Research Paper Engineering

Solar Power Tower

* Prof. Chandan Kumar ** Gaurav Kumawat

* Mechanical Engg, MECRC, Jodhpur, Rajasthan

** Mechanical Engg, MECRC, Jodhpur, Rajasthan

ABSTRACT

This report represents the study of solar power tower as well as continuing technology development, in order to update the technical and economical status of molten-salt solar power tower. It has endeavoured to explain the solar power tower with an overview of energy, form of energy, what is renewable energy, solar energy, solar photovoltaic, and solar thermal. The second section discusses History of solar power tower development. The third section presents progression from solar one to solar Two. The fifth section details of the molten-salt – what is molten-salt and its properties. The sixth section details of components of solar power tower- Heliostat system, receiver system, thermal storage system, steam generator system and electric generation system. In seventh section discuss about advantage of solar power tower. The opportunity in India of this concept has discussed in eighth section. The ninth section discusses various research and development of solar components. In final Section summarize the successes of solar power tower and current technology development activities.

Keywords:

1. INTRODUCTION

1.1 ENERGY: Energy lights our cities, powers our vehicles, and runs machinery in factories. It warms and cools our homes, cooks our food, plays our music, and gives us picture on television.

"Energy is defined as the capacity to do work". We use energy to do work and make all movements. When we eat, our bodies transform the food into energy to do work. When we run or walk or do some work, we 'burn' energy in our bodies. Cars, planes, trolleys, boats, and machinery also transform energy in to work.

1.2 FORMS OF ENERGY

Renewable Energy
Non-Renewable Energy

1.3 WHAT IS RENEWABLE ENERGY

In the past century, it has been seen that the consumption of non-renewable sources of energy has caused more environmental damage than any other human activity. Electricity generated from fossil fuels such as coal and crude oil has led to high concentrations of harmful gases in the atmosphere. This has in turn led to many problems being faced today such as ozone depletion and global warming. Vehicular pollution has also been a major problem. Therefore, alternative sources of energy have become very important and relevant to today's world. These sources, such as the sun and wind, can never be exhausted and therefore are called renewable. Their use can, to a large extent, reduce chemical, radioactive, and thermal pollution. They stand out as a viable source of clean and limitless energy. These are also known as non-conventional sources of energy. Most of the renewable sources of energy are fairly non-polluting and considered clean though biomass, a renewable source, is a major polluter indoors. Renewable energy sources include the sun, wind, water, agricultural residue, fuel wood, and animal dung. Fossil fuels are non-renewable sources. Energy generated from the sun is known as solar energy.

1.4 SOLAR ENERGY

Solar energy is the most readily available source of energy. It does not belong to anybody and is, therefore, free. It is also the most important of the non-conventional sources of energy because it is non-polluting and, therefore, helps in lessening the greenhouse effect. Solar energy has been used since prehistoric times, but in a most primitive manner. Before 1970, some research and development was carried out in a few countries to exploit solar energy more efficiently, but most of this work remained mainly academic. After the dramatic rise in oil prices in the 1970s, several countries began to formulate extensive research and development programs to exploit solar energy. When we hang out our clothes to dry in the sun, we use the energy of the sun. In the same way, solar panels absorb the energy of the sun to provide heat for cooking and for heating water. Such systems are available in the market and are being used in homes and factories.

1.5 SOLAR PHOTOVOLTIC

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide.

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy.

Application

- Buildings
- Transport
- Standalone Device
- Rural Electrification and
- Medical Refrigeration

1.6 SOLAR THERMAL

Solar thermal energy (STE) is an innovative technology for harnessing solar energy for thermal energy (heat). Solar thermal collectors are classified as low-, medium-, or high-temperature collectors. Low-temperature collectors are flat plates generally used to heat swimming pools. Medium-temperature collectors are also usually flat plates but are used for heating water or air for residential and commercial use. High-temperature collectors concentrate sunlight using mirrors or lenses and are generally used for electric power production. STE is different from it, which converts solar energy directly into electricity. “Power towers” capture and focus the sun's thermal energy with thousands of tracking mirrors in roughly a two square mile field. A tower resides in the center of the heliostat field. The heliostats focus concentrated sunlight on a receiver which sits on top of the tower. Within the receiver the concentrated sunlight heats molten salt to over 1,000 °F. The heated molten salt then flows into a thermal storage tank where it is stored, maintaining 98% thermal efficiency, and eventually pumped to a steam generator. The steam drives a standard turbine to generate electricity. This process, also known as the "Rankine cycle" is similar to a standard coal-fired power plant, except it is fueled by clean and free solar energy.

