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Electricity capacity expansion plan for Lesotho – implications on energy policy

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ABSTRACT

This study aims to produce a research-based integrated electricity expansion plan for Lesotho that focuses on the security of supply at national level. The Autoregressive Integrated Moving Average (ARIMA) is used to model electrical demand and the PLEXOS modelling tool is used to analyse the cost of investing and producing future electricity for the country. The results underscore the need for investment geared towards local generation particularly in large hydro up to 0.22 GW, PV up to and 1.1 GW and pumped storage up to 0.5 GW by 2050, to keep up with future demand and reduce the cost of imported electricity in the country. Succinctly, the investigation reveals, *inter-alia,* that: 1) Lesotho's energy demand will continue to increase over the modelled period (up to 2050), with the gap between the local generation and demand concomitantly increasing; 2) large hydro generation, if harnessed will guarantee long-term energy security and cheaper energy relative to both imports and small hydro; 3) any shift in the energy policies of external suppliers at current tariff structures, will increase Lesotho's energy costs significantly, thus, negatively impacting on the country's economy; and 4) investing in local energy generation will guarantee long-term national energy security and affordability.

1. Introduction

Access to adequate and reliable electricity power supply is a prerequisite for sustainable development of any nation. Lesotho reached 42% of household electrification level in 2015 (Lesotho Electricity and Water Authority, 2015), up from 10% in 2005 (Bureau of Statistics Lesotho, 2006) and (Lesotho Electricity Authority, 2006). This continued electrification drive has resulted in Lesotho having a baseload and peak demand of 100 MW and 155 MW respectively (Lesotho Electricity Company, 2016). Given stagnant household income levels over this period, the increase in residential sector share of electricity demand (see Fig. 2 in Section 2) can be attributed to increased connection efforts. Although demand was increasing, the generation capacity of 76 MW has not increased since 1998, resulting in a national baseload deficit of 24% and peak load deficit of 44%, and the importation of approximately half of the 683 GWh consumed in 2014 (Lesotho Electricity and Water Authority, 2015).

Given the above scenario of increasing demand and absence of investment in local generation capacity, the security of Lesotho' electricity supply is topical. The Ministry of Energy and Meteorology has recently commenced to attract investment into electricity generation programmes, as highlighted by the drafting of the Energy Policy of 2015 and issuance of Lesotho's first (solar PV) Independent Power Producer (IPP) procurement. The main objective of the policy is to ensure that the increasing base load requirements are met through local generation by 2020 and beyond (Ministry of Energy and Meteorology, 2015b).

Arguably, a key starting point for increasing the baseload generation capacity will be putting in place a practically and economically feasible integrated resource plan (IRP). Presently, Lesotho does not have an effective plan that considers detailed technical and financial implications of self-generation using indigenous resources for replacing

Abbreviations: SADC, Southern African Development Community; LHDA, Lesotho Highlands Development Authority; EDM, Electricidade De Mozambique;; LEC, Lesotho Electricity Company; MEM, Ministry of Energy and Meteorology's; SAPP, South African Power Pool;; RM, Reserve Margin;; BAU, Business as usual; VOLL, Value of lost load;; ARIMA, Autoregressive integrated moving average;; ACF, Autocorrelation function;; PACF, Partial autocorrelation function;; CPI, Consumer price index; GDP, Gross Domestic Product;; WEPS, Wholesale electricity pricing;; M, Maloti (the currency of Lesotho)

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imports to meet the increasing demand for electricity.

A number of studies have analysed the electricity capacity expansion plan for Lesotho as components of optimising the generation capacity for the entire region of the Southern African Development Community (SADC). The most recent study (Spalding-Fecher et al., 2017) used LEAP energy modelling tool for SADC countries. In one of the scenarios modelled, solar PV was found to be the cheapest supply option for Lesotho, supplemented by imports. The results also indicated that cheap imports would be beneficial as aside from PV Lesotho could not build its own generation in a least cost manner. Another study by (IRENA, 2013) looked at expansion plans for the region using MESSAGE modelling tool. In this study, the predictions of the model showed that Lesotho would have total installed capacity of 242 MW by 2030 while the excess demand would be met through imports. Earlier in the 2000s, (Alfstad, 2004) conducted an expansion electricity plan for SADC using TIMES model. The conclusion in this study was that it would be more expensive for Lesotho to build its own hydro plants than for the county to import its electricity from South Africa. The modelling approach adopted in (Spalding-Fecher et al., 2017), (IRENA, 2013) and (Alfstad, 2004) however considered low resolution data (annual load and annual capacity factors) for representation of intermittent renewables energy technologies (wind and solar photovoltaic (PV)) and did not exploit the increased granularity available in models that capture the variability and uncertainty in power production (IRENA, 2016). Notably, the above studies converge to the conclusion that imports will be beneficial to Lesotho, but in its latest reports, the Lesotho Electricity Company (LEC) has emphasized the massive costs of importing power from external sources (Lesotho Electricity Company, 2016) and (Lesotho Electricity Company, 2016).

