CHAPTER II

LITERATURE REVIEW

Energy from the sun can be used as a source of heat in a heat engine to generate electricity or mechanical energy. To do this the heat from the sun needs to be concentrated by focusing mirrors or mirrors on a working fluid which can reach the high temperatures required. This is workable but not yet commercial method of producing electricity.

Legend has it that as early as 212 BC the Greek scientist, Archimedes, used the reflective properties of bronze shields to focus sunlight and set fire to wooden ships from the Roman Empire which were besieging Syracuse. Although no proof of such a feat exists, the Greek navy recreated the experiment in 1973 and successfully set fire to a wooden boat at a distance of 50 m.

In the 1860s French mathematician August Mouchet proposed an idea for solar power steam engines. In the following two decades he and his assistant, Abel Pifre, constructed the first solar power engines from modern parabolic dish collectors. At the conclusion of World War Two, scientist and novelist Arthur C Clark proposed the idea of satellites using solar powered steam engines.

In 1969 the Odeillo solar furnace was constructed in France. This featured an 8 storey parabolic mirror but it wasn't until the development of power tower in the 1980s that the large scale solar thermal electric generators were built.

High temperature solar thermal systems require concentrators to focus solar radiation onto the receiver. Three common forms of concentrating systems are used:

1. Parabolic troughs
2. Parabolic dishes
3. Central receivers

2.1 Solar Parabolic Trough

Parabolic trough technology is currently the most proven solar thermal electric technology. The first of this technology has been operating in the California Mojave Desert since 1984. There plants, which continue to operate on a daily basis, range in size from 14 to 80 MW and represent a total of 354 MW of installed electric generating capacity.

The reflective surface of a parabolic trough concentrates sunlight onto a receiver tube located along the trough's focal line, heating the fluid flowing in the tube which is then transported through pipes to a steam turbine or generator. The troughs are normally designed to track the sun about one axis, predominantly north-south. This technology may be used to provide process heat or to drive chemical reactions, but is currently best known for its applications in providing electrical power. Concentration ratios of parabolic troughs range from 10 to 100, and temperatures range up to 400 °C.

