Ulster University
Faculty of Computing, Engineering and the Built Environment

LoT-NET

Effect of Various Heat Transfer Enhancement Methods on the Thermal Performance of a Latent Heat Thermal Energy Storage System

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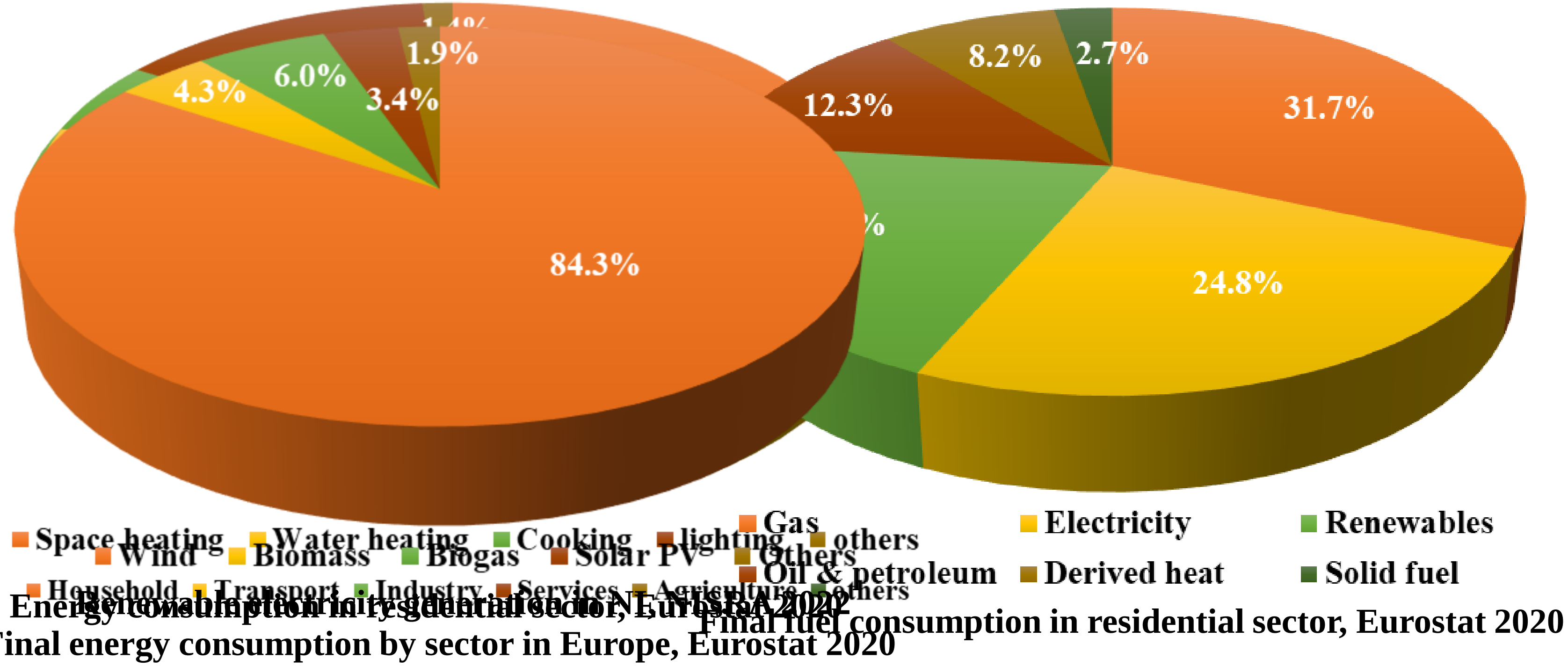
Contents

1. Why the thermal energy storage is important?

- In Europe, domestic sector accounts for the 28% of total energy consumption.
- Around 80% of the domestic energy consumption is for space heating and domestic hot water production
- Net zero carbon policy-2050
- Heat decarbonization through electrification
- 1300GWh wind electricity wastage since 2021
- An efficient TES technology is required to bridge the supply and demand of energy



Classification of TES

TES

Sensible heat storage

- Stored energy is a function of specific heat and temperature difference
- Low energy storage density, high energy loss
- Water, mineral oils, brick, concrete

