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Issues of small scale renewable energy systems installed in rural Soum centres in Mongolia

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ABSTRACT

In Mongolia, 43% of the total population lives in remote areas where supplying sufficient electricity through the existing grid is difficult due to terrain. The Mongolian government intends to utilize renewable energy systems to supply electricity in these areas and, as a first stage, financed 12 renewable energy hybrid systems but these systems failed to operate as planned. These projects are evaluated in this study based on government documents and other research reports and it is found that most of these systems are unsuccessful in providing the required services. The lessons learned from the failed installations are documented in this paper. Local technician training and user education is also important as technology transfer is very important for remote area systems. The research reveals the fact that introducing new technology does not solve a problem. To reduce the chance of failure, proper sizing and quality equipment selection are very important in such a harsh climatic zone. The results of the analysis show that inadequate attention was given to sizing the system, which led to customer dissatisfaction and unwillingness to pay.

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Introduction

Electricity plays a vital role in contributing social and economic benefits to rural communities which comprise 52% of the world population (Byrne et al., 2007). The World Summit on Sustainable Development explicitly identified having access to primary energy is essential for achieving the UN Millennium Development Goal of reducing poverty by 50% in the world's poorest countries by 2015 (Modi et al., 2006). According to a recent United Nations Development Programme (UNDP) report more than 1.3 billion people in rural areas of developing countries currently lack access to reliable electricity (World Energy Outlook, 2013).

Providing electrification in remote rural communities using renewable energy (RE) technologies is a practical option (Urmee and Harries, 2009). Small-scale diesel/gasoline generators have been used for decades to serve the rural electricity needs. In places where grid access is technically impossible and financially infeasible, renewable energy systems can play an important role in power supply. These technologies are especially suitable for remote places where it is difficult to supply diesel fuel and where people cannot afford to pay the high cost of electricity produced by fossil fuel technology (Surendra et al., 2011).

In Mongolian rural areas, especially for *Soum* (village or settled area) centres (SCs) which are located more than 1000 km from the capital city and over 500 km from the Aymag (province) centres, electricity supply is vital for providing the basic needs of the people in those areas. Supplying these areas with electricity from diesel generators is not feasible as it requires imported diesel fuel paid by foreign currency, which is sensitive to foreign exchange rates and high cost for transportation due to poor infrastructure, resulting in a high bill for the customers (ESCAP, 2007). The government of Mongolia intends to utilize renewable energy systems as an energy supply solution for rural SC in the future (ESCAP, 2007). In 2007 and 2008, the government of Mongolia financed 12 projects out of the State budget which were aimed at creating RE systems at remote SCs. However, most of the installed RE systems had both technical and non-technical problems which resulted in the shutting down of the operation of these systems after a few years of operation. Almost all of the renewable energy systems installed in the SCs have experienced technical faults and problems since their inception (EAM, 2010n). In order to learn lessons for future projects, this paper will investigate and identify the drivers and barriers that have been experienced by these 12 RE projects.

Background

Mongolia is a land-locked country located within 87° 44′E and 119° 56′E longitude and between 41° 35′–44′N and 52° 09′N latitude in the North of Central Asia (Maps of World. Mongolia Latitude, 2013). The total land area is 1,564,116 sq km with landscapes that include vast semi-desert and desert plains as well as grassy plains. It has an extremely large land mass with a majority of the population living in rural areas. Mongolia has five ecological zones namely, Forest Steppe, High mountain, Steppe, desert steppe and Desert (Jamsranjav, 2009). Mongolia has a democratic political structure. There are 21 Aymags (provinces), and 1

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metropolis (Ulaanbaatar) (see Fig. 1); within the 21 Aymags there are 331 *Soums*, which are the lowest units of provincial administration.

The *Soums* are composed of 1453 baghs which are the lowest level in the Mongolian administration in rural areas. This research studied the systems installed in Altai, Bayankhongor, Umnugovi, Dornogovi, Hovd and Dornod Aymag. These Aymags are situated in very diverse geographic areas e.g. the mountainous and wooded Khangai, steppe region, and the Gobi desert region. The selected SCs under this study are mostly in the steppe and Gobi regions.

Ulaanbaatar city, the coldest capital city in the world has 9 districts which are subdivided into 117 khoroos, which are the lowest units of city administration. These local administrative units (baghs and khoroos) are the base of a political hierarchy which is topped by the national government (USAID, 2010). Mongolia's climate is harsh continental (ADB (Asian Development Bank), 2011). The average altitude of the Mongolian plateau is about 1580 m above sea level.

According to a survey carried out by the National Statistical Office of Mongolia in 2010, the average annual household income ranges from MNT 1,296,000–2,400,000 (US$673.2–US$1308.5)[1] depending on geographical location and the size of the *Soum* (for instance some *Soums* close to Aymag centres or big cities, or railways or paved road, or borders, or having access to the centralized electricity grid, have more income opportunities (NSO, 2011)). About 33% of the population live without electricity; and 43% is without access to central heating. This lack of access to electricity is especially acute outside of urban areas, where there is limited energy infrastructure (USAID, 2006).

