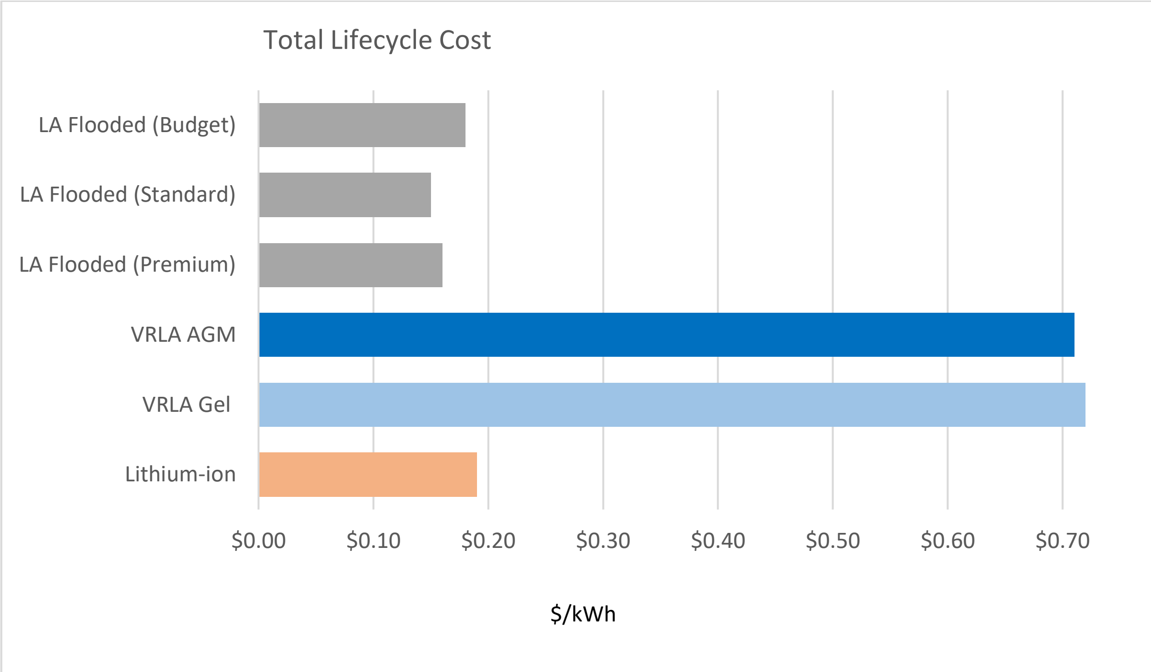
Battery storage offers both important storage capacities, along with rapid responsiveness for large surge loads, especially when arranged in parallel. They also have moderate lifespans, moderate maintenance, are scalable and are on the whole easily transported. Lead based batteries are 100% recyclable while current lithium-ion based batteries are not recyclable. Battery technologies currently widely used in the electric power generation industry include the lead acid battery (PbA), which is well established but heavy and a less dense storage technology, with higher internal resistance compared to Li based batteries. Comparatively PbA is Capex cheaper compared to the newer Lithium-ion (Li-ion) battery.

Traditional PbA are operated with a DoD (depth of discharge) of 30-50%, as exceeding 50%, results in significant drops in PbA lifespans. There are liquid filled and gel versions, with the liquid filled having longer lifespans and lower capital costs but more maintenance needs for lifespan support. BMS for PbA is fairly straight forward compared to Li based batteries.

The Li-ion is a high capacity battery that is operated using 80% DoD, with approximately three to four times the energy storage, 1/3 the weight and half the volume but costs four times traditional PbA. Li-ion performance is less temperature sensitive than PbA, but is often destructively reactive to elevated temperatures or rupture (thermal runaway). Figure 106, below, illustrates the key characteristics considered in deciding on Battery solutions: comparisons between energy density and lifecycle costs for the various major technologies. The most notable of which are PbA and Li-ion.

Figure 106. Comparisons of PbA and Li-ion Energy density and total lifecycle





Source: Unicon-reconstructed

In addition, Li-Ion in order to prevent over discharging and charging, plus thermal decomposition require an excellent BMS. Li-ion batteries are easier to transport. Newer LiFe and LiNMC batteries are more expensive, last longer than Li-ion, and do not have the same destructive reactivity of Li-ion batteries.

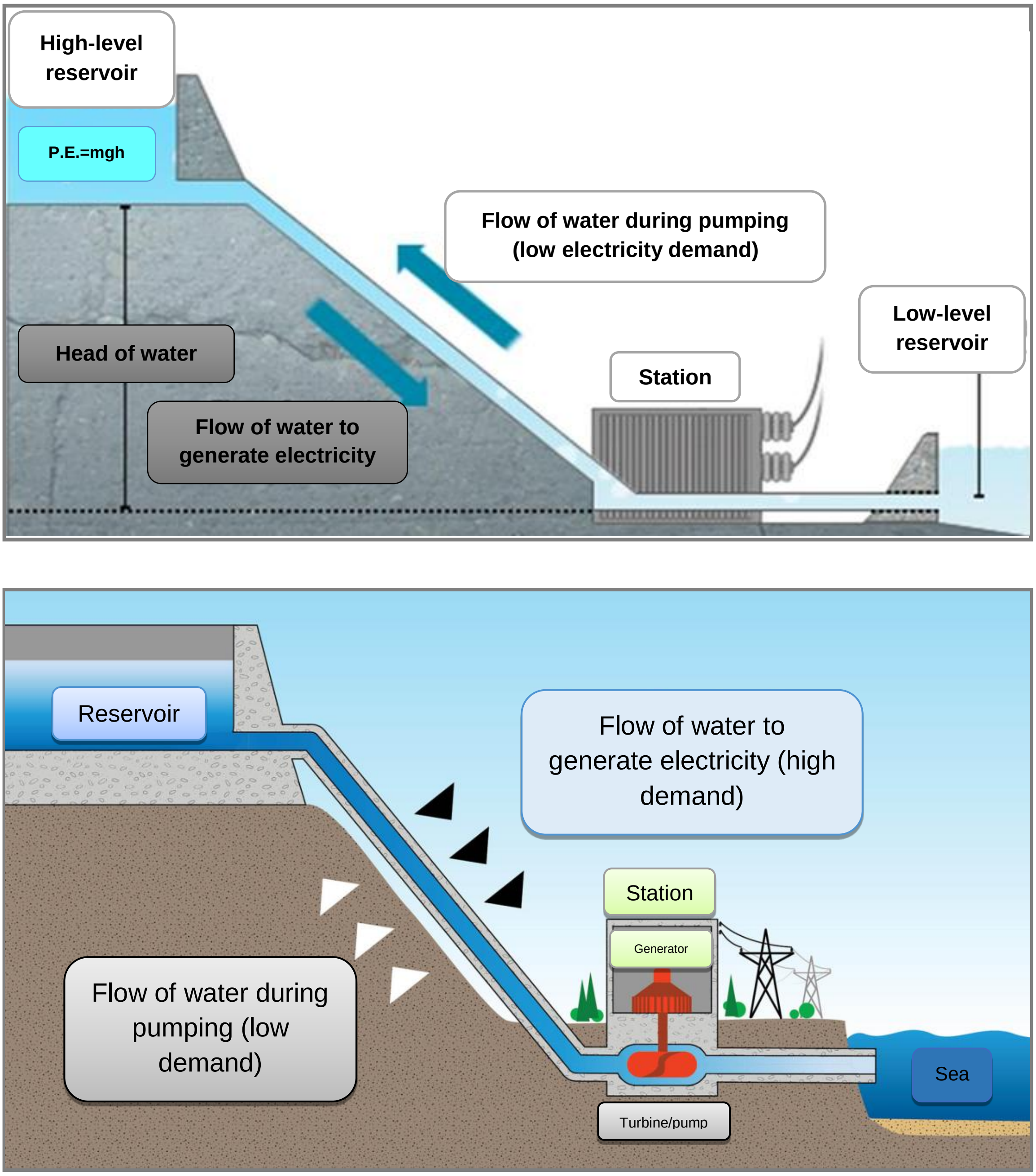
There is also a new PbA based hybrid capacitor technology entering the market, that suggests a two to four times longer life spans, low cost, 100% recyclable and 80% DoD characteristics (Ecoult-Ultrabattery). It has been developed for various applications including grid UPS, electric vehicles, motor vehicles and renewable hybrid systems. These too are managed by an advanced BMS and are 100% recyclable.

