

Lesotho Energy Needs Assessment

Stakeholders Working in Silos

Draft Report

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SOUTHERN AFRICAN SUSTAINABLE ENERGY INITIATIVE (SASEI) Project

Department of Physics & Electronics – National University of Lesotho

Southern
African
Sustainable
Energy
Initiative



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List of Acronyms

AAP	Africa Adaptation Programme
BOS	Bureau of Statistics
DOE	Department of Energy
DSM	Demand Side Management
EE	Energy Efficiency
GHGs	Greenhouse Gases
GoL	Government of Lesotho
IPP	Independent Power Producer
LEC	Lesotho Electricity Company
LEMP	Lesotho Energy Master Plan
LEWA	Lesotho Electricity and Water Authority
LHWP	Lesotho Highlands Water Project
LMS	Lesotho Meteorological Services
LREBRE	Lesotho Renewable Energy Based Rural Electrification
NSDP	National Strategic Development Plan
NUL	National University of Lesotho
PPA	Power Purchase Agreements
PRS	Poverty Reduction Strategy
ProBEC	Programme for Biomass Energy Conservation
RE	Renewable Energy
RES	Renewable Energy Sources
RET	Renewable Energy Technologies
SACREEE	Southern African Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SASEI	SOUTHERN AFRICAN SUSTAINABLE ENERGY INITIATIVE (Edulink II – Project)
SE4ALL	Sustainable Energy For All
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

The National University of Lesotho (NUL) in collaboration with the University of Botswana (UB) and Polytechnic of Namibia (PON) are carrying out the Energy Sector Needs Assessment of their respective countries funded by the EU through the Edulink II – SASEI (SOUTHERN AFRICAN SUSTAINABLE ENERGY INITIATIVE) Project. The objective is to identify national priorities, challenges and tentative solutions. As academic institutions we aim to help in identifying solutions and even more crucially, help in implementing the solutions that have to do with human capital and knowledge dissemination.

The first stage we have undertaken in order to assess the energy situation in Lesotho is to analyse the published literature. This report is a summary of a diverse number of documents, a total of **49**, which are representative of the energy sector in Lesotho in terms of priorities, projects, challenges and solutions. This document shows that Lesotho's energy challenges are mind-boggling. These include the lack of: relevant policies; credible technical data to support existing policies, clean energy for the majority of rural population; sufficient grid electricity; institutional co-ordination; etc. Ironically there is a huge amount of literature especially desktop analysis and/or pre-feasibility consultancies carried out predominantly by foreign organisations/companies on behalf of local institutions/companies. This in itself implies that Lesotho's expertise (education & skills) levels are low and the situation is not being corrected by skills transfer through the various costly consultancies hence the vicious cycle continues.

The documents provide a number of interventions and solutions. Due to lack of effective co-ordination some challenges are analysed repeatedly with the same solutions recommended over and over through various costly studies. To avoid this, a number of consultancies including the 2007 GTZ funded Household Energy Access Strategy Report (Section H) recommended that a co-ordination secretariat be established and funded. Seven years later the secretariat is yet to be established.

For each set of documents analysed in this report, three main factors are shown, namely: **Findings/Priorities, Challenges and Solutions**. Solutions that the academic institution, NUL, can help with to address the challenges are prominently highlighted in **bold** and/or **red** font. Some of the recurring themes throughout the documents which can be addressed by academic institutions include:

- **Technical Data Availability:** this can be achieved through collaborative research in place of costly consultancies. The spin offs being human capital capacity building on the side of involved students/researchers and institution/company.
- **Training:** technology advances and changes hence both short frequent courses and degree courses are needed to address the low expertise pool
- **Co-ordination Secretariat/Centre:** Offer both online and hardcopy database services of all energy data and study reports. **It is hard to impossible to access literature or data produced in Lesotho.** Ironically everybody/institution/company complains about this issue yet the same people/institutions/companies refuse (or make it impossible) to give the data/literature they have.

We hope you will find the report informative and attend the related workshops so that we can all put our hands together and realistically solve the energy needs of Lesotho.

A: SADC & Lesotho Government General Documents

Summary

This review has looked into a number of energy-related documents covering:

- Publications from the regional body SADC, of which Lesotho is a Member State and signatory to its energy initiatives, aimed at enhancing socio-economic development, regional integration and energy security
- Government of Lesotho documents formulating medium to long-term strategies for poverty reduction and national economic growth through development of key energy/electricity infrastructure, enhancement of skills base, appropriate technology adoption and building effective institutions
- Primary and secondary legislation related to the national energy/electricity sector regulation, together with other publications that prescribe strategies, guidelines, processes and procedures towards attaining security of supply in electricity

The challenges emerging out of the review are cross-cutting and can be summarized as follows:

- Lack of national policy on energy (including renewable energy) which inhibits promotion of sustainable energy technologies and anchoring of new regulatory instruments (guidelines for IPPs and PPAs) for private participation, posing a threat to security of supply options in electricity
- Lack of appropriate human resources development and individual/institutional capacity to effectively implement and monitor sustainable energy programs
- Lack of financial resources and political will to support promotion of collaborative scientific research and development (to encourage knowledge transfer in and adoption of green energy technologies)
- Lack of access to information, public awareness and education with regard to sustainable energy as a measure/strategy towards climate change mitigation and provision of energy security

Key recommendations, for the role that *academia* can play in addressing the above challenges, are:

- Collaboration with the Department of Energy in developing a comprehensive national Energy Policy to strengthen the regulatory and institutional frameworks for a coordinated approach to sustainable energy strategy formulation and planning, investment attraction, pro-poor pricing, etc
- Development of relevant sustainable energy content/curriculum and targeted education, training and capacity building programs (e.g. short courses, modules in current under-graduate programs, full-fledged postgraduate program in Sustainable Energy, etc) to empower different stakeholder sectors (policy-makers, regulator, network operators, managers, economists, scientists, engineers, technicians, etc)
- Establishment of an effective and efficient knowledge management system (e.g. Energy Research Centre at NUL) for comprehensive baseline studies on energy access, long-term research and development of low-cost and cleaner energy technologies, data collection, management and dissemination, and monitoring and evaluation to inform future strategies and policy revisions

1. SADC Protocol on Energy 1996

1.1 Aim / Objectives

The SADC Protocol on Energy recognized the need for a coordinated approach to **energy strategy formulation and planning** for the SADC region and intended to promote the harmonious **development of national energy policies** and matters of common interest for the balanced and equitable development of energy throughout the SADC region. General principles of the protocol for Member States included using energy to support economic growth and development, **encouraging development and transfer of science and technology** related to energy through the **promotion of scientific research and development**, ensuring that the development and use of energy is environmentally sound and creating a conducive environment for the private sector to participate fully in energy development in the region.

The protocol further identified several objectives including co-operation in the development of energy and energy pooling to ensure security and reliability of energy supply and minimization of costs, **promotion of joint development of human resources and organization capacity building in the energy sector and co-operation in the research, development, adaptation and dissemination and transfer of low cost energy technologies**. It envisioned the establishment of a Commission with the Technical Unit to coordinate regional energy activities in support of regional integration and socio-economic development. Different energy sub-sectors of interest, although not exclusive, were identified as electricity, petroleum, natural gas, coal, wood fuel, new and renewable energy sources, energy efficiency and conservation.

1.2 Major priorities

- Coordinated approach to energy policy, strategy and plans
- Establishment and maintenance of energy database and facilitation of information exchange
- Formulate and implement strategies for **human resource development** in the energy sector
- Mobilize finance for implementing energy programmes and projects
- Promote **research and development** in the energy sector

2. SADC Regional Energy Access Strategy and Action Plan 2010

2.1 Aim / Objectives

The SADC Regional Energy Access Strategy aimed to support and complement Member States' endeavours to have as a strategic goal the harnessing of regional energy resources to ensure, through national and regional action, that all the people of the SADC Region have **access to adequate, reliable, least cost, environmentally sustainable energy services**. At the operational level, the goal is to endeavour to halve the proportion of people without such access within 10 years for each end-use and halve again in successive 5 year periods until there is universal access for all end-uses (lighting, power and heat).

2.2 Major strategic framework elements:

- **Statistics** – accurate quantitative information on energy access
- Applications – focus on energy end-uses rather than technologies
- Biomass – recognition of the dominant role of biomass
- Prices – cost-reflective but competitive prices
- Subsidies– prioritize access over consumption subsidies
- Development – focus on use of energy to enhance economic productivity for poverty reduction and enhanced quality of life
- **Capacity** – ability and willingness to implement, operate and maintain energy access projects and programs

2.3 Conclusions

- **Capacity building** for managerial and technical skills (involving institutional and individual skills development) required to implement low-cost technologies(energy access projects and programs)
- Need to develop capacity to undertake the necessary engineering analysis and planning work to optimize network and equipment design
- **Research and development** focused on adapting production of technologies to local needs and capabilities will not only create employment, but ensure spare parts are readily available

3. SADC Regional Infrastructure Development Master Plan – Energy Sector Plan 2012

3.1 Aim / Objectives

The SADC Energy Sector Plan aims to define regional infrastructure requirements and conditions to facilitate the realization of key infrastructure in the energy sector by 2027. It covers electricity, petroleum and gas, coal, renewable energy, nuclear energy, energy efficiency and climate change sub-sectors. Such infrastructure would enable the SADC region to attain regional integration, economic growth, poverty eradication and achieving environmental sustainability.