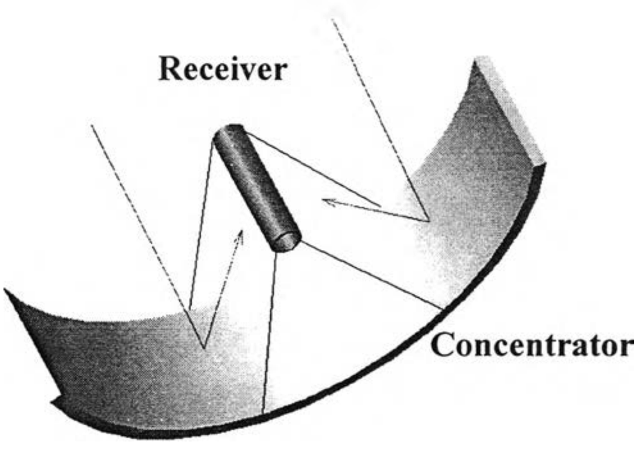

Figure 2.1: Schematic of a parabolic trough concentrator

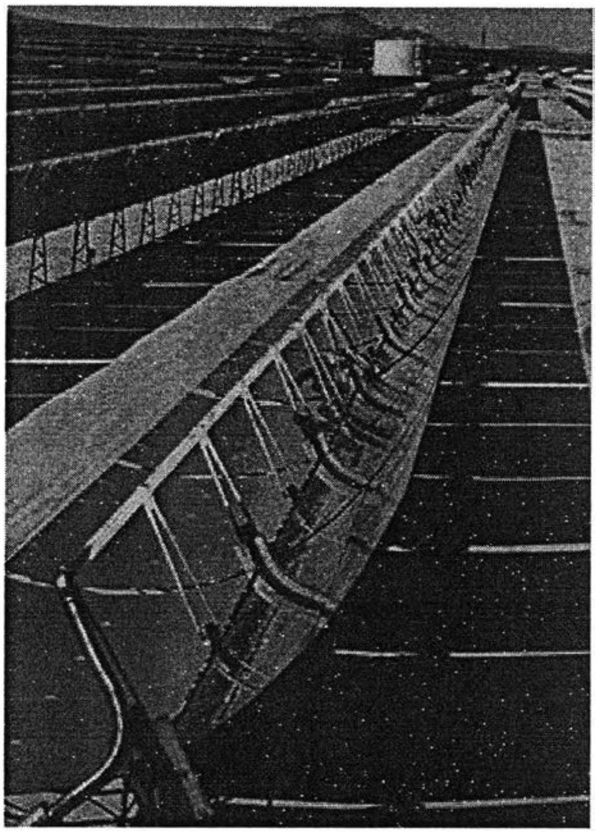

Figure 2.2: SEGS parabolic trough collector field at Kramer Junction, California

2.2 Parabolic Dish System

A parabolic dish system consists of a parabolic disk concentrator that reflects solar radiation onto a receiver mounted at the focal point. This concentrator must be mechanically driven to follow the sun. The collected heat is typically utilized directly by a Stirling heat engine mounted on the receiver.

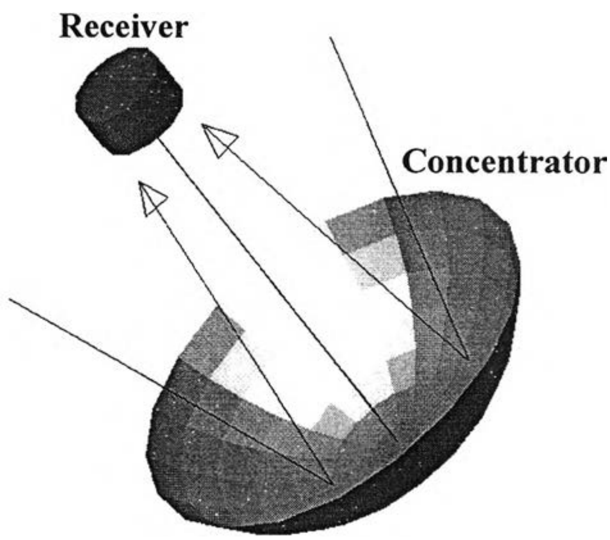

Figure 2.3: Schematic of a parabolic dish concentrator

They typically have concentration ratios ranging from 600 to 2,000, and thus are highly efficient at thermal energy absorption and power conversion.

An example of this type of system is research and development work in Australia National University. They have two parabolic dish systems, one of which is the world's largest single dish with an area of 400 m^2 which enables it to produce steam at 5,000 C°.

Another example is manufactured by McDonnell Douglas as shown in Figure 2.5. This parabolic concentrator comprises 82 curved mirror facets, having a total normal projected area of 87 m^2. It can deliver 70 kW at a peak concentration ratio of 4,000 suns.

