



UNIVERSITY OF  
BIRMINGHAM



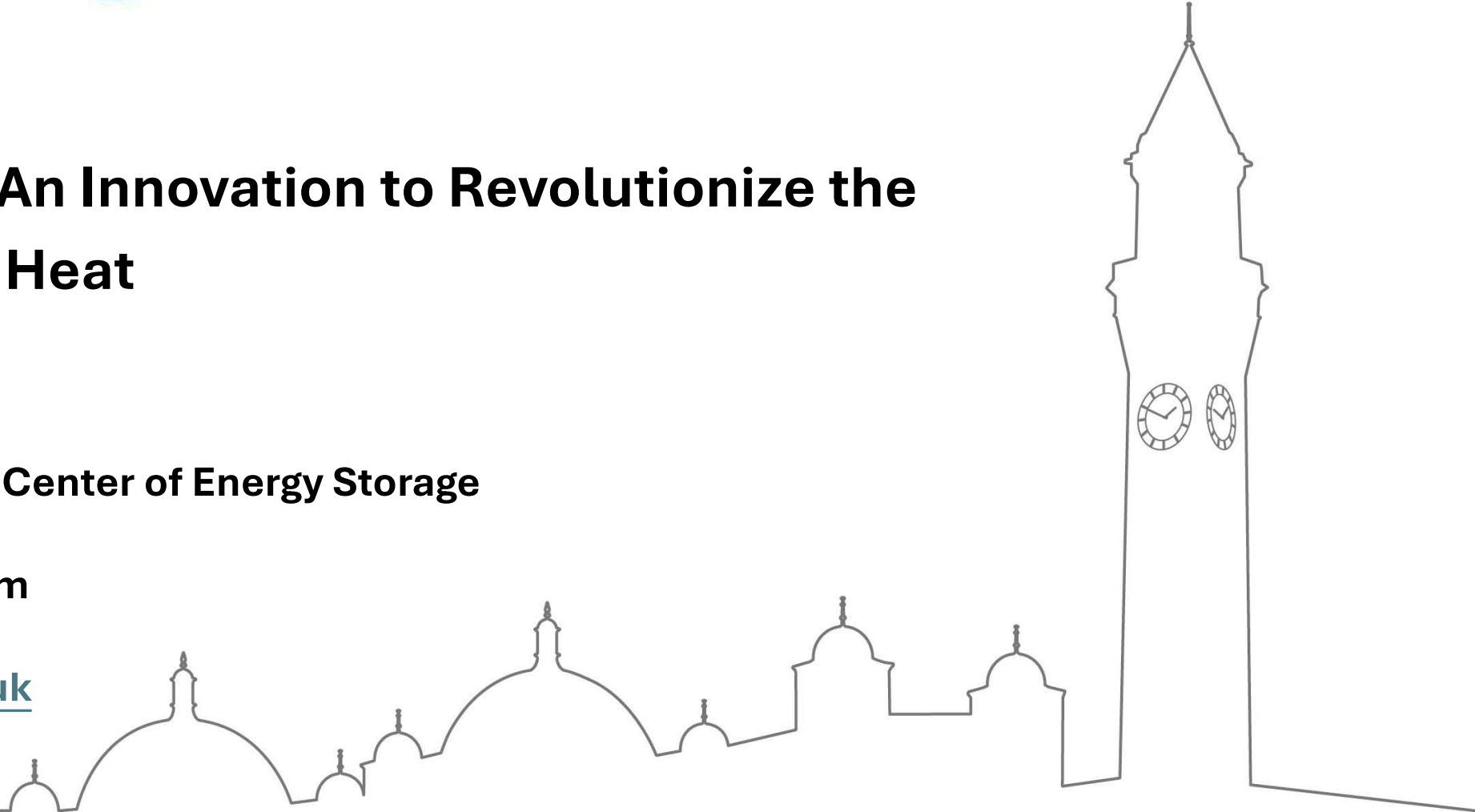
# e-Thermal Bank: An Innovation to Revolutionize the Electrification of Heat

Professor Yongliang Li

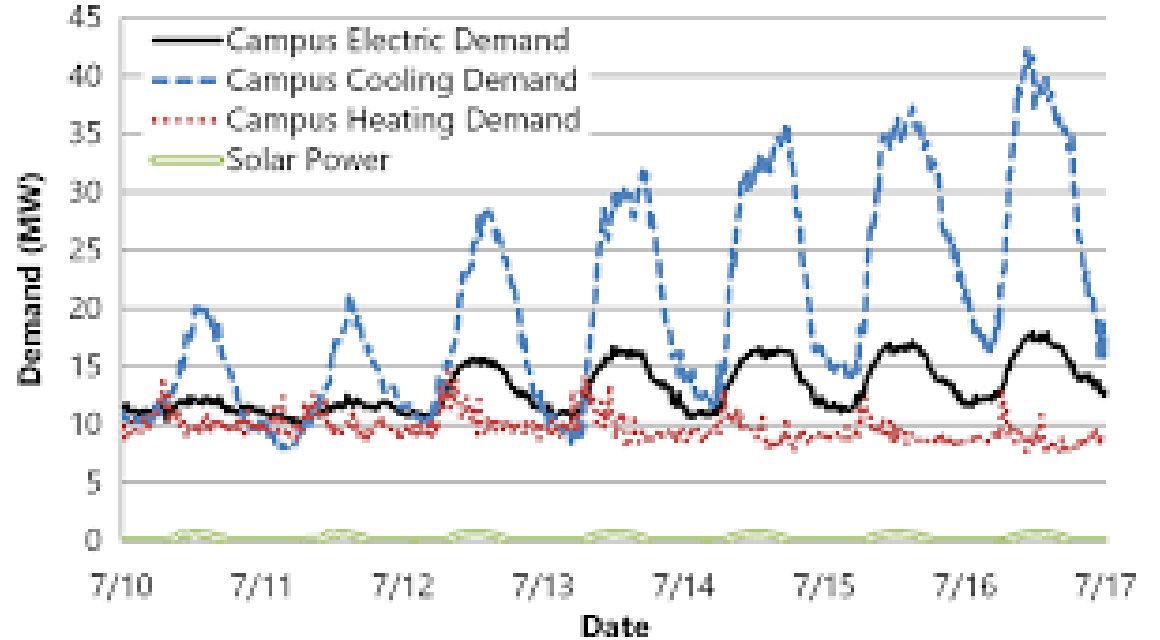
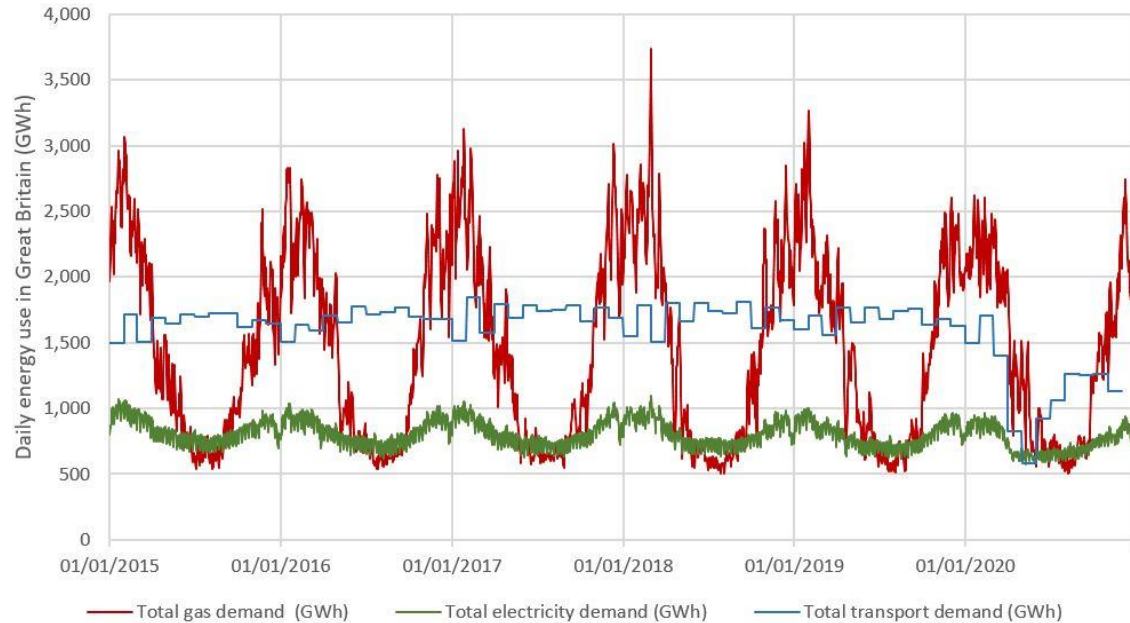
Director of Birmingham Center of Energy Storage  
(BCES)

University of Birmingham

Email: [y.li.1@bham.ac.uk](mailto:y.li.1@bham.ac.uk)



