Ministry of Education and Science of the
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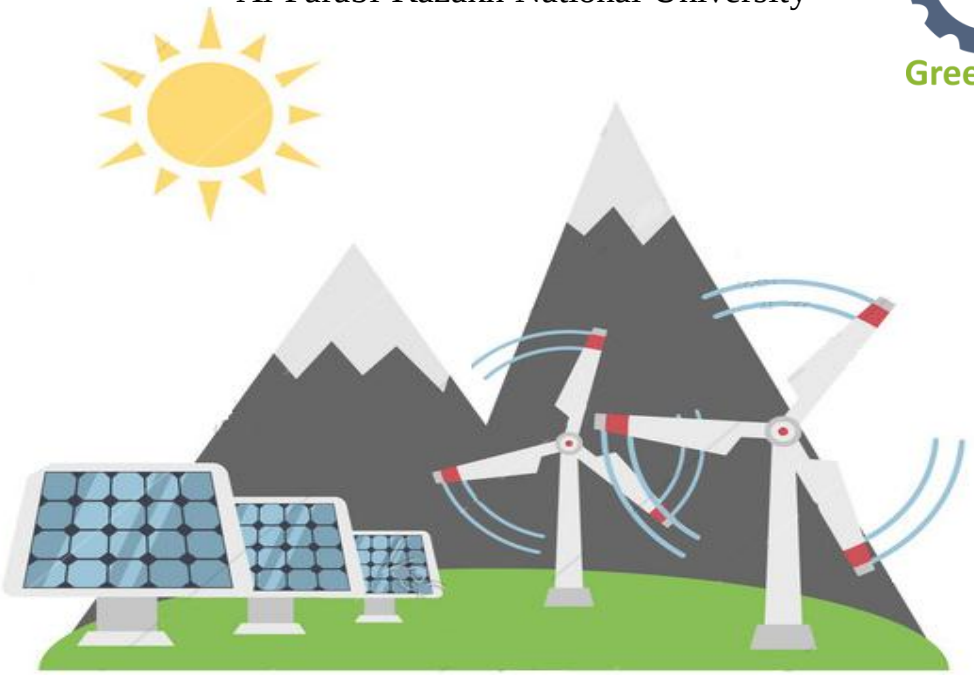

Study of the efficiency of thermal energy storage in various types of short – term thermal energy storages

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Supervisor : Tungatarova M.S.

Relevance of the project: the short-term TES performing diurnal heat regulation (for example, based on peak-valley electricity rates) has a higher operation applicability and deployment flexibility, and therefore received increasing attention in recent years. The higher efficiency would lead to energy conservation and improve cost effectiveness. This work will help to study the efficiency of energy storage in safer thermal accumulators.

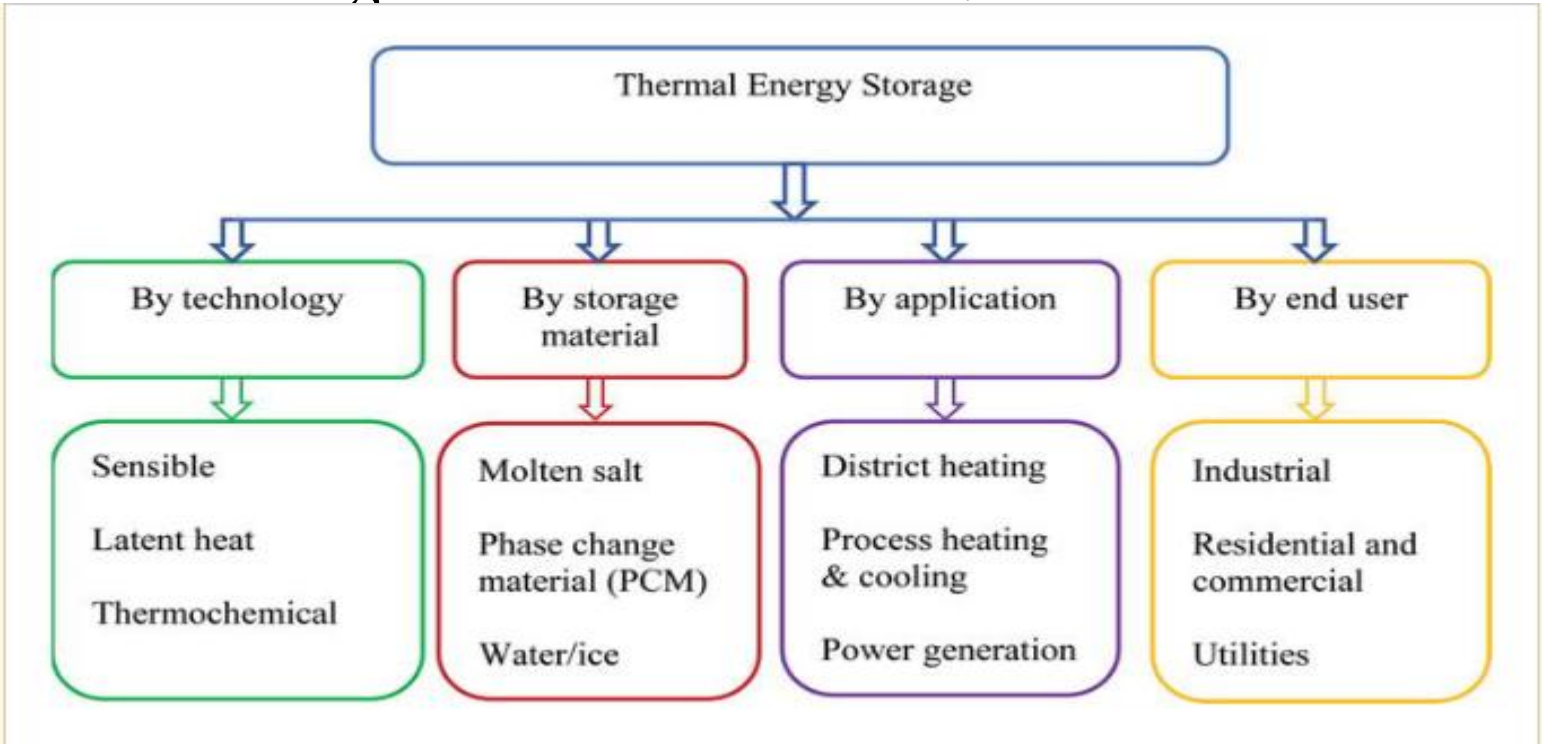
Purpose of the work: to study of the efficiency of thermal energy storage in various types of short – term thermal energy storages.

