

NAS[®] Battery for Small Distribution Network



ENERGY STORAGE

NAS
Sodium Sulfur Battery

June, 2018
NGK INSULATORS, LTD.

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 - High Efficiency Operation of Diesel Generator
 - Renewable Power Supply System at Off-grid

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

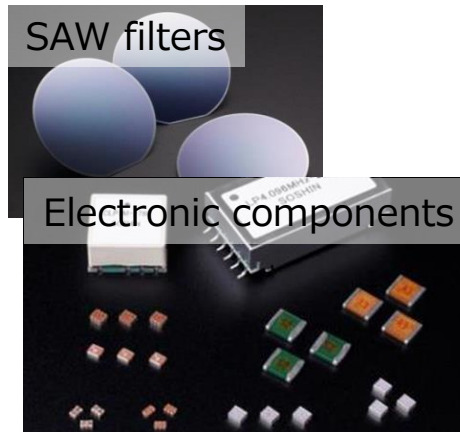


Diesel Particulate Filters

Electronics Business

SAW filters

Electronic components



Process Technology Business

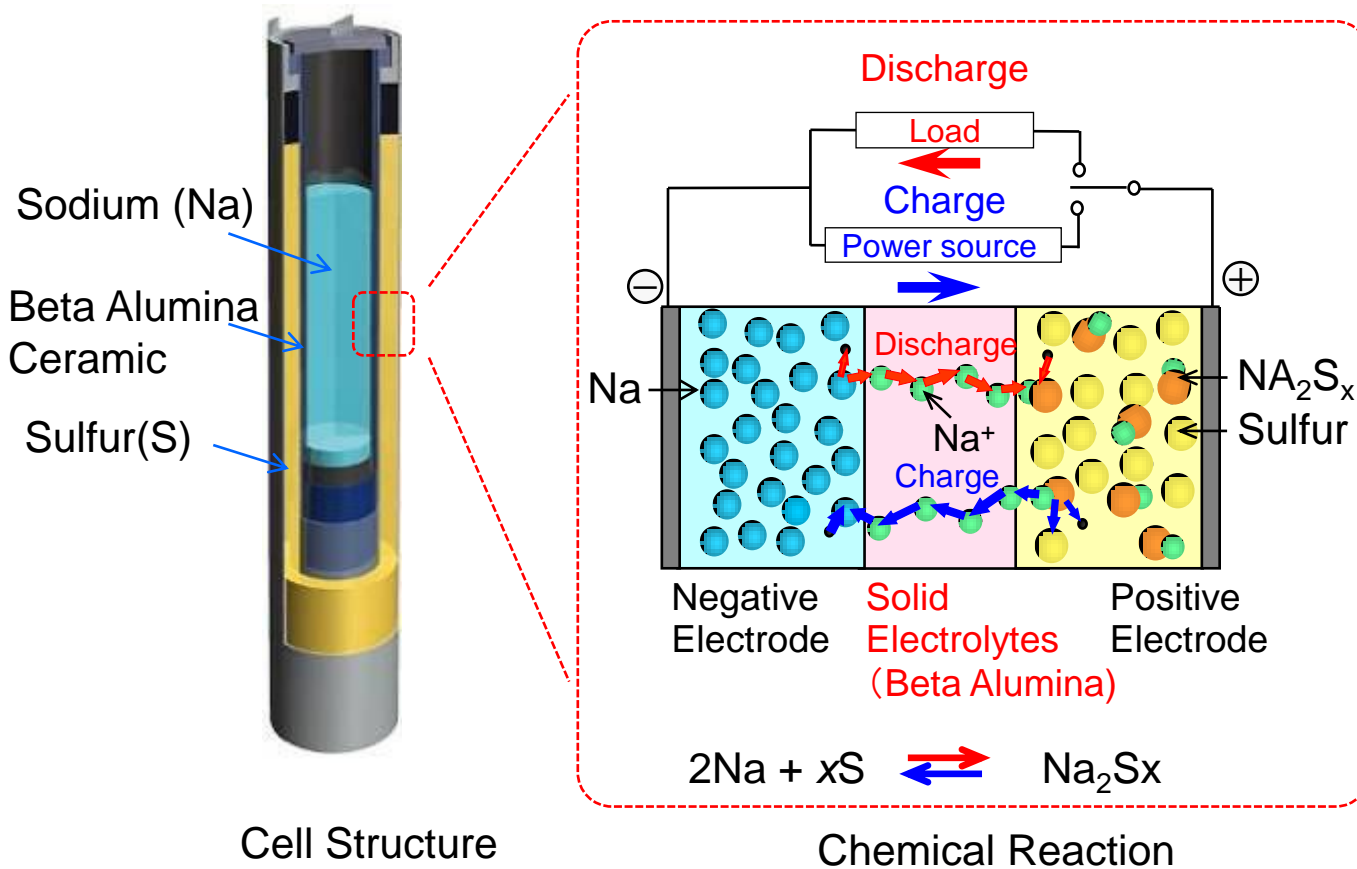
Semiconductor Manufacturing Equipment



drying systems

Structure of NAS Battery Cell

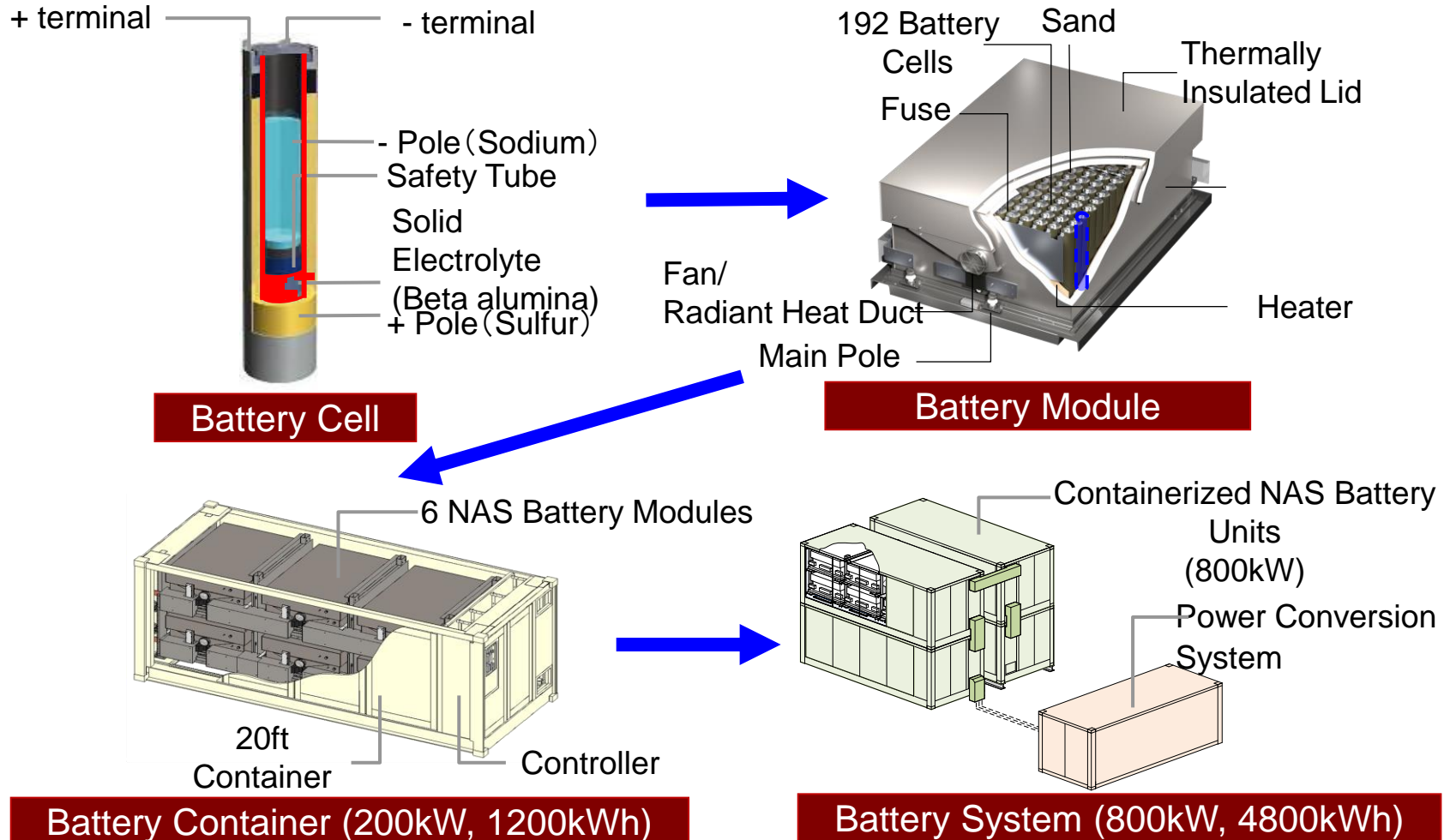
- Abundant material, Sodium and Sulfur, are used for active material of NAS Battery.
- Beta Alumina Ceramic Tube is the key part of NAS Battery.



