CHAPTER I

INTRODUCTION

Background

Mongolia is a landlocked country located between latitudes, 41° and 52°N and longitudes, 87° and 120°E in Central-Northeast Asia, with an area of about 1.6 million square kilometers. The average elevation of the country is 1,580 m above sea level. The weather condition is a typical continental climate with the minimum air temperature of -40 C in winter and the maximum air temperature of +32°C in summer.

There are 2.75 million people in the country, of which more than 40% live in rural areas and are mainly nomadic livestock herders. Capital city is Ulaanbaatar with approximately 1 million populations. Other major cities are Darkhan, an industrial center near the Russian border in the northern part of Mongolia, and Erdenet, known with its large copper plant, also located in the northern part. The country's administration unit is divided into 21 Aimags (provinces), which are in turn divided into 329 Soums (districts). Approximately 90% of Soum centers have been connected on the on-grid system by the end of 2007. Around 32 soum center's electricity demand is supplied by renewable energy [1].

This paper focused on techno-economic study of electric power generated by using solar energy in Dalanzadgad and Sainshand cities, where are located at good solar radiation resources. Dalanzadgad is the capital of Umnugobi Aimag, with population of approximately 14 thousands (2006). The city with 7 Soums is supplied by 6 MW coal-fired heat power plant both heat and electricity. Due to low capacity of the power plant and unstable operation, heat demand cannot fully be reached when outside temperatures are very low. The government promises to connect Umnugobi Aimag on centralized grid with high voltage electric line by June 2012.

Sainshand is the capital of Dornogobi Aimag located in the eastern Gobi steppe with population of 25 thousands (2006), through which Trans-Mongolian railway and main road pass. The city is connected with 110kV high voltage electricity transmission.

Overview of energy consumption

Mongolia is served by a power system that consists of four detached segments, the Central Energy System (CES), the Western Energy System (WES), the Eastern Energy System (EES) and the Altai-Uliastain Energy System (AUES), comprising seven coal-fired heat power plants with heat extraction (CHP), plus regional two hydropower plant (HPP) and seven distribution systems.

The CES with five CHPs is the based-load plant, which is unable to properly follow the daily power consumption regulated by the Russian Power Grid System.

The other three grid systems are relatively small. The WES area is powered by 12 MW Durgun hydropower plant and from Russia. The EES is powered by CHP, supplying 3 isolated aimags and 27 soums. The AUES including two aimags, are remote system based on diesel power stations and connected with the new 11MW Taishir hydropower plant. The South Gobi region has one small 6MW CHP supplying electricity to their 7 soums. The AUES and South Gobi region are identified off-grid systems.

The South Gobi region is currently isolated from the CES. Demand in the region is expected to grow rapidly as a result of the various mining developments, notably the Oyu Tolgoi gold and copper mine being developed by Ivanhoe Mines Ltd, the Naryin Suhait, Ovoot Tolgoi coal mines, and the Tavan Tolgoi coal mine. The world's largest undeveloped copper and gold mine is Oyu Tolgoi, which is located in the southern in Mongolia. Based on Ivanhoe Mines discoveries during the past nine years, independently verify its resource. That contains about 81,000 million pounds of copper and 46 million ounces of gold in measured, and inferred resources.

Renewable energy policy

The Mongolian Government has starting to implement "100,000 Solar Home" a national program since 1999, which plans to power over 180,000 herding households with solar home system so that start to develop renewable energy. At present it is estimated that almost 60,000 independent solar home (Photovoltaic) systems are being utilized by herders for operating lights, radios, televisions and satellite dishes [2].

The second important Government policy is National Renewable Energy Program, which was approved by the State Great Hural (Parliament) of Mongolia, on

June 9, 2005. The program aims to create the conditions ensuring ecological balance, unemployment, and poverty reduction and sustainable socio-economic development by increasing the share of renewable energy in the energy balance. The Program maintains following ambitious targets for renewable energy development in the country:

1. An increase of the share of renewable energy in the total energy supply to 3-5% by 2010 and to 20-25% by 2020 (up from 0.9% in 2005).

