Technology: Flow Battery

GENERAL DESCRIPTION

Mode of energy intake and output

Power-to-power

Summary of the storage process

A flow battery is an electrochemical battery, which uses liquid electrolytes stored in two tanks as its active energy storage component. For charging and discharging, these are pumped through reaction cells, so-called stacks, where H+ ions pass through a selective membrane from one side to the other, while, in the external circuit, electrons travel in the same direction, inducing a current. Consequently, chemical energy is converted into electricity (when discharging) or vice versa (when charging).

Figure 1: Organic-flow battery arrays with dark grey stacks in front and electrolyte tanks in the back (© CMBlu)

Due to their comparably high energy density, the most common and technically mature flow batteries use vanadium compounds as their electrolytes. These also bring the advantage that such systems use only vanadium as their active material.

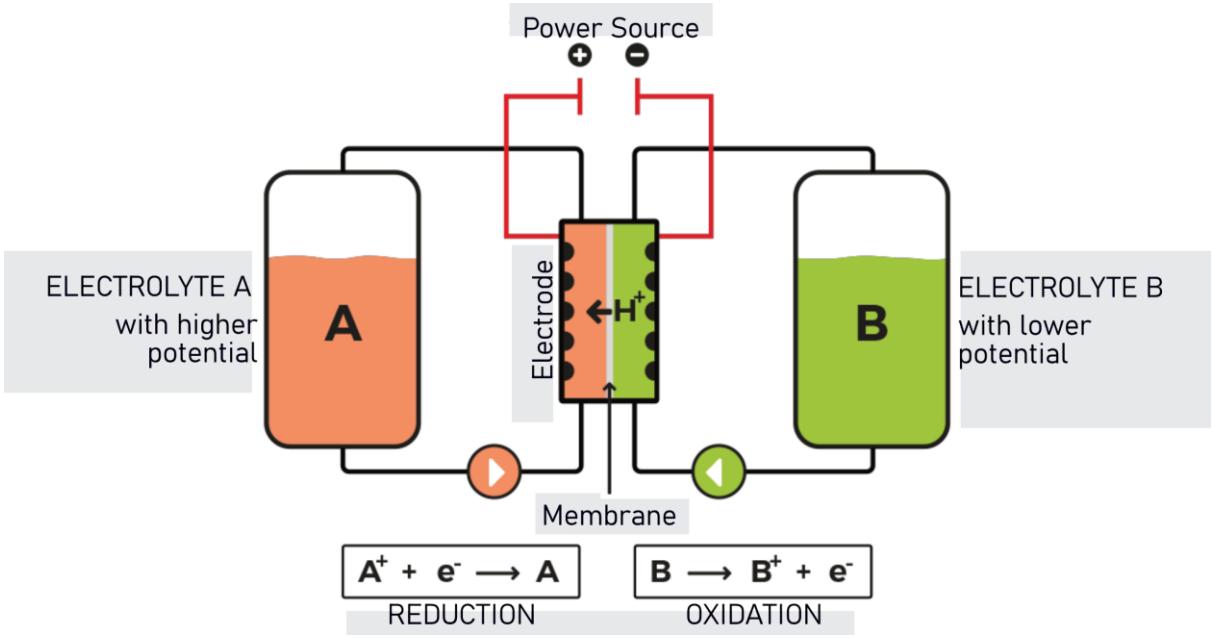

Figure 2: Schematic of a flow battery with two electrolyte tanks and a stack in the middle (© CMBlu)

Focus on provision of power or energy

Both, power and energy, possible.

The major characteristic and benefit flow batteries is the decoupling by design of power and energy. Power is determined by the size and number of cells, energy by the amount of electrolyte.

Suitable fields of application

Their low energy density makes flow batteries unsuited for mobile or residential applications, but attractive on industrial and utility scale. Hence, they are mostly used commercially or by grid operators in the form of stationary electricity storages ranging from about 40 kWh to hundreds of MWh. They are particularly advantageous for applications that require high cycle stability or discharge over several hours, and can help with increasing the self-consumption of solar and wind power, load balancing, provision of primary/secondary control energy, and other grid services like peak shaving. Due to the decoupling of power and energy, such systems may be designed to meet the specific needs of virtually any given application or location.

State of development/commercial availability

Commercially available (TRL 9). Several further research projects are ongoing.

Figure 3: Commercially available vanadium redox flow battery CellCube FB 500 (© Enerox GmbH)

TECHNICAL SPECIFICATIONS

Specific energy storage density	kWh/m³	kWh/t
	15-35 Wh/l	Not relevant
Specific power density	kW/m³	kW/t
	Not relevant	Not relevant
Typical/feasible storage size	kWh_{out}	kW_{out}
	Freely scalable kWh to > 1.000 MWh	Freely scalable kW to > 1.000 MW
System efficiency	70-80 %	
Storage duration	2- over 24 hours (depends on tank size)	
Response time	< 1 s	
Service life (maximum)	Cycles	Years
	> 10,000 cycles	20-25
Loss per time in %	negligible	

Notes

Flow batteries are relatively safe systems that run no risk of thermal runaway. However, gas evolution reactions are possible and need to be monitored.

ECONOMIC SPECIFICATIONS

Investment cost per kWh

The investment depends on the desired values for power and energy. 1 kW of stack power costs about 1.000 €. The cost per kWh of storage decreases with increasing tank size. It currently ranges between 350 and 500 €.

Operating and maintenance cost (based on investment/kW and kWh)

Approx. 2.5 % of overall investment p.a.