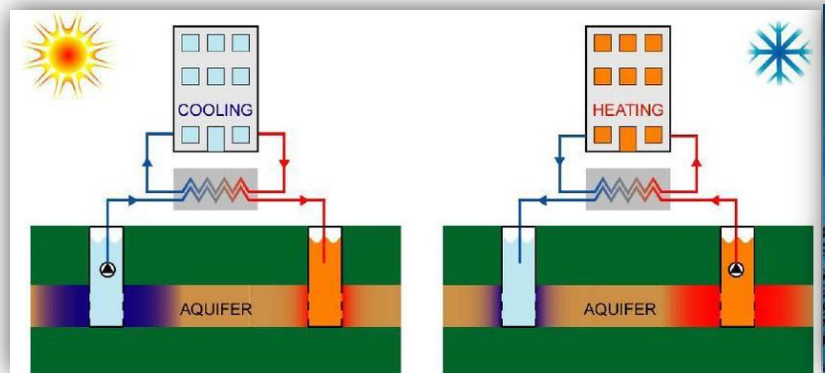
Objectives of the work: The study of the laws and properties of the accumulation of thermal energy in a short-term thermal energy storages. Consider types of thermal energy storage.

Object of research: Short-term thermal energy storages, phase change materials, salt hydrates.

Thermal energy storage

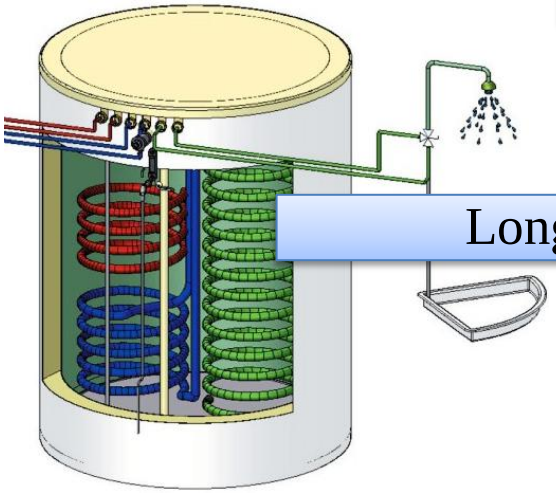
- Thermal energy storage is a technology that allows the transfer of heat and storage in a suitable medium.





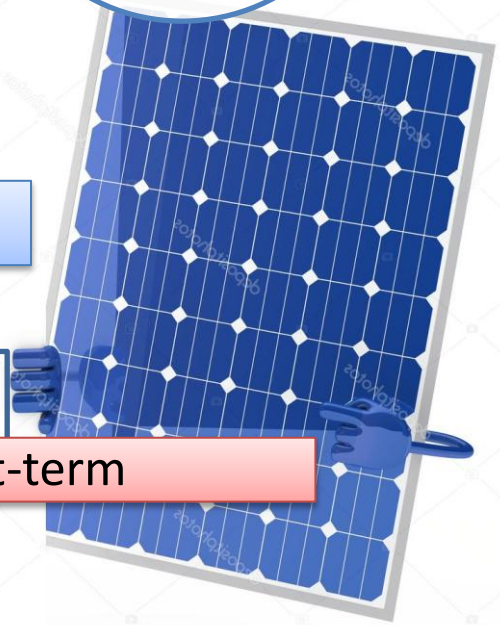
Advantages of using thermal energy storages include:

increased overall efficiency → better reliability → better economics → less pollution of the environment emissions.

