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Sensible Heat Storage for Power Generation

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Abstract: **— The world is seeing a changing trend from conservative power generation sources to most reliable and predominant solar system generation which will be going wild commercially. This paper attempts heat energy storage for power production in which a Molten Salt is proposed for Thermal Energy Storage for Concentrating Solar Power systems. In the concept numerous large, flat, sun-tracking mirrors, recognized as *heliostats* are been used which focuses sunlight against a receiver at the peak of a tall tower. A heat-transfer fluid heated within the receiver is used to generate steam, which, in turn, is used in a conventional turbine generator to produce electricity. Some power towers make use of water/steam as the heat-transfer fluid. Other advanced designs are experimenting with molten nitrate salt because of its superior heat-transfer and energy-storage capabilities. Individual commercial plants can be sized to produce more than 200 megawatts of electricity. Solar power tower convert sunshine into clean electricity. The technology uses many large, sun-tracking mirrors commonly referred as heliostats to focus sunlight on a receiver at the peak of a tower. The huge amount of energy, coming out of the sun rays, concentrated at one point (the tower in the middle), produces temperatures of approximately 550°C to 1500°C. The gained thermal energy can be used for molten salt, which saves the energy for later use.**

Keywords— Concentration Solar Power (CSP), Heliostats, Molten Salt, Thermal Energy Storage, Heat-Transfer Fluid, greenhouse gas, Non pollutant power technology.

INTRODUCTION

Solar technology has its own history which started from 7th Century B.C . In the year 1979 By President Jimmy Carter The first commercial installation of solar-thermal water heater took place at White House in USA. However, increased fuel prices, and demand for energy independence, and a desire to mitigate the effects of greenhouse gases have led India and other countries to invest in solar power generation. The investment led to Today's solar-powered buildings to solar powered vehicles. The question of storing of the heat generated by sun's energy was solved by Molten-salt thermal energy storage in which liquid salt at 290ºC is pumped from a 'cold' storage tank through the receiver where it is heated to 565ºC and then on to a 'hot' tank for storage [1]. When power is needed from the plant, hot salt is pumped to a steam generating system that produces superheated steam for a conventional Rankine cycle turbine/generator, the salt is returned to the cold tank where it is stored and eventually reheated in the receiver. Fig. 1 shows a schematic diagram of the primary flow paths in a molten-salt solar power plant. Determining the optimum storage size to meet power-dispatch requirements is an important part of the system design process. Storage tanks can be designed with sufficient capacity to power a turbine at full output for up to 15 hours. Concentrating solar power (CSP) systems which use concentrated sunlight to run steam turbines have been receiving a lot of attention in recent years as a potential low cost alternative to photovoltaic cells. Like all solar technologies the power delivery profile of CSP depends on the availability of sunlight. Adding energy storage to such systems increases their power delivery flexibility. Unlike PV cells CSP systems can potentially store thermal energy rather than electrical energy giving them a cost advantage in this area because sensible heat storage has lower cost than electrical storage in batteries. This paper propose to use a mixture of nitrate salts as the thermal storage medium for power tower concepts using single-phase receiver fluids, the best of which was a 60% sodium nitrate 40% potassium nitrate molten salt.

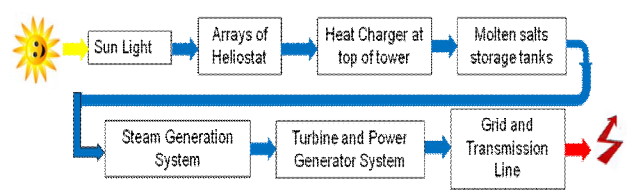

Fig. 1: Block diagram of thermal energy storage and power generation

The technical potential and the cost of renewable energy sources at different is illustrated in fig. 2. As can be seen, the focus was mainly put on power and heat.

1). Hydroelectric power
2). Wind power
3). Solar thermal power
4). Geothermal Energy
5). Solar photo-voltaic, PV
6). Biomass
7). Wave and tidal systems
8). Others

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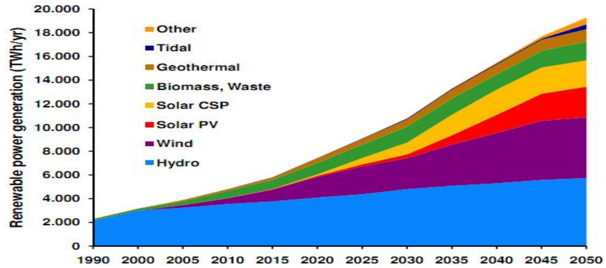

