

MI Research in Sorption Heat Pump Systems

Bob Critoph

9th September 2020

LoT-NET 

A Unique Moment in Time



MISSION INNOVATION

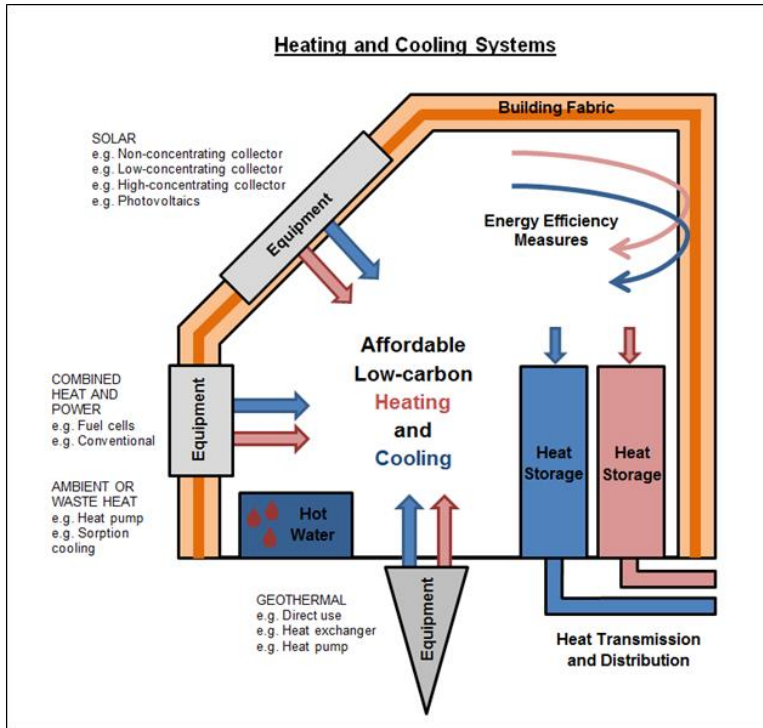
Accelerating the Clean Energy Revolution

www.mission-innovation.net



mission-innovation.net

Heating & Cooling for Buildings Innovation Challenge (IC7)



Affordable Heating & Cooling of Buildings



Co-leads



Timeline:

- ▶ Launch, June 2016
- ▶ Abu Dhabi, November 2017
- ▶ Pisa, July 2018
- ▶ Road map for Sorption Research, September 2018
- ▶

Timeline:

▶ Abu Dhabi, November 2017:

Affordable heating and cooling challenge

- Thermal Energy Storage
- Heat Pumps
- Non-Atmospheric Heat Sinks and Sources
- Predictive Maintenance and Optimization
- Physiological Studies for Thermal Comfort



Timeline:

- ▶ Abu Dhabi, November 2017:

Affordable heating and cooling challenge

Key activities in 'heat pumps':

1. Converting low grade heat to power (Target 60 °C waste heat)
2. Efficient gas to heat and cold (Target Gas Utilisation Efficiency of 1.6 (air source), 1.7 (water source) and 2.0 (in lab))



Timeline:

- ▶ Abu Dhabi, November 2017
- ▶ Pisa, July 2018

BEIS commissions a roadmap on Sorption Technologies for heating and cooling from the IEA Annex on Thermally Driven Heat Pumps.

Timeline:

- ▶ Abu Dhabi, November 2017
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- ▶



Country / Organisation – Collaboration Matrix	UK	NL	Germany				Italy				CAN	USA
	UW	TNO	ISE	TUB	OTH-R	THN	POLIMI	Ariston	ICCOM	ITAE	SFU	SMTI
Domestic heat pump application Action Areas:												
1. Demonstration programmes to increase product acceptance.	■		■	■		■	■	■	■	■		■
2. Refinements to the existing ammonia-water cycle.				■			■	■				
3. Further evaluation of alcohol based absorption pairs				■	■						■	
4. Ammonia adsorption with salts (lower TRL) or active carbon (higher TRL)	■	■							■			
5. Development of compact and cost effective zeolite-water based adsorption systems			■	■	■				■	■	■	
Water refrigerant air conditioning/heat pumping Action Areas:												
6. Reducing the possible cooling temperature using novel evaporator designs.			■	■						■	■	
7. Hybrid compressor/sorption systems, multistage cycles particularly useful in large commercial applications.		■	■	■		■				■		
8. Novel ad/ab sorber designs with improved heat/mass transfer, compact, economic		■	■	■	■					■	■	
Waste heat powered heat transformers Action Areas:												
9. Lithium Bromide absorption systems				■	*							
10. Ammonia-salt resorption which also offers energy storage	■	■	■						■	■		



