TEL AVIV UNIVERSITY
FACULTY OF ENGINEERING
אוניברסיטת תל-אביב
הפאקולטה להנדסה

SOLAR ENERGY STORAGE IN PCM FOR DOMESTIC WATER SYSTEMS

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Why energy storage is needed?

- To bridge between the time of accumulation and the time of demand.

Possibilities:

- Sensible thermal storage.
- Latent thermal storage:

Advantages of latent heat over sensible heat:

- Higher volumetric heat storage
- Store more energy at lower temperatures.
- Better solar collection efficiency
- Reduced losses to the environment

What is PCM?

- PCM= Phase Changing Material:

  Materials that undergo a phase change at specific temperatures.

  From solid → liquid.

  From liquid → gas.

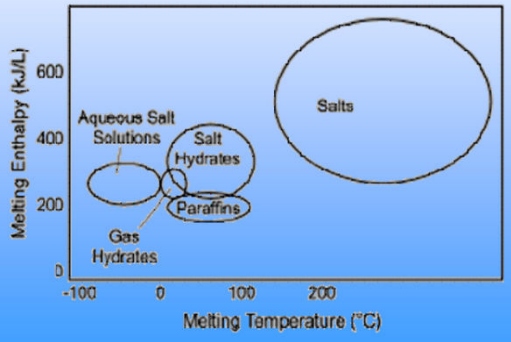
Granulate

Compound

Powder

Types of PCM's

- Gas-hydrates
- Salt-hydrates
- Paraffin's
- Salts



Research objective

- Evaluate the contribution of PCM plates to the storage capacity of domestic water systems (DWS), both experimentally and numerically (code development and calibration).

Reasons for the use of PCM in DWS

- Faster heat accumulation
- PCM reduces the water-tank physical size.
- Improves the collector efficiency
- Enhances the attractiveness of Solar heating systems worldwide.

PCM chosen: Material properties

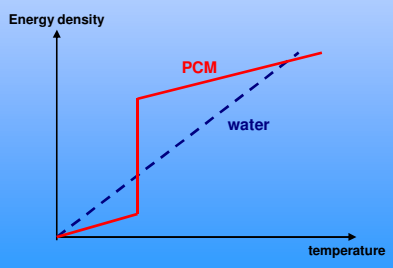
RUBITHERM® RT 55

RUBITHERM PHASE CHANGE MATERIAL

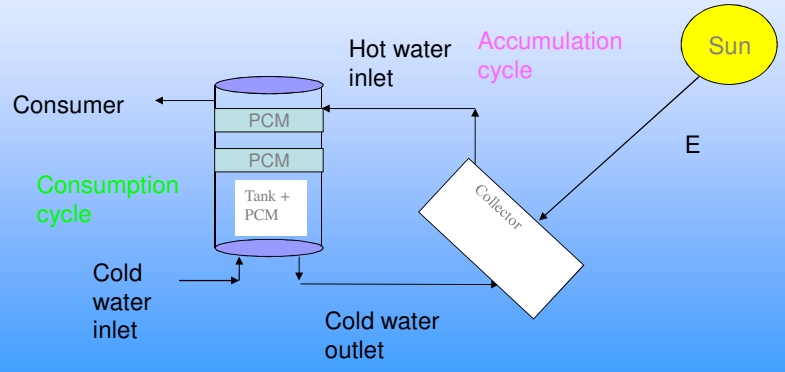
		Typical Values
Melting area	°C	51 - 57 typical being: 55 °C
Congealing area	°C	56 - 51 typical being: 55 °C
Heat storage capacity temperature range 48 °C to 63 °C	kJ/kg	172
Density solid at 15 °C	kg/l	0.88
Density liquid at 80 °C	kg/l	0.77
Volume expansion In phase change range	%	14
Heat conductivity	W/(m*K)	0.2
Kin. Viscosity at 85 °C	mm²/s	34.08
Flash point (PCM)	°C	> 100

Heat Storage Capacity

- For each PCM plates inserted, about 1 liter of water is removed.
- PCM storage capacity versus water.



How does the system work?



