Full of Energy

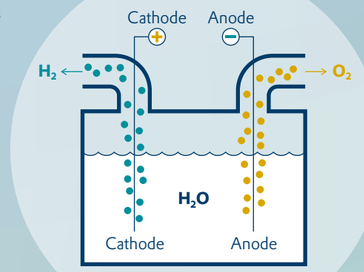
The energy transition can only succeed with the help of high-performance storage technologies. Various technologies are available for this purpose, depending on the area of application. But how do these technologies work, where are they used, and what are their advantages and disadvantages? An overview of the main techniques

TEXT **LUCAS RIEMER**
ILLUSTRATION **MAXIMILIAN NERTINGER**

CHEMICAL STORAGE

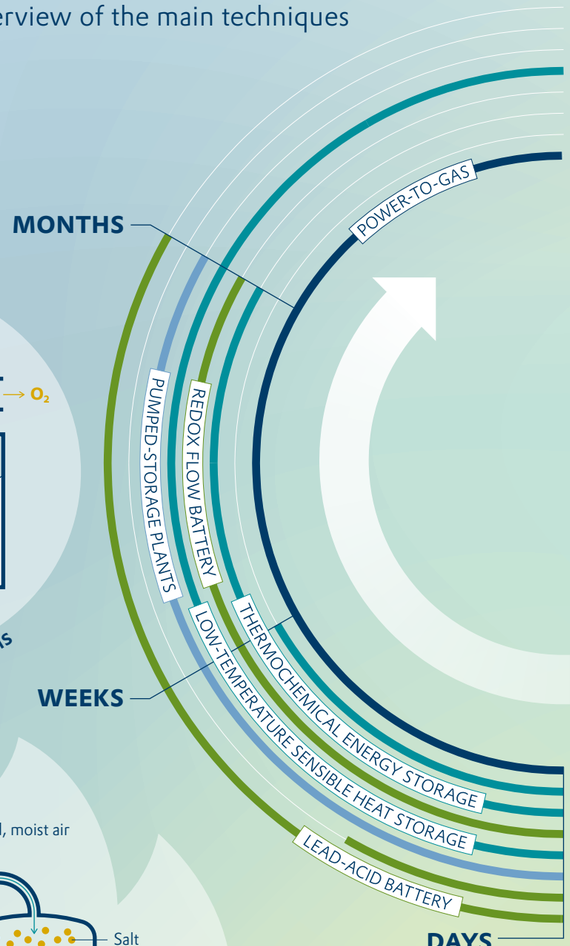
Chemical energy storage converts low-energy substances into high-energy ones. Water, for example, can be converted into hydrogen by means of **electrolysis**. This principle is put to good use in the power-to-gas process, which uses surplus electricity to produce hydrogen.

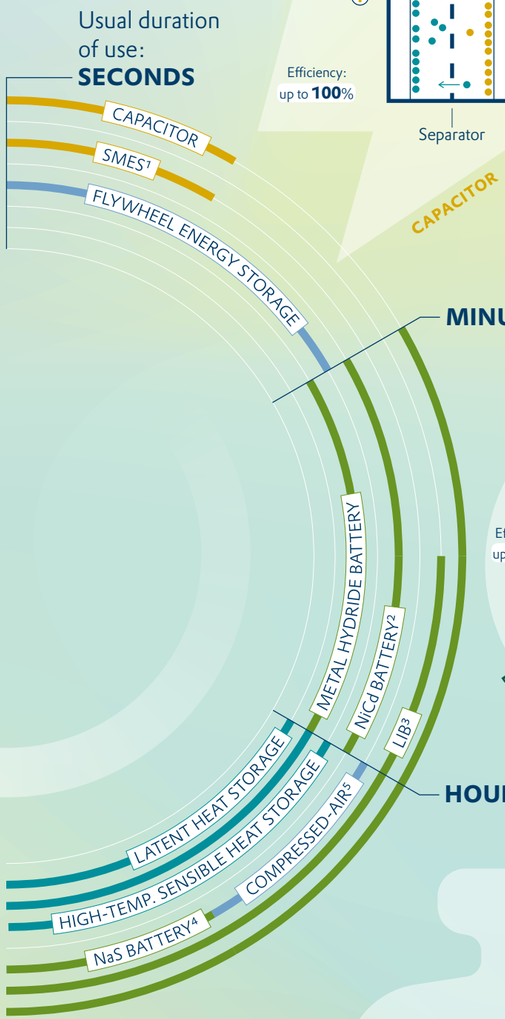
APPLICATIONS Storage of surplus electricity from renewable sources
ADVANTAGES Storage possible for an unlimited time, easy to transport
DISADVANTAGES Because hydrogen can rarely be used directly, it has to be converted further (e.g. into synthetic gasoline), which decreases its efficiency