3.2 Main areas of consideration

- 'Hard' infrastructure projects
 - Electricity generation plants, transmission lines, petroleum and gas refineries, pipelines, storage reserves, coal depots, nuclear demo plants
- 'Soft' interventions
 - Required policies and strategies, regulatory frameworks, institutional arrangements and **capacity building**, financing and cooperation / collaboration

3.3 Conclusions

- **Capacity building programs** necessary to empower institutions to coordinate and develop projects, including the **creation of data management systems** for planning
- Support for **research and development and testing facilities** for renewable energy low cost technologies

4. Southern African Centre for Renewable Energy and Energy Efficiency (SACREEE): Project Document 2013

4.1 Aim / Objectives

This document proposes, in line with the Energy Sector Plan above, the establishment of the Southern African Centre for Renewable Energy and Energy Efficiency (SACREEE) in July/August 2014, for a more coordinated approach to the needs for greater investment in all SADC Member States, in a wide range of **renewable energy technologies** and in improving **energy efficiency**. The draft Project Document presents a comprehensive proposal for the initial governance structure, mandate and activities, scope, and institutional nature of the Centre, together with a start-up programme and indicative budget for the first three years of operation.

4.2 SACREE plans to concentrate on the following enabling factors:

- energy planning and policies
- business models and technical innovation
- finance and risk management
- **capacity building and knowledge management**
- facilitate **“train the trainer” workshops** in existing education and training institutions, using local, regional and international experts, at all levels, including vocational training
- development of a programme of calls for proposals and subsequent funding for quality regional **collaborative research and development** projects in the field of RE & EE

4.3 Conclusions

- coordinate information and **capacity building** in training and policy advice
- outsource most of its technical assistance and capacity building activities to experts from the region and internationally

5. Lesotho Vision 2020

5.1 Aim / Objectives

The Lesotho's Vision 2020 was formulated in 2000 to establish long-term vision for the country up to the year 2020. It identifies seven pillars of national development as democracy, unity, peace, **education and training**, economic growth, **environment management** and **technology advancement**. The Vision is that: "By the year 2020 Lesotho shall be a stable democracy, a united and prosperous nation at peace with itself and its neighbours. It shall have a healthy and well-developed human resource base. Its economy will be strong, its environment well managed and its technology well established."

The vision notes the challenge that renewable energy technologies upon which the majority of Basotho people depend and which are environmentally friendly, supply very little energy in the country.

5.2 Energy-related Priorities

- **Develop curriculum** that responds to the national development priorities
- Component 5 – A strong economy and prosperous nation: A proper economic infrastructure, including **electricity networks**, will be established (Section 2.3.5)
- Component 6 – A well managed environment: **Renewable energy technologies** upon which majority of Basotho people depend and which are environmentally friendly, supply very little energy in the country (Section 3.2.6)
- Component 7 – A well advanced technology: **90%** of Basotho households will have **access to electricity** (Section 2.3.7)
- Matrix 5.9 (Strategic Action no. 8): **Promote use of renewable energy resources**

5.3 Conclusions

- Strengthening development management capacity (improving research capacity, coordinating information management systems, etc)
- Strengthening science and technology education, as well as promoting science and technology research, innovation and development

6. Lesotho Poverty Reduction Strategy

6.1 Aim / Objectives

The Lesotho Poverty Reduction Strategy, first drafted in 2000 (poverty reduction strategy paper) and finalized in 2004 as a 3-year development framework (2004/05 – 2006/07), reflected an ongoing effort by the Government of Lesotho to formulate a comprehensive poverty reduction strategy (PRS) and to identify the steps to be taken in formulating such a strategy through a participatory process. The PRS outlines national priorities, prepares situational analysis, and gives strategies and activities for promoting economic growth and reducing poverty as a first step towards the implementation of Vision 2020. The objective was to promote poverty reduction strategies that are country-driven, results-oriented, comprehensive, partnership-based and framed within a medium term macro-economic strategy.

Among challenges noted under infrastructure development, Lesotho experiences **energy shortage**, relies on biomass leading to depletion of reserves and has limited access to electricity, with most connections found in the lowlands. *“In short, energy is both an environmental and a poverty issue – and one which the Government of Lesotho is determined to tackle.”*

6.2 Energy-related Issues

- Objectives, 6.2: Increase access to clean and affordable energy supplies
- Proposed strategies, 3(g) and 6.3.5: Develop and implement National Rural Electrification Programme (rural electrification masterplan, electricity access pilot projects, national rural electrification fund) to improve access to energy
- Introduce appropriate reform measures; **develop institutional capacities** and energy service delivery in rural areas (establish regulator and rural electrification unit, complete LEC privatization and the financial restructuring of ‘Muela Hydropower Plant, and develop **training plan for capacity building** of electricity institutions and their stakeholders)
- **Promote use of renewable energy for sustainable development**

7. Lesotho National Strategic Development Plan

7.1 Aim / Objectives

The National Strategic Development Plan (NSDP) is a successor to the Poverty Reduction Strategy above and also serves to implement the National Vision 2020 for the fiscal years 2012/13 – 2016/17. The NSDP strategic goals will be to: (I) Pursue high, shared and employment creating economic growth; (II) Develop key infrastructure; (III) Enhance the skills base, technology adoption and foundation for innovation; (IV) Improve health, combat HIV and AIDS and reduce vulnerability; (V) Reverse environmental degradation and adapt to climate change; and (VI) Promote peace, democratic governance and build effective institutions.

7.2 Energy and climate change related issues

(Sections 5.2.3 and 5.5)

- Revamp electricity distribution network to improve safety and reliability
- Expand connections to households and potential growth areas (e.g. mines, etc)
- Mobilize resources to tap established potential of 1785 MW wind power and 1200 MW hydro-power / pump storage
- **Promote use of solar energy** and other potential niche energy markets, especially in remote off-grid areas
- Scale-up efforts to **promote energy efficiency**, including safe and **efficient use of bio-fuels**
- Develop a medium-long term strategy for improving **national energy security**
- Increase cost-effective and **clean energy production capacity**
- **Promote research** and private participation in green technology development (solar, etc)
- Explore opportunities for carbon trading

7.3 Conclusions

- **It is critical that capacity is developed** to explore small-scale electricity generation models that are viable for communities, where connection to the national power grid is not cost-effective
- Find ways and means to **improve the scientific capacity** to assess climate change vulnerabilities and adaptation, and generate and communicate information that is useful for adaptation planning and action

8. Lesotho's National Communication to the Conference of Parties (CoP) of the United Nations Framework Convention on Climate Change (UNFCCC)

8.1 Aim / Objectives

As a Party to the UNFCCC, Lesotho first prepared and submitted its Initial National Communication (INC) to CoP in 2000 and the Second National Communication (SNC) in 2013 to communicate policies and measures the country has taken towards implementation of the Convention. The SNC, particularly, highlights Lesotho's efforts in areas of mitigating climate change and adaptation to the impacts thereof. The report also includes greenhouse gases (GHGs) inventories for 1995-2000 (base year 2000), and addresses pertinent issues, particularly with regard to public awareness, **technology transfer** and **capacity building needs** as well as gaps, constraints and recommendations.

8.2 Energy-related Adaptation Measures and Strategies

- Accessing reliable and user-friendly sources of energy
- Fast-track solar and wind energy installations and expansion of electricity grid
- Revision of electrification targets (2015:40%, 2020:50%, 2030:60%) to allow more Basotho access to clean energy for lighting, heating and cooking
- Dissemination of solar home systems to reduce the use of paraffin for lighting
- Main thrust of energy policies is conservation, involving more efficient energy use, and import substitution, particularly involving the promotion of renewable sources of energy (hydro-power, solar, wind sources)
- Developing information and education materials on energy efficiency in the transport sector

8.3 Conclusions

- To-date, energy remains a delicate and high priority issue in the country
- Government is committed to promote the use of cleaner energy sources and technologies
- **Capacity building** on energy and climate change within institutions – including human resources, appropriate technologies and other material resources

9. Stakeholder Capacity Development Assessment Needs in Climate Change Adaptation – Lesotho (Draft) – September 2011

9.1 Aim / Objectives

This project was designed to identify priority capacity needs for adaptation to climate change in Lesotho to **facilitate implementation of capacity development and training needs** in the various stakeholder sectors to address the effects of climate change in the country. Lesotho's national capacity self assessment process **has identified the need to address policy, institutional and legislative gaps**. The most serious challenges relate to budgetary limitations, institutional and cultural rigidities and technological limitations. A lack of political will on the part of the political elite also prevents effective administrative reforms for enhancing the state's capacity to implement climate change related policies.

9.2 Key findings

- **No curriculum or courses exist in our academic institutions** that deal directly with climate change or energy issues (some research in renewable energy at NUL and content in sporadic subjects available)
- Lack of finance for research, lack of appropriate human resources
- **Lack of policy on renewable energy**, making it difficult for government to prioritize the issue at national level
- Lack of climate change policy to guide the way forward and justify allocation of funds from the national budget
- Lack of implementation and follow-through of programs
- Need for capacity to develop project proposals so as to have access to international opportunities

10.Regulatory Instruments

10.1 Legislation

The Lesotho Electricity Authority (LEA) 2002 Act (as amended) provided for the establishment of the Lesotho Electricity Authority (later transformed to Lesotho Electricity and Water Authority – LEWA)

- Regulation and supervision of activities in the electricity sector, extended to urban water and sewerage services in 2011
- Application for a license to generate, transmit, distribute and supply or import and export electricity
- Licensing (Rules, 2012)

Quality of Service and Supply Standards (QoSSS)

- Processing of requests for supply, credit and prepayment metering, handling network faults, customer complaints and enquiries, communication and **customer education**
- Frequency of supply voltage, voltage regulation, voltage unbalance, **inter-utilities interfacing**

Guidelines on efficient use of electricity (for residential sector and for industrial and commercial sectors)

- **Energy management** guidelines for residences and industry (human behaviour, operational / organizational and technical)
- Educating the public on **energy efficiency** in general

10.2 Regulator's Strategic Plan (2014/15 – 2018/19)

- Formulate pro-poor pricing mechanism for electricity (proposes inclined block tariffs)
- Determine security of supply options in electricity
- Review and identify gaps in the current regulatory framework
- **Develop guidelines for IPP's (independent power producers) and PPA's (power purchase agreements)**

Operational challenges identified:

- **Lack of a national energy policy** on which new regulatory instruments would be anchored
- Non-compliance by licensees
- **Developing appropriate regulatory skills**

10.3 Lesotho Transmission Grid Code (Draft)

- Aims to fully cater for grid integration of generation from other intermittent **renewable energy sources** (hydro, wind and solar)

- Covers governance, connection, performance standards, planning, operations, metering, protection and information exchange codes

References:

- [1] SADC Protocol on Energy 1996
- [2] SADC Regional Energy Access Strategy and Action Plan 2010
- [3] SADC Regional Infrastructure Development Master Plan – Energy Sector Plan 2012
- [4] Southern African Centre for Renewable Energy and Energy Efficiency (SACREEE): Project Document 2013
- [5] Lesotho Vision 2020
- [6] Lesotho Poverty Reduction Strategy
- [7] Lesotho National Strategic Development Plan
- [8] Lesotho’s National Communication to the Conference of Parties (CoP) of the United Nations Framework Convention on Climate Change (UNFCCC)
- [9] Stakeholder Capacity Development Assessment Needs in Climate Change Adaptation – Lesotho (Draft) – September 2011
- [10] Lesotho Electricity Authority (LEA) 2002 Act (as amended)
- [11] LEA Quality of Service and Supply Standards (QoSSS)
- [12] Lesotho Transmission Grid Code (Draft)

B: Lesotho Renewable Energy Policy 2013

Background

The Government of Lesotho believes that renewable energy could play an increased role in the country's energy mix augmenting the hydro power generation and providing energy solutions in rural Lesotho where 74% people live without access to modern forms of energy. However the efforts to develop the renewable energy sources in Lesotho have so far been constrained by the absence of a policy framework promoting renewable energy. Lesotho has good renewable energy resources; the hydro power potential in the country is estimated at 14,000 MW. Lesotho also has good solar energy resources with over 300 sunny days in a year with annual average insolation levels of 5.25 – 5.53 kWh/m²/year. The country also has good wind energy resources with measured annual average wind speeds of 3.7 to 4.7 m/s/year at 10 m heights. Renewable energy sources have the potential to play an increased role in the country increasing the energy access rate and displacing imported fuels. The Lesotho Renewable Energy Policy (LesREP) is expected to significantly increase the use of renewable energy in the country.

6.0 POLICY MEASURES

Renewable Electricity

6.1 All renewable electricity generators will have guaranteed access to the Electricity grid in Lesotho. Renewable Energy Generators of less than 500 kW will have guaranteed access to the distribution network and those above 500 kW will have guaranteed access to the transmission network;

6.2 Renewable Electricity Generators of a size of less than 500 kW will be offered a net-metering scheme where the customer will only pay for the net energy consumption. Each kWh of renewable electricity exported to the low voltage network will be treated as 1.13 kWh to account for the Transmission and Distribution (T&D) losses of LEC.

6.3 Renewable electricity generators above 500 kW would be offered a feed-in-tariff. The price discovery will be through a reverse bidding process by technically qualified bidders. The government will invite bids for specified amounts of renewable energy capacity additions and will have a procedure to assess the technical feasibility of the bids and qualify a minimum of three bidders¹⁰. The technically qualified bidders who offer the lowest feed-in-tariffs would be offered a power purchase contract by the energy utility -LEC.

NUL can participate in the development of Feed-in-tariffs

8.0 TECHNICAL STANDARDS AND QUALITY ASSURANCE

8.1 The Department of Standards and Quality Assurance (DSQA) will establish the national standardization and quality assurance frame work at the earliest and become a member of the IEC.

8.2 Lesotho will start using the 123 IEC and ISO standards for assuring the technical performance of renewable energy equipment which is important into the country. Where manufacturers are based in South Africa the relevant SANS standards can be used.

8.3 Once a an accreditation body is established under the national standardization and quality assurance framework, the accreditation body will accredit test labs in the countries which are major sources of renewable energy equipment to Lesotho;

8.4 Once the standardization body is established it should harmonize relevant IEC and ISO standards as Lesotho national standards and replace the IEC and ISO standards which are in use. Equipment can then be tested and certified against Lesotho national standards in the countries of origin;

8.5 Once a national laboratory for testing and certification is established, Lesotho may require that renewable energy equipment to be imported into the country be tested and certified in the national laboratory in Lesotho, starting with larger projects and initiatives;

8.6 Once the Lesotho national standards for renewables and the national laboratory is in place, the government should initiate an effort for encouraging local manufacture of renewable energy equipment starting with low-tech

8.9 National University of Lesotho (NUL), Lerotholi Polytechnic and Bethel Business and Community Development Centre (BBCDC) will be supported by the government to strengthen the existing technical training programmes to increase the number of technicians trained and improve the quality of education through accreditation to international technical and vocational training quality frameworks.

References:

[1] Lesotho Renewable Energy Policy 2013

Lesotho Power Generation Master Plan (2011?)

Executive Summary:

The master plan is aimed at advising LEC on Lesotho's power generation potential. The renewable sources under this study are **hydro, wind** and **solar**. A number of documents (Draft Energy Policy, Lesotho National Electricity Master Plan, etc) were used to inform this study.

The study estimated Lesotho's potential installed power capacity of about 360 MW from hydro, 40 MW from solar (both PV and CSP) and 750 MW from wind. What is needed now is follow up in the form of feasibility studies of the identified potentials which will inform the ultimate realisation of the power. One of the main challenges identified by the study is the ownership model as the financing of the projects will definitely depend on who is charged to do what. For example, is LEC going to build, operate, own and finance the projects?

<p>Priorities/Findings/Issues (Energy use in the country, current state of affairs, supply, demand)</p> <p>Hydro [2]:</p> <ul style="list-style-type: none"> * Resources estimated at 361 MW * Proposed schemes: Senqu, Makhaleng and Mokhotlong Rivers, and their tributaries, being the Hlotse, Putiatsana, Khubelu, Mokhotlong, Tsoelike, Makhaleng and Quthing Rivers. * Single stage hydropower stations identified on the Hlotse, Putiatsana, Khubelu, Mokhotlong and Tsoelike * Four stage cascades on Makhaleng and two stage cascades on Senqu. * Feasible to construct an 1800 MW (generation regime) pump storage plant on the Quthing River. <p>Solar [4]:</p> <ul style="list-style-type: none"> * PV Potentials: Maseru 20 MW; Hlotse 2 MW; Mafeteng 2 MW; Maputsoe 1 MW; Mohale's Hoek 5 MW. Cost: R24.00 per watt. * CSP Potentials: Maseru 10 MW. Cost R100m upfront capital <p>Wind [5]:</p> <ul style="list-style-type: none"> * Total estimated capacity is 758MW * 5 km resolution mesoscale map produced with data from 3Tier * Fifteen wind farm sites from 20 MW to 134 MW were identified within the three Regions of Potential Development based on a 2 MW wind turbine, considering a 90 m rotor diameter 	<p>Challenges (constraints, global warming and climate change)</p> <p>The documents relating to technical information and data are not to the same comprehensive level as the policies [1].</p> <p>Some source data, if not available at all, may set the generation master plan exercise back. This will be due to additional time and financial resources necessary to solicit data needed [1].</p> <p>INFORMATION GAPS:</p> <p>Comprehensive reports of all treaties; Detailed hydrological data; wind atlas; comprehensive solar radiation data [1]</p> <p>Education levels in Lesotho are low, with the education system focusing on the provision of primary education [3].</p> <p>Duplication of expensive wind mesoscale maps as AAP project engaged the Danish WAsP (Wind Atlas Analysis and Application Program) team to produce the map</p> <p>Ownership [6]: Government should specialize in planning, structuring, and regulation while the private sector should specialize in management, investment, construction and financing. Unbundling and the introduction of competition may be undertaken through Power Purchase Agreements (PPA) with private sector entities.</p> <p>Finance: The source of financing depends on the ownership model to be explored</p> <p>Acquisition of data:</p> <p>Solar and wind micro-measurements by Africa Adaptation Program/Lesotho Meteorology Services sites: Ideal optimal locations with regard to the LPGM findings?</p>	<p>Implementation/ Solutions</p> <p>Co-ordination: Different stakeholders engaging different consultants to carry out exactly the same type of analysis; Optimal location of sites for studies</p> <p>Research: Lack of comprehensive technical data</p> <p>Research studies as opposed to consultancies hence build capacity</p> <p>Training: Education levels low; New and advancing technologies</p> <p>Central data source: Avoid data inaccessibility and duplication</p> <p>Ownership Policy: With regard to power who is expected to do what? Enabling environment for private sector involvement and competition?</p> <p>Policies: should be backed by credible comprehensive technical data to make them viable</p>
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References

- [1] Lesotho Power Generation Master Plan (LPGMP): Document Review Final Report Rev 1
- [2] LPGMP: Volume 1 - Part 1.1 Hydro Power Generation Option
- [3] LPGMP: Final Milestones Report -Volume 3 - Economical report -25-7-11
- [4] LPGMP: Volume 1 - Part 1. 3 Solar Power Generation Option
- [5] LPGMP: Volume 1 - Part 1.2 Wind Power Generation Option
- [6] LPGMP: Final Milestones report - Volume 4 - Ownership and Funding 25-7-11

D: Sustainable Energy For All (SE4ALL)

OBJECTIVE

The purpose of Rapid Assessment and Gap Analysis is to provide:

- A quick brief look of the energy situation in the country within the context of its economic and social development and poverty eradication
- A good review of where the country is in terms of the three SE4ALL goals, and
- A good estimate of the main challenges and opportunities vis-à-vis the three goals of SE4ALL where the major investments, policies and enabling environments will be required
- A sound basis and background for an Action Plan that may follow as part of the SE4ALL activities in the country

EXECUTIVE SUMMARY

A brief summary of key findings and conclusions, i.e. current situation in terms of three SE4ALL goals, main challenges, opportunities and requirements for achievement of national goals and the effects that addressing these could have on the social and economic situation in the country

The key gaps, barriers and additional requirements to achieve SE4All in thermal energy applications, power sector and modern energy for productive use are as follows;

- Absence of an approved policy and strategy for energy, renewable energy and energy efficiency promotion
- Lack of data for proper analysis of the energy sector.
- Fragmented institutional and legal framework
- Lack of private investment in modern energy supplies and technologies for cooking and other thermal applications Barriers to private investment in new on-grid and off-grid power generation capacity (especially for RES), grid extension/maintenance, demand-side management (DSM) and energy efficiencyModern energy for productive sectors:
- Barriers to private investment in modern energy for productive and socio-economic uses with a focus on energy efficient and renewable energy technologies and solutions

Section 3: Challenges and opportunities for achieving SE4ALL goals

There are no national institutions for promoting alternative energy fuels such as LPG and the efficient use of biomass. This function has been left with the private sector and NGOs. The price of paraffin is set by the NPF and the price of LPG is left to the private sector.

