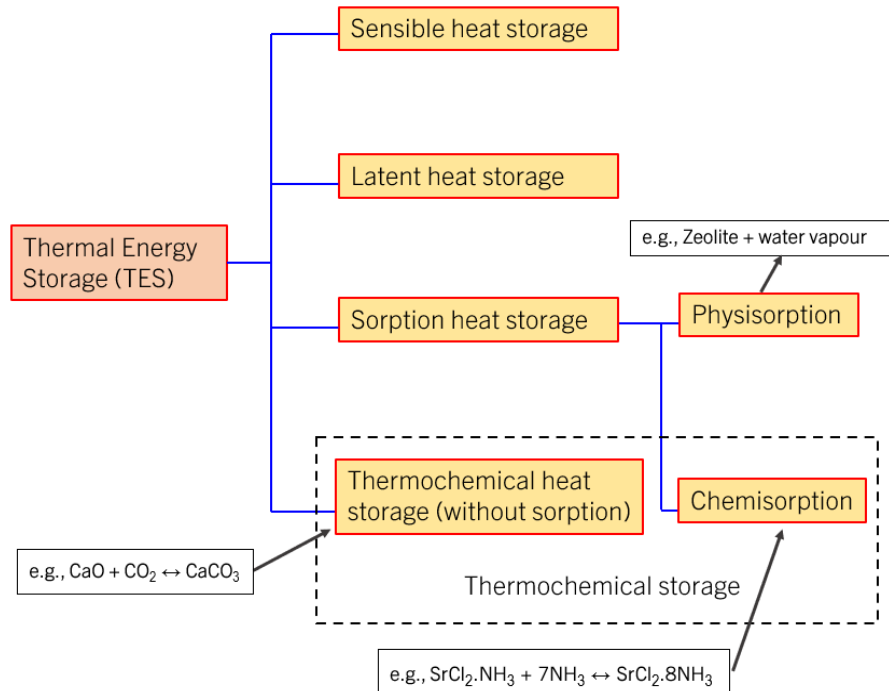
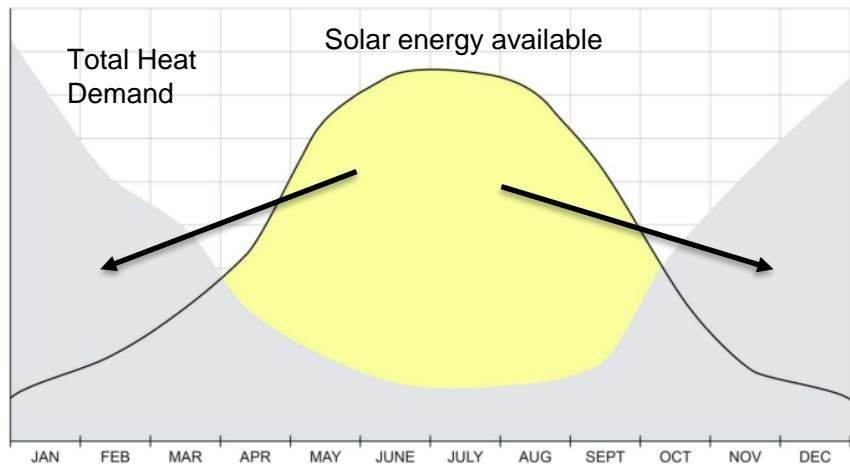


Advanced hybrid thermochemical- compression seasonal solar energy storage and heat pump system (Solar S&HP)

Dr Zhiwei Ma
Durham University

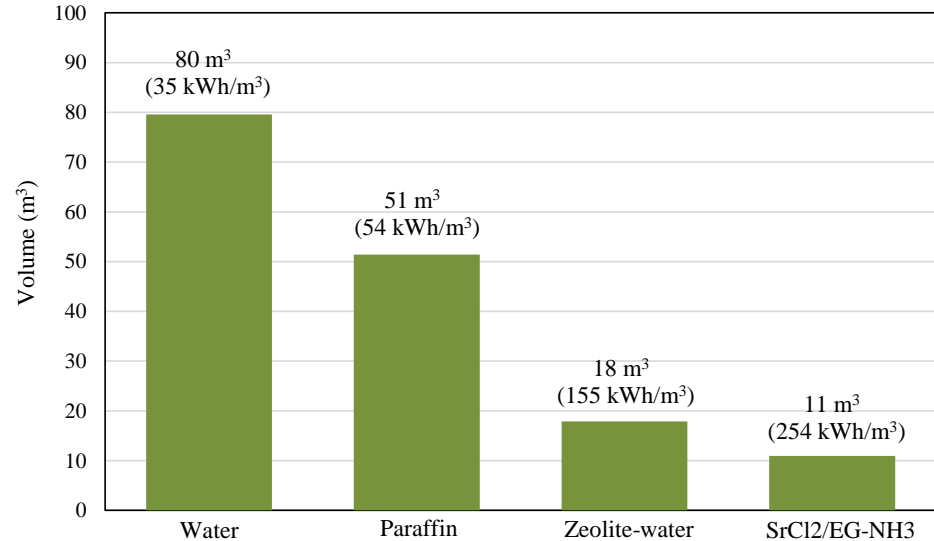
1. Seasonal solar thermal energy storage



