What types of PCM materials are available today?

Ragnhild Sæterli, TES Workshop 12 nov 2021

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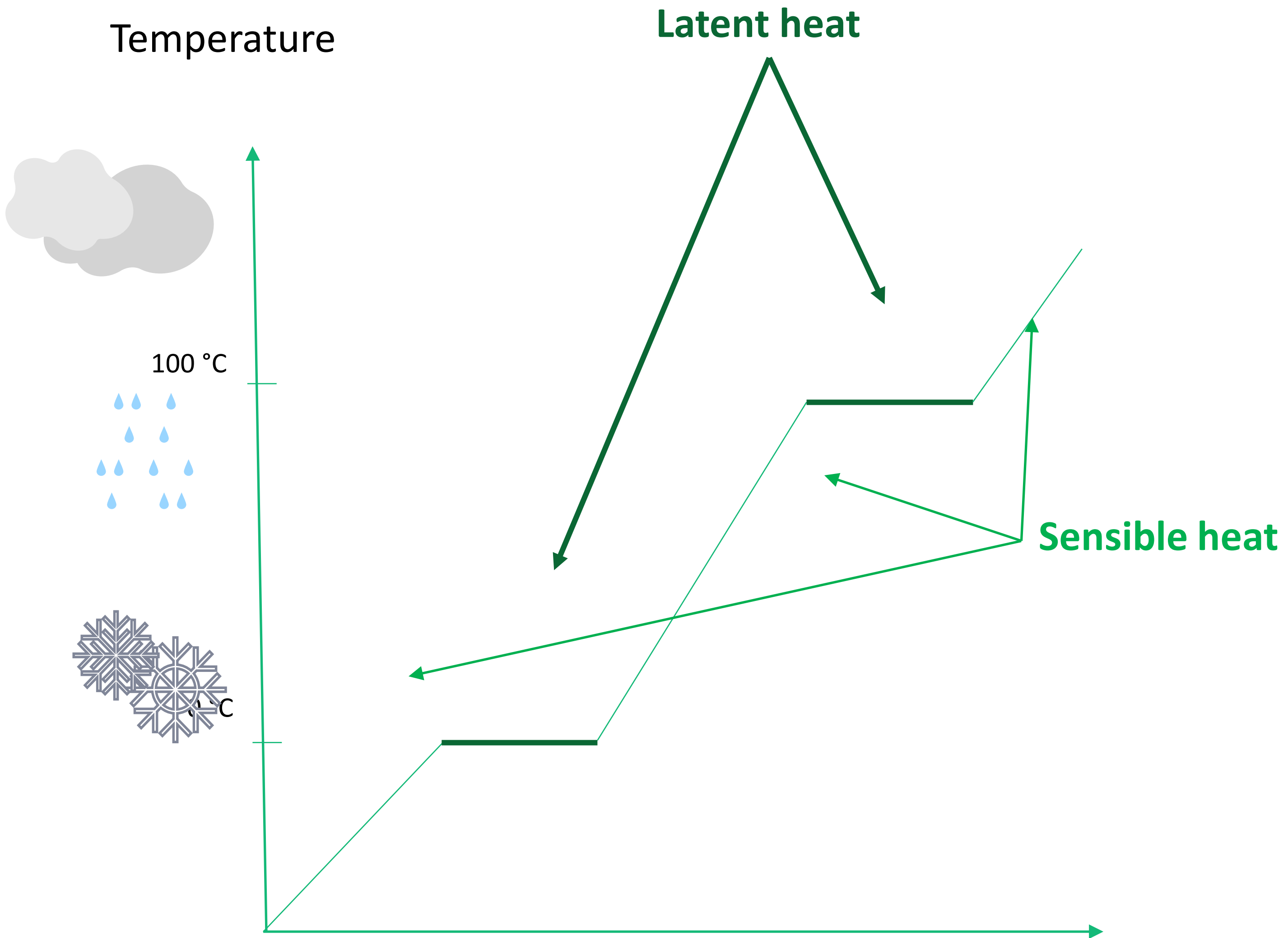
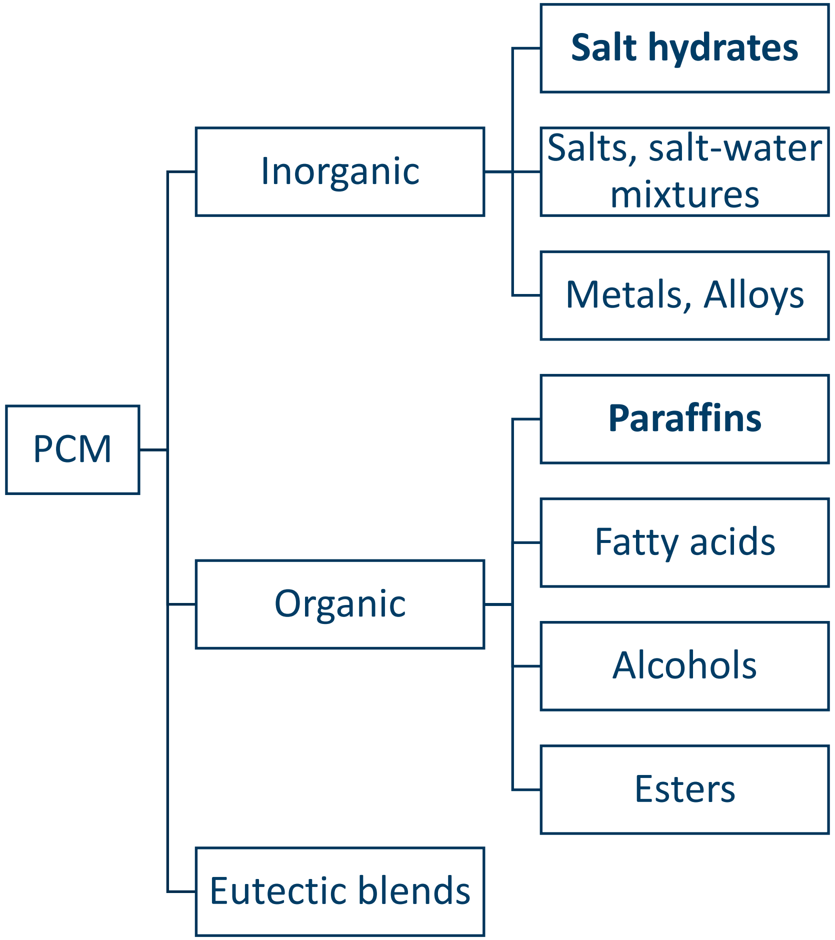
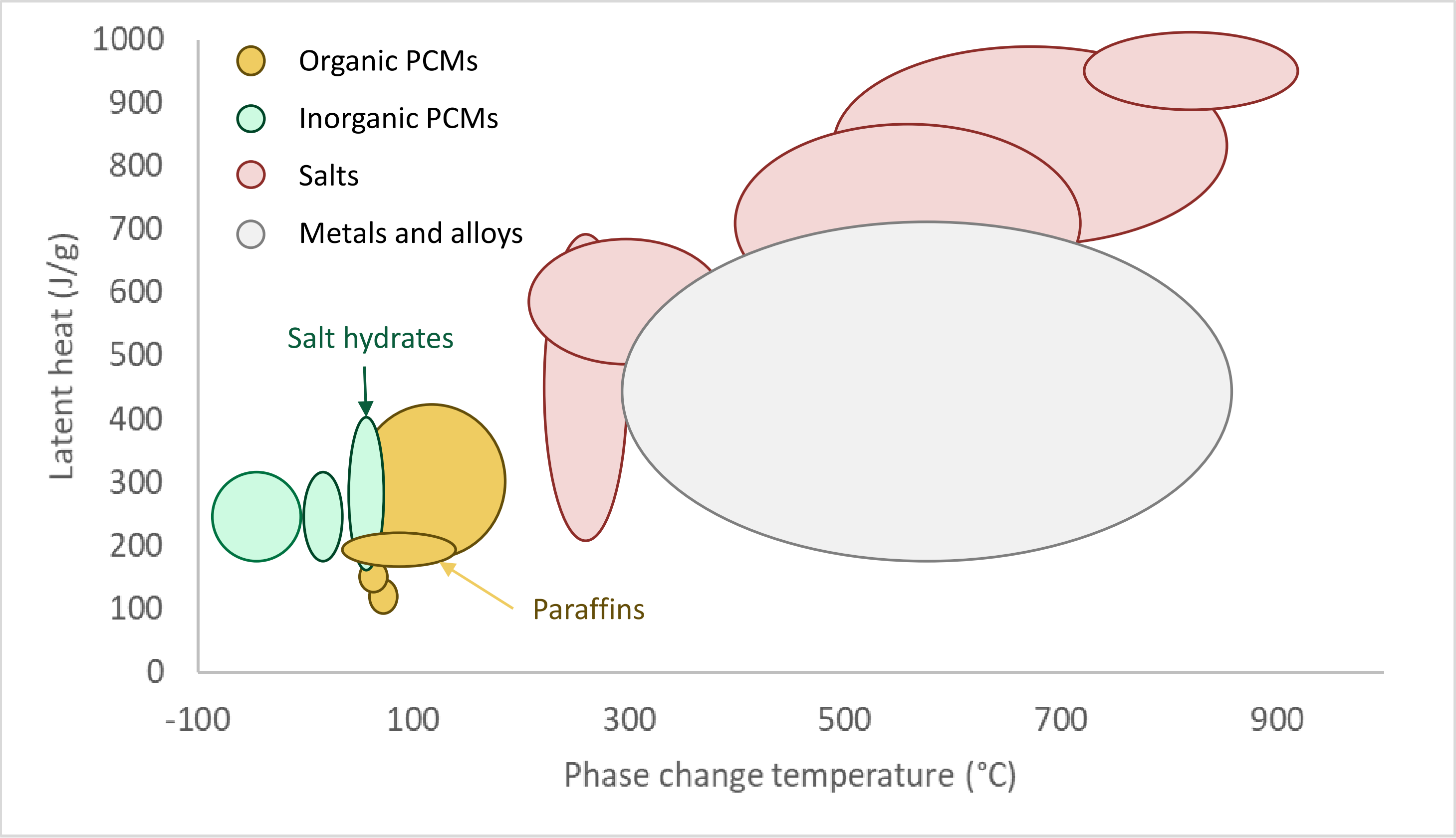
What is a Phase Change Material?



