



ENERGY STORAGE

NAS
Sodium Sulfur Battery

November, 2018
NGK INSULATORS, LTD.

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 - Wind Power Stabilization and Energy Time Shift
 - Solar Power Stabilization and Energy Time Shift
 - Frequency Control and Energy Time Shift
 - Hybrid Battery System

Outline of NGK Insulators, Ltd.



Established Year

1919 in Nagoya, Japan
(As the first Japanese manufacturer of ceramic insulators.)

Paid-in Capital

US\$ 0.6 Bil (69.8 billion Yen)

Number of Employees

18,737 (consolidated)

Consolidated Subsidiaries

58 companies

Annual Net Sales

US\$ 4.2 Bil (451 billion Yen) (as of March 2018, Consolidated)



NGK's diversified products are based on ceramic material & manufacturing technologies.

Power Business

Insulators for power transmission



NAS battery

Ceramic Business

Honeycomb ceramics for automobile

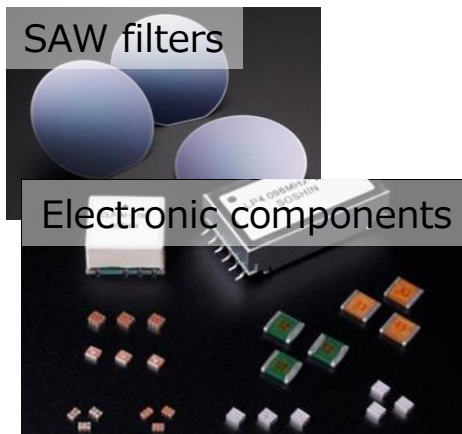


Diesel Particulate Filters

Electronics Business

SAW filters

Electronic components



Process Technology Business

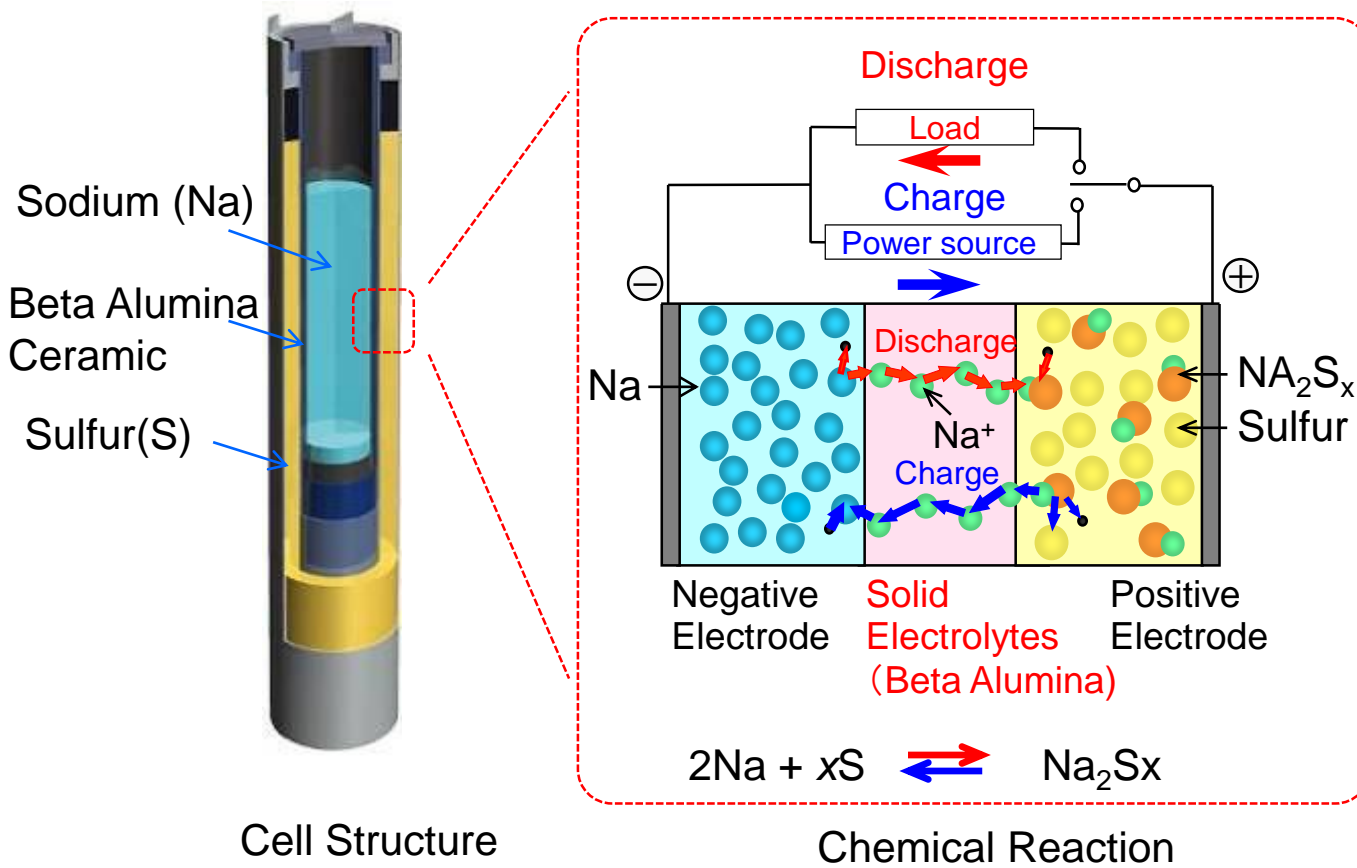
Semiconductor Manufacturing Equipment



drying systems

Structure of NAS Battery Cell

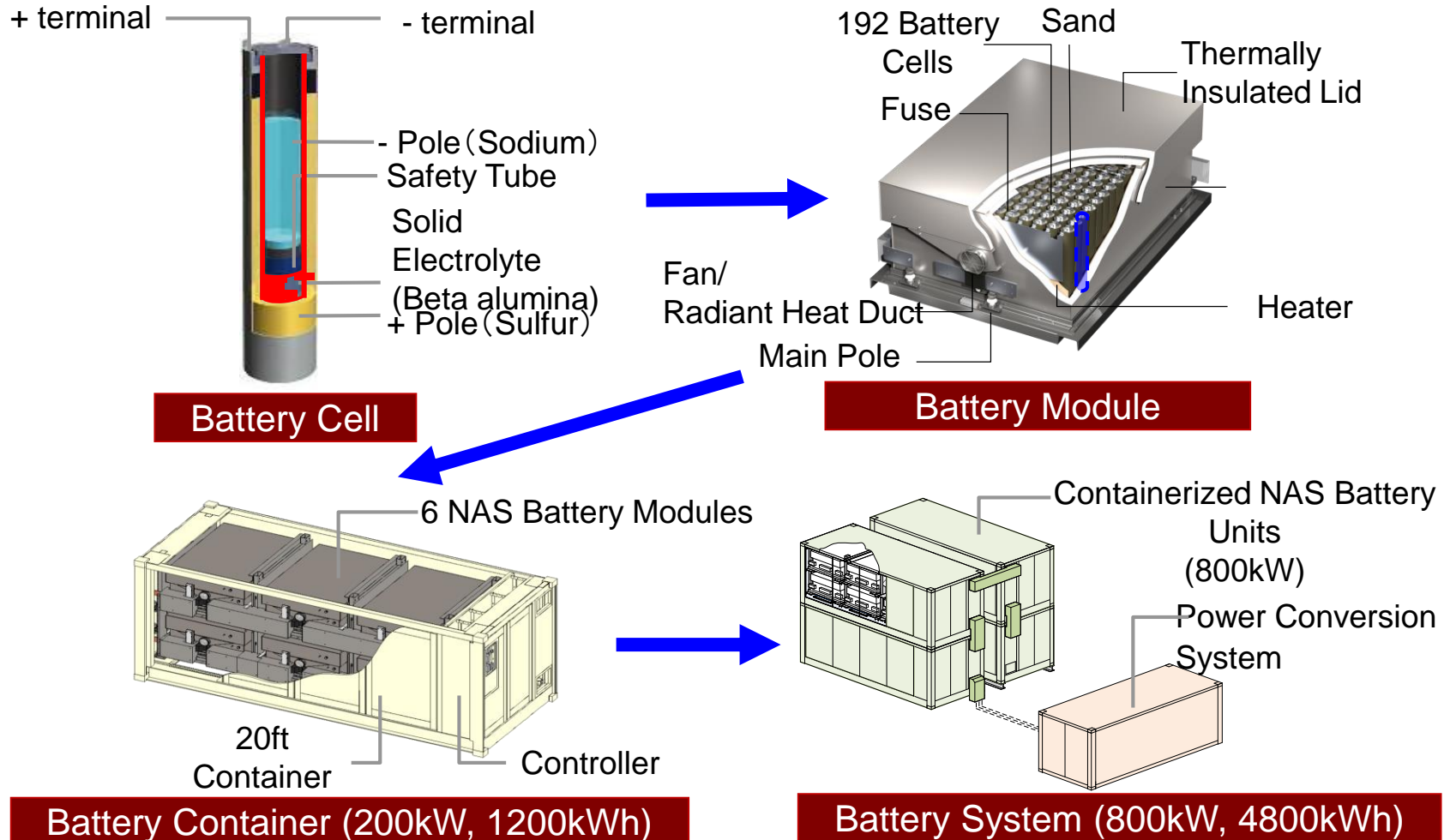
- Abundant material, Sodium and Sulfur, are used for active material of NAS Battery.
- Beta Alumina Ceramic Tube is the key part of NAS Battery.