Beta Alumina Ceramic

Structure of NAS Battery System

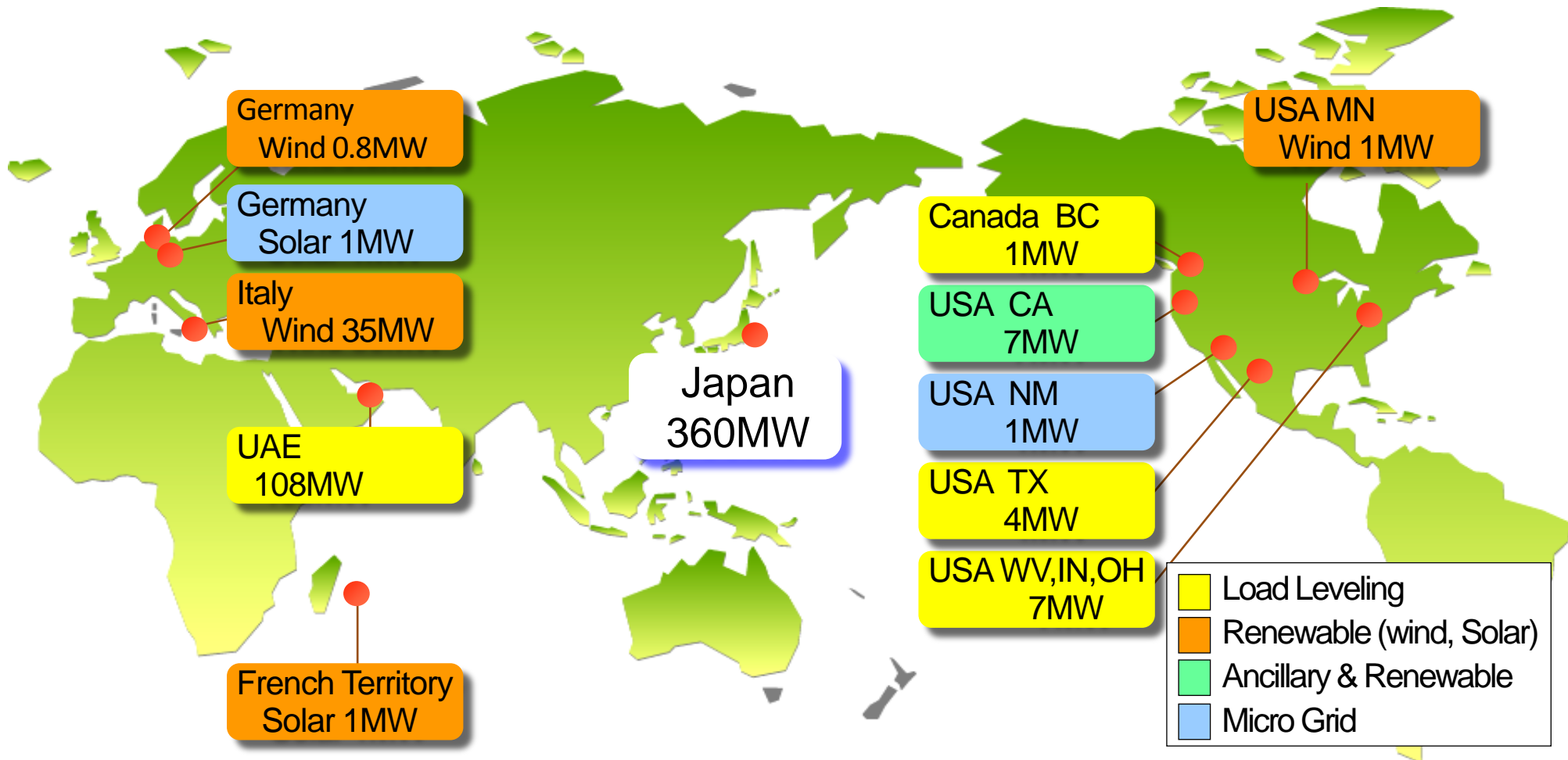
- **Containerized system** minimize the transportation and installation cost.
- NAS battery **can be used at high temperature area** because inside of Battery Module is high temperature.
- NAS Battery **can be recycled** after the end of battery life.