Another form of electrochemical electricity storage is also in the market, called flow batteries. These use the storage of charged and discharged electrolytes, which flow through a battery cell system. These are still very much in development for wider commercial markets and will not be expounded upon here.

Mechanical: Mechanical storage involves the storage of potential energy, which is then used to drive turbines to produce electricity. Two main forms of mechanical storage are primarily available for electricity generation. One is pumped hydro-storage, traditionally used for storing large energy reserves, providing 100’s MW to even GW level generation as part of a hydroelectric generation networks, which provide highly responsive peak, base-load and surge electricity generation.

More recently the use of pumped hydro is viewed as a very effective form of large energy storage for hybrid generation systems where geography permits their construction. Efficiency of pumped hydro as a form of energy is 75-80%, with service lifespans of 60+ years. Its vulnerability is the need for geographic locations with rapid vertical changes in altitude and sufficient water resources to maintain the fixed upper and lower reservoirs and the replacement of lost water due to evaporation.

Figure 107. Forms of pumped hydro (PH) for energy storage in hybrid systems (fresh and marine)



Source: Energy Australia Spencer Gulf project, Unicon-reconstructed

Another form of energy storage for generation is via Compressed Air Energy Storage (CAES). This is an emerging technology, which offers significant benefits in efficiency, longevity, modular applications, scalability, resistance to temperature changes and transportability. Like batteries it can be situated at the locations where it is required, and the compressed air turbines response times for generation to load demands is comparable to the fast peak load matching offered by hydroelectric generation. CAES systems offer efficiencies in the order of 60-70%, with lifespan expectancies of 20+ years.

Including batteries or mechanical storage in electricity generation takes the place of the chemical energy stored in thermal fuels that power thermal generators. Consequently, storage permits independent load demand operations, which can range from:

- independent standalone extended operations;
- provide base-load generation through grid inverters or storage driven generators;
- provide floating generation through grid inverters or storage driven generators to support a varying load;
- provide for peak load demands;
- load demand replacement when renewables or thermal generation exceeds loads;
- rapid grid fault or peak demand responses, by storage systems preserve electricity generation (network frequency and voltage) when thermal or rotating generation trips off network; and
- high speed (millisecond) grid fault responses, by battery storage with grid inverters, preserves electricity generation (network frequency and voltage) when any generation trips off. Grid level UPS.

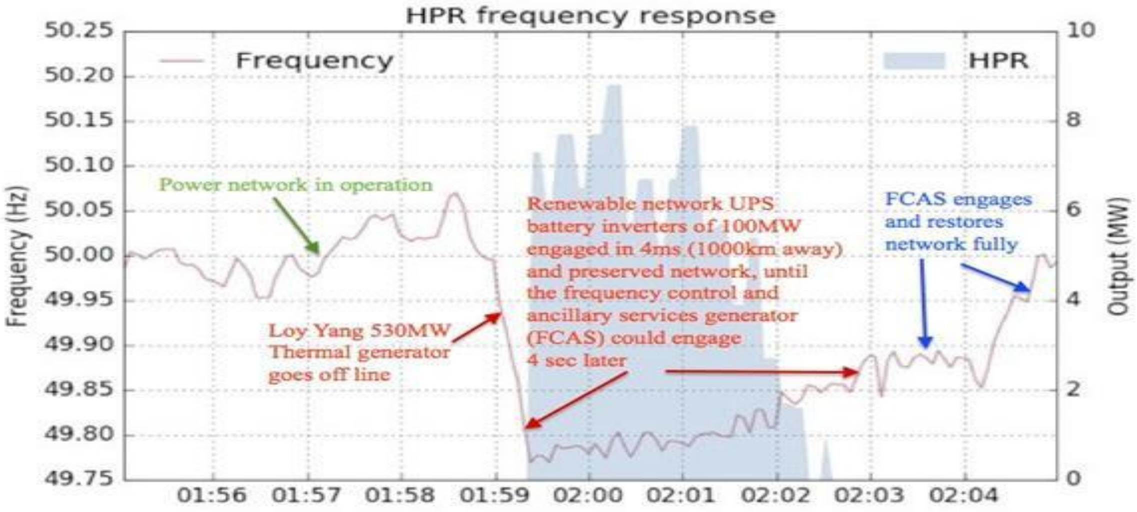
In fact, battery and storage in general is not just about extending or back stopping the variability of renewable energy generation, it provides reliable power networks in a hybrid generation network.

Energy and electricity storage is a catalyst for greater technical integration and decentralisation in electricity generation. It targets quality of life and econo-technical integration. In highly developed economies storage is for enhancing robustness in electricity generation networks.

In developing economies, it is a key instrument for raising the reliability of access to electrical energy as part of improving the quality of life, reducing rural flight and powering productive activities in both urban and rural communities. It enhances econo-technical integration and economic growth, while reducing fossil fuel costs and rotating generation.

Figure 108 below is a graph showing an example of how battery storage used as a network UPS maintains an electricity network's functional integrity. Table 79 presents the characteristics for Storage modalities.

