October 3rd 2019

ENERGY STORAGE

NAS Sodium Sulfur Battery

SECOND BILATERAL BUSINESS MATCHMAKING EVENT FOR THE JOINT CREDITING MECHANISM

Sodium-Sulfur (NAS®) Battery and Application

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）
- High environmental resistance, which is advantage of high temperature battery.
  Outdoor installation is available even in severe environment, i.e. desert.

LONG DURATION

NAS is the most effective battery to store large amounts of electric energy.

COMPACT

NAS can be flexibly deployed where it is needed in less space than other battery technologies.

FAST RESPONCE

Electric energy is stored and delivered within millseconds of an electronic command.

RELIABILITY & SAFETY

NAS is reliable and safe by design and proven operation.

MAINTENANCE

Minimal maintenance and staffing required with our Remote Monitoring System.

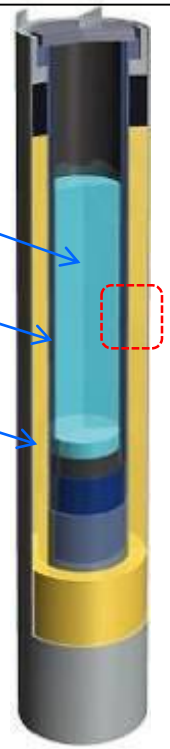
Cycle Life : 4500 full discharge
Calendar Life : 15 years
Round Trip Efficiency : 75-80%
Easy Installation with containerized system

Operational ambient Temperature -20C to 55C

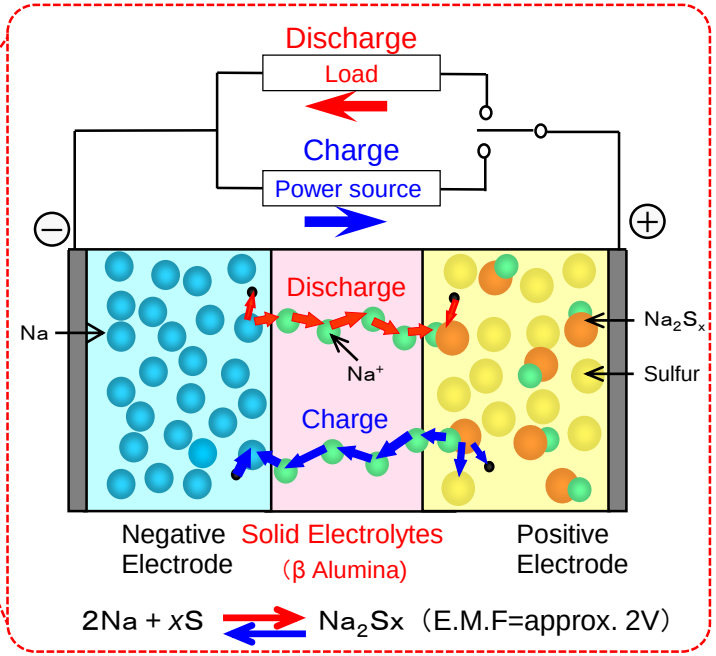
Principle of Sodium Sulfur Battery

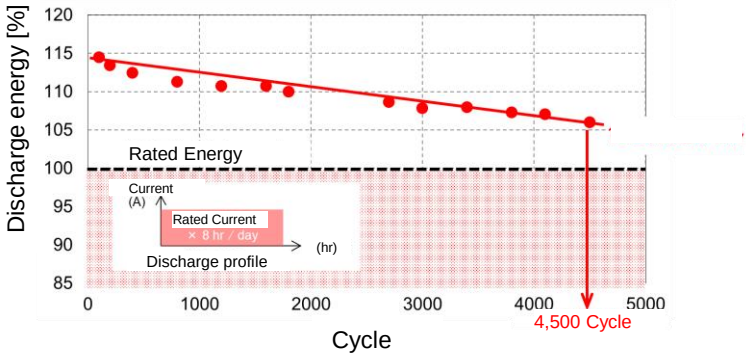
- Sodium Sulfur Battery is a high temperature battery which operational temperature is 300-360 degree centigrade.
- Fully discharge (SOC 100% to 0%) is available without capacity degradation.
- No self-discharge