- *Relevant targets, policies, strategies, plans*
The only target for household energy use is the electricity access of 35% by 2015 and 40% by 2020. Besides these there are no national targets or plans for increasing the uptake of energy sources that can be used for thermal applications at household level such as LPG. In addition, there are also no national targets for the promotion of energy efficient biomass cooking devices at household level.

Barriers

According to UNDP Lesotho, the main barriers that hamper the large-scale utilisation of RETs in Lesotho can be classified into four categories, i.e.:-

1. Institutional
 - Lack of an effective infrastructure for RET services on a sustainable basis
 - Fragmented institutional responsibilities and lack of integrated planning
2. Economic, commercial and market
 - Small potential market
 - Limited private sector capacity supply, distribution, installation and maintenance of RETs
 - Limited business skills
 - Lack of suitable financing arrangements for renewable energy companies end users
 - Low income levels of rural population
3. Technical and information
 - Poor workmanship in the installation, operation and maintenance of RETs
 - Lack of skilled manpower
 - Inaccessibility of the rural population to service centres and towns
4. Education and training
 - Lack of access to necessary information
 - Lack of public awareness of the technologies
 - Lack of trained manpower at all levels
 - Insufficient qualified personnel for maintenance for renewable energy systems

The key barriers to sustainable energy for all in Lesotho are:-

- Poor Policy and Legal framework as evidenced by the absence of an approved policy and strategy for energy, renewable energy and energy efficiency promotion
- Lack of data for proper analysis of the energy sector.
- Fragmented institutional and legal framework
- Lack of private investment in modern energy supplies and technologies for cooking and other thermal applications Barriers to private investment in new on-grid and off-grid power generation capacity (especially for RES), grid extension/maintenance, demand-side management (DSM) and energy efficiencyModern energy for productive sectors:
- Barriers to private investment in modern energy for productive and socio-economic uses with a focus on energy efficient and renewable energy technologies and solutions
- Lack of financial arrangements for RET supply companies and lack of access to finance by the users
- Low income by rural populations
- Lack of data is a significant barrier to the analysis of the sector and for planning.
- Lack of Skilled Manpower
- Lack of Business skills
- Low awareness about RETs and access to information on RETs.

References:

- [1] Technical Report: RERA Publication on Electricity Tariffs & Selected Performance Indicators for the SADC Region, 2009
- [2] Financing renewable energy in developing countries, Drivers and barriers for private finance in sub-Saharan Africa, UNEP. February 2012.
- [3] Renewable Energy Technologies In Southern Africa, A Guide For Investors, September 1999
- [4] Renewable and Sustainable Energy Reviews 16 (2012) 973 – 980

E: Assessment of Energy for Rural Development in Lesotho

This section documents features of the Energy Sector in Lesotho. It covers a stakeholder analysis that includes key actors such as user groups, civil society, financiers and developers. It also covers a problem analysis of the sector with particular attention to rural areas, giving a perspective on how the problems affect men, women and children.

Summary of Key Problem Areas

The foremost problem facing the energy sector is lack of adopted policy and accompanying strategies. The Draft energy policy was developed in 2003 and suffers two drawbacks. It remains a draft to date with no supporting *de jure* master plans or strategies, and while it is primitive it is biased towards commercial energies in terms of focus. Demand and supply side data used for analysis in the policy document was acquired more than 30 years ago during development of the Lesotho Energy Master Plan (LEMP) and therefore it does not cover recent developments including new institutions and their roles and current levels of energy supply and energy demand, among other issues

Another propagating factor is ignorance. This may not come across as clear given that Lesotho has an 87% adult literacy rate (BOS, 2009). However, it is 'energy literacy' that is being referred to. Knowledge of alternative energy sources, energy efficiency and energy management techniques, energy technologies and basics for use of energy appliances remain a challenge in the rural areas.

Problems facing the energy sector are further exacerbated by the socioeconomic conditions in the rural areas including the incidence of poverty and lack of energy information.

Rural communities are affected by being forced to depend on inferior energy technologies that are harmful to health, the environment and that threaten biodiversity.

Unsecure energy supply is another problem area. The country relies on imported power to manage a peak electricity supply deficit of that reached 66 MW in 2010 for a peak demand of 138 MW against installed capacity of only 72 MW. Power is imported from EDM, Mozambique and Eskom, South Africa. On the same note, 100% of petroleum products (petrol, diesel, paraffin, jet fuel and LPGas) are imported from South Africa. Having no local coal reserves, the country also imports from South Africa for all coal demand. These imports contribute to inflated energy prices, proneness to low coverage, the disadvantages of a poor yet consumptive economy and yet reliance on biomass.

Table 1: Summary of Challenges Facing the Energy Sector

Sector	Nature of challenges
Household sector	to increase the choice of affordable energy options; to reduce indoor pollution resulting from the burning of biomass; to provide information on alternative energy sources; and to promote thermally-efficient dwellings.

Transport	to reduce pollution from vehicle exhausts; and to establish a reliable fuel supply.
Industry/Commerce/Government	to ensure competitive energy pricing; and to promote the efficient use of available energy
Biomass energy	to improve availability of biomass resources; to promote sustainable use of biomass resources; to protect and improve management of indigenous trees and shrubs; and to compile and update a data bank on availability and utilization of biomass resources.
Petroleum products	to regulate coal imports; to promote awareness of alternative sources of energy; to reduce pollution resulting from coal combustion; to ensure availability and fair pricing of petroleum products; to ensure awareness of LP gas and paraffin; and to ensure participation by locals in the petroleum sector.
Electricity	to increase the level of electrification generation; to increase the level of electrification; to promote energy efficiency and safe use of electricity; and to harvest benefits of regional cooperation.
Other renewable energies	to make renewable technologies more affordable and accessible; to improve information dissemination and public awareness; to reduce theft and vandalism of PV panels; and to develop and enforce standards of renewable energy systems.

Source: Energy Policy Framework for the Kingdom of Lesotho (2002), Mhlanga (2004)

Energy Management and by-products/waste disposal programme

Replacement of light bulbs in households, installations of solar water heaters in institutions, energy auditing introduce time-of-use tariffs for all consumer groups. Phase out incandescent bulbs and promote energy saving bulbs especially LEDs Phase out bar heaters and promote oil heaters; Install solar water heaters in new houses and institutional buildings; Solar street lighting.

Other identified initiatives

a. Information and communication Programme

Programme	Projects
Information and communication Programme	<ol style="list-style-type: none"> 1. Energy Data Management 2. Comprehensive National Energy Survey 3. Information Dissemination Project 4. Department of energy website 5. High School Energy Awareness Project 6. Information dissemination fairs (Moriya, Public service day, others) 7. Annual Reports (Sectoral, DOE) 8. consumer education programmes on dangers associated with coal and LPG usage;

b. Energy research and development Programme

Programme	Projects
Energy research and development Programme	<ol style="list-style-type: none">1. Biomass resource base study2. Studies on bio-fuels3. Develop and exploit hydropower potential from all the hydro related schemes/ projects such as irrigation, water supply projects such as Metolong dam4. Review or undertake a study to review the hydropower potential in the Country taking into consideration modern technology developments under Lesotho Highlands Water Project, Metolong dam, pup coming LHWP Phase II etc5. Review power load forecasting on annual basis taking into consideration the existing studies such NEMP and other models.6. Determine the solar thermal power potential in the Country in liaison with the Department of Meteorology and the NUL7. Develop Lesotho Wind Atlas and Solar Radiation Map

References:

- [1] Assessment of Energy for Rural Development in Lesotho, December 2011
- [2] Energy Policy Framework for the Kingdom of Lesotho (2002)

F: Renewable Energy Based Rural Electrification in Lesotho (LREBRE)

Summary

The Lesotho Renewable Energy Based Rural Electrification project was a Five Year FullSize Project funded by UNDP/GEF/GOL aiming to improve people's livelihoods by promoting the utilization of renewable energy (PV, wind and hydro) to provide basic electricity services to the rural areas in Lesotho in the districts of Mokhotlong, ThabaTseka and Qacha'sNek, thus reducing the country's energy related CO2 emissions by substitution of fossil fuels (paraffin and diesel). This was to be achieved through the removal of institutional, financial, information and technical barriers inhibiting the wide-scale utilization of PV, mini hydro-diesel hybrids and wind-PV hybrid systems in Lesotho.

The project aimed initially to accomplish this through activities supporting 6 outcomes, these being:

- 1) Delivery of renewable energy-based technology packages, 2) Awareness raising, 3) Private and public sector strengthening and training, 4) Policy support and policy framework, 5) Financial mechanisms and 6) Learning and replication.

Changes in co-financing affected the scope of outcomes 1, 4, 5, and 6 and several expected outputs were removed.