Fig. 2: Growth of Renewable in the India and around the world

BACKGROUND AND SYSTEM DESCRIPTION

Solar power tower convert sunshine into clean electricity. The technology uses many large, sun-tracking mirrors commonly referred as heliostats to focus sunlight on a receiver at the top of a tower. The enormous amount of energy, coming out of the sun rays, concentrated at one point (the tower in the middle), produces temperatures of approx. 550°C to 1500°C. The gained thermal energy can be used for heating water or molten salt, which saves the energy for later use. Heated water converts to steam, which is used to move the turbine-generator. This way thermal energy is converted into electricity. Water is the oldest and simplest way for heat transfer. But the difference is that the method in which molten salt is used, allows storing the heat when the sun is behind clouds or even at night.

than water/steam systems and allows the incorporation of a cost-effective energy storage system.

Energy storage allows the solar electricity to be dispatched to the utility grid when the power is needed most, which increases the economic value of solar energy. In 1992, a team composed of utilities, private industries, and government agencies collaborated to demonstrate molten-salt power towers at the 10-MWe Solar Two plants, which were constructed by retrofitting Solar One with molten salt technology. The Solar One heliostat field, the tower, and the turbine/generator required only minimal modifications shown in figure 3.

CENTRAL RECEİVER SYSTEMS FROM HELIOSTATS

A heliostat (from helios, the Greek word for sun, and stat, as in stationary) is a device that includes a mirror, usually a plane mirror, which turns so as to keep reflecting sunlight toward a predetermined target, compensating for the sun's apparent motions in the sky. The target may be a physical object, distant from the heliostat, or a direction in space. To do this, the reflective surface of the mirror is kept perpendicular to the bisector of the angle between the directions of the sun and the target as seen from the mirror. In almost every case,

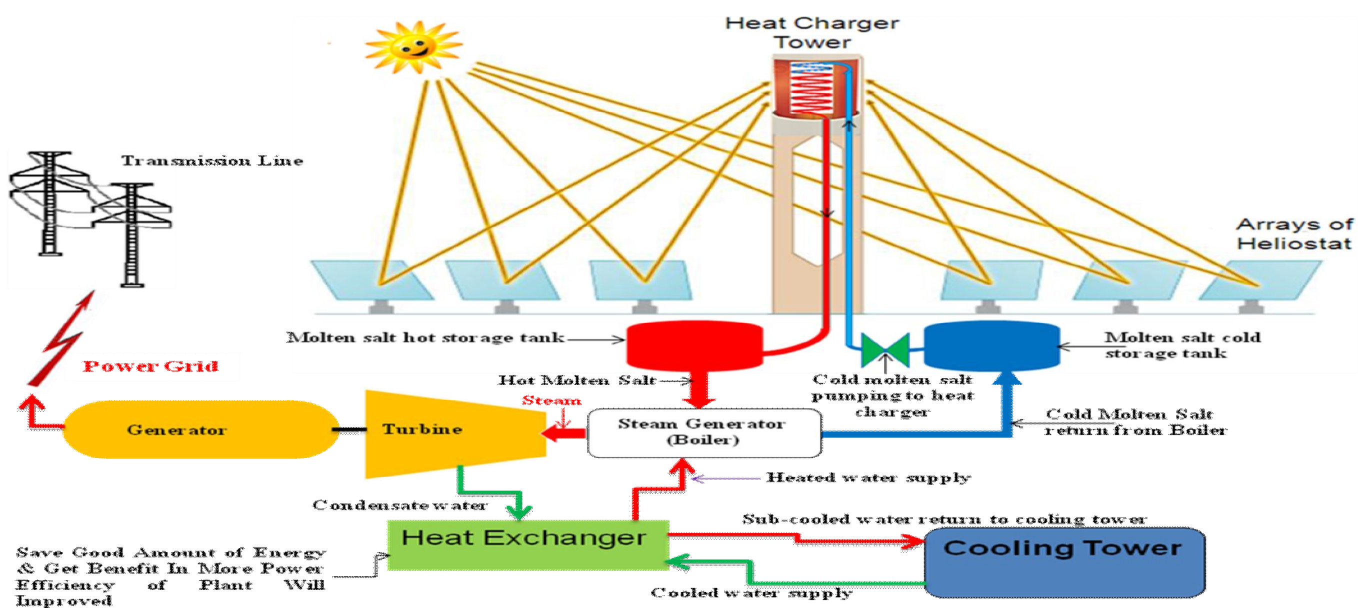

Fig. 3: The operating principle of a molten-salt power tower ‘‘Cold’’ molten salt is pumped to the heat charger where it is heated up to 565°C to 580°C.