- 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

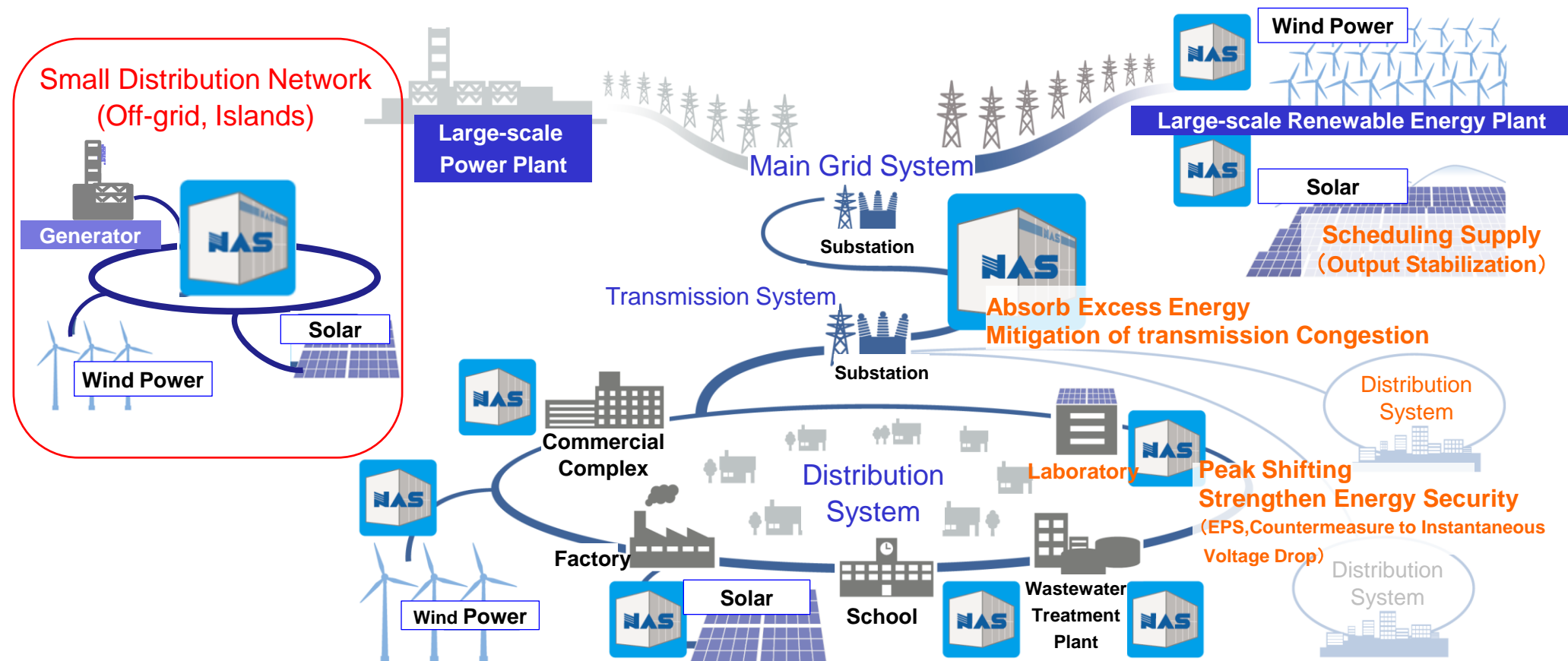
NAS Battery Installations Around the World