Priorities/Findings/Issues (Energy use in the country, current state of affairs, supply, demand)	Challenges (constraints, global warming and climate change)	Implementation/Solutions
Awareness on PV solar is high among the public and decision makers as a result of the project awareness program with radio broadcast program being the most effective	Project outcomes: the outcomes are interlinked and shortcomings from one impact the ability of the project to deliver others. Outcome 1 reduced in scope to include only one delivery model, one target end-user group & one technology package (Solar PV)	Courses (short, degree, etc): Technical, Economic, Environmental, etc to address the local skills
The basic approach, to strategically identify and remove barriers to the uptake of renewable energy (solar, wind and hydro) was via a market-based approach, however, GoL subsidised 84% of the cost	Market: Finance mechanism betrayed market-based approach and private sector participation as Gov. change its position on the subsidy mechanism. Withdrawal of co-financing partner hindered the project even more. AAP provided SHSs free to households thus distorting the market in the rural areas	Research Support: Provide manpower support for Policy issues such as Renewable Energy Policy
Government led approach initiated the delivery of 1537 solar home systems to rural household at high subsidy level thus distortion of the market	Lack of Policy: lack of emphasis on creating an effective policy and regulatory context and this ultimately contributed to weaken the project's transformative potential and sustainability.	
Training provided to solar installer enabled them to install 1000 or more SHS outside the project	Local Skill: Workmanship on SHS installation not satisfactory prior to 2008	
People's livelihood improved in three districts as 5735 system reached them in 5 years as compared to 735 from baseline study even though this can't be attributed to the project.	Monitoring & Evaluation: the M&E was designed but its implementation was unsatisfactory hence difficult to assess attainment of objectives	

References:

- [1] Renewable Energy-based Rural Electrification in Lesotho Project Document (2006)
- [2] Renewable Energy-based Rural Electrification in Lesotho Mid-term Evaluation Report (2011)
- [3] Renewable Energy-based Rural Electrification in Lesotho Terminal Evaluation Report, June (2013)

G: Africa Adaptation Programme

Summary

Lesotho faces serious economic and social Climate Change (CC) related challenges and has been identified as one of those countries most vulnerable to CC worldwide. The Africa Adaptation Programme (AAP) goal was to support integrated and comprehensive approaches to climate change adaptation in Lesotho. Participating individuals, institutions and communities were capacitated with the technical knowledge, skills, information and resources to plan for and implement effective and timely climate change responses.

The proposed project sought to ensure that climate change risks are addressed under the following AAP Global Project outputs;

- (1) strengthening institutional and human resource capacities,
- (2) improving policies and implementing measures, including specific pilot activities assisting communities in developing CCA Strategies and Action Plans and developing robust responses in energy and health sectors,
- (3) developing an innovative, sustainable financing, and
- (4) implementing knowledge management and information dissemination activities on national and international levels.

The project opted finally to develop more demonstration projects on the ground instead of focusing on contributing to policy making. The single most significant change brought about by the AAP is difficult to fit into the specific outputs or to actually measure. It could be summarized as “Having prepared the groundwork, from a technical and institutional perspective, for Lesotho to start developing measures and policies that deal with CCA”.

Priorities/Findings/Issues
Nothing done in the first year of the project, however, in its last year of life a lot was achieved
Increased knowledge and awareness in Gov. ministries and public opinion about the need for CCA. i) Youth Climate Change Ambassadors' drama & poetry on CCA, ii) CC inclusion in NSDP
Technical studies undertaken and procurement & installation of technical equipment to allow collecting, processing & generating of data and information that can be used in CCA. i) capacity development (target training :- CC modeling, GIS mapping, solar/wind atlases preparation
Attainment of specific outputs:- i) Leadership capacities & institutional framework are strengthened, ii) climate-resilient policies and measures in energy & health sector implemented & community-based adaptation action promoted

Challenges
Local skills: i) unclear if level of knowledge in Lesotho allowed for developing sector specific policies; may be the reason why “strategic & policy development” was not pursued even though was the core business of the project. ii) the initial capacity assessment of partners in order to identify the capacity level within government in order to formulate realistic targets for implementation
Staffing: late recruitment of project staff, e.g. Project office, Communications specialist, etc.
Stakeholder: Stakeholders other LMS, DOE and Environmental Health Department in MOH were not involved in the design of the project
Lack of Policy: Initial Policy paper in the energy sector was rejected
Sustainability: No relays to take financing issue further in order to identify and use available CC resources that are currently not exploited, it is not known what and how much of the AAP will be carried over into the government sectors as the interest and commitment from the political levels of the government is not evident

Implementation/Solutions
Courses (short, degree, etc): Technical, Economic, Environmental, etc to address the local skills
Research Support: Provide manpower support for Policy issues.
Improve Communication: Input of stakeholders

References:

[1] Africa Adaptation Programme Project Document (2008)

[2] Africa Adaptation Programme Terminal Evaluation Report, March 2013

H: Energy Balance Report

- Aim and objectives of the document (what the paper is for)

Energy Balance serves to show energy sources used in a country in different sectors and industries. It provides an easy to read format showing all different energy sources available in the country from their origins and flow to final use. And most importantly, Energy Balance checks the amount of energy supplied and consumed in a particular year of interest. The energy balance is a multipurpose tool. The main purposes of its compilation includes among others:

- (a) To enhance the relevance of energy statistics by providing comprehensive reconciled information on energy situation on national territory.
- (b) To provide comprehensive information on energy supply and demand in national territories in order to **understand energy security and to formulate energy policies**.
- (c) To determine **a country's dependence on energy imports and exports**.
- (d) To ensure comparability between different years and between different countries

- Major findings

Lesotho Energy Balance 2009

The main sources of energy utilized in Lesotho are Hard coal, Renewables and Waste, Petroleum and Electricity. **Renewables and Waste**(wood, crop waste and dung) was the major source of energy (52.9 %) of all energy sources consumed in 2009 and all was consumed in **households**. The overall domestic energy supply was 58,337.17 TJ and 25,241.02 TJ **(43.2%)** of energy in stock were **imports** in 2009. The statistical difference, which is defined as the excess of supply over demand, of electricity and petroleum are **-141.58 TJ** and **-1,127.93 TJ**. **The negative figure indicates demand exceeds supply**. This implies that final consumption of electricity and petroleum is more than the supply by **14.1%** and **6.4%** respectively.

Lesotho Energy Balance 2010

The total energy supply in 2010 was 61,333.48 TJ, which is an increase of 5.1% in the overall supply from 2009. There was also an increase of 1.5% in the energy which was imported in 2010 (44.7%) and Renewables and waste (52.0%) were still major sources of energy, which was all consumed in household sector. The statistical difference of 101.13 TJ (1.0%) and 368.71 TJ (14.2%) for petroleum and electricity respectively were observed. The major consumer of petroleum is the road transportation with 56.3%.

Lesotho Energy Balance 2011

Only data for electricity and petroleum were available in 2011, and it is shown that there was a total supply of 11,095.98 TJ of which 10,836.32 TJ was consumed and 76.5% of the energy supplied was constituted by petroleum. There was a statistical difference of 0.02 TJ and 259.64 TJ for petroleum and electricity respectively.

- Implementation / solutions / challenges

The data used in this report is **incomplete** as there have not been updates on biomass data and **studies regarding collecting of other sources of energy data have not been conducted**. These include energy sources consumed by Manufacturing industries, petroleum fuels consumed by

Mining/Quarrying, Domestic/Residential and Agricultural sector. Biomass data was projected up to 2010 during a study conducted by the Department of Energy.

Central Database: collation of all energy related data and ease of access to address lack of data

- Important conclusions

The energy consumption increased from 2009 (59,281.9 TJ) to 2010 (60,863.6 TJ) by 2.7%. The major source of energy consumed in Lesotho was Renewables and Waste constituting 52.9% in 2009 and 52.0% in 2010 of all the energy available. Lesotho imports had a substantial amount of energy sources accounting for 43.2% and 44.7% in 2009 and 2010 respectively. Total consumption of electricity and petroleum increased from 2009 to 2010 then decreased in 2011.

2012 Energy, Air and Climate Change

- Aim and objectives of the document

This section is two pronged in the sense that it has two sections, namely Energy, Air and Climate Change. Under energy section electricity and petroleum will be looked into and data used for electricity covers the years 2007 through 2012 and while for petroleum oils (Illuminating paraffin, Diesel, Unleaded and Leaded Petrol) is from 2010 to 2011. The Lesotho Highlands Development Authority (LHDA) being the sole producer of electricity in the country sells its product to the Lesotho Electricity Company (LEC) which distributes electricity to the consumers. LHDA also exports some electricity to RSA when there is excess generation since electricity cannot be stored. The energy section focuses on **the generation, export and sales** of electricity by 'Muela Hydro Power Station. It also looks into the electricity purchases by LEC from 'Muela Hydro Power Station, Eskom (RSA) and Electricidade De Mozambique (EDM) and utilization of the electricity from LEC by different sector in the country. While petroleum section focuses on the **amount of fuel imported** and how it **was consumed** in the country in different sectors.

The Air and Climate Change section focuses on **factors affecting the quality of air** such as emissions of greenhouse gases and their sources, population and their effects on the environment. Air emissions predominantly arise from the combustion of fossil fuels mainly in; transport, agricultural industries and manufacturing and other kinds of fuel combustion activities. The time frame for ambient air data is from Nov 2006 to Feb 2007 in summer and from July to Nov 2007 in winter. Diseases related to air pollution data is from 2007 to 2011. For the temperature and rainfall, data is for the period 2007 to 2011 and ODS from 2001 to 2011.