The 10-MWe Solar One Pilot Plant, which operated from 1982 to 1988 in Barstow, California, was the largest demonstration of first-generation power-tower technology (Radosevich, 1988). During the operation of Solar One and after its shutdown, significant progress was made in the U.S. on more advanced second-generation power-tower designs. The primary difference between first and second-generation systems was the choice of receiver heat-transfer fluid. Solar One used water/steam, and the second-generation designs in the U.S. used molten salt. The molten-salt power tower design decouples the solar collection from electricity generation better

the target is stationary relative to the heliostat, so the light is reflected in a fixed direction.

The flat mirror surface can be made by metallization of float glass or flexible plastic sheets. In view of the life expectancy of plant (up to 30 years say), glass and plastic seem less appropriate because their optical and mechanical properties are liable to change with time. Float metalized with silver or aluminum provides reflectivity of 93% and 82% to 86% respectively, subject to cleaning [2] shown in fig. 4.

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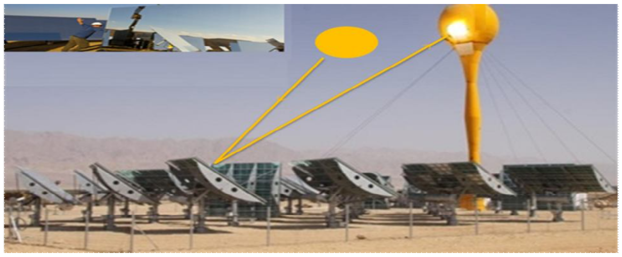

Fig. 4: Two axis type heliostat, with horizontal and azimuth (up and down) freedom of movement

A. Basic Concept of Sunlight Collection

Sunlight's "direct beam" carries about 90% of the solar energy. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible. The energy contributed by the direct beam drops off with the cosine of the angle between the incoming light and the panel. In addition, the reflectance (averaged across all polarizations) is approximately constant for angles of incidence up to around 50°, beyond which reflectance degrades rapidly shows the table 1.

Table 1: sun move 23 degrees on either side east-west.

Θ	Lost = 1- cos(Θ)	Θ	Hours	Lost
0°	0%	15°	1	3.4%
1°	0.015%	30°	2	13.4%
3°	0.14%	45°	3	30%
8°	1%	60°	4	>50%
23.4°	8.3%	75°	5	>75%

The sun travels through 360 degrees east-west a day, but from the perspective of any fixed location the visible portion is 180 degrees during an average 1/2 day period (more in spring and summer; less, fall and winter). Local horizon effects reduce this somewhat, making the effective motion about 150 degrees. A solar panel in a fixed orientation between the dawn and sunset extremes will see a motion of 75 degrees on either side, and thus, according to the table above, will lose 75% of the energy in the morning and evening. Rotating the panels to the east and west can help recapture these losses. A tracker rotating in the east-west direction is known as a single-axis tracker.

One simple alternative is for the mirror to rotate around a polar aligned primary axis, driven by a mechanical, often clockwork, mechanism at 15 degrees per hour, compensating for the earth's rotation relative to the sun. The mirror is aligned to reflect sunlight along the same polar axis in the direction of one of the celestial poles. There is a perpendicular secondary axis allowing occasional manual adjustment of the mirror (daily or less often as necessary) to compensate for the shift in the sun's declination with the seasons. The setting of the drive clock can also be occasionally adjusted to compensate for changes in the Equation of Time shown in fig. 5.

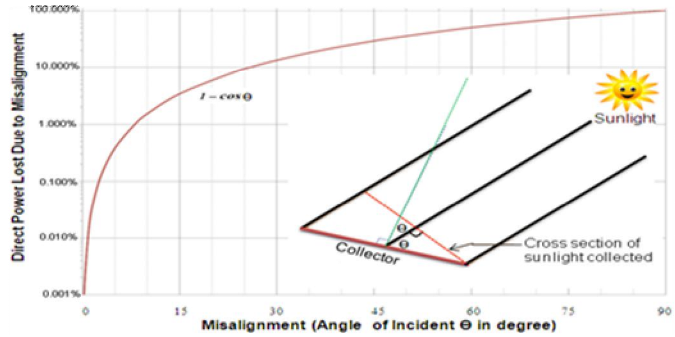

Fig. 5: The effective collection area of a flat-panel sunlight collector varies with the cosine of the misalignment of the panel with the Sun.