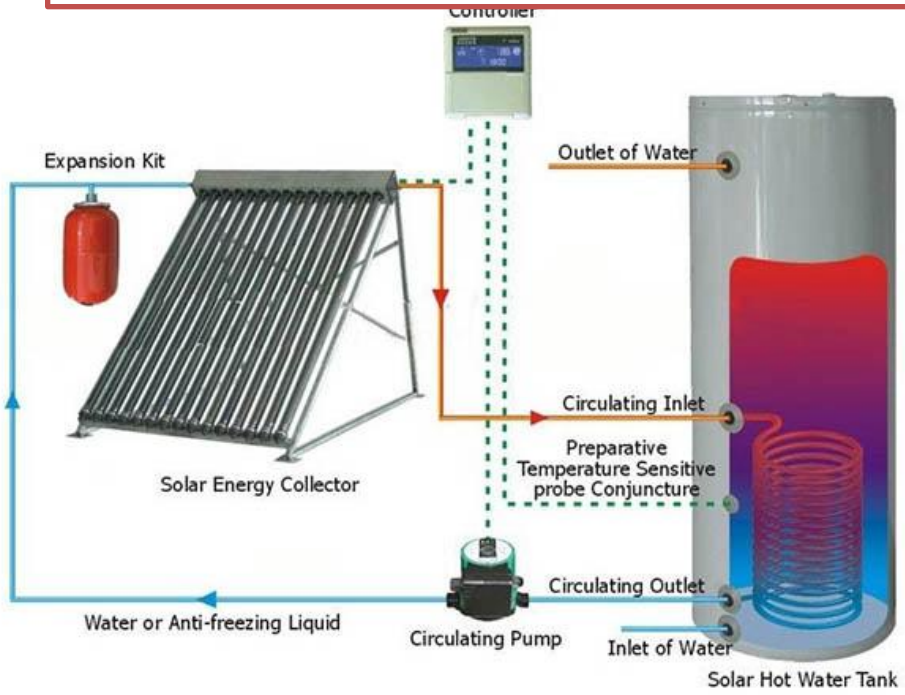


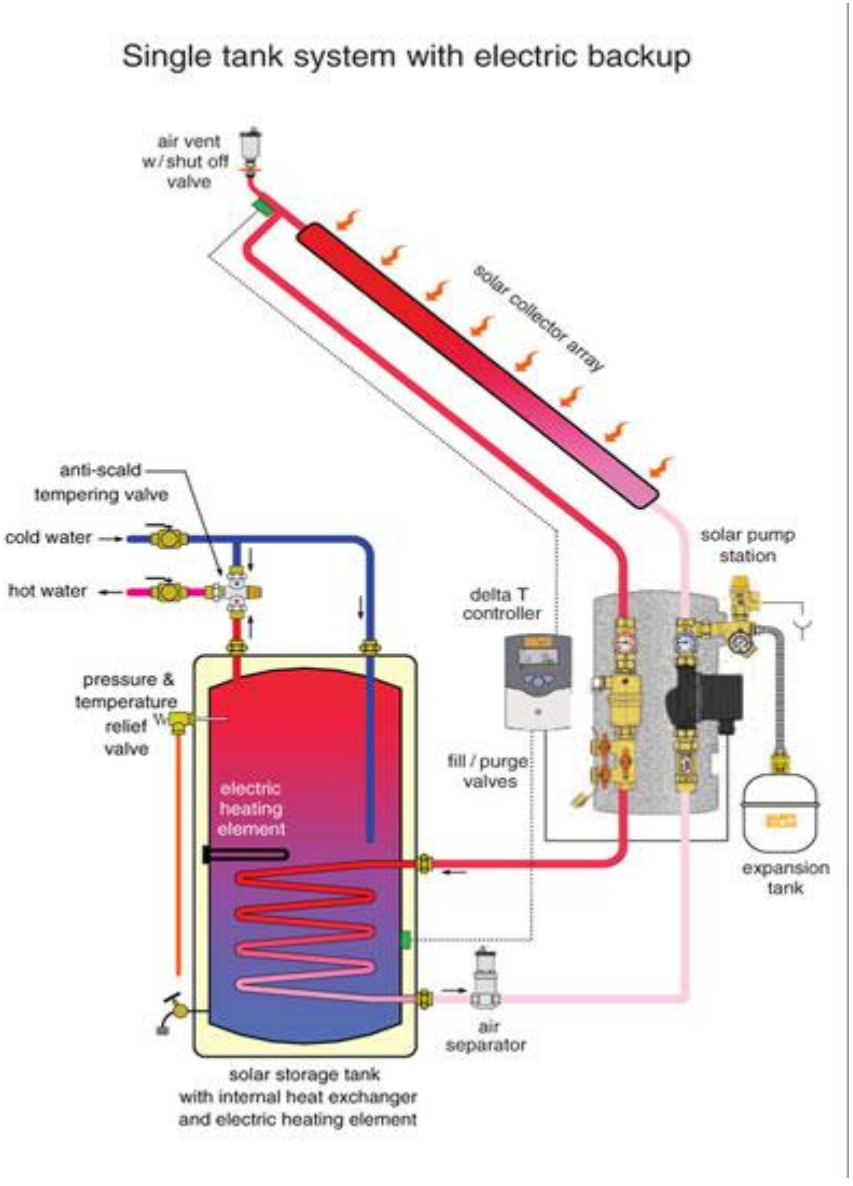
Thermal energy storage

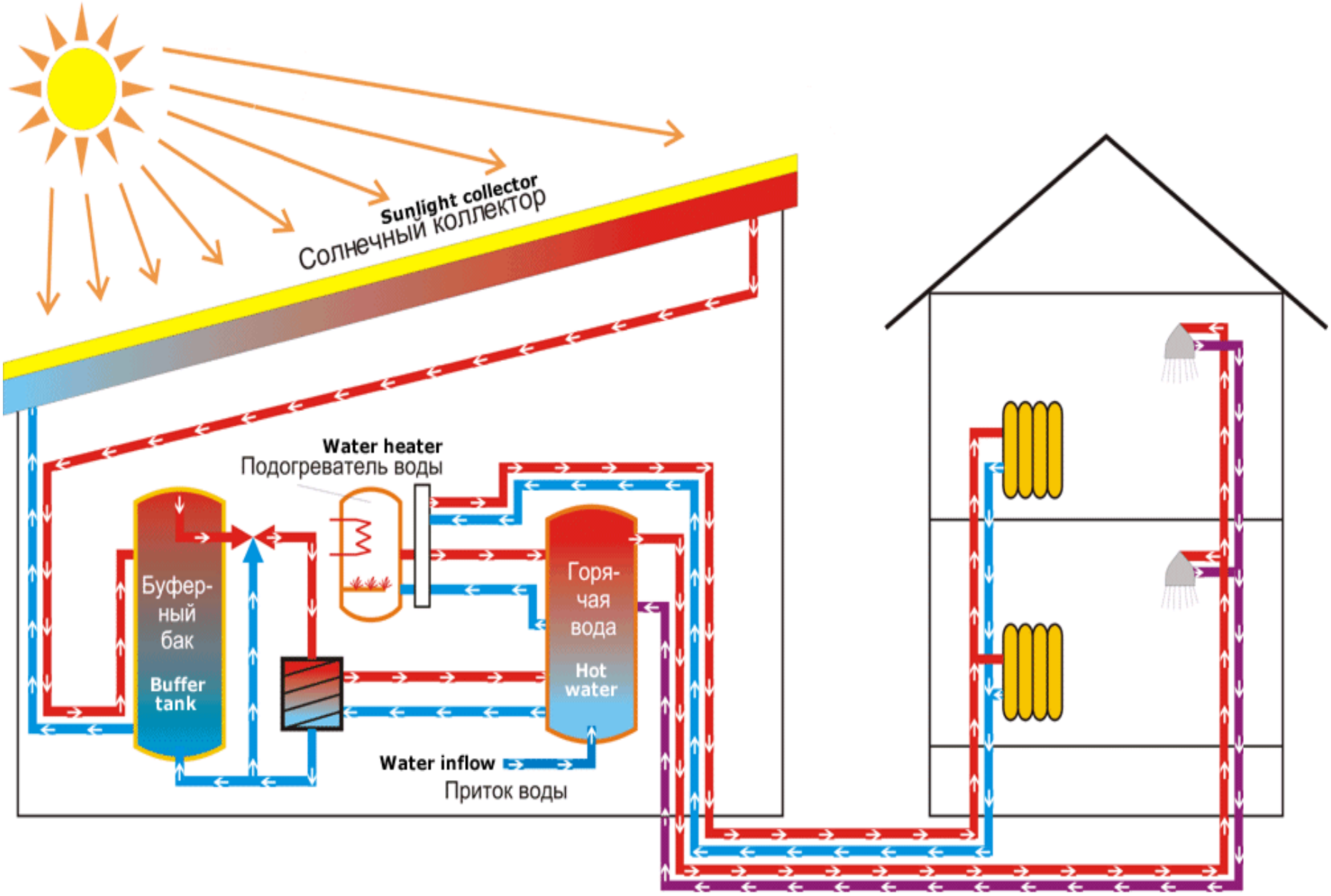
- Long-term
- Short-term



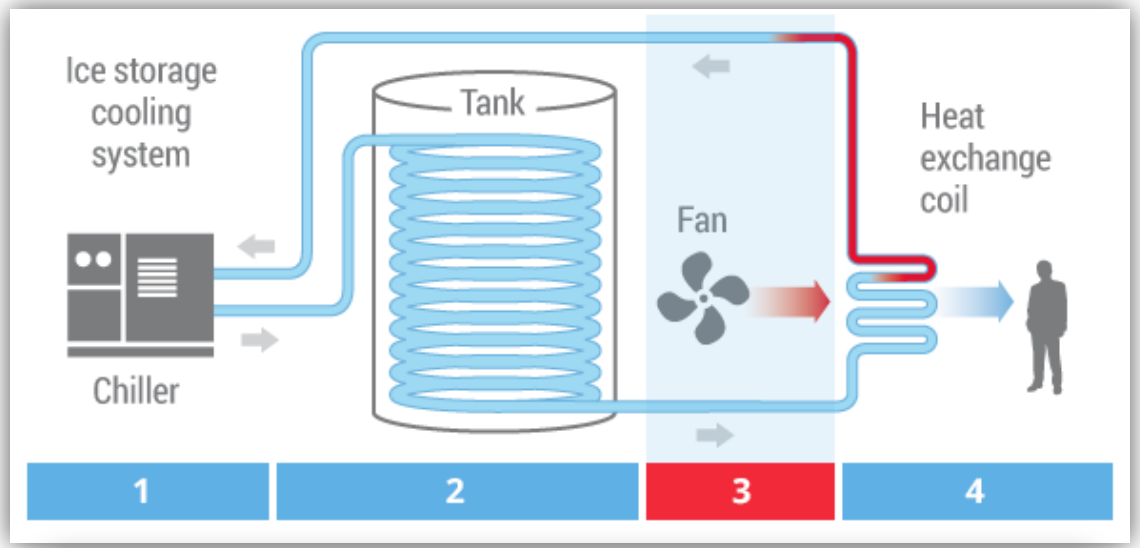
Solar hot water storage

