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Webinar on Rechargeable Battery Development and Evaluation for Energy Storage

Stabilizing Renewable Energy Supply with Sodium-Sulfur Batteries: A Path to Carbon Neutrality



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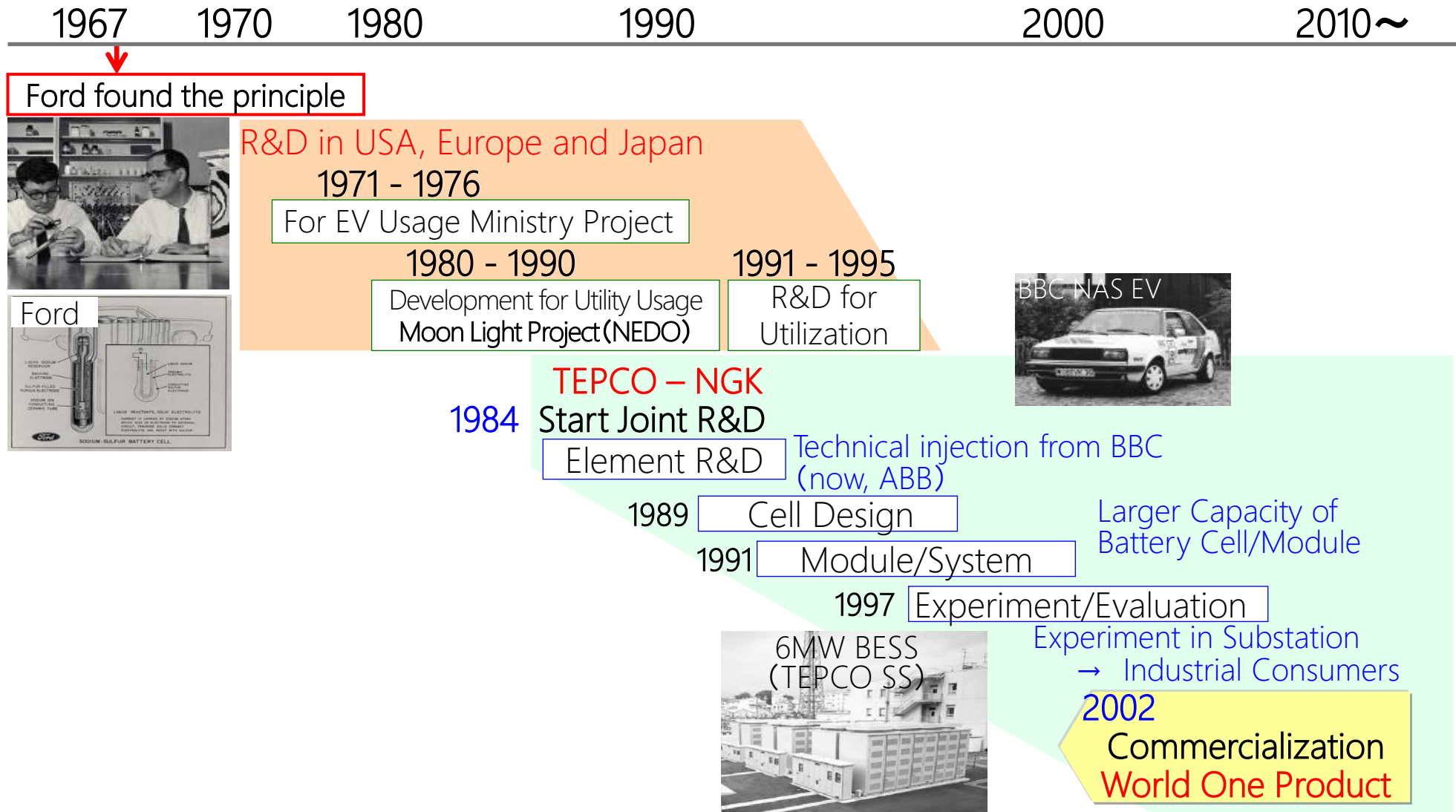
*** NAS[®] Battery: NGK's Product Name for Sodium Sulfur Battery**

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History of NAS[®] Battery Development

- NGK started R&D of NAS battery with TEPCO in 1984 and commercialized it in 2002.