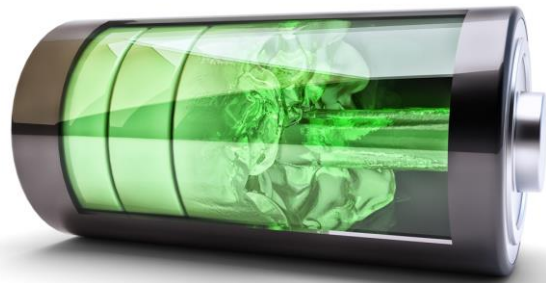
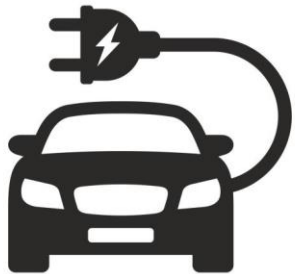
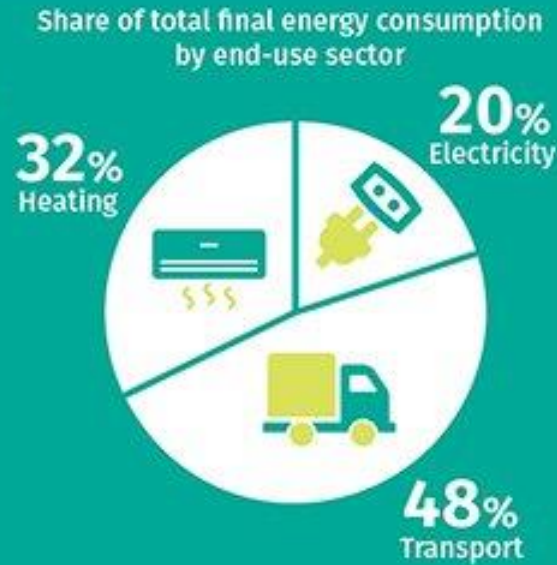
# Challenges for heating/cooling decarbonization



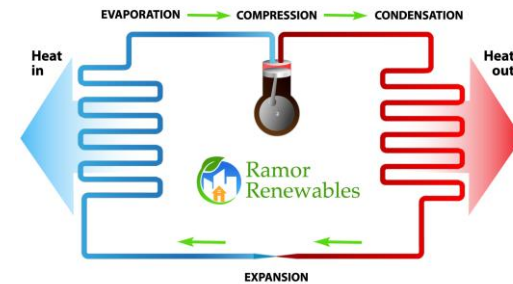
The regional consistency of heating/cooling requirements and resulted in demand spikes making thermal management more challenging than electricity management in a purely electrified future (direct electrical heating and/or electric heat pumps).

# What do we learn from the fast development of electric vehicles?

Thanks to declining costs of wind and solar, the electricity sector has made rapid progress reaching a renewable share of 22.8% in 2015. However, the remaining 80% of energy consumption comes from sectors with renewable shares that are either very low, such as transport, or stagnant, such as heating.



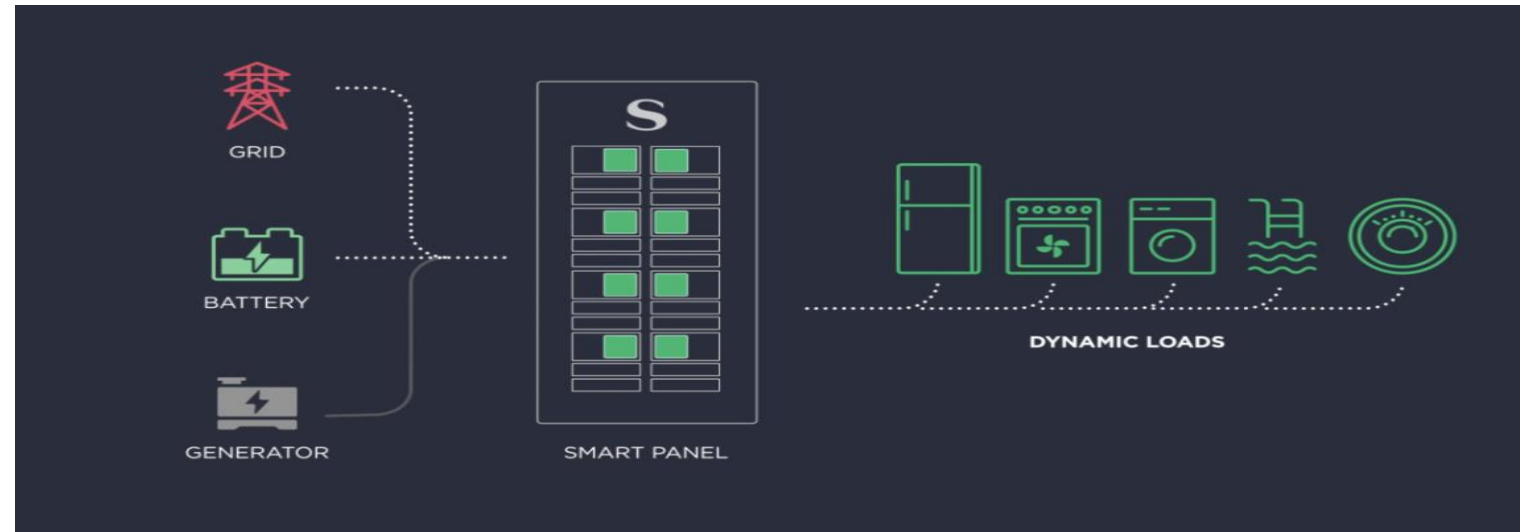
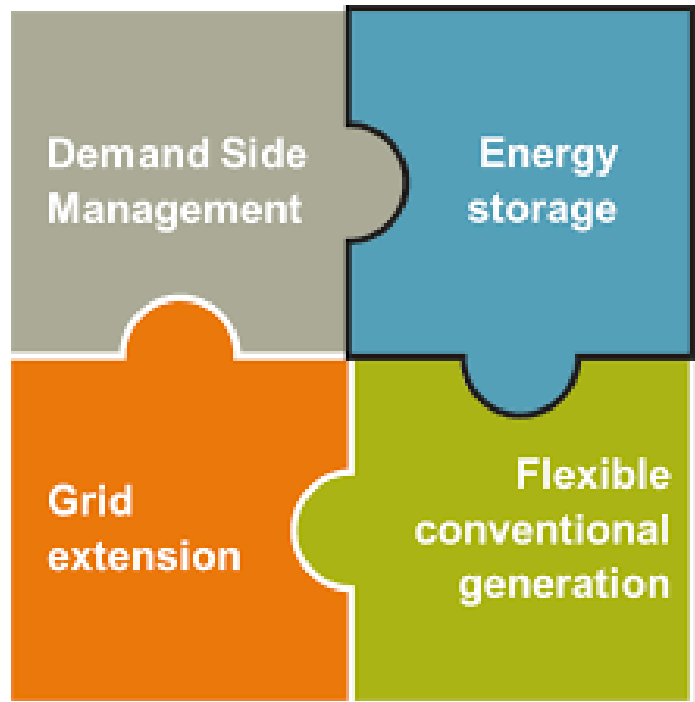
## How does a heat pump work?



# What is the idealized next-generation 'heat pumps'?



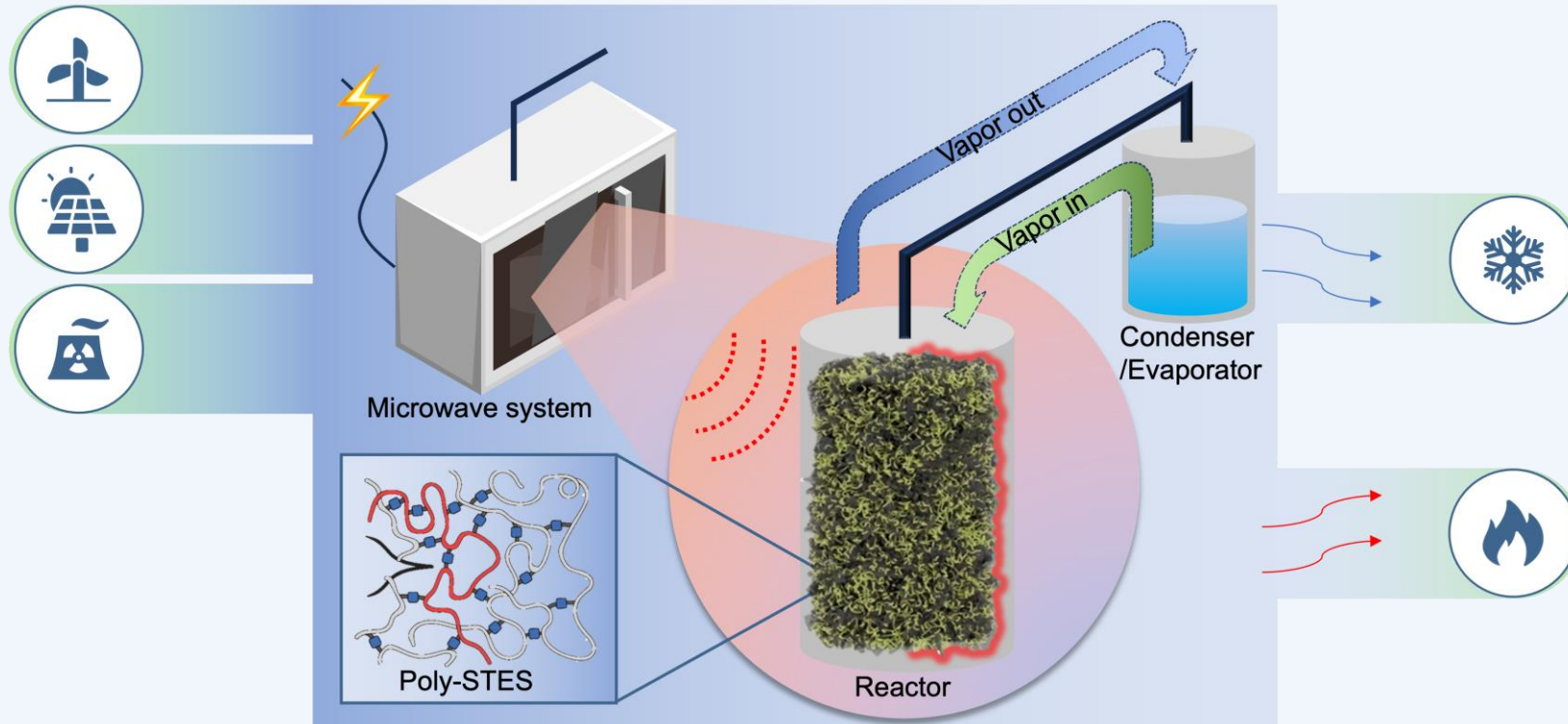
- A secondary function for 'storage'
- Highly flexible 'charging' for fast response
- Collective grid interconnection when connecting to smart meters
- Behind-the-Meter demand side flexibility



The next generation 'heat pump' should be able to revolutionize the demand side energy consumption pattern from being based on when it is needed to when it is available.