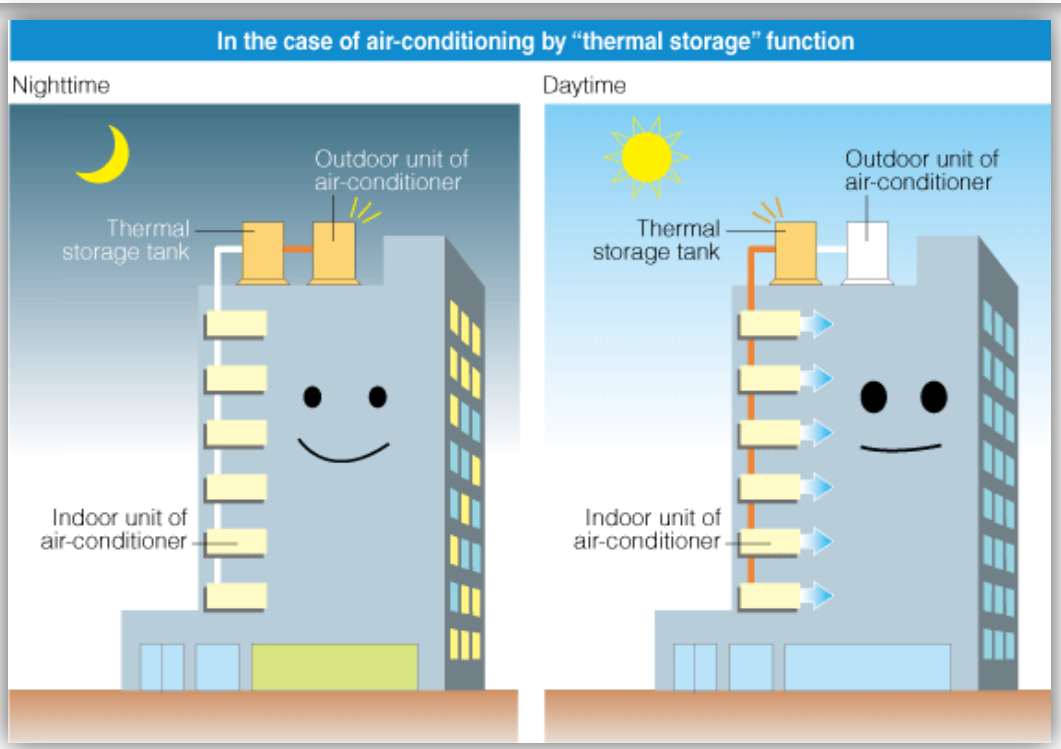




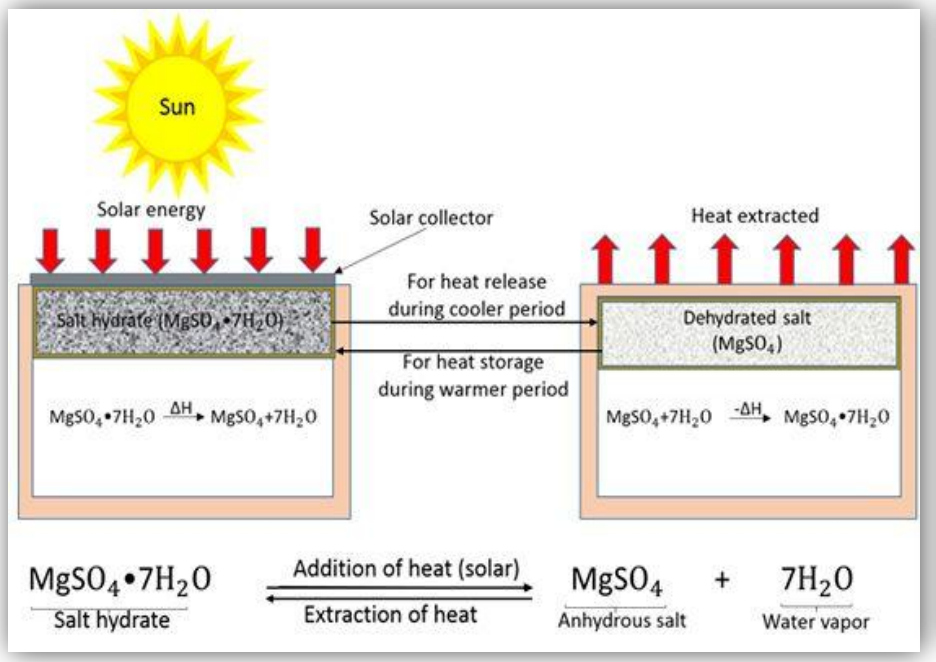

Sunlight collector
Солнечный коллектор
Water heater
Подогреватель воды
Буфер-
ный
бак
Buffer
tank
Горя-
чая
вода
Hot
water
Water inflow
Приток воды