Beta Alumina Ceramic

Structure of NAS Battery System

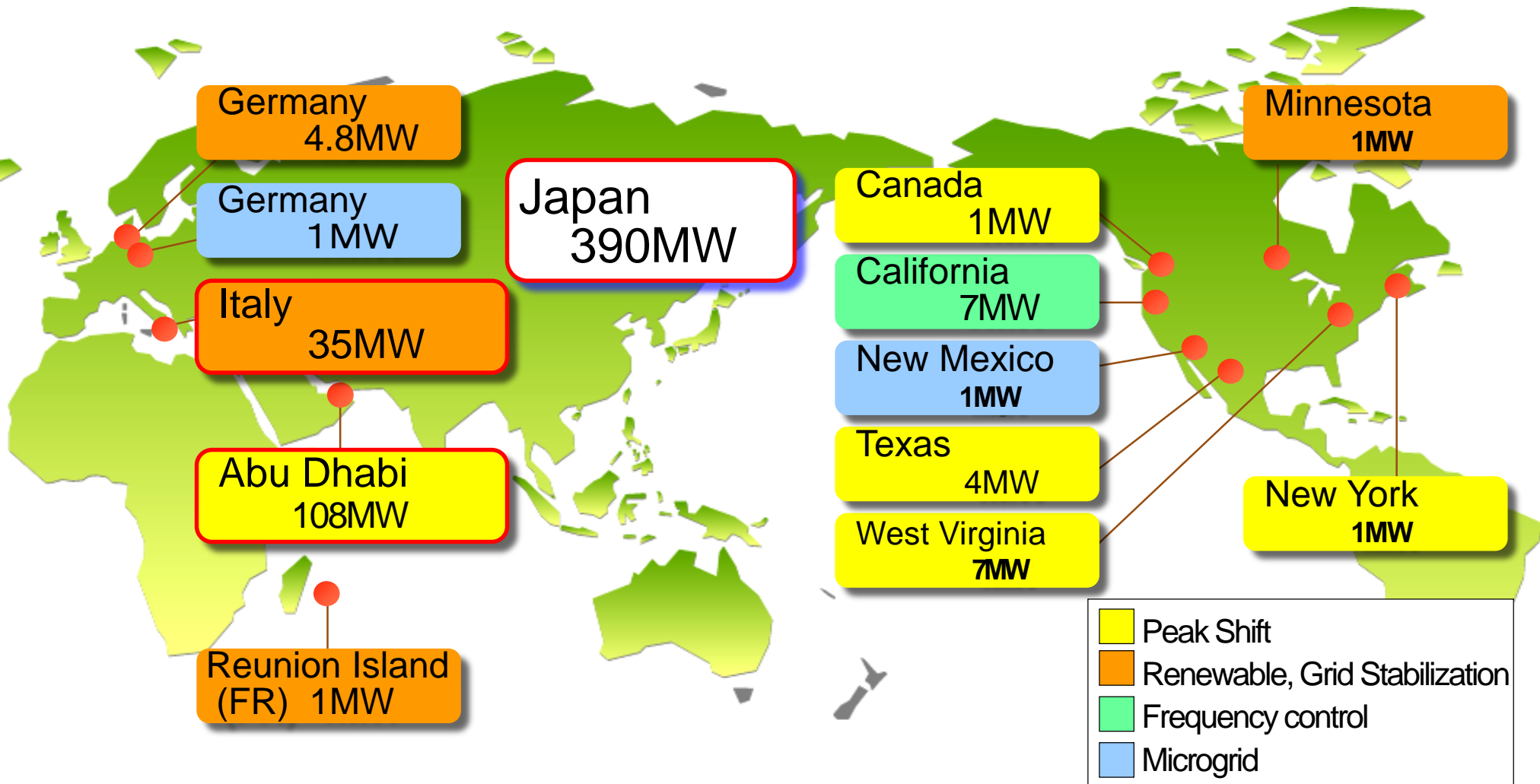
- **Containerized system** minimize the transportation and installation cost.
- NAS battery **can be used at high temperature area** because inside of Battery Module is high temperature.
- NAS Battery **can be recycled** after the end of battery life.



- Long Duration
 - Can store energy up to 6 hours
- Compact Layout
 - 3 times energy density compared to lead acid battery
- Fast Response
 - Prompt response – full power charge to discharge in 2 milliseconds
- High level of reliability
 - Uses ceramic for electrolyte. No self discharge, superior long term durability
- High level of safety
 - Multiple safety features and quality control incorporated to ensure safety
- Easy to install and relocating
 - “Plug & Play” Containerized NAS Battery is available
- Easy Maintenance
 - Minimal planned maintenance required. Remote operation

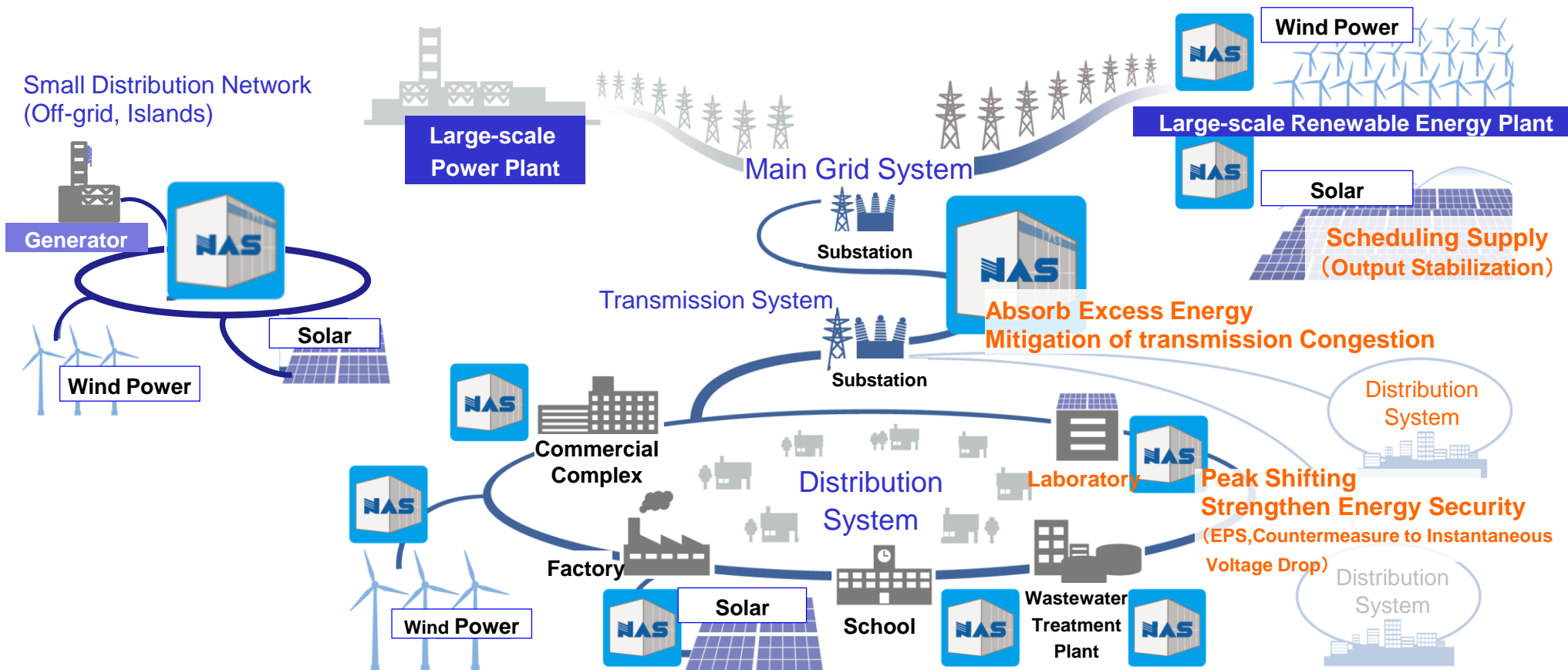
NAS Battery Installations Around the World

