Exercise A.

1. Provide (at least) three types of energy storage systems. Please explain the principles and give examples.
2. Exemplify (at least) three major benefits of integrating energy storage into an energy system. Please motivate the answers.
3. Explain (at least) three types of operating strategies (control strategies) of using storage in a system. Please use examples.

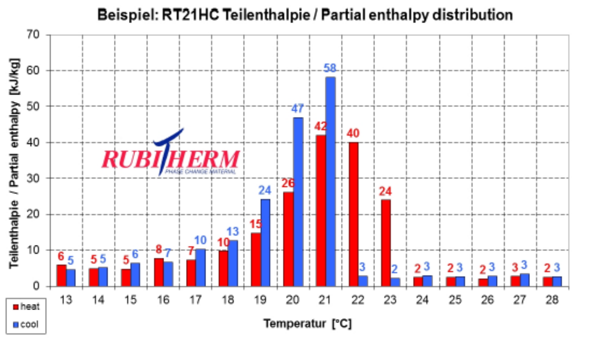
Exercise B.

Compare the amount of enthalpy change of sensible heat water storage between 15°C and 28°C to that of RT21HC PCM latent storage over the same temperature interval. [Write down the equations before you do the calculations.]

1. What is the energy storage density of water from 15°C to 28°C? [In kJ/kg and in kJ/L] To simplify the problem, take cp of water as constant 4.18 kJ/kg-K and density as 1 kg/L.
2. What is the energy storage density of RT21HC from 15°C to 28°C? [In kJ/kg and in kJ/L]. To simplify the problem, you may use average density of solid phase and liquid phase, and you may use average heating and cooling enthalpy.
3. The latent heat based PCM storage system has a packing factor of 0.7, what is the energy storage density of the storage system?
4. For the same amount of energy storage capacity, how much smaller [in %] would be the latent heat PCM storage system volume as compared to the sensible water storage system? (assuming packing factor of water storage is 1)
5. For the same amount of energy storage capacity, how much lighter [in %] would be the latent heat PCM storage system mass as compared to the sensible water storage system? (assuming packing factor of water storage is 1)

Properties of commercial PCM RT21HC are shown below.

Density solid at 15 °C	**0,88**	**[kg/l]**
Density liquid at 25 °C	**0,77**	**[kg/l]**
Heat conductivity (both phases)	**0,2**	**[W/(m·K)]**
Volume expansion	**14**	**[%]**
Flash point (PCM)	**140**	**[°C]**
Max. operation temperature	**45**	**[°C]**



Exercise C.

Let us have a closer look at Compressed Air Energy Storage system (CAES). Air can be compressed to store potential energy, then released later to drive gas turbine for electricity generation.

1. Please derive reversible adiabatic (isentropic) compression work ($W_{isentropic}$) required to compress ideal gas. The initial pressure, volume and temperature conditions are P1, V1, T1, and after compression the conditions are P2, V2, T2.
2. What is the isentropic work required to compress 1 m^3 of air from 1 bar to 60 bar? (use 1.4 as the ratio of specific heat of air)

Exercise D.

Imagine you are designing a storage system, what are some of the design aspects to consider? Please approach this question from technical perspective, but include also economic, environmental, social, political and other factors.