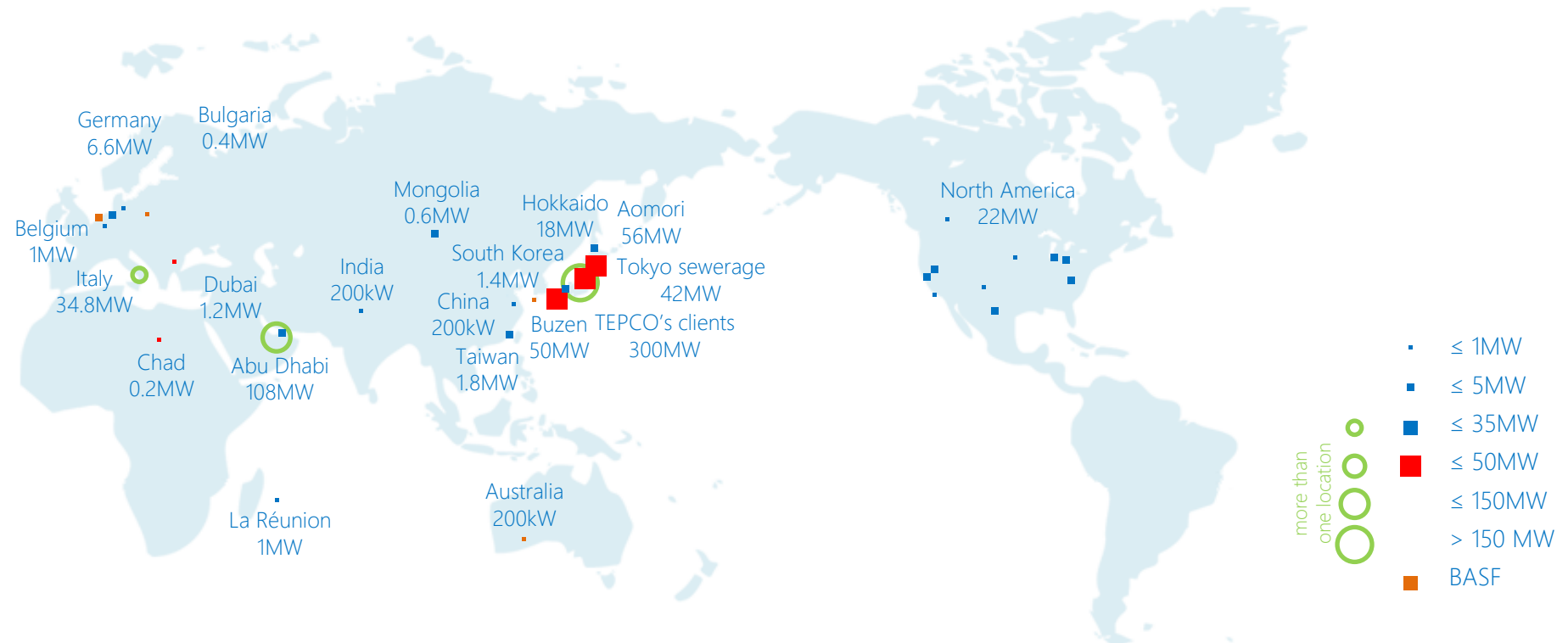


Supply record around the World

720 MW / 5 GWh

Domestic (Japan) Total 540MW

Overseas Total 180MW



Movie: about NAS[®] Battery



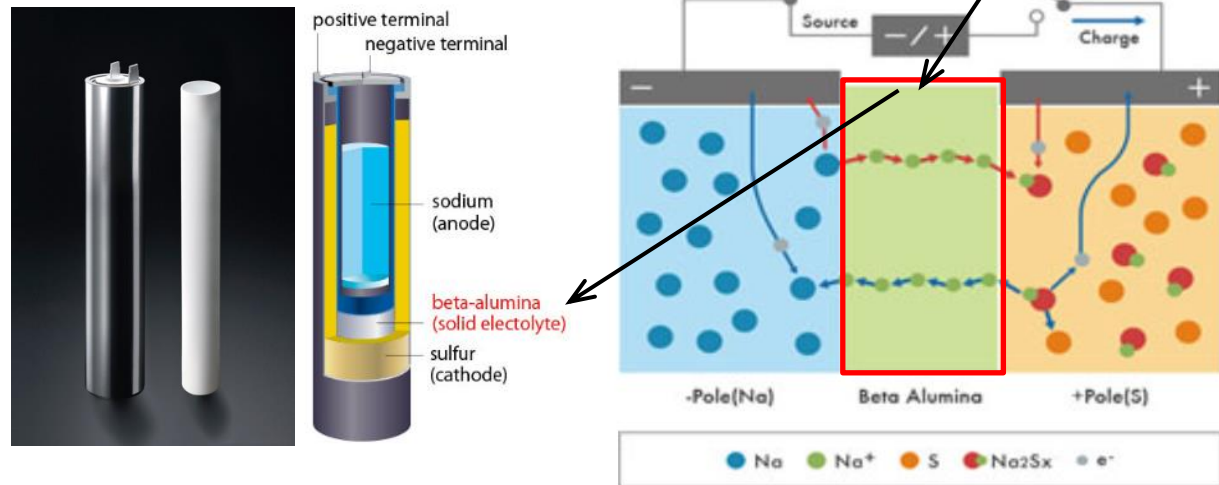
Surprising Ceramics.

Features of NAS[®] Battery Energy Storage

- Proven energy storage technology for high power, large energy capacity.
- Fully commercially available technology (large manufacturing capacity)
- Uses only common materials (Sodium and Sulfur, No rare materials used)

Principle

- Charge and discharge by chemical reaction between Na/S electrode
- Beta Alumina ceramics tube is a key component.

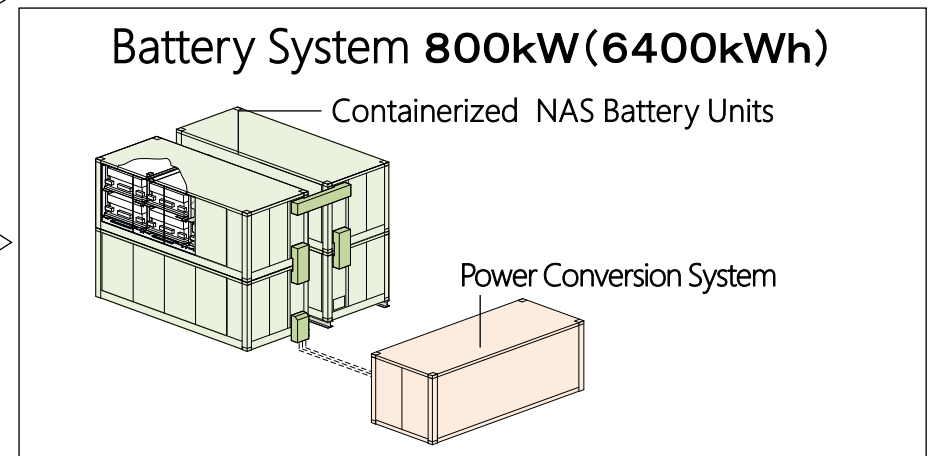
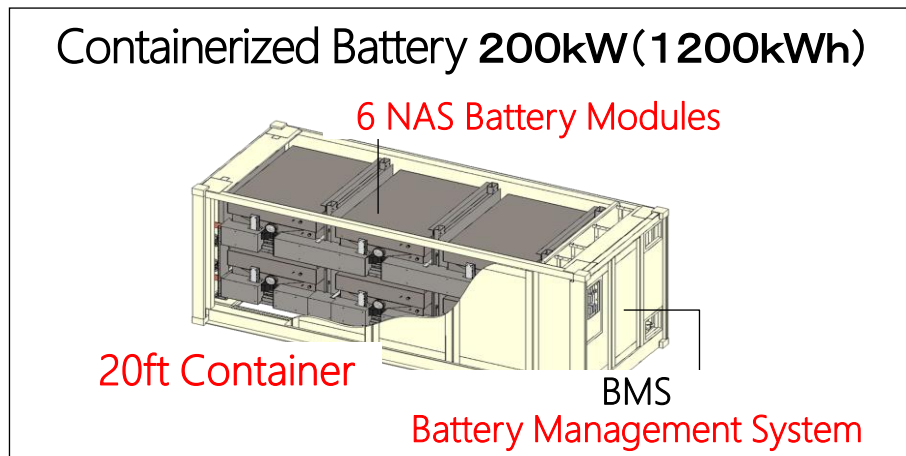
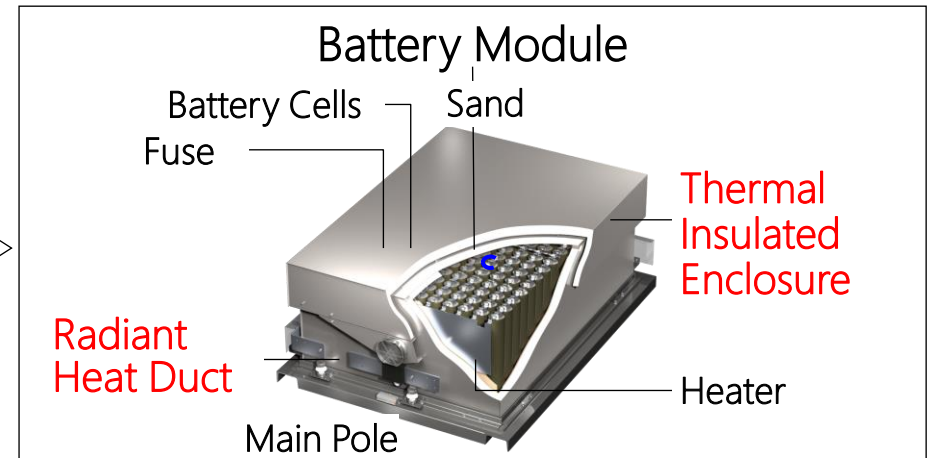
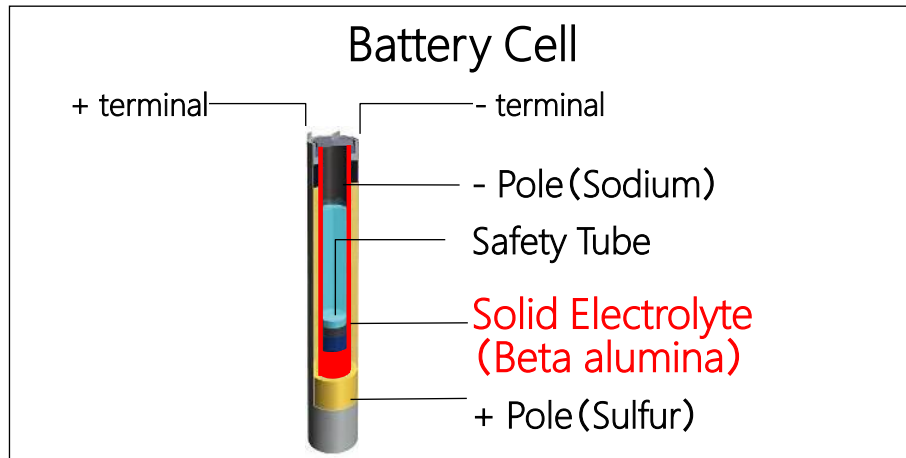


