SUNSPOT

The **S**tellenbosch **UN**iversity **S**olar **PO**wer **T**hermodynamic cycle

by

Emeritus professor Detlev G. Kröger, D.Sc. Eng (multi), D. Eng h.c. (multi), LFASME

Department of Mechanical and Mechatronic Engineering

University of Stellenbosch

Stellenbosch

South Africa

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The Department of Mechanical and Mechatronic Engineering at the University of Stellenbosch is currently involved in the evaluation and development of different solar thermal power generating plants. One such concept, also referred to as the SUNSPOT cycle (**S**tellenbosch **UN**iversity **S**olar **PO**wer **T**hermodynamic cycle) as proposed by professor Detlev Kröger in 2008, is an appropriate and efficient cycle for generating electricity in South Africa and other parts of the world. A schematic of the basic SUNSPOT cycle is shown in figure 1.

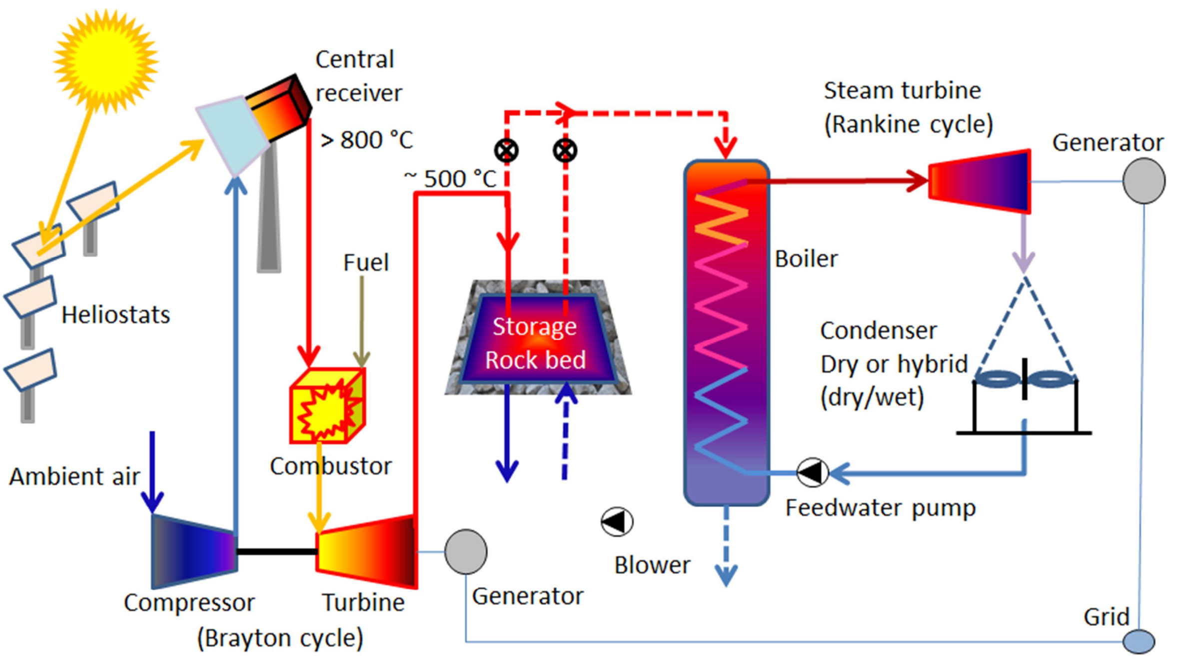

Figure 1: The SUNSPOT cycle.

Solar radiation is concentrated onto a central receiver heat exchanger by means of a field of mirrors or heliostats. An example of a central receiver power plant (steam cycle) is shown in figure 2. In the SUNSPOT cycle compressed ambient air is heated to more than 800°C in the central receiver. The hot air thereafter flows through a turbine which drives the compressor and a generator that supplies electricity to a grid or transmission system. Air leaving the turbine at approximately 500°C is ducted into a packed rock bed thermal storage facility. After sunset, heated air from the rock bed is blown across a finned tube boiler. Steam generated in the boiler flows through a steam turbine which drives a generator to supply electricity to the grid at night. The steam leaving the turbine condenses in a cooling system which rejects heat to the environment.