Figure 108. Example of renewables powered battery storage UPS (HPR=100MW/129MWh) preserving an electrical networks integrity when any form of generation goes down



Source: Australian Energy Market Operator data; Loy Yang A3 failure; Unicon-reconstructed

Table 79. Characteristics of battery and storage

escription	Indicator	Pb A battery	Fuel Type / DoD 50%	Li-Ion battery	Fuel Type / DoD 80%	Simultaneous Pumped Hydro	Fuel Type / DoD 100%
			Liquid filled or Gel		Gel		Water
Size	Size range kW	10		500		10,000	
		3,000		100,000		1,000,000	
	Lifespan years	10	24hrs / day	10	24hrs / day	80+	24hrs / day
	CAPEX $/kW	550		2,000		2,550	
	Constructi on time years	0.5		0.5		2.5	0.5
Fuel Use	Fuel use Lt/kWh	0		0		0	
	Fuel use gm/kWh	0		0		0	
	Increase in Load served	35.0%		35.0%			
	Capacity Factor					90.0%	50.0%
Mode	Prime-Continuou s	NO		NO		✓	
	Peak	✓		✓		✓	
	Standby	✓		✓		✓	

escription	Indicator	Pb A battery	Fuel Type / DoD 50% Liquid filled or Gel	Li-Ion battery	Fuel Type / DoD 80% Gel	Simultaneous Pumped Hydro	Fuel Type / DoD 100% Water
	Blackstart	✓		✓		✓	
	STOR	✓		✓		✓	
Performance	Efficiency	85.0%		99.0%		80.0%	75.0%
O&M	O&M fixed $/kW yr	27.5		60.0		25.5	
	O&M var $/MWh	0		0		0	
	Main maintenance yrs	0.5		0.5		0.5	
	Full overhaul cycle yrs	10		10		80+	
	Scheduled downtime days/year per unit	0		0		0	
	Replacement time year	0.25		0.25		0.5	
	Emissions Carbon cost $/tonne	0		0		0	

Source: Unicon

Thermal storage: This field has been the subject of extensive research and pilot plants, but to date its applications are more towards heat sources for Air conditioning, climate control and industrial uses of heat rather than electricity generation. It is a key element of CHP but in CHP the heat is used primarily as part of captive generation situations.

The eventual commercialisation of concentrated solar thermal offers applications for this modality in providing nocturnal electricity generation. Currently it is not commercially part of electricity generation and not expected to be used in Somaliland, for urban electricity generation in the coming years.

Hybrid Electricity Generation Plants

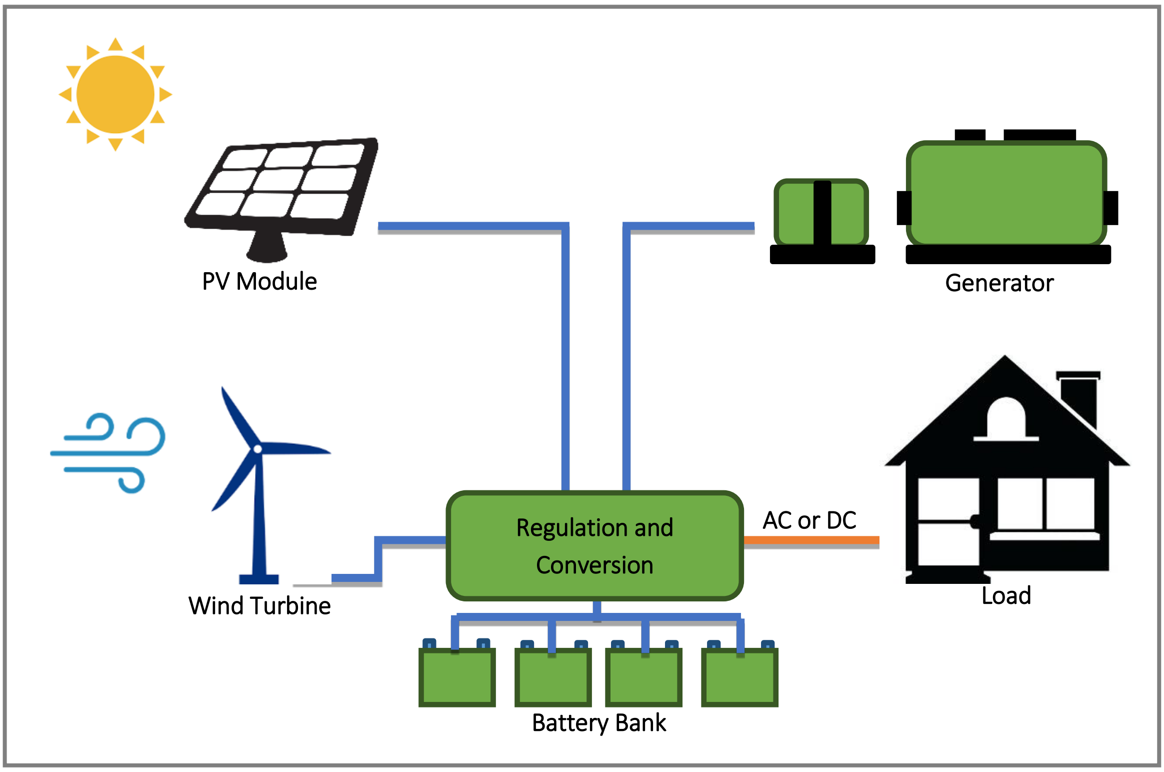
The principal goal of hybrid electricity generation systems is to create a collective of electricity generation systems that are complementary. The term in regard to thermal electricity generation plants refers to different applications of Combined Heat and Power (CHP) where usable waste heat is used as heat for economic processes, whether to produce further electricity generation or productive activities. One such example is the CCGT systems already mentioned.

In terms of renewables based electricity generation, hybrid electricity generation is where two or more renewable energy sources are combined to provide daily and seasonal generation complementarity. The combination should also provide for diversity and redundancy in reducing power outage risks. It also permits load sharing and incremental increases in generation capacity and future additions, due to modular components and designs.

As a concept, hybrid generation is well suited to both standalone captive generation and the integration of different synchronised generation sources into a common distribution grid/network. It is essential that any hybrid system:

- incorporates the coordination and prioritisation of the different energy sources through the management of AC and DC electricity generation;
- accepts electricity from the different generating units;
- monitors and updates the status of energy/electricity storage;
- prevents over storage and shunts excess electricity to suitable loads or arrests generation.

Figure 109. Hybrid thermal + renewables electricity power generation schematic



Source: Unicon-reconstructed

Hybrid electricity generation for urban centres

Thermal HSDG + grid tied solar PV: The current electrical generation context of multiple or single ESPs in each major urban centre, with their own captive customers and distribution network imposes a limit on how effectively an ESP can expand its generation towards a customer base and market share, when it must also create a distribution network for future customers.

Current thermal HSDG generation in hybrid combination with some grid tied solar PV is the current dominant form of operative hybrid electricity generation in the mandated region. The current ESPs using grid tied solar PV have successfully shown some success, in solar PV suitable regions. Their peers and competitive ESPs are now planning to implement solar PV as part of their daytime generation.