# e-Thermal Bank - concept

Turning intermittent renewable electricity into dispatchable heating/cooling energy



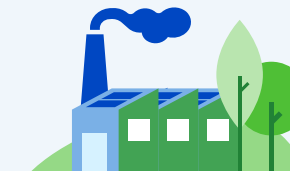
Think of it as a super-efficient combination of a battery and a heat pump, but it's more affordable, smaller, and easier to use.



To decrease the energy bill and mitigate the energy poverty

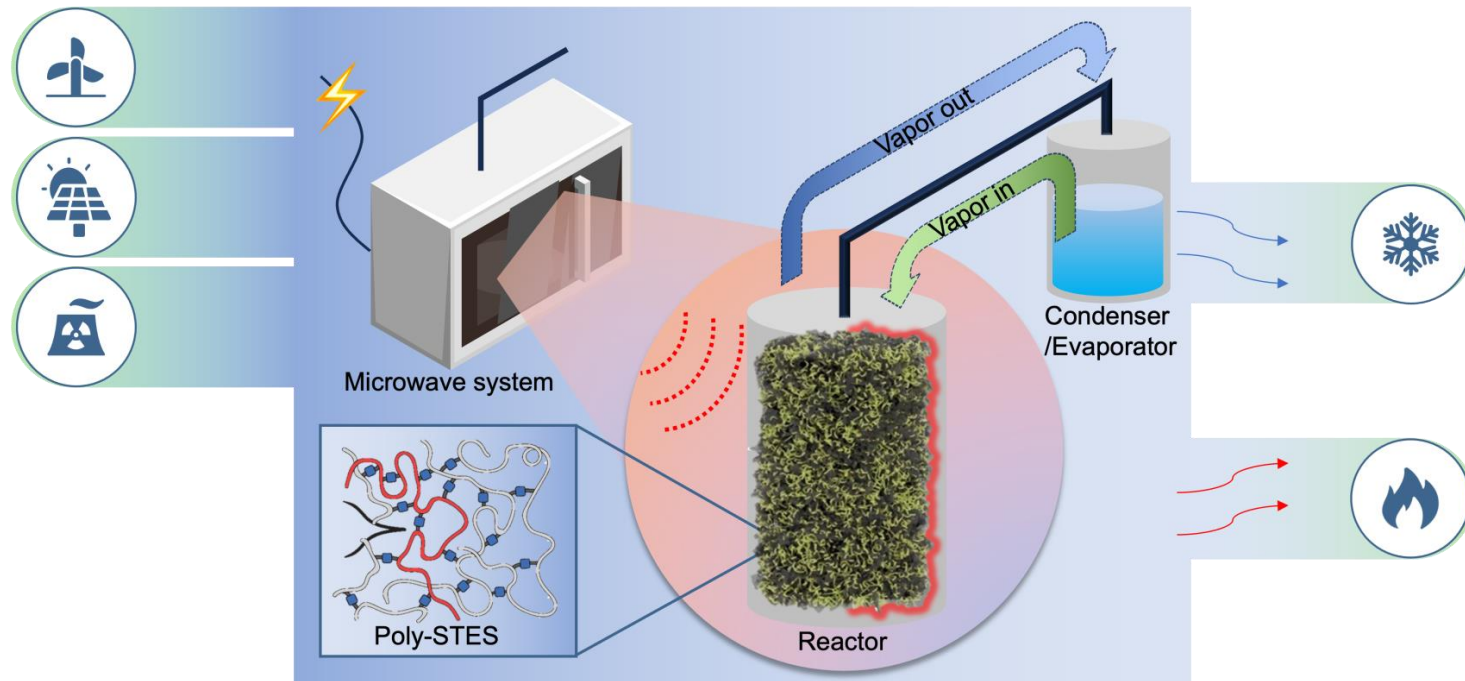


To avoid 'range anxiety' of EVs in very hot/cold days



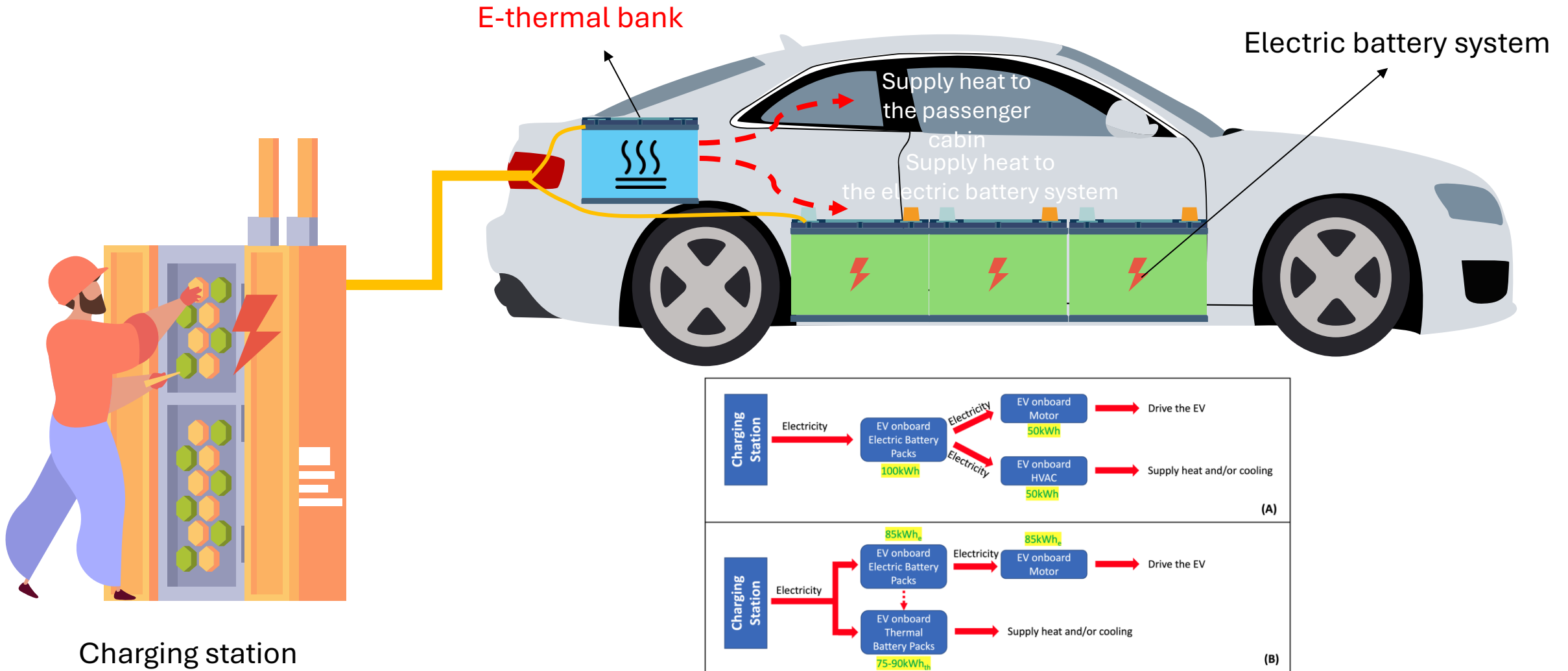
To recover the waste heat and save the energy cost

