

High Temperature Thermochemical Energy Storage: Operation Modes of a 10kW Pilot Reactor based on $\text{CaO}/\text{Ca}(\text{OH})_2$

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High Temperature Thermochemical Energy Storage

Applications

- Decoupling of solar radiation from electricity production
- Flexibility of conventional power plants
- Reutilization of industrial waste heat



High Temperature Thermochemical Energy Storage

Limestone as a promising storage material

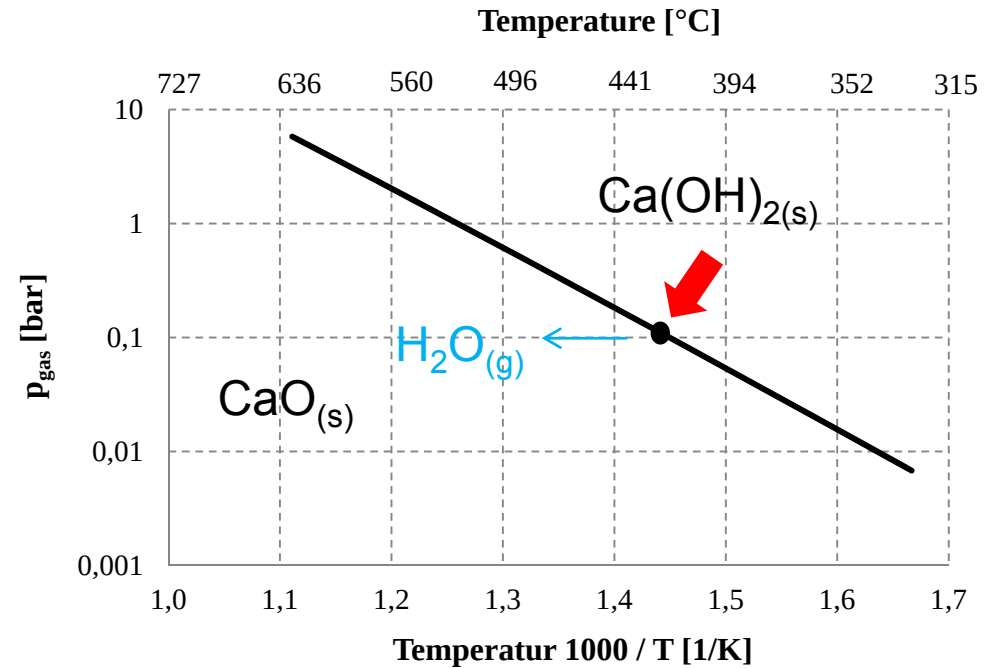
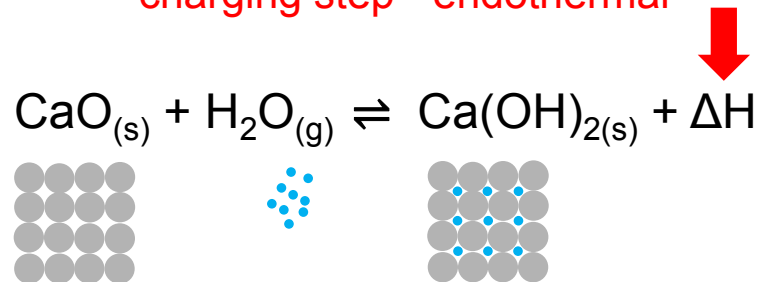
- Cheap raw material (70\$ per ton)
- Environmental friendly and nontoxic
- Production in industrial scale
- Additional chemical potential with the reaction with water vapor