Clearly, the fuel savings have been identified and more of the same seems the easiest way forward, towards increasing the level of solar PV generation in Somaliland, where solar PV generation is suitable.

Grid tied solar PV, on technical grounds, can be easily increased to 20-25% of total daylight electrical energy generation for each of the current ESPs, situated in solar PV suitable areas, without difficulties. Upgrading of generation with renewables can immediately relieve fuel costs, while enhancing the availability of existing HSDGs to provide for varying and peak load demands. A 20-25 % penetration by solar PV will be easy to sustain and maintain with upgrades in generation and training within each ESP, particularly since solar PV systems are modular and easy to upscale as urban electricity demands grow for each of the ESPs.

This combination of a floating renewables daylight load of 20-25% will permit HSDGs to easily operate in their peak fuel efficient 75-80% load zone and be able to provide 100% if needed on short notice. In effect, a network that has 100-125% of its potential daytime load assured by thermal + solar PV generation and 20-25% of its daytime load demand assured by renewables.

Somaliland all has excellent solar PV irradiation. In addition, this modality is applicable for nearly all urban centres in the country.

Solid waste thermal generation + HSDG + gas turbines + solar PV: The pyrolysis treatment of carbon rich solid urban waste in the major urban centres will significantly reduce landfill at the urban dumpsites and produce electricity from syngas, fuel oil and land fill from biochar. The fuel oil can power parallel HSDGs, a MSD or even new generation High Efficiency Small Gas Turbines (HEGT 400-450kW) to produce electricity generation. Syngas gas also can power HEGT or even IC engines designed for syngas fuel.

Such a waste and biomass fuelled thermal generation plant can also be augmented with at least 20-25% of daytime electricity generation by grid tied solar PV generation. The solar PV would preserve fuel oil and syngas for nocturnal generation and prolong the lifespans of the HSDGs. In addition, if HEGT are used then mixed combined cycle steam generation can be produced for electricity generation and/or the CHP can assist in the pyrolysis processing.

The biochar can be useful as an inert landfill, soil amendment for agricultural activity or as a replacement for charcoal to reduce deforestation, while forests are being re-established. It is a key ingredient for terra preta, a highly regarded soil amendment for market gardens and agricultural remediation.

Thermal HSDG + wind power + grid tied solar PV where suitable: The addition of wind turbines to ESPs in areas of good wind, offers significant reductions in 24/7 diesel use. Many locations in Somaliland that have good wind are also recipients of good solar irradiation. Wind generation can easily provide 30% (even 50%) of average 24/7 generation in good wind areas. Wind capacity factors are usually rated at 30-50% in good wind areas.

Combining two renewable and one thermal electricity generation as a modality will result in significant savings on HSDG fuel use, optimise HSDG performance to peak load demands and maintain a low base-load, with a reliable renewables powered floating load. The combination of a floating renewables daylight load of 40-50% will permit HSDGs to still operate in their fuel efficient 50-80% load zone and be able to provide 100% if needed on short notice. In effect, such a network would have 100-150% of its potential load assured by thermal + renewables generation and 40-50% of its load demand assured by renewables.

Thermal HSDG + wind power + grid tied solar PV + batteries: The addition of battery storage and UPS, plus wind turbines and solar PV to ESPs in areas of good wind, offers significant reductions in 24/7 diesel use. The capacity of electrical energy from batteries to power short-term fast UPS generation for an ESP reduces the need for spare HSDGs to be maintained in rolling operation.

A battery bank UPS can easily provide 500-1,000kW for more than several minutes while a HSDG is started up or battery charging inverters/rectifiers can utilise excess generation on the network for storage. Such combinations permit wind generation and solar PV to provide at least 50-60%, or occasionally more, of average 24/7 generation in good winds.

Wind power + pumped hydro + grid tied solar PV: The combination of wind power, solar PV and simultaneous pumped hydro (SPH) offers the potential for 100% renewables generation for geographically suitable locations. The use of pumped hydroelectric generation is totally dependent on suitable geologic and geographic locations that enable the implementation of vertical infrastructure, upper and lower reservoirs, and optimally, proximity to urban centres that can benefit from a renewables powered base-load, floating load and peak loads. In such a situation the pumped hydro provides both for a low base load and peak load demands, while variable wind and daylight solar PV provide for the varying loads and charging for the pumped hydroelectric.

Such systems require simultaneous hydroelectric generation and pumped hydroelectric, in contrast to traditional pumped hydroelectric generation. Traditionally, Francis turbines provide both for the generation or the needed pumping for storage of excess network generation for later use at peak demand loads. Simultaneous pumped hydroelectric (SPH) systems convert variable electricity generation into reliable generation that can not only assist in meeting base and peak loads but can also be a Short Term Operating Reserve (STOR), providing fast response to short-term rapid changes in power demand or sudden loss of power generation.

The efficiency on pumped hydroelectric generation is usually in the 75-80% range. That is, for every 100 units of electricity used to pump water to the upper storage reservoir, 75-80 units of electricity are produced in hydroelectric generation. Already, traditional pumped hydro (PH) permits the storage of large amount of energy for dynamic multi MW extended operations to even GW peak generation in some countries.

Due to the elevated levels of evaporation found in Somaliland, and such similar countries, the reservoirs should be covered with solar PV to provide both daytime generation for electricity generation pumping and eliminate more than 90% of the evaporation from the reservoirs. Reduced evaporative losses can be easily replaced either by using reserve reservoirs, ground water pumping or fully treated water effluent from urban liquid waste outputs or a combination of all.

The use of SPH generation permits incremental concurrent expansion of generation and pumping. Increases in reservoir storage can also be carried out, as the system becomes a large electricity storage battery.

Potential applications of SPH generation have been identified in the Ogo mountains of Somaliland. An important variation on SPH generation is marine pumped hydroelectric generation (SMPH).

