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Energy situation, potential and application status of small-scale hydropower systems in Malawi

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ABSTRACT

Sustainable energy is required for any national development. This paper has reviewed and documented energy situation and small-scale hydropower potential and application status in Malawi. The country's energy sector is dominated by traditional forms of biomass. Level of modern forms of energy supply is low. In particular, electricity supply is unreliable and small in capacity. Decentralised energy supply systems like small-scale hydropower are some of the recommended energy projects for developing countries.

The paper adds knowledge on small-scale hydropower in Malawi. The study has reviewed Government reports and other documents. Informants were also consulted. Information from documents and informants was confirmed through site visits.

The analysis of the small-scale hydropower potential sites indicates that the country has considerable potential for decentralised hydropower generation, which if fully exploited, can contribute to the country's electricity and power supply especially for rural electrification. Most of the identified potential sites are located in the northern parts of the country. From the information on the assessed sites, a proven potential of 7.6 MW can be harnessed. An inventory of small-scale hydropower systems shows there is an installed capacity of 5.8 MW with most of the plants not functioning due to various reasons. Challenges and opportunities towards popularisation of the technology have been identified and discussed.

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1. Introduction

Energy is quoted as one of the ingredients in the social and economic development process of any nation and especially so for the developing countries [1,2]. All aspects of development—social, economic, and environmental—including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues are affected by energy. In developing countries, improvement in the quality and quantity of energy services is necessary in order to meet the Millennium Development Goals [2]. In developing countries where small and medium enterprises (SMEs) are booming, access to electricity can increase productivity levels through use of efficient electricity powered tools that replace human labour. Access to electricity also increases productivity through lengthening working time and business time (it is possible to work and do business at night because of provision of light).

Business in rural growth centres, small-scale mining and agro-based processing activities are some of the areas where electricity can be used for income generating purposes. However, in most of the developing countries, especially in sub-Saharan Africa (except South Africa) such development activities are hindered by acute shortage and unreliability of the already small electricity supply and extremely low popular electricity access levels in rural areas. In most of the sub-Saharan Africa countries, there are disproportionately large gaps between urban and rural electrification levels: an indicator of social inequality. The poor state of electricity sector in sub-Saharan Africa is well documented by Eberhard and others [3]. Decentralised (off-grid or stand-alone) electricity generating plants are considered as some of the options for rural electricity supply unlike grid extension from central electricity generating stations Kaundinya and others [4]. The latter is prohibitively expensive and technically challenging to implement considering the long electricity transmission distances from generating stations to load points, difficult terrain with poor or no access roads and sparseness of rural human settlements.

The decentralised power system is characterised by generation of power nearer to the power consumption points, focusing mainly on meeting local energy needs (remote settlement, rural town or localised industry). For this reason, this power supply system is usually small scale. Because of short distances between generation point and load points, decentralised power systems are more efficient than the centralised (grid-based) electricity supply system. The decentralised power system can function either in the presence of grid, where it can feed the surplus power generated to the grid, or as an isolated power system. The latter has localised grid network linking the generating station to load points. Further, a decentralised power system is also classified on the basis of type of energy resources used: renewable and fossil fuel. In sub-Saharan Africa, fossil fuel powered decentralised power systems (gensets) can be expensive to run because of high pump price of oil and costs of transporting oil to the power stations. A genset power system would not be appropriate in areas without access road. Therefore it would really be useful to promote renewable energy power decentralised power systems in such areas. It is a question of mapping the important renewable energy resources for electricity generation at national level so as to inform the type and design of decentralised power systems. Small-scale hydropower (SHP) systems are recommended for decentralised power supply because of their robustness and assurance of availability of firm power.

Promotion of decentralised power supply seems to be one of the realistic ways of increasing the electricity generating capacity incrementally in a sustainable manner for most of the sub-Saharan African countries that are associated with economic challenges. Decentralised energy systems can trigger economic growth and social development to an off-grid community and therefore play a very central role in the rural economic growth and development plans. Studies have affirmed this fact [5,6]. For example, Kirubi et al. [6] conducted a detailed case study on the Mpeketoni Electricity Project a community-based, diesel-powered micro-grid system in rural Kenya and they concluded that access to electricity, in conjunction with complementary infrastructure such as markets, roads, and communications, contributed to increased productivity in two key economic sectors of rural livelihoods namely SMEs and agriculture [3]. Not only in Kenya, but in other developing countries like Nepal, decentralised energy systems have brought economic and social development [7].

Further, if localised energy resources are utilised for electricity generation, the decentralised power systems can provide a more reliable rural electricity supply and provide a direct source of income for the community. For example, the use of agricultural and forest wastes, as well as other biomass resources for electricity generation decreases the dependence on imported fossil fuels and can provide income to local communities derived from biomass collection and transportation. The technical requirements to design, manufacture and manage the decentralised power systems create local techno-entrepreneurships opportunities such as in Nepal for SHP systems (Nepal). Renewable energy decentralised power systems such as the SHP systems are environmentally benign power supply technologies and are not associated with gaseous emissions. Such technologies are attractive for carbon trading such as the Clean Development Mechanism (CDM) of the United Nations Convention of Climate Change (UNFCCC).

Small-scale hydropower (SHP) is a robust renewable energy technology that generates mechanical power and electricity or both at the same time. In some countries like India, apart from generating power to remote off-grid areas, SHP is one of the clean energy technologies for carbon trading under the CDM [8]. Currently, the SHP technology is not new to Malawi and the rest of sub-Saharan countries. Installed SHP systems at some missions and tea estates date back to so many years ago, having been installed there by the early European missionaries and tea planters as the case with Malawi, Kenya and Tanzania [9]. Despite having significant SHP potential, SHP as a decentralised energy technology is not widely applied in sub-Saharan Africa as compared to other regions such as South East Asia and South America. In Malawi, focus on decentralised renewable energy systems by the government and other development partners has been on solar PV and very little on wind, and as a result there is limited information on potential and utilisation of small scale hydropower in the country. The SHP information available is sketchy, in scattered form and not in a position to be used as a reference document for energy researchers, policy and other stakeholders who may want to work in the field of SHP in Malawi.