Thermochemical Energy Storage

Reaction System CaO/ Ca(OH)₂

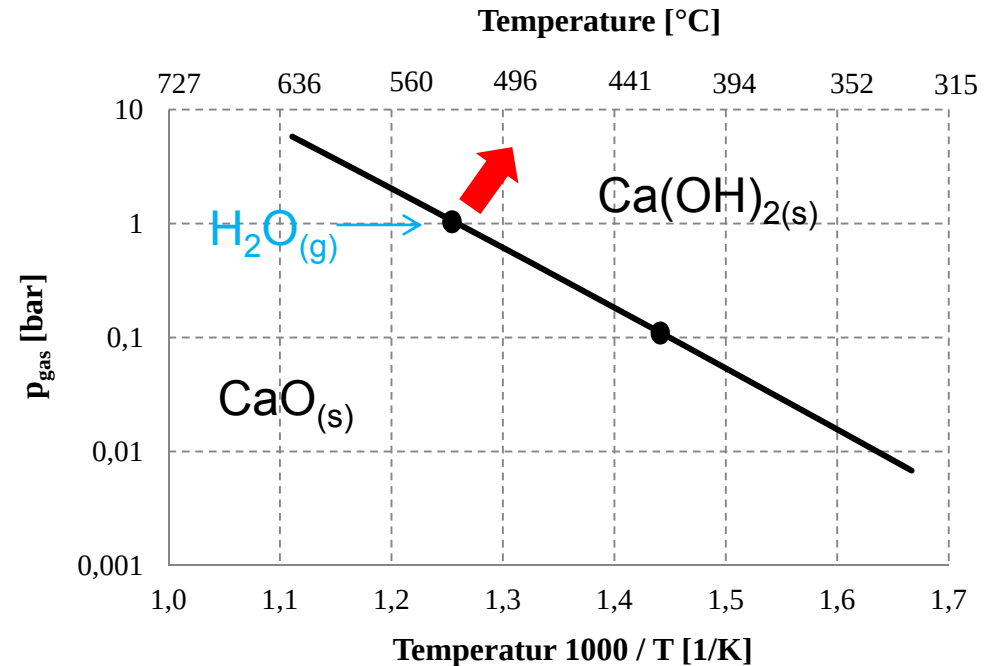
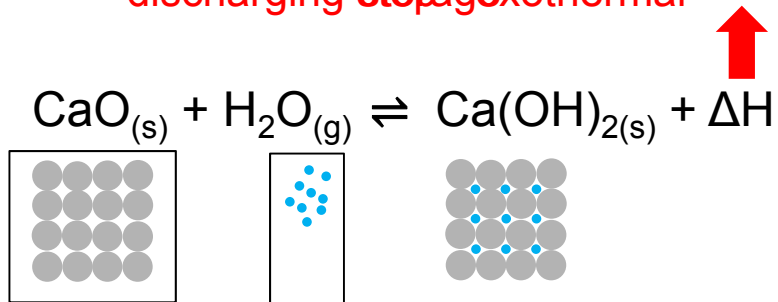
charging step - endothermal



Thermochemical Energy Storage

Reaction System $\text{CaO} / \text{Ca(OH)}_2$

discharging ~~step~~ exothermal

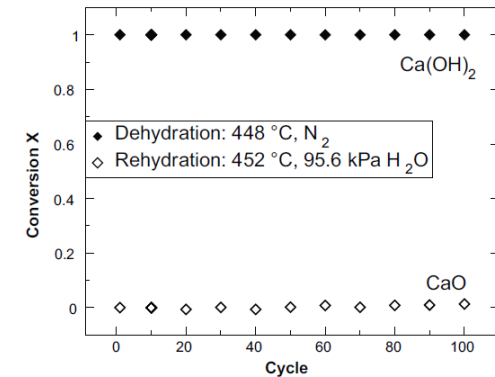
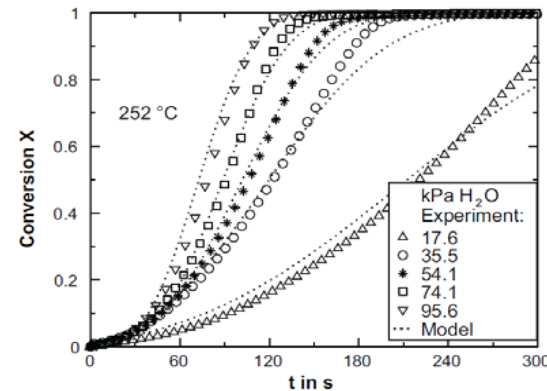


- Very high energy density – 0,4 kWh/kg
- Adjustability of charge and discharge temperature
- Possibility to transform heat
- Loss free storage of chemical potential



Material Properties - $\text{CaO}/\text{Ca}(\text{OH})_2$

Chemical properties:



F. Schaub et al. (2012). A thermodynamic and kinetic study of the de- and rehydration of $\text{Ca}(\text{OH})_2$ at high H_2O partial pressures for thermochemical heat storage. *Thermochimica Acta* 538(2012) 9 - 20