The various types of available PCMs





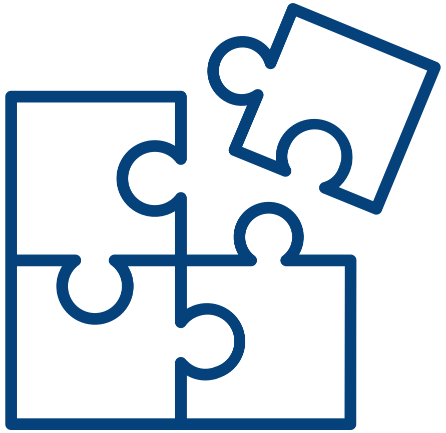
Adapted from Li, G et al., Energy 51 (2013): 1–17 and Murat M. Kenisarin,, Renewable and Sustainable Energy Reviews, Volume 14 (3) 2010, p955

What characterises a good PCM?

- Suitable Phase Change temperature
- High latent heat
- Reversible phase change, high number of cycles

- High thermal conductivity
- No/low supercooling
- Small volume changes
- Suitable operating temperatures

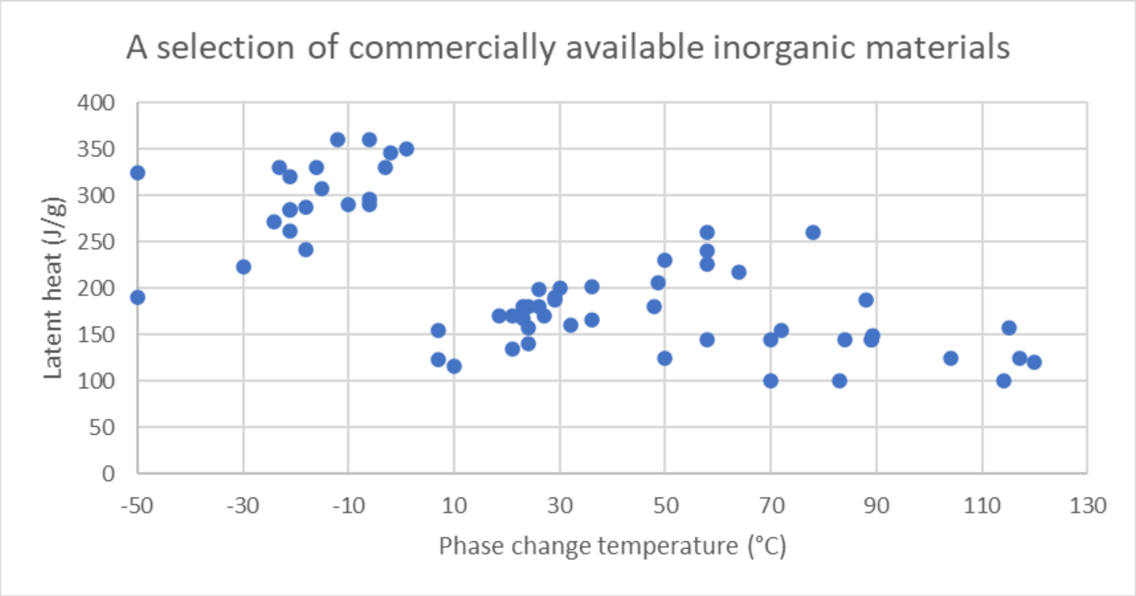
- Corrosiveness, toxicity, flammability, cost, sustainability …



Salt hydrates

+
- Broad phase change range
- Cheap, readily available
- High latent heat
- Reasonable thermal conducticity

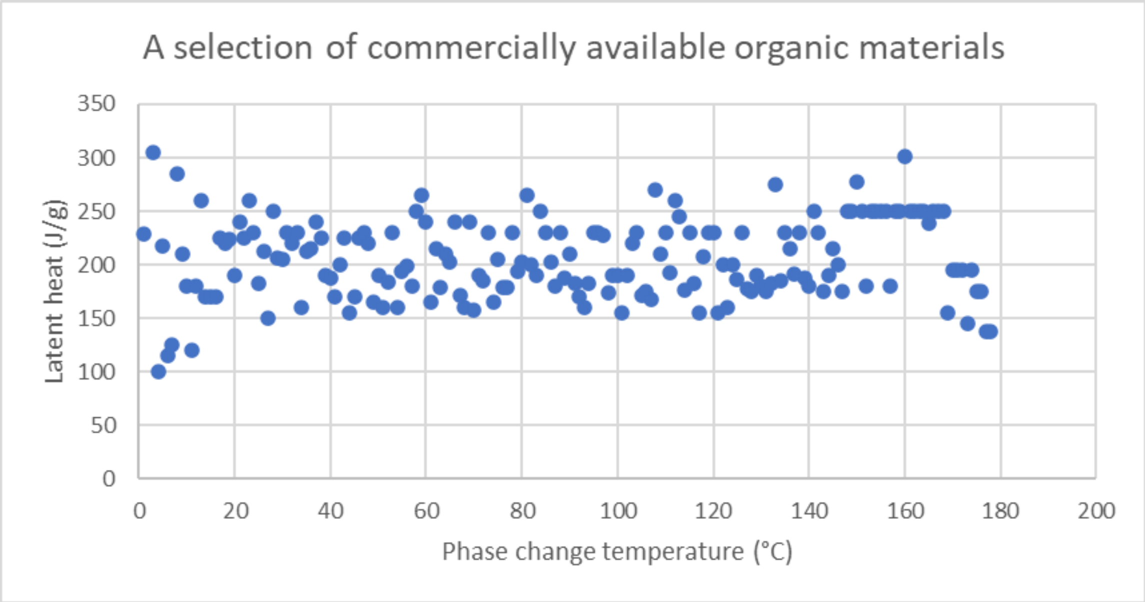
−
- Phase separation issues
- Supercooling
- Possibly corrosive, toxic