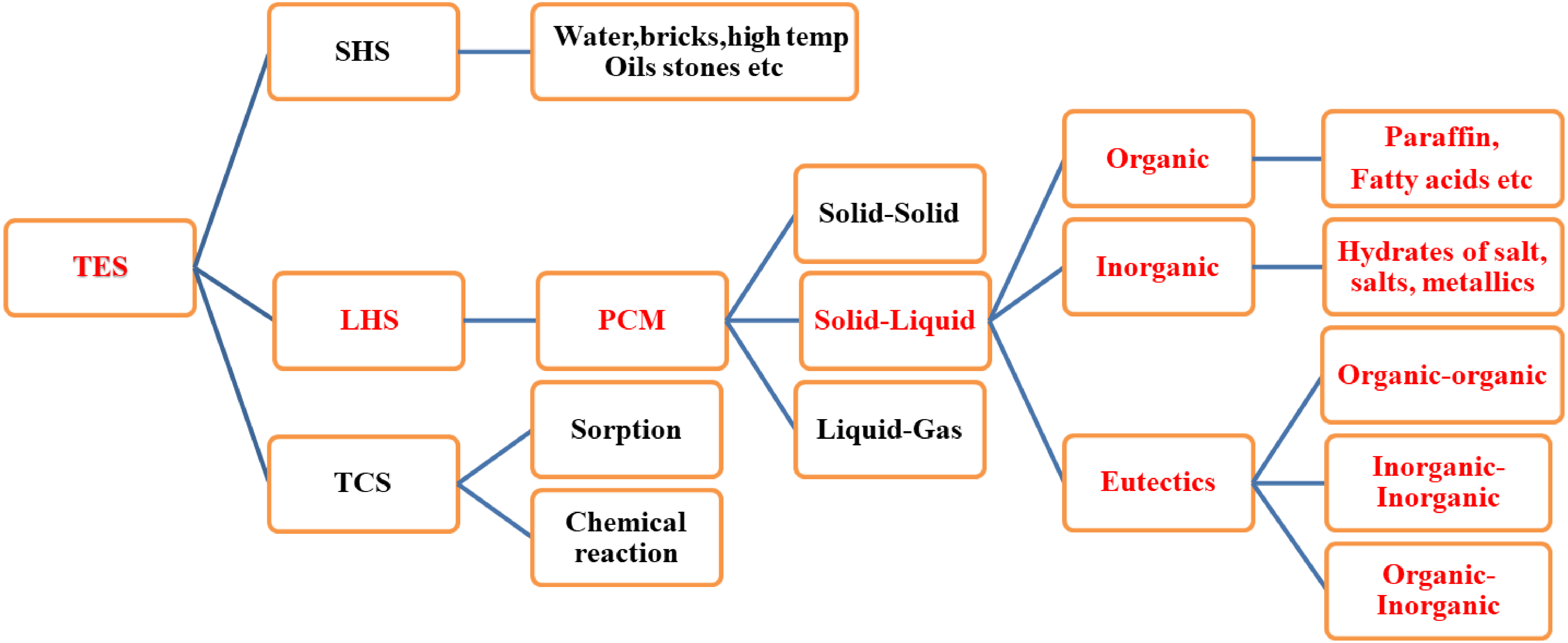
Latent heat storage

- Store energy in sensible and latent heat form
- High energy storage density than sensible storage
- Low energy loss as energy stored at a narrow temperature range
- Water, paraffin wax, salt hydrates,

Thermo chemical

- Store/ release energy during thermo chemical reaction
- High energy storage density
- low energy loss, temperature difference not involved
- Low heat transfer kinetics
- High cost
- Metal hydride, silica, zeolite, hydration of metallic oxide

Classification of TES



Why Phase change materials ?

- PCM materials offers most flexible operating range
- Comparatively high energy density
- High durability at reasonable cost