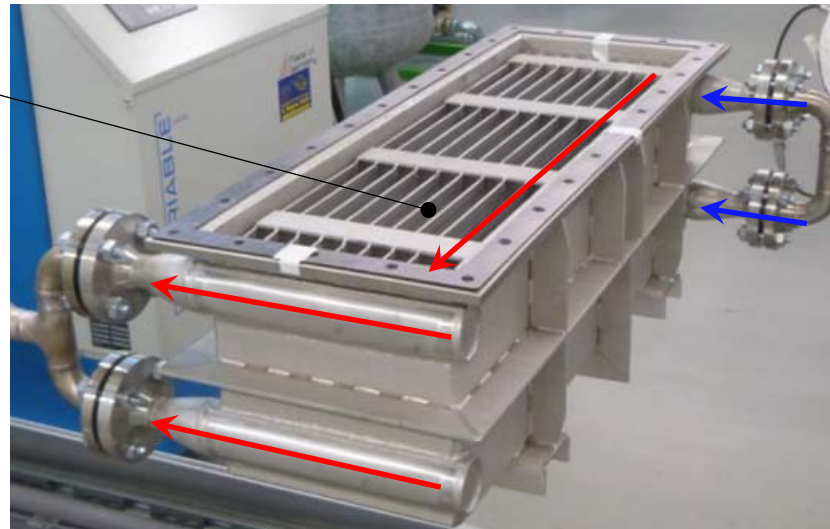
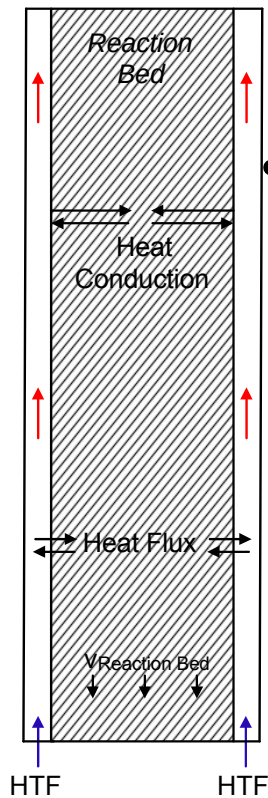
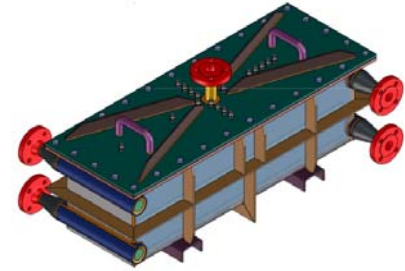
Thermophysical properties:



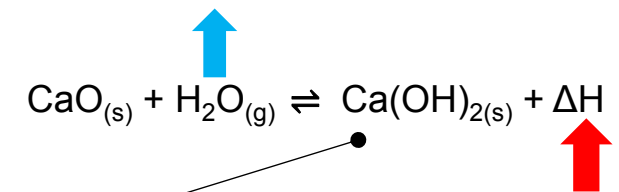
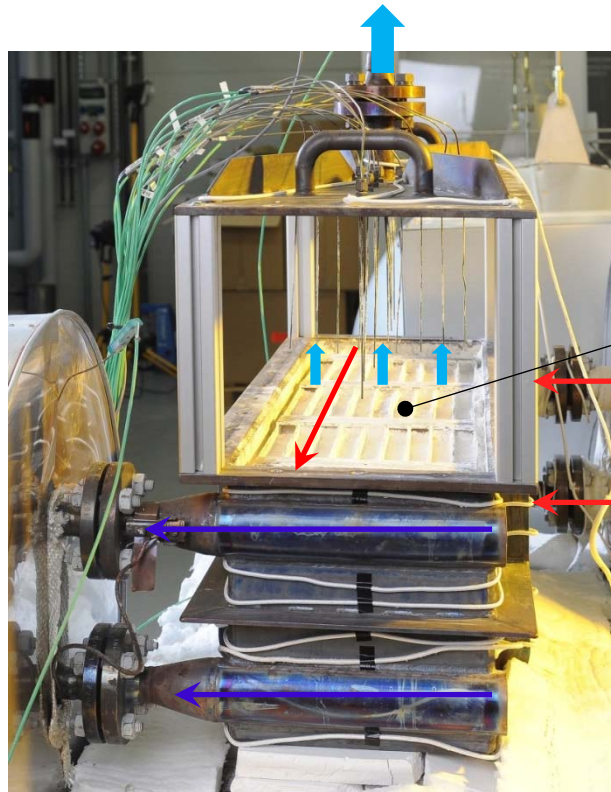
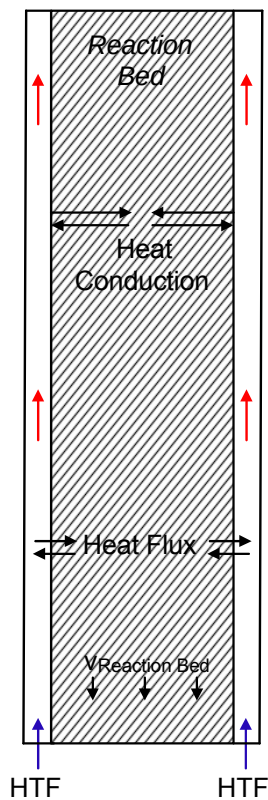
C. Roßkopf et. al (2014) Investigation of Nano Coated $\text{CaO}/\text{Ca}(\text{OH})_2$ Cycled in Thermochemical in a Thermochemical Heat Storage, submitted