- Major issues / priorities / findings

Energy

Lesotho produces hydroelectricity, which is mostly consumed nationwide and the remainder is exported to South Africa. The 'Muela Hydro Power Station (MHPS) generated more electricity in 2007 (507.3 GWh) than any other year, while 2011 is the year in which the least amount, 489.5 GWh, of electricity was generated. The Lesotho Electricity Company (LEC) established to generate, transmit, distribute and supply electricity purchased most of the electricity from MHPS. LEC also purchases electricity from Eskom and Electricidade De Mozambique (EDM). LEC purchased 70.7% of the total electricity in 2010 from MHPS and the remaining electricity from Eskom and EDM, which constituted

23.2% and 6.1% respectively. The same pattern was observed in 2011 but there was more electricity purchased by 3.1% as compared to 2010. Furthermore the proportion of electricity from Eskom increased from 23.2% to 32.0% while MHPS decreased from 70.7% to 62.8% from 2010 to 2011. The amount of electricity exported to South Africa in 2011 was 39.2 GWh; the reason why the proportion of electricity purchased from MHPS by LEC decreased. The most amount of electricity (511.6 GWh) sold to LEC was in 2008.

There are numerous sectors in Lesotho that utilize electricity from LEC, and these include Special Domestic Consumer, General Purpose Special, Commercial, Industrial, LHDA, Pre-paid Domestic and Pre-paid General Purpose. The majority of customers (>90%) are in the Pre-paid Domestic sector across all years followed by the Pre-paid General Purpose. The electricity consumption in the pre-paid sector has been increasing steadily over the years, as well as in the commercial sector.

Petroleum fuels which are the byproducts of crude oil are imported as Lesotho doesn't produce any. Petroleum products include transportation fuels, fuel oil for heating and electricity generation. There was a decrease of 0.4% in the volume of the total imported. Despite that, there was higher proportion of imported unleaded petrol (27.3%) and Diesel (35.9%) in 2011 than there was in 2010, but the proportion of leaded petrol and illuminating paraffin decreased in 2010. Paraffin is used for lighting and heating in conjunction with wood and dung constituting 66.6% and 3.8% respectively in the rural areas of Lesotho where 77.0% resides. Paraffin and electricity are used for lighting in the urban areas, and they are also used for heating including wood with 64.0%, 11.2% and 8.1% respectively.

Air and Climate Change

The report covers data on ambient air and climate change. Ambient air data was collected from selected places in Maseru (6), Ha Thetsane, Ha Ts'osane, Ha Matala, Maseru Industrial Area, Thetsane Private Hospital and UNESCO Building and Maputsoe (2), Ha Nyenye and Chief Maboso's place (between two industrial sites) and the following were used as indicators when assessing ambient air quality: Particulate matter, Nitrogen Dioxide and Sulphur Dioxide. Climate change was covered with the following as indicators: Temperature, rainfall and Ozone Depleting Substances (ODS).

Particulate Matter (PM₁₀) which refers to solids or liquids that are very small and usually found in the air. PM₁₀ concentrations measured at all the sites were highest in winter in all stations except Thetsane Private Hospital and Maputsoe Ha Nyenye and the highest concentration was observed at Ha Matala with 496.01µg/m³.

Nitrogen Dioxide (NO₂) is a reddish-brown gas with pungent, irritating odour. It is one of the most important components of smog. NO₂ occurs naturally as a result of bacterial processes, biological growth and decay, lightning, forest and grassland fires and also are produced by man's activities such as burning of fossil fuels. Nitrogen oxides concentration were higher in winter than in summer for all the stations except Ha Matala (Maseru3) whose summer and winter concentration differ by 1.9%. The highest increase was in Maputsoe Ha Nyenye from 8.74µg/m³ in summer to 48.67µg/m³ in winter.

Sulphur Dioxide (SO₂) is a colourless gas, released from burning fossil fuels like coal and oil. Naturally is found in air at low concentration from natural releases such as volcanoes and forest fires.

SO₂ can cause breathing difficulties and is toxic to plants as it causes acid rain when reacting with moisture in the air. The highest average concentrations were in Ha Thetsane (Maseru1) with 42.58µg/m³ while the least were in Ha Matala (Maseru3) with 1.44µg/m³.

Diseases Related to air pollution

Air pollution is a mixture of natural and man-made substances in the air that we breathe such as fine particles produced by burning fossil fuels. The health effects of air pollution include respiratory diseases such as asthma, cardiovascular diseases and changes in lung function. The number of patients with asthma was high for all the years from 2007 to 2011 and these numbers have been increasing except in 2009 where a decrease was observed from 7,649 patients in 2008 to 7,024 patients in 2009. However, patients with Lung cancer and Allergies were highest in 2008.

“Climate Change” affects more than just a change in the weather; it refers to seasonal changes over a long period of time. Climate includes patterns of temperature, precipitation humidity, wind and seasons. These patterns play a fundamental role in shaping natural ecosystems, and the human economies as well as cultures that depend on them.

Minimum and Maximum Temperature

The average minimum and maximum temperature by month for the period 2007 to 2011 shows the lowest average minimum temperature was in July 2009 with -2.5°C and the highest in January 2009 with 13.5°C. However, the highest maximum temp was in Feb 2007 with 27.6°C and the lowest in July 2011 with 12.3°C.

Rainfall

Rainfall is the precipitation that occurs when water vapor in the atmosphere condenses into droplets that can no longer be suspended in the air. The amount of rainfall in Lesotho has been increasing throughout the years 2007 to 2011, where the highest increase was observed from 2009 (762mm) to 2010 (865mm) constituting 13.5%.

Ozone Depleting Substances (ODS)

Ozone Depleting Substances (ODS) generally contain chlorine, fluorine, bromine, carbon and hydrogen in varying proportions and are often described by the general term halocarbons. Chlorofluorocarbons (CFCs), Carbon tetrachloride and methyl chloroform are important human-produced ozone-depleting gases that have been used in many applications including refrigeration, air conditioning, cleaning of electronics components and solvents, fortunately the imports of these are no longer existent. But the HCFCs are still imported and the highest amount was in 2009 with 3.8 metric tonnes (mt) followed by 2008 with 3.3mt and the lowest was in 2001, 2003 and 2004 with 0.9mt in each year.

- Important conclusions

Energy Section:

Lesotho exported 3.0% of all the electricity that was generated in Muela since 2006 until 2011. Most LEC customers are in the Prepaid Domestic sector, which its proportion has been increasing from 2009 to 2012. Much of the electricity from LEC is consumed by industries. Other major consumers of electricity include the Prepaid Domestic, Commercial and Prepaid General Purpose sectors.

Petroleum fuel prices were highest in December 2011 where a litre of diesel cost M10.80. There was a decrease from 2010 to 2011 in the overall imported petroleum.

In the urban areas, paraffin and electricity were used for lighting and cooking while gas and paraffin were mainly used for cooking. In the rural areas, wood was the main source of energy for cooking and heating while paraffin was used for lighting.

Air and Climate Change Section:

In general, for ambient air, winter concentrations were higher than those of summer. The maximum PM₁₀ concentrations were high in Maseru3 (496.01µg/m³) and minimum concentrations were also in Maseru3 (0.80µg/m³). Maseru3 was the only station where NO₂ average summer concentrations (10.92µg/m³) were high than winter concentrations (10.25µg/m³). The lowest average minimum temperature was recorded in July 2009 with -2.5°C and the highest average maximum temperature was in February 2007 with 27.6°C. Lesotho's rainfall has been increasing throughout the years where the highest rainfall was recorded in 2011 with 956mm. The number of patients with Asthma was higher than that of patients with other diseases.

References:

- [1] Bureau of Statistics, 2012 Energy, Air and Climate Change Report No. 17: 2013
- [2] Bureau of Statistics, 2009 – 2011 Energy Balance Report No. 18: 2013

I: Backward Energy Sources

Summary

The GTZ-administered study on household energy access developed a strategy for the promotion of access to modern energy for low-income groups in rural and peri-urban areas [1]. Although electrification rates are low and even people who are connected to the grid supplement with other fuels to cut on the cost of electricity, unfortunately the development of other forms of energy is perceived to be **backwards** and not moving people forward. Even though 90% of energy source in the rural areas is sourced from indigenous biomass fuels consisting of shrubs, fire wood, crop residues and animal waste, donors and government institutions are prioritising electrification projects hence issues affecting the majority of the population are not addressed [2].

A number of projects have been initiated that aim to address the plight of the rural people and to reduce deforestation by using solar cookers and energy efficient stoves [2-5]. Other advantages of these projects include less pollution and a healthier population considering that a majority of the people live in the rural areas. Unless a serious attention is given to this sector Lesotho faces a huge deforestation disaster and poverty as electrification rates in Lesotho are very low and chances of everyone having access are low let alone affordability even for households that are connected to the grid. The survey carried out in Maseru concluded that even for people who are connected to the grid the use of other fuel types is prevalent in order to reduce the high cost of electricity usage [5]. This implies that even if 100% electrification rate is achieved other types of fuels will still be utilised due high electricity tariffs.

