Solar Tower Concepts for Ultra Supercritical Steam Cycles

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The outlooks and perspectives dealing with international energy economy plans state that the first commercial "700 °C generation" power plants shall start operation around 2014. Five to eight years of operation experience with ultra supercritical (USC) power plants have already demonstrated that the "600 °C generation" power plants will end up as a true success. A power plant deficit of 300,000 MW is estimated around 2020 due to increasing demand for electricity and the replacement of power plants that are more than 40 years old. Taking increasing fossil fuel prices into account, it is estimated that concentrating solar power (CSP) plants will be competitive with oil and gas assets around 2015 and with coal assets around 2025.

Particular attention has been paid to plant efficiency during the development of electric power generation systems through the last decades. Today's state-of-the-art super critical plants operate with steam parameters at 250 bar and 540–560°C, while offering net efficiencies around 44%. The thermodynamic comparison of increased steam cycle parameters shows increased net efficiencies up to 51% in the case of fossil fuel firing, which results in 53% steam cycle efficiency at temperatures around 700 °C and pressures around 350 bar. Using CSP combined with a USC steam cycle, which offers a net efficiency of approximately 53%, might end in a significant improvement of the levelized electricity costs (LEC).

For different solar tower concepts, a detailed analysis and optimisation that focuses on 50MWel and 100MWel solar tower plants is planned. Besides choosing a solar tower concept, it is important to find out which concept and configuration of many variations is the most promising to reach a competitive LEC in the future. The presentation gives an overview of the state-of-the-art of supercritical steam cycles and about the gained knowledge while reviewing established publications about CSP and USC technologies. A systematic approach will be introduced that allows a consistent categorisation of CSP plants by classifying them according to the physical phenomena which occur while the energy conversion from solar radiation to electricity generation takes place. This systematic approach is used to identify concepts for combination of solar towers with supercritical steam cycles. Finally, critical issues of solar heated supercritical steam cycles will be described.