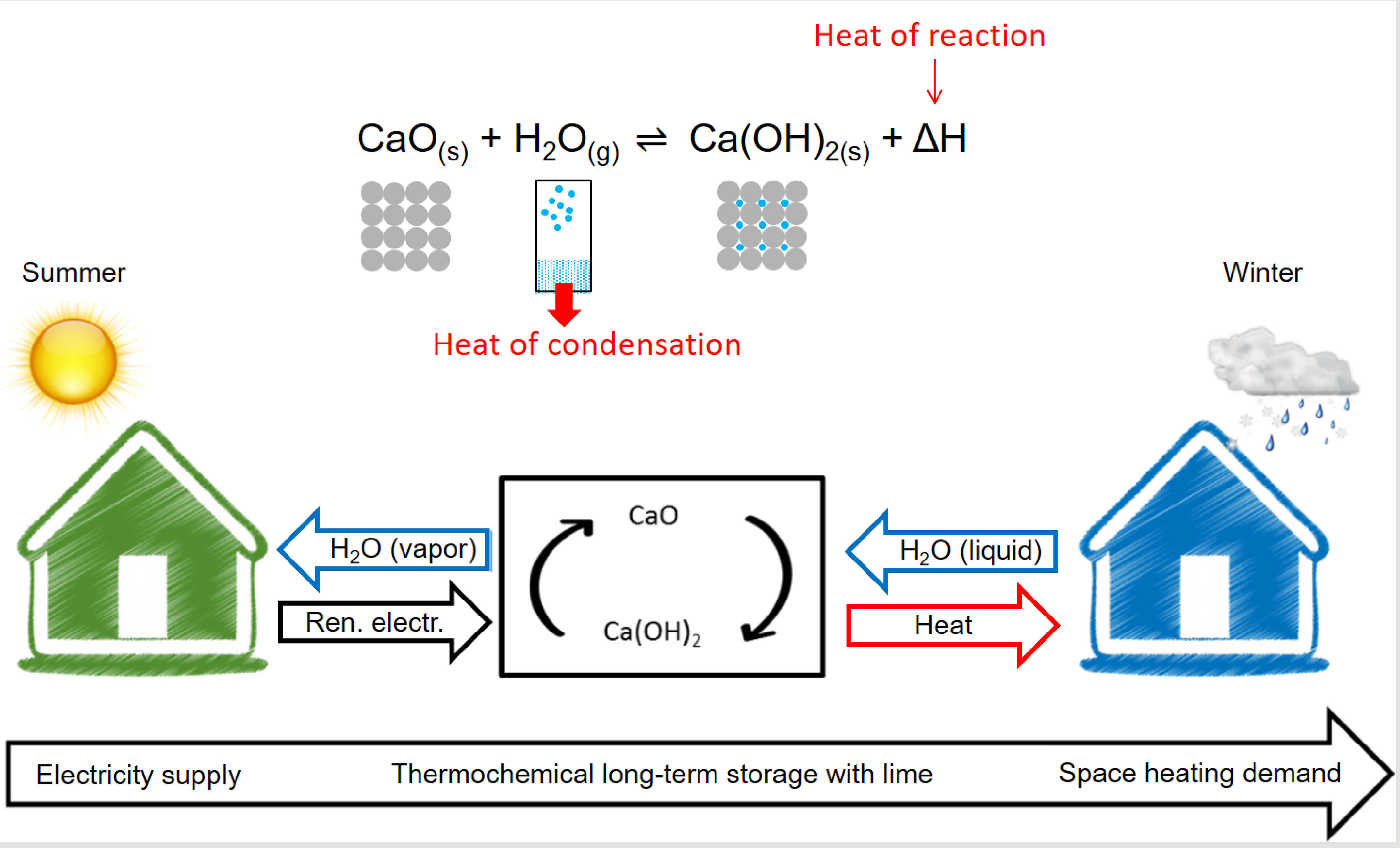
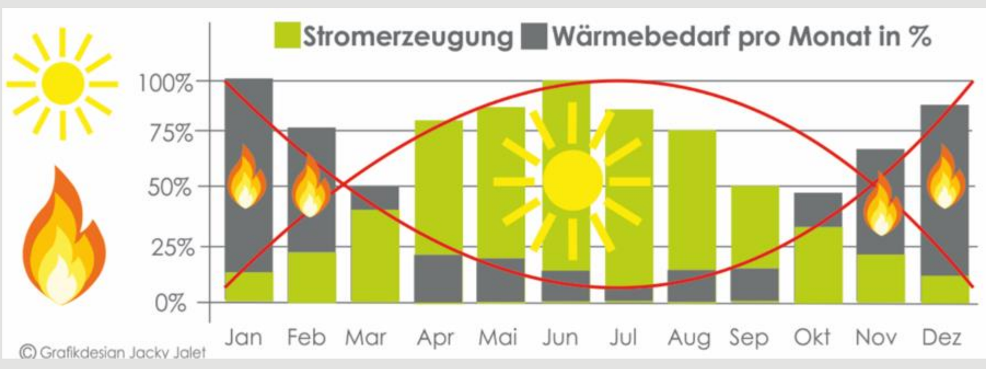
Seasonal Power-to-Heat Storage based on $Ca(OH)_2$ - Development of Pilot Plant