The lack of consensus on the optimal electricity supply strategy strongly necessitates a comprehensive and long range electricity sector plan that considers security of supply as well as the risk that short term import contracts pose to the economy, e.g. when supply is curtailed or becomes expensive. For example, Eskom experienced a serious supply deficit between 2006 and 2008 resulting in a curtailment of the power available to Lesotho (from unlimited to 20 MW) (Lesotho Electricity Company, 2011). This reduction forced LEC to assume a new import arrangement with Electricidade de Mozambique (EDM) to procure 40 MW. Both Eskom and EDM contracts are annually reviewed and subject to volatile market conditions that can result in increased expense or a constriction of the electricity supply to Lesotho. The Lesotho Times newspaper reported in October 2017 that LEC was ending power imports from Mozambique because it was becoming too expensive (Phakela, 2017), but eventually a new re-negotiated deal to import between 10 MW and 30 MW was signed in February 2018.

It is against this background that this paper seeks to propose a research-based electricity expansion plan (integrated resource plan) that focuses on the security of supply at the national level. In particular, the research seeks to determine the least-cost electricity generation capacity needed to meet growing electricity demand. The modelling timeframe is from 2016 to 2050. The analysis considers 2 demand growth scenarios: Business as usual (BAU) scenario, and high growth (HIGH) scenario. Under the BAU, the energy consumption is assumed to increase by 2% annually on average between 2016 and 2050. The high demand scenario assumes the annual demand increase of 5% from 2016 to 2050. ARIMA is used to forecast electricity consumption demand and peak electricity demand. To determine the generation capacity mix, the PLEXOS modelling tool is used. The results of interest will be the least cost capacity to be installed, the timing of the installations, and the net present value of the total system cost (electricity production costs and investment costs) of the installed capacity.

The high demand growth scenario tests what the generation plan will look like when subjected to high economic growth. Under each economic growth three possible cases of capacity investments are assessed. The three capacity cases are as presented in Table 2.

The rest of paper is structured as follows: Section 2 gives an overview of the electrical system in Lesotho discussing supply, demand and system reliability. Section 3 explains the modelling methodology followed in this research together with explanation of the tool used and highlights the data and assumptions used. Section 4 presents and discusses the results with recommendations and implications for policy options following in Section 5.

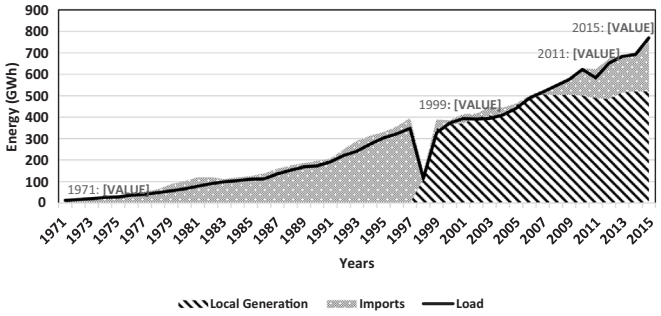

Fig. 1. Load, imports and local generation in Lesotho.
Source: (Ministry of Energy and Meteorology, 2015b)

2. Background into Lesotho's electrical system supply and demand

2.1. Picture of electricity supply and demand: demand, imports and local generation

The development of the energy sector is the mandate of the National Government of Lesotho through Lesotho Highlands Development Authority (LHDA) as water asset owners, Ministry of Energy and Meteorology (MEM) and LEC. The power generated at plants that are developed as part of LHDA projects is sold to LEC. LEC is mandated to supplement this with power from LEC's own generation assets and imports which is then transmitted and distributed to the customers. Fig. 1 shows that Lesotho electricity consumption is 770 GWh. About two thirds of electricity is consumed by the residential and industrial sectors. The share of electricity consumption by sector from 2011 to 2014 is shown in Fig. 2.

From the 1970's until 1998, Eskom was the sole supplier of electricity to Lesotho. In 1998 'Muela hydro power plant (owned by LHDA), with installed capacity of 72 MW, was completed and commissioned resulting in a steep decline in electricity imports in Lesotho (see Fig. 1). This reduction in imports was two-fold: commissioning of 'Muela and a depressed demand from economic activity due to political instability occurring during that time. Up to 2005, 'Muela substantially met the demand of the country, while imports started increasing steadily from 2006 onwards (Ministry of Energy and Meteorology, 2015a) to reach 33% of national demand in 2015 (see Fig. 3). In 2011, EDM and Eskom supplied Lesotho with 6% and 26% of its electricity needs respectively (Lesotho Electricity Company, 2011). The local plants that were

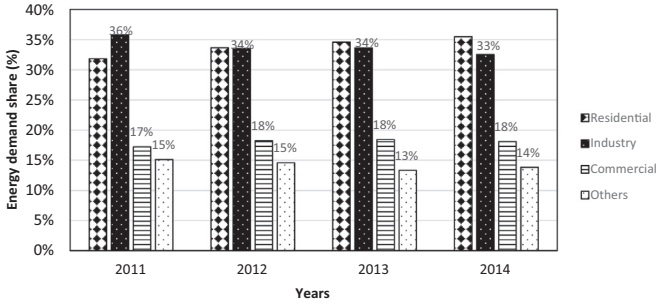

Fig. 2. Share of electricity consumption by sector for years 2010/2011–2013/2014.
Source: (Ministry of Energy and Meteorology, 2015)