Cell Structure



Chemical Reaction

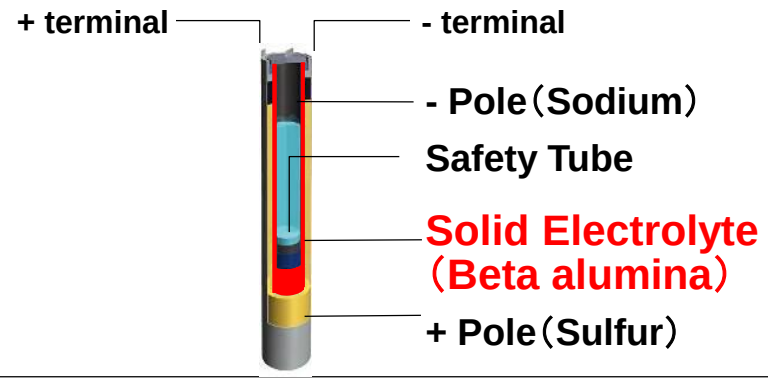




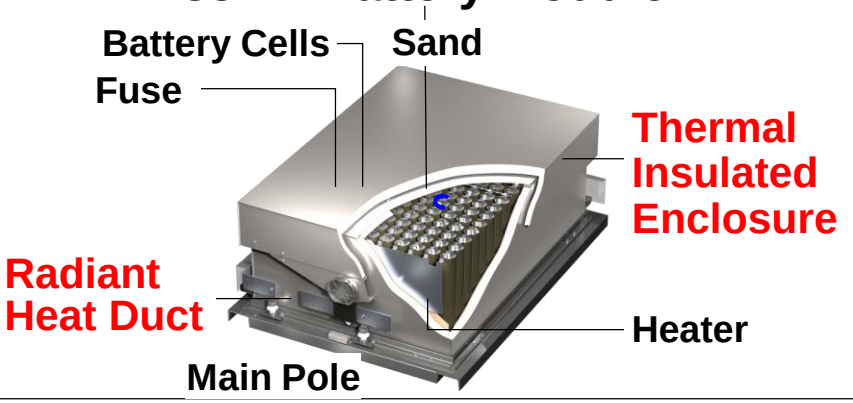
Structure of NAS® Containerized Battery System

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

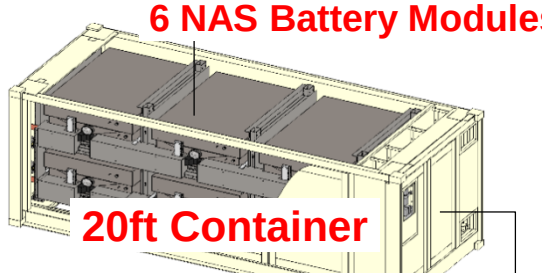
Battery Cell



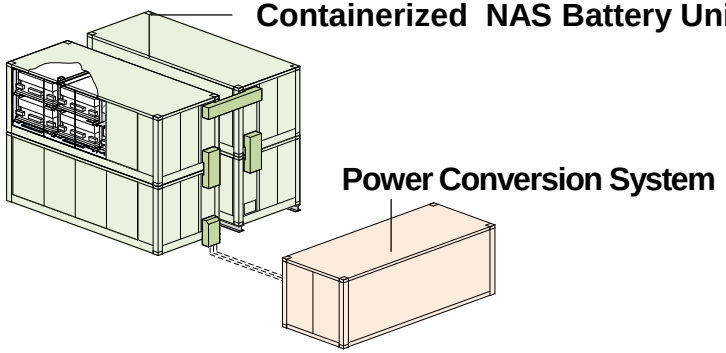
33kW Battery Module



Containerized Battery 200kW (1200kWh)



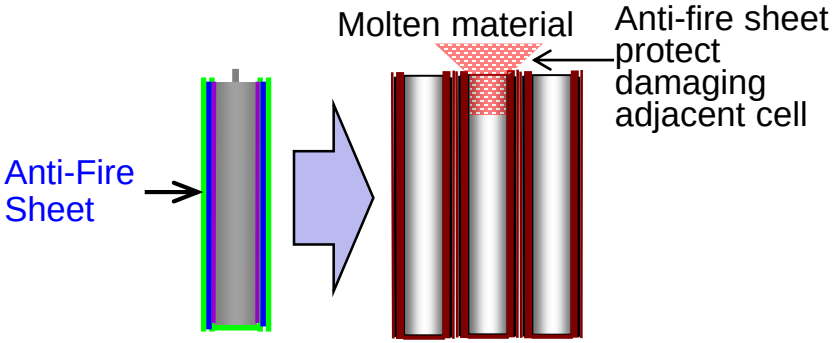
Battery System 800kW (4800kWh)



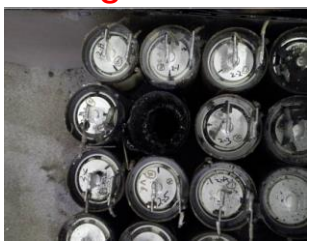
Safety of NAS® battery

- Anti-fire sheet to every cell prevents fire expansion even in worst case of cell fire.

- Japanese Fire and Disaster Management Agency (FDMA) defines 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



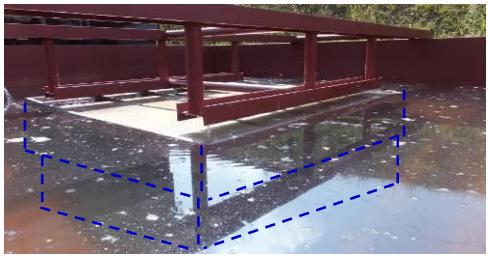
No damage
to the surrounding cells

[Examples of Safety Test]