Government energy policy and strategy

The Mongolian Government restructured the energy sector, through the enactment of a new energy law approved by the Parliament of Mongolia in 2001. The former Energy Authority was a vertically integrated monopoly which was “unbundled” so that 18 new state-owned energy companies could be established. Energy activities were divided into different fields such as generation, transmission, distribution, supply, and dispatching. The implemented Energy Law provides a basic regulatory, inspection, and enforcement structure for generators, transmitters, distributors, suppliers, and consumers. The Energy Law allows private and public sector involvement in the production of energy and establishes key policies in the areas of tariffs, energy efficiency, environmental quality, and safety (ADB, 2007).

The government has also focused on improving rural living conditions to reduce the migration of the rural population to the cities, in particular, to the capital Ulaanbaatar. This migration creates additional demands on schools, hospitals, and other social infrastructure services that cannot be met in the short to medium term. Government funds are no longer adequate to fully meet public infrastructure needs for health, education, and energy supply. The disparity between the reality and expectations based on past service levels in rural areas (which were based on heavily subsidized services provided by a centralized government) is contributing to the accelerated migration toward city centres, particularly to Ulaanbaatar. Poor electricity supply is a key contributor to the deterioration of these public services in rural areas. The Government of Mongolia has taken the initiative to increase the RE share of electricity generation (James et al., 2002). Current RE share is 3.3% (REN21, 2014) and the government set an ambitious goal to generate 15–20 % of the total electricity through renewable energy by 2020. In the last 10 years, the Government of Mongolia has invested heavily in constructing many mini hydro power plants and hybrid renewable energy plants in rural areas. The government is promoting the development of renewable energy, both in large-scale utility and small-scale remote area power supply applications (ADB, 2007).

[1] US$1 = 1700 MNT.

Profile of Mongolia's energy sector

Mongolia has three interconnected electricity grids, two isolated grids as well as electricity imports from Russia. The energy sector consists of four independent electric power systems (Srinivasan, 2005):

- Central Energy System (CES)
- Eastern Energy System (EES)
- Western Energy System (WES)
- Altai Uliastai Energy System

There are essentially three separate markets for electricity in Mongolia. The first and largest market includes all grid-connected cities and towns and is dominated by Ulaanbaatar, the capital city. Total capacity of the CES as of 2011 is 786.3 MW. This market accounts for some 87% of the total electricity supply, and reliability averages 23 h/day (IEEJ, 2012). The second market, the EES, consists of mainly off-grid *Soum* centres, where stand-alone diesel generators, with a total capacity of only 36 MW, provide limited services. This market accounts for about 3% of the total electricity supply. The EES supplies electricity to two provincial capitals (Sukhbaatar and Dornod); there are about 18 *Soum* centres in these provinces. The EES also supplies heat to the provincial capital of Dornod province (James et al., 2002).

The WES and CES have a constant supply from Russia. Around 10 MW is imported from Russia into the WES and up to 130 MW into CES during peak demand. Maximum available capacity from Russia is 250 MW (IEEJ, 2012). The WES market services the nomadic herders; is highly decentralized, and remains largely undeveloped. Household-based power supply systems are the only option for this market. Numerous off-grid rural *Soum* centres have a local diesel power supply (REEEP, 2012a). Due to increased demand for electricity, Mongolia is in danger of a serious shortfall of energy by early 2020 (IEEJ, 2012). Power imported from Russia may not be able to meet the increased demand and, even if it did, it would be very expensive; therefore, renewable energy systems have extremely good potential to supply power in remote rural areas.

Renewable energy applications in Mongolia

Mongolia has good solar energy resources, typically receiving annual average solar irradiation values of between 4.55 and 6 kWh/m^2 per day (ESCAP, 2007). It has significant wind energy resources (IRENA, 2012). In almost every part of the steppe region, the average annual wind speed is no less than 5 m/s, while mean wind speeds of 5–6.5 m/s are available in the Gobi region (ESCAP, 2007). Wind energy is a practical and economical solution for the nomadic families and at bagh-centres, which are the service units closest to the nomadic livestock herders (Surendra et al., 2011; ESCAP, 2007; Batsuk, 1996). In 2002, 40,000 herders received solar home systems (SHS) through a national programme supported by the Chinese government and the Japan International Cooperation Agency (JICA) (REEEP, 2012b). Some village power systems comprising wind/PV hybrid systems and Solar Photovoltaic (PV) village power systems were also built. These were financed by the New Energy Industrial Technology Development Organization (NEDO) of Japan (REEEP, 2012b).

A large number of the renewable energy projects implemented were demonstration projects, financed by foreign donor organizations. Equipment used in these projects was mostly imported. Experts, scientists and technicians of the Mongolian Academy of Sciences, and the Universities, undertook these projects. At present, more than 105,000 solar home systems (SHSs) reportedly are in use by herders for lighting, operating radio receivers, TV sets, satellite dishes or charging mobile phones. The PV systems have capacities in the range of 5 to 200 Wp. In addition, over 4500 wind generators are reportedly in use in rural areas, with capacities mainly between 50 and 200 W (NREC, 2007).

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