- Commercialized in Year 2002
- Total Installation Record of 530MW (3700MWh)
Domestic 360MW, Overseas 170MW
- Annual Production Capacity 150MW(1000MWh)



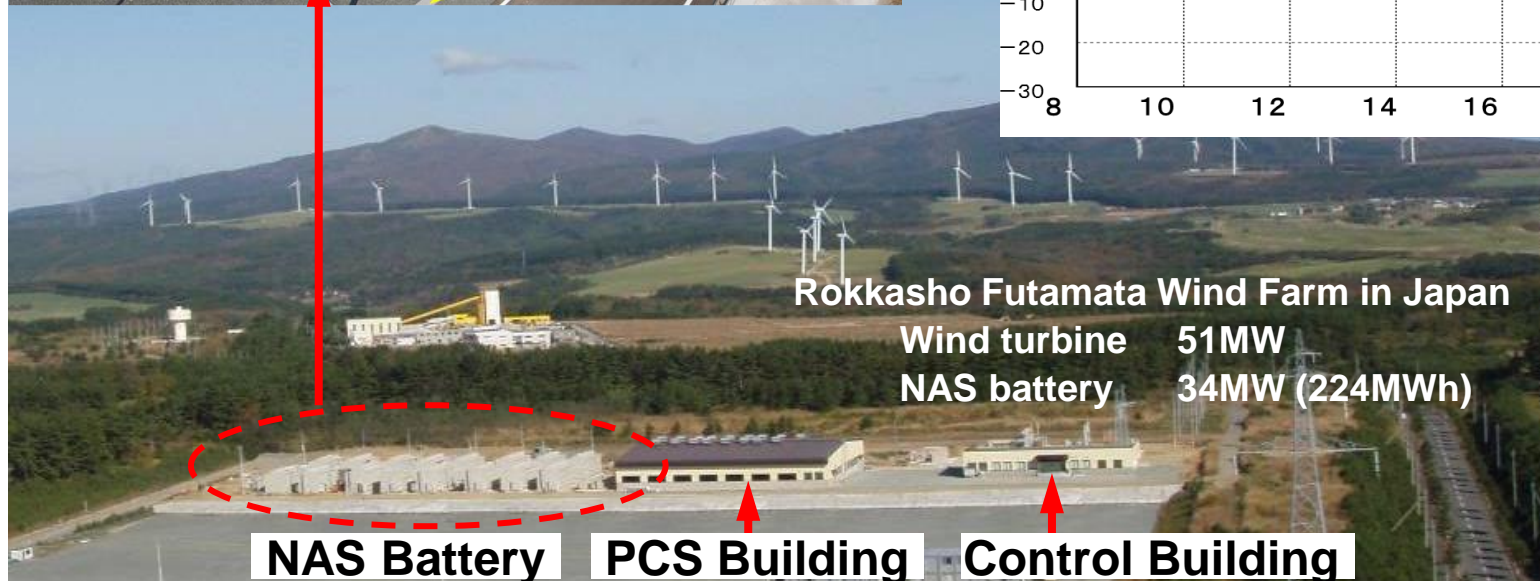
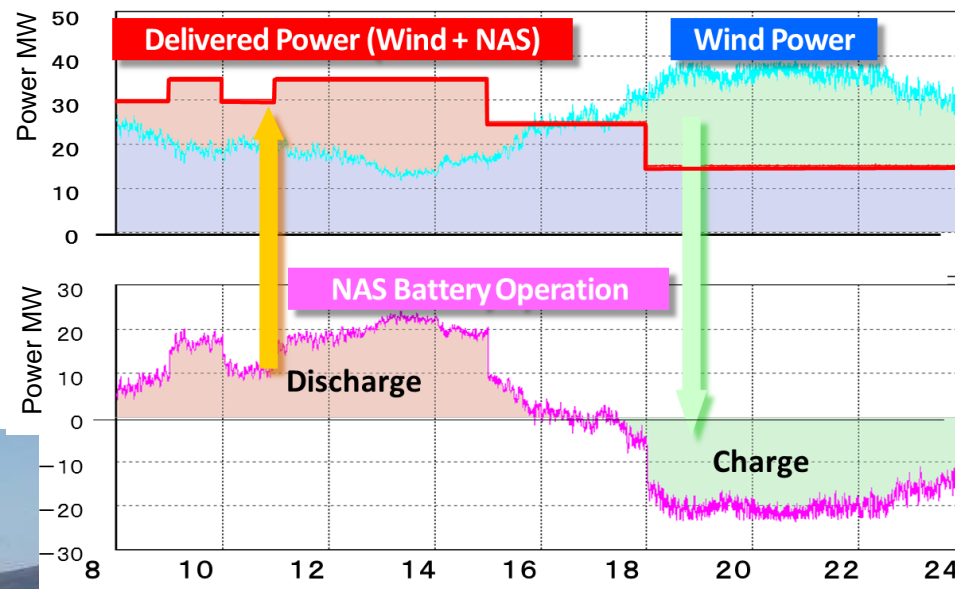
Various applications of NAS Battery System