Short circuit

Fire Exposure

Submerge

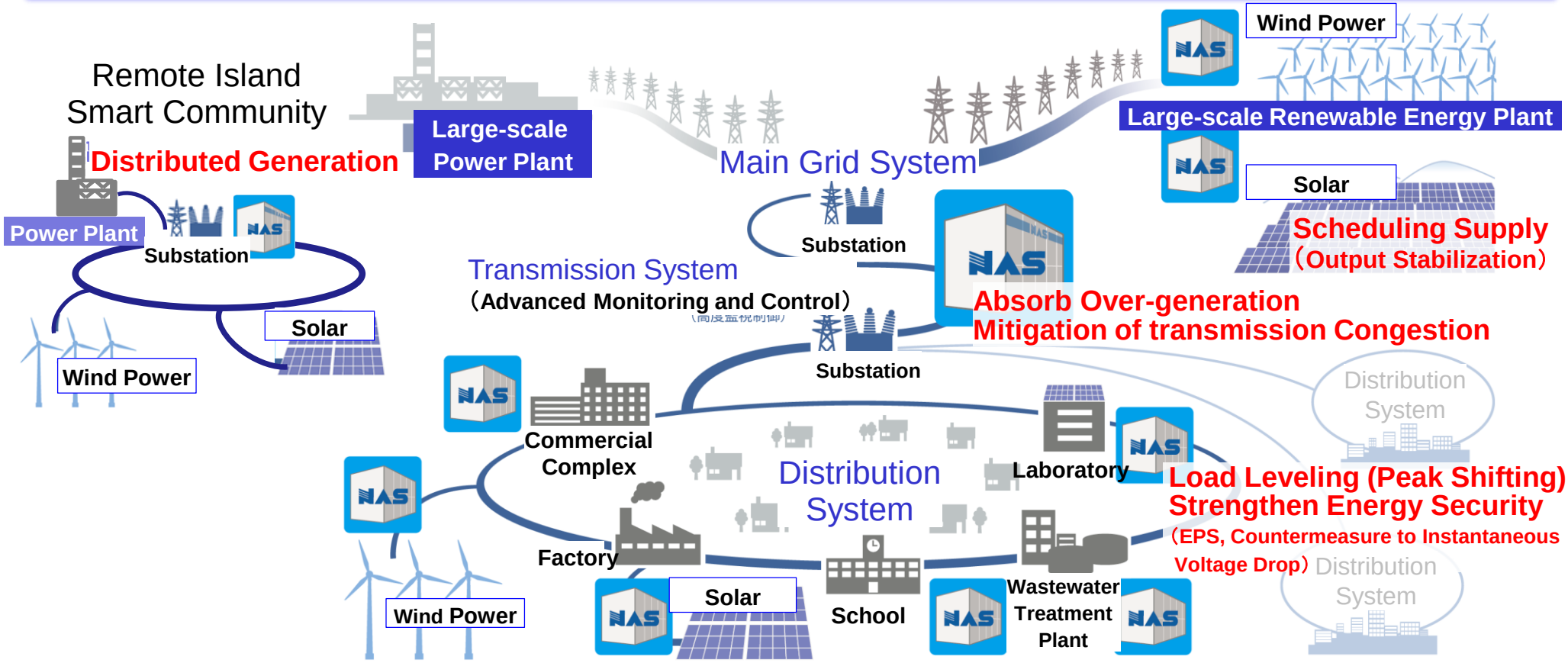


Drop

After the Test

Various applications of NAS® Battery System

- Introduction of massive volume of renewable energy into existing energy system causes quality and reliability problem of electricity.
- NAS® Battery can play an important roles at each point of the grid to maintain and increase energy security (no location and time constraint).