Superior performance

Large capacity	• Long discharge duration with high energy density
Long life	• 20 years, 7,300 cycles life expectancy
High reliability & Proven safety	• Ample supply record (Approx. 720MW) with 20 years field experience • UL1973 certified (Cell & Module), UL9540A test report (Cell, Module, Installation),
High environmental resistance	• Operational ambient temperature : From -20 to +45°C (Optional: From -40 to 55°C) • No need of cooling system for battery, No influence from ambient temperature

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



Structure of Container-Type NAS Battery

- Plug and Play battery, released in 2015
- Minimized heating power
- Stackable by two containers
- Minimum system size 1.45MWh subunit, up to four 1.45MWh subunit unit can be connected in series



5.8MWh Subunit	1.45MWh Subunit x 4 sets
	Weight: 84 ton Floor Load 2.8 ton/m ²

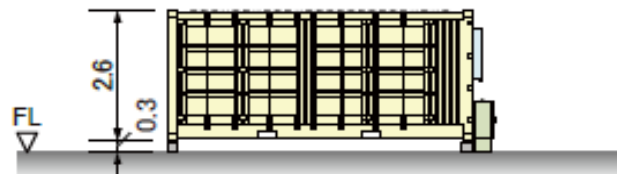
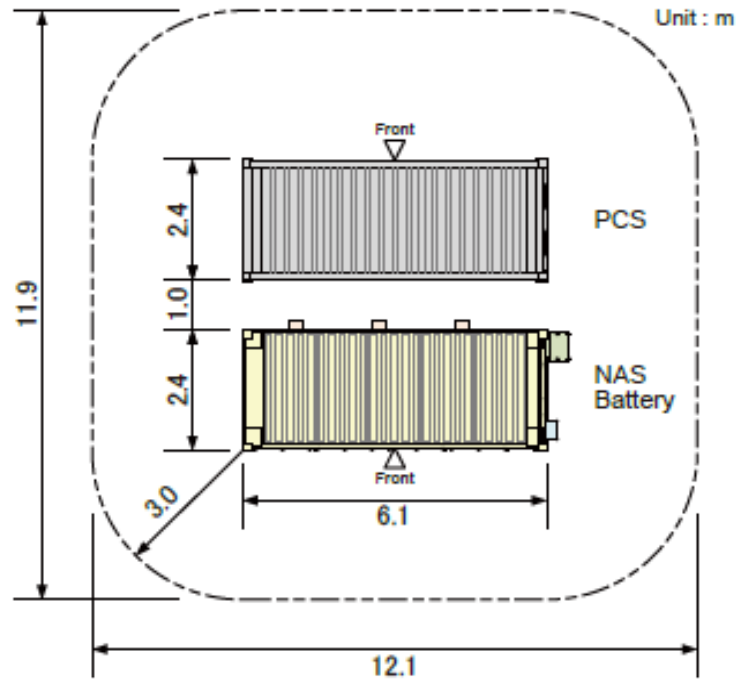


Battery Controllers

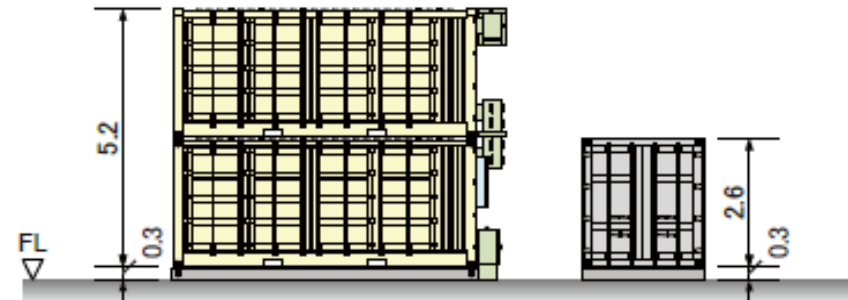
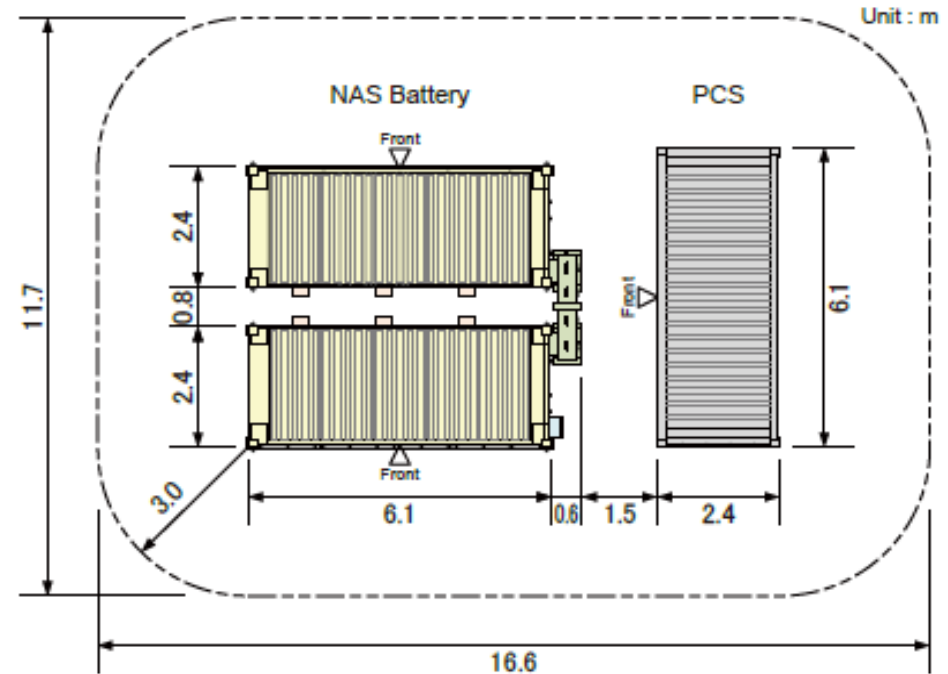