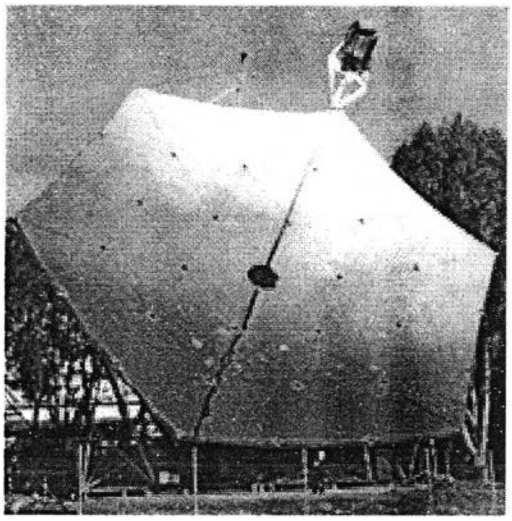

Figure 2.4: Australian National University 400-m^2 Dish in Canberra

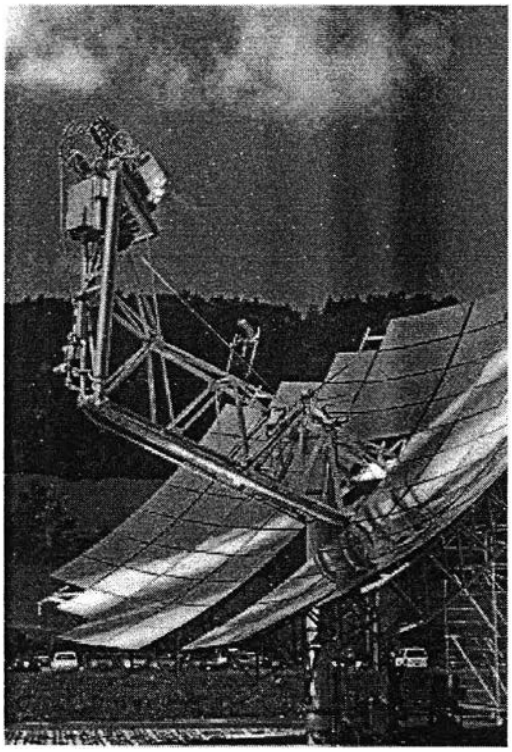

Figure 2.5: Parabolic Dish manufactured by McDonnell Douglas

2.3 Solar Power Tower

Solar power tower generates electric power from sunlight by reflecting solar radiation onto a tower- mounted heat receiver. The system uses hundreds of sun-tracking mirror, so-called heliostat, to reflect the incident sunlight onto the receiver. The plants are best suited for utility-scale applications in the 30 to 400 MW range.

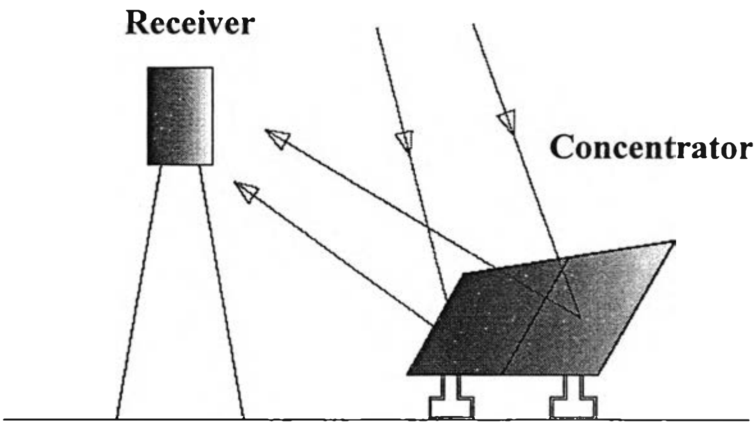

Figure 2.6: Schematic of a power tower

Although solar power towers are commercially less mature than parabolic trough systems, a number of component and experimental systems have been field tested around the world in the last 15 years, demonstrating the engineering feasibility and economic potential of the technology. Since the early 1980s, solar power towers have been constructed in Russia, Italy, Spain, Japan, France, and the United States.

In table 2.2, these experiments are listed along with some of their important characteristics. Solar power tower have proven to be technically feasible in projects using different heat- transfer media in the thermal cycle and with different heliostat designs. These experiment facilities were built to prove that solar power towers can produce electricity and to prove and improve on the individual system components.

Early solar power tower, such as Solar One plant, utilized steam as the heat transfer fluid. Current United State designs utilize molten nitrate salt because of its superior heat transfer and energy storage capabilities.

Figure 2.7 shows Solar One which operates from 1982 to 1988 it is the world's largest power tower plant. It proved that large-scale power production with power towers was feasible. In that plant, water was converted to steam in the receiver. The heliostat field consisted of 1,818 heliostats of 39.3 m^2 reflective area each.

Figure 2.7: The central receiver power plant Solar One at Barstow, USA

In Thailand, the yearly average daily global solar radiation is found to be 18.2 MJ/m^2-day. Figure 2.8 shows the yearly average daily global radiation map demonstrating that the region which receive highest solar radiation are in the north-east and the central parts of the country. The regions with yearly average daily radiation of 19-20 MJ/m^2-day represent 14.3% of the total area of the country. 50.2% of the areas the country receive the yearly average daily global solar radiation in the range of 18 – 19 MJ/m^2-day and only 0.5% receive radiation less than 16 MJ/m^2-day. The result indicate that Thailand has fairly high solar energy potentials. In this work, we select central receiver system because this system is easy to design scale up, and suitable for Thailand geography.