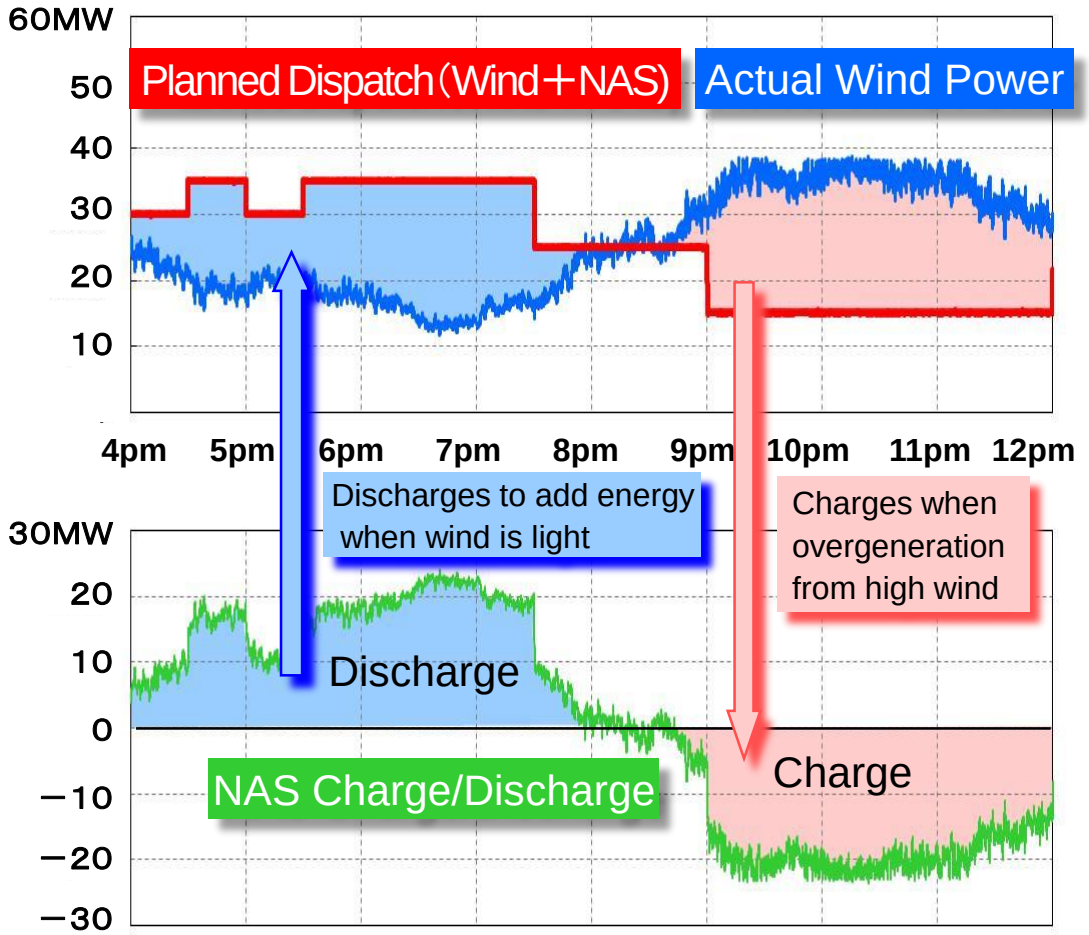


Scheduled Supply of Wind Power (Rokkasho Japan)

- Huge introduction of wind power causes imbalance of supply and demand for 24h
- Energy Type Battery makes the wind power stable & schedulable, more environmental 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)



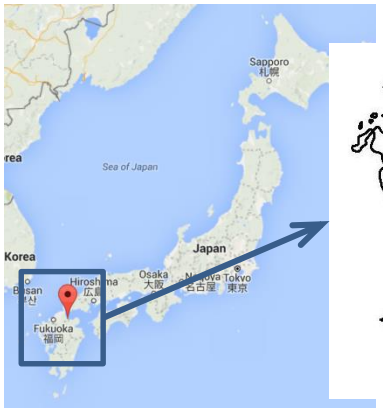
Absorb Over-generation (Kyushu in Japan)

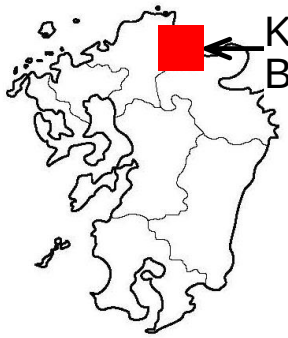
■ Planned PV connections to the grid were suspended due to over-generation problem. The government of Japan decided an emergency plan to install large scale battery in a short project schedule.

■ NAS® (50MW/300MWh) was successfully deployed only in 10 months after order.

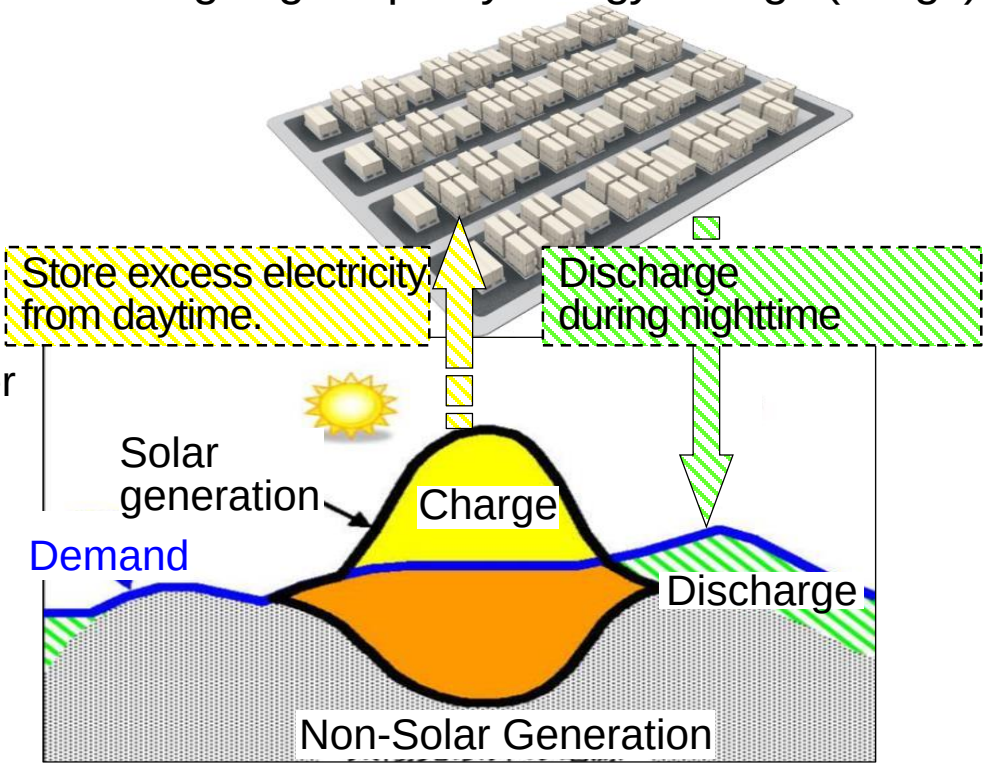
■Planned Equipment

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).