- 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 **in small distribution network at off-grid**.



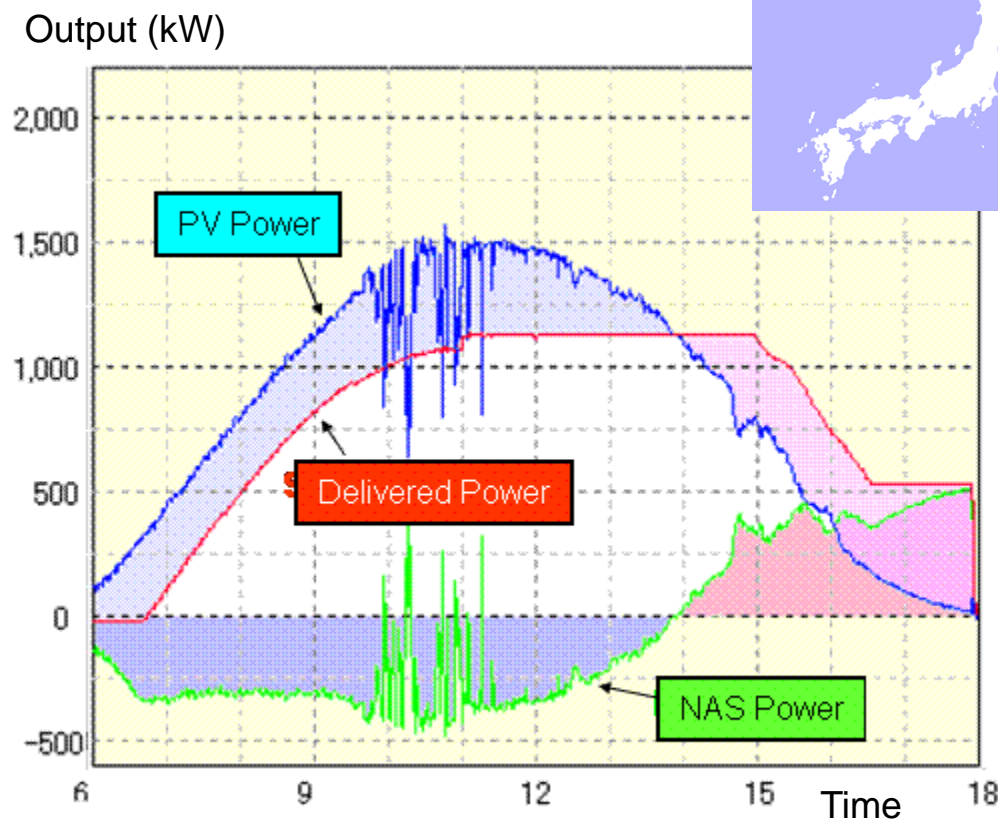
Wind Power Stabilization and Energy Time Shift

