

Storing Heat in Glazed Constructions: A Review of the Integration of Phase Change Materials to Windows.

Petros Dalavouras

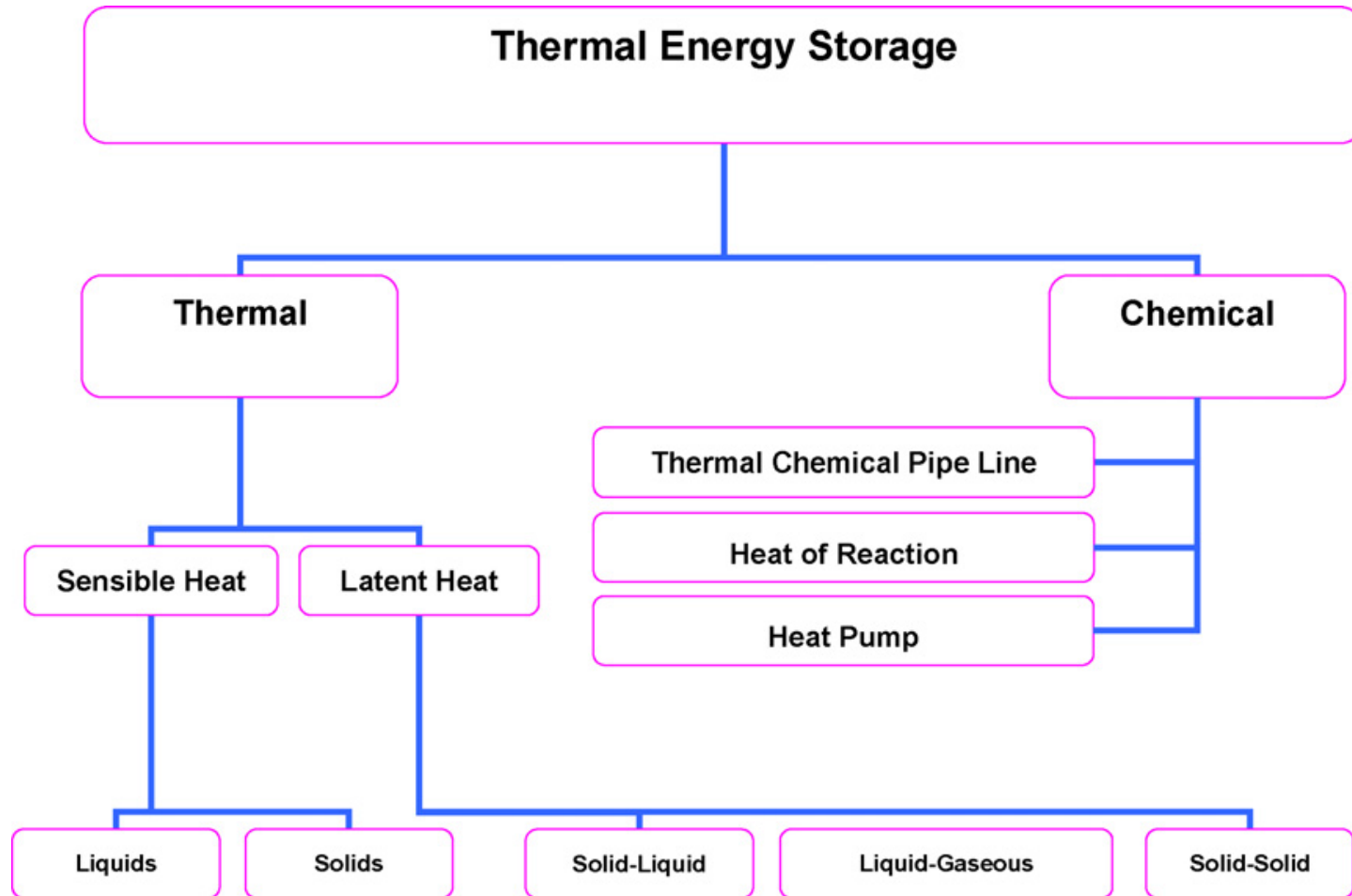
Email: petros@general-refrigeration.gr

Architect Engineer MSc, ASHRAE BEMP
Certified, BREEAM Assessor, NZEB Designer



ΓΕΝΙΚΗ
ΨΥΚΤΙΚΗ
Α.Τ.Ε.Κ.Ε.