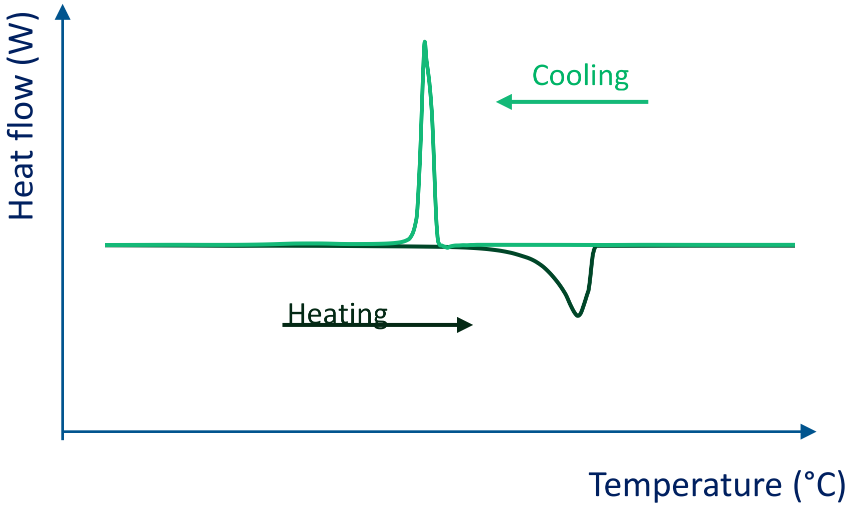
Organic PCMs

+
- Little subcooling
- Not corrosive
- Often non-toxic, can be made from sustainable sources

−
- Lower latent heat
- Low thermal conductivity
- Low degradation temperature



Characterisation of PCMs



	Producer	DSC1	DSC2	Comparable technique: 3LC
Latent heat (J/g) – salt water solution	224	190	170	220
Latent heat (J/g) - Paraffin	229	170	130	180

Calibration of instrument (as always..)

Experimental setup:

- Accuracy in mass (evaporation), thermal contact sample/holder/instrument, influence of heating rate, …

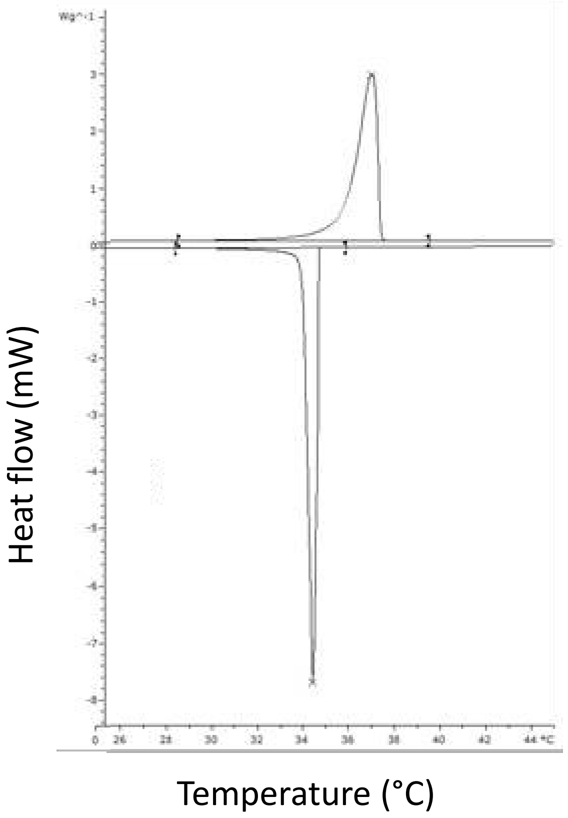
Interpretation of results

- Latent or sensible heat (or both)?
- Multiple peaks, baseline (and other) corrections, …

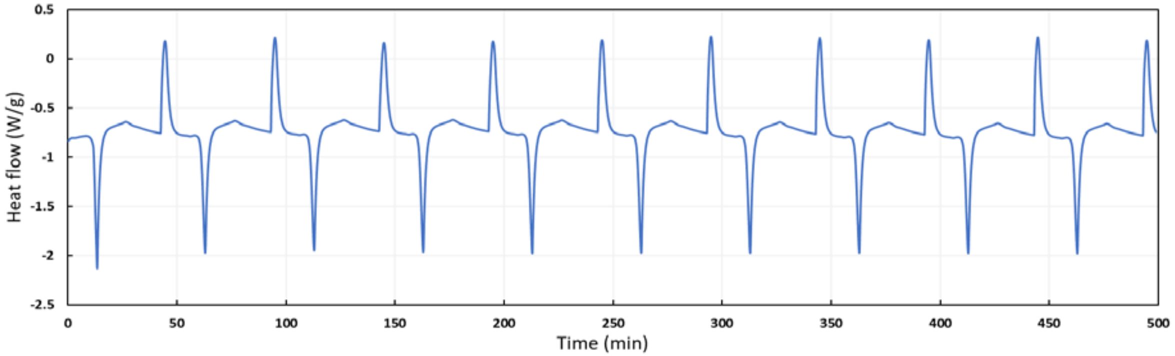
A case study: Bio-based wax

- Crodaterm-37
- Used in ZEB lab heat storage

Differential Scanning Calorimetry (DSC)