Pilot Reactor - 10kW, 25kg Ca(OH)_2 plate heat exchanger



Pilot Reactor - 10kW, 25kg Ca(OH)_2 plate heat exchanger

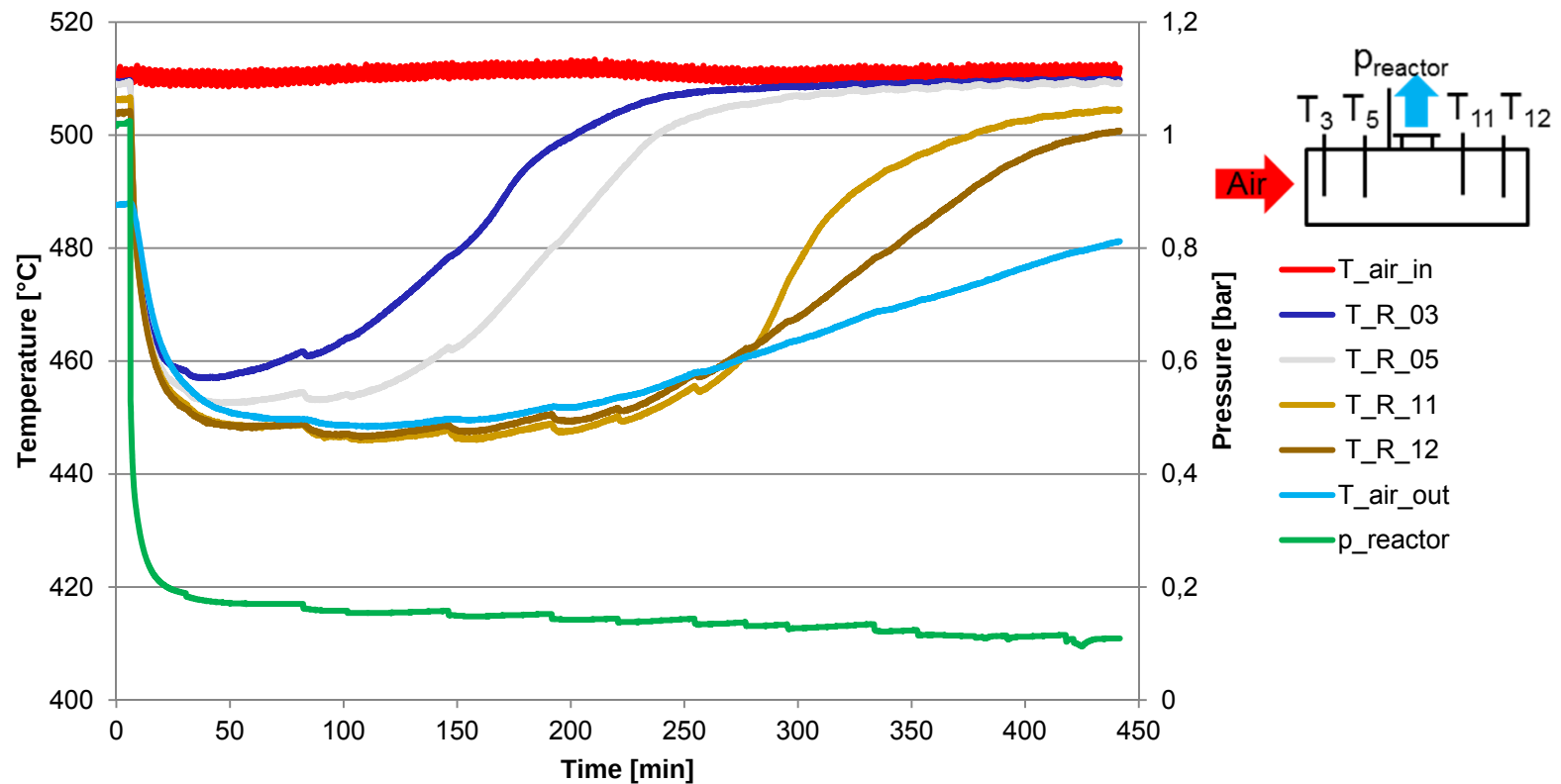


510°C



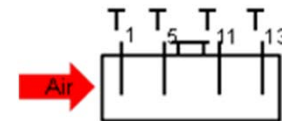
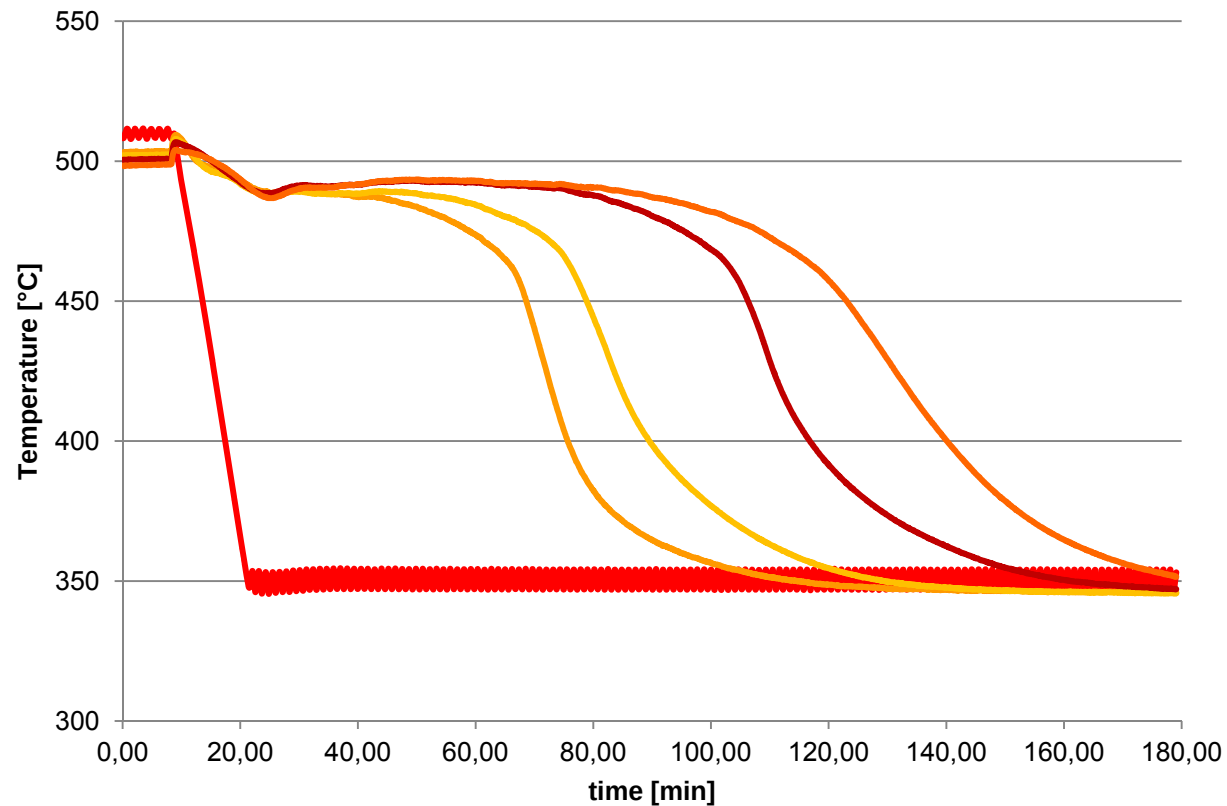
Charging Mode