(Solar Power Tower)

2. HISTORY OF POWER TOWER DEVELOPMENT

Solar power towers generate electric power from sunlight by focusing concentrated solar radiation

on a tower-mounted heat exchanger (receiver). The system uses a few thousand sun tracking mirrors called heliostats to reflect the incident sunlight onto the receiver. These plants are best suited for utility-scale applications in the 10 to 100 MW range. The technology has been the subject of research and development in the United States since the mid-1970s and the Solar Two project represents the culmination of that effort. Although power towers are commercially less mature than parabolic trough systems, a number of component and system experiments have been fielded around the world in the last 20 years, demonstrating the engineering feasibility and economic potential of the technology. Since the early 1980s, power towers have been fielded in Russia, Italy, Spain, Japan, France, and the United States (Meinecke and Bohn, 1995).

(Heliostate At The Experimental Station)

3. SOLAR ONE

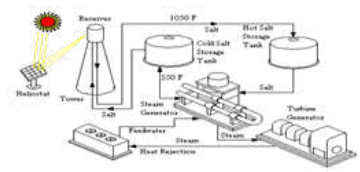
Solar One, power tower technology is effective, reliable, and practical for scale power generation Evaluation of Molten Salt Power Tower Technology. Solar one is based on rankine cycle with conversion of water into steam.

(The Solar One Power Tower plant)

The Solar One thermal storage system stored solar heat in a tank filled with rocks and sand using oil as the heat-transfer fluid. Several banks of heat exchangers allowed the heat to pass between the oil/rock storage tank and the steam cycles used in the receiver and turbine. The system extended the plant’s power-generation capability into the night and provided heat for generating low-grade steam to keep parts of the plant warm during off-hours and for morning startup. Unfortunately, the design of the storage system was complex, thermodynamically inefficient, and used a flammable working fluid that eventually led to its destruction. While Solar One successfully demonstrated power tower technology.

4. SOLAR TWO (MOLTEN-SALT POWER TOWER TECHNOLOGY)

At Solar Two, molten-nitrate salt was the working fluid in the solar receiver. This distinguishes it from other power tower technologies. Liquid salt at 550°F (288°C) is pumped from a ‘cold’ storage tank through the receiver, where it is heated to 1050°F (565°C), and then on to a ‘hot’ tank for storage. When power is needed from the plant, hot salt is pumped to a steam generating system that produces superheated steam for the turbine/generator. From the steam generator, the salt is returned to the cold tank where it is stored and eventually reheated in the receiver. Figure is a schematic diagram of the primary flow paths. Determining the optimum storage size to meet power-dispatch requirements is an important part of the system design process.



(Molten Salt Power tower System)

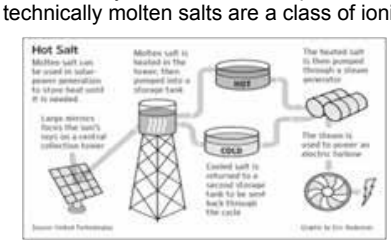
The heliostat field that surrounds the tower is laid out to optimize the annual performance of the plant. The field and the receiver are also sized depending on the needs of the utility. In a typical installation, solar energy collection occurs at a rate that exceeds the maximum heat rate required to provide steam to the turbine. Consequently, the thermal storage system can be charged at the same time that the plant is producing power at full capacity. With a solar multiple of ~3, a molten-salt plant located in a high-insolation region can be designed for an annual capacity factor of ~70%. Consequently, power towers could potentially operate at full power for 70% of the year without the need for a back-up fuel source. By varying the size of the solar field, solar receiver, and size of the thermal storage, plants can be designed with annual capacity factors ranging between 20 to 70% .

(The Solar Two Plant in Operation)

5. MOLTEN SALT

5.1 WHAT IS MOLTEN SALT

Molten salt refers to a salt, which is normally a solid at standard temperature and pressure (STP), being in the liquid phase due to elevated temperature. A salt that is normally liquid even at STP is usually called a room temperature ionic liquid, although technically molten salts are a class of ionic liquids.



It uses a Sodium Nitrite/Nitrate mixture to absorb and store the sun's heat from the focus of many mirrors in the desert upon a central tower. The heat from the salt is then transfered via a heat exchanger to produce steam to drive a conventional steam turbine and generator to produce electricity from the sun.