Final proposal was a compromise:

- Budget from UK £300k
- Duration 27 months from June 2020
- No direct funding of overseas partners, so only voluntary contributions! – but we can fund meetings.





SIMON FRASER
UNIVERSITY



Consiglio Nazionale
delle Ricerche

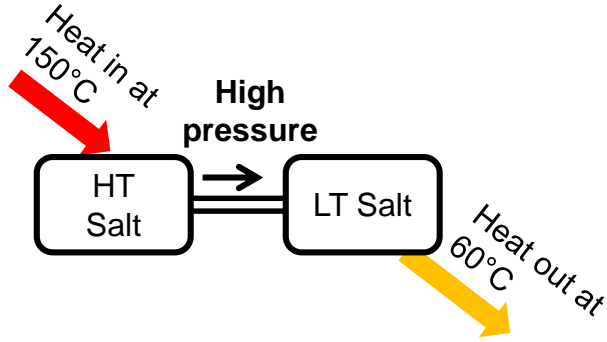


上海交通大学
SHANGHAI JIAO TONG UNIVERSITY

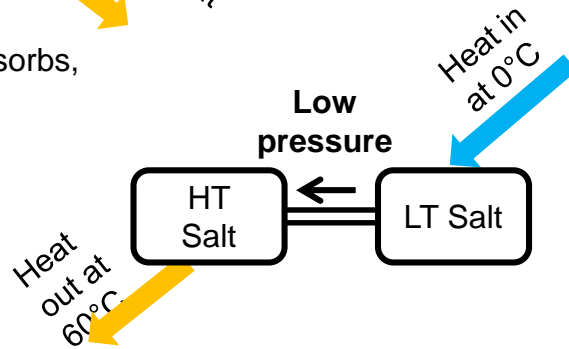
www.lot-net.org/missioninnovation.html



Domestic heat pumps:



Phase 1: LT salt adsorbs,
HT salt desorbs



Phase 2: LT salt desorbs,
HT salt adsorbs

Ammonia – salt adsorption

- Simpler
- Low capital cost
- GUE 2 salt – 1.6
- GUE 3 salt – 2.0

D1 (Month 10) Report on equilibrium and dynamic data for a range of salt and salt mixtures for heat pumping, refrigeration and storage measured by UW, SJTU, ICCOM and compiled by UW.



D2 (Month 12) Report on design and expected performance of 2-salt resorption heat pump (UW)

D3 (Month 12) Report on design and expected performance of advance 3-salt system (SJTU).



D4 (Month 27) Report on 2-bed heat pump performance (UW)

D5 (Month 27) Report on 3-bed cascaded heat pump simulation (UW)

D6 (Month 27) Report on 3-bed system performance (SJTU)



D7 a,b,c,d,e,f. UW will organise the kick-off, 6-monthly meetings (4) and Final Workshop, as above. The last will be extended to include a 3rd 'Sorption Friends' meeting, maximising the dissemination opportunity.

D8 (Month 31) The final 'Sorption Friends' meeting will be used to generate a final experts report to cover technical and economic potential, policy implications, etc.



Other activities that are not deliverables:

CNR-ICCOM (Pisa) characterization of ammonia adsorption into salt mixtures by NMR and FTIR techniques, including the verification of any degradation process due to aging.

CNR-ITAE (Messina) will model alternative applications of the technology to higher temperatures (for use in industry) and storage as well as simulating and optimising different reactor designs.