- Outstanding supply record in Large Scale Battery Energy Storage
Total Installation Record of 560MW(4,000MWh)
- Annual Production Capacity 150MW(1GWh)



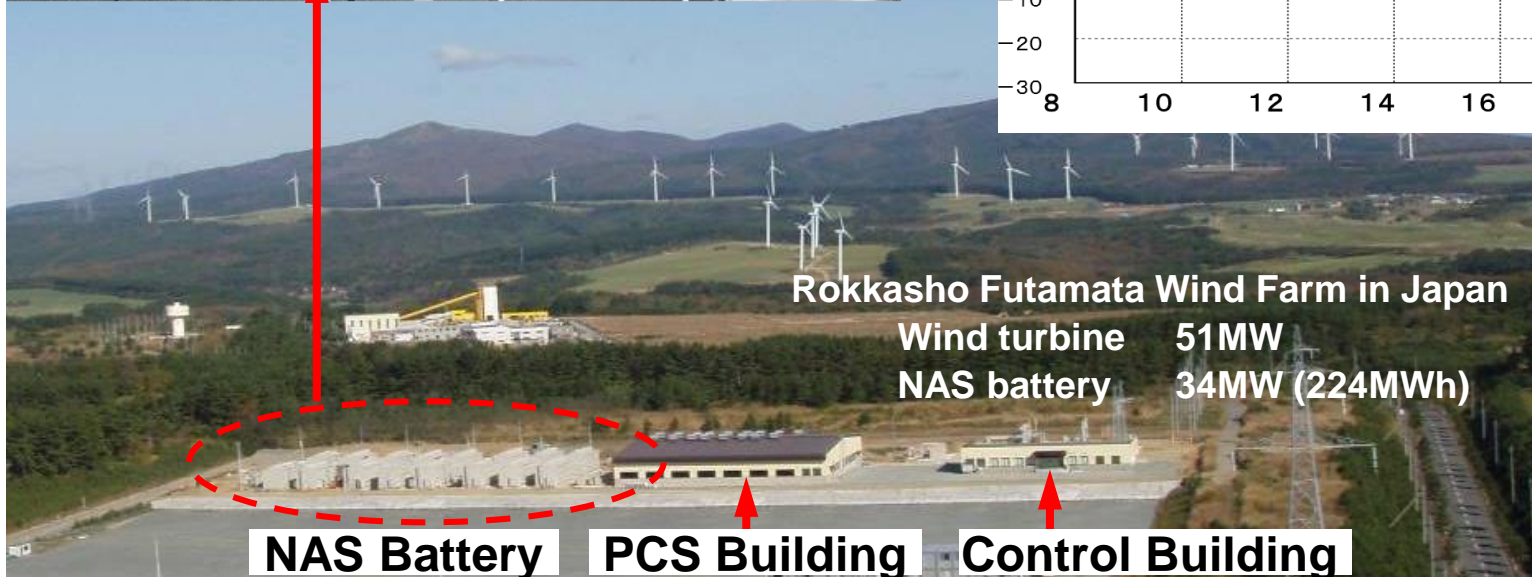
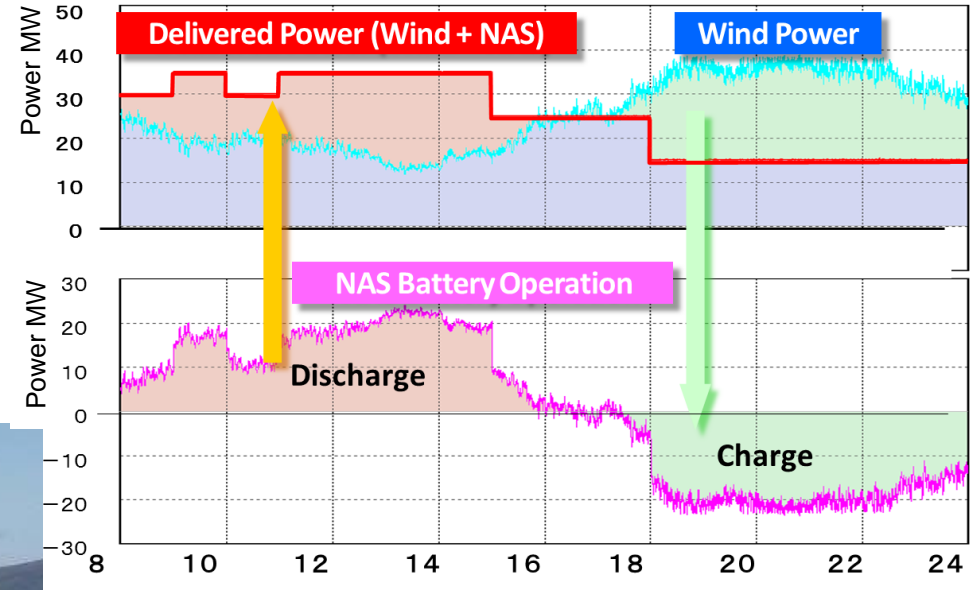
Various applications of NAS Battery System

