Zürcher Hochschule
für Angewandte Wissenschaften

School of
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Energy storage systems:

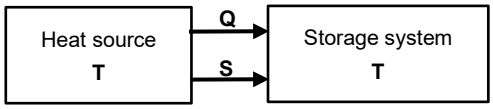
Energy storage systems enable a temporal adjustment of the energy production to the energy demand. They serve to prevent shortages in the energy supply and dissipation (qualitative degradation) of energy due to excess production.

Energy storage systems can be distinguished by the **energy form**:

- **Electrical** and electrochemical energy storage systems
- **Mechanical** storage systems
- **Chemical** storage systems
- **Thermal** energy storage systems (heat storages)

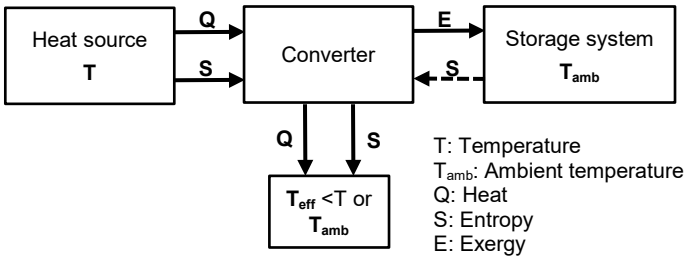
Some energy storage systems do not store any energy in the physical sense but only a "**potential**", used to alter the quality of the energy (e.g. converting ambient heat into thermal heat at higher temperatures). In the case of absorption storage systems, a chemical potential is stored in the form of a concentrated salt solution. In contrast toto direct (***self-sufficient***) thermal energy storage systems, a ***higher energy density is*** achieved in absorption storage systems and **no thermal losses** occur (the storage takes place at ambient temperature) allowing for long time storages.

Self-sufficient thermal storages:



- Thermal energy is fed directly to the storage system
- Thermal energy in the storage system can be in the form of
  - thermal energy => temperature rise => ***sensible thermal energy storage***
  - binding energy => phase change => ***latent thermal energy storage***
- The temperature of the storage medium is above or below the ambient temperature (warm or cold storage system) => ***thermal storage losses*** due to heat exchange with the environment

No self-sufficient thermal storages:



- Conversion of thermal energy into a "potential" (driving source, exergy), which can be used to produce thermal energy using anergy from the environment
- **Thermochemical storage systems** (reversible chemical reaction, adsorption / absorption storage systems)
- ***Thermal engine / heat pump + mechanical energy storage***

Advantages of no self-sufficient systems:

- High energy density; only the exergy portion is stored and the portion of anergy is discharged to or taken from the environment
- No thermal storage losses, as stored at ambient temperature

Disadvantage:

- Converter required (energy conversion) => thermodynamic losses

Basic structure of energy storage systems:

- ***Storage tank with storage medium***
  - Storage of thermal energy => transformation of internal energy/enthalpy
  - Storage of mechanical energy => transformation of external energy (kinetic / potential)
- ***Charging and discharging device***
  - Electric motor – generator => energy conversion electric – mechanical
  - Pump / compressor – turbine => energy conversion potential – kinetic
  - Heat exchanger => transmission of thermal energy between storage medium and heat transfer medium (transport of thermal energy)

Parameters of energy storage systems:

- ***Storage capacity***
  Amount of energy a storage medium can absorb in the case of a specific change in the state of the storage medium within specified limits (temperature change, difference in altitude)
- ***Charge and discharge capacity***
  Amount of energy which can be stored or delivered (determined by charging /discharging device, transport medium) per time (dE/dt => energy flow, power)
- ***Utilization ratio***
  Ratio between the amount of energy stored to the amount of energy delivered in one duty cycle (energy content of the storage system is constant before and after the cycle)
- ***Energy density***
  Stored energy per unit volume or mass of the storage system or storage medium
- ***Specific costs***
  Costs of the storage system per unit storage capacity or charge or discharge capacity