ΜΕΛΕΤΗ | ΕΓΚΑΤΑΣΤΑΣΗ | ΣΥΝΤΗΡΗΣΗ



Phase Change solid- liquid

Ice 0°C -> Water 0°C

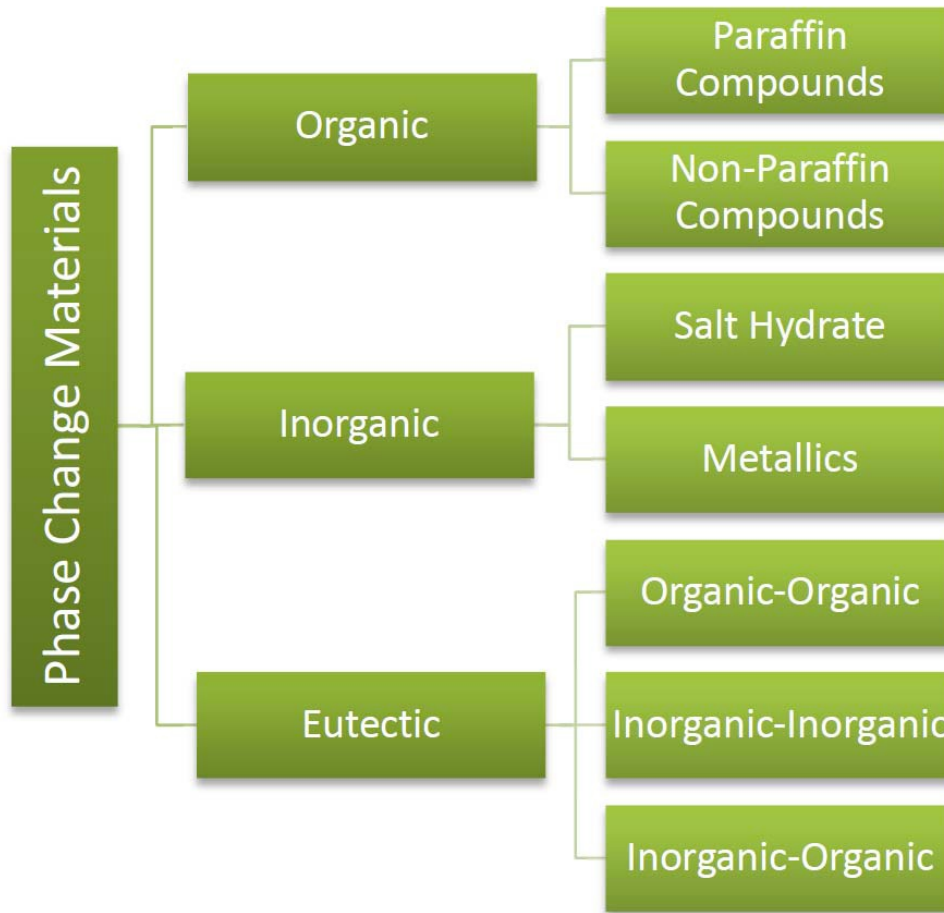
Energy = 333 KJ/kg

Energy

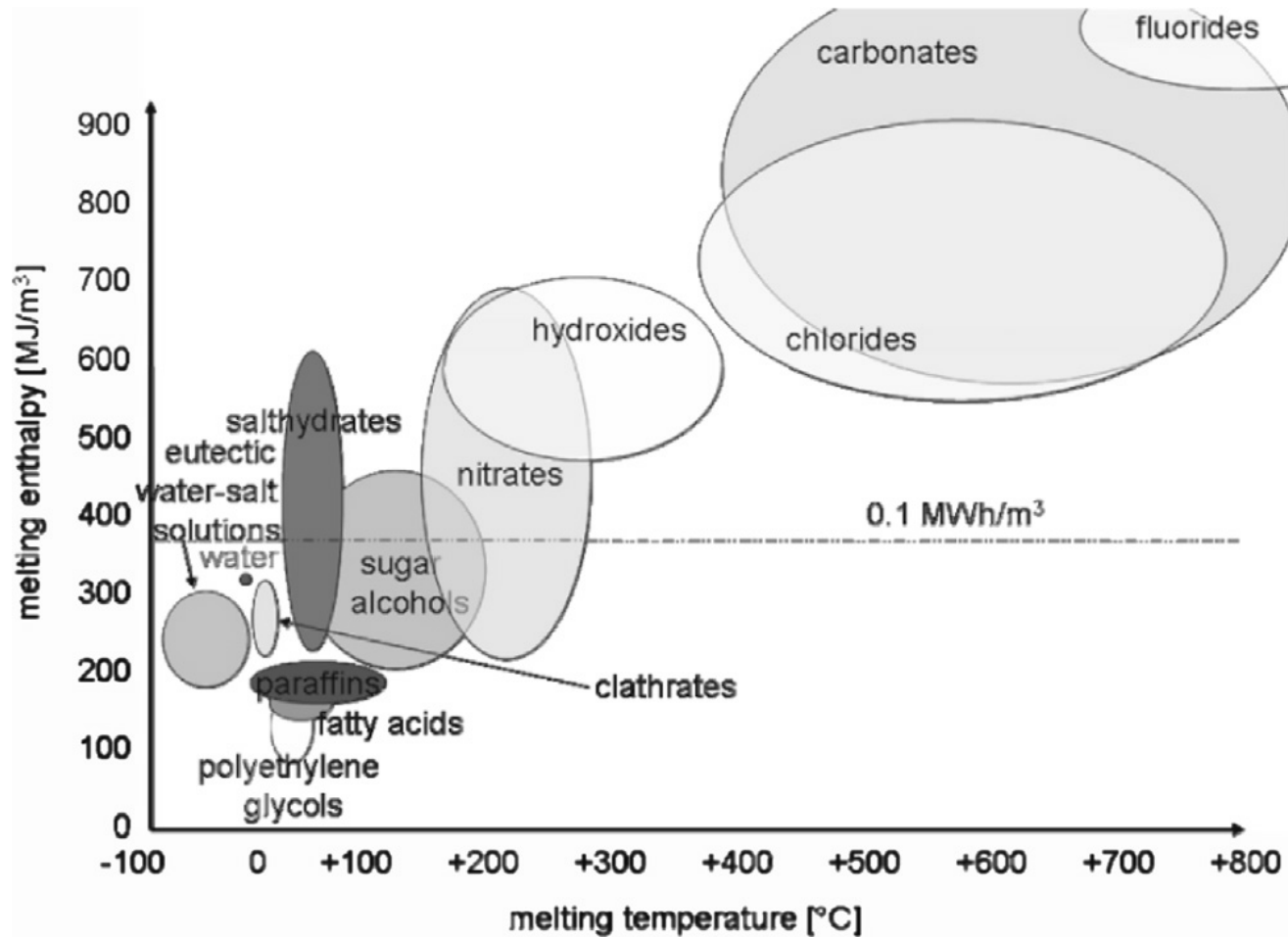
333 KJ/kg = 1 °C -> 80 °C



Classification of PCMs



Classification of PCMs



Source: Solé et al., 2014, p. 3 figure 1

Thermophysical Properties

- Phase transition in the desired operating temperature
- High latent heat of fusion per unit volume