V. E. Sourmelis Terzopoulos*[1], M. Linder[2] and M. Schmidt[1]

[1]German Aerospace Center (DLR), Institute of Engineering Thermodynamics, Cologne, Germany
[2]German Aerospace Center (DLR), Institute of Engineering Thermodynamics, Stuttgart, Germany
*Venizelos.SourmelisTerzopoulos@dlr.de

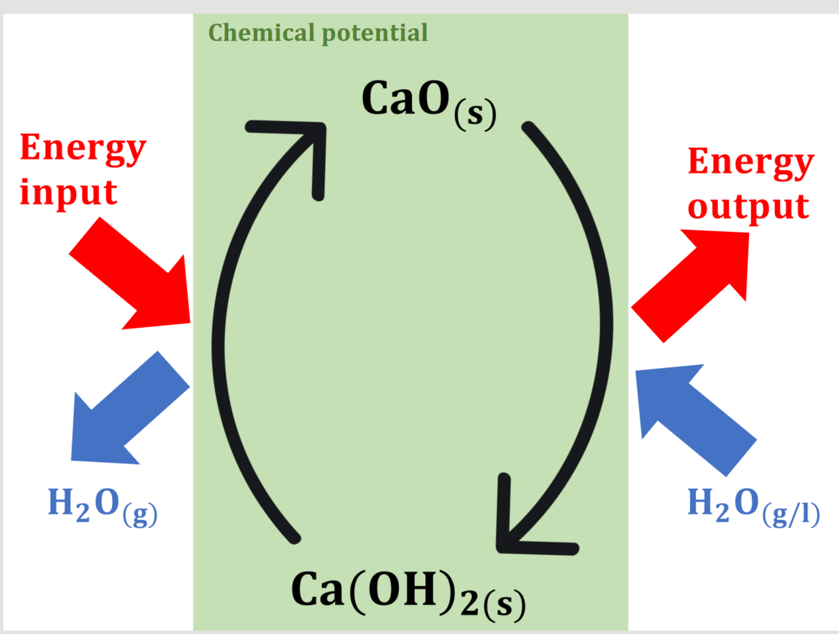


1. Motivation



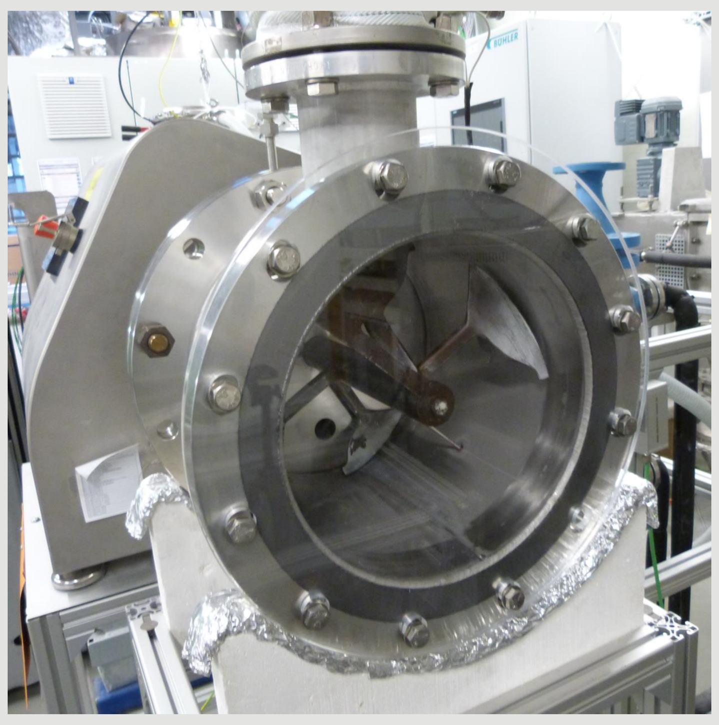
- Over 80 % of the energy requirements of an average German household account for heating, a demand still covered mainly by the combustion of fossil fuels [1]