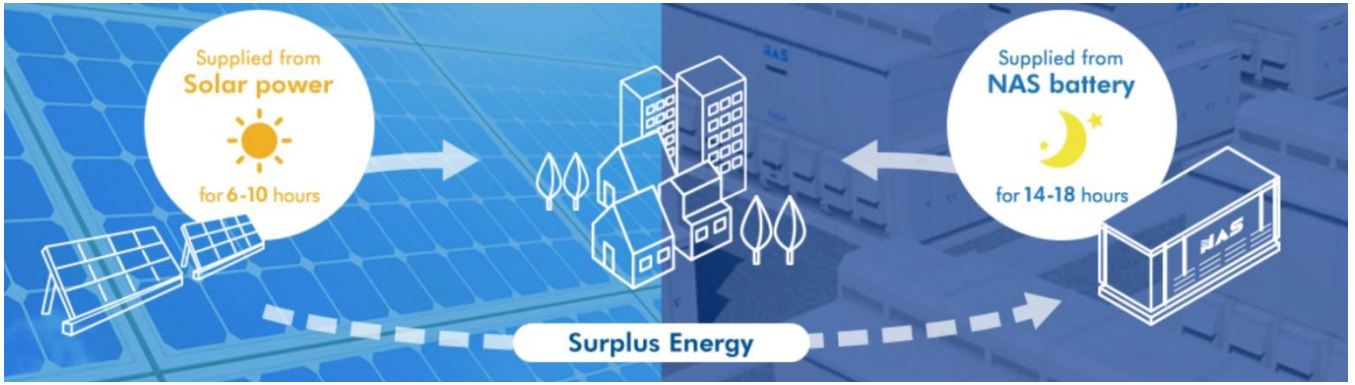


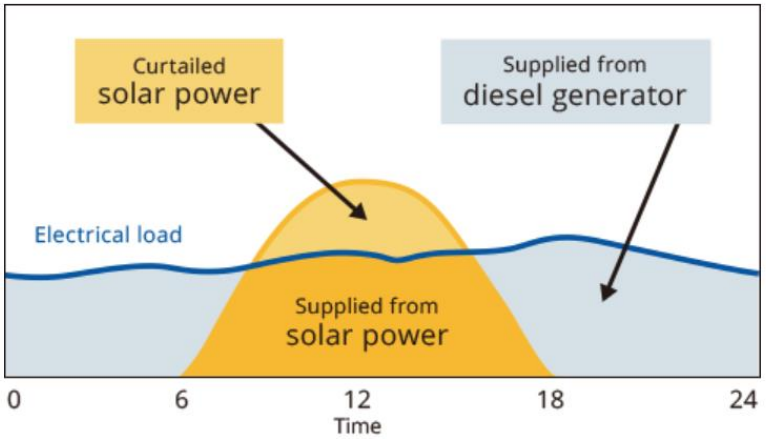
50MW/300MWh NAS battery system

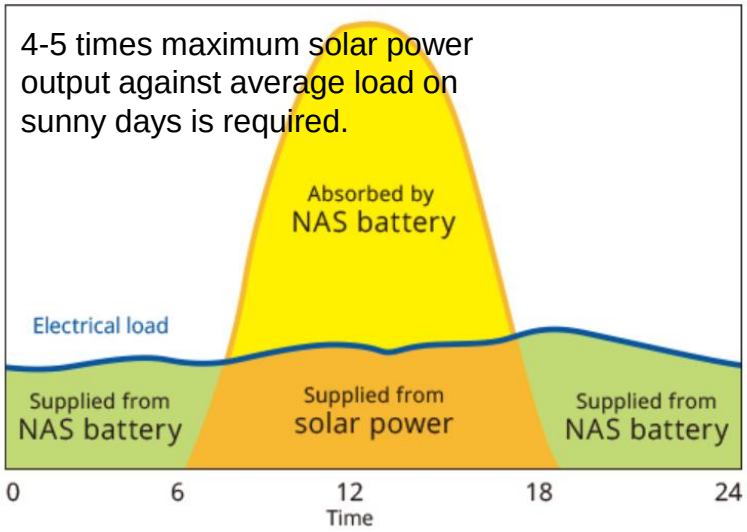
Buzen Power Plant, Kyushu Electric Power Company

24/7 Power Supply Utilizing Solar Power

■ Combination of solar power plus NAS® can offer optimum use of solar power and reduction of diesel generator's operation by providing clean energy for 24/7.







NAS battery with capacity of 2/3 against solar power can cover the most of the load for 24/7 by discharging for 14-18hs.