- High specific heat, density and thermal conductivity on both phases
- Negligible volume changes on phase transition and vapor pressure
- Congruent melting of the PCM with each cycle

Kinetic Properties

- High nucleation rate
- High Crystallization rate

Chemical Properties

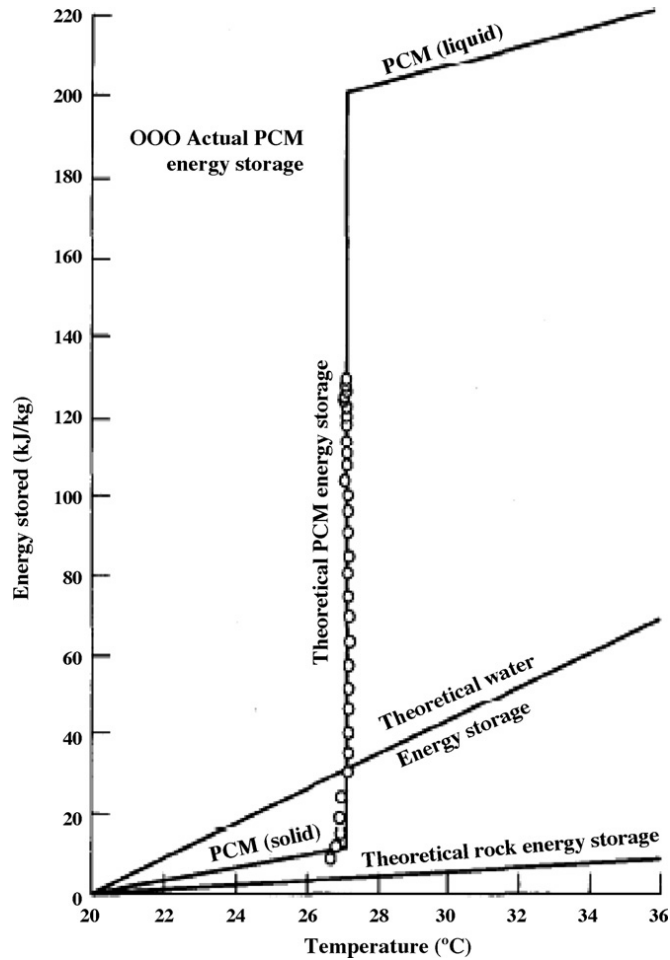
- Chemical stability
- Complete reversible freeze/melt cycle
- Compatibility with construction materials
- Safe