1. Seasonal solar thermal energy storage

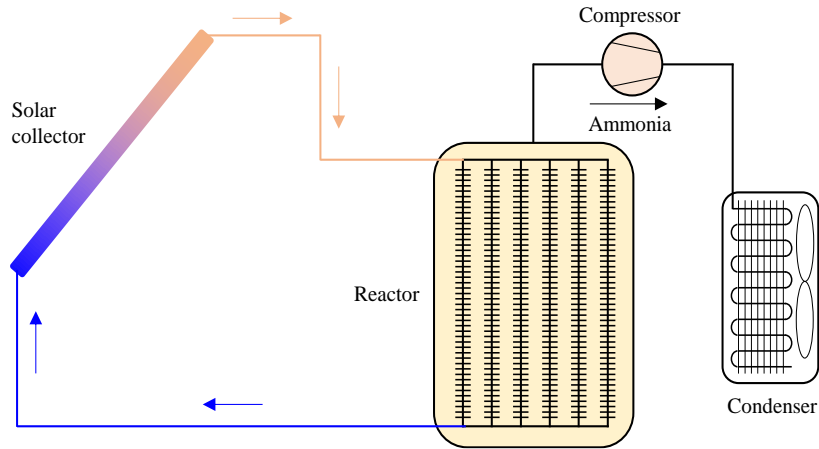
Material volumes required to store 10 GJ (2778 kWh) heat:

- [Water](#): 55-95 °C storage temperature with 25% heat loss;
- [Paraffin](#): triacontane, 66 °C phase change temperature, 55-95 °C storage temperature with 25% heat loss;
- [Zeolite-H₂O](#): 650 kg/m³ bulk density, 0.25 g/g water uptake, no loss of sorption heat;
- [SrCl₂/EG-NH₃](#): 500 kg/m³ salt packing density, no loss of sorption heat.

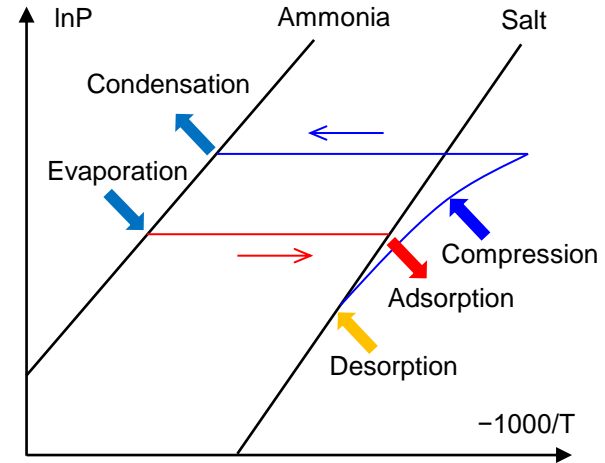


1. Seasonal solar thermal energy storage

- To use solar heat at relatively lower temperature
- To increase the solar fraction for space heating
- Secure the heat supply at sufficient high temperature in winter