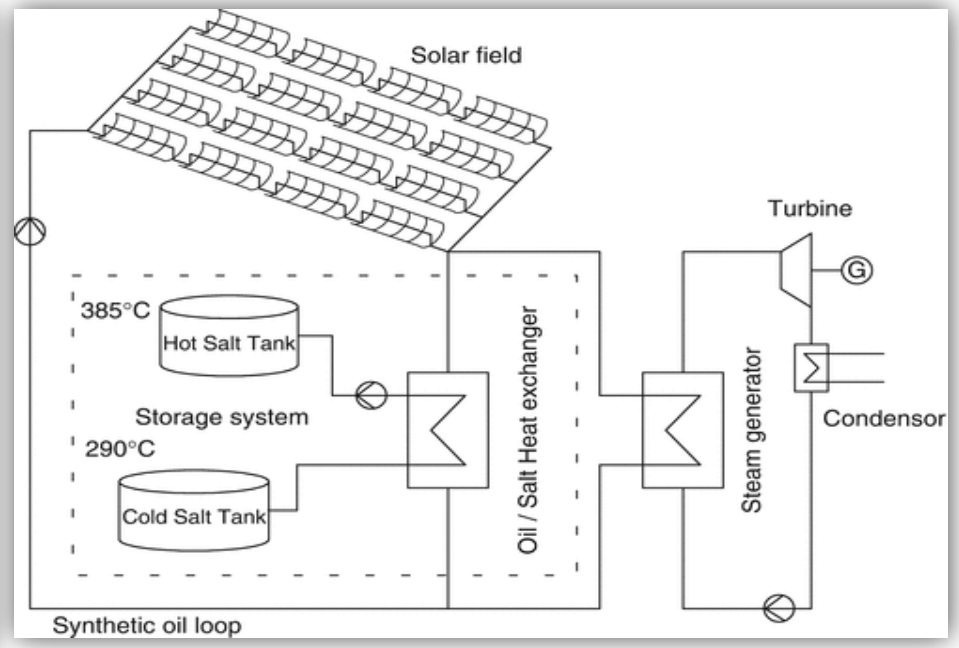
Ice thermal energy storage





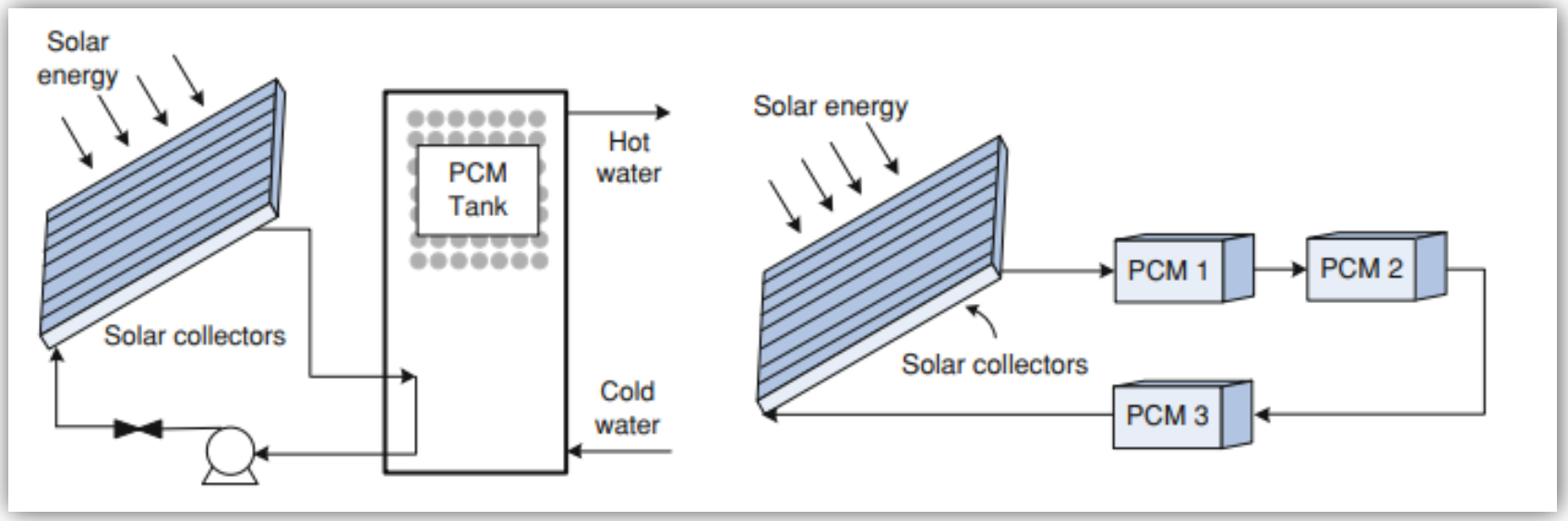
Short-term thermal energy storage sing salt hydrates for building heating