Other activities that are not deliverables:

SJTU (China)

- Share in experience of ammonia – salt systems and combatting long-term cycling degradation
- When material equilibrium and dynamic properties are characterised by UW (4th quarter 2020) they will use them to simulate the realistic machine performance that can be expected of a number of advanced 3-bed cycles and will build a 3-salt prototype by 2022
- Host a project meeting in 2021 linked to ICCR2021



Other activities that are not deliverables:

SFU (Canada)

- Assist in developing a long-lasting composite sorbent materials
- Graphite heat exchangers for sorption reactors
- Analytical model that can be used for design and optimization
- SFU will also host a mid-term (Summer 2021) workshop / meeting for all participants

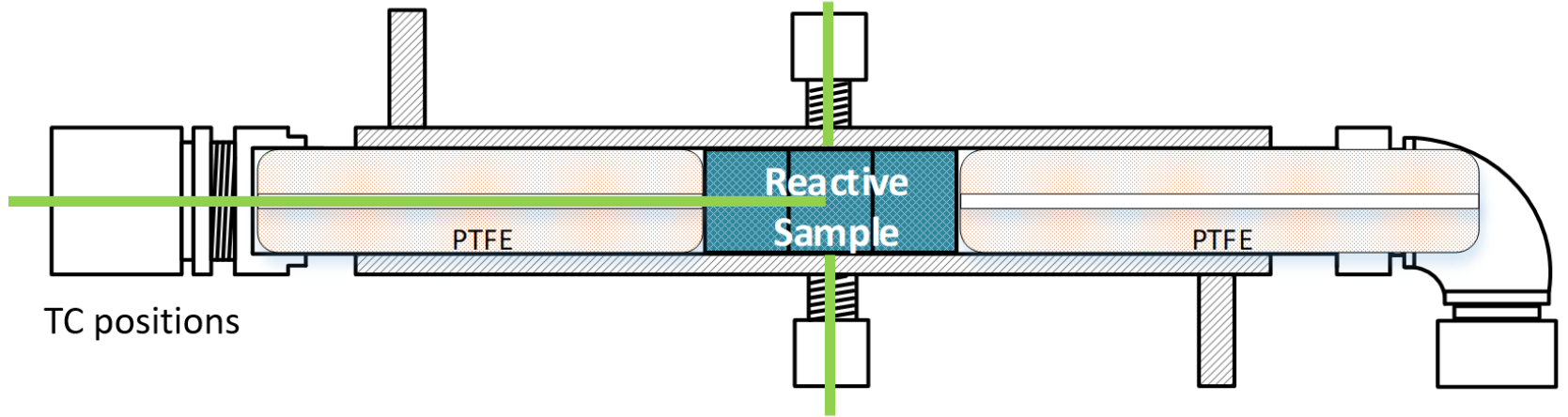
Other activities that are not deliverables:
TNO ????



Warwick research

LTJ Tests:

Large Temperature Jump Reactor



TC positions

1/2 inch pipe
centre

1 inch pipe
jacket

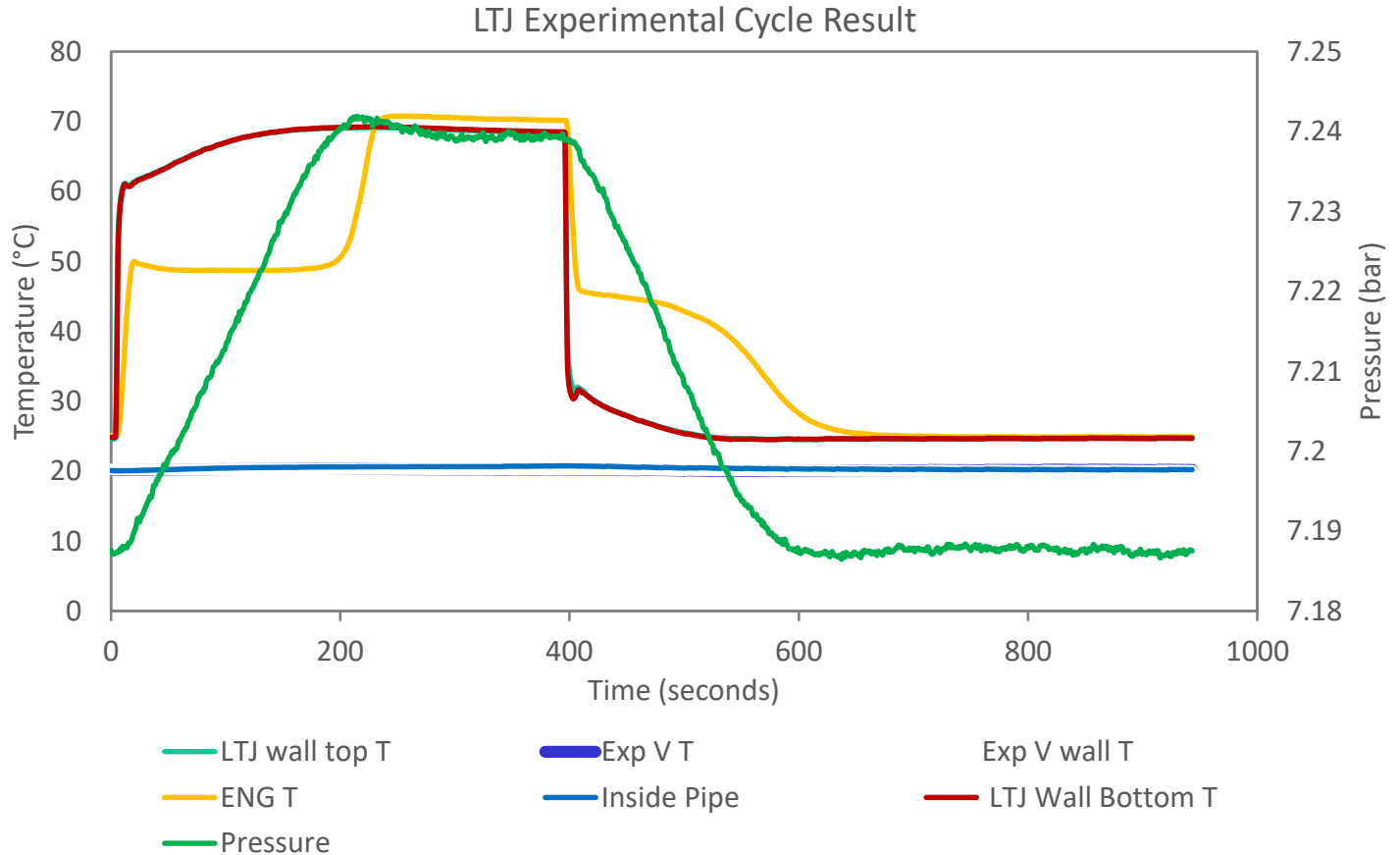
PTFE to fill
heated volume

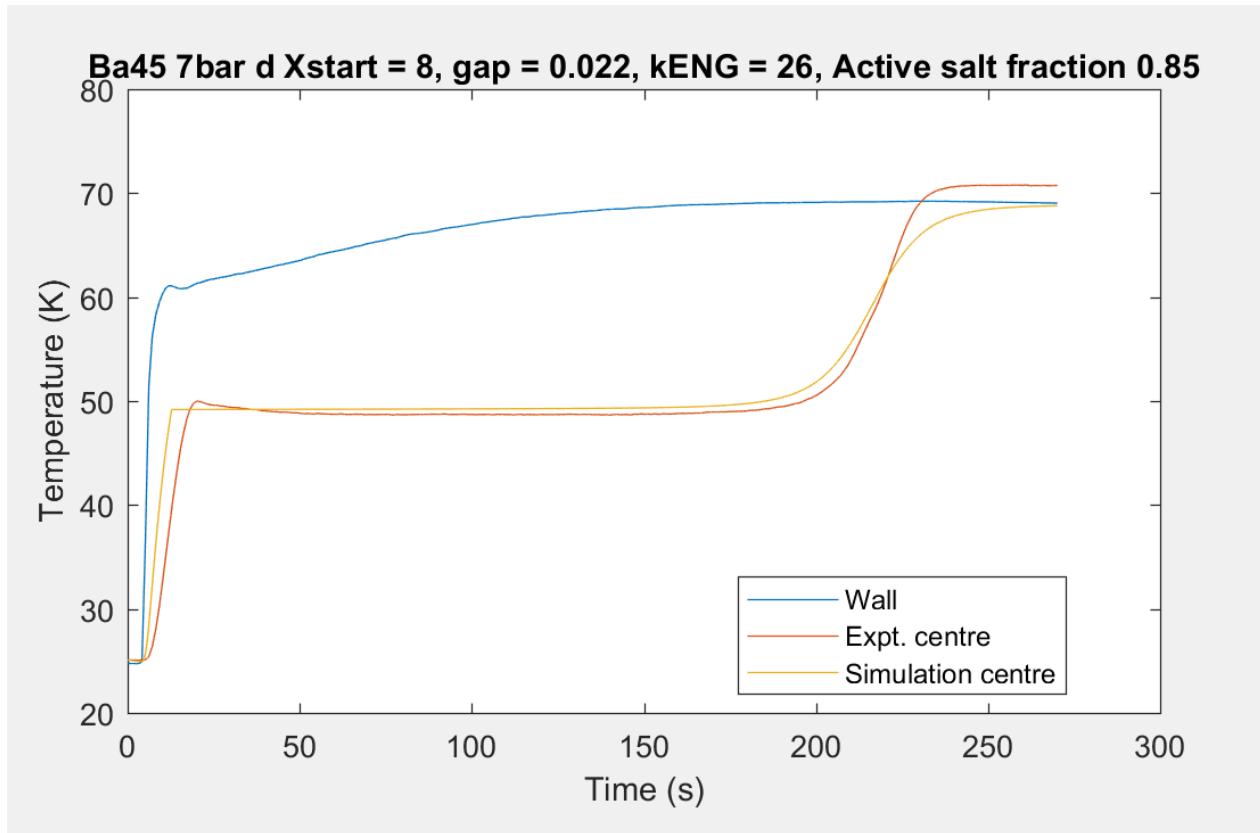