- Renewable energy production limited in winter/excess in summer
- Seasonal energy storage required

2. Thermochemical Energy Storage



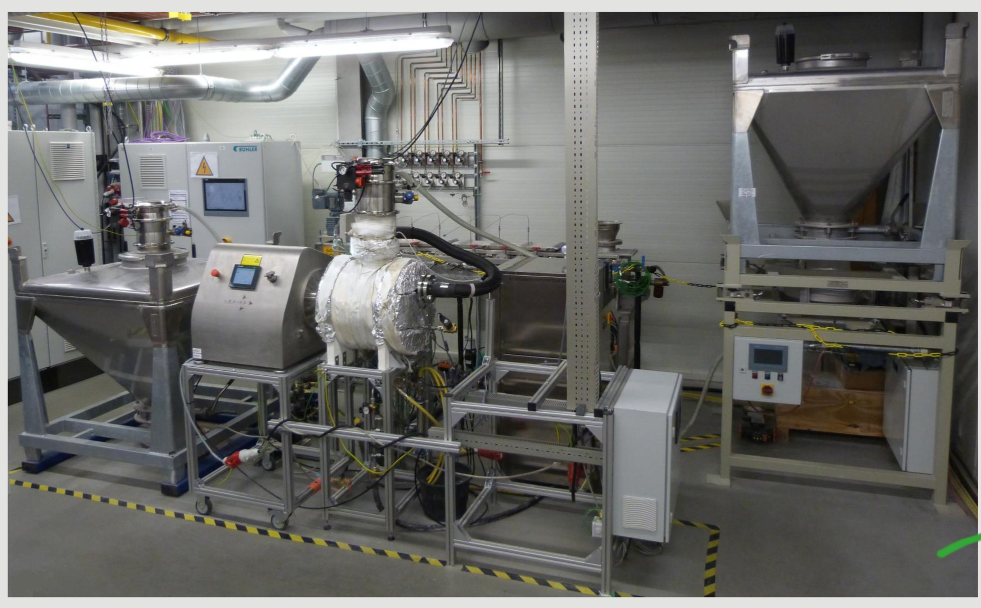
- Charging in summer with excess renewable electricity → CaO (quicklime)
- Exothermal, reverse reaction in winter with liquid water → $Ca(OH)_2$ (hydrated lime) + Heat
- Storage without thermal losses
- High energy density $\left(\approx 215\ \frac{kWh}{m^3}\right)$
- Inexpensive, environmentally benign and globally abundant limestone