# Potential application – space heating & cooling

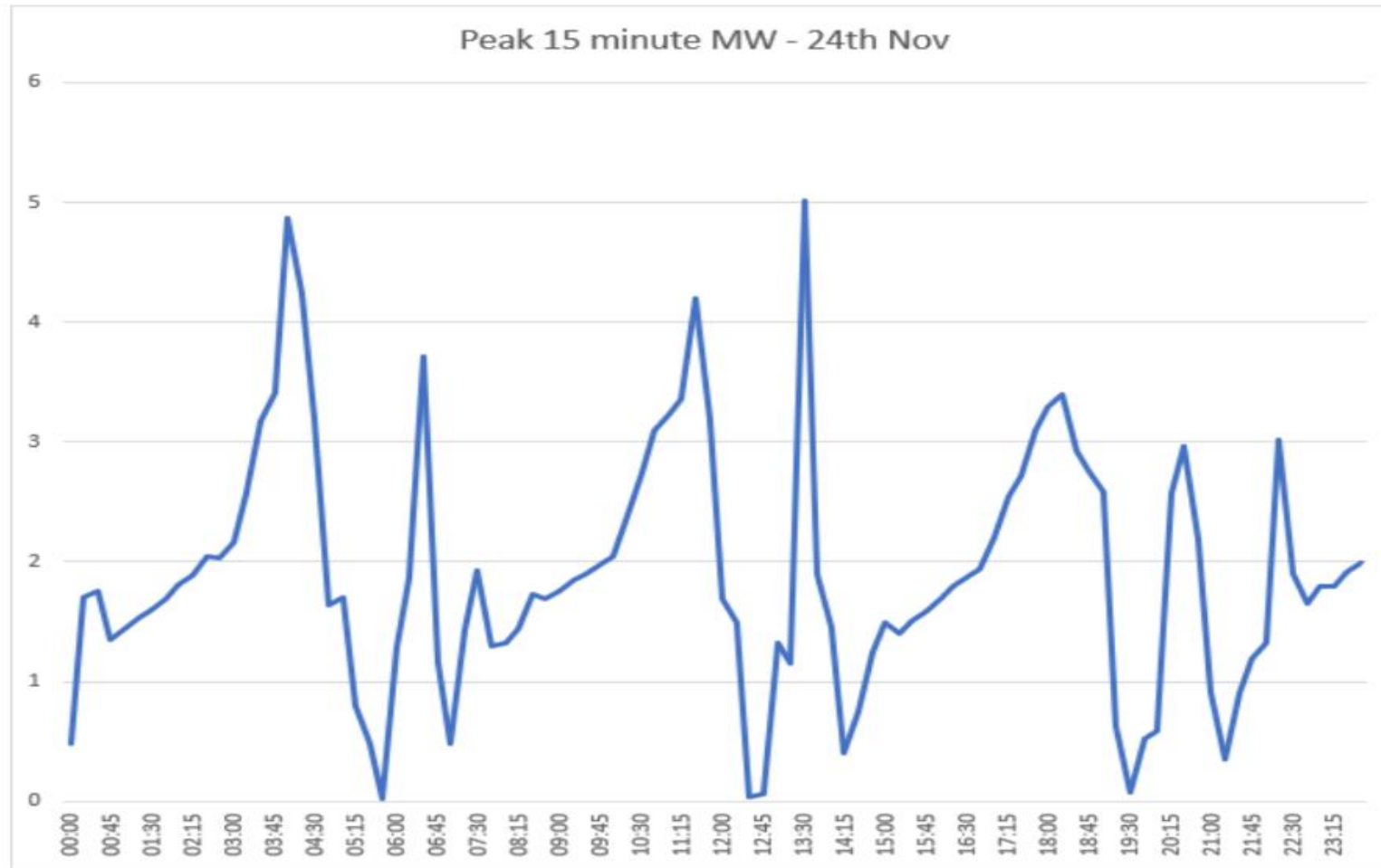


- **Efficiency:** up to 300 %
- **Energy density:** up to 1600 Wh/kg
- **Heat loss:** negligible
- **Cooling:** Yes
- **Waste heat recovery:** Yes

# Potential application – EV range extension

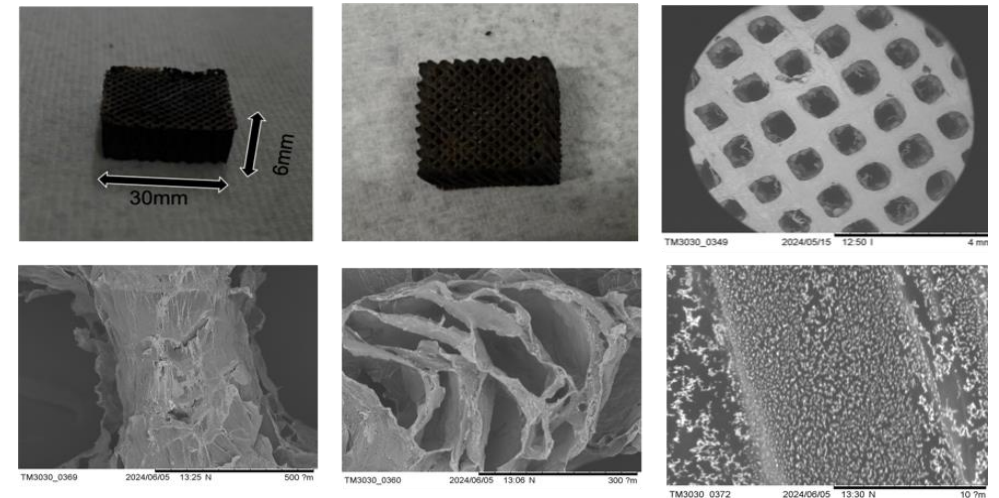
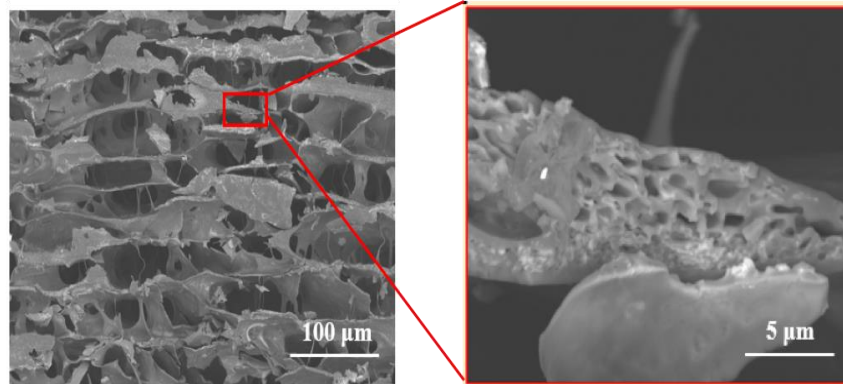
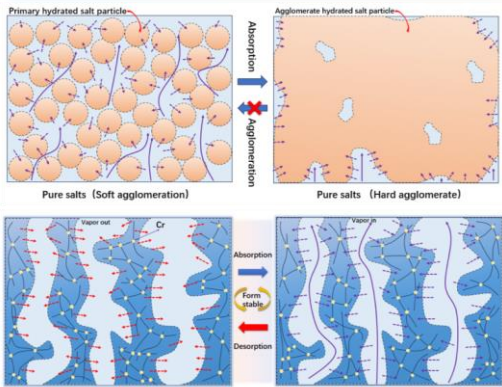
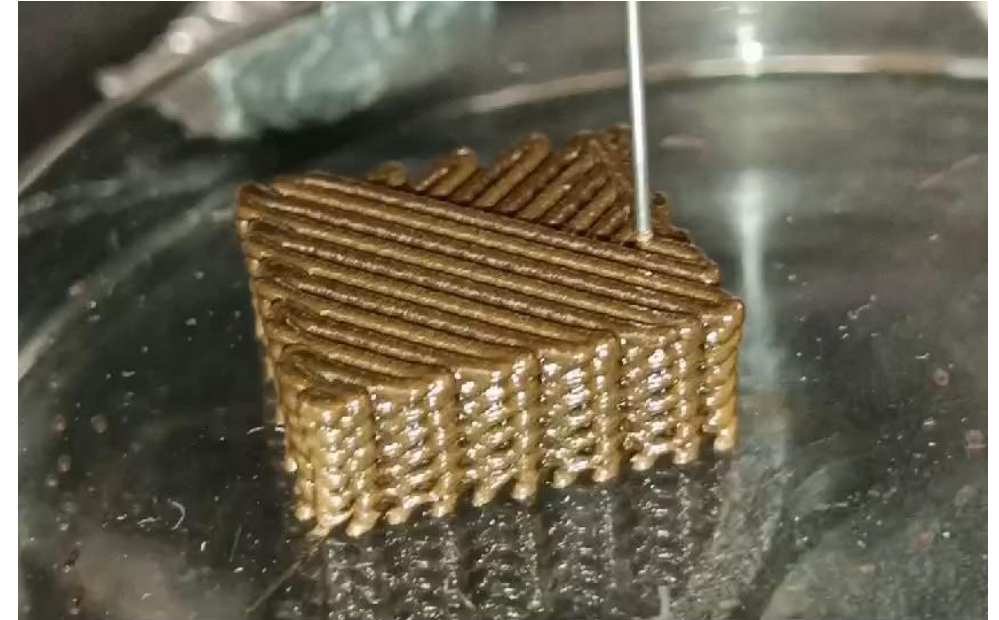
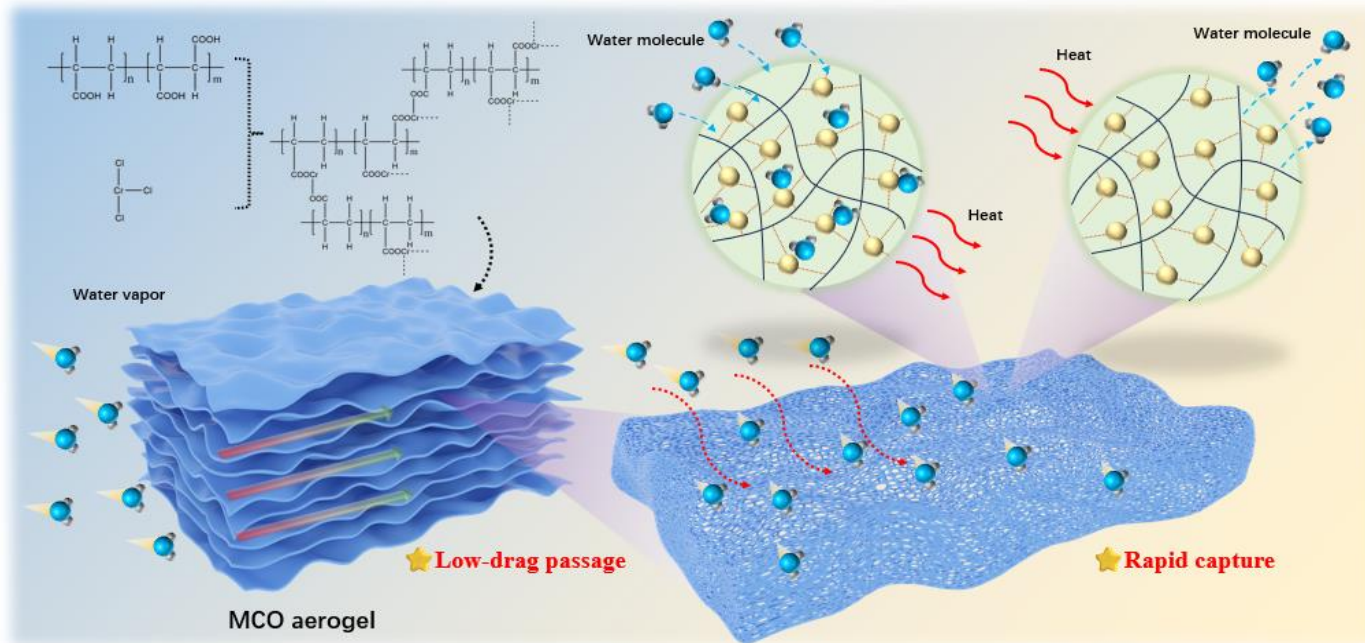