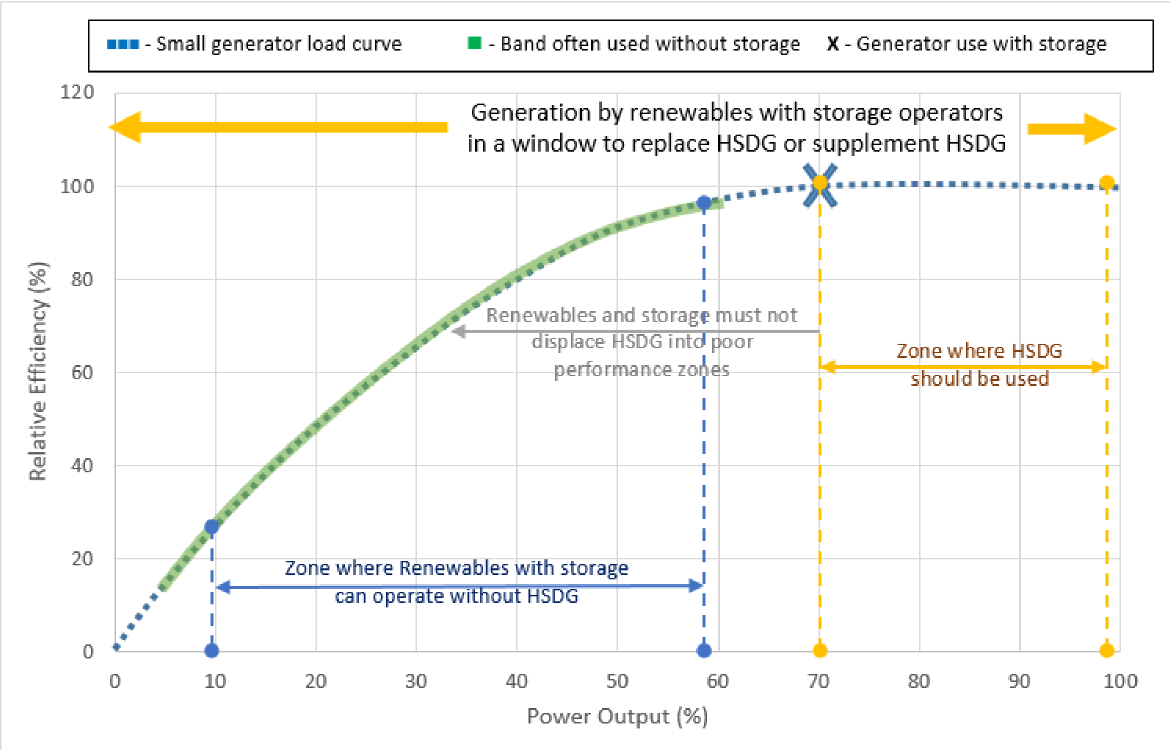
Another potential implementation of SPH generation is in integration with marine desalination as part of the distribution of fresh water supplies to multiple urban centres and electricity generation for same said communities.

Hybrid rural electricity generation for remote rural areas: For remote and isolated communities the transport of fossil fuels is often a significant problem for providing reliable electricity generation via thermal generation units. For the less remote urban centres, a better solution resides in the application of hybrid HSDG combinations with modular units of *solar PV + battery* for daytime generation and limited nocturnal electricity generation.

The performance context for hybrids of synchronised HSDG and renewable generation are illustrated below in Figure 110; which is further illustrated in Table 80 with more detailed options; for a normalised HSDG hybrid generic rural electrification generation site with high demands.

Figure 110 illustrates the efficient (blue) and wasteful (green) operation zones of HSDGs and the range over which Renewable (REN) generation, with battery storage inverter generation, can be combined with a HSDG to form hybrid systems. From Figure 110 it can be deduced that the goal of REN is to reduce fuel, pollution, operation and maintenance costs by keeping the HSDG near 70%. Plus these permit elevated delivery of available electricity for productive activities during daylight, and replace HSDG where it is inefficient. Additionally, it provides reserve electrical power for low or excessive demands and emergency power when HSDGs fail to operate.

Figure 110. Benefits of hybrids and synchronisation for HSDG hybrid options for a generic rural electrification generation site



Source: Unicon-reconstructed

As mentioned above if there is reliable wind; such generation can also be added to provide even greater periods of electricity service and even 24/7 electricity generation; with the battery storage inverter generation providing minimum base-load and peak demand support.

In more extreme isolation cases, then purely solar PV + battery for daytime generation and limited night time electricity is possible; the addition of wind, where possible, offers more generation reserve and relief, including for nocturnal use of electricity. These cases are further covered in Annex 6 covering Off-grid & On-grid.

As is the case for all renewable electricity generation, the context of the geographic and meteorological specifics of the location and the actual human population and activities that require electricity must be considered in discerning the appropriate and necessary electricity generation solution for improving the quality of life, the value of productive activities and the community's resilience to climate change and negative influences.

Table 80 displays options for a normalised HSDG hybrid generic rural electrification generation site with 2 HSDGs, which can be synchronised with various Renewable energy sourced generation (REN) options. The top grouping in Table 80 is HSDG generation alone, which shows that efficient HSDG generation can be sized to the 2 higher demand windows (HSDG > 70% => Green box), of Day and Evening, but this results in poor midnight fuel performance (HSDG > 70% => Red box), plus the overall fuel cost while optimised for the major demands will be significant. The second grouping, HSDG + Solar PV, is HSDG generation with 20% of the daytime load satisfied by grid tied Solar PV. This shows that potentially a savings of 20% in daytime fuel use (REN => Blue box), plus again optimised evening fuel performance (HSDG > 70% => Green box), but again poor midnight fuel performance (HSDG > 70% => Red box).

Table 80. Table showing normalised synchronised HSDG hybrid options for a generic rural electrification generation site with high demands

						NORMALIZED GENERATION OPTIONS							
	Normal Load	Reference Max Load			HSDG >70%	**HSDG**	Performance window 50% -100%	**HSDG**	Performance window 50% -100%	% REN	**Solar PV**	**Wind**	**Battery UPS**
	100%	**130%**	**Max Load**	**HSDG Normal load**		**100**		**80**			**20**	**30**	**20**
	1 HSDG alone												
Day	100	130	180%	100%		100	100%	spare	X		0	0	0
Evening	70	91	143%	70%		70	70%	spare	X		0	0	0
Evening	70	91	114%	88%		spare	X	70	88%		0	0	0
Midnight	30	39	267%	38%		spare	X	30	38%		0	0	0
	2 HSDG + Solar PV					**100**		**80**			**20**	**30**	**20**
Day	100	130	200%	80%		80	80%	spare	X	20%	20%	0	0
Evening	70	91	114%	88%		spare	X	70	88%		0	0	0
Midnight	30	39	267%	38%		spare	X	30	38%		0	0	0
	3 HSDG + Solar PV + Wind					**100**		**80**			**20**	**30**	**20**
Day	100	130	230%	63%		spare	X	50	63%	50%	20%	30%	0
Evening	70	91	157%	50%		spare	X	40	50%	43%	0	30%	0
Midnight	30	39	367%	0%		spare	X	spare	X	100%	0	30%	0
	4 HSDG + Solar PV + Wind + Battery					**100**		**80**			**20**	**30**	**20**
Day	100	130	250%	38%		spare	X	30	38%	70%	20%	30%	20%
Evening	70	91	186%	25%		spare	X	20	25%	71%	0	30%	20%
Midnight	30	39	433%	0%		spare	X	spare	X	167%	0	30%	20%
	5 36% Size HSDG + Solar PV + Wind + Battery					40	Window	25	Window		20	30	20
Day	100	130	135%	38%		30	75%	spare	X	50%	20%	30%	20%
Evening	70	91	129%	40%		spare	X	20	80%	71%	0	30%	20%
Midnight	30	39	383%	0%		spare	X	spare	X	167%	0	30%	20%
	6 HSDG + Solar PV + Battery					**100**		**80**			**20**	**30**	**20**
Day	100	130	220%	75%		spare	X	60	75%	40%	20%	0	20%
Evening	70	91	143%	63%		spare	X	50	63%	29%	0	0	20%
Midnight	30	39	733%	13%		spare	X	10	13%	67%	0	0	20%
	7 43% Size HSDG + Solar PV + Battery					65	Window	12	Window		20	30	20
Day	100	130	117%	46%		60	92%	spare	X	40%	20%	0	20%
Evening	70	91	121%	38%		50	77%	spare	X	29%	0	0	20%
Midnight	30	39	323%	83%		spare	X	10	83%	67%	0	0	20%