2. A decrease in overall energy losses by 5 percentage points by 2010 and by 10 percentage points by 2020 through the introduction of advanced energy efficiency and renewable energy technologies;

In order to satisfy the increasing demand in a cost efficient and environmentally sustainable way of energy supply, the State Great Hural (Parliament) of Mongolia adopted in January 11, 2007 the Law on Renewable Energy, which promotes and encourages foreign investment and supports the production of energy from renewable sources by regulating generation, transmission, and pricing of green energy.

This law supports the development of a renewable energy industry in Mongolia in part by fixing tariffs to be paid to private sector companies (known as Feed-In Tariffs (FIT)) in a band ranging from US 4.5 cents to 30 cents per kWh for electricity generated with renewable sources [3]. It states that FIT of 0.15 – 0.18 USD/kWh (0.12 – 0.14 €/kWh) will be paid for energy produced by solar technologies which connect to the grid. But for solar technologies standalone system will be paid of 0.2 – 0.3 USD/kWh (0.14 – 0.21 €/kWh).

Solar energy resource

The global solar radiation is measured by using meteorological data for 130 stations entire Mongolia. All meteorological stations belong to the National Agency for Meteorology and Environment Monitoring /NAMEM/, is the government's implementing agency.

Results of these measurements are shown as the approximately 70 percent of country has good solar resource. The northern and southern regions of the country receive annual solar global radiation ranging from 1,163 kWh per square meter to

1,628 kWh per square meter, respectively. A majority of this solar resource area is the South Gobi region (Gobi desert).

Almost in entire country observed from 270 to 300 clear days and sunshine duration from 2250 to 3300 hours in an average year. Global solar radiation distribution is decreasing with the latitude from south to north. The 17 percent of the territory receiving global solar radiation more than 1600 kWh/m^2, 25 percent 1600-1400 kWh/m^2, 51 percent 1400-1200 kWh/m^2 and 7 percent receives less than 1200 kWh/m^2 per year and total yearly solar radiation potential in entire country is estimated as 2.2x10^{12} MW [4].

This study is being proposed to assess the direct normal radiation for the feasibility of concentrating solar power plant in the Gobi desert.

Purposes of the study

Purpose of this study is techno-economic evaluation for future perspective of parabolic trough concentrated solar power (CSP) plant in Mongolia.

The most important parameters of the study can be divided as following categories:

1. Location of the parabolic trough CSP plant and meteorological data
2. Assessment of direct normal irradiance on two cities of the South Gobi region
3. Energy situation, electrical network, and infrastructure
4. Design of a parabolic trough CSP plant
5. Economic evaluation and electricity sales
6. Environmental, planning and carbon trading considerations

The study which is shown the investment cost for development solar thermal energy in the renewable energy sector is suggested to revise renewable energy roadmap to compare with international CSP development. If renewable energy policy revised, it'd drove to develop national renewable energy program through increasing percentage of investment solar thermal energy in the energy supply of Mongolia, improving structure of energy supply, and widely using solar thermal energy to provide mining sector.

Benefit of the study

The benefit of this study allows to verify the possibility of using solar thermal energy by studying techno-economic aspects of a parabolic trough CSP plant and reviewing roadmap of CSP technology development in Mongolia. The recommendation will be useful for government policy leaders to be proactive in the development of solar energy technologies and help to create viable solar thermal energy market in Mongolia.

The study is focused to estimate direct normal solar radiation of the specific location of South Gobi region. Solar resources are given a great opportunity for Mongolian desert in the future installed CSP. In the future CSP, that presents a good opportunity to implement national renewable energy program for the government, will play to increase in a sustainable manner thermal power plant, their energy supply. The use of CSP could not only create jobs, boost economies, but also might help to reduce the risks of energy related conflicts. Moreover, this technology could play a major role in combating climate change by means of flexible instruments defined in the Kyoto Protocol. Additional benefits include production of clean energy; make environmental friendly CDM project, and decreasing emission of greenhouse gases.

CSP presents a great opportunity for Mongolian energy system to increase their access to electricity and supply for increasing demand in mining area. This thesis provides technical guidelines for the selection of a CSP plant installation in the South Gobi region Mongolia.