# Potential application – industrial low grade waste heat upgrade

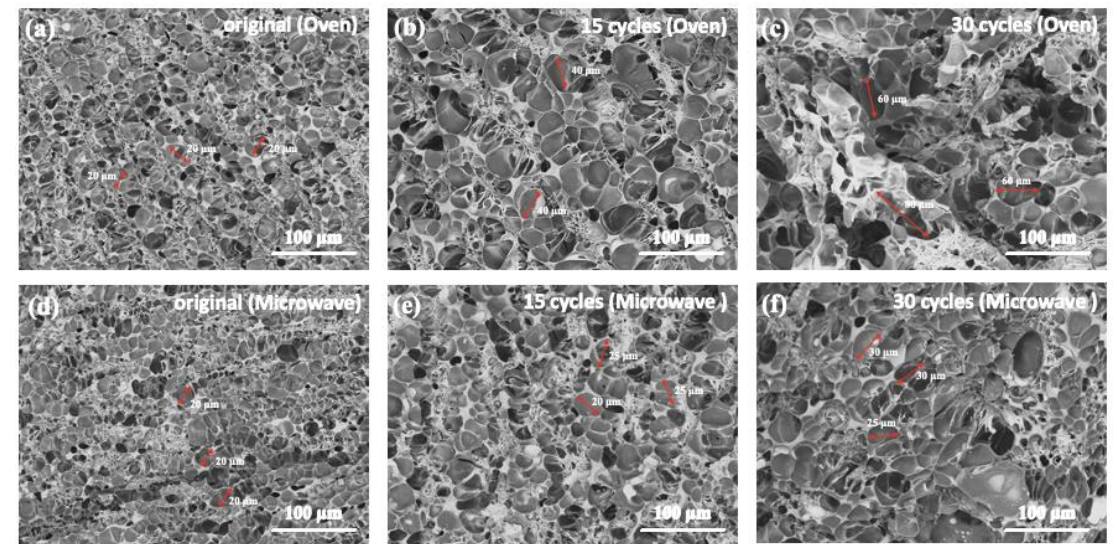
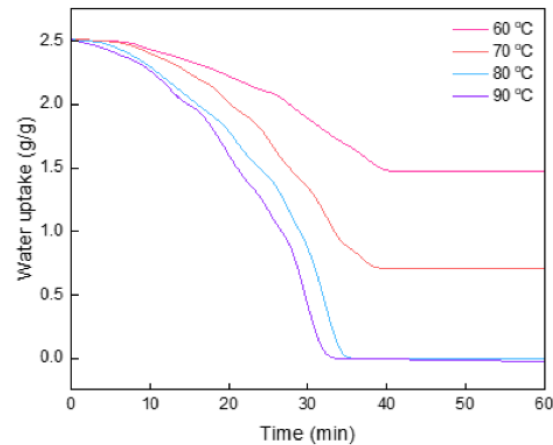
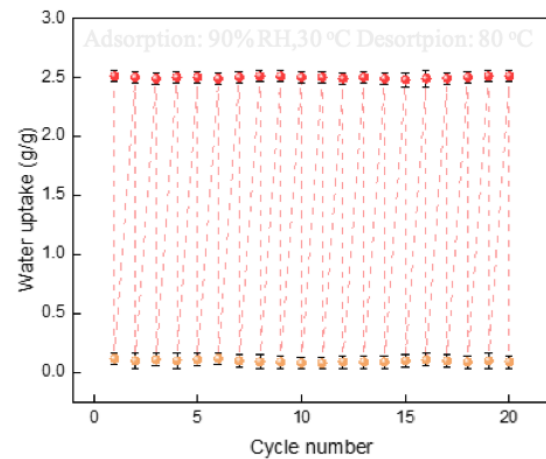
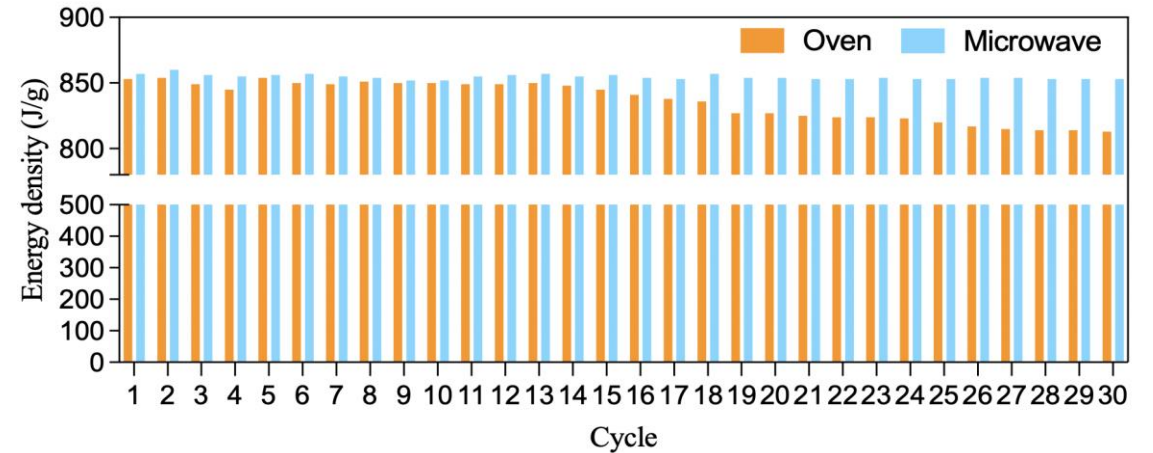
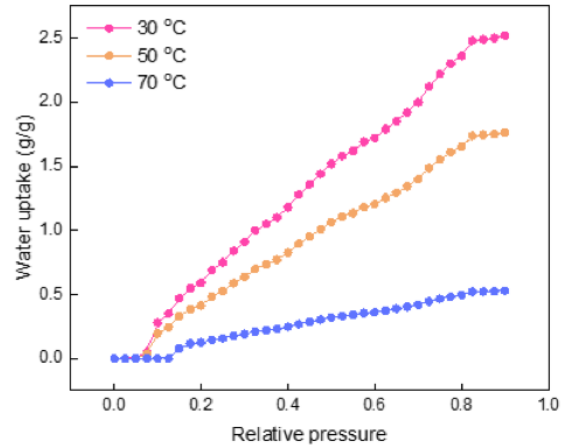
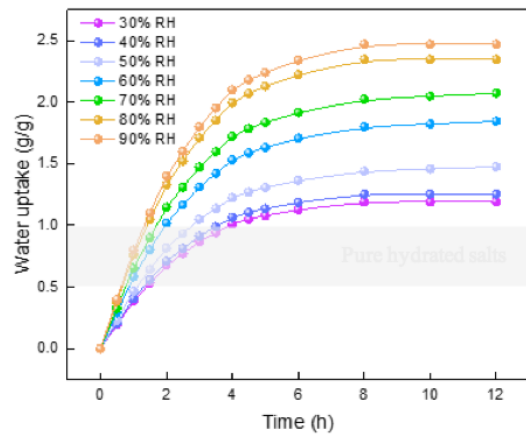