*One of the recurring crucial barriers observed in these studies is the need for **co-ordination** and **co-operation** in the energy sector.*

<p>Priorities/Findings/Issues (Energy use in the country, current state of affairs, supply, demand)</p> <p>The baseline survey from households and micro businesses (often household-based) in un-electrified areas of Lesotho showed [1]:</p> <ul style="list-style-type: none"> * All energy carriers are available except electricity * Practically all commercial fuels are considered too expensive * The typical household cooks mainly with wood, complemented by some paraffin * Lighting is with almost exclusive use of paraffin <p>Stoves [2]:</p> <ul style="list-style-type: none"> * Achieve improved livelihoods and an improved local and global environment through up-scaling the dissemination of fire wood saving energy efficient household stoves in rural areas in Lesotho. * The 3 project communities are in the districts of Mafeteng, Qacha's Nek and Quthing. * Laboratory and field tests show savings of 40% of fuel wood compared to open fire * Cost per stove: M375 <p>Programme for Biomass Energy Conservation (ProBEC) Lesotho [3]:</p> <p>Objective - Relevant stakeholders (GoL, NGO, private sector) in the field of BEC (Biomass Energy Conservation) in Lesotho are enhanced to promote, produce and sell bio energy efficient technologies and techniques</p>	<p>Challenges (constraints, global warming and climate change)</p> <p>Fossil fuels are not affordable, bio-fuels pose problems of availability and environmental impact [1]</p> <p>Income and Costs:</p> <p>Poverty is widespread and although it varies across regions in Lesotho, household income levels are very low. Bureau of Statistics (2007) states that 67.5% of households in rural areas did not earn an income, while 32.5% of households in urban also areas earned no income [1]. In a survey conducted in various suburban areas of Maseru the prevailing types of energy use are electricity, gas and paraffin with limited amounts of wood also being used. In most cases these fuel types are used in combination with other fuels. The use of a combination of fuel types is an attempt to reduce the high cost of electricity [5]</p> <p>The current ruling paradigm in energy supply is to focus on electricity – households desire it, Governments aspire to achieve universal access to electricity in their countries and donor organisations fund expensive grid and non-grid expansion projects. This forms a barrier to implement a Household Energy Strategy at a number of levels. Firstly, households equate electricity with modernity and projects attempting to implement improved biomass stoves for example are criticised for “trying to take people backwards, instead of forwards” [1].</p> <p>The efficient ARC/SSM stove challenges [2]:</p> <ul style="list-style-type: none"> * The stove is currently produced in China and imported to Lesotho through South African dealers * Maintenance of stoves may require skills that are not available in the villages * As rural households are used to maintaining open fire in their homes for heating, the ARC/SSM stoves may not correspond to their traditional perception of space heating and they might abandon their use <p>Deforestation [2]:</p> <ul style="list-style-type: none"> * Almost 90% of energy consumption in the rural areas is sourced from indigenous biomass fuels consisting of shrubs, fire wood, crop residues and animal waste. * It is highly predictable that the woodlots and reserves of shrubs will soon be no longer be available * The consequences in the environment are devastating, further perpetuating the poverty cycle <p>Stoves Market [3]: Even though more than 300 stoves have been produced and sold, the products are not showing an effective demand from potential end users.</p>	<p>Implementation/ Solutions</p> <p>Increasing efficiency: Biomass efficient cook stove programme [1].</p> <p>Communication & Planning [1]: Stakeholders should embark on a national communication campaign, clearly outlining the electricity expansion plans for the future, so that communities will be certain where they stand in terms of planning. Leapfrogging requires a clear picture of: The past - what has been tried, what were the accomplishments, errors and the results; The present possibilities, needs and limits.</p> <p>All available resources should not be for electrification projects, but also for “less-desirable” projects such as improved cook stoves [1]</p> <p>Efficient institutional co-ordination initiative.</p> <p>The need for co-ordination and co-operation in the energy sector is real and immediate. It is recommended that a Multi-sector Energy Co-ordination Committee be established and funded to be supported by a secretariat [1].</p> <p>Capacity Building: Make stoves locally – materials, cost & expertise a challenge</p> <p>Households pay 10% of the stove cost. Contribution to the cost of the stove is important to generate ownership; users benefit from improved health (reduced indoor air pollution) and less time spent for collecting wood and cooking [2]</p> <p>Collaborations: Pursue partnerships with NGOs and other stakeholders [2]. Appropriate Technology Section (ATS) is at present the strongest Governmental supporting partner of ProBEC [3]. For the clay stove development, a group of stakeholders crystallizes around ATS, BEDCO, Mineworkers Union, TED, Loti Brick and ProBEC [3].</p> <p>Training on how to efficiently use the different technologies needs to be ensured for users [3]. The demand is due to increase since the users regard the cookers helpful. This will lead to biomass energy saving and improvement of the lives of biomass users.</p>
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References:

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- [2] GEF Small Grants Programme: IMPROVED STOVES IMPROVED LIVELIHOODS IMPROVED ENVIRONMENT (ISILIE) – Technologies for Economic Development (TED) PROJECT PROPOSAL 30-07-2010
- [3] Christopher Kellner, Assessment of the Market for ProBEC Products in Lesotho, 22 April 2005
- [4] Lucy Khalema Redeby, Final Assessment of Cooker Testing in Lesotho, June 2004
- [5] E. NTHUNYA, FINDINGS OF A SURVEY ON THE ACCEPTANCE OF A HEAT RETENTION DEVICE IN LESOTHO, 2007

J: Prefeasibility Study for Wind Power at Lekhalong Le Lesehla Pass in Lesotho

Summary:

A prefeasibility Study has been performed for a proposed wind power farm to be located at Lekhalong Le Lesehla Pass in southern Lesotho; the site is in the proximity of **33kV line** to be built. Medium-sized wind turbines (1.6 MW) have been considered as the main option for the report mainly because infrastructure that would be used to transport both the turbine and crane is not known. The cost estimates for turbines as well as infrastructure and the electrical connection are provided. Annual wind speed required has been estimated due to lack of actual measurements.

The electricity prices in Lesotho have been studied and currently show that the prices are **too low for wind power** installation. Vattenfall Power Consultant recommends that a full feasibility study be conducted, with extra focus on wind measurement, infrastructure and possible local wind turbine production.

Installation of wind farm (10MW) would not close power deficit, but would allow water to be stored in the dam only to be used during power shortages

<i>Priorities/Findings/Issues</i>	<i>Challenges</i>	<i>Implementation/Solutions</i>
Infrastructure	<ul style="list-style-type: none"> Lack of roads and bridges for turbine and crane transportation. Extra long transport vehicles needed due to the length of the blades Focus is on commercially available turbine 	<p>Build roads or explore other transport options(helicopters)</p> <p>Local production of turbine would be very beneficial, interesting prospect is Windex, who plans to start an assembly line for 750 kW turbines</p>
Electricity price in Lesotho has to be comparable with MHPS	<p>Too low for wind power production</p> <p>(M400-M600/MWh is the only appealing price for electricity)</p>	<p>Renewable Energy Feed-in Tariff (REFIT) may make a wind power installation a very economical choice (Renewable Energy Policy required)</p>
Wind speed	No data for the chosen location, measurements from other location were used in different scenarios	Full feasibility study must be done with extra focus on wind measurements
Life time expectancy of turbine is 20 years	Pay-off time from different scenarios exceeded 20 years	Pay-off time less than the life expectancy of turbines in all the scenarios should only be considered.

References:

[1] Prefeasibility Study for Wind Power at Lekhalong Le Lesehla Pass in Lesotho: March 15, 2010

K: Monont'sa Pumped Storage Power Plant Project Pre-feasibility Study

Summary:

This is a planned 1,200 MW pumped storage that will primarily address the Eskom peak demand challenge [1,2]. The realisation of the project can only happen with Eskom as a key partner.

A economic simulation conducted including Monont'sa PSPP showed that the plant would be competing mainly with existing plant i.e. displacing energy generated by plant that are already in operation in South Africa. It will also displace the implementation of some gas turbine peaking plant currently being planned. The benefit derived from this displacement is not sufficient to cover the capital and operating cost of the Monont'sa PSPP. Therefore the development of the scheme is not economically viable.

Moreover, for the assessment of the Monont'sa PSPP project, if strict compliance with the South African IRP10 is retained, the simulations of the South African supply system for years 2025 and 2030 have shown that there is no need for this PSPP nor for off-peak to peak transfers neither for capacity purposes. Therefore, in the context of the IRP10 framework, the project is not economically viable.

<p>Priorities/Findings/Issues (Energy use in the country, current state of affairs, supply, demand)</p> <p>Power output of 1,200 MW for 21hrs</p> <p>4 pumping-generating units each with unit power of 300 MW; 400 kV Substation connected to the Drakensberg Switching Substation into the South African transmission grid.</p> <p>Network redundancy criteria based on the South African Grid Code requirements</p> <p>The project cost estimated at US\$1.830 billion</p> <p>Five and a half year construction period; Starting in January 2024 and 72 months construction period; To be commissioned in January 2030</p> <p>Results consistent with the ESKOM Kobong PSPP project study performed in 2011</p>	<p>Challenges (constraints, global warming and climate change)</p> <p>Local skills: Pre-feasibility JV made up of European and SA companies</p> <p>Lack of data: hydrology data limited and not enough information related to the requirements in terms of environmental water release. This could result in excessive reservoir filling which would delay commissioning and operation with huge financial consequences.</p> <p>Customer: Eskom indicated that they do not have the mandate to enter into any discussions.</p> <p>Lack of Policy: South African Grid code requirements used in this study</p> <p>National Power: How the Lesotho network can best take advantage of the new scheme is to be discussed in detail at a later stage of the project</p> <p>South African IRP 2010-2030 UPDATE REPORT (page32):The utilisation of the pump storage in Lesotho in the model remained low for the full study period indicating that <i>it may not be the most cost effective use of capital to invest in yet another pumped storage scheme</i>[3].</p>	<p>Implementation/ Solutions</p> <p>Courses (short, degree, etc): Technical, Economic, Environmental, etc to address the local skills</p> <p>Central Database: collation of all energy related data and ease of access to address lack of data</p> <p>Research Support: Provide manpower support for Policy issues such as Grid Code Requirements</p> <p>Improve Communication: Input of stakeholders; Eskom</p>
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References:

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- [2] Economic and Financial Analysis: MPSPPP Report, February 2014
- [3] South African INTEGRATED RESOURCE PLAN FOR ELECTRICITY (IRP) 2010-2030 Report, Update 2013

L: Published Journal Articles on Lesotho

Summary

This document provides a review of the 8 publicly available documents discussing energy issues in Lesotho. The documents cover solar photo-voltaic (PV), wind, hydro, biomass and petroleum energy sources [1-8].