Scope of the study

In this research, the suitability of the Mongolian climate condition for parabolic trough CSP technology will be defined. The Microsoft Excel and Microsoft Word programs will be used as a tool for the calculation physical data's and work in the graphs.

This work consists of the technical and economic assessment can be summarized as follows:

A. The technical assessment of the parabolic trough CSP plant

1. Estimate Direct Normal Irradiation (DNI) on the site

2. To check the renewable energy policy, analyze energy demand and to set up the target of electricity supply

3. Assessment of availability land, water resource, infrastructure and meteorology

4. Design of parabolic trough CSP technology under Mongolian climate.

B. Economic and environmental evaluation of the parabolic trough CSP plant

1. Capital expenditure of CSP (The fundamental cost, system and equipment cost, installation and construction cost, etc.)

2. Operation and maintenance (O&M) expenditure (Operating cost, staff expense, maintenance, replacement of system, etc.)

3. Income (tariff, service factors, other income)

4. Estimate future levelized costs of electricity (LCOE), net present value (NPV), benefit to cost ratio (BCR), internal rate of return (IRR), and payback period (PBP).

5. Estimate CO_2 emission reductions

Location

Parabolic trough concentrated solar power plant would be installed in the future in Mongolian Gobi Desert. In this research paper, two possible locations will determined, such as the locations are Dalanzadgad in Umnugobi Aimag and Sainshand in Dornogobi Aimag (See Table 1 and Figure 1).

Table 1 Different locations which will be considered in this study

Location	State	Geography		
		Latitude (^{o}N)	Longitude (^{o}E)	Altitude (m)
Dalanzadgad	Umnugobi	43.35	104.25	1469
Sainshand	Dornogobi	44.53	110.10	938

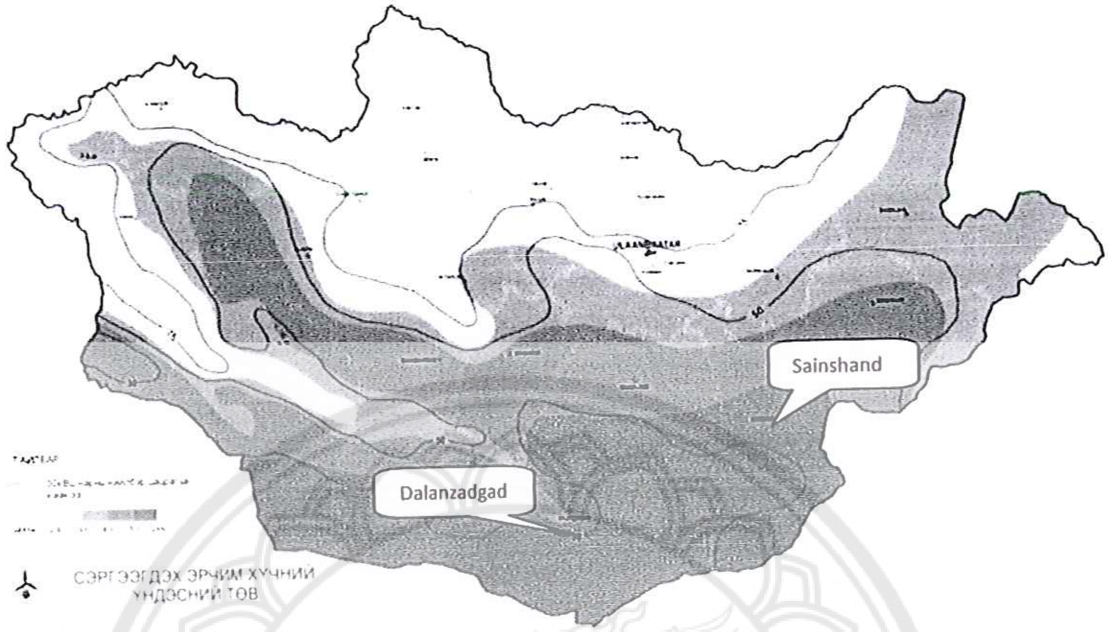

Figure 1 Global solar radiation map and proposed sites

Source: Mongolian National Renewable Energy Center