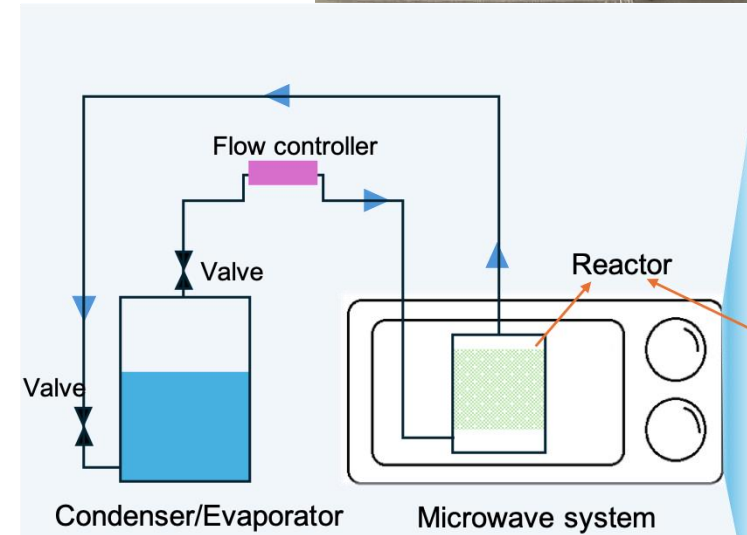
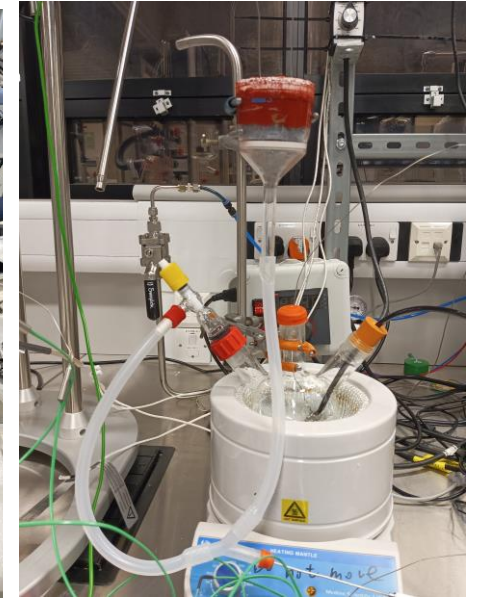
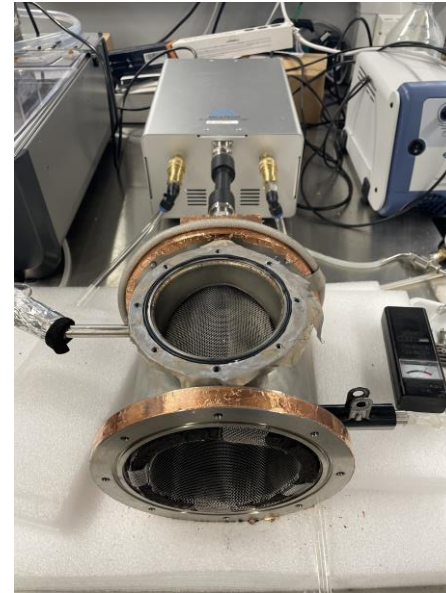
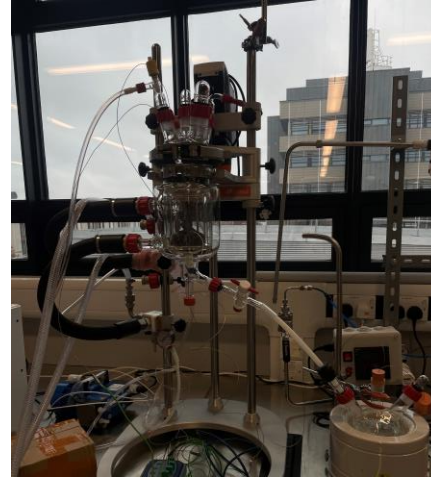
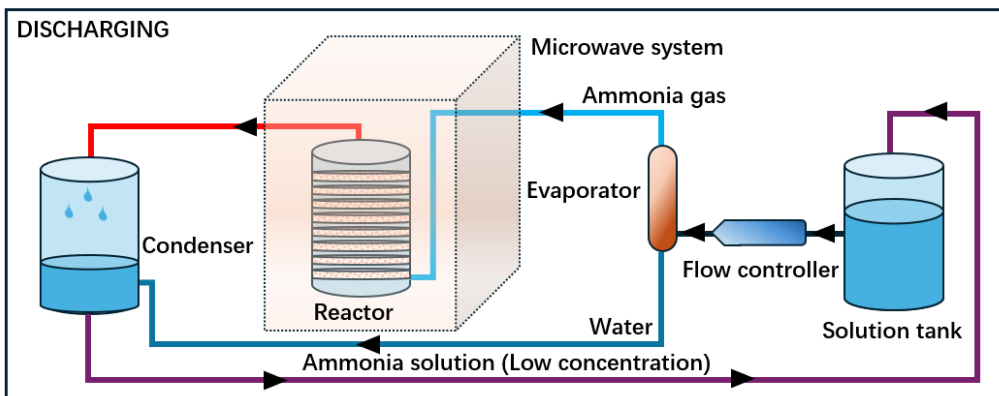
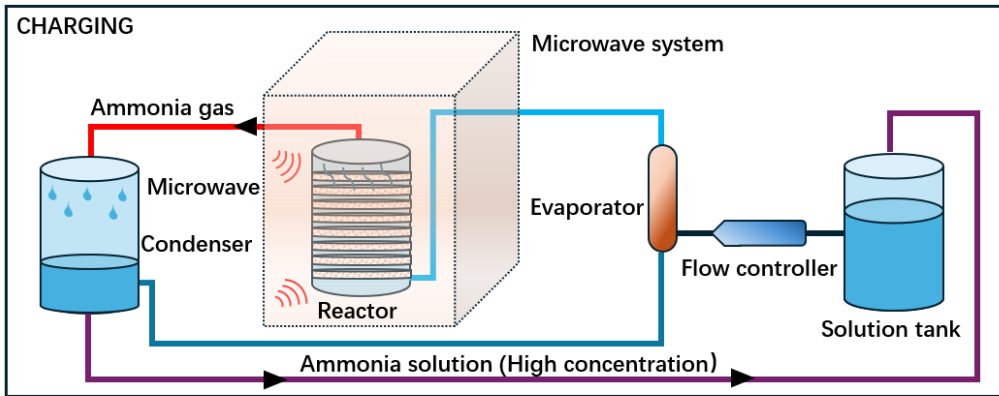
# Innovation in material pair development



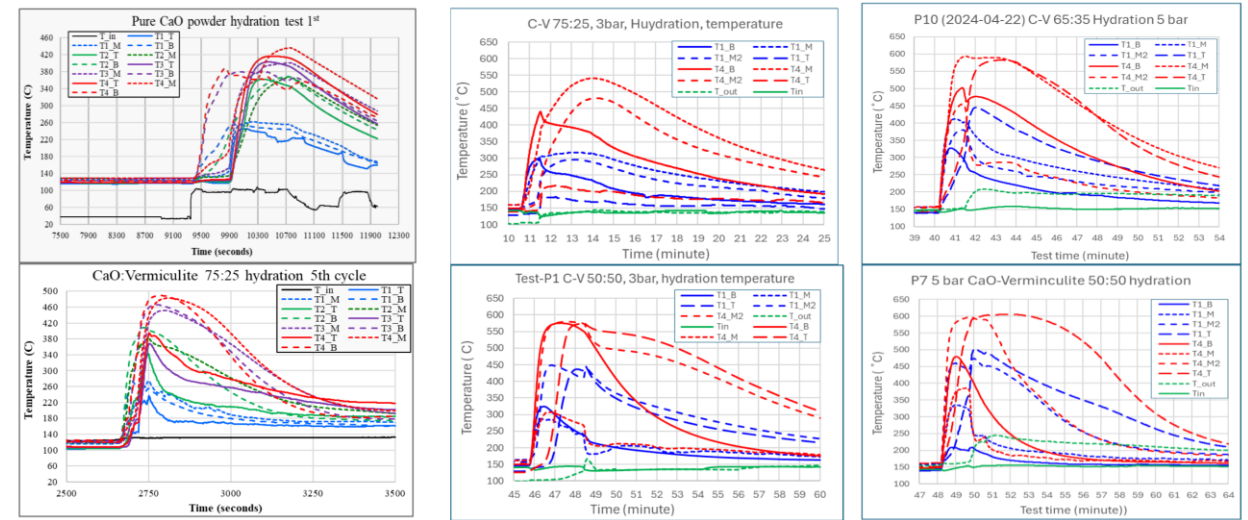
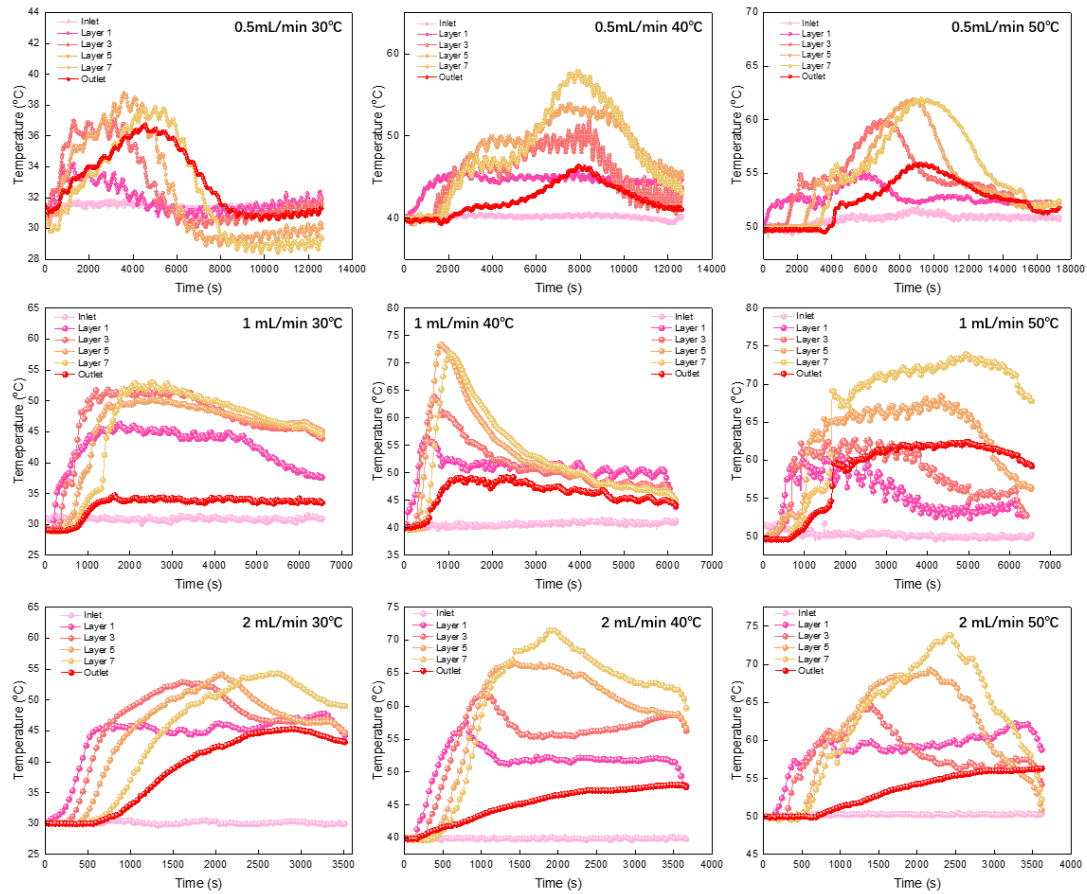
# Innovation in material pair development