Typical Layout of NAS[®] Battery

1.45MWh Subunit



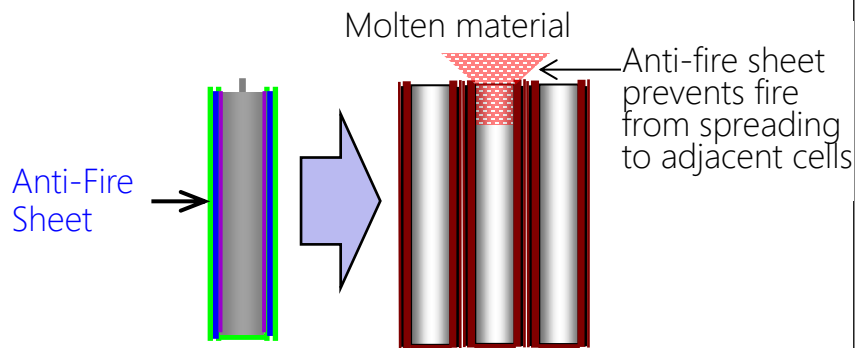
5.8MWh Subunit



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; thermal runaway.

- 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



Cell ignition test



No damage to the surrounding cells

Safety tests conducted on NAS module

Short circuit



Fire Exposure



Submerge



Drop



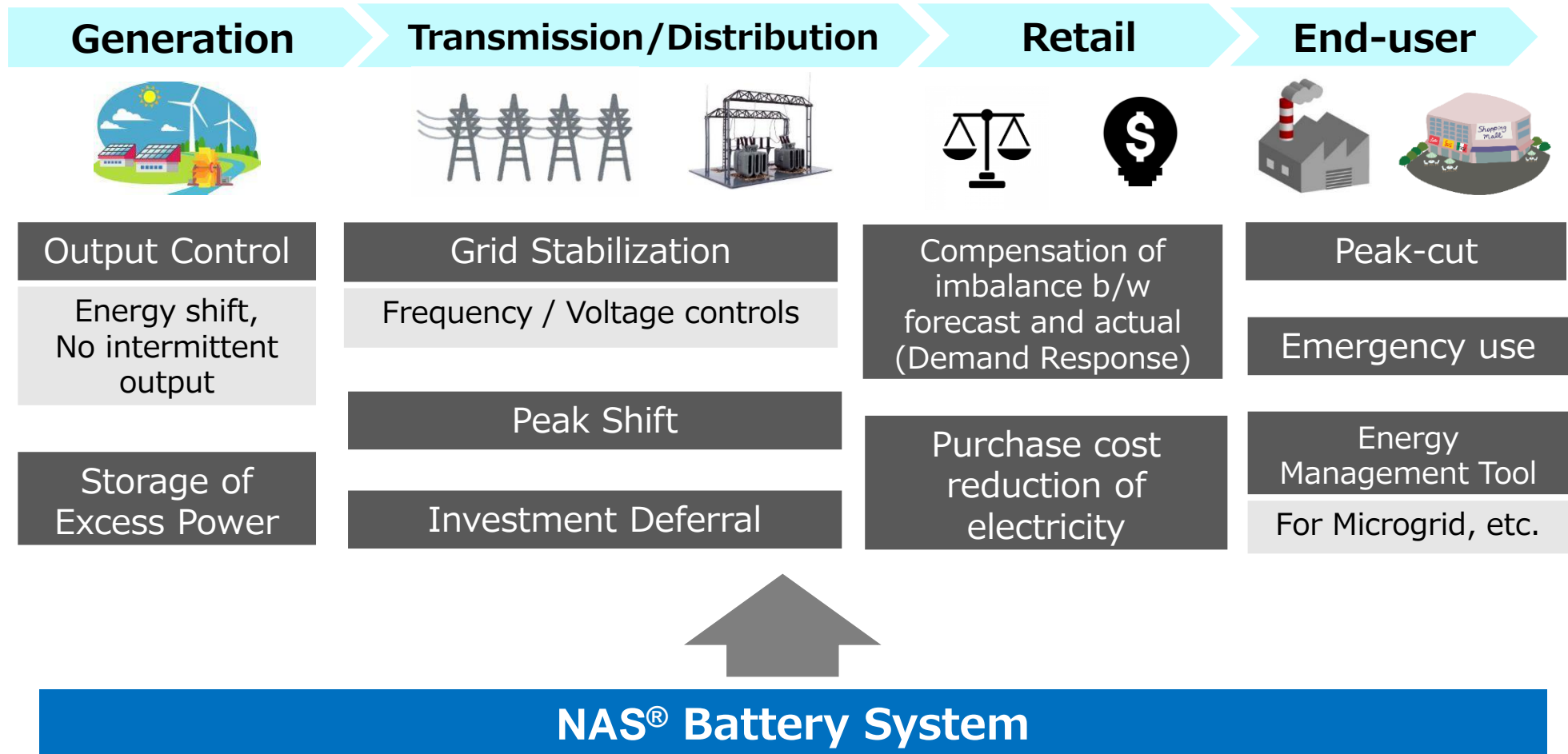
After the Test



- UL9540A test reports have been obtained at cell, module, and installation level.

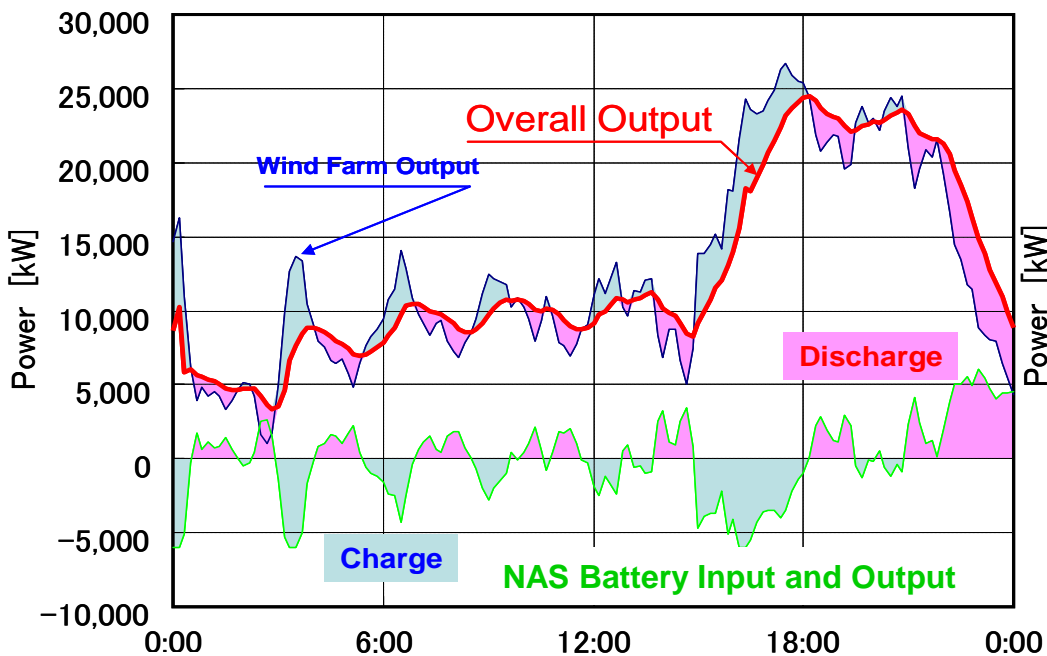
Various applications of NAS[®] Battery System

- Multi-tasks can be applied to various customers with NAS[®] Battery, having ample service experiences/records even in harsh environments.