O-ring Swagelok
face seal fitting

LTJ Tests:

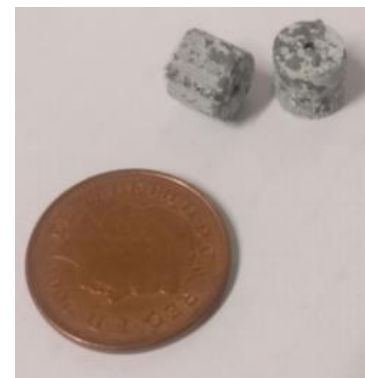
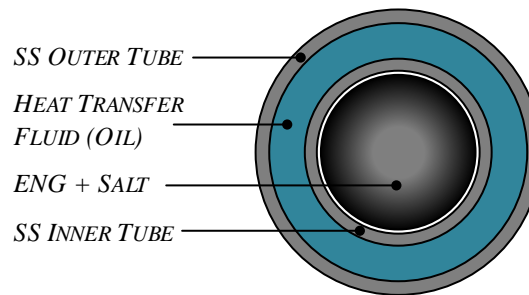
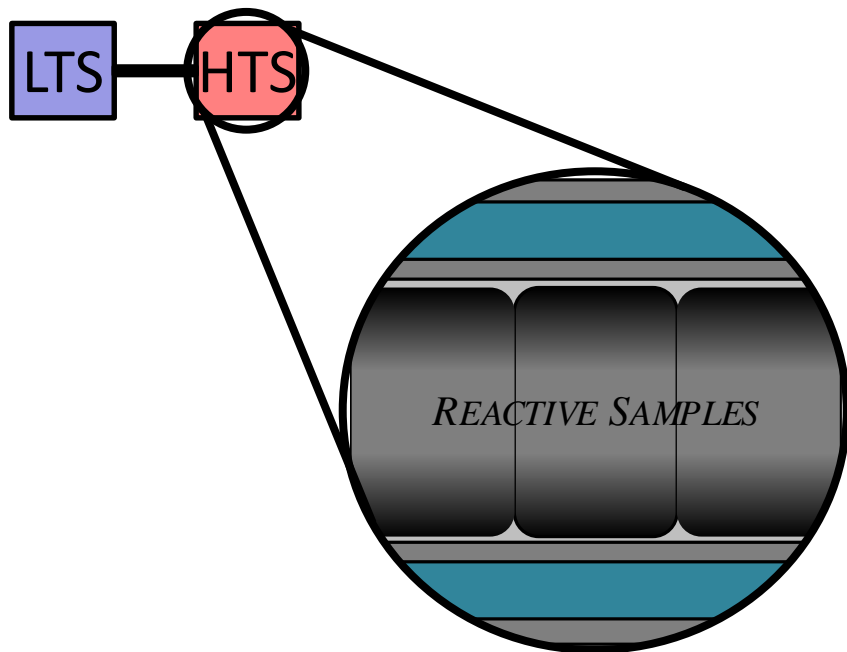