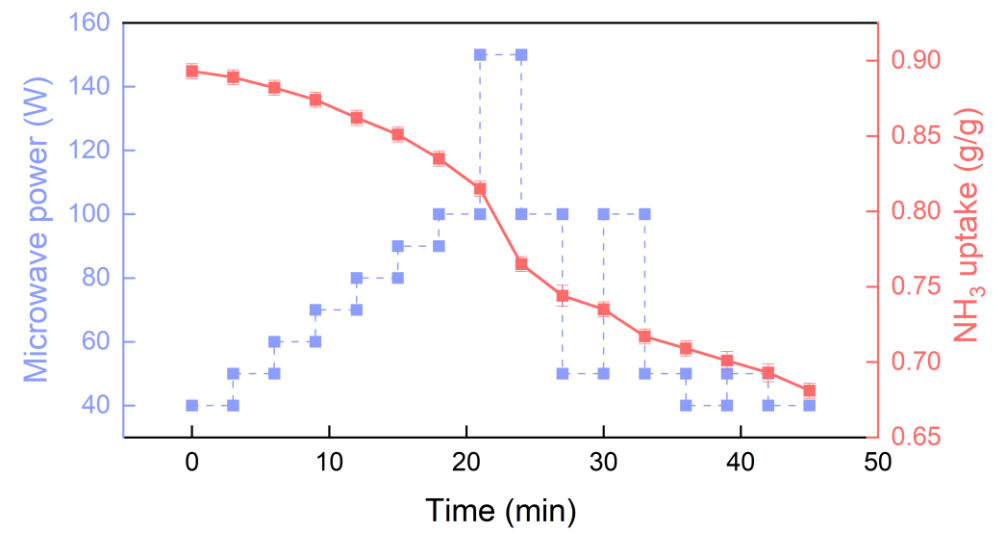
# Innovation in system integration



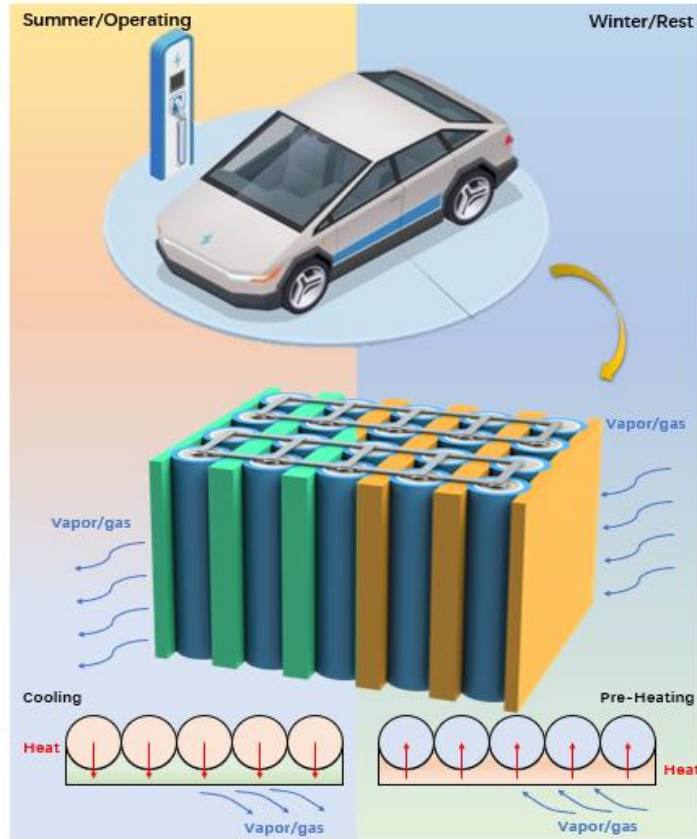
# Innovation in system integration



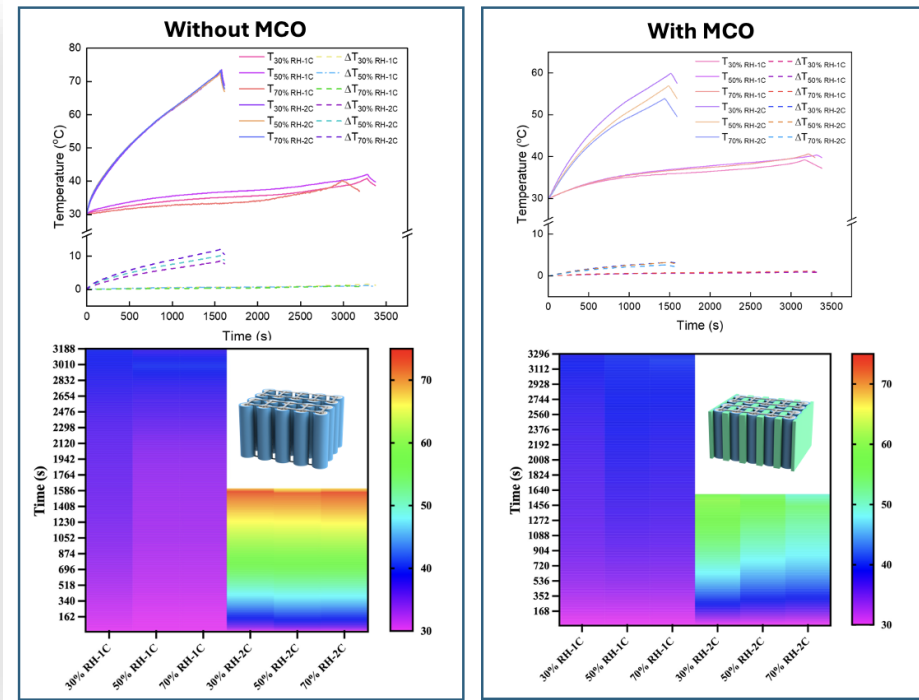
1 bar 440-490                      3 bar 554-580                      5 bar 594-605



