International Journal of Science Engineering and Advance Technology

An Effective Utilization of Concentrated Solar Energy

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Abstract-This thesis describes a new Concentrating Solar Energy with Integral thermal storage that is applied in a solar thermal power station. Solar radiation is concentrated on the boiler of a conventional power station by the technics ofParabolic trough and Fresnel trough, Central receiver system, Solar updraft tower plant The study on the several new CSP projects following the stagnation period of next 35 years. This projects discuses about the past present and future status of the energy demand. Taking the three scenarios pessimistic, optimistic-realistic, very optimistic describes solar thermal technology development pathways. The contribution analysis showed that in case of thermo oil based power plant concepts are taken into consideration to analyze the emission from the plant and environment issues. Life Cycle results for current and future technology configuration are carried out for better analysis.

1. Introduction

Solar Thermal Power generation systems capture energy from solar radiation, transform it into heat, and generate electricity from the heat using steam turbines, gas turbines or pressure staged turbines. The four main types of solar thermal power plants developed and tested so far are Parabolic trough and Fresnel trough technology, Central receiver system, Central receiver system, Solar updraft tower plant.
With about 300 clear sunny days in a year, India's theoretical solar power reception, on only its land area is about 5000 Petawatt-hours per year (PWh/yr) (i.e. 5,000 trillion kWh/yr or about 600,000 GW). The daily average solar energy incident over India varies from 4 to 7 kWh/m^2 with about 1,500–2,000 sunshine hours per year (depending upon location), which is far more than current total energy consumption. For example, assuming the efficiency of PV modules were as low as 10%, this would still be a thousand times greater than the domestic electricity demand projected for 2015.

2.Types of technologies.Parabolic trough systems

Parabolic trough systems consist of trough solar collector arrays and a conventional power block with steam turbine and generator. A heat transfer fluid, currently synthetic thermo oil, is pumped through the collector array and heated up to 400 °C. This oil is used to produce steam in heat exchangers before being circulated back to the array. The steam is used in a conventional steam turbine-based power plant.

Central receiver systems

Central receiver (CR) systems consist of a field of heliostats (almost plane mirrors), a tower,and a receiver at the top of the tower. The field of heliostats all move independently to one another and beam the solar radiation to one single point, the receiver. Heliostat fields can either surround the tower or be spread out on the shadow side of the tower.

Central receivers have the advantage that the energy conversion takes place at a single fixed point, which reduces the need for energy transport. By the high concentration factor operation temperatures of more than 1,000 °C can be reached. This rises the conversion efficiency and allows for advanced energy conversion systems (combined cycle instead of steam cycle).

Dish-engine systems

Parabolic dish concentrators focus solar radiation onto a point focus receiver. Like parabolic trough systems they require continuous adjustment of its position to maintain the focus. Dish based solar thermal power systems can be divided into two groups: Those that generate electricity with engines at the focus of each dish and Those that transport heat from an array of dishes to a single central power-generating block.
Stirling engines are well suited for construction at the size needed for operation on single
dish systems, and they function with good efficiency. Dish-stirling units of 25 kW_{el} have achieved overall efficiency of close to 30%. This represents the maximum net solar-to-electricity conversion efficiency achieved by any non-laboratory solar energy conversion technology.

Solar Updraft Tower Plant

A solar updraft tower plant (sometimes also called solar chimney) is a solar thermal power plant working with a combination of a non-concentrating solar collector for heating air and a central updraft tube to generate a solar induced convective flow. This air flow drives pressure staged turbines to generate electricity. The collector consists of a circular translucent roof open at the periphery and the natural ground below. Air is heated by solar radiation under this collector. In the middle of the collector there is a vertical tower with large inlets at its base. As hot air is lighter than cold air it rises up the tower. Suction from the tower then draws in more hot air from the collector, and cold air comes in from the outer perimeter.
Continuous 24 hour operation can be achieved by placing tight water-filled tubes or bags under the roof. The water heats up during day-time and releases its heat at night. Thus solar radiation causes a constant updraft in the tower (although this storage system has never been installed or tested up to now). The energy contained in the updraft is converted into mechanical energy by pressure-staged turbines at the base of the tower, and into electrical energy by conventional generators.

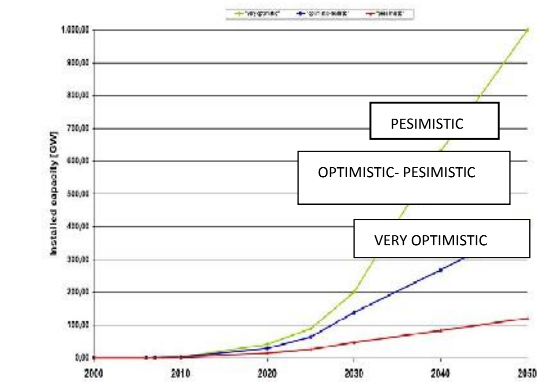
3.0 Future envisaged technology development Scenarios

The different market development conditions considered for this study are outlined in three future envisaged technology development scenarios. We distinguish between an "optimistic-realistic" scenario and two extreme developments, a "very optimistic" view on the one hand and a "pessimistic" view on the other hand.

