Storage in an island grid

Jointly with SSE, MHI is installing a demonstration battery energy storage grid stabilisation system in the UK's Orkney Islands.

Mitsubishi Heavy Industries, (MHI), jointly with SSE plc (formerly Scottish and Southern Energy plc), is currently installing an energy storage system demonstration project connected to the power grid in the Orkneys, a group of small islands to the north of the UK mainland. The islands are highly suited to such a demonstation because they have a modest overall demand coupled to a supply with a high proportion of renewable energy generation, mainly wind, in relation to that demand.

The project aims at demonstrating power supply stabilisation in the islands by introducing a cargo container-type large capacity energy storage system based on MHI's lithium-ion rechargeable battery system. The installation, which will have a maximum power output capacity of 2 MW, is scheduled to be handed over for operational use in early 2013.

The demonstration project will be conducted with the support of the New Energy and Industrial Technology Development organisation (NEDO) of Japan, under its 'Development of Technology for Safe, Low-cost, Large-size Battery System' programme. In the project, Mitsubishi Power Systems Europe Ltd. (MPSE, MHI's power system operations in Europe), and SSE Generation, the power generation arm of SSE group, will provide the energy storage services to Scottish Hydro Electric Power Distribution plc (SHEPD), another SSE company that handles the group's power distribution business in Scotland.

Behind the project is a July 2010 agreement between SSE and MHI to collaborate in the development of low-carbon energy. The two companies have been studying a broad range of collaboration, including offshore wind turbine power generation systems, carbon sequestration and storage (CCS) and high-efficiency power generation systems. The two companies intend to further strengthen their collaborative relationship and hope to take a lead in what they recognise as the globally important drive to create a low-carbon society.

MHI's large high-performance lithium-ion batteries have been designed with power storage in mind. They have been developed for high capacity and power output, combined with long operating life, by optimising a new and original combination of the electrode elements, primarily the electrode materials, the separator, and the electrolyte. The battery structure was also put through the optimisation process – development work was carried out on shaping of the electrodes, the current collecting structure, outer package, and the manufacturing processes and methods, such as slurry mixing, battery assembly, and inspection. MHI completed the construction of its testing and mass production at the Nagasaki Shipyard and Machinery Works in November 2010, and started battery production.

Table 1. Salient characteristics, P140 battery

	P140	Notes
Nominal capacity	50 Ah	
Nominal voltage	3.7 V	
Voltage range	4.15–2.70 V	0.2°C, 25°C
Energy density by volume	266 Wh/l	
Energy density by weight	132 Wh/kg	
Dimensions (H×W×D) mm	166.5 × 109.9 × 38.0	
Operational temperature range		
Charge	0 to 50°C	
Discharge	-20 to 50°C	
Storage	-30 to 40°C	
Maximum current		
Continuous	100A	25°C
Instantaneous	300A	25°C, 10s
Cycle life	3500 or more	80% DOD @ 1°C
Self discharge rate	2% or less	per month
Weight	1.4 kg	

The energy storage system during installation

Operation

The storage system, which has a capacity of approximately 800 kWh nominal, and 500 kWh in normal usage, consists of two 40 ft-long container units for the batteries and a 40 ft-long container unit for the power conditioning system. Each battery container houses more than 2000 lithium-ion rechargeable units. The power conditioning system container houses an inverter and the associated input/output controls.

The system will be installed at SHEPD's Kirkwall power station. The islands' power grid is connected to the mainland via a submarine cable that in current use compensates for power shortage or power surplus by transmitting power to and from the mainland grid.

But when power available exceeds demand and the export capacity of the subsea link combined, renewable generation has to be constrained. The storage system will reduce the necessity for this constraint by importing at least some of the excess energy. MPS

The battery

The basic battery unit is designated MLiX and comes in two standard packages, the 50 Ah class P140 and the P060, capacity 20 Ah. In its industrially applicable maufactured form it is multiplied up in containerised packages.

Li-ion cells have several properties that fit them for use in power storage batteries. They are light and compact with a high energy density, can undergo rapid charge/discharge at high charging/discharging efficiencies stemming from low internal resistance, they exhibit no memory effect, and they can have a high operating life.

Component development

The goals aimed at were high voltage and high capacity, a high energy density to volume and weight, a high charge/discharge rate, and long service life. A lithium oxide combined with the appropriate transition elements, such as nickel, manganese, and cobalt, was selected for the positive electrode material. Optimisation of the negative electrode design resulted in the use of a natural graphite base, a high-strength separator, and additives to the electrolyte.

A flat-plate stacked structure of the electrode was found to achieve high charge/discharge rates, longer life, and a higher level of safety compared to a spiral structure by eliminating the stress difference generated at the inner/outer spiral electrode and at small radius positions caused by expansion/shrinkage of the electrode, and by directional heat transfer.

It turned out that a rectangle-shaped battery provided a better volumetric efficiency and energy density in a module or package compared to a round-shape. The aluminum metal case used for the external body, and the integrated resin forming with the lid and terminals, allowed a robust and completely sealed structure. Also, the use of direct air/water cooling produced high heat radiation efficiency leading to long-lasting reliability and life.

Generally speaking, a spiral electrode structure can be produced more efficiently than a stacked structure. To compensate for this MHI developed a fully automated production line that applies fast and accurate stacking and inspection technologies tailored specifically to the production of large stacked batteries.