- NAS Batteries are used at **renewable generation site**, transmission line, substation and behind the meter (consumer).
- NAS Battery is useful for **energy time shifting, stabilizing renewable energy, adjusting demand & supply and backup power supply.**



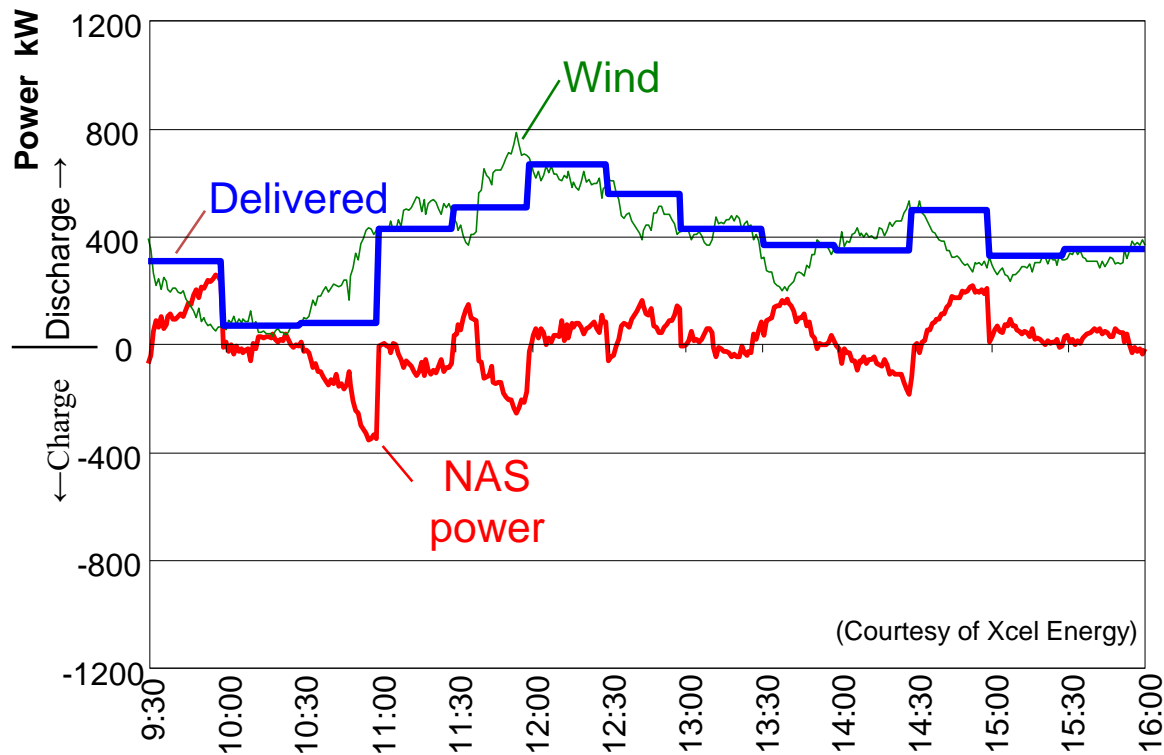
Wind Power Stabilization and Energy Time Shift – Rokkasho

- NAS Battery absorb the fluctuation of output power from wind generator and time-shift the energy.



Wind Power Stabilization – Xcel Energy

- NAS Battery **absorbs the fluctuation** of output power from wind generator.
- The combined power from wind generator and NAS Battery is **constant in 30 minutes time block**.