LTJ Tests:

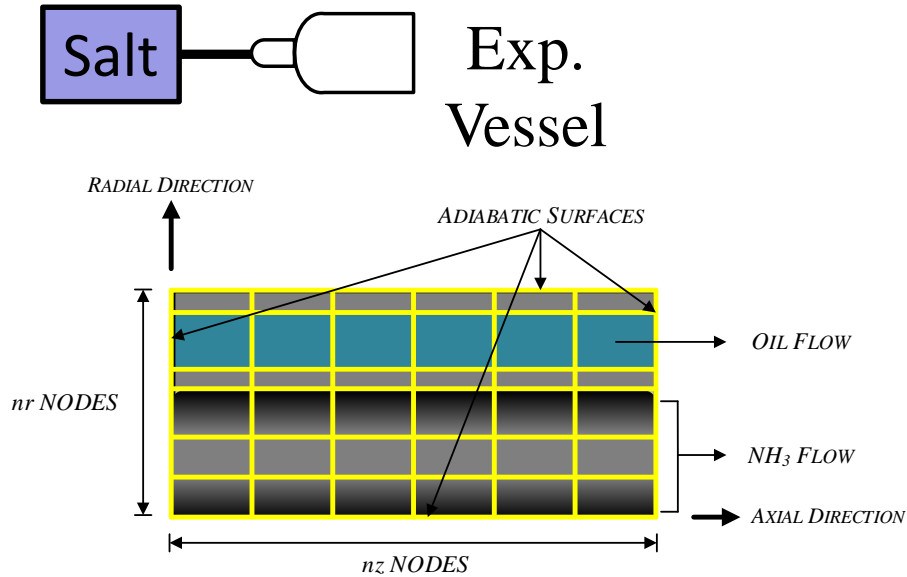




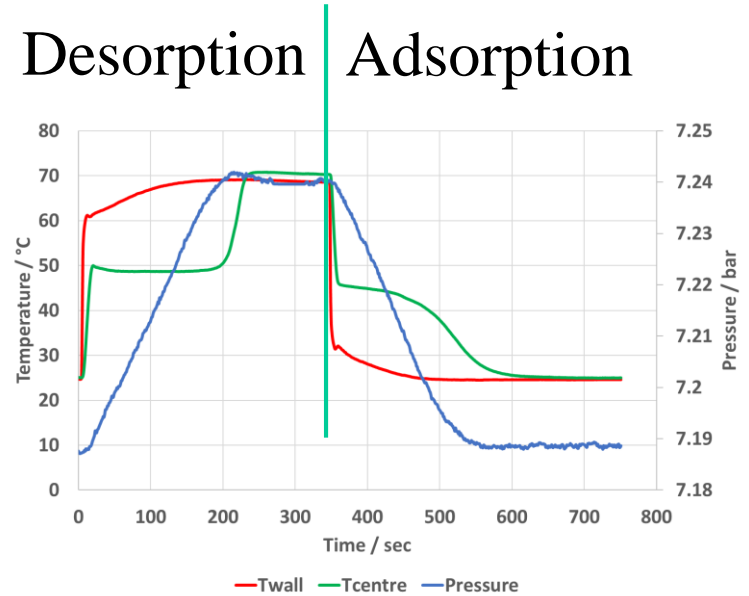
Current work



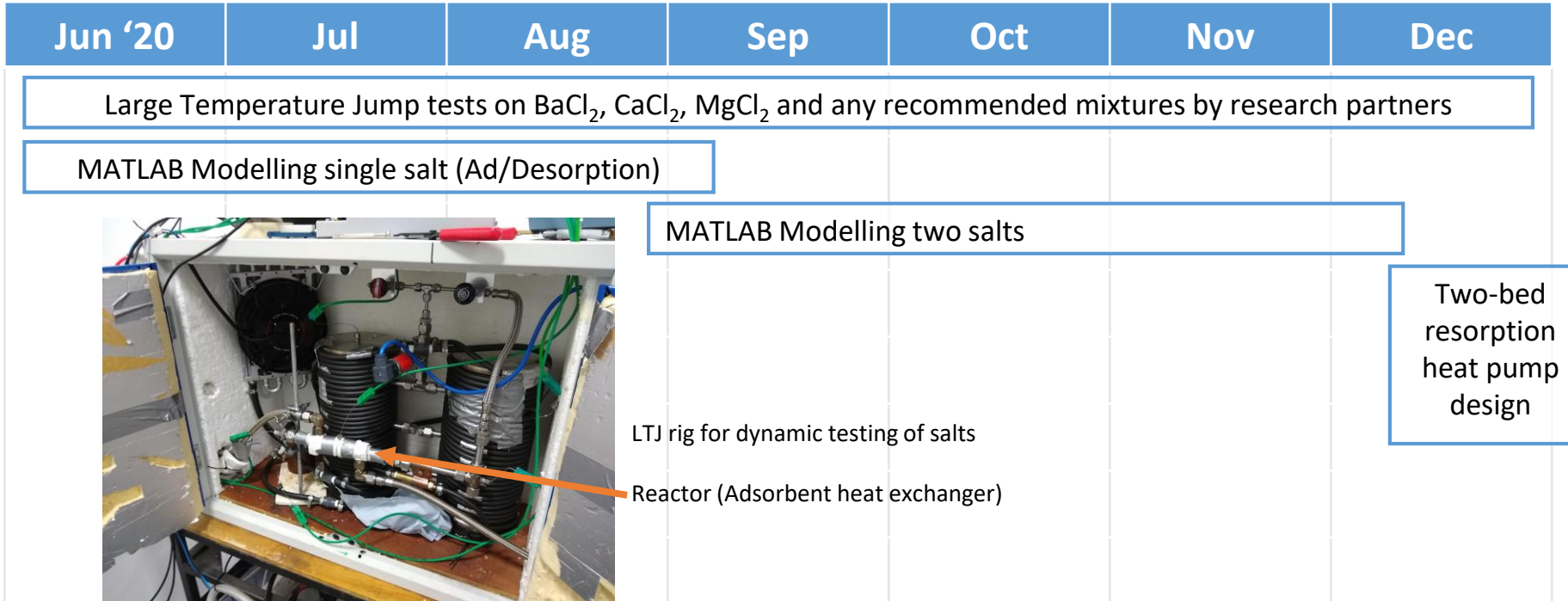
Current work



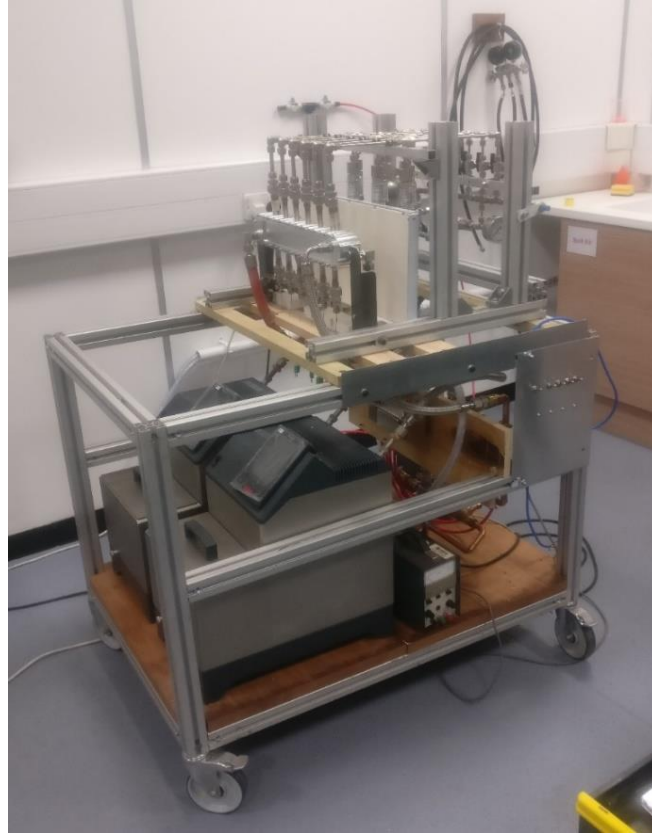