3. Reactor Development



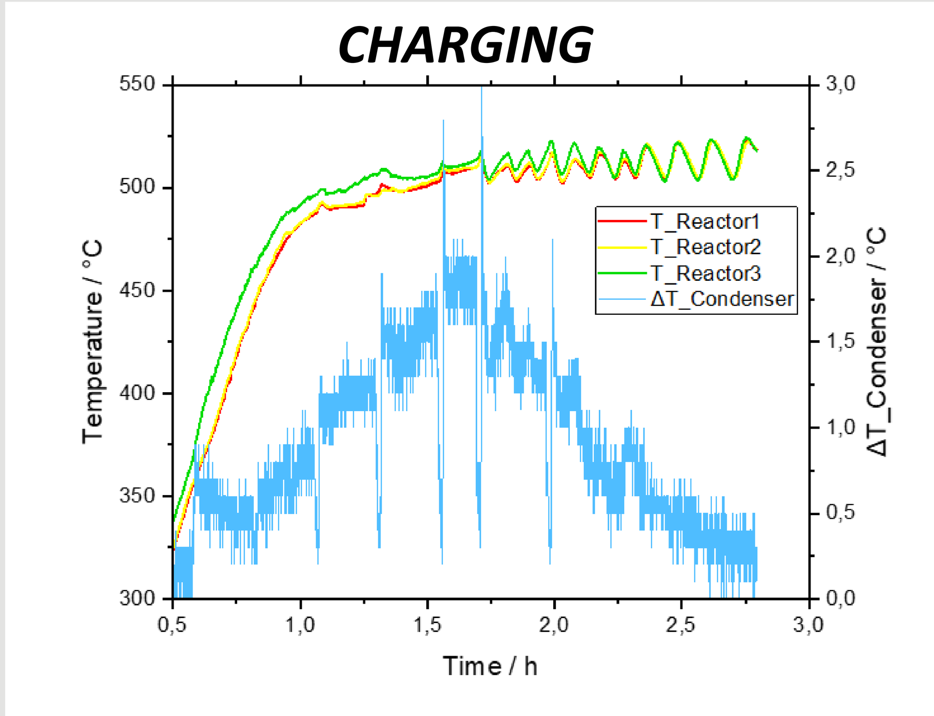
- Novel reactor concept developed and experimentally verified
- Electrical charging and thermal discharging
- Heat transfer coefficient of 150 - 250 $\frac{W}{m^2K}$ proven [2]
- Mitigated agglomeration of powder lime via mechanical fluidization