Example of Leveling Wind Power

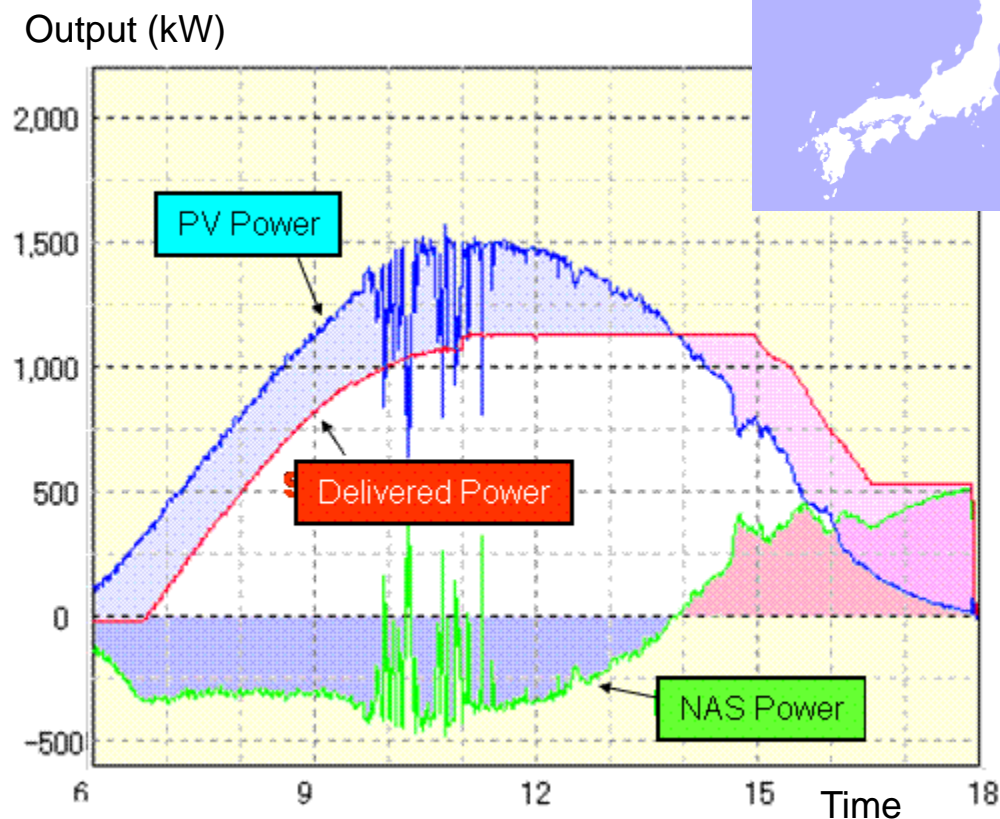


NAS Battery system for Xcel Energy (1MW, COD 2008)

(Courtesy of Xcel Energy)

Solar Power Stabilization and Energy Time Shift – Wakkanai

- NAS Battery absorb the fluctuation of output power from PV and time-shift the energy.



Example of Operation pattern

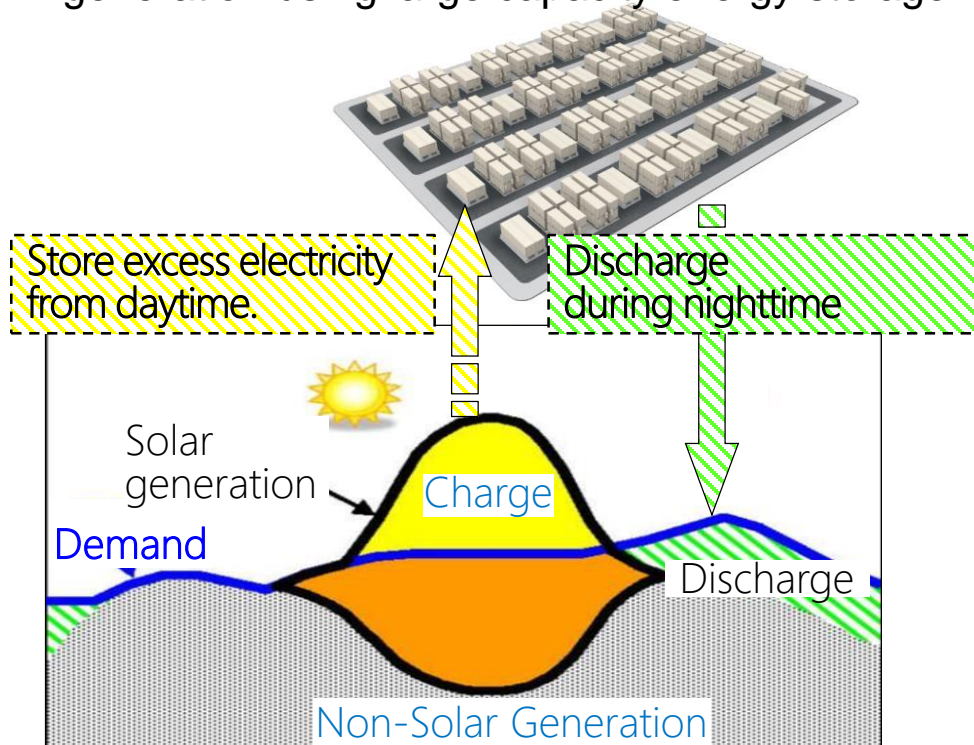
Financed by NEDO
(New Energy and Industrial Technology Development Organization)

Solar Energy Time Shift – Buzen, Kyushu

- Planned PV connections to the grid were suspended due to over-generation problem. The government of Japan decided to install large scale battery in a short project schedule.
- NAS battery (50MW/300MWh) was **successfully deployed only in 10 months after order.**

■ Improving Demand-and-Supply balance of solar generation using large capacity energy storage.