PV-NAS® Hybrid: Wakkanai Mega Solar Project

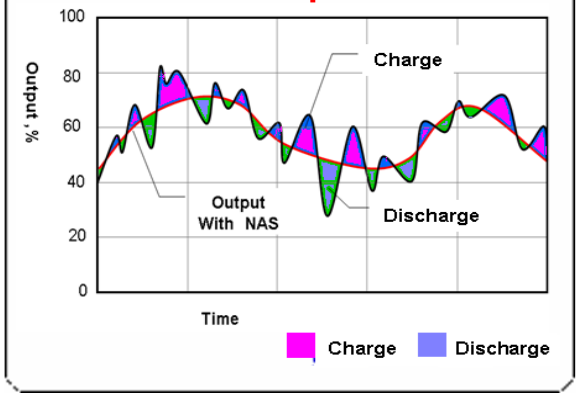
■ Smoothing or peak shifting is conducted in PV-NAS Hybrid system.

PV : 5.0MW
NAS: 1.5MW

Start of Operation : Feb 2010

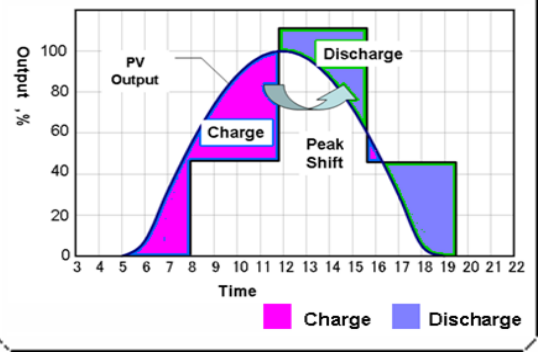
Absorb PV output fluctuation

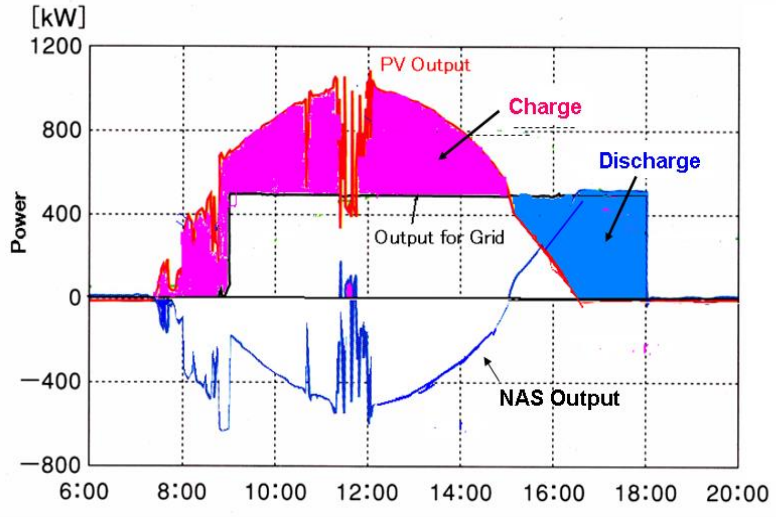
Absorption short-time fluctution of PV output



Peak Shift

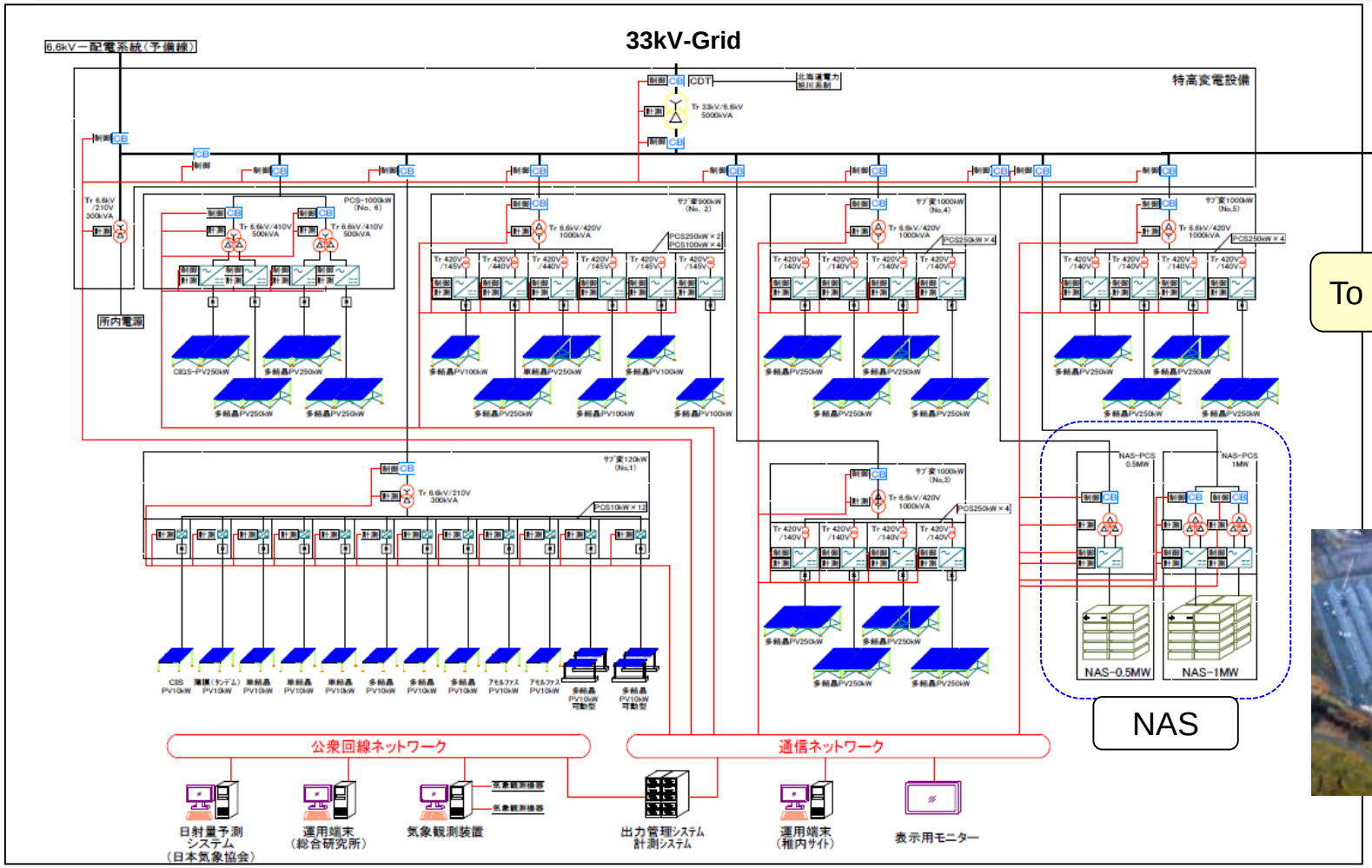
Peak time discharge (Evening etc.) by Storing Day-time Energy