About 77% of the population in Lesotho lives in rural areas [7]. The majority of the rural population relies on wood for cooking (71%) and heating purposes (67%). Lesotho's vegetation is that of an alpine climate, dominated by shrubs and grasses [7]. This makes firewood scarce and its harvesting causes significant amounts of land degradation [6]. Lesotho neither produces nor refines petroleum products and it is therefore totally reliant on petroleum imports [7]. The rural areas are characterised by sparse populations located mainly within the rugged mountainous region of the country [6], away from the electricity grid. This makes electricity access expensive for rural areas [1, 3, 4]. Lesotho currently has one of the lowest electrification rates within the Southern African Power Pool (SAPP) [3]. Lesotho has significant amount of solar radiation and there is a growing market of solar Photovoltaic (PV) systems. A project aimed at installing PV systems in 5000 rural homes is currently underway [2]. The mountain region of Lesotho has a noteworthy potential in small hydro and wind energy [3, 4]. All of the local electricity in Lesotho is generated by hydro power and only 4 of the 22 small hydro sites have been exploited [3]. The Lesotho Meteorological Services is currently monitoring wind energy resources from three sites in Lesotho and there is currently no wind electricity plant in the country. Current research indicates that the available wind resources are suitable for small-scale, micro-grid and large scale grid integration [4, 5].

Weak institutional framework, lack of financial incentives, poor operations and management, local skills shortage, under capacity within the energy industry and remoteness of the rural communities are the key challenges facing energy access in Lesotho. The significant amount of renewable resources (mostly in rural areas) and regional interconnection offered by the SAPP, present opportunities for exploitation of renewable energy in Lesotho. The strengthening of the Lesotho Electricity and Water Authority (LEWA), establishment of the rural electrification unit (REU) and the national rural electrification fund (NREF), are some of the promising policy directions that will increase access to reliable energy sources [3].

In view of the current situation, **academic institutions** can play a crucial role in the energy sector in **four** areas, namely; **research, education, training and expert consulting**. These institutions can have centres that will lead research into appropriate energy technologies, such as micro-grids. They can offer programmes on renewable energy so as to provide skills for the efficient operation and management of power plants. Academic institution can also provide training course to up-skill the current labour force. They can also partner with both the public and private sector institutions to provide expertise for the successful implementation of energy projects.

Table 1: A summary of the considered literature

Reference	Priorities/Findings/issues	Challenges & potential solutions
Solar Photo-voltaic Energy		
[1]	<ul style="list-style-type: none"> • Lesotho has low levels of electrification and the rural communities are the worst affected. • Grid extension to the rural areas is costly. • PV technology will stimulate business. • PV for water pumping is an important market for farm irrigation and domestic consumption. • With proper economic support and utilization of efficient RETs, developing countries like Lesotho can meet their basic energy demands and alleviate the problems of energy shortages. 	<ul style="list-style-type: none"> • In addition to technology transfer, possibly the determining factors for the success of PV in Lesotho are the needed financial incentives <ul style="list-style-type: none"> ◦ Establish a national renewable credit scheme with much relaxed terms of payment. • Current cost of PV devices, though lower than a decade ago, is still too high to provide power to the industry or to compete with conventional electric supply. <ul style="list-style-type: none"> ◦ Allow materials imported for usage in the manufacture of solar devices and improved cooking stoves to enter duty-free. • The shortage of indigenous experts, technical know-how and material resources. <ul style="list-style-type: none"> ◦ Introduce courses in RETs and related areas supported with relevant industrial attachment training at tertiary levels. • Lesotho is not economically strong enough to establish and run centres for solar energy research and development • The local technology industries may not be in a position to meet national demand for solar energy equipment • Resistance against solar energy utilization from many fossil fuel oriented members of the public accustomed to use of fossil fuels.
[2]	<ul style="list-style-type: none"> • The UNDP/GEF-LREBRE project intends to install 5000 solar home systems in selected rural settlements. • Demand for RETs in Lesotho and general awareness of the benefits of RETS among both policy-makers 	<p>The general challenges relate to energy are:</p> <ul style="list-style-type: none"> • Lesotho's energy balance is dominated by unsustainable use of traditional forms of biomass and, • exposure to high and unstable oil

	<p>and the general public has increased exponentially because of UNDP/GEF-LREBRE project activities.</p> <ul style="list-style-type: none"> • There has also been a decline in direct sales of PV systems through cash purchases as many rural customers wait for their turn in the government subsidy program • Policies to encourage the dissemination of solar energy systems in the country have been put in place but specific policies and incentives for solar PV are lacking. • More promotional and training activities are needed to ensure that PV takes up a reasonable share of the energy supply mix of the country in future. 	<p>import prices.</p> <ul style="list-style-type: none"> • Global issues, such as climate change, economic downturn and volatile energy prices have exacerbated the problem of energy access in the country. • informal operators has been that often people who have no expertise or training in PV systems carry out the installations, and as a result such systems experience breakdowns within a short time of installation. • the increase in theft and vandalism of PV panels and equipment from rooftops
Hydro Power		
[3,7]	<ul style="list-style-type: none"> • Lesotho has an abundance of hydro energy resources mainly located within the rugged mountainous region of the country that accounts for 2/3 of the area. • In 2010 29.3% of electricity (700.72GWh) was imported from RSA and Mozambique. • The hydro resources remain largely untapped; 83% of the 450MW large hydro is untapped. Only 4 of the 22 potential small hydro sites have been exploited. • Small hydro with its minimal environmental and ecological impact • It is well poised to supply electricity to the sparse and remote communities in the mountainous areas of Lesotho where the grid is too expensive to reach. • Small hydro is better than other renewables because of its predictability, high capacity factor and it's a mature technology • It provides for easy integration with other essential water projects such as; drinking water supply, fishing and crop irrigation. 	<p>The challenges and current solutions to the issues relating to small hydro are:</p> <ul style="list-style-type: none"> • The need for institutional support framework and supporting that will make hydro power a viable option. – E.g local electricity purchasing points/ systems and no financial support to potential energy providers. <ul style="list-style-type: none"> ○ The establishment of LEWA in (2002) to regulate the electricity sector and encourage competition for the benefit of consumers. ○ DOE's establishment of the rural electrification unit (REU) to spur the electrification of rural communities. ○ DOE's establishment of the national rural electrification fund (NREF) to provide financial support for electrification projects. • Effective management of hydro plants. <ul style="list-style-type: none"> ○ Public-private partnership for running of mini-hydro plant currently being tested.

	<ul style="list-style-type: none"> • Poor maintenance, management, siltation and lack of local expertise and spare parts has rendered small hydro plants uneconomical and two plants have been shut-down. 	
Wind Energy		
[4,5]	<p>The need to exploit wind energy is motivated by:</p> <ul style="list-style-type: none"> • Lesotho is one of the windiest countries in Africa. • Lesotho has a large mountainous and sparsely populate area where majority population lives – wind turbine could take advantage of the hill effect and turbines can be place sufficiently far away from communities. • Grid connection of sparse remote communities is prohibitively expensive resulting in the current low electrification rates. • Wind energy technology is quickly maturing and there are opportunities to sell clean energy to neighboring countries interconnected within the SAPP. • All potential site assessed have high wind resource availability and are viable for different ways of exploitation; Masitise for small-scale application, Sani for a mini-grid and Letšeng for large-scale grid integration. 	<p>The current challenges that may hinder exploitation of wind energy resources and their respective solutions are:</p> <ul style="list-style-type: none"> • The excessive cost and technical challenge of transporting and erecting large wind turbines. <ul style="list-style-type: none"> ○ Use relatively shorter turbines since the wind speed in some sites does not vary very much with height. • Implementing large scale wind energy projects is expensive and may not be economically viable for remote sites. <ul style="list-style-type: none"> ○ Implement policy that will attract investment into the wind energy sector. ○ Remote micro-grids could be combined with other economic activities such as tourism resorts to make them more economically viable. • The long distance between wind resource rich sites and the electricity grid. <ul style="list-style-type: none"> ○ Implement independent micro-grids. ○ Implement off-line energy services centre to charge consumer's batteries and satisfy the current need of about 22% household using batteries for infotainment. • The intermittency of wind energy as a source. <ul style="list-style-type: none"> ○ Use wind turbines together with PV within micro-grids in order to maintain a slightly more stable power source. ○ Integrate wind sites from a number of areas located far apart so as to balance out the effect of wind speed fluctuations in one area.

Bio-mass		
[6]	<ul style="list-style-type: none"> • A significant number of the rural poor population relies on biomass for their energy equipments largely for heating. • Cheche (<i>Leucosidea sericea</i>) is the most used plant for firewood – in the foothills region. • 1728 Kg per house hold per year of fire wood is collected on average. • The flooding of large areas in Bokong by Katse Dam caused a local shortage in supply of biomass. • The primary energy source are 76% - Biomass, 17% Petroleum products, 5% Coal and 2 % electricity. (as of 1999) 	<ul style="list-style-type: none"> • The collection of bio mass results in massive scales land degradation. This situation will become worse as more land is designated for protection within national parks.
[9]	<ul style="list-style-type: none"> • Africa has the 25 % of the world's tropical forest. • The agricultural residue mainly from maize stock is estimated to be capable of supplying a 9 MW at 30% availability rate. • The agricultural residue can either be used directly to produce electricity or gasified to produce fuel gas and charcoal. 	<ul style="list-style-type: none"> • The majority of Lesotho is at high altitude with an alpine climate where no forest trees can grow. • The biomass resources are sparse spread of resource around the country.
Petroleum products		
[7]	<ul style="list-style-type: none"> • Lesotho does not refine or produce crude oil. • As off 2011, the petroleum products imported were Diesel, Unleaded petrol, leaded petrol and paraffin accounted for 36%, 27%, 20% and 17% of the total imports. • Paraffin is the most common type of fuel used for illumination accounting for 64% and 45% in rural and urban areas, respectively. • The majority (64%) of urban dwellers use paraffin for heating while the majority of (67%) of rural population uses wood. • 71% of the rural population uses wood for cooking while 48% of the urban population relies on Gas. 	<ul style="list-style-type: none"> • The use of fossil fuels results into increase levels of particulate mater in especially winter in urban centres.

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