March 10th, 2021

DOE Long Duration Energy Storage Workshop

Sodium-Sulfur (NAS®) Battery

Tomio Tamakoshi
<table>
<thead>
<tr>
<th><strong>Company Name</strong></th>
<th>NGK INSULATORS, LTD.</th>
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<tbody>
<tr>
<td><strong>Date of Establishment</strong></td>
<td>May 5, 1919</td>
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<tr>
<td><strong>Paid-in Capital</strong></td>
<td>69,849 Million Yen</td>
</tr>
<tr>
<td><strong>Representative Directors</strong></td>
<td></td>
</tr>
<tr>
<td>President</td>
<td>Taku Oshima</td>
</tr>
<tr>
<td>Executive Vice President</td>
<td>Hiroshi Kanie</td>
</tr>
<tr>
<td>Chiaki Niwa</td>
<td></td>
</tr>
<tr>
<td><strong>Number of Employees (consolidated)</strong></td>
<td>20,000  ※Outside Japan employees 61%</td>
</tr>
<tr>
<td><strong>Consolidated Subsidiaries</strong></td>
<td>55 companies  ※Outside Japan Subsidiaries 35</td>
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Principle of Sodium Sulfur Battery

- Sodium Sulfur Battery is a high temperature battery which the operational temperature is 300-360 degree Celsius (572-680 °F)
- Full discharge (SOC 100% to 0%) is available without capacity degradation.
- No self-discharge
- Best performed with long duration application for more than 6hrs.

Chemical Reaction

\[ 2\text{Na} + x\text{S} \rightarrow \text{Na}_2\text{S}_x \quad (\text{E.M.F}=\text{approx. 2V}) \]

Cell Structure

- Sodium (Na)
- Beta Alumina
- Sulfur

- Discharge
- Charge
- Load
- Power source

Cycle Life : 4500 full discharge
Calendar Life : 15 years
Round Trip Efficiency : 75-80%
Easy Installation with containerized system
Structure of NAS® Containerized Battery System

- High efficiency achieved by combination of vacuum thermal insulation and cooling
- Plug & Play battery of 20ft container with modules and battery management system

Battery Cell

- + terminal
- - terminal
- Pole (Sodium)
- Safety Tube
- Solid Electrolyte (Beta alumina)
- + Pole (Sulfur)

33kW Battery Module

- Battery Cells
- Sand
- Thermal Insulated Enclosure
- Radiant Heat Duct
- Main Pole
- Heater

Containerized Battery 200kW (1200kWh)

- 6 NAS Battery Modules
- 20ft Container
- BMS
- Battery Management System

Battery System 800kW (4800kWh)

- Containerized NAS Battery Units
- Power Conversion System
Safety of NAS® battery

- Anti-fire sheet applied to every cell prevents fire from propagating, even in the worst case of a cell catching fire.

- Japanese Fire and Disaster Management Agency (FDMA) defines the fire safety requirements for Sodium Sulfur batteries.
- Japanese Hazardous Materials Safety Techniques Association (HMSTA) witnessed the test and validated the testing methods and results.

Safety tests conducted on NAS module

- Cell ignition test

  - Molten material
  - Anti-fire sheet prevents fire from spreading to adjacent cells
  - No damage to the surrounding cells

- Short circuit
- Fire Exposure
  - After the Test

- Submerge
- Drop
  - 10ft
NAS® Battery Installations around the World

- Outstanding supply record in Large Scale Battery Energy Storage
  Total Installation Record of 600MW (4,100MWh)
- Annual Production Capacity 150MW (1GWh)

**Map of Battery Installations:***

- **Germany:**
  - 4.8MW
  - 1MW
- **Italy:**
  - 35MW
- **Abu Dhabi:**
  - 108MW
- **Dubai:**
  - 1.2MW
- **Reunion Island (FR):**
  - 1MW
- **Japan:**
  - 430MW
- **Canada:**
  - 1MW
- **California:**
  - 7MW
- **New Mexico:**
  - 1MW
- **Texas:**
  - 4MW
- **West Virginia:**
  - 7MW
- **New York:**
  - 1MW
- **Minnesota:**
  - 1MW

**Energy Applications:**

- Peak Shift (Load Leveling)
- Renewable, Grid Stabilization
- Frequency control
- Microgrid

**Total Installation Record of 600MW (4,100MWh)**

**Annual Production Capacity 150MW (1GWh)**
Example of Long Term Operation

- 1MW/7.2MWh NAS® Battery system is in operation since July 2012. (9 years)
- No major failure
- No battery replacement since commencement of system operation
- Maintaining enough capacity after 9 years of operation

1MW/7.2MWh NAS® Battery system at Catalina Island (SCE Pebbly Beach Generating Station)
50MW/300MWh NAS battery system

- 50MW/300MWh NAS® Battery start operation from March 2016.
- Main usage is to store over-generated PV energy and utilize it during nighttime.
- The system is intermittently operated to contribute to Load Frequency Control (LFC).

Buzen Power Plant, Kyushu Electric Power Company

- Store excess electricity from daytime.
- Discharge during nighttime

Solar generation
Charge
Non-Solar Generation
Demand
Discharge

50MW/300MWh NAS® Battery start operation from March 2016.
Main usage is to store over-generated PV energy and utilize it during nighttime.
The system is intermittently operated to contribute to Load Frequency Control (LFC).
108MW/648MWh NAS battery system

- 4 to 20MW size of NAS® Battery are installed in 11 substations in Abu Dhabi.
- Abu Dhabi has 1GW of PV to extend 6.5GW PV in 2026.
- 5.6 GW Nuclear power operation is planned from 2026.
- Energy storage will be necessary for frequency control and energy shifting.

UAE integrates 648MWh of sodium sulfur batteries in one swoop

One of the three 20MW NGK NAS (sodium sulfur) battery energy storage systems deployed as part of the project. Image: NGK Insulators / Google Maps.

Sodium sulfur (NAS) batteries produced by Japan's NGK Insulators are being put into use on a massive scale in Abu Dhabi, the capital of the United Arab Emirates.
NGK Battery Products

Nickel-Zinc Battery (ZNB)

High safety battery targeted for indoor usage currently under field test stage.

In addition, **Zinc-Air battery** under development.

EnerCera® Lithium-ion battery

Applications of EnerCera battery

- **Wearable Devices**
- **On-board power source**
- **Smartcard (Credit Card, ID Card)**

Coin and Pouch type lithium-ion rechargeable battery for smart card and various IoT devices.

(Commercialized)
END

URL : https://www.ngk.co.jp/nas/

Contact : NAS Battery Sales & Marketing, Energy Device Department, Energy Infrastructure Business Group

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Takayuki (Tak) Eguchi : eguchi@ngk.co.jp