Particles-based thermochemical storage through solar rotary kiln and a vertical moving bed reactor at pilot scale

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The capability of storing energy at high temperature is one of the key advantages of concentrated solar energy in comparison to other renewables. At present, most concentrated solar systems store the heat in sensible form through molten salts. The stored energy is limited by the salt characteristics, which freezes at low temperature and decompose at high temperature. Higher energy densities can be reached through larger operating temperature range and by adding chemical energy. Thermochemical storage (TCS) systems can operate in almost any temperature range, depending on the chosen material, provide higher energy densities through a reversible reaction and allow long term storage.

For these reasons the interest on TCS has grown in the last years and several systems were analysed. Due to its relative recent development, most of the studies are limited to laboratory scale and only few reactors were demonstrated at pilot scale. The present work, shows the development and the experimental evaluation of a complete TCS system at pilot scale. The storage material is a metal oxide, precisely a mix of manganese and iron oxide, which undergoes consecutive reduction (endothermic) and oxidation (exothermic) reaction. The metal oxide is shaped in mm-size granules. The TCS is composed by two reactors: one operates on-sun and is used to store the heat and a separate one, operating off-sun, for the heat release. The first reactor is a solar rotary kiln which directly transfers the concentrated solar power to the reactive particles, which get heated and react. The heat release takes place on a vertical moving bed reactor, in which the air, flowing counter-current in respect to the particles is heated by their heat and by the reverse chemical reaction. The system can treat several tenths of kg per hour at temperatures up to 1100°C, allowing to store a power of about 3kW.