Economics

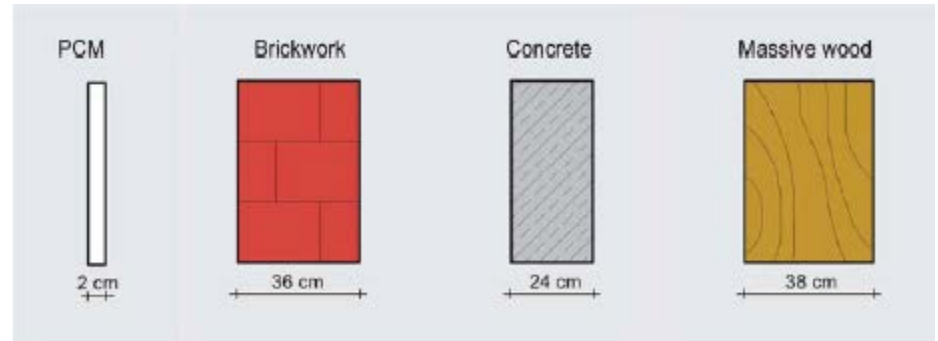
- Low cost
- Large scale availability

		Advantages	Disadvantages
Organic	Paraffins	Safe, predictable, chemically stable, minor volume changes, non-corrosive, reliable	Low thermal conductivity, flammable, compatibility issues with plastic containers
	Non-paraffins	high heat of fusion, inflammability	low flash points, low thermal conductivity
Inorganic	Salt Hydrates	high thermal conductivity, high latent heat of fusion, negligible volume changes, non-flammable	poor nucleating properties , corrosive, phase separation
	Metallics	high heat of fusion per unit volume, high thermal conductivity, low vapor pressure	weight, large supercooling effect, low specific heat