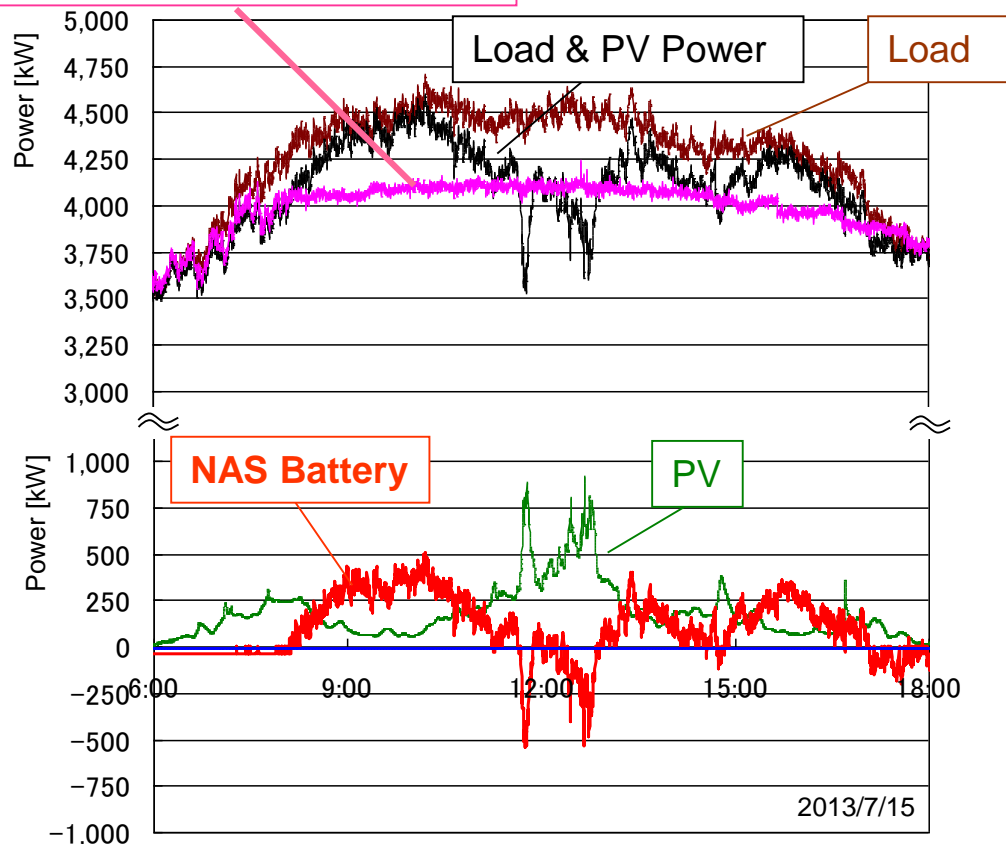
■ Start of Operation March 3, 2016



Solar Power Stabilization – Los Alamos

- Fluctuation of “Load & PV power” is leveled by NAS Battery.
- Output power of NAS Battery is controlled by EMS to level “Power Flow at Tie-Line” (connecting point of the internal feeder and the external power grid).

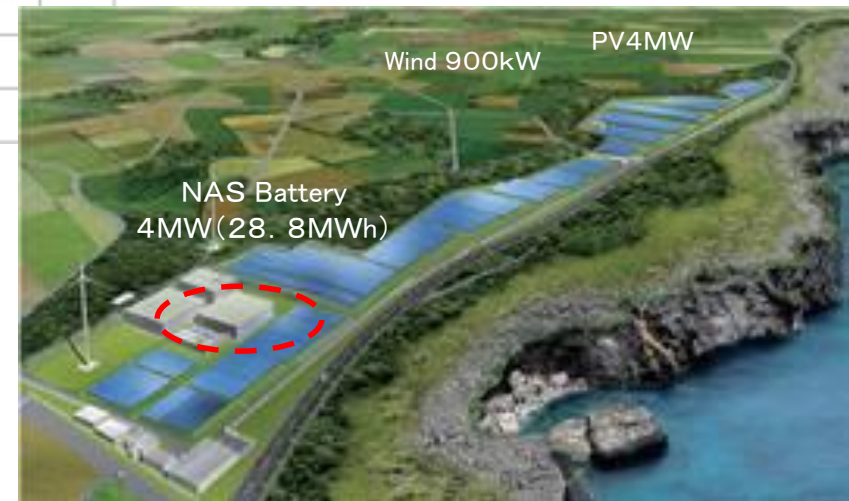
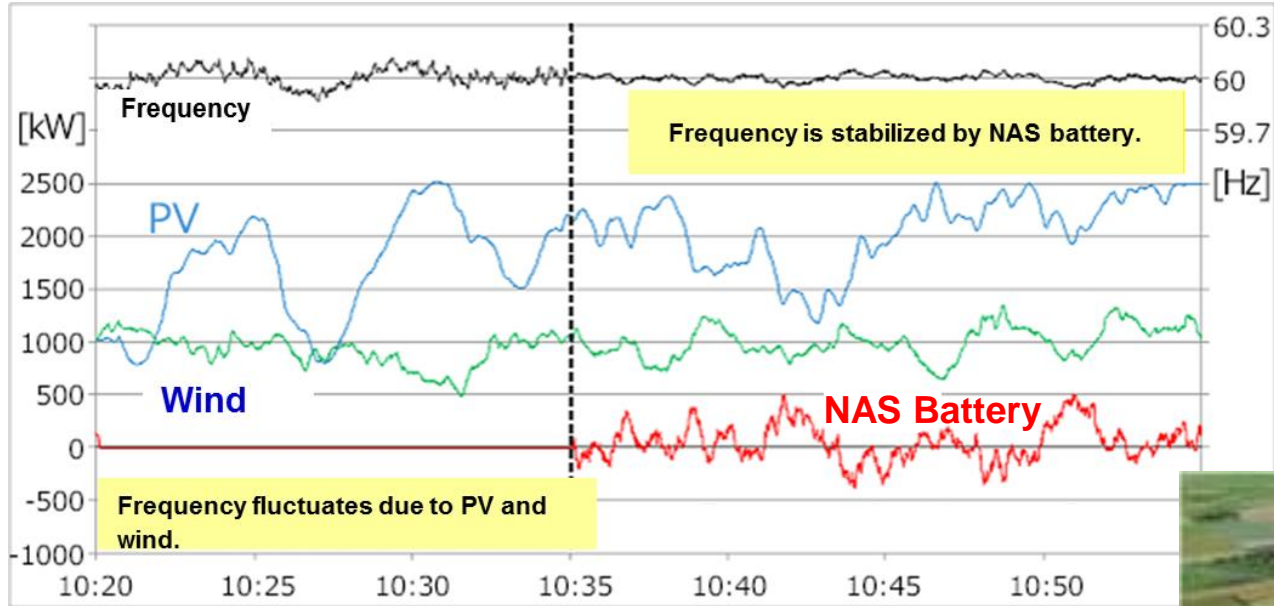
Power Flow at Tie-line
(Load & PV & NAS Battery)