Table 2.1: Experimental power tower [3]

Project	Country	Power Output (MW)	Heat Transfer Fluid	Operation Began
SSPS	Spain	0.5	Liquid Sodium	1981
EURELIOS	Italy	1	Stream	1981
SUNSHINE	Japan	1	Stream	1981
Solar One	USA	10	Stream	1982
CESA-1	Spain	1	Stream	1983
MSEE	USA	1	Molten Nitrate	1984
THEMIS	France	2.5	Hi-Tec Salt	1984
SPP-5	Russia	5	Stream	1986
TSA	Spain	1	Air	1993
Solar Two	USA	10	Molten Nitrate	1996

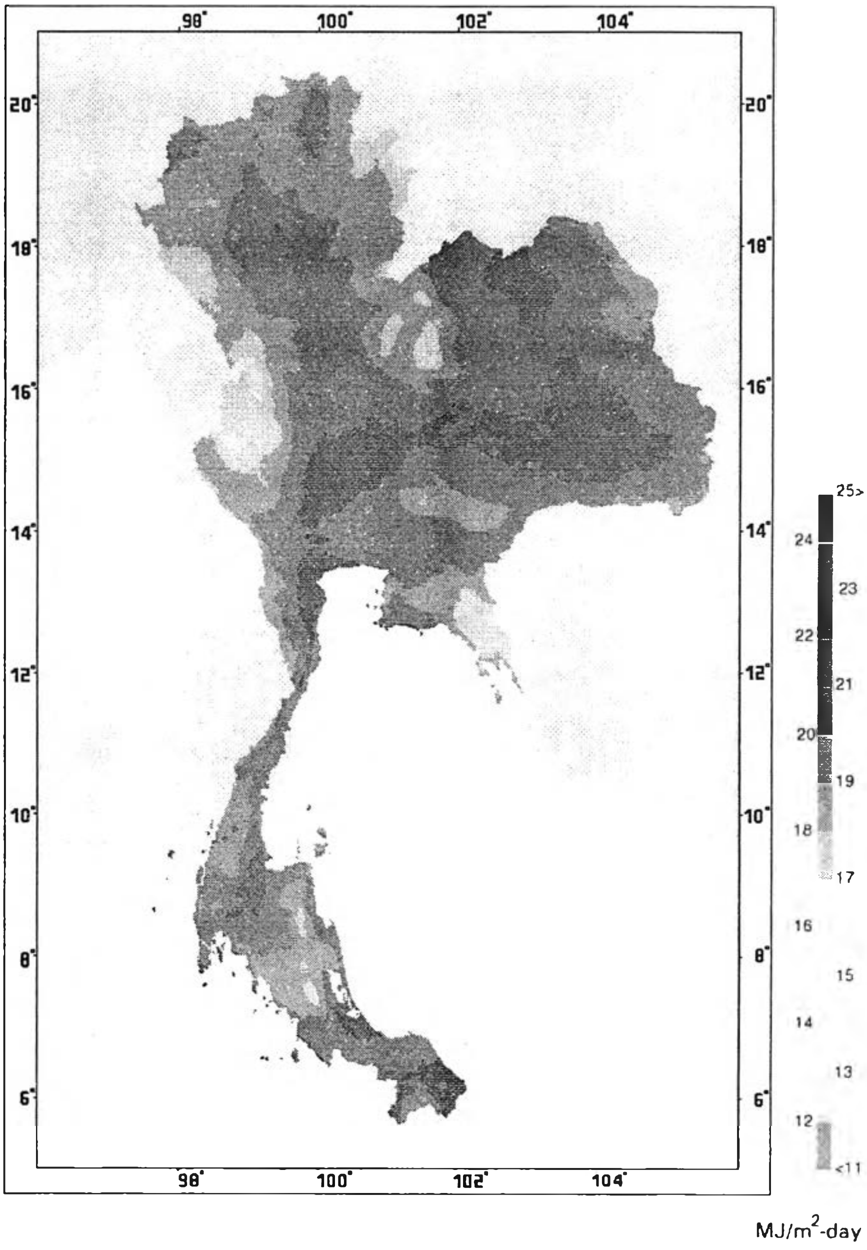

Figure 2.8: The yearly average daily global solar radiation of Thailand [4]