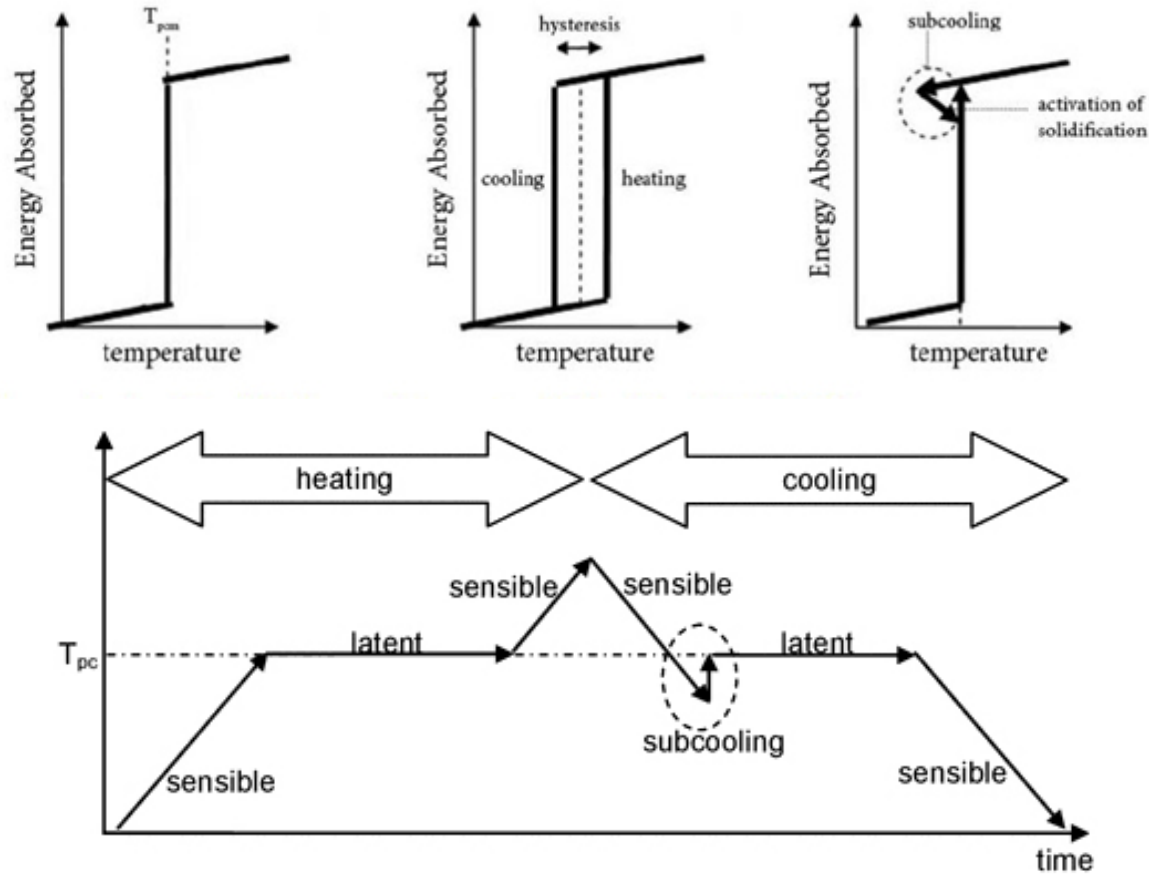
PCM Comparison



Source: Sharma et al., 2007

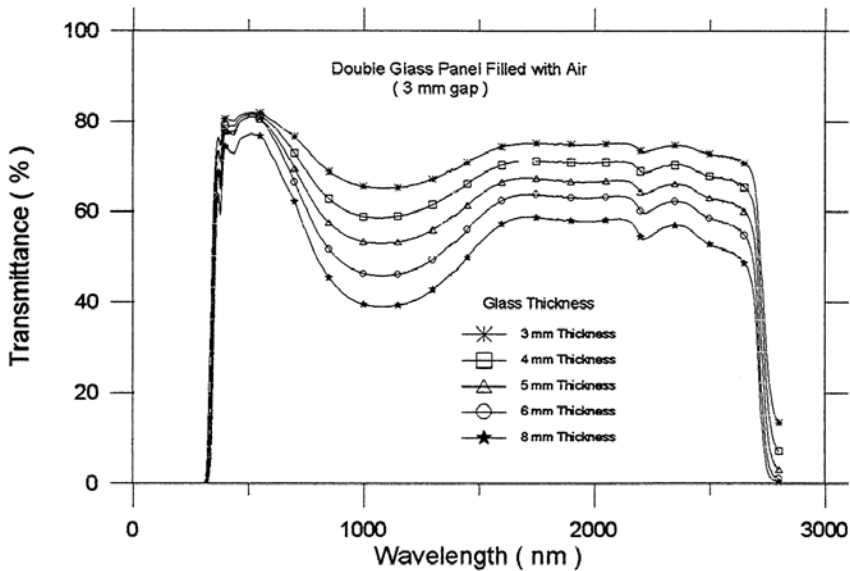


Operation of PCM

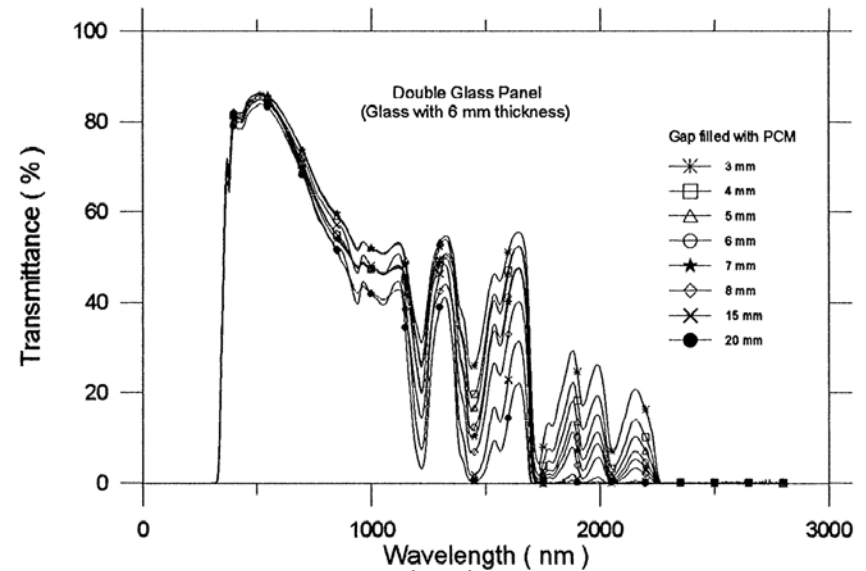


Source: Mehling and Cabeza, 2008.