Dehydration of $\text{Ca}(\text{OH})_2$ at 100mbar vapor pressure



Discharging Mode

hydration of CaO at 1 bar vapor

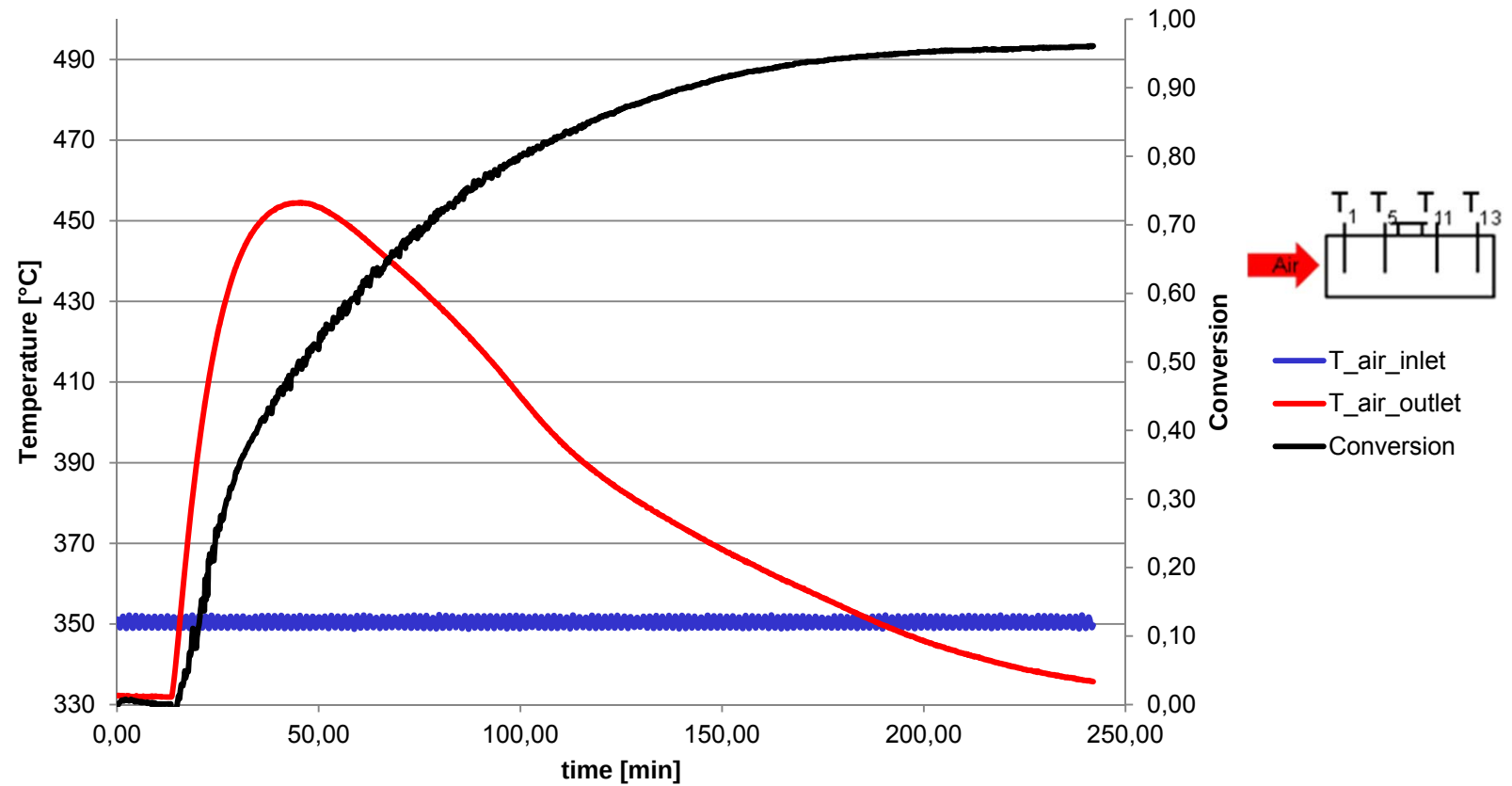
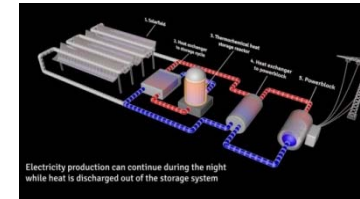