PV-NAS® Hybrid operation during black out

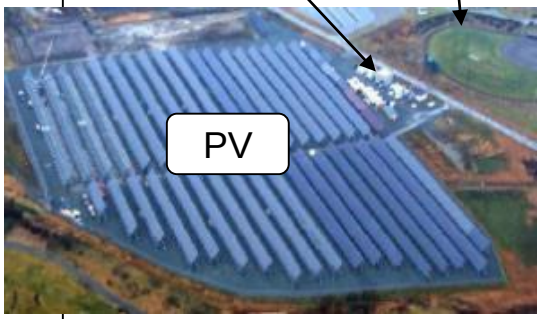
- Black out occurred after earthquake in Hokkaido on September 6th, 2018.
- Black out continued a few days. Renewable stayed disconnected until major fire power plant recovered.



To Ball Park

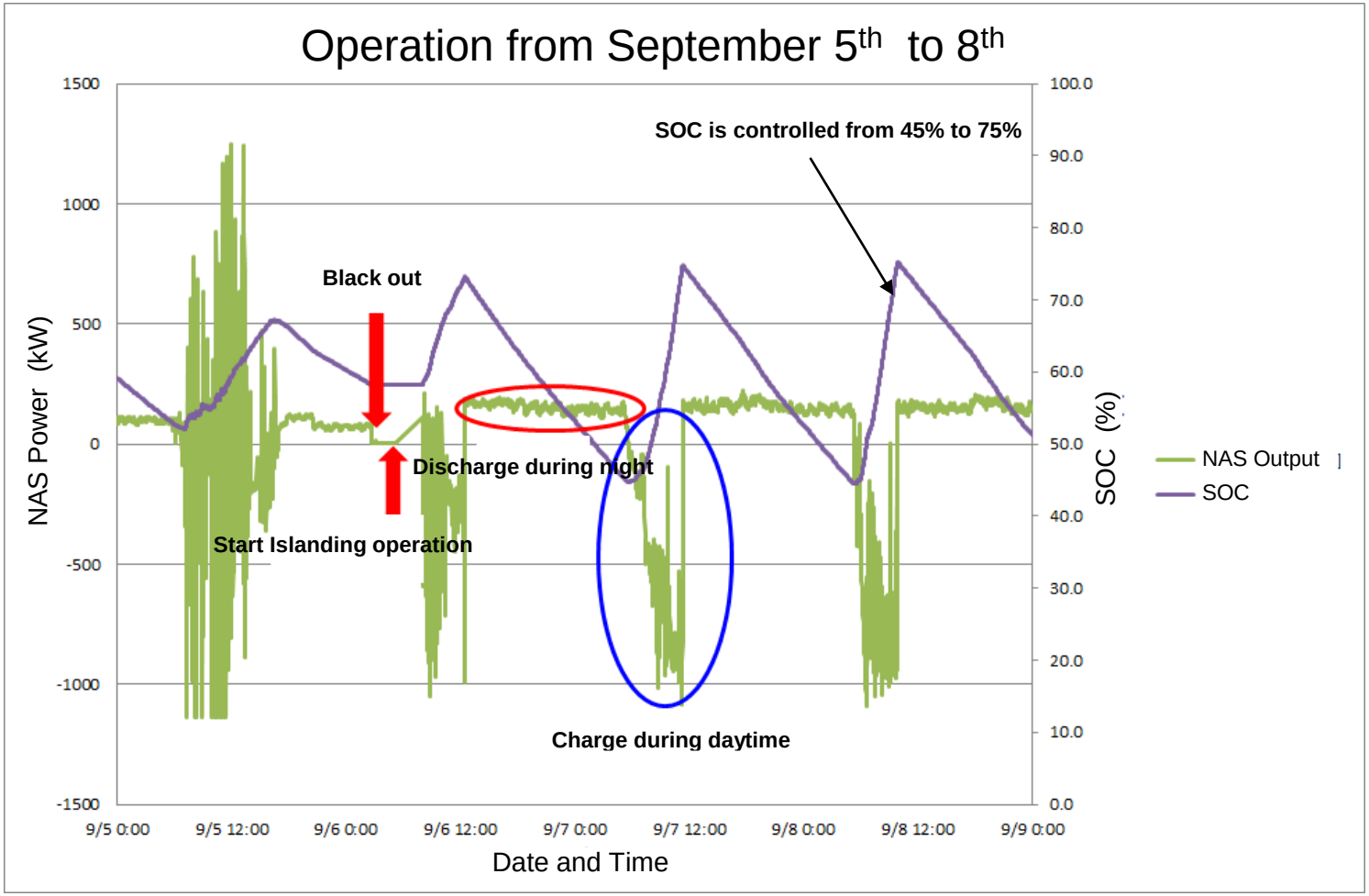
Ball Park

NAS



PV-NAS® Hybrid operation during black out

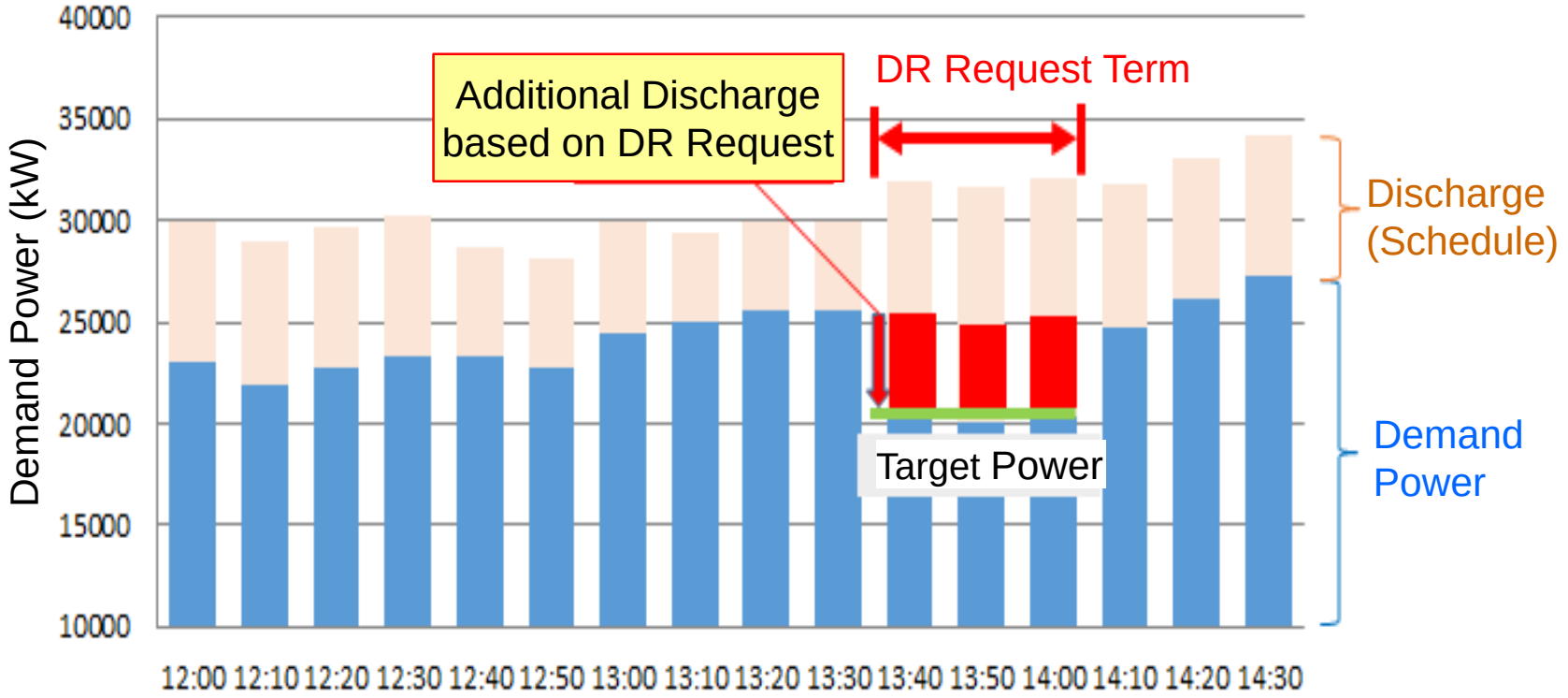
- During black out, NAS worked islanding operation, which allows PV to generate Power.
- NAS battery provide power during night and charge from PV during day, continuously provide power to station service and nearby ball park for a week.



VPP using NAS battery in Japan

- DR request was dispatched 13 times from end of Jan. to Feb. in 2018 due to the unexpected record cold winter in Tokyo.
- NAS Battery provided very fast and accurate DER to network.

Example of Demand Response



Thank you for your time

END

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

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