Energy balance equations for the numerical model:

- The model accounts for:

Convection, conduction and solar irradiation.

$$(m \cdot Cp \cdot T)_{i-1}^{t+\Delta t}$$

PCM / Water $(m \cdot Cp \cdot T)_i^t$

$$m \cdot c \frac{T_i^{j+1} - T_i^j}{\Delta t} + \dot{m} \cdot c \frac{T_i - T_{i+1}}{\Delta x} =$$

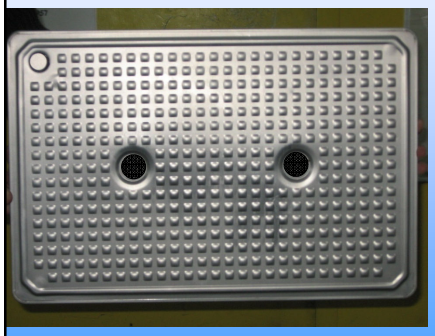
$$A \cdot k \left[\left(\frac{T_{i+1} - T_i}{\Delta x} \right) + \left(\frac{T_{i-1} - T_i}{\Delta x} \right) \right] - U \cdot A_p (T_i - T_\infty)$$

PCM / Water $(m \cdot Cp \cdot T)_i^{t+\Delta t}$

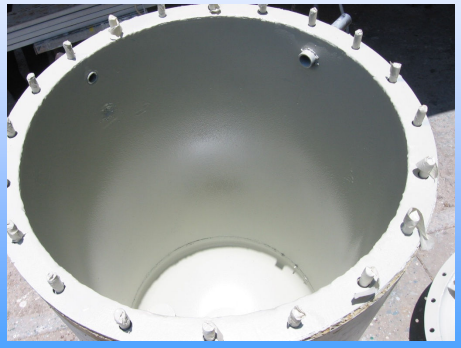
$$(m \cdot Cp \cdot T)_{i+1}^{t+\Delta}$$

PCM plate and tank

- PCM plate



- Water tank – Flange

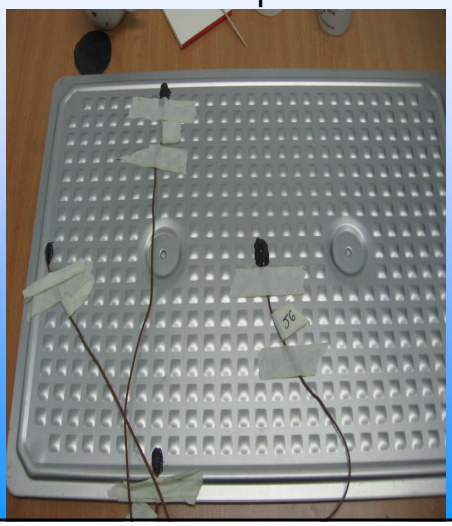


PCM assembly technique

- Top dome

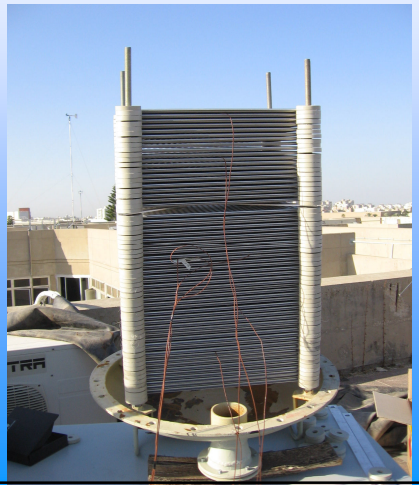
- Thermocouple ports

- PCM - Thermocouples



- Spacers (Polypropylene)

- The PCM assembly

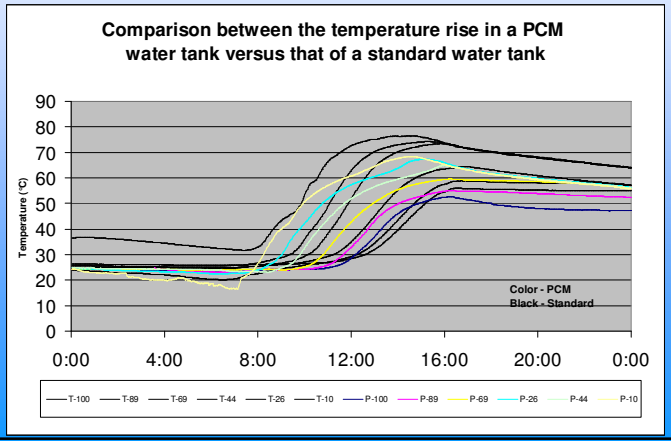


- Assembly insertion

300 liters water tank with two collectors

Experimental Results

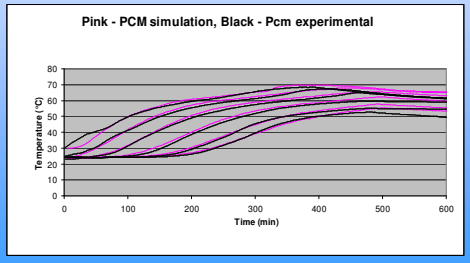
- Faster initial temperature rise.
- Lower maximal temperature (reduced losses)
- Lowest layer temperature decreases fast owing to low sensible heat capacity.