— T_{air_inlet}
— T_{R_01}
— T_{R_05}
— T_{R_11}
— T_{R_13}



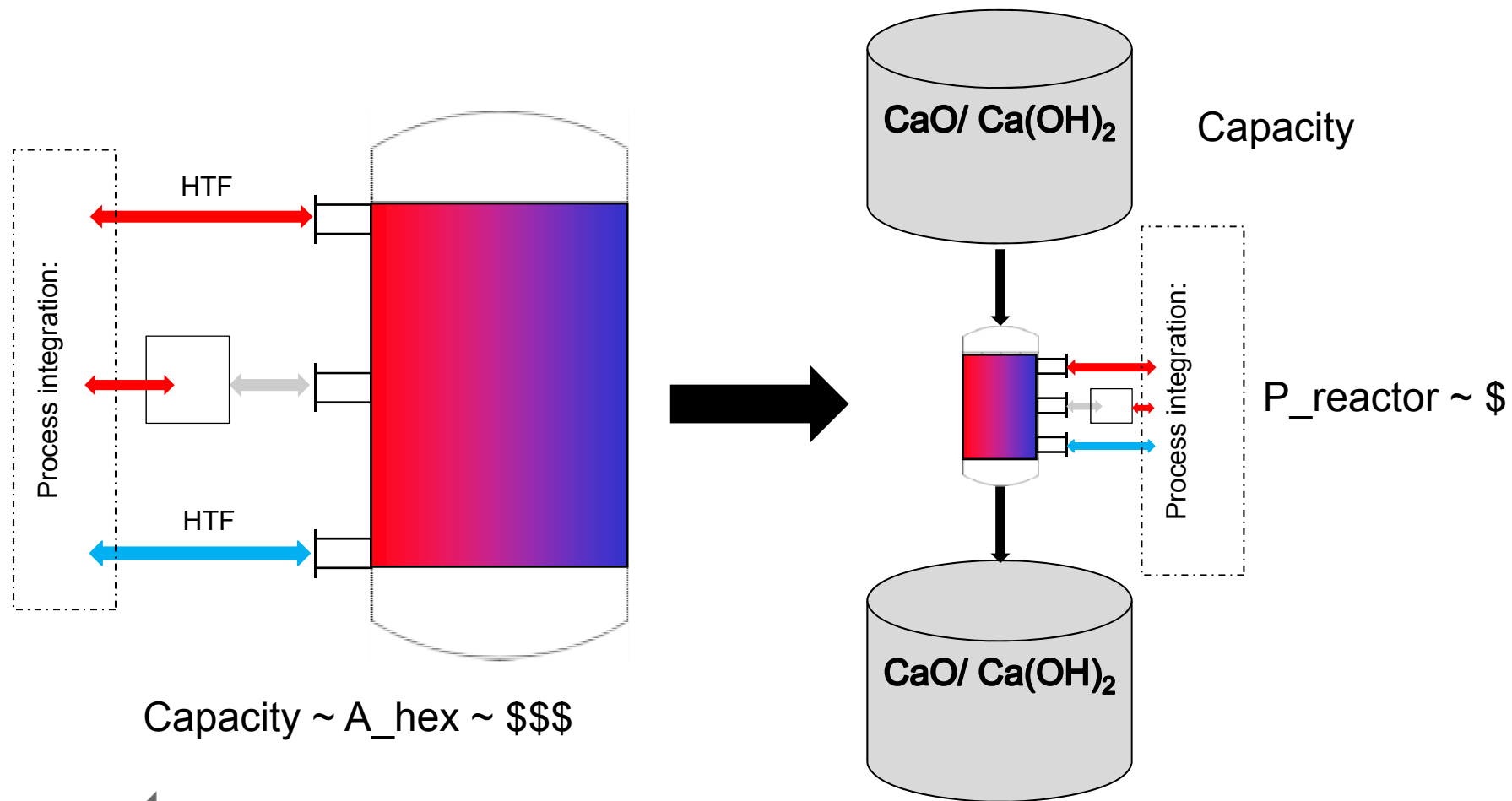
Heat Generation Mode

Hydration of CaO, starting temperature of 350°C



Next Steps

Separation of Power and Capacity

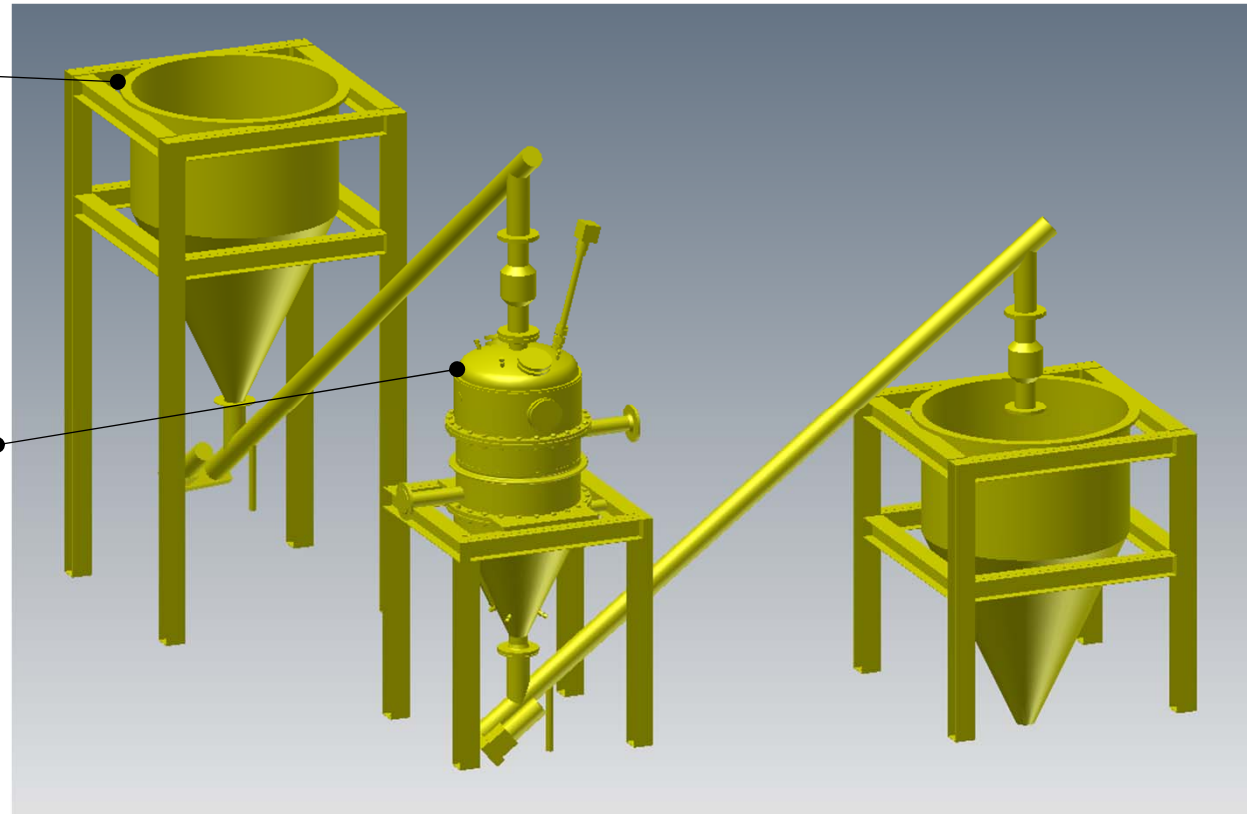


Next Steps

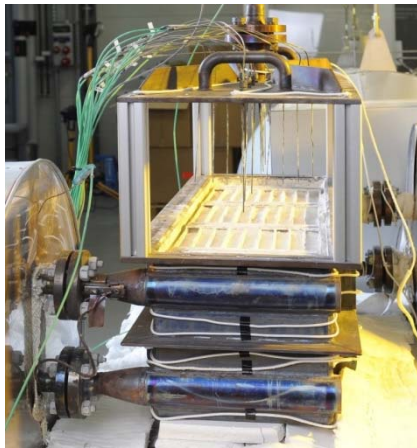
Separation of Power and Capacity – Pilot Plant in 2015

Capacity: 100 kWh
~ 250 kg Ca(OH)_2

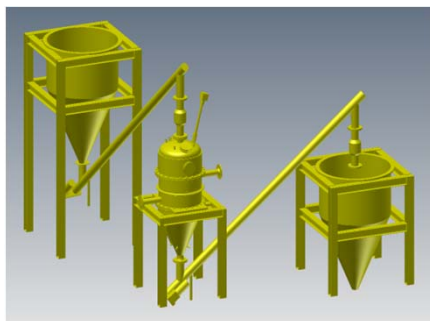
Reactor: 10 kW
~ 25 kg/h



Summary



- Thermochemical energy storage with $\text{CaO}/\text{Ca(OH)}_2$ demonstrated in kW scale
- Peak power of 8 kW
- Charging at 450°C
- Discharging at 490°C and 545°C



- Demonstration of moving bed pilot plant scheduled for beginning of 2015



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