4. Pilot Plant Development

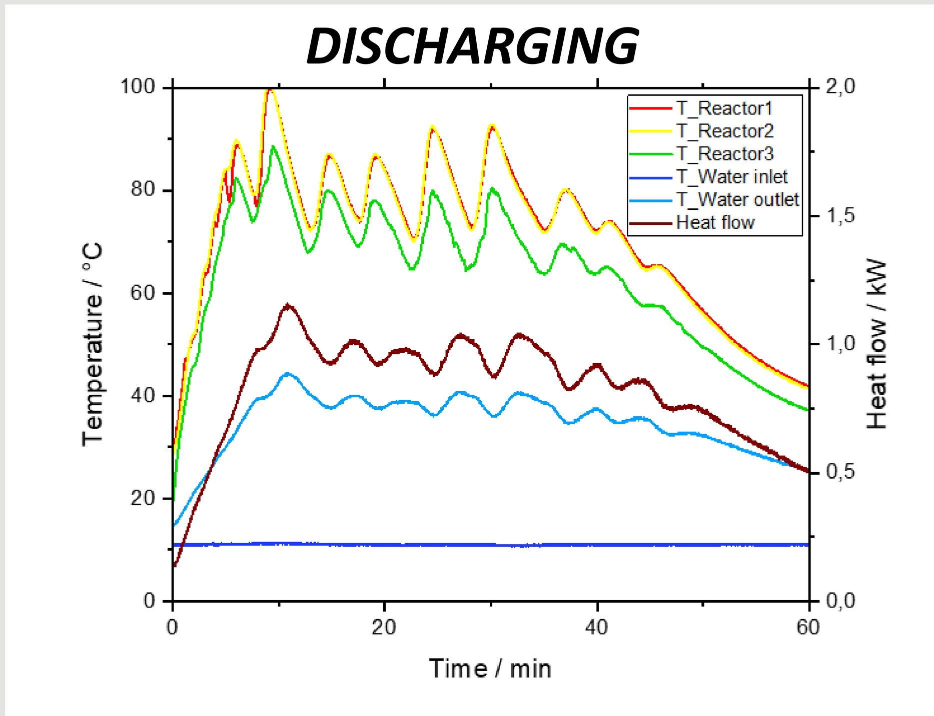


- Development of whole system with separated power and capacity
- Storage 100 kWh thermal energy
- Reactor 10 kW thermal power

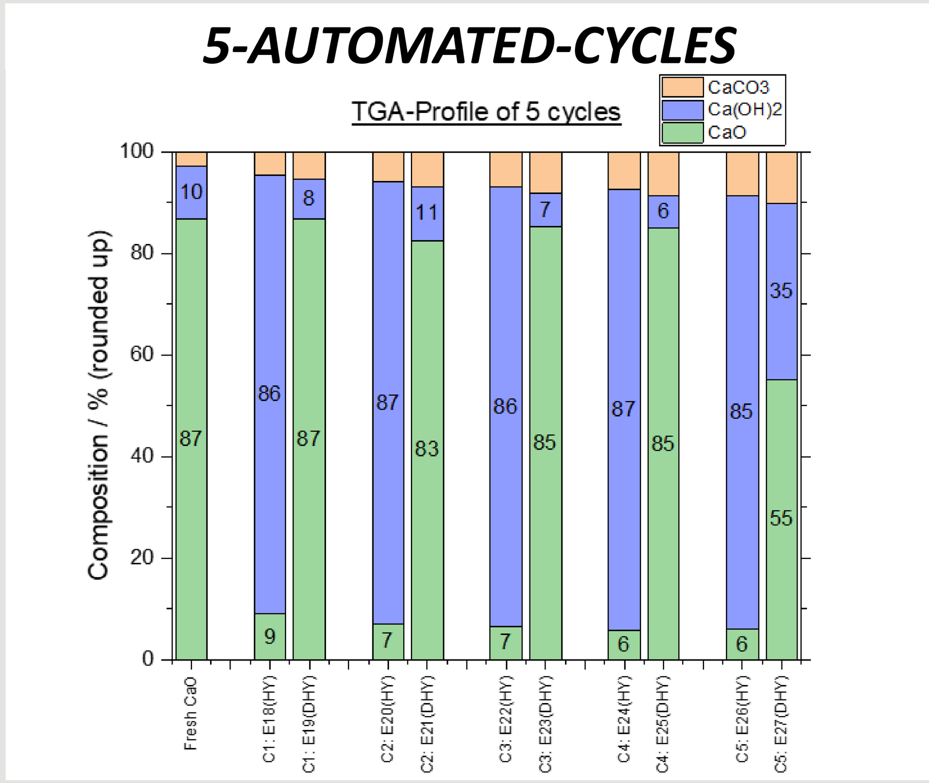
5. Experimental Results



- Duration 90 min at 500 °C
- Thermal charging power 1,9 kW
- Specific power density 7,9 $\frac{kW}{m^2}$



- Discharging 40 °C hot water (ΔT = 30 K)
- Constant thermal power 1 kW for 45 min



- Successful demonstration of five consecutive, automated cycles with same batch of storage material in our lab
- Reproducible full charging & discharging reaction under same operating conditions

6. Outlook

- Energy efficiency optimization and development of automation control
- Integration and field demonstration in a high-rise building by 2023

[1] M. Schmidt, M. Linder, Frontiers in Energy Research, 2020, https://doi.org/10.3389/fenrg.2020.00137
[2] K. Risthaus et al., Applied Energy, 2022, https://doi.org/10.1016/j.apenergy.2022.118976

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