NAS Battery system for Los Alamos
(1MW, COD 2013)

Frequency Control and Energy Time Shift – Miyako

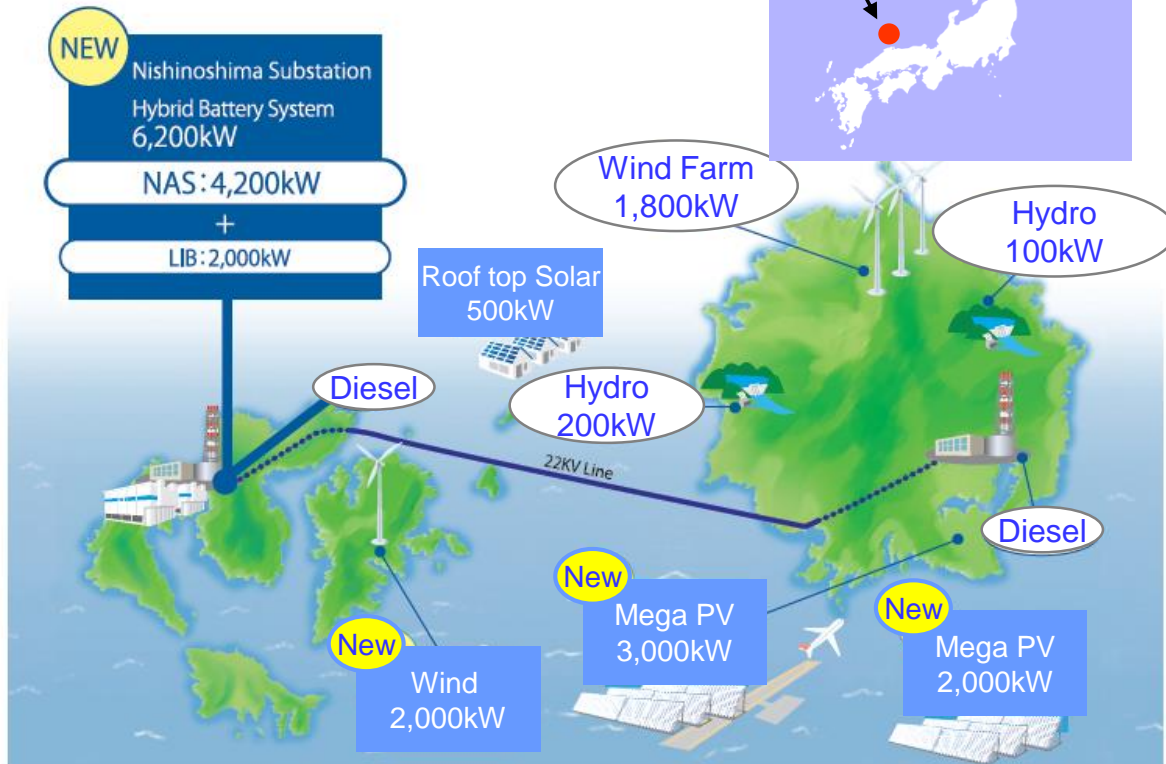
- NAS Battery **stabilizes grid frequency** in remote island.
- NAS Battery also **shifts energy** and **absorbs surplus PV output** during daytime.



Hybrid Battery System - Oki

- Hybrid system of 4.2MW NAS battery and 2MW Lithium-ion battery enables to install additional 8MW of renewable energy.
- Even though NAS battery can absorb both long and small fluctuation caused by solar and wind power, the hybrid system is also an effective solution in some cases.

Size of Oki Islands: 346KM²
Population: 25,000 people



4.2MW of NAS[®] Battery System



2MW of LiB System

1. NAS Battery is reliable and effective battery to store large amounts of electric energy by using well-established ceramic technology.
2. NAS Battery is systematically integrated in ocean container. It is easy to install, operate and maintenance.
3. The capability and durability of NAS Battery are proven by abundant field experiences.
4. By integrating NAS Battery and renewable energy power sources, stable, clean and low cost power can be supplied.



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