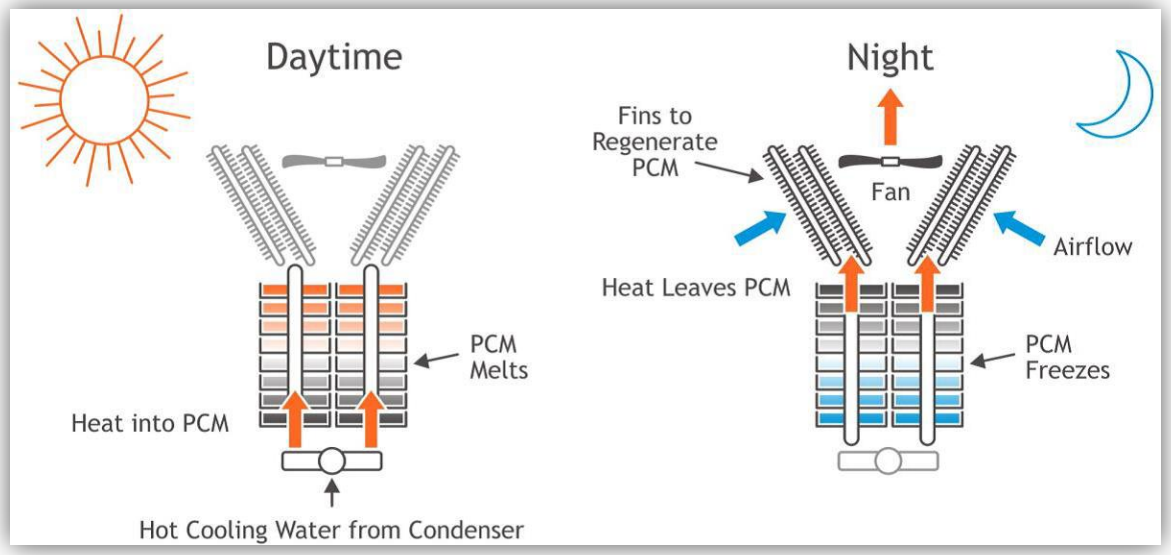




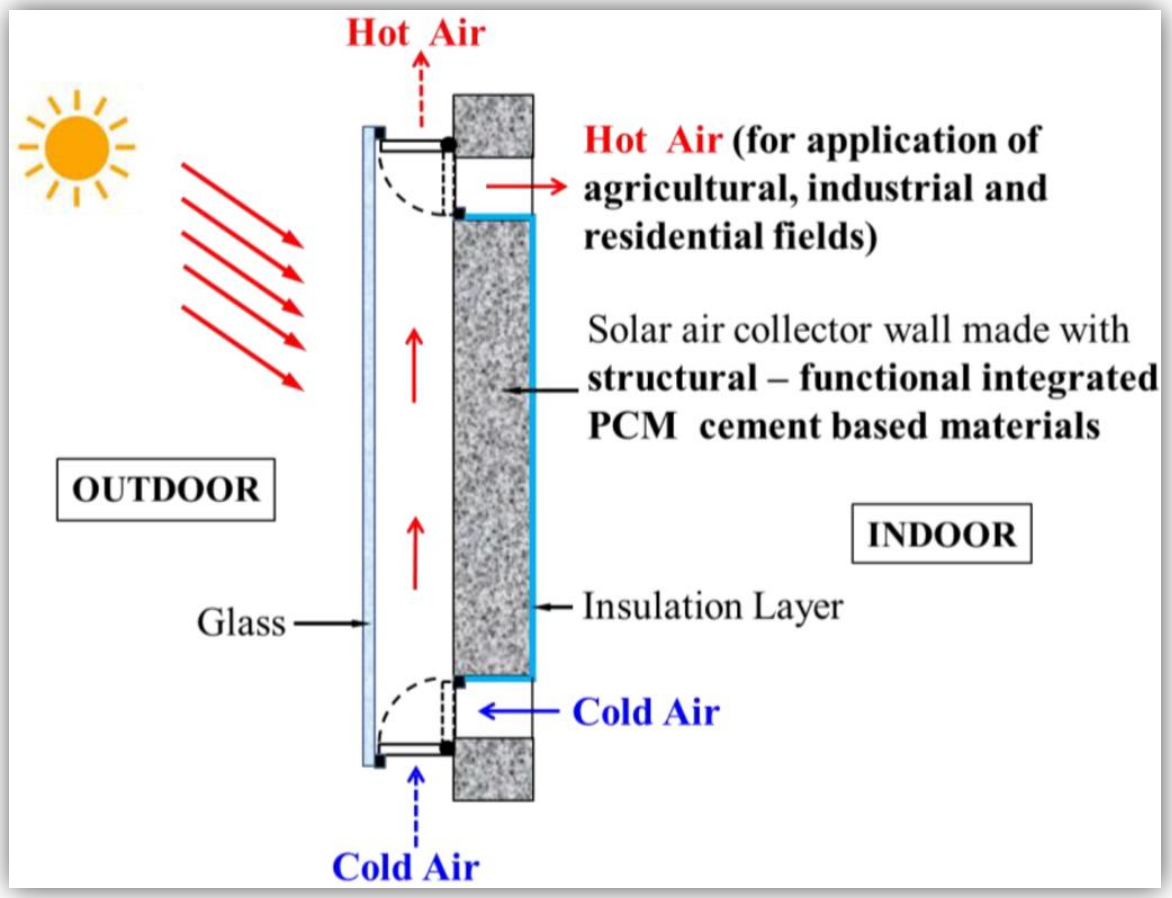
Material	T_r (1 bar) (°C)	$\Delta h_{r,educt}$ (kJ/mol)	$\Delta h_{r,educt}$ (KWh/t)	$\Delta h_{r,educt}$ [a] (KWh/m^3)	Δh_{sys} [a,b] (KWh/m^3)
Salt hydrates					
$MgSO_4 \cdot 7H_2O \leftrightarrow MgSO_4 + 7H_2O$	122	411	463	389	272
$CaCl_2 \cdot 2H_2O \leftrightarrow CaCl_2 \cdot H_2O + H_2O$	174	48	91	84	75
$CuSO_4 \cdot 5H_2O \leftrightarrow CuSO_4 \cdot H_2O + 4H_2O$	104	226	251	287	216
$CuSO4 \cdot H_2O \leftrightarrow CuSO_4 + H_2O$	205	73	114	163	142