Optical Properties

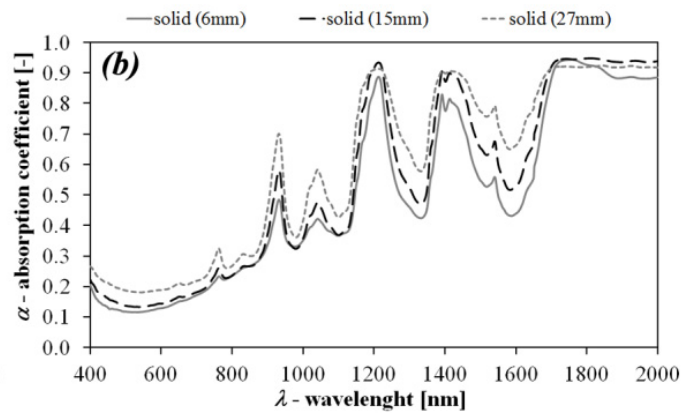
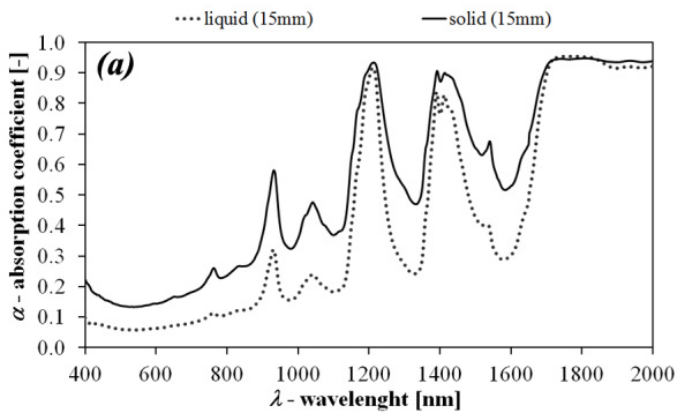
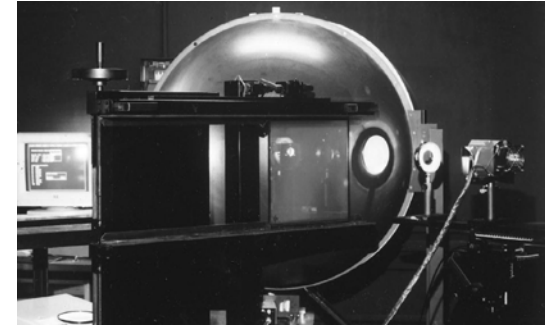
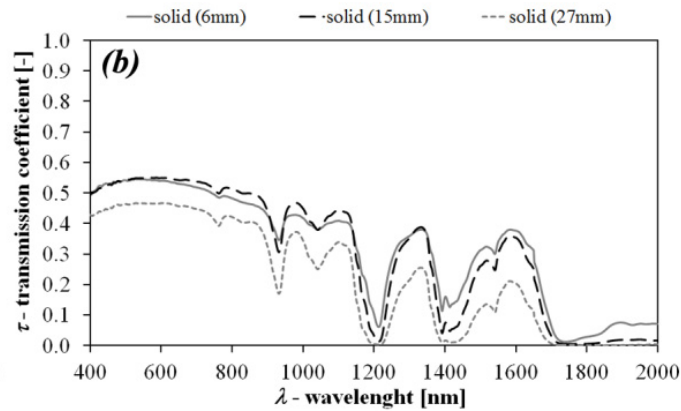
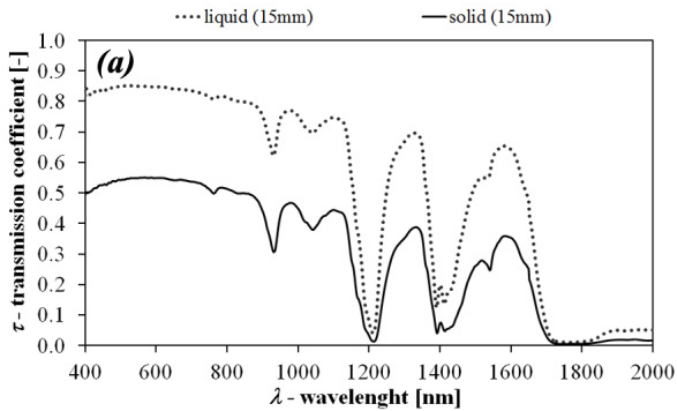