The proposed hybrid thermochemical-compression
Solar S&HP system



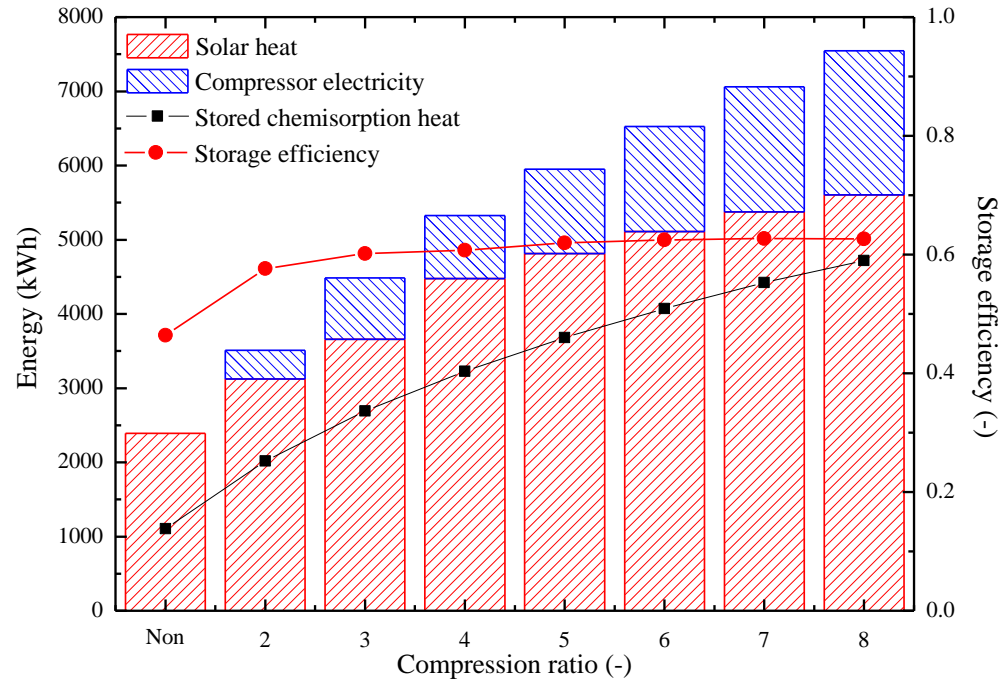
P-T diagram of Solar S&HP system

2. Thermodynamic calculation

Ammonia thermochemical sorption + Compressor

- Newcastle weather data;
- 20 m² flat-plate solar collector facing south, 45° inclination;
- SrCl₂-NH₃ as the working pair;
- No thermal insulation;

- Lower sensible heat consumption;
- All the desorption heat is provided by low-grade solar heat;
- System energy storage density, 147 kWh/m³



3. Chemisorption reactors

Mesh tube



Longitudinal fin
tube



Heat transfer test

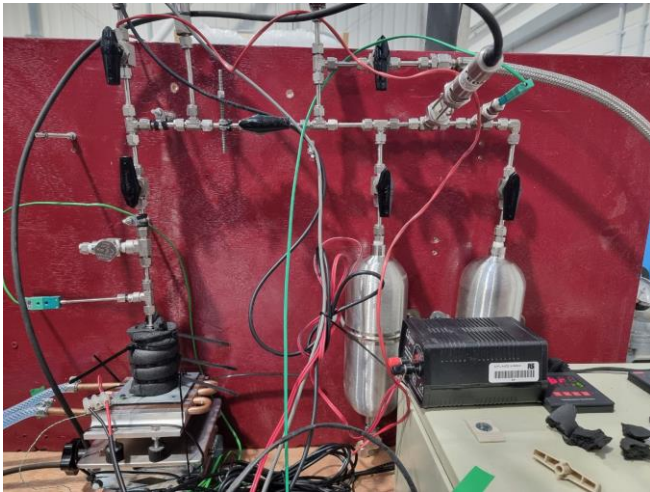


1st generation reactors
and test rig

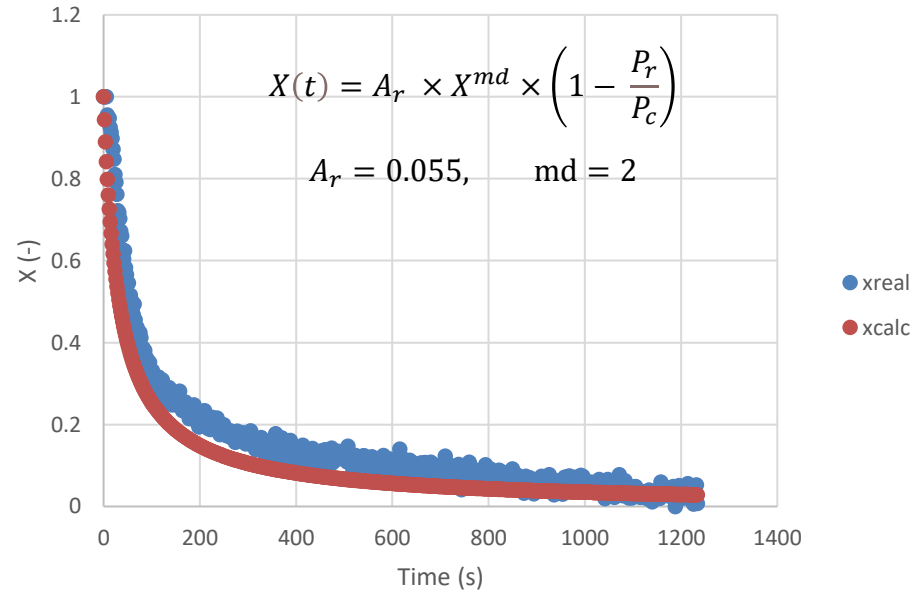
4. Kinetic test rig

To measure:

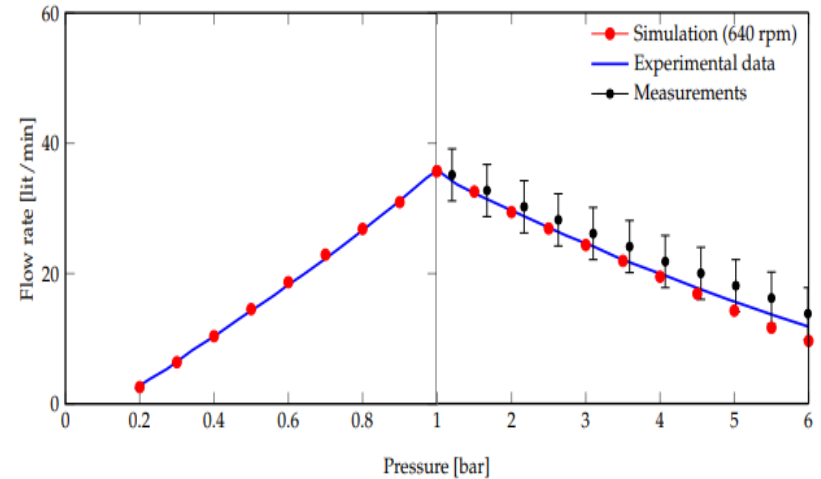
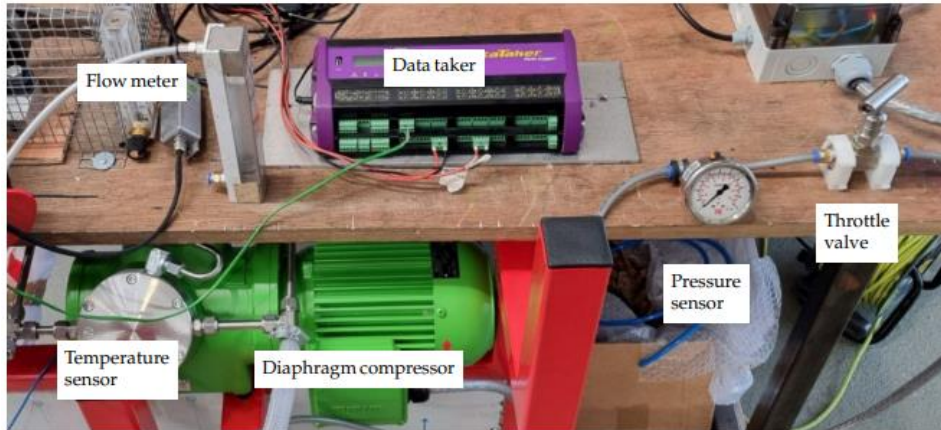
- Phase equilibrium;
- Kinetics of adsorption and desorption;