Efficiency: **25–65**%

HYDROGEN ELECTROLYSIS

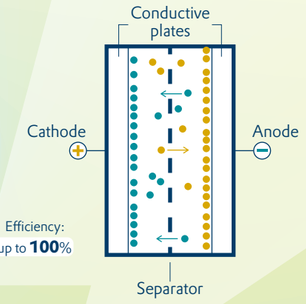




ELECTRICAL STORAGE

Capacitors store electricity with the help of an electric field. Today's **double-layer capacitors** are especially effective, due to their porous surfaces. Coils store energy in electromagnetic fields. **Superconducting magnetic energy storage** (SMES) operates according to the same principle.

APPLICATIONS Short-term stabilization of power grids during peak loads; supplements batteries in hybrid and electric vehicles; bicycle stand lights (double-layer capacitors)
ADVANTAGES Very high efficiency, rechargeable many times, energy is quickly available
DISADVANTAGES High level of self-discharge, SMES needs to be cooled to below -200 degrees Celsius



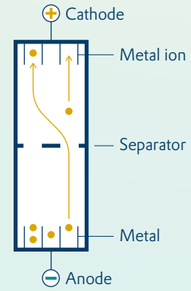
Efficiency: up to **100**%

CAPACITOR

ELECTROCHEMICAL STORAGE

The electrodes in normal and rechargeable batteries are connected by an electrolyte. During discharge, the chemical energy is converted into electrical energy. This reaction is reversible in rechargeable batteries. Whereas **lead-acid** and **lithium(Li)-ion batteries** work at moderate ambient temperatures, **sodium-sulfur batteries** only operate at temperatures above 200 degrees Celsius. **Redox flow batteries** use tanks to store energy.

APPLICATIONS Electric vehicles and small devices (primarily Li-ion batteries), offsetting grid fluctuations
ADVANTAGES High level of efficiency, fast response time, low self-discharge
DISADVANTAGES Fire hazard (Li-ion batteries), high cost and maintenance (redox flow battery)



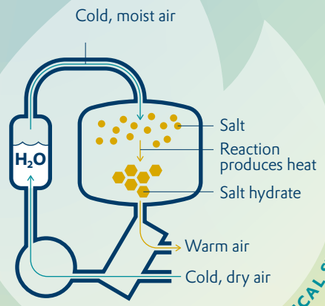
Efficiency: up to **95**%

BATTERY

THERMAL STORAGE

Heat is mostly stored in liquids or solids. The possible storage times range from a few hours (storage heaters) to several months (heat batteries). The temperature of **sensible heat storage systems** changes as they charge and discharge. However, it remains constant in **latent heat storage systems**, although the storage medium undergoes a phase transition. **Thermochemical storage systems** store heat using endothermal and exothermal reactions.

APPLICATIONS Heating of process water and buildings, solar thermal power plants
ADVANTAGES Robust technology, low costs
DISADVANTAGES High energy losses in some cases due to waste heat



Efficiency: up to **100**%

THERMOCHEMICAL STORAGE

1 SMES
Superconducting magnetic energy storage

2 NiCd BATTERY
Nickel-cadmium battery

3 LIB
Lithium-ion battery

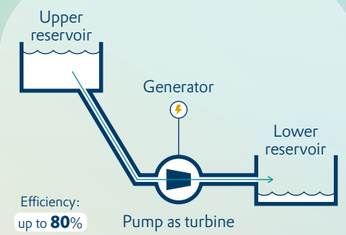
4 NaS BATTERY
Sodium-sulfur battery

5 COMPRESSED-AIR ENERGY STORAGE

MECHANICAL STORAGE

Electricity can be stored for long periods by converting it into other forms of energy. Examples include **compressed-air energy storage** and **flywheel energy storage**. **Pumped-storage plants** account for most of the electricity storage capacity worldwide.

APPLICATIONS Offsetting of peak loads in the power grid, safeguarding of the electricity supply, e.g. in hospitals (flywheel energy storage)
ADVANTAGES Relatively inexpensive, large amounts of energy can be stored for long periods (pumped storage), fast access (flywheel energy storage)
DISADVANTAGES Impact on landscape (except flywheel energy storage), high level of self-discharge (flywheel energy storage)



Efficiency: up to **80**%

PUMPED-STORAGE PLANT

Source: Energieagentur NRW, own research