Source: Ismail and Henriquez. 1997.



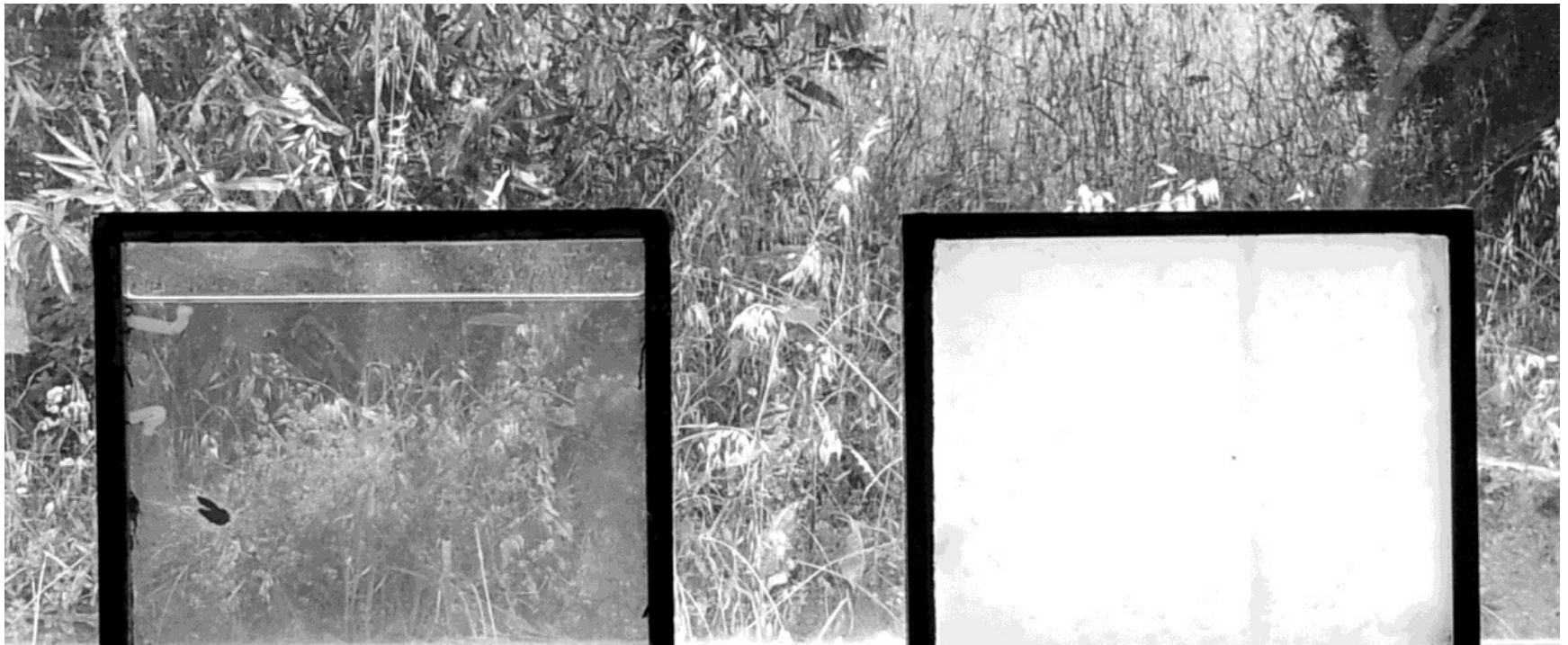
Source: Ismail and Henriquez. 1997.

