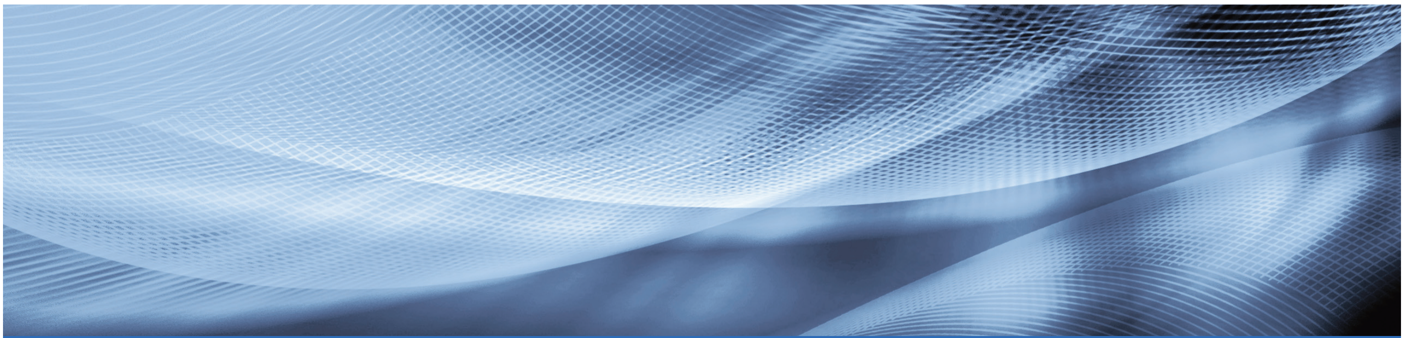
Sodium-Ion Battery



Electrochemical Energy Storage

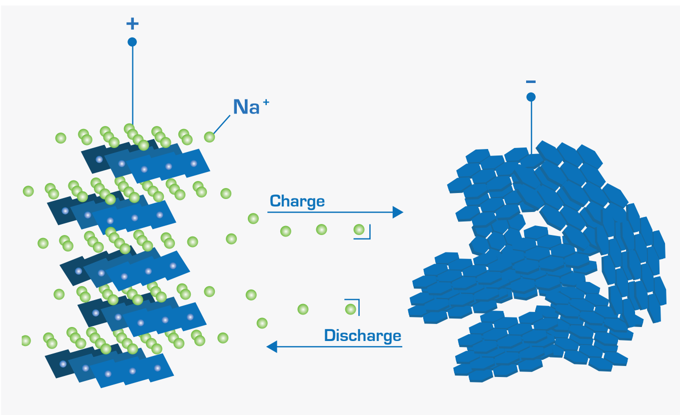
1. Technical description

A. Physical principles

A Sodium-Ion (Na-Ion) Battery System is an energy storage system based on electrochemical charge/discharge reactions that occur between a positive electrode (cathode) composed of sodium-containing layered materials, and a negative electrode (anode) that is typically made of hard carbons or intercalation compounds. The electrodes are separated by some porous material which allow ionic flow between them and are immersed in an electrolyte that can be made up of either aqueous solution (such as Na_2SO_4 solution) or non-aqueous solution (e.g. salts in propylene carbonate).

When the battery is being charged, Na atoms in the cathode release electrons to the external circuit and become ions which migrate through the electrolyte toward the anode, where they combine with electrons from the external circuit while reacting with the layered anode material. This process is reversed during discharge.