10 melting/solid. cycles



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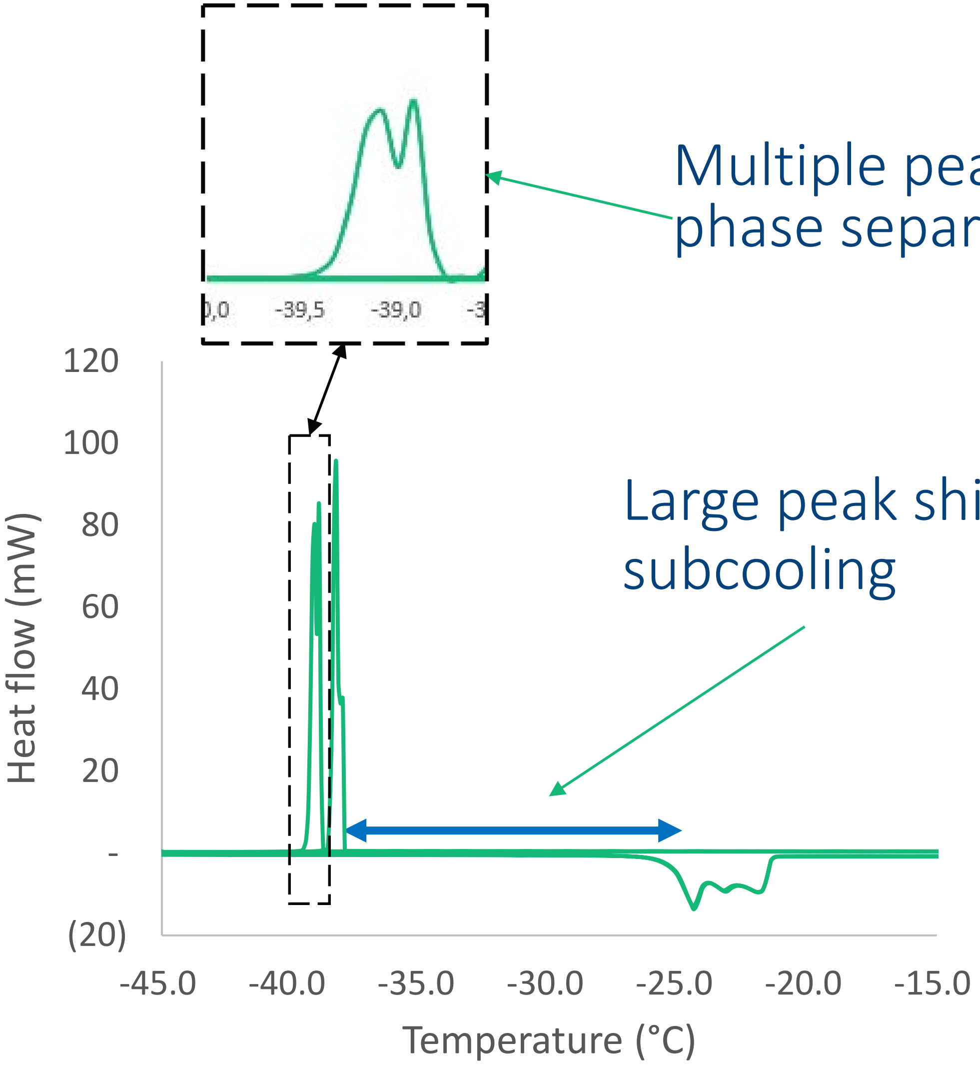
A case study: Salt water solution