Renewable Energy Applications

- **Smoothing operation** : Absorbing short-time fluctuations
→ Reduction of regulating power by fossil fuel.
- **Flat operation** : Firm capacity can be supplied as scheduled.

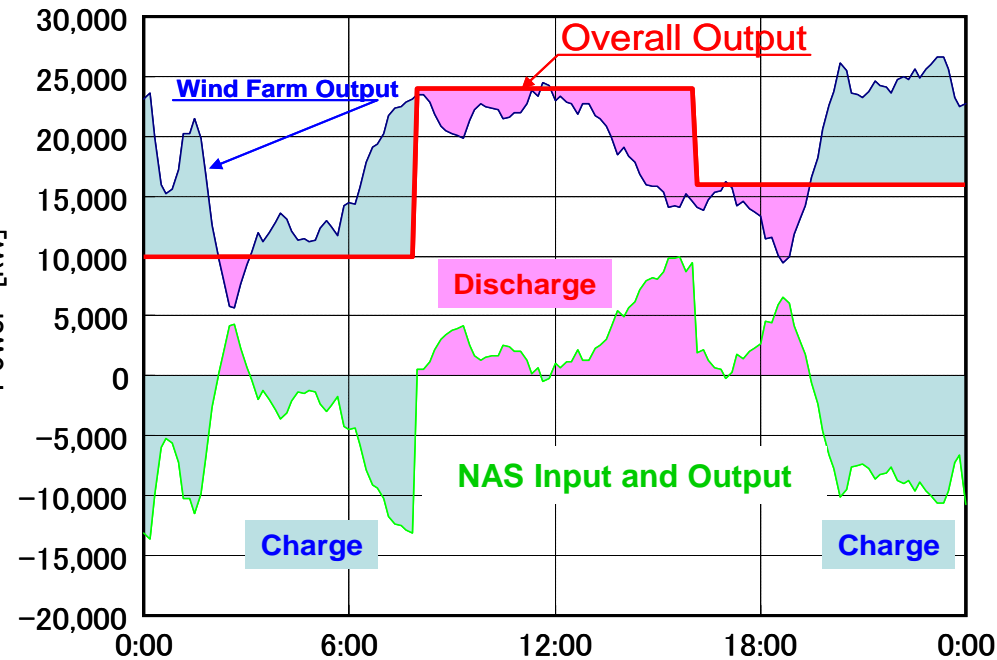


Smoothing Operation

Simulated Condition

- Wind Farm: 30MW
- NAS Battery: 6MW (36MWh)

NAS: 1/5



Flat Operation

Simulated Condition

- Wind Farm: 30MW
- NAS Battery: 20MW (120MWh)

NAS: 2/3

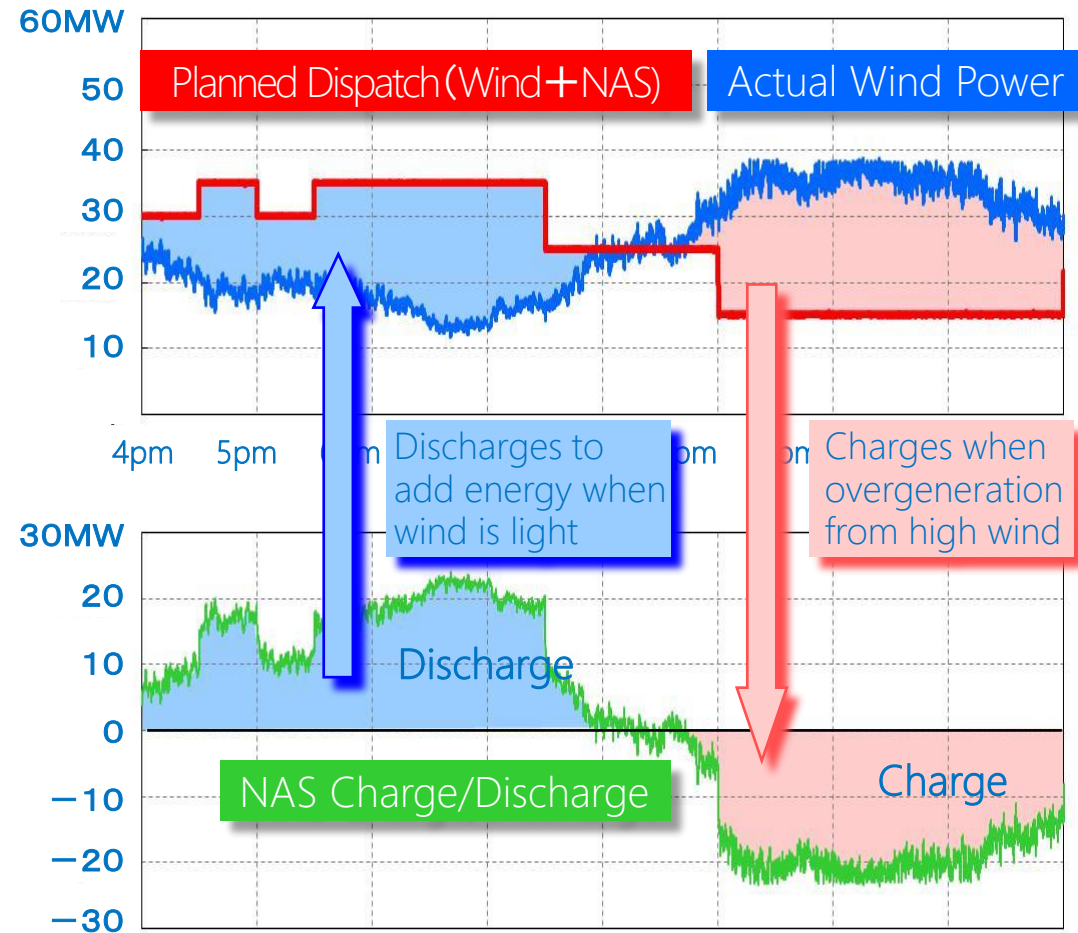
Scheduled Supply of Wind Power (Rokkasho Japan)

- Huge introduction of wind power causes **imbalance of supply and demand for 24h**
- **Energy Type Battery** makes the wind power stable & schedulable, more environmentally friendly by load following and energy shift.