Source: Unicon

The third grouping, HSDG + Solar PV + Wind, is the same original sized HSDG generation along with 20% and 30% of daytime load being satisfied by Solar PV and Wind turbines respectively. Here it is indicated that the REN generation, of Solar PV and Wind actually forces the HSDGs into operating less efficiently (HSDG > 70% => Brown box). The midnight generation is fully satisfied by REN (REN => Green box), but the daytime and evening forcing of the HSDG into less efficient operations also causes Wet

Stacking and further fuel and maintenance costs. In the fourth grouping, HSDG + Solar PV + Wind + Battery, the addition of battery storage can further exacerbate forcing of the HSDGs into poorer performance. Which in no way, is compensated for, by fully REN midnight generation.

In the fifth group, 36% Size HSDG + Solar PV + Wind + Battery, the sizing of the HSDG takes into account the hybrid REN components as part of the system design. Herein the sizing and therefore investment and fuel costs for the HSDGs are significantly reduced by 64%; which results in efficient HSDG generation from smaller HSDGs and significant REN contributions to overall electricity generation during Day, Evening and Midnight periods. Clearly this type of configuration is only worth implementing where good reliable wind is available.

Group six in Table 80, HSDG + Solar PV + Battery, uses the original HSDG sizes, and like group three results in overall poor performance with regard to fuel consumption and efficiency of HSDG generation. The last group seven, 43% Size HSDG + Solar PV + Battery, adapts the size of the 2 HSDG generators to REN components within the system. Again, similarly to group five, the sizing and therefore investment and fuel costs for the HSDGs are significantly reduced, herein by 57%; which results in efficient HSDG generation from smaller HSDGs and significant REN contributions to overall electricity generation during Day, Evening and Midnight periods. This type of configuration is well suited to those isolated localities where no wind is practicable.

<u>Hybrid electricity generation for contemporary rural small towns</u>

There are very cogent arguments for implementing rural electrification in small rural urban centres using hybrid generation:

- it permits the rural urban centres to provide more electricity for residents, for institutional facilities and services and commerce;
- provides electricity for daytime manufacturing and value adding activities, which result in employment, entrepreneurial stimulation and revenue creating activities for the urban community and its businesses;
- enhanced local productivity and quality of life has been shown to prevent rural flight to larger urban centres, build national and regional economies and to attract city residents to return to rural areas.

Electricity generation and distribution for rural urban centres creates isolated island networks, which generally use radial or longitudinal bus distribution for smaller towns and potentially a ring distribution network for larger townships.

As a rule, if distribution distances are less than 1 km from the generation source a LV distribution can be implemented. This results in an urban Mini-Grid. Longer distances will require distribution step up and step down transformers, and result in an electricity power grid that is an island distribution network.

Generation Example for Small Town

A generation example with load graphs for a generic rural small-town, of 20,000 inhabitants, using hybrid HSDG diesel generation and local grid-tied solar PV with battery storage, is shown below. The town has approximately 3,000 households, with a significant focus in the overall urban area for daytime value adding via electricity use by manufacturing, education, communications, institutions, construction and support for general commerce.

Example: Generic Rural small town – Hybrid HSDG + Local grid tied solar PV + Battery Storage for Rural town of 20,000 habitants with 3,333 households (6 person/home) and daytime value adding activity

- Optimised Hybrid HSDG + Solar PV + Battery
- Hybrid HSDG + Solar PV AC coupled grid tied system with Value Adding generation 800kW
- Average daily load 15.6 MWh/d
- Solar PV generates 900 kWp solar PV providing 4.56 MWh/d focused for daytime value adding activities combined with Battery storage
- HSDG (750kW + 3x250kW synchronised) can generate a maximum of 1.5 MW to provide 11.1 MWh/d
- Total 24 hour solar PV penetration 29%, Daytime solar PV penetration 42%
- PbA fluid filled batteries of 37,800Ah X 48V storage (6 banks of 24x2V (6,300Ah) batteries)
- provide a 25% DoD over 1.2 hour and 50% DoD over 2.4 hours. 15 year lifespan for Batteries at 20C
- Total community electricity use is 0.78 kWh/d capita = 285 kWh/y cap; HDI is 0.59

Largest Limitation to Further Electricity Generation Growth

The situation of large urban centres having multiple ESPs with multiple island radial distribution networks limits the development of larger electricity generation. The creation of urban distribution rings will permit better use of existing generation resources. It will permit larger less expensive generation expansion, based on electricity providers utilising their competencies to synchronise their generation to an urban distribution network and collaboratively assure the network's stability.

The key element required for capitalising on the benefits of renewable resources for electricity generation is mastering the necessary skills to synchronise the blending and management of hybrid electricity reserves. In addition; their generation distribution locally and thereafter further afield by transmission lines, when large scale generation sites are offered by specific geographic benefits.

Frontier Regions and Regional Partnerships

Frontier Region Electricity Generation Partnerships

As was noted in Annex 6, the situation of frontier communities is usually one of homologous communities either side of the frontier. The consequence of these side by side communities in their shared isolation from the government, national electricity infrastructure and poor transport access is that they create trans-frontier local electricity generation infrastructure.

The fact of them often having local familial and tribal affiliations means commercial and social interrelationships are facilitated across the frontier. These engagements are purposeful to maintain cohesiveness amongst the two communities in their shared isolation and to assist in the transfer of goods and services across the frontier. This phenomenon is an example of what is broadly transpiring within the country.

Expressly in the context of electricity generation, the modality is primarily distributed generation, where one or more ESPs evolve. In doing this, a series of dispersed independent distributions are constructed, which cannot satisfy more than a limited number of consumers and load size, to advance further the electricity distribution in an area needs to be collectivised and managed. This collectivisation poses the challenge of how will it be controlled.

Since the processes of familial and clan relationships has created effective and peaceful exchanges of commerce, social law and order and infrastructure support across the frontier, this needs to be built upon. In effect, these collective cooperative engagements are significant tools of peace and commerce. From game theory it is noted that tight constraints on collective goals is a potent actuator for collective solutions to specific goals.