Optical Properties



Source: Goia et al., 2012, p.431 figure 1

Optical Properties



Source: Goia et al., 2012, p.431 figure 1

Optical Properties



Freezing process of a
Paraffin Wax

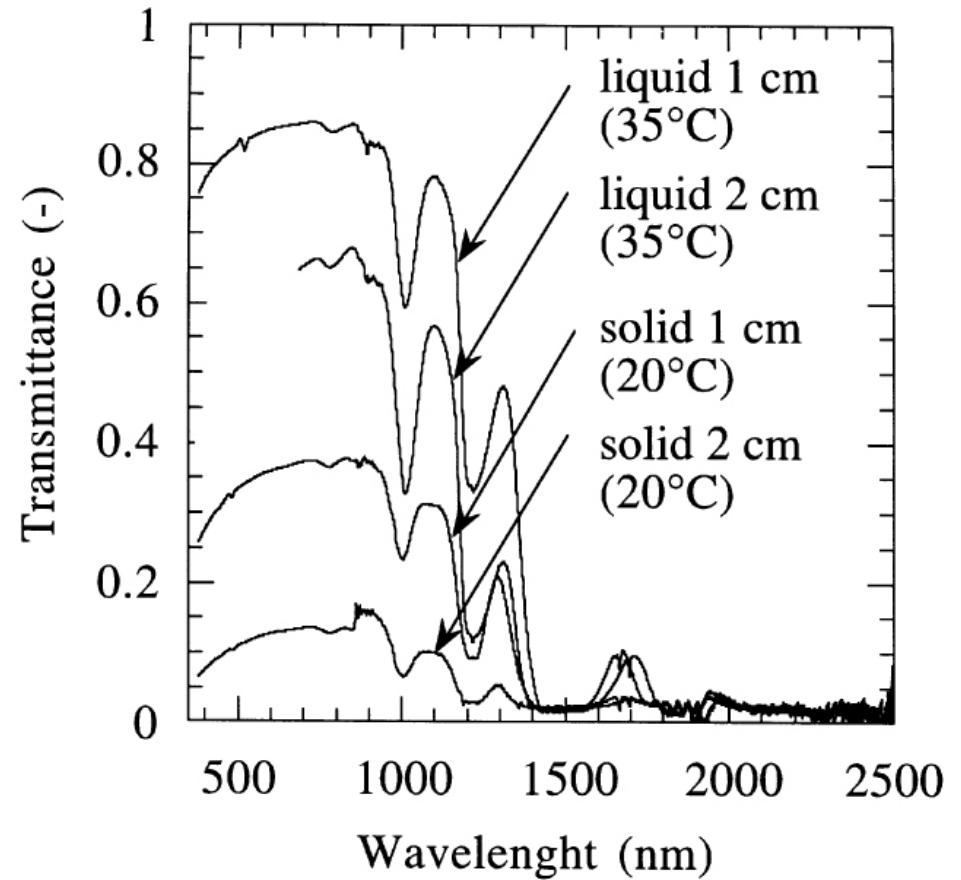


Freezing process of a
Salt Hydrate

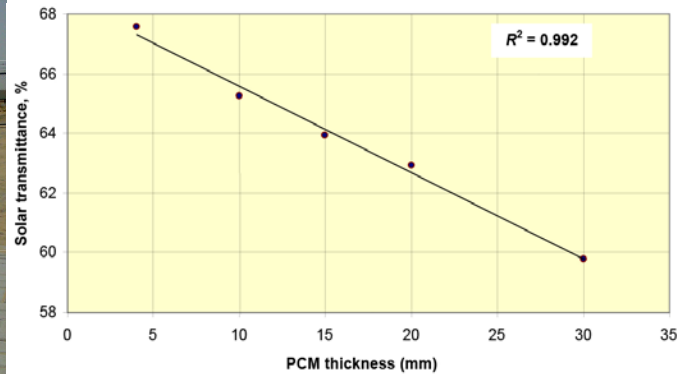
Experiments



Source: Manz et al., 1997



Experiments



Transmittance of PCM Alone.

PCM thickness (mm)	4	10	15	20	30
PCM alone transmittance (%)	90.7	87.5	85.7	84.4	80.3

Comparison of Solar Transmittance of PCM with Water and Air.

Material	Transmittance @15 mm
PCM	63.9
Water	60.4
Air	74.6

Source: Jain and Sharma. 2009

Benefits

- Daylight elements
- Absorb infrared radiation
- Equalize heat balance
- Isothermal phase change
- Increased heat storage
- Alleviated peak temperatures

Petros Dalavouras

Email: petros@general-refrigeration.gr