THE PRINCIPLE OF MOLTEN-SALT STORAGE

The most important characteristics thermal storage system is its very high efficiency of the storage, with a possibility of annual efficiency of 99% for commercial plants. The only losses come from slow heat loss through the tank walls, which is kept to a minimum via insulation.

The heat exchange process between mediums, i. e., salt to steam for towers, or oil to salt, salt to oil, and then to steam, in the case of a trough system. When these steams is converted to electricity, the typical net steam (Rankine) cycle efficiency for a superheat plus reheat system at 565^{0}C and 100 bar is 38%. As with any thermal power generation (including coal and gas), the conversion from heat to electricity gives the largest energy loss in the system.

Because the energy generation system is completely independent of the energy collection system, a steady flow of power can be produced regardless of whether the sun is shining at full strength, or partial strength, or whether it is cloudy, or nighttime as long as there is sufficient energy stored in the hot salt tank. The mirror fields are oversized to allow the storage tanks to be filled during the day while electric power is generated simultaneously. The exact balance of mirror field size, to turbine size, to storage size can be optimized depending on the desired performance of the CSP plant. For example, a plant with upwards of 20h of storage can act as a base-load power plant, while a plant with 10 to12 h of storage but a larger turbine can meet the afternoon evening peak power demand shown in fig. 6.

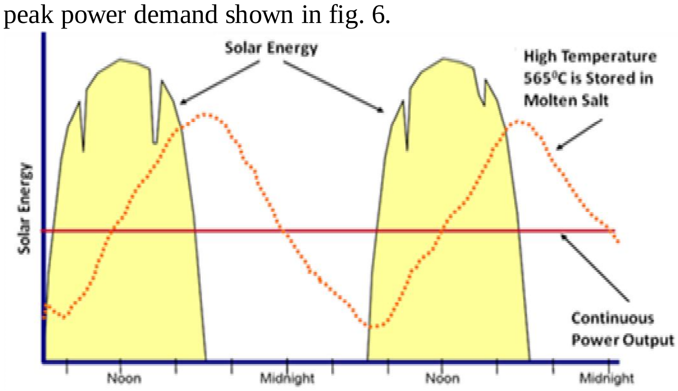

Fig. 6: Daytime and nighttime operation of a solar power tower with thermal energy is storage in molten salt [3].

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MOLTEN-SALT PROPERTIES

Currently, both trough and tower plants use the same molten-salt mix for storage a 60 wt% to 40 wt% mix of sodium and potassium nitrate know as Solar Salt, illustrated in Fig. 7 (a) & (b). At room temperature, Solar Salt is a white crystalline solid. Therefore, during plant commissioning, it is necessary to melt the entire salt inventory. The salt inventory then remains in the liquid state for the operating life of the plant.

Fig. 7 (a) & (b): Potassium and sodium nitrate prior to the melting process. In the liquid state, it is clear with a yellow tinge, like beer [5].

Solar Salt is a eutectic mixture, meaning that this particular composition melts at a lower temperature than any other ratio of the two salts, and that at this ratio; both of the salts begin melting at the same temperature. Solar Salt was chosen for use with molten-salt power towers because its upper stability temperature limit (600^0C) allows high-efficiency Rankine cycle turbines to be used for example, a superheat plus reheat system, or potentially a supercritical plus reheat system.

Table 2 lists the compositions and properties of a variety of salt mixtures.

Heat transfer salt	Melting point (^{0}C)	Thermal stability limit(^{0}C)	Density at 300^{0}C (kg/m^3)	Velocity at 300^{0}C (Pa. s)	Heat capacity at 300^{0}C (J/kg. K)	Thermal conductivity (W/(m.K))
Solar salt (60:40 Na:K nitrate)	220	600	1899	0.00	1495	0,55 (at 400^{0}C)
Hitec (7:53 Na:K nitrate, 40 Na nitrate)	142	535	1640	0.00316	1560	
HitecXL (7:45:48 Na:K: Ca nitrate)	120	500	1992	0.00637	1447	

Table 2 lists the compositions and properties of a variety of salt mixtures used as heat transfer fluids. In addition to Solar Salt, both Hitec and HitecXL are commercially available. Hitec and HitecXL have lower melting points than Solar Salt. Hitec,containing a nitrite salt, requires an N2 cover at atmospheric pressure in the thermal storage tanks to prevent conversion to nitrate