Wind Generating Station
(e.g. Rokkasho Wind Farm, Japan, 100MW)



Battery Station
(e.g. NAS Battery, 56MW/370MWh)



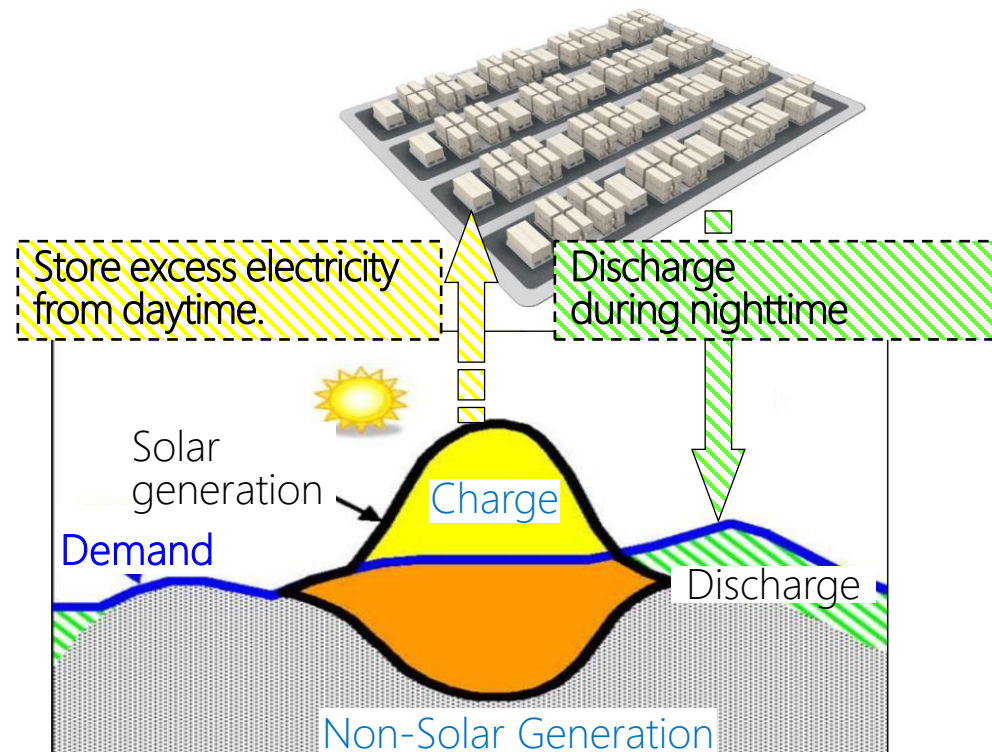
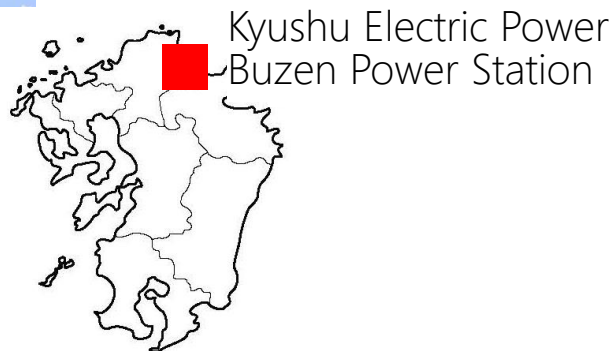
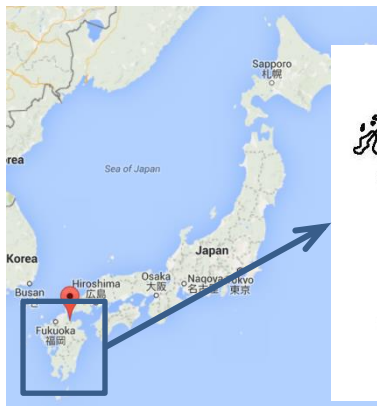
Absorb Over-generation (Kyushu in Japan)

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

◆Planned Equipment

Output Power	50MW
Energy Capacity	300MWh
Start of Operation	March 3, 2016
Location	Buzen city, Fukuoka pref.

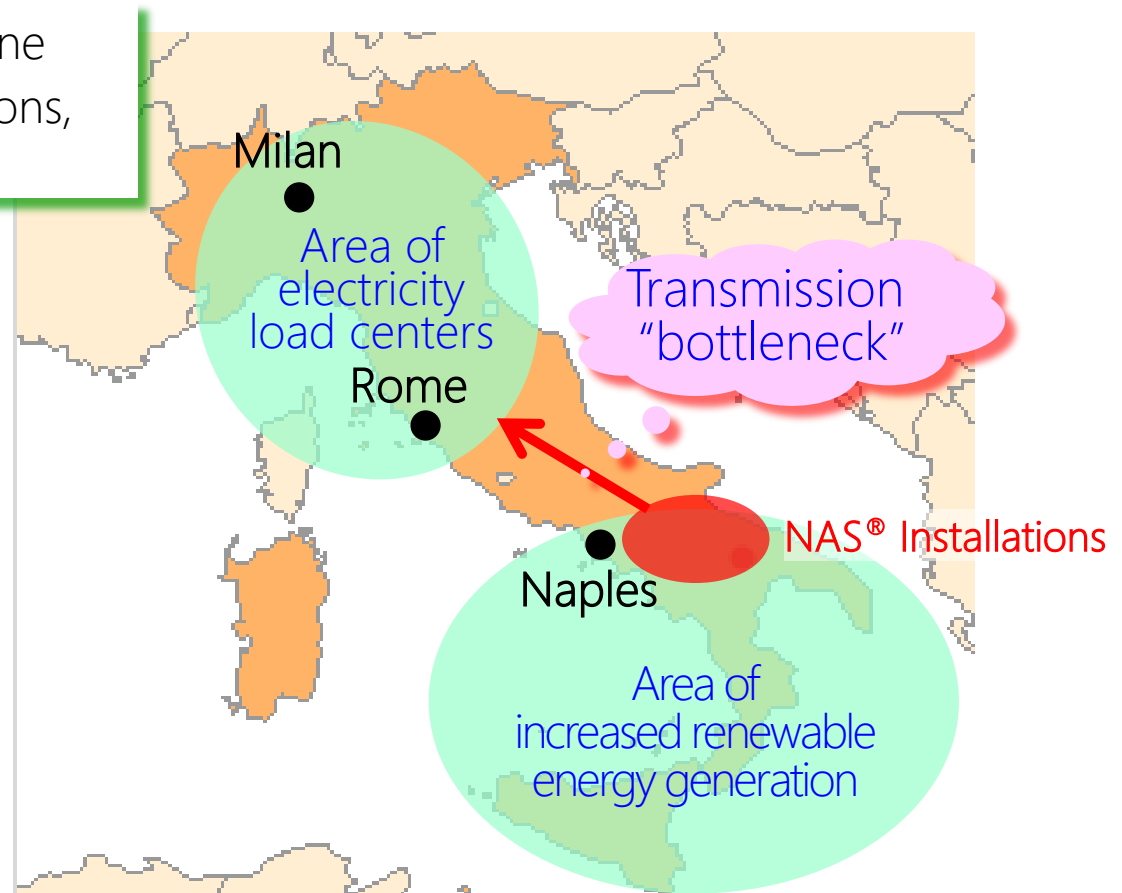
- ◆Improving Demand-and-Supply balance of solar generation using large capacity energy storage (Image).



