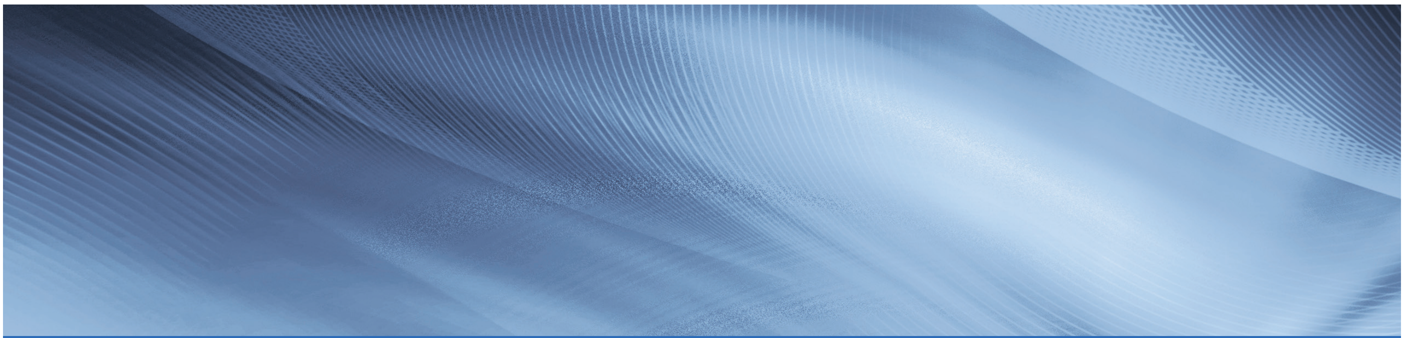
Flow Battery

European Association for Storage of Energy



Electrochemical Energy Storage

1. Technical description

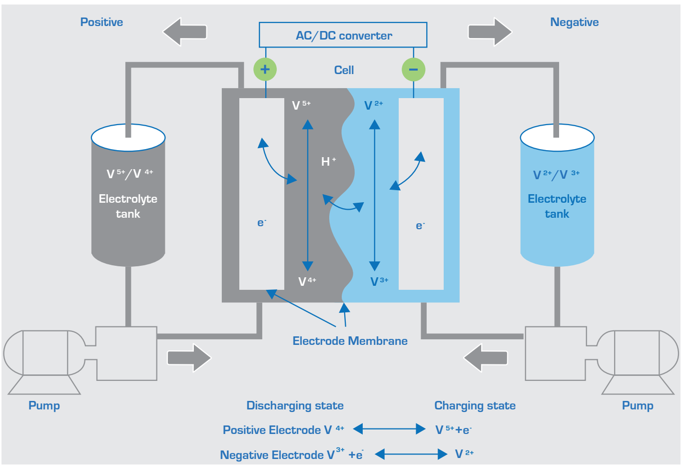
A. Physical principles

Flow batteries are rechargeable batteries which use two liquid electrolytes - one with a positive charged and one with a negative charged - as energy carriers. The electrolytes are separated using an ion-selective membrane, which under charging and discharging conditions allows selected ions to pass and complete chemical reactions. The singular characteristic of this technology is the total decoupling between power and energy ratings.

The power rate is determined by the active surface of the membrane (size of electrochemical cells stack) and by hydraulic pumps management. Energy capability depends from the amount of electrolytes used and also from the capacity of the tanks. The electrolytes are stored in separate tanks and are pumped into the battery when required.

The storage capacity of flow batteries can be increased by simply utilising larger storage tanks for the electrolytes. Several combinations of chemical components are possible for the battery.

Illustration: Charging principal of Flow Battery



B. Important components

The main components are the following:

- Cell stack: single cells are stacked together and electrically connected in series to achieve higher voltage
- Electrolyte tank systems
- Pumps for electrolyte circulation
- Control systems
- Power Conversion System (PCS)

C. Key performance data

Power range	several kW to some MW
Energy range	from 100kWh to some MWh
Discharge time	Some h
Cycle life	>12,000 cycles
Life duration	10 – 20 years
Reaction time	Some millisec
Efficiency	70 – 75 % (*)
Energy (power) density	10 – 25 Wh/liter
CAPEX: energy	100 – 400 €/kWh
CAPEX: power	500 – 1,300 €/kW

* Battery system auxiliary absorption is included in DC/DC round trip calculation

D. Design variants (non exhaustive)

The different design variants are based on:

- The used redox couples: vanadium, zinc-bromine (Zn-Br), polysulphide-bromide (PSB), etc
- The battery system size: bigger systems show a modular design. Several sub stacks are grouped together. Modularity gives redundancy and reliability.

Furthermore, flow batteries can be divided into two categories:

- True redox, where all the chemical species active in storing energy are fully dissolved in solution at all times (vanadium/vanadium, iron/chromium).
- Hybrid redox, where at least one chemical species is plated as a solid (zinc) in the electrochemical cells during charge (zinc/bromine, zinc/chlorine)

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2. State of the art

Flow batteries have been developed since 1970. In the USA, NASA began developing these batteries in the early 70s and since then has developed different chemistries (iron chrome, all vanadium etc.). During the 80s, several prototypes were developed mainly by the University of New South Wales (UNSW), and during the 90s, several prototype systems were tested in the multi-kW range, especially by Asian companies that installed and tested such systems. Plants with up to 200 kW and 800 kWh storage capacity have been constructed and operated.

3. Future developments

The development work is focused on further cost reduction of these flow systems. One of the major cost drivers is the cation exchange membrane. Research & Development (R&D) work is on-going to develop cost-effective new membranes as well as to study new redox couples. Additionally, thinner and more active reaction felts will help to increase the power density of the cell, which will also help to reduce stack size and costs.

4. Relevance in Europe

Most of the Flow Batteries development is done in Asia (Japan and China), Australia and in the USA. In Europe, the development is on-going and products are available in the class of 10 kW and 200 kW.

5. Applications

Flow batteries offer a greater flexibility to independently tailored power and energy ratings for a given application, rather than other technologies when it comes to storing electrical energy. Despite this, because of the relatively low energy density of the vanadium electrolyte, big storage tanks are necessary. This limits the area of applicability of flow battery technology for the following:

- Large-scale non-mobile energy storage applications
- Peak shaving
- Energy time shifting

6. Sources of information

- EASE Members
- Fraunhofer UMSICHT
- Prudent
- A Review of Energy Storage Technologies For the integration of fluctuating renewable energy (David Connolly, University of Limerick)
- EPRI
- EDF
- ARUP

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