ECONOMİC AND ENVİRONMENTAL CONSİDERATİONS

The economical factor driving the solar energy system design process is as shown in fig. 7. Although there are factors other than economics that enter into a decision of when to use solar energy; i.e. no pollution, no greenhouse gas generation, security of the energy resource etc., design decisions are almost exclusively dominated by the 'levelized energy cost'. This or some similar economic parameter, gives the expected cost of the energy produced by the solar energy system, averaged over the lifetime of the system. Commercial applications from a few kilowatts to hundreds of megawatts are now feasible, and plants totaling 354 MW have been in operation in throught world since the 1980s. Plants can function in dispatchable, grid-connected markets or in distributed, stand-alone applications. They are suitable for

fossil-hybrid operation or can include cost-effective storage to meet dispatchability requirements. They can operate worldwide in regions having high beam-normal insolation, including large areas of the southwestern United States, and Central and South America, Africa, Australia, China, India, the Mediterranean region, and the

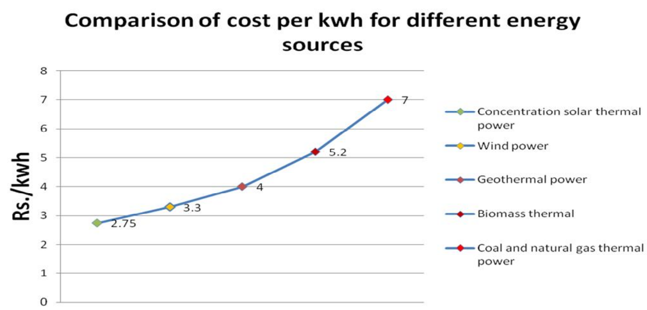

Fig. 8: Comperison of cost Rs. Per kwh of different energy

CONCLUSION

Utilities are showing increasing interest in the deployment of concentrating solar power plants to meet the requirements of state renewable energy electricity standards. Concentration solar power is a reliable, proven renewable technology for generating electricity. Based in the sunny regions of the World, like India, Southern Europe and the Middle East and North Africa (MENA) region in particular, it can potentially make a substantial contribution to mitigating greenhouse gas emissions and establishing a sustainable energy system.

It is very efficient system and the efficiency can be increased by hybridizing it with the other conventional plants. It is Very economical excluding initial cost; molten salt has the best Heat capacity. It is Non pollutant power technology and it will be very important power source for developing countries.

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A. FUTURE SCOPE

Saudi Arabian Govt. has raised the fund for its renewable energy program, taking its target from the previously announced 41GW to an even more ambitious 54GW by 2032. The kingdom has now taken action by formulating a preliminary procurement process for industry feedback. What can Concentration solar power developers expect in terms of challenges and incentives?

REFERENCES

[1] By Rebecca I. Dunn, Patrick J. Hearps, and Matthew N. Wright Molten-Salt Power Towers: Newly Commercial Concentrating Solar Storage, in proc. of the IEEE Vol. 100, No. 2, February 2012 page No. 504 to 515

[2] S. Relloso and E. Delgado, Experience with molten salt thermal storage in a commercial parabolic trough plant. Andasol-1 commissioning and operation, in Proc. 15th Solar PACES Conf., Berlin, Germany, 2009, article no. 11396.

[3] J. Lata, S. Alcalde, D. Ferna´ndez, and X. Lekube. First surrounding field of heliostats in the world for commercial solar power plants Gemasolar, in Proc. 16th Solar PACES Conf., Perpignan, France, 2010, article no. 113

[4] J. Pacheco, R. Bradshaw, D. Dawson, W. De la Rosa, R. Gilbert, S. Goods, M. J. Hale, P. Jacobs, S. Jones, G. Kolb, M. Prairie, H. Reilly, S. Showalter, and L. Vant-Hull, B Final test and evaluation results from the Solar Two project, Solar Thermal Technol. Dept., Sandia Nat. Labs. NM, Tech. Rep. SAND2002-0120. [Online]. Available: http://www.osti.gov/bridge/ product. biblio.jsp?osti_id=793226

[5] N. Siegel, C. Ho, S. Khalsa, and G. Kolb, B Development and evaluation of a prototype solid particle receiver: On-sun testing and model validation,[ASME J. Solar Energy Eng.,
vol. 132, pp. 021008-1–021008-8, May 2010.

[6] S. Zunft, M. Ha¨nel, M. Kru¨ger, and V. Drei*A*igacker, BHigh-temperature heat storage for air-cooled solar central receiver plants: A design study,[in Proc. 15th Solar PACES Conf., Berlin, Germany, 2009, article no. 16113.

[7] C. Richter, J. Blanco, P. Heller, M. Mehos, A. Meier, R. Meyer, and W. Weiss. (2009). International Energy Agency (IEA) solar power and chemical energy systems,'' SolarPACES Annual Report 2008. [Online].