In the specific sense of isolated communities and their electricity generation and delivery, it is beneficial to further encourage additional collective methodologies and partnerships to create a manager for the collective electricity load and distribution resource that is independent of the point source electricity generators. This would, in name and task, be an independent service operator for the electrical distribution infrastructure.

This will enable the creation of more electricity generation by independent power providers on a collective network and be better able to adapt their infrastructure into the future integration of the isolated communities into their respective national electricity networks. Not forgetting that Ethiopia and Somaliland have a common LV electricity system of 230VAC 50Hz.

Locally built and managed distribution networks are best suited to the collective needs of the parallel communities and enhance local peace and solidarity.

This same process of collective engagement by the commercial and social affiliations engaged in using and generating electricity, to create a collective distribution network is equally pertinent to the larger urban centres in Somaliland. As mentioned, earlier they can create an independent electricity service operator.

Electricity Import/Export

The prospects for enhancing national and regional economic development through establishing significant imports and exports of electricity are attractive. This is beyond the local exchange of electricity across the frontier because of collective cooperation by homologous communities with common interests. This will require the engagements of the main political and electricity generating institutions of the respective countries and the stakeholders in such endeavours.

The current electrical infrastructure of Somaliland currently does not have any transmission lines, nor collectively operated electricity distribution in any of the urban centres. The modality by which electricity generation has developed has been through distributed generation and dispersed distribution driven by small private enterprises.

This contrasts with the electricity generation modality in Ethiopia, which is one of a centralised national plan. The interests of Ethiopia in bringing transmission lines into Somaliland would be for the purposes of exporting their electricity and enhancing their electrical infrastructure. Moreover, such infrastructure must serve their socio-economic interests within and traversing another country, which could benefit the region as a whole if effective socio-economic reciprocity occurs.

In order for the urban centres of Somaliland to connect to and benefit from international transmission lines each urban centre requires a coordinated collective urban electricity network. Such a network must possess a distribution ring or nodes that can collectively handle the introduction of electricity generation from multiple suppliers.

If Somaliland wishes to participate in the reciprocal exchange of electricity with its neighbours, it has to create the electricity generation resources and capabilities to do so, such that they are economically competitive with their neighbours. Otherwise, they will become the recipients of the generation decisions and problems of distal generators, while ignoring a key necessity of having urban and local electricity generation infrastructure that provides for local resilience and adaptability to local conditions.

Modelling and Evaluation of Electricity Generation Expansion Projects

Proportion of Population Receiving Electricity

As mentioned in Annex 6 the proportion of urban populations accessing electricity, was only sampled through ESP generation surveys and energy usage by households, businesses and institutions. This data enabled estimates of median monthly per capita electricity consumption for Somaliland. These is 11.1 kWh / month person. This value when applied to annual per capita electricity use result in the median annual per capita electricity consumption is 133kWh (11.1x12) per capita year.

Moreover, when this value is applied to the estimated populations, it provides an estimate of the proportion of the urban populations served by ESPs. It is estimated that some 29% of the urban populations in Somaliland do not receive electricity from the surveyed ESPs. (uncertainties in data collected is compounded by three of the six Hargeysa ESPs not giving data).

Notwithstanding that population estimates for the country are known to be imprecise, the population of urban dwellers not being served by the larger ESPs is significant. Based on current estimates, some 770 thousand people within urban centres do not receive electricity from major ESPs.

The estimates calculated for median annual per capita electricity consumption permit a calculation of what is the current level of human development within Somaliland. The purpose of this is to determine an estimate of where is the country in the process of achieving a developed society and economy. A developed society bespeaks to a good quality of life for the majority of a country's citizens.

The Human Development Index (HDI) and the work that Alan D. Pasternak and others since, have demonstrated that failing to take human development needs and their link to electricity utilisation by a society, can seriously undermine planning for electricity requirements.

The HDI indicator is a UNEP index for the average achievement of each country in three basic areas of human development: Life Expectancy at birth (LE), Adult Literacy and School Enrolment (LS), and Standard of Living as measured by the Gross National Product per capita (GOP). HDI is a normalised scale from zero to one. Economies seen as "highly developed countries" are recognised as those with a HDI of 0.8-0.85. Greater values indicate a society as advanced industrialised.

Generation Modelling Accounting for Human Development

From the 2009 UNDP Human Development Report, nations are divided into three groups based on HDI levels:

- High human development economies (HHD) = HDI≥0.85;
- Medium human development economies (MHD) = 0.6≤HDI<0.85; and
- Low human development economies (LHD) = HDI<0.6.

The annual per capita use of electricity, Annual per Capita Electricity Consumption (ACEC), was shown by Pastemak (2,000) and others, that no country with an ACEC below 4,000 kWh (14.4 GJ) per person has an HDI of 0.9 or greater. Moreover, as ACEC increases above 4,000 kWh/annual capita, no significant increase in HDI is observed.

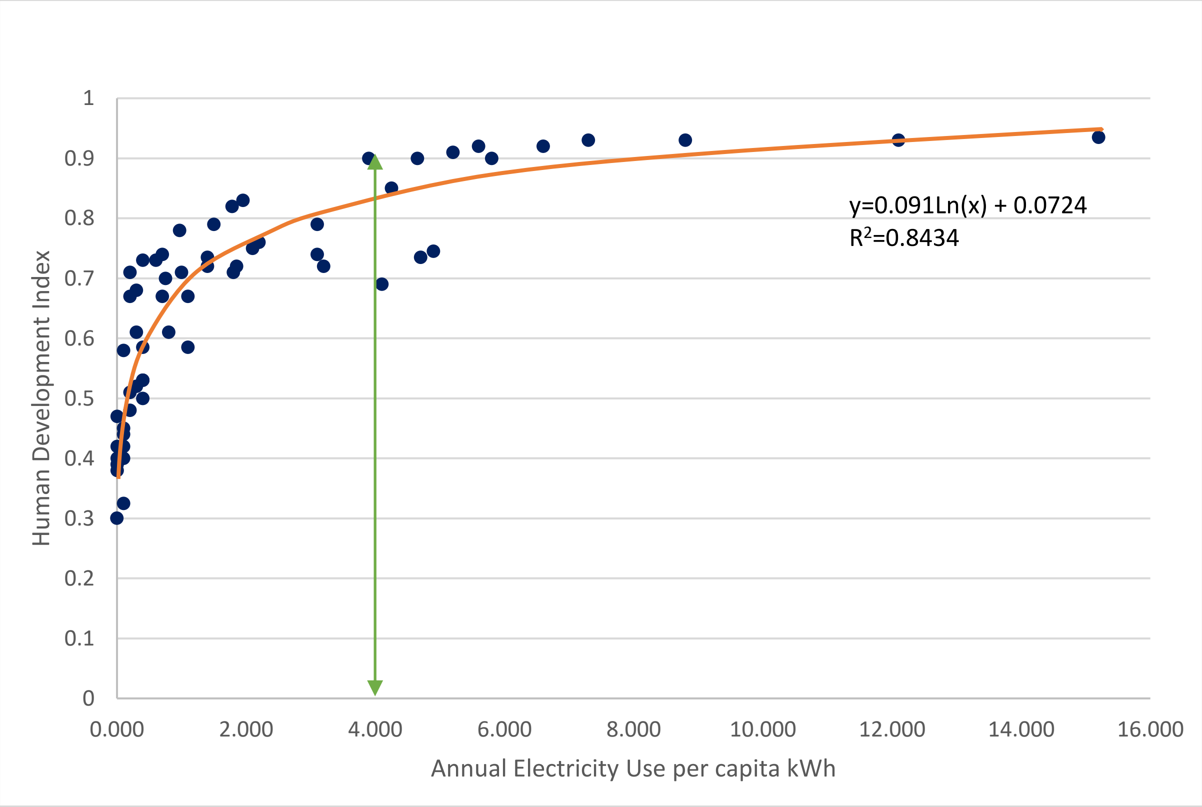
In fact, based on current global data the HDI becomes decoupled from electricity above 4,000 kWh/annual capita. Consequently, moving towards effective development, the maximum ACEC or generation should be constrained to an upper limit of 4,000 kWh per capita per year.