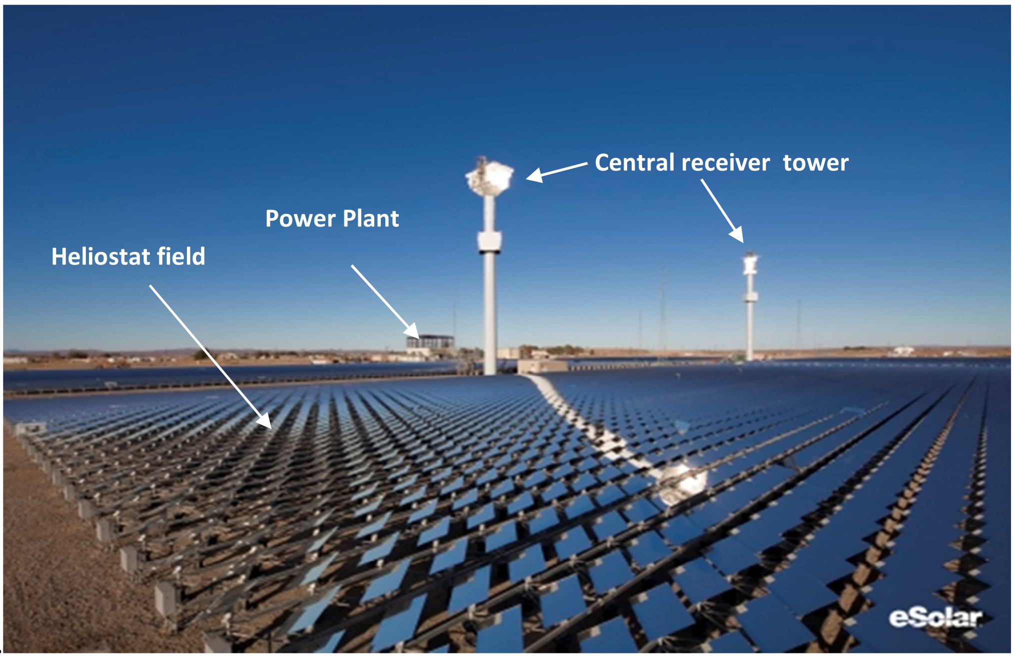

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Figure 2: Example of a central receiver power plant (courtesy of eSolar).

Further research and development of the SUNSPOT cycle receiver system may achieve higher air temperatures and increased cycle efficiencies. The latter will result in a corresponding reduction in the cost of electricity.

With suitable gas (e.g. hydrogen generated by the SUNSPOT cycle or natural gas with limited carbon dioxide generation etc.) or bio-fuel (e.g. ethanol from sugar cane etc.) burners or combustors located upstream of the turbine, changes in electrical output due to fluctuations in solar radiation during cloudy or rainy periods lasting hours or even days may be eliminated. By burning additional fuel, turbine temperature and efficiency can be increased to maximize plant output during daily peak power demand periods. Together with a large thermal storage facility the resultant flexibility in the control of power generation that satisfies the demand pattern will essentially eliminate the need for a sophisticated and costly national power grid or transmission system.

By employing local natural rock (e.g. granite or dolerite) a large low-cost thermal energy storage capacity is made available to act as thermal store for the hot turbine exhaust gas. Such a rock bed is effective from sunset to sunrise. Other storage options such as metallic phase change materials or molten salts may also be considered although they tend to be relatively expensive and are usually limited to only a few hours of operation. The steam cycle also generates power during the day if some hot turbine exhaust gas is fed directly to the boiler.

Most solar power generating plants will be located in relatively arid regions of the world where an adequate supply of cooling water is usually not available. Dry-cooled (air) or hybrid (dry/wet) cooling systems will thus be considered. A novelty of the SUNSPOT cycle is the fact that most of its cooling (condensing steam) is required during the night when ambient air temperatures may be 10°C to 20°C lower than during the day and dry-cooling will be correspondingly more effective. If limited amounts of brackish or waste water are available cycle efficiency can be enhanced during the hottest hours by installing a hybrid (dry/wet) cooling system.

Depending on demand pattern and cost structures, hot exhaust air from the proposed plant may be employed to distil limited amounts of water.