Thermal energy storage on enclosed phase change material

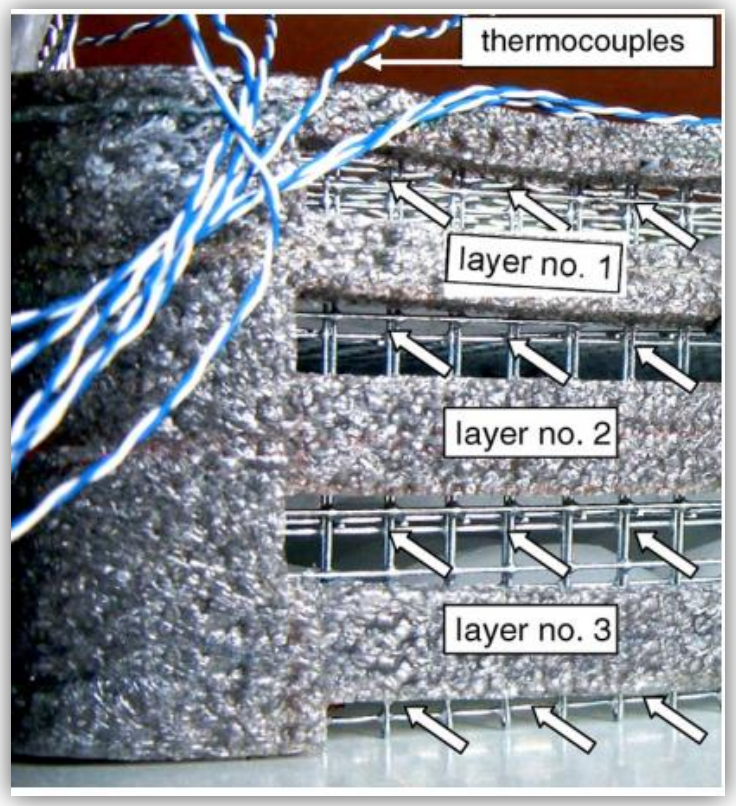


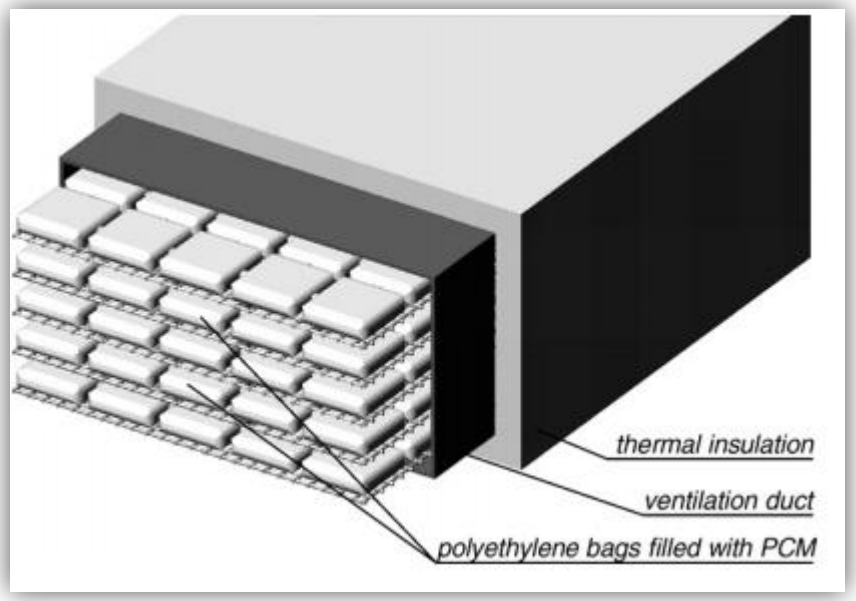


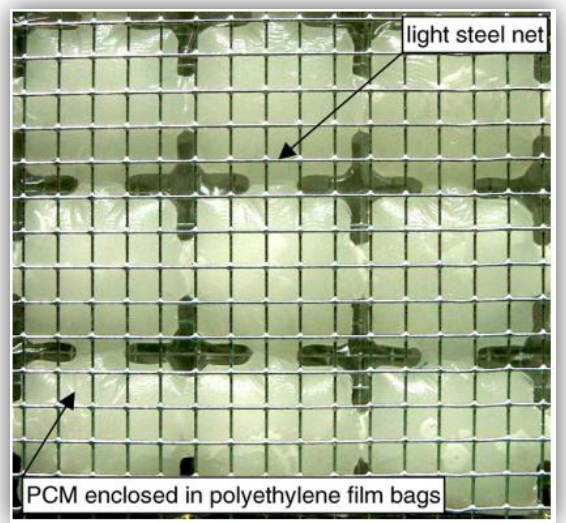
Thermal energy storage on enclosed phase change material

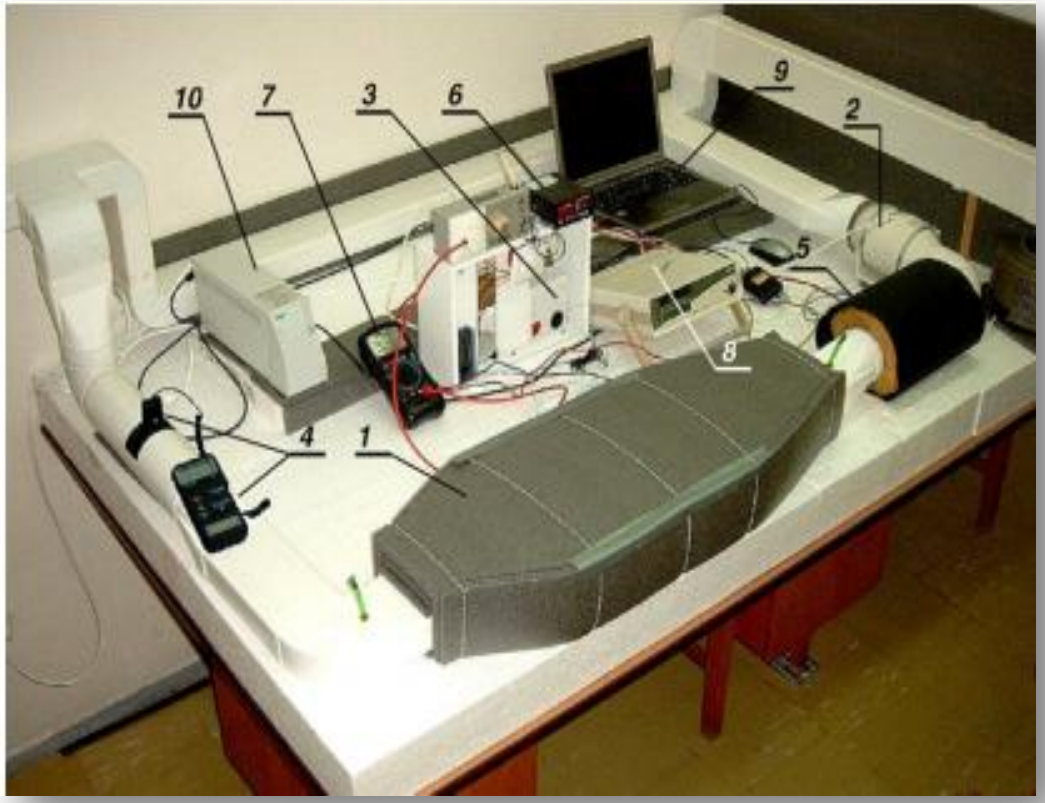


Short term thermal energy storage unit based on enclosed phase change material in polyethylene film bag