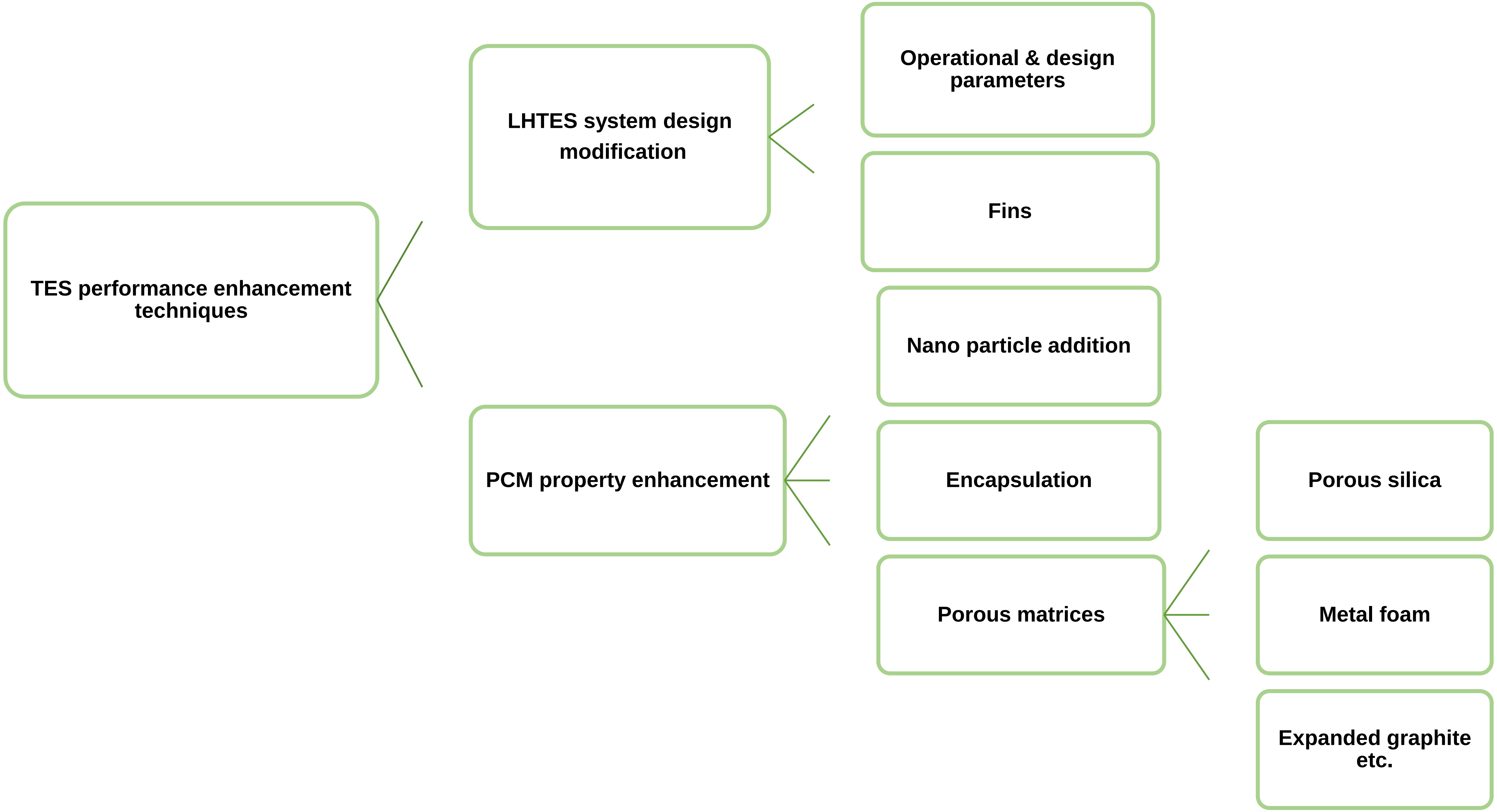
Desirable properties

- ➢High heat of fusion
- ➢High thermal conductivity
- ➢Congruent melting
- ➢Freeze without supercooling
- ➢High thermal reliability
- ➢Compatibility with containment materials
- ➢Low volumetric expansion

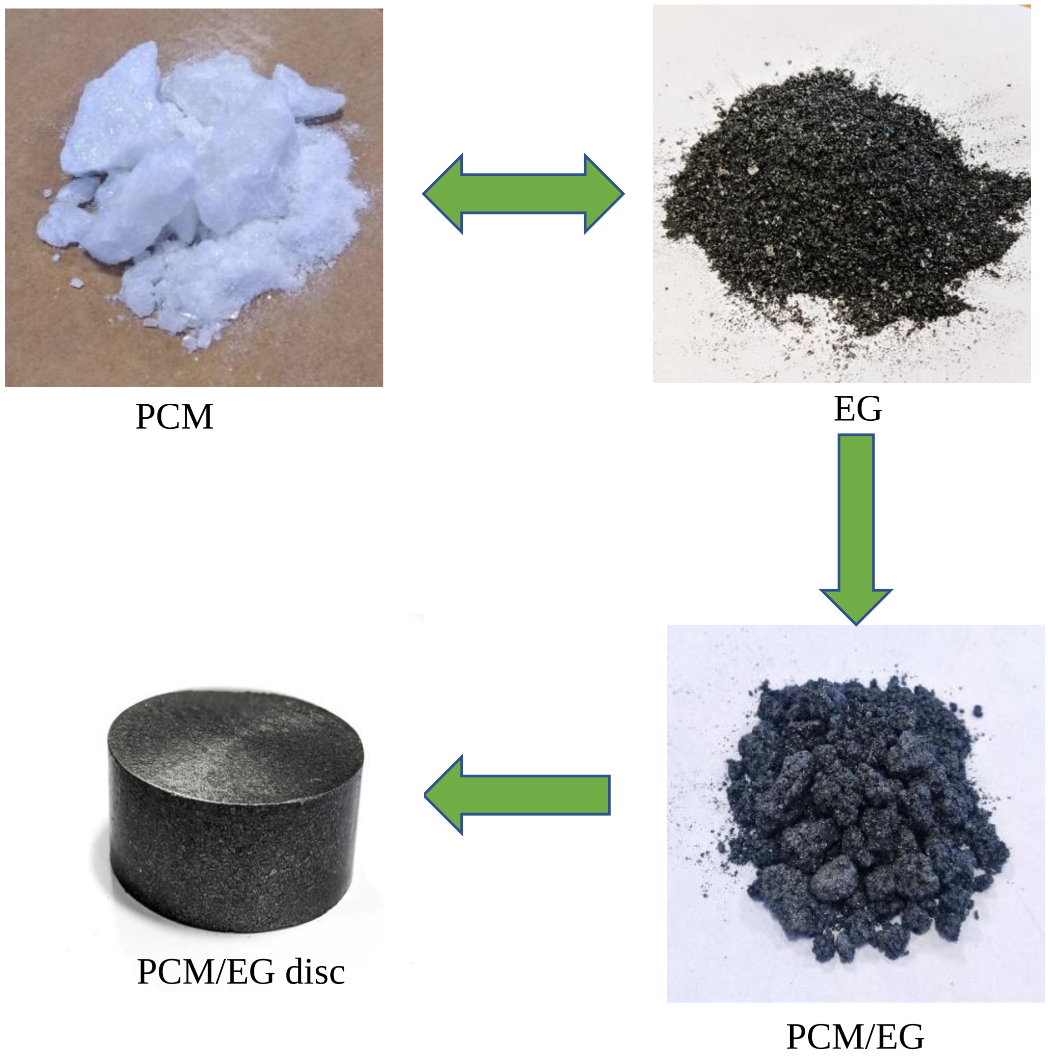
Challenges

- ➢Low thermal conductivity
- ➢Corrosion
- ➢Supercooling
- ➢Volumetric expansion
- ➢Leakage
- ➢Thermal reliability

How to overcome these challenges?