Mitigation of Transmission Congestion (Italy)

- Fast and massive growth of renewable energy in south region could not be transmitted to electrical load center in north due to transmission bottle neck.
- NAS[®] Battery optimize integration of renewable energy and reduce transmission congestions, and allow investment deferral of new transmission line.

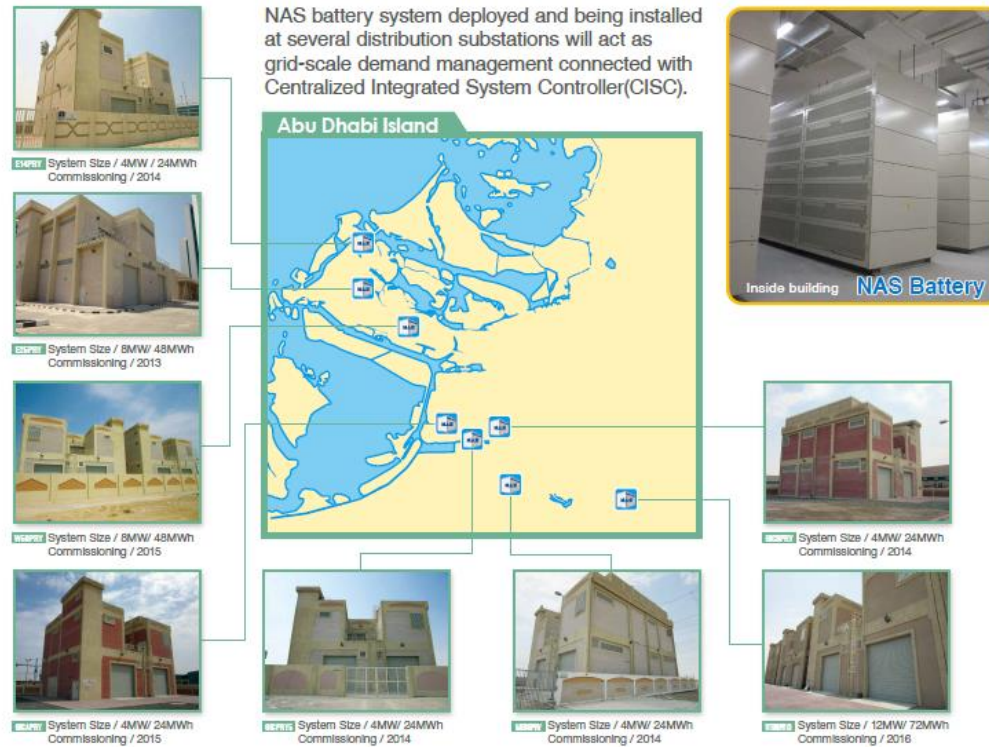
NAS[®] Battery connected to transmission line in Italy. Total 35MW/230MWh at 3 substations, Commissioned in 2015.



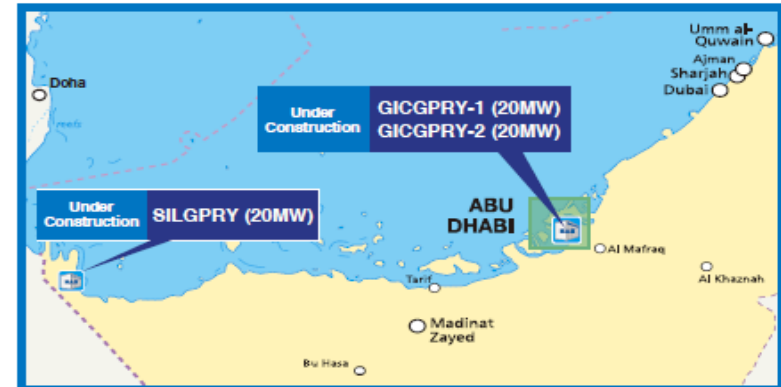
Grid-Scaled Load Leveling (Abu Dhabi in UAE)

- NAS[®] Battery (648MWh/108MW) distributed in 10 sub-stations (4-40MW/site) can work as a grid-scaled demand management system through Centralized Integrated System Controller (CISC) supplied by NGK for Virtual Power Plant.

1st 48MW



2nd 60MW



Centralized Integrated System Controller (CISC)



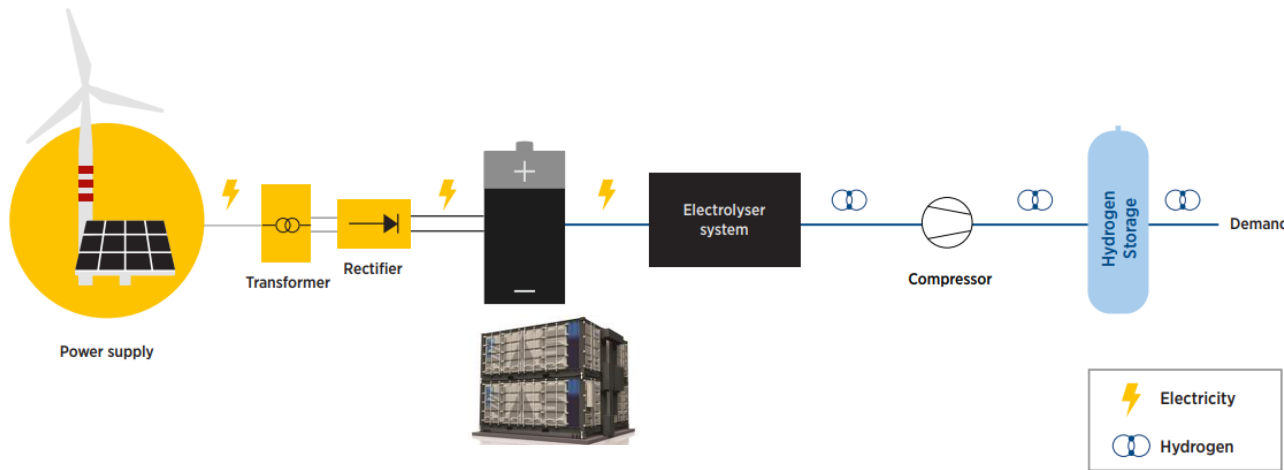
Commission Starting from Dec. 2009 and completed Aug. 2018.