# What's more –battery thermal management



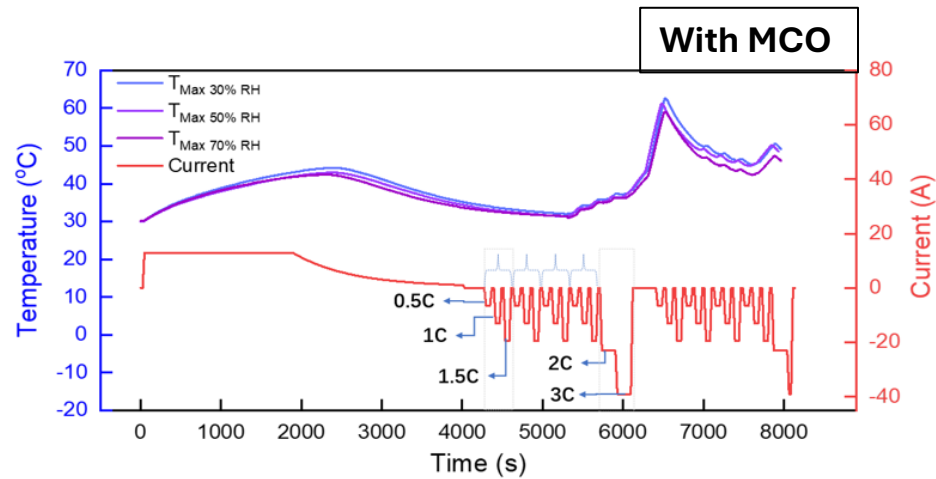
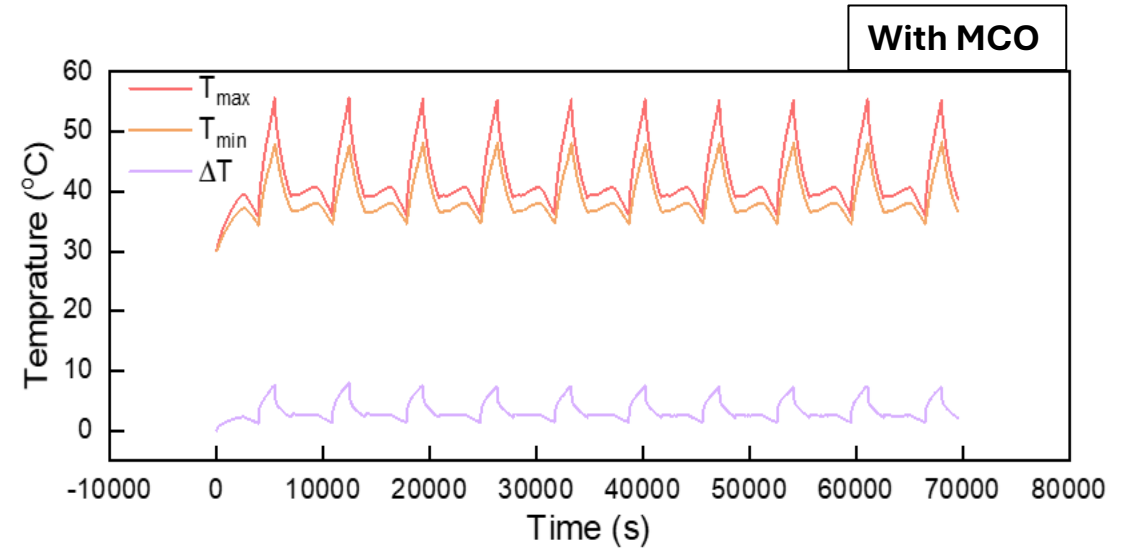
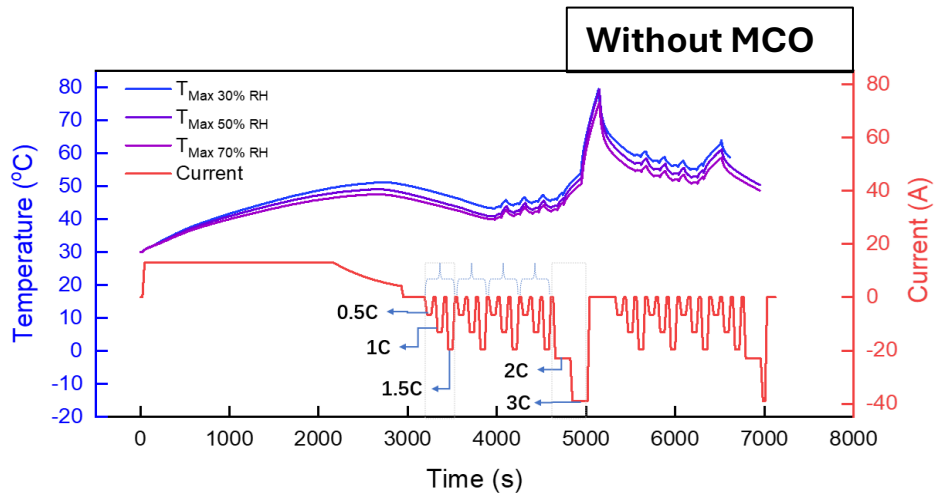
Cooling/preheating dual function thermal management system



Comparison of cooling capacity under different ambient humidity

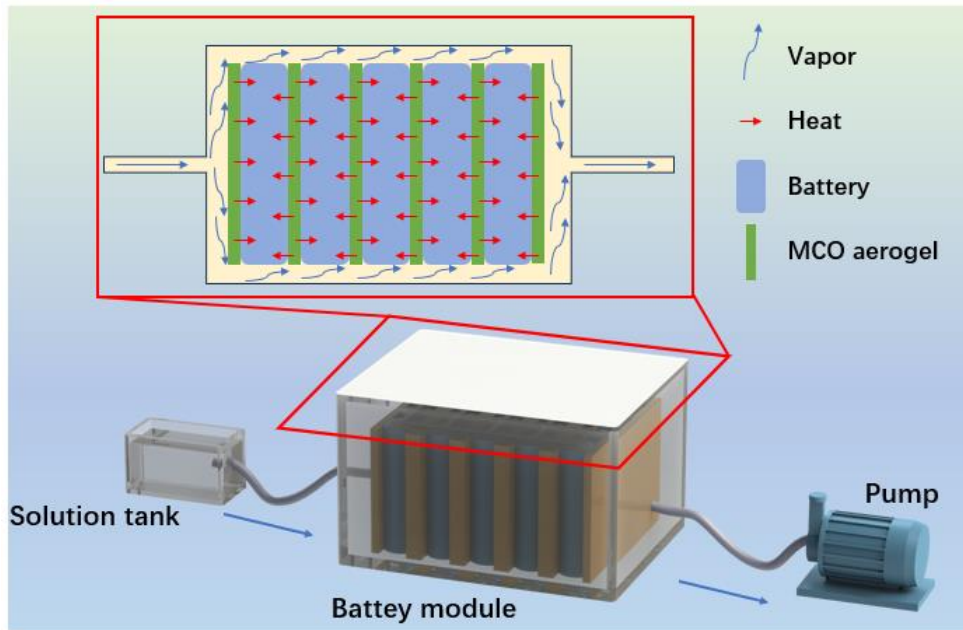
- Ambient humidity has little effect on battery heat production
- The high humidity environment can increase the cooling capacity of the MCO aerogel and achieve better cooling capacity

# What's more –battery thermal management



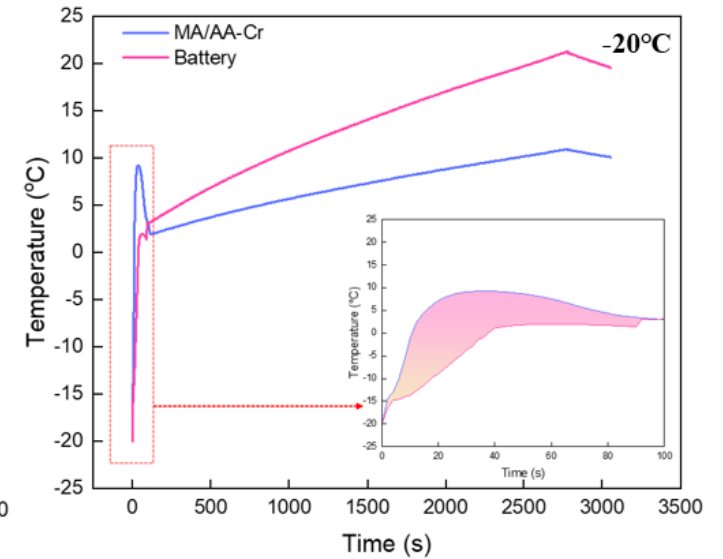
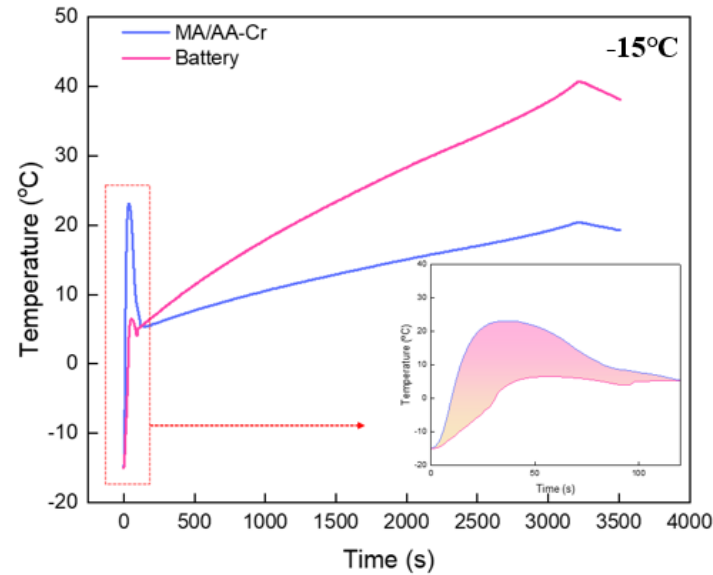
- Efficient, stable cooling capacity
- Suitable for long operation applications
- High temperature practicality

# What's more – fast response (battery thermal management)



Pre-heating system

- Simple structure, lightweight
- Fast heating
- Low temperature suitability



Low temperature preheating test of battery module

- The preheating program (20-30 s) and the discharge program of battery (40-50 s)
- The heating time can be controlled according to the ambient temperature and demand



UNIVERSITY OF  
BIRMINGHAM



## e-Thermal Bank:

- **Converts, stores, and amplifies energy**
- **Turns intermittent renewables into dispatchable thermal**
- **Shifts thermal users' electricity consumption pattern from 'when it is needed' to 'when it is available' (demand-driven to supply-driven)**