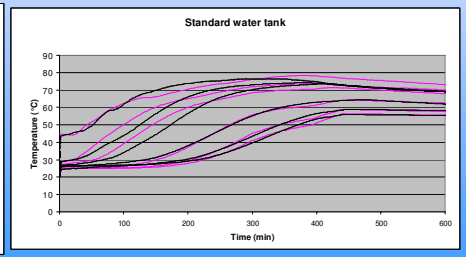
Results

Comparison of the temperature rise in standard water tank to that of a tank containing PCM plates.

The calibrated model allows analyses of different assemblies.

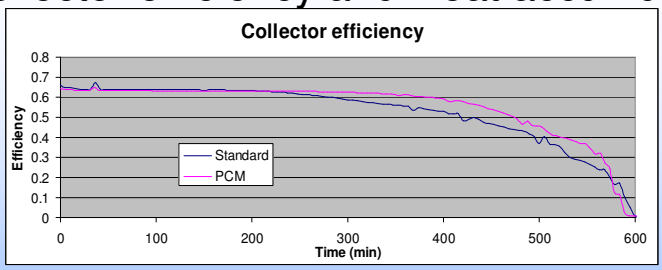


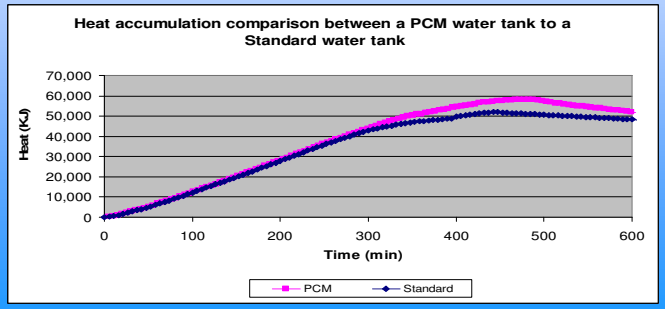
Water tank with PCM plates



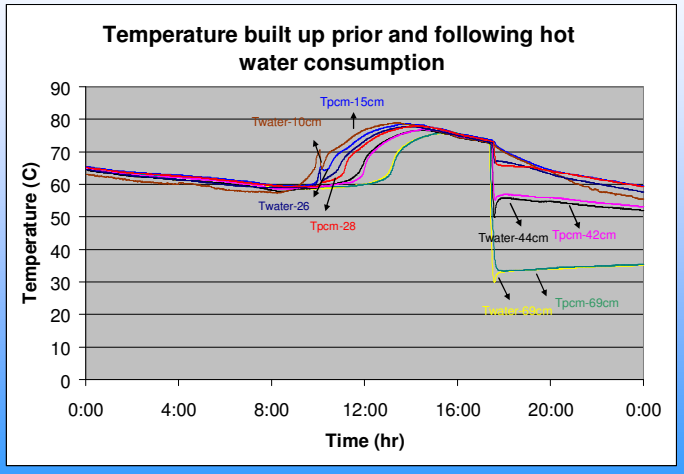
Standard water tank

Collector efficiency and Heat accumulation



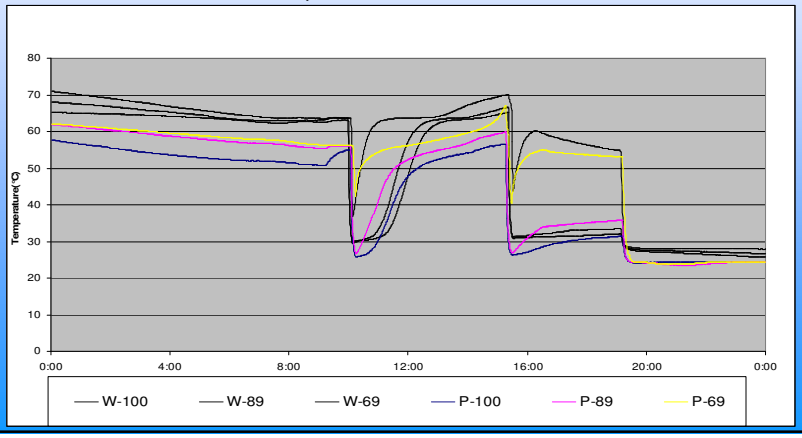


PCM water tank consumption results



PCM DWS and DWS

- Temperature rise is faster following consecutive hot water consumptions (allowing shorter intervals between consecutive showers).



Conclusions

- The use of PCM in DWS becomes substantially advantageous after 3 to 4 hours of heat accumulation.
- The tested PCM water tank can accumulate up to 16% more heat than a standard water tank.
- The response time of a PCM tank is shorter than that of a standard tank.
- The numerical code calibration revealed an overall heat transfer coefficient of 1.2W/$m^{2\circ}$c.

Thank you for listening

Questions?