Applying the conclusions of the many studies on the linkage of electricity use to the HDI, and the equation derived by Pasternak, (HDI = 0.091 x Ln(ACEC) + 0.0724) it is identified that currently that currently Somaliland, with an ACEC of 133kWh/a capita, has a HDI of 0.52. Somaliland fall within the category of Low Human Development economies (LHD) = HDI<0.6.

Based on the constraint that Human Development decouples from electricity usage, above 4,000 kWh/annual capita, this value should be the maximum limit on generation for national consumption, and thereafter generation should be viewed with a perspective for commercially competitive exports to less developed regions or alternate markets, i.e. exports via transmission.

Figure 111 below provides a graph of HDI versus electricity use per capita. Table 81 summarises electricity generation requirements when constrained to HDI data estimates.

Figure 111. Graph of human development index to per capita annual electricity use (ACEC)



Note: 4,000kWh/Cap year cut-off and the descriptive equation

Source: Human Development Report 1999, UNDP

Table 81. Generation limits targeting national socio-economic development per the HDI and the electricity consumption expected by citizens of a well developed economy

Description	Somaliland
Estimated population	3,500,000
Estimated population in 10 years (2.9%/an)	4,677,496
Estimated population in 20 years (2.9%/an)	6,251,135
CURRENT Estimated per capita month use kWh/ cap month	11.1
CURRENT Estimated per capita annual use kWh/ cap year	133.2
Applying Paternal equation Current HDI	0.52
Current estimated generation by surveyed ESPs MWh/d	581.7
Current Generation potential with Automation and synchronisation MWh/d	1,635
Generation expected for HDI cut-off 4,000kWh/an cap MWh/day (fixed population)	38,356
Generation expected for HDI cut-off 4,000kWh/an cap MWh/day 10 years (2.9% growth population)	51,260
Generation expected for HDI cut-off 4,000kWh/an cap MWh/day 20 years (2.9% growth population)	68,506
Generation Capacity required at a 130% surge rate (fixed population) MW	2,078
Generation Capacity required at a 130% surge rate (2.9% growth population) 10 years MW	2,777
Generation Capacity required at a 130% surge rate (2.9% growth population) 20 years MW	3,711
Multiplication in Generation required after Automation and Synchronisation of current systems; to attain Developed society and economy: HDI of 0.85 (fixed population)	23
Multiplication in Generation required after Automation and Synchronisation of current systems; to attain Developed society and economy: HDI of 0.85 for 10 years (2.9% per annum population growth)	31
Multiplication in Generation required after Automation and Synchronisation of current systems; to attain Developed society and economy: HDI of 0.85 for 20 years (2.9% per annum population growth)	42

Description	Somaliland
Generation Capacity from which international Transmission lines would permit commercially competitive electricity exports to be made (fixed population) 10% extra MW	2,285

Source: Unicon

Assuming a Fixed Population

Extrapolating from optimised synchronised current electricity generation, Somaliland needs to expand current optimised synchronised electricity generation capacity to 2.1 GW, to provide its citizens with a socio-economically developed quality of life. Furthermore, Somaliland, once optimised to fully synchronised generation, should increase current generation of electricity for distribution by 20-30 times, in order that its citizens have a developed quality of life. Thereafter electricity generation is completely disposable for electricity exports.

Assuming a 2.9% Population Growth

Clearly, increases in population will actually raise generation requirements, but the actual electricity generation in Somaliland are not precisely known, because not all urban centres or ESPs provided data. Notwithstanding the above, the absence of data would lower the actual generation multiplier; a population increase of 2.9% per annum will raise the multiplier required for a society to attain a HDI of 0.85.

For a 10 year span the generation increase required, for a 2.9% annual population growth, must be in the order of 32-35% over the fixed rate, while for a similar 2.9% per annum population growth, during a 20 year span the generation increases must be in the order of 79-83% over the fixed rate.

It should also be noted that these observations indicate that implementation of energy efficiency programmes within a nation increases the rate of increase in HDI, with a commensurate faster realisation of elevated qualities of life for citizens.

The following key issues need to be considered in considering generation expansion projects:

- Significant distances in Somaliland;
- Growing size of urban centres due to rural flight aggravated by climate change;
- Importance of local urban ESPs to growth and development;
- Need to provide effective electricity generation for smaller urban centres to suppress over rapid growth of large urban centres;
- Need to reduce stress on fresh water resources and aquifers supplying large urban centres;

- Need to support the lifestyles of remote and pastoral communities in the face of ongoing climate changes.

Such projects should first raise electricity generation efficiency and thereafter augment generation growth through the increased use of synchronised renewables and thermal generation via hybrid generation. Generation growth should also be aligned towards clear long-term goals of combining large-scale storage and use of energy and water for enhancing the quality of life for citizens, enhancing economic growth and strengthening both agricultural and pastoral activities and reinvigorating regional eco-systems.

Conclusions Related to Generation Options

Based on the analysis in this chapter the generation options retained for meeting future load requirements are as follows:

- Improve the efficiency of existing generation by automation and synchronisation of generation units thereby reducing 'wet stacking';
- Convert existing generation to hybrid systems using solar photovoltaic installations;
- Consider the use of wind generation in zones with high wind potential:
  - Ensure that the implementation of such systems includes appropriate training to avoid repeating the mistakes made with earlier installations.
- New generation options retained include:
  - High speed diesel generators in size ranges from those existing in each system up to 2,000 kW;
  - Medium speed diesel generation in the common size ranges of 1,000 kW to 10,000 kW;
  - Simple gas turbines burning diesel fuel in size ranges of 1,000 to 10,000 kW;
  - Solar photovoltaic systems to be added to the fossil fuel generation;
  - Wind generation to be considered in high potential areas.

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