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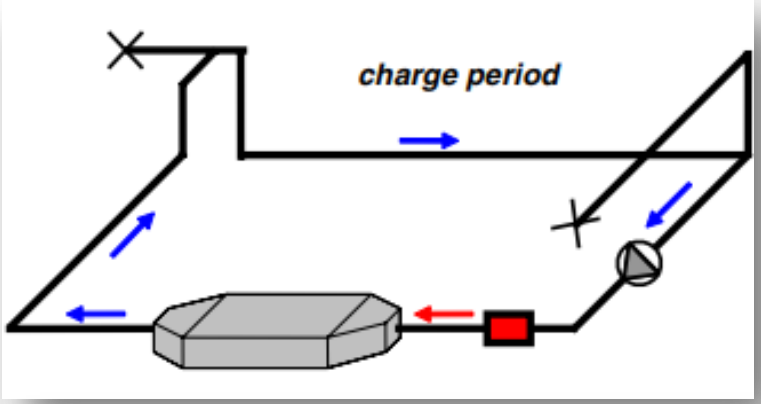
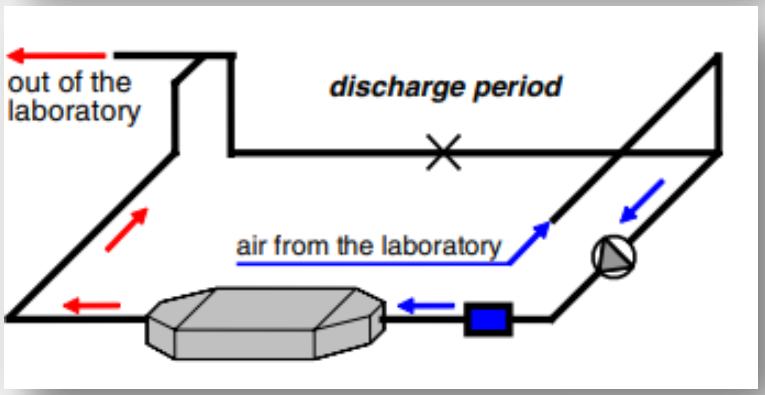
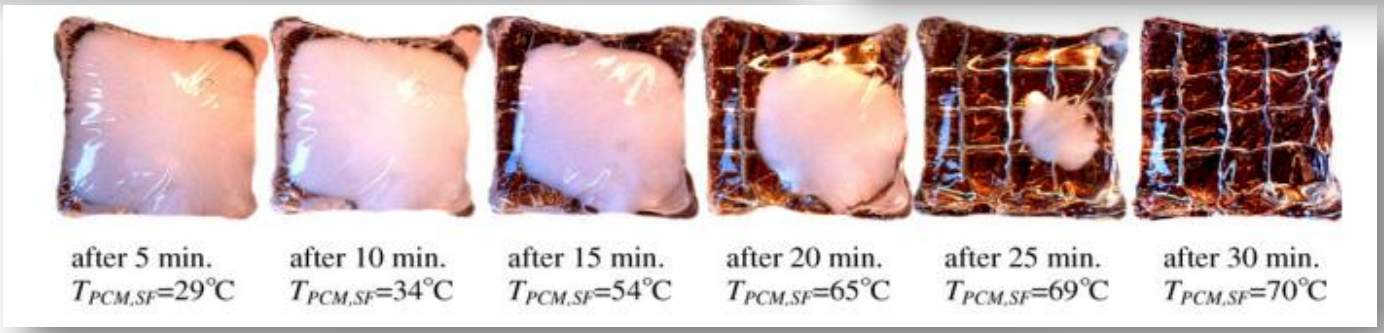
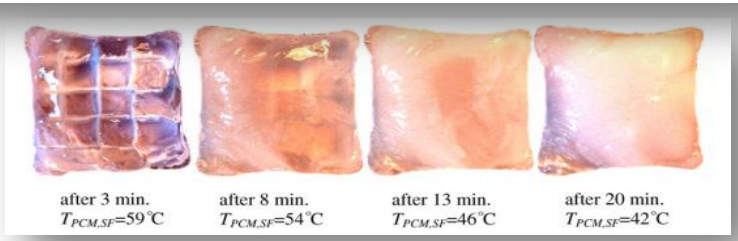

charge period


out of the laboratory
discharge period
air from the laboratory


after 5 min. $T_{PCM,SF}$=29°C
after 10 min. $T_{PCM,SF}$=34°C
after 15 min. $T_{PCM,SF}$=54°C
after 20 min. $T_{PCM,SF}$=65°C
after 25 min. $T_{PCM,SF}$=69°C
after 30 min. $T_{PCM,SF}$=70°C


after 3 min. $T_{PCM,SF}$=59°C
after 8 min. $T_{PCM,SF}$=54°C
after 13 min. $T_{PCM,SF}$=46°C
after 20 min. $T_{PCM,SF}$=42°C

Some materials used for heat storage in the form of sensible heating, volumetric heat capacity or energy density is defined by qCp = J/m3K

Material	Temp. Range T °C	Density ρ kg/m^3	Heat capacity $C_{p,av}$ J/kg °C	Energy density $\rho C_{p,av}$ kJ/m^3 °C
[a]50% Ethylene Glycol 50% water	0–100	1,075	3,480	3,741
Dowtherm A	12–260	867	2,200	1,907
Therminol 66	−9–343	750	2,100	1,575
Water	0–100	1,000	4,190	4,190
Grainte	–	2,400	790	1,896
Draw salt: 50% $NaNO_3$–50%KNO_3	220–540	1,733	1,550	2,686
[a]Molten salt: 50% KNO_3−40% $NaNO_2$−7% $NaNO_3$	142–540	1,680	1,560	2,620

[a] Weight percentages

Comparison of typical storage densities of various materials for energy storage in the forms of sensible and latent heats

Method/Material	kJ/l	kJ/kg	Temperature (°C)
Paraffin	180	200	5–130
Paraffin C18	196	244	28
Salthydrate	300	200	5–130
Salt	600–1,500	300–700	300–800

Methods of Thermal Energy Storage

sensible heat storage	latent heat storage
• $E = m\int_{T_1}^{T_2} C_p dT$	• $E = m\boldsymbol{\lambda}$ • $E = m\left[\left\{\int_{T_1}^{T^+} C_p dT\right\} + \lambda + \left\{\int_{T^*}^{T_2} C_{pl} dT\right\}\right]$

The first-law efficiency of thermal energy storage systems can be defined as the ratio of the energy extracted from the storage to the energy stored into it

$$\eta = \frac{m_1 C_1 (T - T_0)}{m_2 C_2 (T_\infty - T_2)}$$

Efficiency	Definition 1	Definition 2
η	$\frac{\text{Energy recovered from TES}}{\text{Energy input to TES}}$	$\frac{\text{Energy recovered from and remaining in TES}}{\text{Energy input to and originally in TES}}$

Conclusion

- In this work, I considered storing thermal energies in various types of thermal energy storages. I studied the types of short-term batteries thermal energy storages and the principle of work and how to storage thermal energy. I considered the formula for finding the energy efficiency of thermal energy storages.


Thank you for your attention