Multiple peaks due to phase separation

Large peak shift due to subcooling

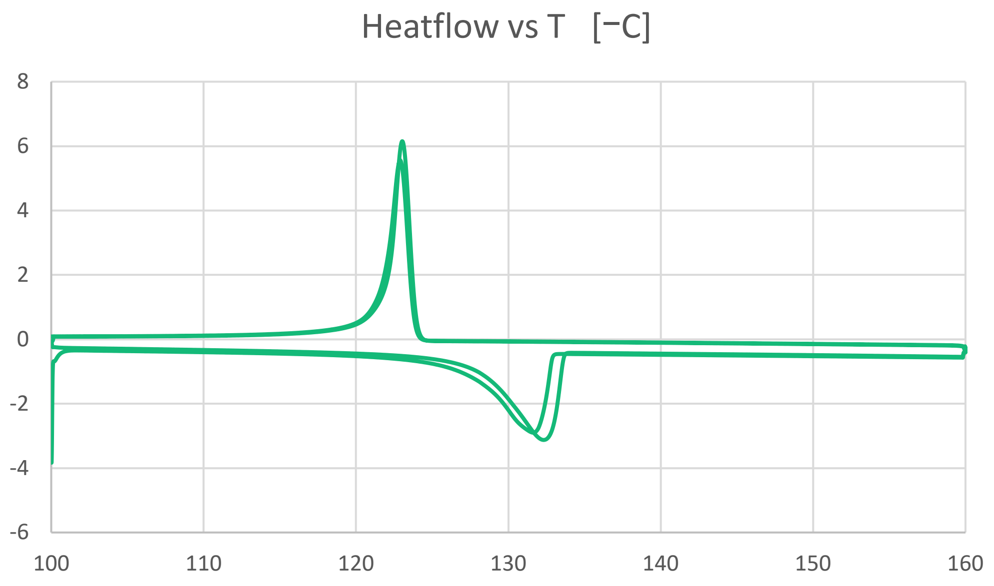
Pluss HS26N

- Melting temperature -26 °C
- Latent heat >250 J/g

Before and after 18 heating/cooling cycles

A case study: HDPE

- High Density PolyEthylene (common polymer)
  - Latent heat >200 J/g
  - Melting temperature ~124 °C



No supercooling, no phase segregation, but

- Oxidation of surface
- Degradation at high temperature

Some current PCM trends

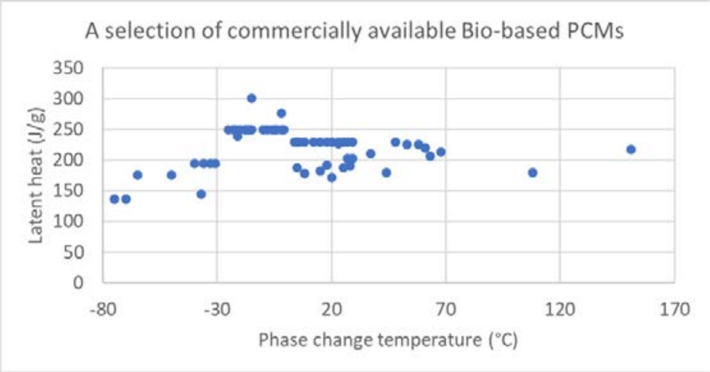
- Macro/micro/nanoencapsulations
  - Buildings, clothing
  - Slurries; increased heat transfer

- Bio-based (sustainable) PCMs

savENRG® Phase Change Material

PureTemp®

CRODATHERM
Bio-Based Phase Change Material



- Form stable PCM composites
  - No liquid phase
  - Higher thermal conductivity
  - For e.g thermal management of batteries

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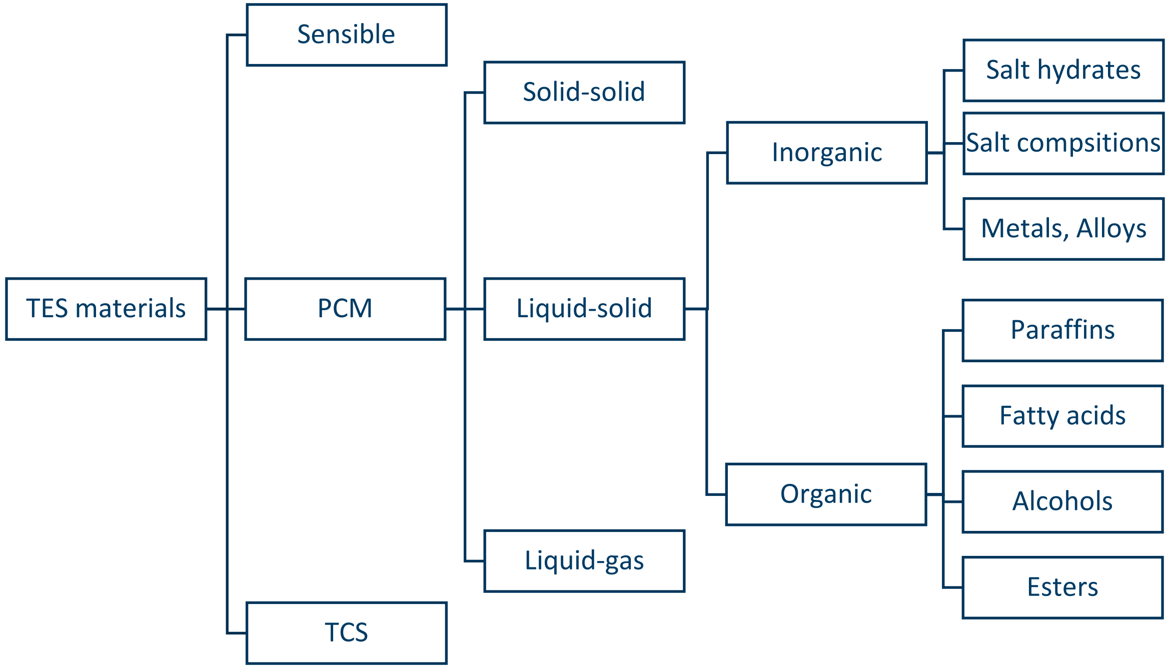
The PCM jungle



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RUBITHERM PHASE CHANGE MATERIAL