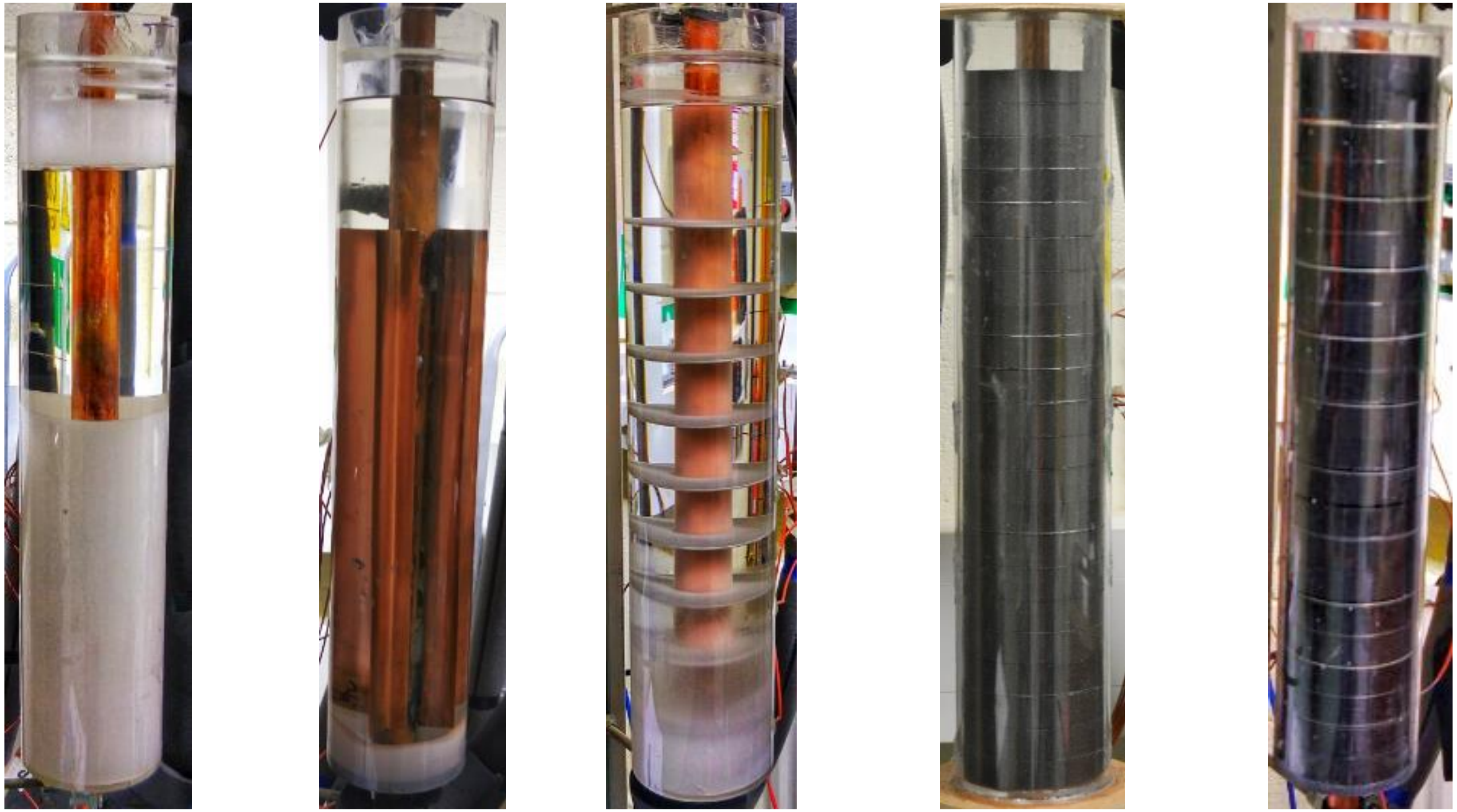


Methodology



- PCM-EG composite preparation
- PCM/25wt%EG was prepared by melt blending
- Optimization of the EG/PCM mass ratio: 15,20,25 and 30wt% of EG
- Thermo-physical property measurement: Thermal conductivity, phase change properties

