Ess iron flow battery

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Iron flow batteries. Long-duration energy storage (LDES) is the linchpin of the ...

The Iron Redox Flow Battery (IRFB), also known as Iron Salt Battery (ISB), stores and releases energy through the electrochemical reaction of iron salt. This type of battery belongs to the class of redox-flow batteries (RFB), which are alternative solutions to Lithium-Ion Batteries (LIB) for stationary applications. The IRFB can achieve up to 70% round trip energy efficiency. In comparison, other long duration storage technologies such as pumped hydro energy storage provide around 80% round trip energy efficiency [1].

The single cells are then stacked and electrically connected in series via bipolar plates, forming a battery stack.[3]

The energy storage is based on the electrochemical reaction of iron. During charge, iron(II) oxidizes to iron(III) in the positive half-cell (Reaction 1) while in the negative half-cell iron(II) is reduced to iron(0) (Reaction 2). The latter reaction is also called the plating reaction, as iron(0) is deposited on the negative electrode. During discharge, the plated iron(0) is dissolved into the electrolyte forming iron(II), while iron(III) reduces to iron(II) in the positive half-cell.[1]

Unwanted side reactions lead to coulombic efficiency and capacity loss because charge is irreversibly lost.

The acidic iron electrolyte can oxidize when it is in contact with air, therefore, mitigating measures need to be taken (e.g., operating under inert atmosphere) to prevent air oxidation (Reaction 4).[1][4]

Air oxidation: 4 Fe2+(aq) + O2 + 4 H+ -> 4 Fe3+(aq)+ 2 H2O   (4)

Further, Fe3+ can migrate through the separator and react with the plated Fe0 on the negative side forming Fe2+. This migration especially takes place when using a microporous separator (Reaction 5).[2]

Crossover reaction: Fe3+(aq)+ Fe0(s)? 2 Fe2+(aq)

       (5)

During charge, hydrogen will evolve, as the standard potential of the hydrogen evolution reaction (HER) lies between the standard potential of Fe2+/Fe3+ and of Fe2+/Fe0. The acidic protons H+ in solution react to form hydrogen gas (Reaction 7) whilst iron(II) oxidises in the positive half-cell (Reaction 6). The HER is pH dependent. At lower pH values, the concentration of H+ is high, which increases the kinetics of the side reaction. Over time, the pH increases on the negative side. At a pH >= ~4, insoluble iron hydroxide forms and deposits onto the separator. This leads to increased resistance of ionic transfer, reduced coulombic and voltaic efficiency and ultimately cell failure.[2]

Positive half-cell: Fe2+(aq) -> Fe3+(aq) + e-   E0 = +0.77 V   (6)

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