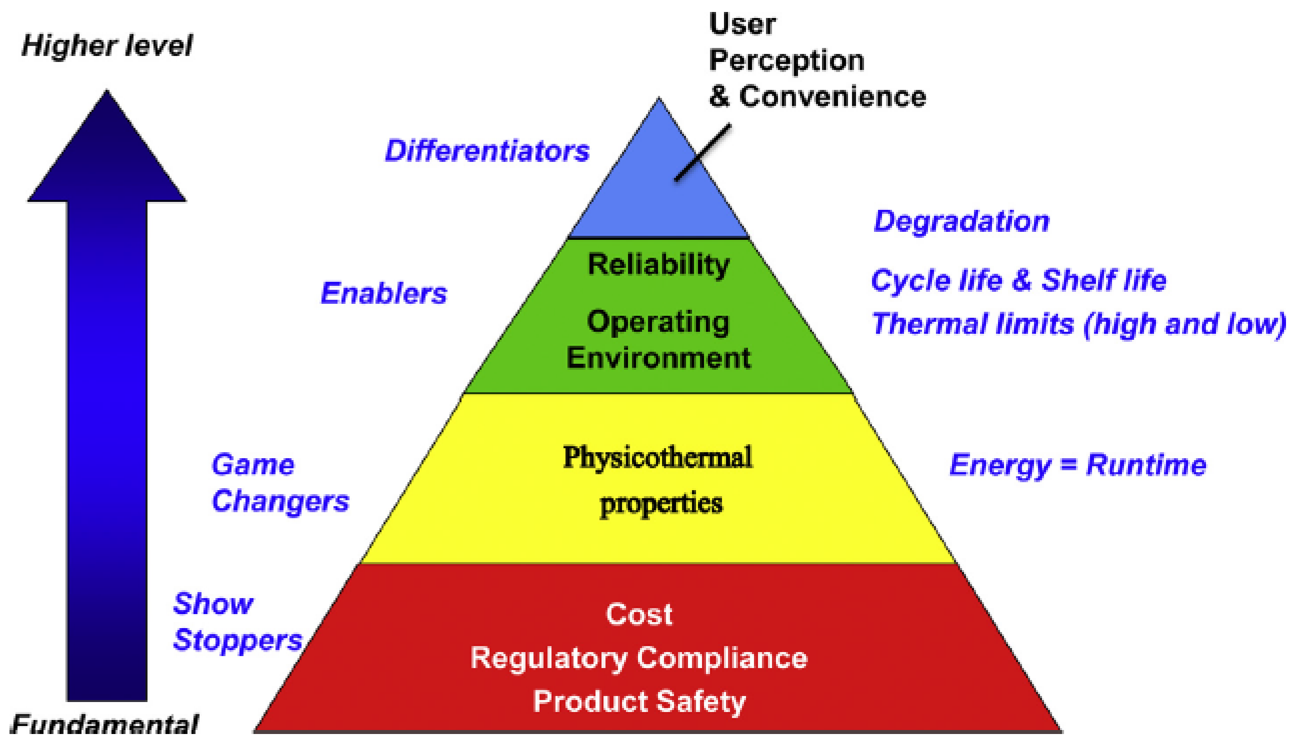
PCM

microtek laboratories, inc.

PureTemp®

savENRG® Phase Change Material

Summary



H. Nazir et al. / International Journal of Heat and Mass Transfer 129 (2019) 491–523

- Lots of options (vendors, type of material)
- Need to consider a number of properties specific for each application

Standardized tests of available materials

Library of tested materials available across PCM projects

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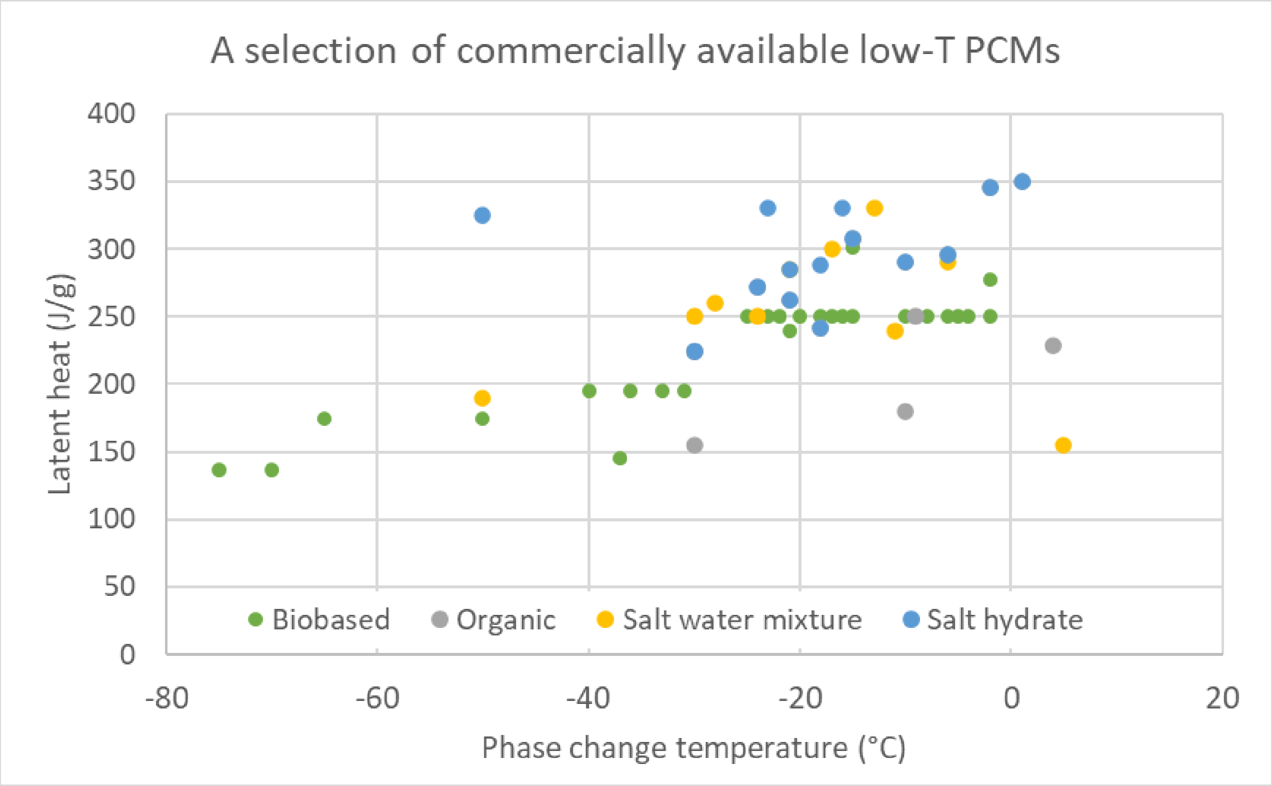
Low-T PCMs:



A selection of commercially available low-T PCMs
Latent heat (J/g)
400
350
300
250
200
150
100
50
0
-80
-60
-40
-20
0
20
Phase change temperature (°C)
Biobased
Organic
Salt water mixture
Salt hydrate

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High-T PCMs: Metals and molten salts

Metals

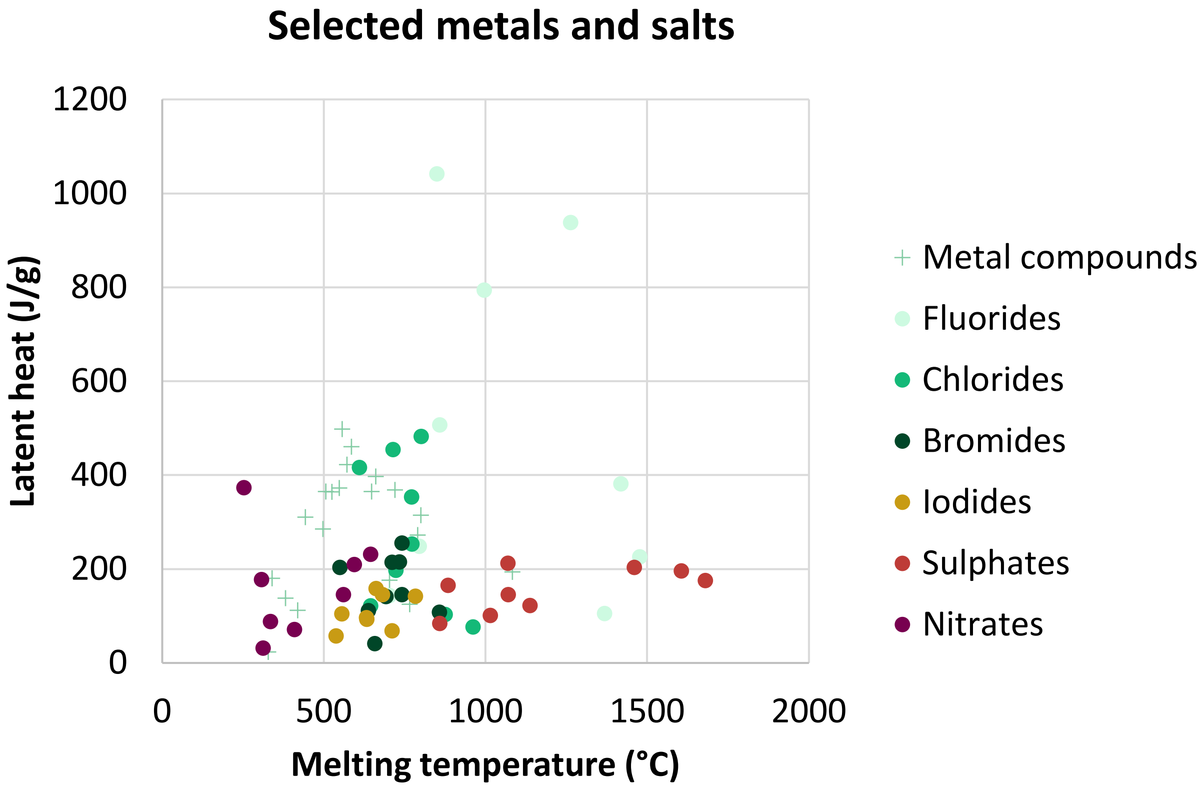
+
- Excellent cyclability
- Excellent heat transfer

−
- Cost
- Weight

Salts

+
- Low cost

−
- Low thermal conductivity
- Corrosive



S A. Mohamed et al., A review on current status and challenges of inorganic phase change materials for thermal energy storage systems, Renewable and Sustainable Energy Reviews, Volume 70, 2017, Pages 1072-1089
Murat M. Kenisarin, High-temperature phase change materials for thermal energy storage, Renewable and Sustainable Energy Reviews, Volume 14, Issue 3, 2010, Pages 955-970,

Phase Change Materials