Reaction ratio



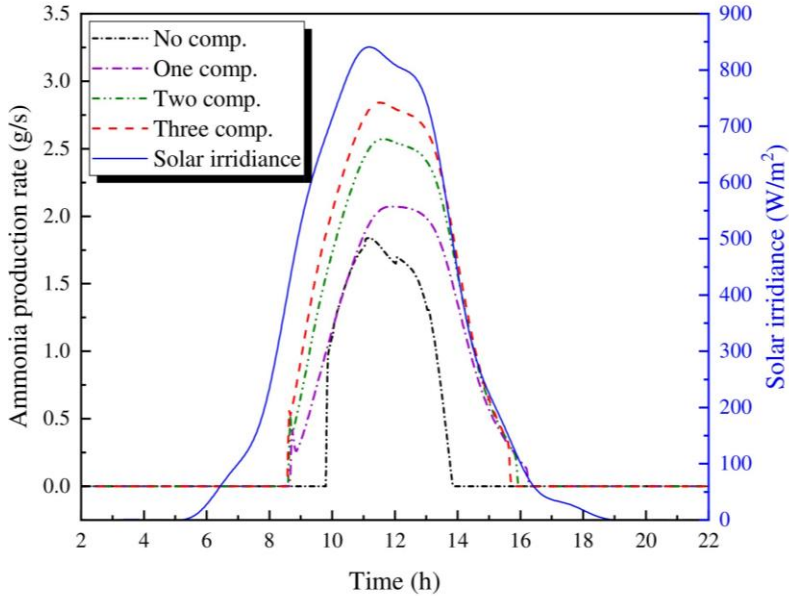
5. Compressor modelling and validation



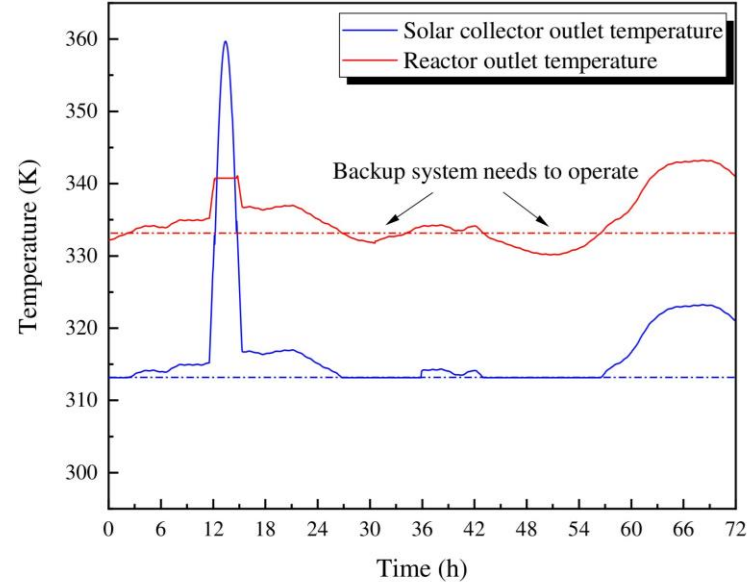
* Najjaran A, **Meibodi S**, Ma Z, Bao H, Roskilly T. Experimentally Validated Modelling of an Oscillating Diaphragm Compressor for Chemisorption Energy Technology Applications. *Energies*. 2023

6. Dynamic Simulation

- Newcastle weather data;
- 40 m² flat-plate solar collector facing south, 45° inclination;
- SrCl₂-NH₃ as the working pair;

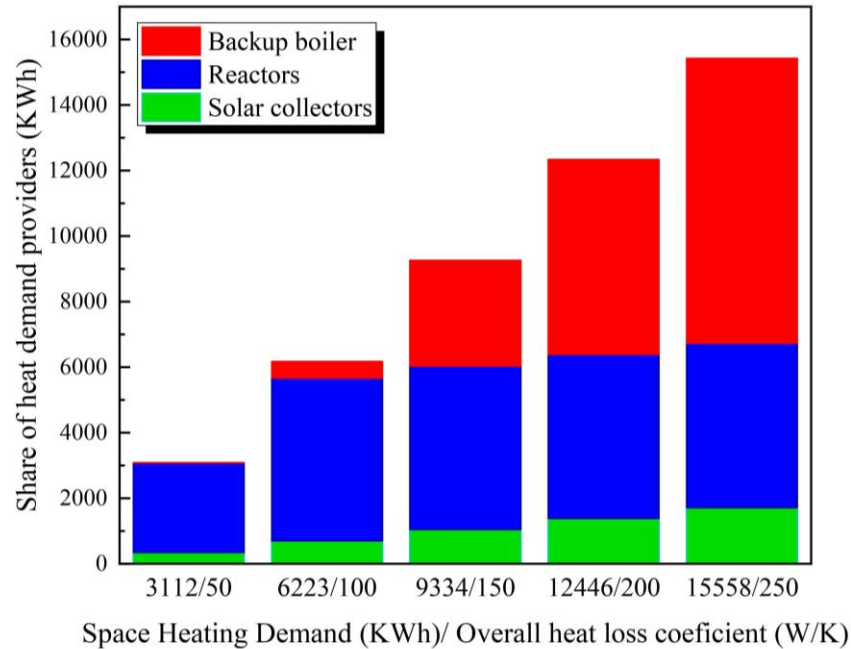


Charging process



Discharging process

6. Dynamic Simulation



Different insulation & heating demand

7. Experimental demonstration

- SrCl₂-NH₃ as working pair
- 2.5 kg active ammonia mass
- 1.8 kWh sorption heat storage capacity



Condenser /
Evaporator

Reactor I

Reactor II

Compressor



THANK
YOU