# CHAPTER III

# RESEARCH METHODOLOGY

This research has been conducted in four parts. They are the data collection and data analyses, the technical evaluation of parabolic trough CSP plant, the economic and environmental evaluation for parabolic trough CSP plant, and the recommendation for development CSP technology in Mongolia.

**Data collection and data analyses**

The data will be collected through the reviewing of relevant reports, articles in the journals, policies and programs, websites of the various agencies and institutions. The purpose of data collection of this study is categorized into the following schemes: the renewable energy policy, energy demands, infrastructure, solar radiation data, data geographical and water resources, and data of meteorology. A detailed list is prepared based on the available information of the organizations in each category presented in Table 5.

**Table 5 List of organizations**

| No | Organizations | Data sources |
|---|---|---|
| 1 | Ministry of Mineral recourses & Energy | Energy policy, Strategy and Planning |
| 2 | Energy Authority | Implementation RE projects, expected energy demands |
| 3 | Energy Regulatory Authority | Electricity tariff and price |
| 4 | National Center of Construction, Urban development and Public Utilities | Geographical & topographical data for land resources |
| 5 | Water Agency | Water resources for Gobi Desert |

**Table 5 (Cont.)**

| No | Organizations | Data sources |
|---|---|---|
| 6 | National Agency for Meteorology, Hydrology & Environment Monitoring* | Data for meteorology |
| 7 | National Statistical Office | Statistical information |
| 8 | National Renewable Energy Center** | Solar radiation for South Gobi Region |
| 9 | National Dispatching Center | Information of Daily Energy Consumption |
| 10 | The Central Regional Electricity Transmission Grid State Owned Stock Company. | Possibility for Grid Connection of CSP |

**Source:** * In the meteorology data collection is analyzed weather condition selected site of CSP plant less than last 10 years. The meteorology will be included temperature, humidity, wind speed and direction, rain, snow, dust storm, and soil cover condition.

** National Renewable Energy Center measures the solar radiation and other climatic parameters over various locations across the country, which the measuring stations are recorded only global solar irradiation on horizontal surfaces. However, the direct normal solar irradiation data obtained meteorological station for specific locations.

DNI data is also investigated by using NASA Surface Meteorology and Solar Energy website. The result of NASA data is obtained by latitude and longitude of the location. All solar radiation values are monthly and annual mean values for a 22- year period.

**Technical evaluation for parabolic trough power plant**

The evaluation for parabolic trough solar power plant implementation depends on identifying and analyzing the fit between required parameters of CSP systems. While these parameters cover many technological, economic, and environmental variables, the 20 years of commercial operating experience at SEGS power plants in California pinpoints the key parabolic trough solar power plant parameters with the most significant impacts on cost.

Therefore, research paper is identified key parameters for Mongolia's respective characteristics. Those key parameters identify: 1) solar resource; 2) land topography; 3) land space and use, 4) power grid availability and capacity; 5) water availability; 6) infrastructure; and 7) fossil fuel availability (in the case of hybridization). Table 6 describes the key factors.

**Table 6 Summary of key factors**

| Factors | Requirements |
|---|---|
| Solar Resource | > 1800 kWh/m$^2$ per yr or 5 kWh/m$^2$ per day for economical operation |
| Land Topography | 0% to 3% grade as potential. Less than 1% grade most economical |
| Land Space | 5 acres or 20 km$^2$ per MWe |
| Grid Availability & Capacity | Close by. |
| Water Availability | Water required for steam turbine. Water required 2.9 – 3.5 m$^3$/MWh |
| Transportation Infrastructure | Proximity to roads and railways necessary for access and construction |
| Fossil Fuel Availability | Needed for hybridization, but not considered critical |

**Source:**Q. Hang, et al. [25]

The papers and journals about technical evaluation of CSP plant show the important role such as assessment of DNI, simulation method of CSP plant, the energy demand, the water resources, the availability of land, the infrastructure transportation, and the meteorology.

Final analysis for the technical evaluation would be 5 MW parabolic trough power plant design for two selected sites.

**Economic evaluation for parabolic trough power plant**

The economic evaluations of CSP utilizing are the most important aspect in the proper technology selecting for any site location. If convenient location is chosen, concentrated solar power plants will be economically viable options for the production of electricity.

Economic evaluation of the parabolic trough solar field technology can give answer such as questions as how much capacity could be installed, how much electricity could be generated, and at what economic, ecological and CSP cost?

It is important to study on the development of CSP technology in the country which could be supply increasing electricity demand in mining production in South Gobi region and thus make, a good possibility to transfer high technology in developing country.

A major evaluation in the assessment of the parabolic trough solar power plant viability in Mongolia is the analysis of the cost of energy or electricity produced by the system.

The economic evaluation of this research uses method of economic efficiency analyze such as levelized cost of energy (LCOE), net present value (NPV), benefit to cost ratio (BCR), internal rate of return (IRR), and payback period (PBP).

Power plants are compared on the basis of their Levelized cost of energy (LCOE), which depends on the capital cost of the plant, annuity factor, and annual operation and maintenance costs to the annual production of electricity, the plant life should be assumed about 20-25 years.

Vallentin and Viebahn, 2010 [11], studied focusing on the economic opportunities for CSP technology. This study was defined in an economic analysis of the Andasol III plant (parabolic trough), which invested Schott Solar, Flabeg or Solar

Millennium German technology providers. This study report useful for the thesis to calculate the cost analyze on the specific components of CSP technologies.

**The roadmap of CSP global outlook**

The concentrating solar power global outlook 2009 [10] is analyzed outlook scenarios high industrial CSP technologies, which could meet up to 7% of the world's power needs by 2030 and fully one quarter by 2050.

Feed-in tariffs

The general idea among the entrepreneurs is that a legislated feed-in tariff of between 24 and 27 eurocents per kWh with a guarantee of 20 to 25 years is required by the CSP industry players in Southern Europe. Also feed-in tariff need to:

1. To provide investor confidence that project returns on investment can be met
2. To have clear and published time-scales eligibility for project
3. After projects are paid-off, then to consider the tariff is lowered, so it would an unnecessary effect on the consumer price for electricity.

Loan Guarantees

The investment funds for CSP require new loan guarantee, programs using multilateral banks, existing national lending programs via existing windows at national lending programs and global environmental programs such as GEF, UNEP and United national development program.

Supporting new technology development

Like with any developing industry, the next generation technologies will be drive down costs. To allow for cost reductions requires:

1. Fund and loan guarantees for next generation demonstration plants to enter the market.
2. Research and development fund for innovative material and component.

Results from this study will be useful for government's policy leaders to be proactive in the development of solar energy and revision of law and Renewable Energy Policy. This research work will assess a roadmap, which is given advisement to the renewable energy policy and assessment of possibility to connect power grid and future demand of electricity.