Desorption Adsorption



Plan of action (inline with MI timeline)



Cycling rig:



Analytical equipment:

- Rubotherm magnetic suspension balance
- High pressure DSC for sorbate properties
- Thermal conductivity
- STA high pressure ammonia

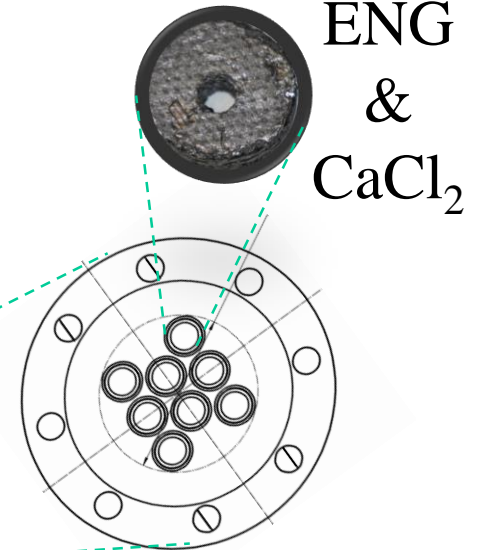
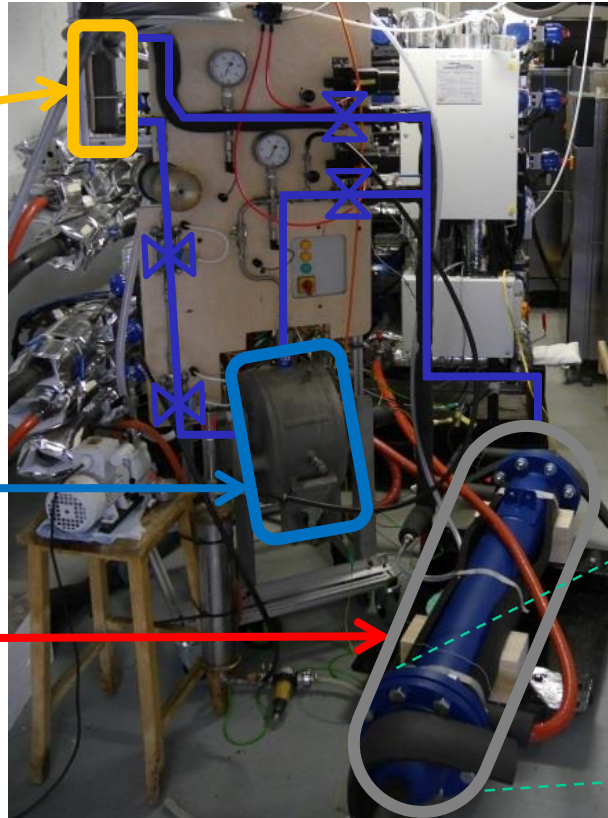
ThermExS Lab:

Condenser

Michel van der Pal's
 CaCl_2 - NH_3 reactor
under test

Evaporator

Reactor



Thank you!

Questions??