5.2 PROPERTIES OF MOLTEN SALT

The Molten Salt eutectic mixture, 60% $NANO_3$-40% KNO_3. These salts are widely used as fertilizer, they are low cost and available in large quantities. Their temperature varies from 290 to 550 °C when the solar field is operating.

- Sodium Nitrate (NaNO3): 60% w.
- Potassium Nitrate (KNO3): 40% w.
- Operative temperatures: 260-550°C.
- Non flammable and non toxic fluid.
- Low cost fluid; - Good heat transport.
- Freezing Temperature: 238°C.
- Melting Temperature: 221°C.
- Heat of Fusion: 161 kJ/kg.
- Volume Change on Fusion: 4,6%.

COMPONENTS OF SOLAR POWER TOWER

Solar Two have mainly five components:-

(a) Heliostat System.
(b) Receiver System.
(c) Thermal Storage System.
(d) Steam Generator System.
(e) Electric Generation System.

6. ADVANTAGE OF SOLAR POWER TOWER

• Easy to Operate: One key advantage that solar power towers have is that they are easy to implement compared to many other forms of energy generation.

• Environmental Neutrality: Solar power towers also have a negligible effect on the environment, even compared to other forms of renewable energy.

• Falling Costs: Solar power towers are also cost effective and are becoming even more cost effective. A report from the National Renewable Energy Laboratory estimates that by 2020 the levelised cost of energy produced by solar power towers could be as little as 5.47 cents per kWh.

• Renewable Energy: Another obvious advantage of solar power towers over many other conventional means of energy generation is that it is a renewable form of energy, while many other sources are not.

• No Fuel Cost: Solar Thermal Energy does not require any fuel like most other sources of renewable energy. This is a huge advantage over other fossil fuels whose costs are increasing at a drastic rateevery year.

• Predictable, 24/7 Power: Solar Thermal Energy can generate power 24 hours a day. This is made possible as solar thermal power plants store the energy in the form of molten salts etc.

• **System Benefits:** The availability of an inexpensive and efficient energy storage system may give power towers a competitive advantage.

Table provides a comparison of the predicted cost, performance, and lifetime of solar-energy storage technologies for hypothetical 200 MW plants

	Installed cost of energy storage for a 200 MW plant (□/KWhrs)	Life-time of storage system (year)	Round –trip storage efficiency (%)	Maximum operating temperature (ºF)
Molten -salt power tower	1,625	30	99	1,053
Synthetic-oil parabolic trough	10,800	30	95	734
Battery storage grid connected	27,000 to 43,200	5 to 10	76	N/A

Comparison of Solar-energy storage system

7. OPPORTUNITY IN INDIA

Energy is considered a prime agent in the generation of wealth and a significant factor in economic development. Limited fossil resources and environmental problems associated with them have emphasized the need for new sustainable energy supply options that use renewable energies. Solar power tower generation systems also known as Solar Thermal Electricity (STE) generating systems are emerging renewable energy technologies and can be developed as viable option for electricity generation in future. This paper discusses the technology options, their current status and opportunities and challenges in developing solar thermal power plants in the context of India. solar power tower also can be one of the efficient and eco-friendly ways to meet the same.

8. CONCLUSION

- Solar power towers offer large-scale, distributed solutions to our nation's energy needs, particularly for peaking power. Like all solar technologies, they are fueled by sunshine and do not release greenhouse gases. They are unique among solar electric technologies in their ability to efficiently store solar energy and dispatch electricity to the grid when needed—even at night or during cloudy weather.
- The solar power tower is an emerging technology & economically erected for the production of electricity. Now a days solar thermal technology had been successfully implemented for future perspectives for overall development.
- In modeling & simulation of 1MW DAHAN solar thermal power plant model was developed & successfully applied to thermal power plant for design & operation.

REFERENCES

Hugh E. Reilly et al Evaluation of Molten salt power tower including Result of the solar two Project" November 2001. | Akiba Segal and Michael Epstein"The optics of the solar tower reflector" 13 September 2000. | Reiner Buck et al"Dual-receiver concept for solar towers" 2 March 2005. | 21 September 2011. | R. Ben-Zvi et al "Simulation of an integrated steam generator for solar tower" 1 November 2011. | A. Ramos a et al Strategies in tower solar power plant optimization" 22 May 2012. | Chao Xu et al "Energy and exergy analysis of solar power tower plants" 24 july 2011. | SpirosAlexopoulos et al "Solar tower power lant in Germany" 8 September2009. | www.google.com & www.wikipedia.com