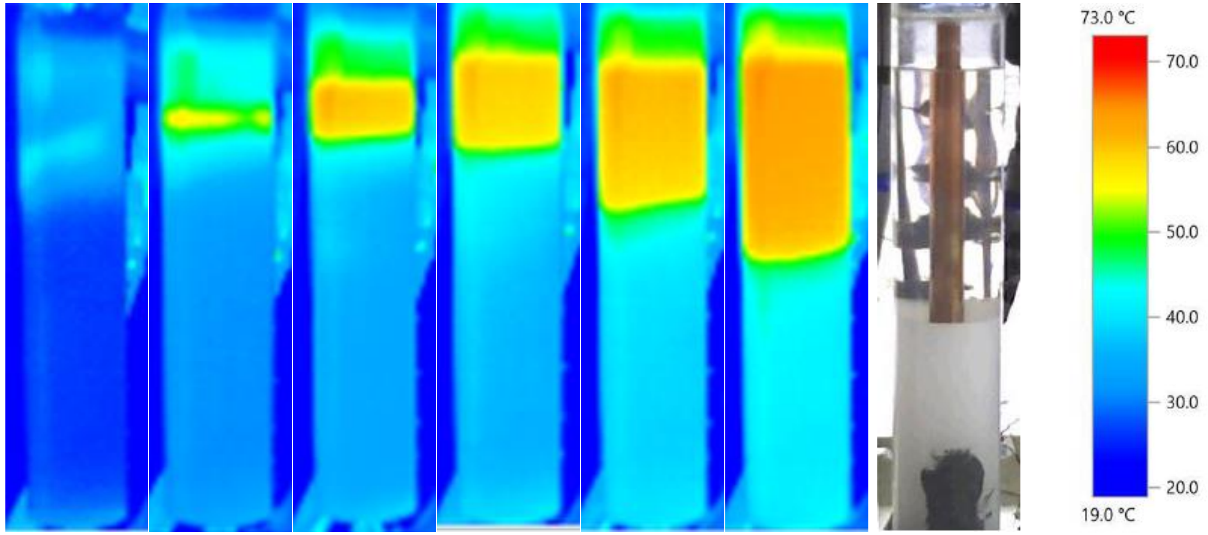
Methodology



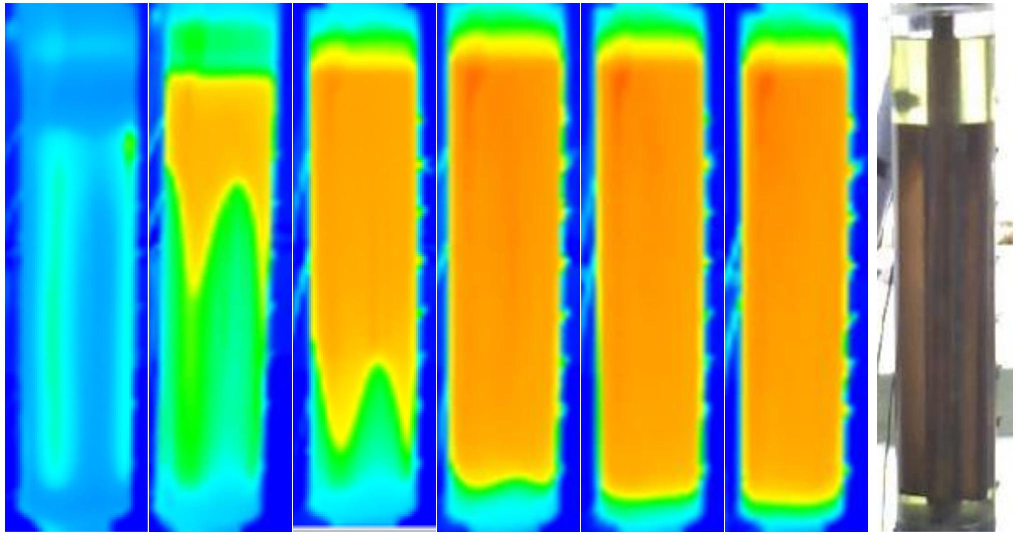
a b c d e

Images of the PCM storage systems tested during this study. (a) PCM HX (b) PCM longitudinal fin HX (c) PCM circular fin HX (d) PCM/EG HX and (e) PCM/EG/fin.