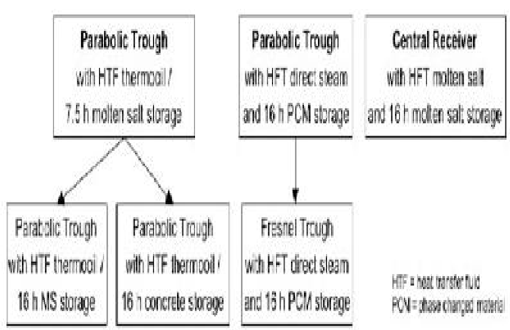
The "**very optimistic"** scenario bases on the assumption that both phases the activating phase as well as the competing phase can fully be explored. Especially in the first phase the maximum of "energy" has to be activated by all instruments discussed above to enable an early increase of solar thermal power plant's capacity. This means that a worldwide and ambitious long-term oriented climate protection regime has to be implemented (under which all renewable energies will be pushed) and suitable regulative framework conditions will be implemented.

The "**optimistic-realistic"** scenario illustrates the progressive targets to be met in the next decades if most of the instruments discussed above are strong enough to activate the market development especially within the next 10 to 15 years. Although the subsidies of fossil and nuclear electricity production may not be swept out and the internalisation of cost of CO_2 reduction will not advance as necessary as assumed for the very optimistic case the other instruments will be strong enough to push both the activation phase and the competing phase. Especially the feed-in-laws and the power purchase agreements supplemented by increasing fossil and nuclear fuel prices will enable an increasing diffusion of solar thermal electricity into the market.

For the "**pessimistic" scenario** it is assumed that the driving forces will push the solar thermal development in the next decade but they will be to weak to enable a high and continuing diffusion as expected for the "optimistic-realistic" or even the "very optimistic" scenario. Solar thermal power plants won't be swept out of the renewables' portfolio but they will only increase on a very retained development path up to 2050. The "activation energy" as described above will neither suffice to push a strong first development phase nor the second phase of participating in the electricity market. We assume that the application of solar thermal power plants will have a slight increase in the U.S. whereas the feed-in laws in Europe will push both the investment in Europe and the import of solar thermal electricity from North Africa on a low level.

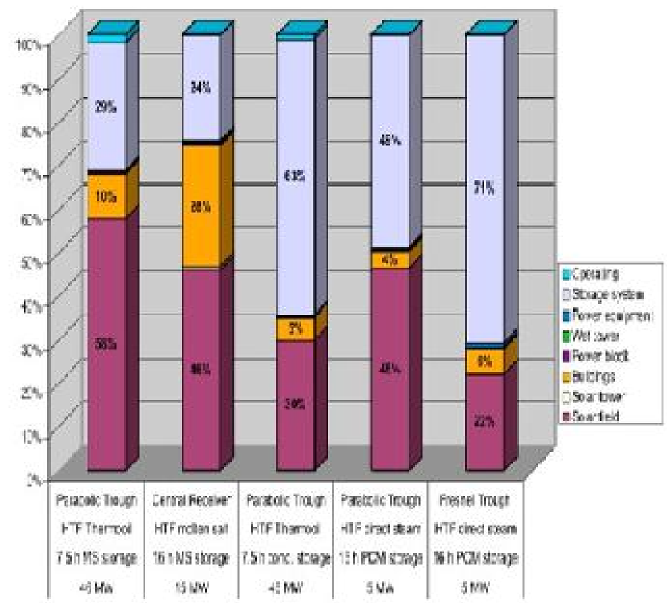


LCI results for current and future technology configurations
Each of the solar thermal power plant configurations modeled in this work package havebeen developed from three basic types: the parabolic trough with thermo oil as heat transferfluid (HTF), the parabolic trough with direct steam as HTF, and thecentral receiver with HTF molten salt ("SolarTres").



Share of components on the total inventory

Basic solar thermal power plants components.



Conclusion :

In the present situation "hybrid" and "solar-only" operated solar thermal power plantsdiffer in three aspects:
Emissions caused mainly by fossil fuels (CO_2 and CH_4) decrease by about 80 to90% if switching to a solar-only mode.
Emissions caused mainly during the construction phase and only for a lower part by the use of fossil fuels (particles, SO_x, N_2O) are reduced only by 30% in the maximum (in case of particles and SO_x) or increase in case of N_2O because N_2O is onlycaused by the salt inventory of the storage system

The contribution analysis showed that in case of thermo oil based power plant conceptsthe operation phase contributes with 10 to 20% to the results mainly caused by thethermo oil upstream process. In contrary in steam based concepts no thermo oil has tobe exchanged during operation which minimizes the share of the emissions. This aspectand the larger inventory of the concrete and PCM based storagesystems lead to a higher importance of the dismantling phase.

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ISSN 2321-6905
September-2014

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