THE WORLD
MAJOR FLOW BATTERY PROJECTS
2020

Compiled, Designed and Produced by La Tene Maps in association with the International Flow Battery Forum
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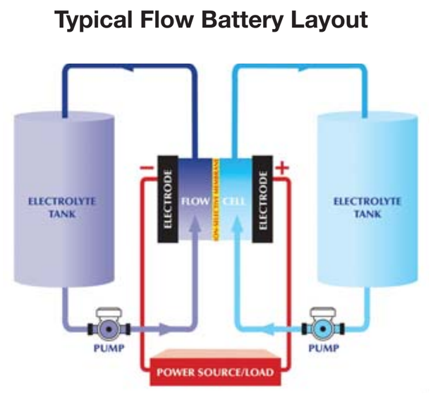
What is a flow battery?

A flow battery is a rechargeable battery in which electrolyte flows through one or more electrochemical cells from one or more tanks. With a simple flow battery, it is straightforward to increase the energy storage capacity by increasing the quantity of electrolyte stored in the tanks. The electrochemical cells can be electrically connected in series or parallel, so determining the power of the flow battery system. This decoupling of energy rating and power rating is an important feature of flow battery systems.

Typical Flow Battery Layout



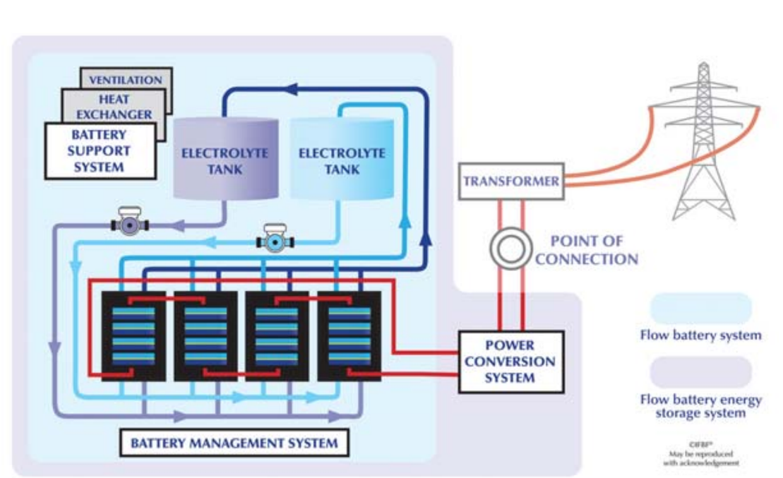
The interconversion of energy between electrical and stored chemical energy takes place in the electrochemical cell. This consists of two half cells separated by a porous or by an ion exchange membrane. As well as permitting ionic conduction, the separator minimises the loss of the generated electroactive species in the half cells and so maintains high coulombic efficiency. The redox reactions during charge and discharge take place at the electrodes of the half cells. In its simplest form, the electrodes themselves, usually carbon felt, are not altered by these electrochemical reactions.

The cell voltage is the difference between the negative electrode reaction and that at the positive electrode. During charging, electrons released at the positive electrode through oxidation of the electroactive species in that half-cell are pushed round the circuit to the negative electrode where reduction of electroactive species in that half-cell takes place. The processes are reversed on discharge. The electroactive materials are redox pairs, i.e. chemical compounds that can reversibly undergo reduction and oxidation.

The choice of redox pairs is often used as a description of the type of flow battery. Some well-known redox pairs are:

- Vanadium / vanadium
  (which uses the four different valency states of vanadium)
- Iron / chromium
- Zinc / bromine

Usually, both the electroactive species in the redox pairs are soluble in aqueous acid or alkali solutions. However, in some flow batteries, such as zinc bromine, one active species (in this case, zinc metal) is deposited on the electrode. These types of batteries are sometimes known as hybrid redox flow batteries. Other flow battery systems use aqueous solutions of organic redox pairs, such as quinones and TEMPO, instead of metal-based redox couples, and other types operate in totally non-aqueous environments, employing organic and organometallic redox couples.



The practical application of a flow battery requires ancillary and support systems as shown in the diagram above.

Western Europe

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Notes:
1. Whilst every effort has been made to ensure the accuracy of this map, La Tene Maps or the International Flow Battery Forum are not liable for any errors or omissions whatsoever

2. La Tene Maps acknowleges the help and assistance from Swanbarton and other companies who contributed information and comments in the preparation of this map.

3. This map represents a snapshot in time. The industry is constantly changing. Some of the technology providers have been taken over, changed names or left the business. Some of these old technology providers may be shown in brackets

4. Some sites are shown by symbol only as they are subject to confidentialty agreements. We think there are at least 150+ other sites not shown on the map which fall into this category and for which we have no information.

5. Decommissioned projects have been removed. Due to space restrictions some names may be shortened. Some projects under construction may be shown as built.

7. For further information on the International Flow Battery Forum see the website www.flowbatteryforum.com

8. Any errors or omissions notified to us will be corrected in the next edition.

Legend

- Vanadium redox flow battery
- Zinc bromine & Zn iron flow battery
- Other & unknown flow battery type*
  *Includes Salt & Hybrids
- Flow battery project under construction
- Planned/proposed flow battery

Project name and/or location — Rated power in kW
Sabiñanigo (3.3kW, 4.5)
Hydraredox
Operator or technology provider — Duration in hours

Madrid — Capital City

Advantages and Benefits of Flow Batteries

Flow batteries have been installed in several places for a wide range of applications. They are a reliable, low cost, environmentally benign method for electrical energy storage.

- Flow battery technology is modular and scalable, so systems can be made to suit a wide range of applications, from power ratings of watts, to megawatts, and with energy durations of many hours or even days.
- The battery can be constructed of low cost and readily available materials, such as thermoplastics and carbon-based materials. Many parts of the battery can be recycled. Electrolytes can be recovered and reused, leading to low cost of ownership.
- The battery materials have low flammability and low environmental impact.
- The electrolytes can be used as part of the heat management strategy for the battery, reducing the need for complex heating or cooling of the battery system. This reduces costs.
- Because electrochemical cells share a common electrolyte, each cell can be at the same state of charge, simplifying cell balancing and battery operation. The state of charge of the whole system can be measured at a single point (or several measurement points can be used to check correct functioning of the battery system).
- Overcharging and fully discharging does not usually cause permanent damage to the electrodes or electrolytes.
- There is limited self-discharge in standby mode, and when shut down, there is no self-discharge.
- Energy storage capacities are independent of their power rating, and so flow batteries are highly suitable for long duration energy storage. As the incremental cost of increasing energy storage capacity reflects the cost of tanks and the electrolyte, the overall cost of a long duration battery is lower than for other battery types.