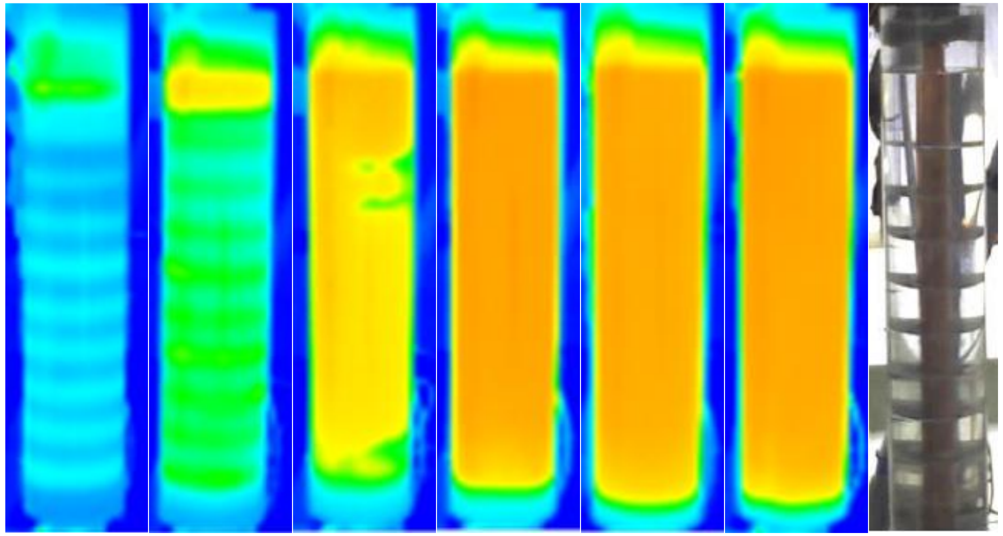
Results



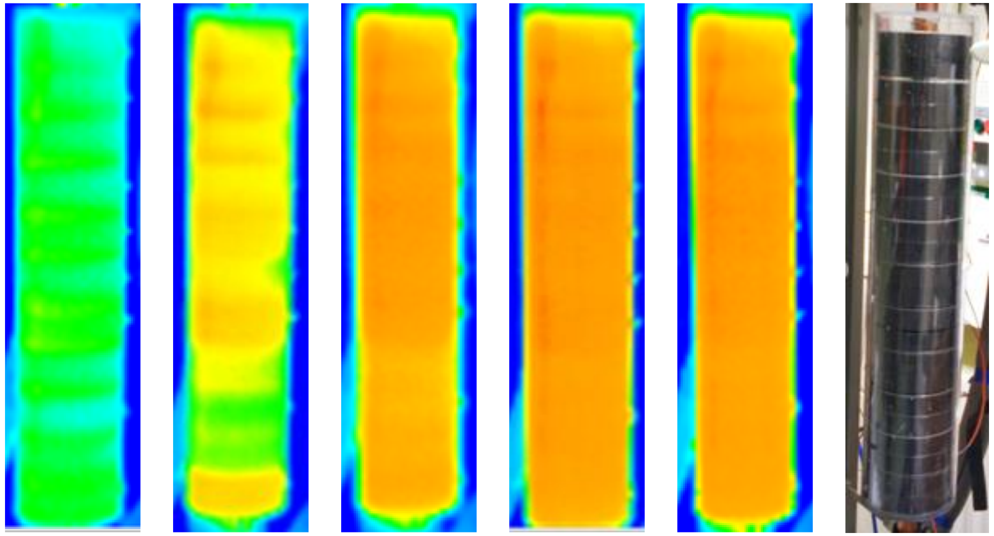
(a) PCM HX system



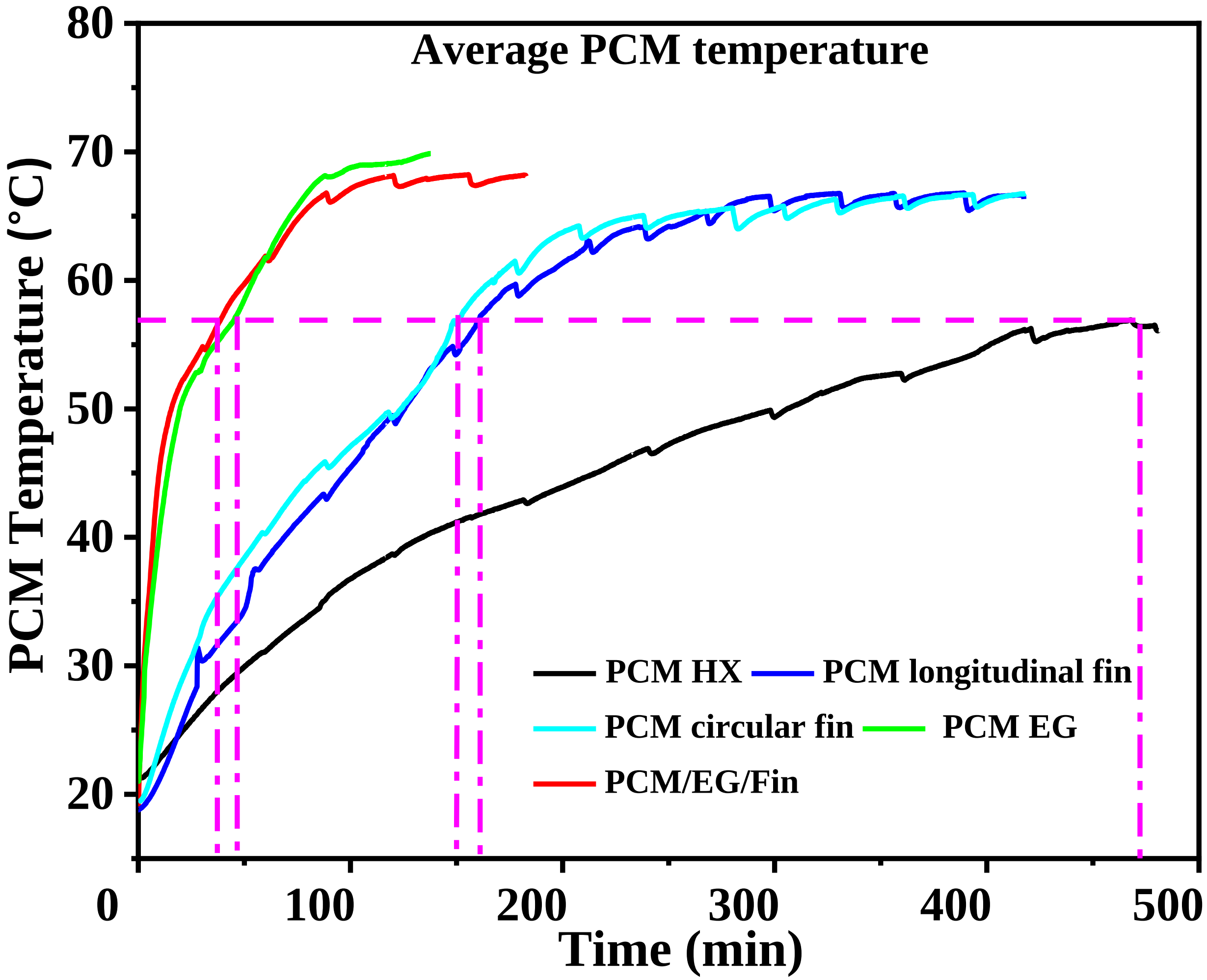
(b) PCM longitudinal fin HX system



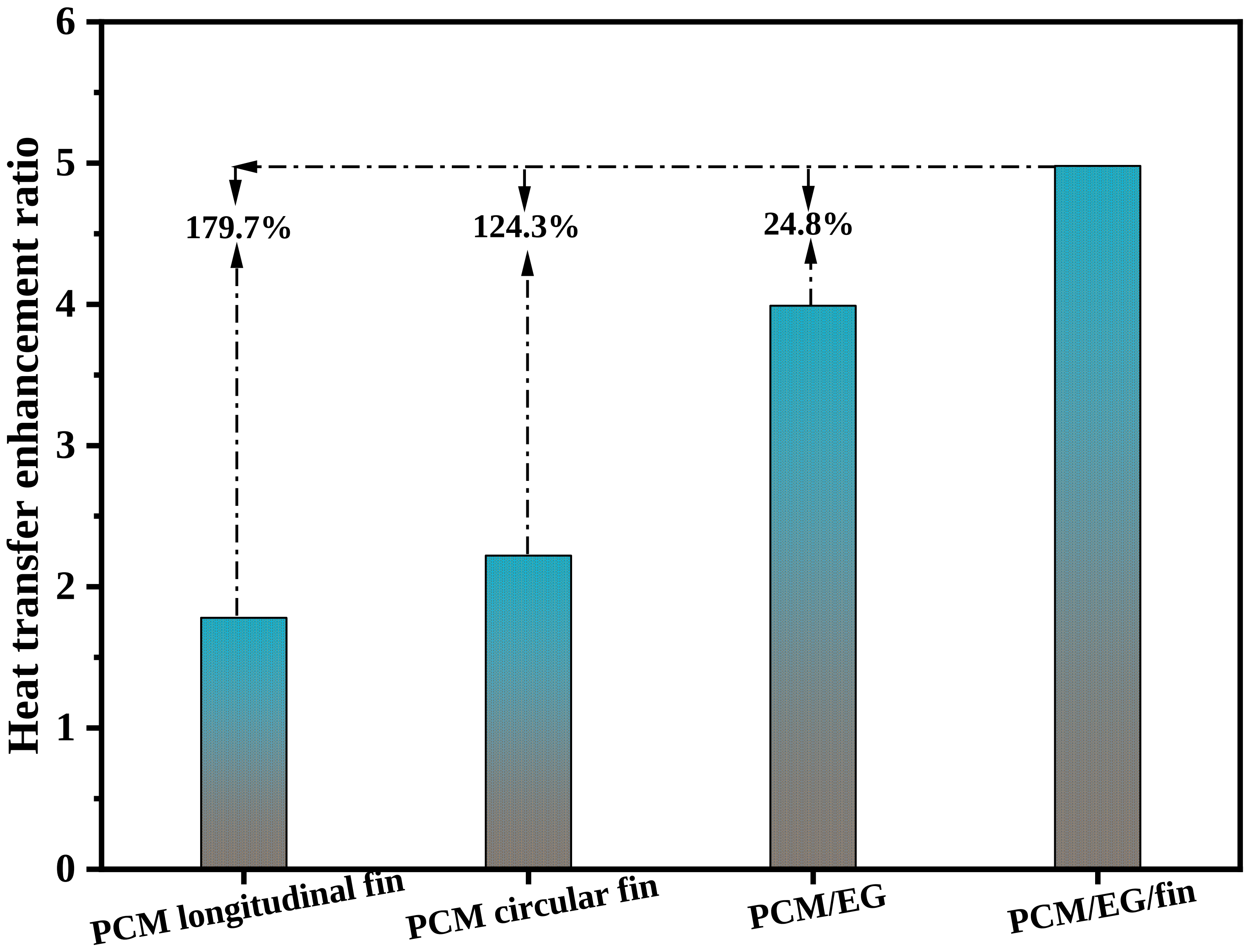
(c) PCM circular fin HX system



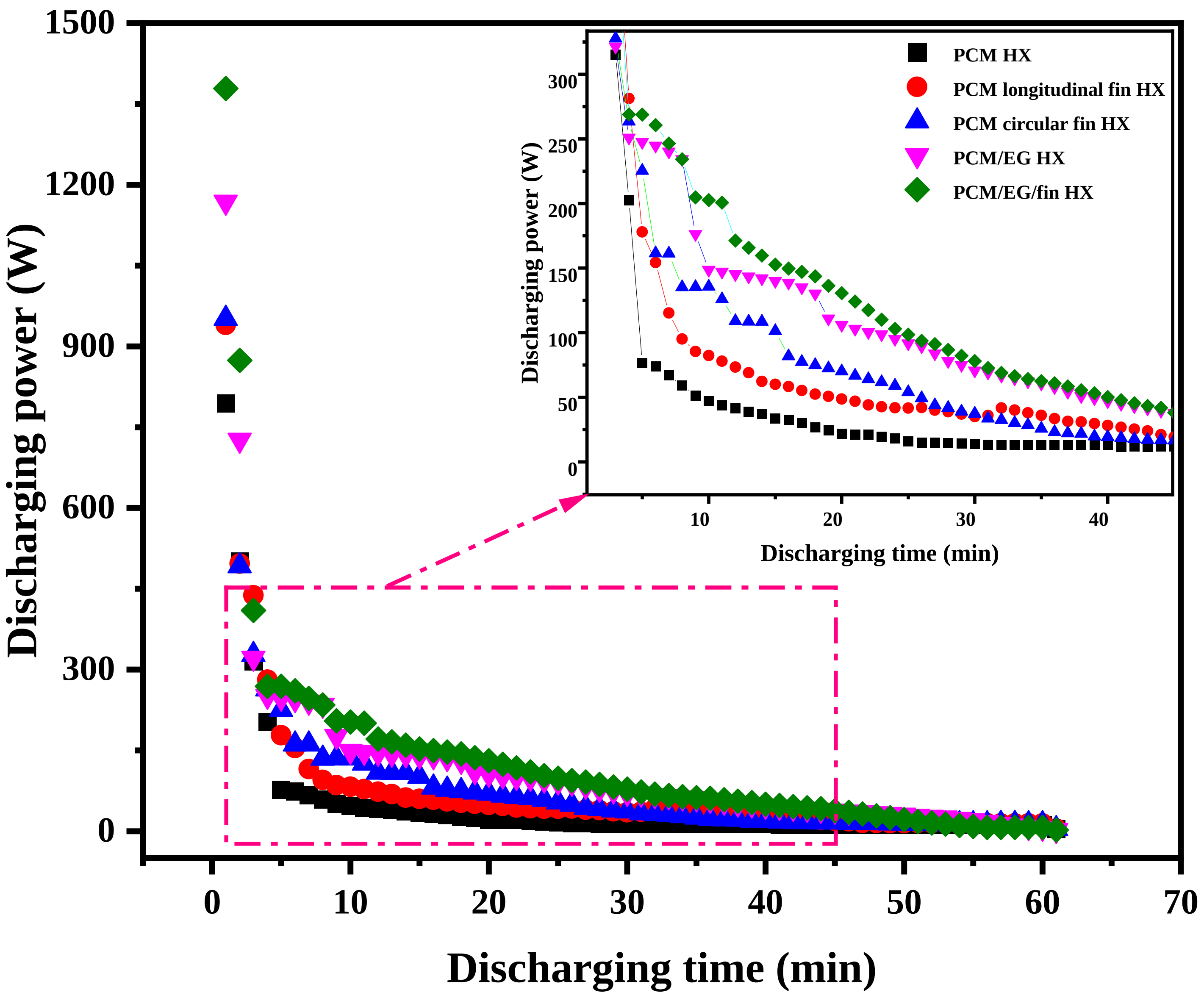
(d) PCM/EG/fin HX system



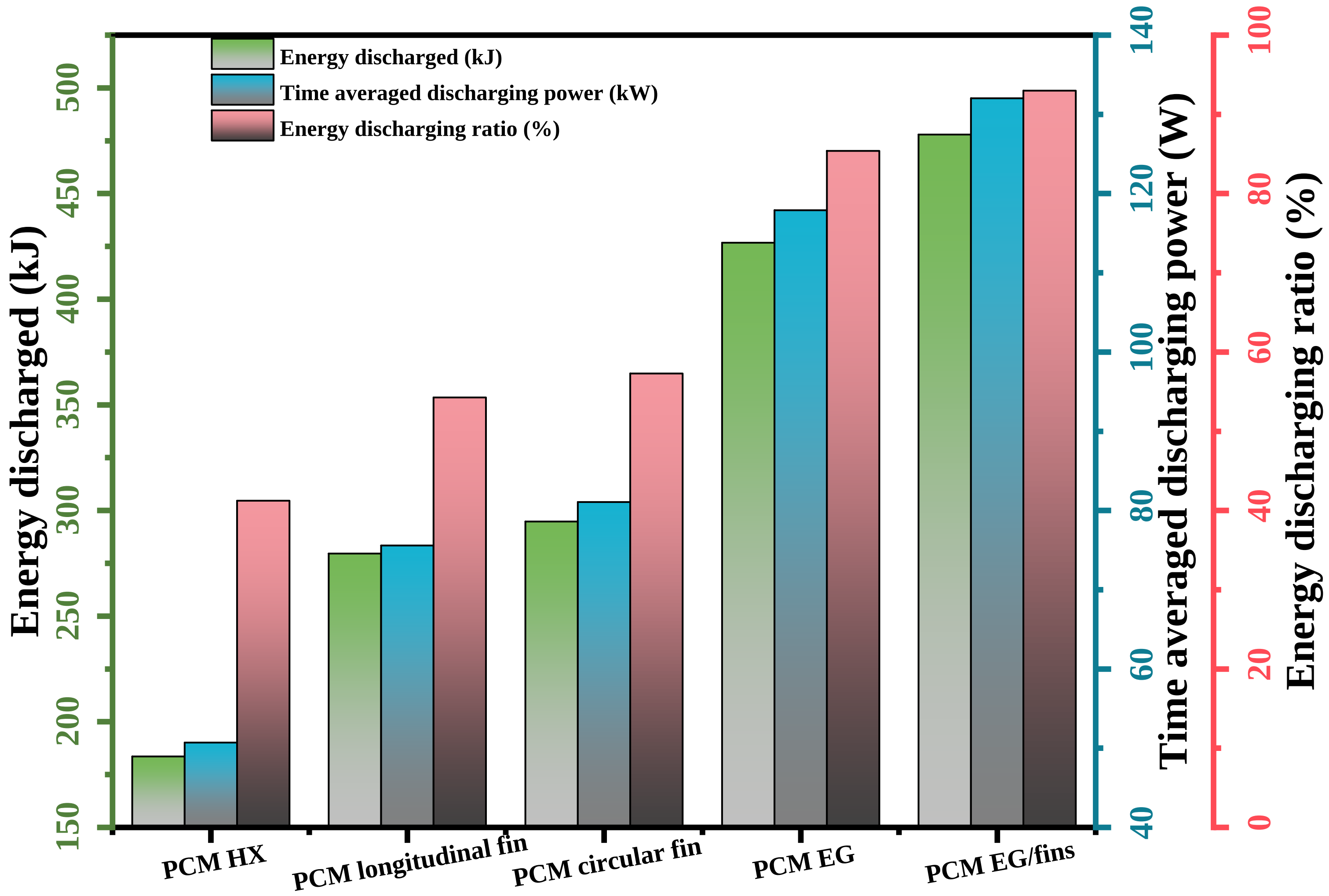
Average PCM temperature during charging with various heat transfer enhancement methods



Comparison of charging heat transfer enhancement of PCM HX with the addition of various heat transfer enhancement methods.



The intensity of thermal energy discharged from the PCM systems every 5 minutes of discharging.



Comparison of the effect of various heat transfer enhancement methods on the discharging performance of PCM TES

Conclusion

- The highly conductive heat transfer network provided by the combination of EG and radial aluminium fins and the multi-pass tube arrangement resulted in uniform temperature variation during charging and discharging
- With an increase in inlet temperature of HTF from 65°C to 80°C, the overall heat transfer rate during the charging process augmented by 2.04 times and the overall charging time was reduced by 51.11% at higher charging temperature of HTF
- Conduction is the major mode of heat transfer during both the charging and discharging period.

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Thank you…!

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