Illustration: Charging principle of Na-Ion



B. Important components

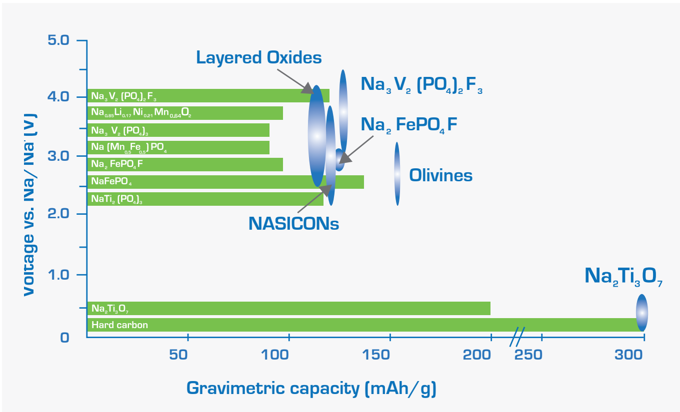
The main components are the following:

- Elementary cell composed of an assembly of electrodes, electrolyte and separator
- Modules composed of serial or parallel assemblies of cells
- Battery systems composed of a large assemblies of cells or modules and of a control system
- Power Conversion System (PCS)

C. Design variants (non exhaustive)

The following design variants are available:

- Different electrochemistries:



- Different electrolytes: aqueous or non aqueous
- Different design according to the size and the application

Avenue Lacombé 59/8 - BE-1030 Brussels - tel: +32 02.743.29.82 - @EASE_ES - info@ease-storage.eu - www.ease-storage.eu

2. State of the art

The Na-Ion batteries are still in a developmental phase but were identified recently as a potential key solution for grid electricity storage applications.
The main research objective is to obtain a lower cost of stored energy (LCOSE) as amortized over the lifetime of the system: < $ 0,1/kWh

To reach this objective, it is necessary to have a battery system with the main following performances:

- Cycle life: > 5 000
- Capex energy: < $300 (usable kWh installed)

As the Li-ion systems are expected to stay more expensive, it was proposed to replace the lithium by sodium that is available at a very low cost. The Na-Ion battery can benefit from some developments made for the Li-Ion systems and can use a cheaper electrolyte such as an aqueous solution.

The Na-Ion technology was identified as a priority jointly by the EC and the DOE in 2010. Some Research efforts were launched all over the world and a US spin-off company (Aquion Energy) from the Carnegie Mellon University was launched in 2009.

In June 2012, Aquion Energy, Inc. completed the testing and demonstration requirements for the U.S. DOE's program with its low-cost, grid-scale, ambient temperature Aqueous Hybrid Ion (AHI) energy storage device.
During the three-year project, Aquion manufactured hundreds of batteries and assembled them into high-voltage, grid-scale systems. This project helped them move their aqueous electrochemical energy storage device from bench-scale testing to pilot-scale manufacturing.

The testing successfully demonstrated a grid-connected, high voltage (>1,000 V), 13.5 kWh system with a 4-hour discharge time.

The main following projected targets were set up after the initial tests:

- Capital cost of less than $250/kWh at pack level
- Deep discharge cycle life of greater than 10,000 cycles
- Volumetric energy density of greater than 20 kWh per cubic meter
- Lifetime of over 10 years

3. Future developments

The following developments are expected to be launched:

- Improvement of negative and positive electrode materials
- Improved conductivity of electrolytes at room temperature
- Better Na-Ion electrochemical systems
- Large Na-Ion systems for bulk storage
- Validation of Na-Ion technology on large scale storage
- Applications in demonstration projects
- Improved manufacturing process

4. Relevance in Europe

The Na-Ion technology is considered as one of the candidates for Li-Ion succession in the following years (5 /10 years) because of the low LCOES perspective and so, can contribute considerably to reaching the Low European Carbon Energy targets.

5. Applications

Based on presently obtained experience (July 2013) the Na-Ion technology appears well suited for electricity storage applications on grid level and consumer level.

6. Sources of information

- EASE members
- Aquion
- Materials Road Map enabling Low Carbon Energy Technologies & DOE
- Maastricht Science Programme, Maastricht University, Maastricht, Netherlands
- Joint EERA/EASE recommendations for a European Energy Storage
- Development Technology Road Map towards 2020
- Zhuoa, H., Wanga, X., Tanga, A., Liua, Z., Gamboab, S. and Sebastian, P.J., J. Pow. Sources, 160 (2006), 698-703