Usage Load leveling, Frequency control

Application for Green Hydrogen Production

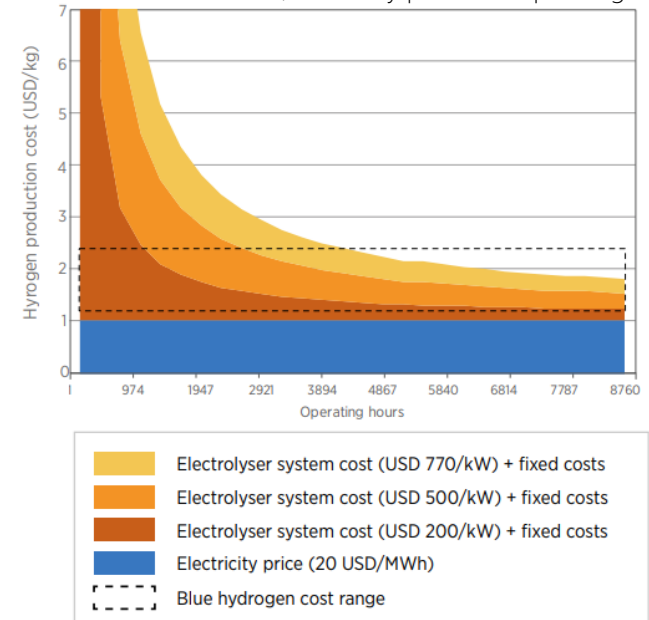
- Cost of green hydrogen production will be cheaper when continuously produced.
- By combining PV with our NAS[®] battery, hydrogen production equipment can be operated for 24/7, and then it will achieve higher efficiency of green hydrogen production and lower cost.

Figure 15. System schematic for green hydrogen production facility that includes electricity and hydrogen storage on site.



Based on IRENA analysis.

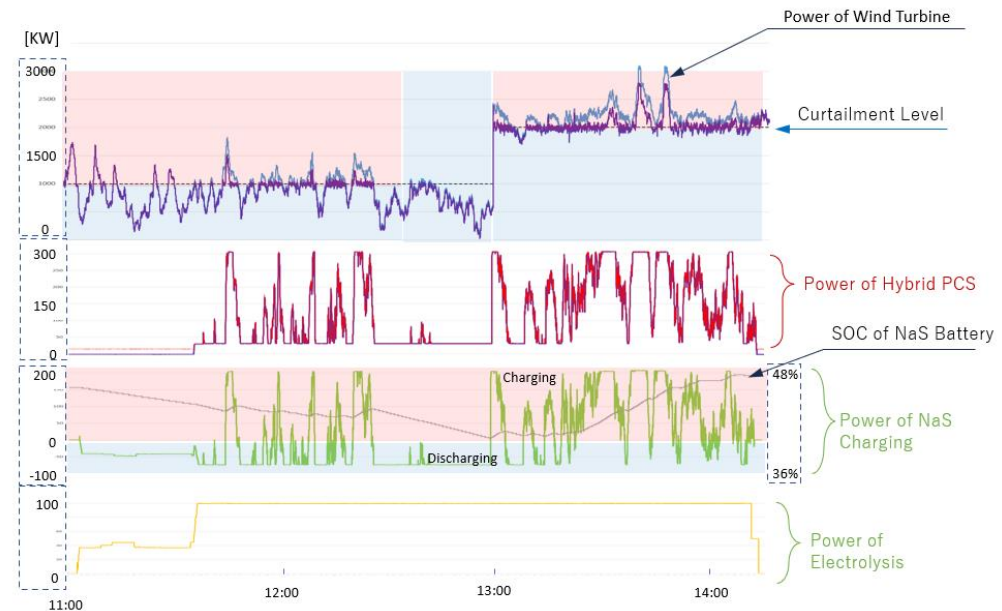
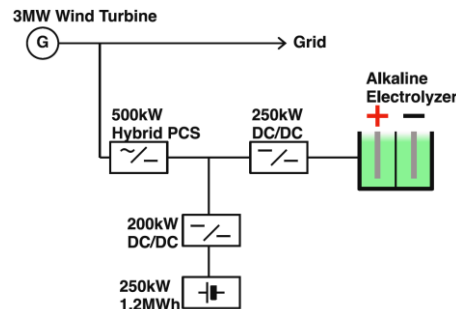
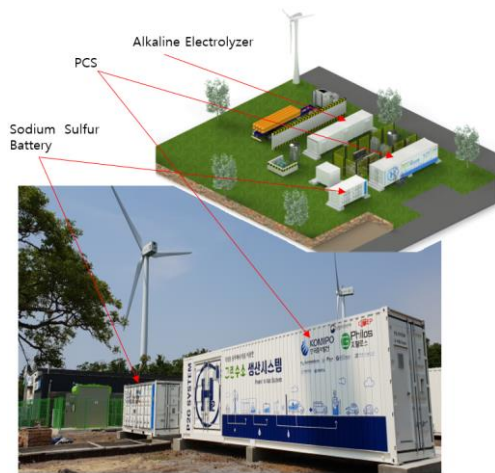
Figure 1. Hydrogen production cost as a function of investment, electricity price and operating hours



Note: This slide is made by NGK with reference to IRENA's Green hydrogen cost reduction (Dec.2020) and some modifications.

Green Hydrogen Production demonstration in Korea

- BASF New Business GmbH and the leading Korean P2G system company G-philos started green hydrogen production in 2020.
- NAS[®] battery keep the power to electrolyzer constant to decrease degradation in electrolyzer.



Global Sales Partner (since June 2019)



NGK INSULATORS, LTD.



Joint Press Release

BASF and NGK enter into sales partnership agreement for NAS[®] battery

Nagoya, Japan and Ludwigshafen, Germany, June 11, 2019 – Japanese ceramics manufacturer NGK INSULATORS, LTD. (NGK), and BASF New Business GmbH (BNB), a wholly-owned subsidiary of the German chemical group BASF today announced the conclusion of a sales partnership agreement (SPA). The agreement gives BNB non-exclusive rights to sell NGK's NAS battery via BASF's global channels. Both partners expect a synergistic effect from the broad business activities of the other.

Reference projects



For BASF Antwerp Verbund site in Belgium
1,000kW-dc(max.power)/6,000kWh-dc@BOL



For G-Philos/Jeju Island in Korea
208kW-dc(max.power)/1250kWh @BOL

*BASF New Business GmbH has changed its name to BASF Stationary Energy Storage GmbH

<https://www.basf.com/global/en/who-we-are/organization/group-companies/BASF-Stationary-Energy-Storage-GmbH.html>

Summary of NAS[®] Battery

- NAS[®] Battery can be utilized in many applications to maintain and increase grid security, even though the surging installation of instable renewable energy. So, **combination of NAS[®] Battery and renewable energy is one of the optimal path to carbon neutrality.**
- Outstanding and abundant supply record in the world for 20 years after extensive R&D back to 30 years ago.
- Short time deployment by containerized system with annual production capacity of 100MW/0.6GWh.
- **Most reliable and effective battery to store large amounts of electricity by using well-established ceramic technology.**

Thank you for your time

END

URL : <https://www.ngk-insulators.com/en/product/nas/index.html>

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