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



Solar Power Stabilization and Energy Time Shift

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

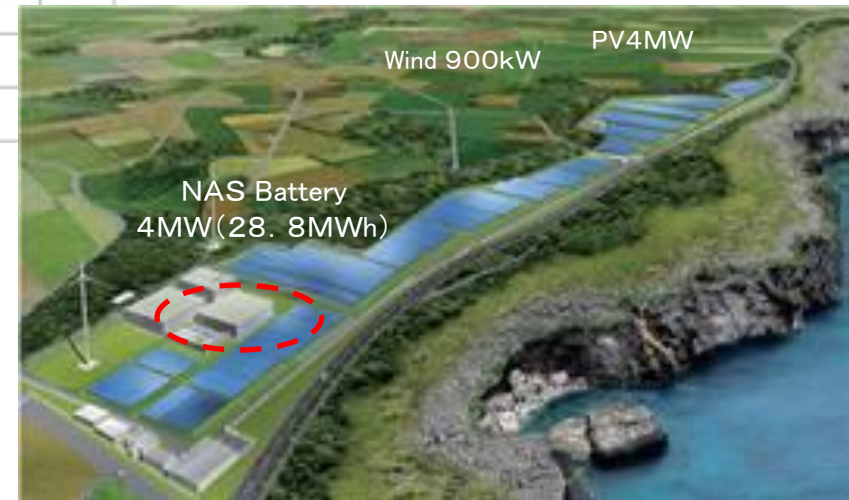
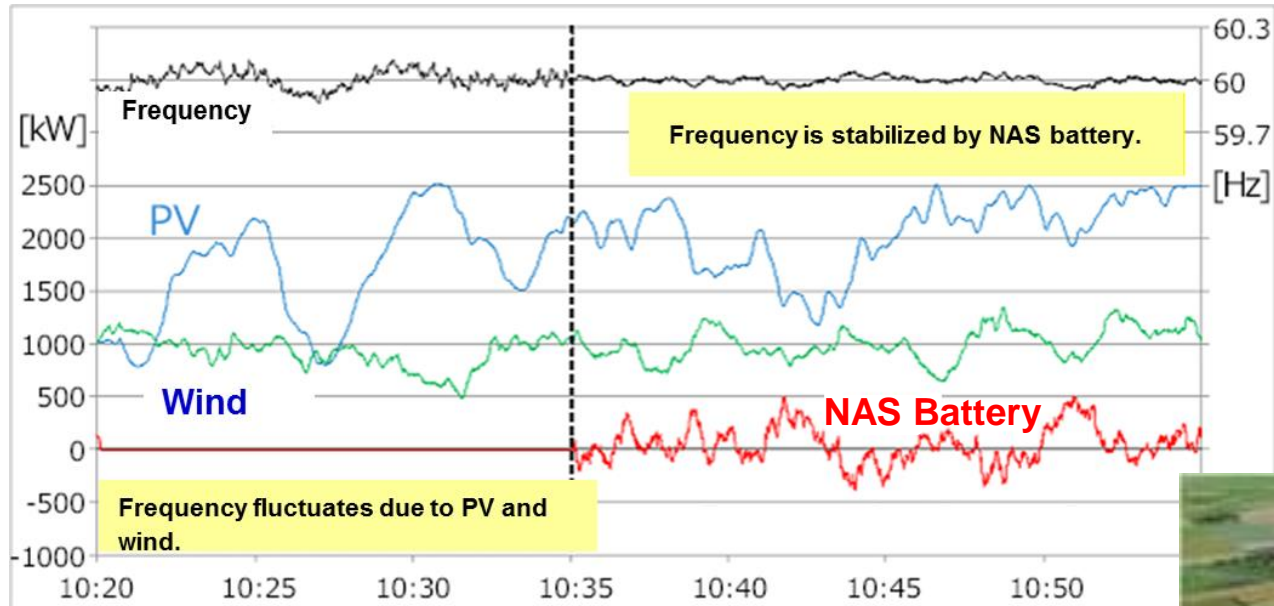


Example of Operation pattern

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

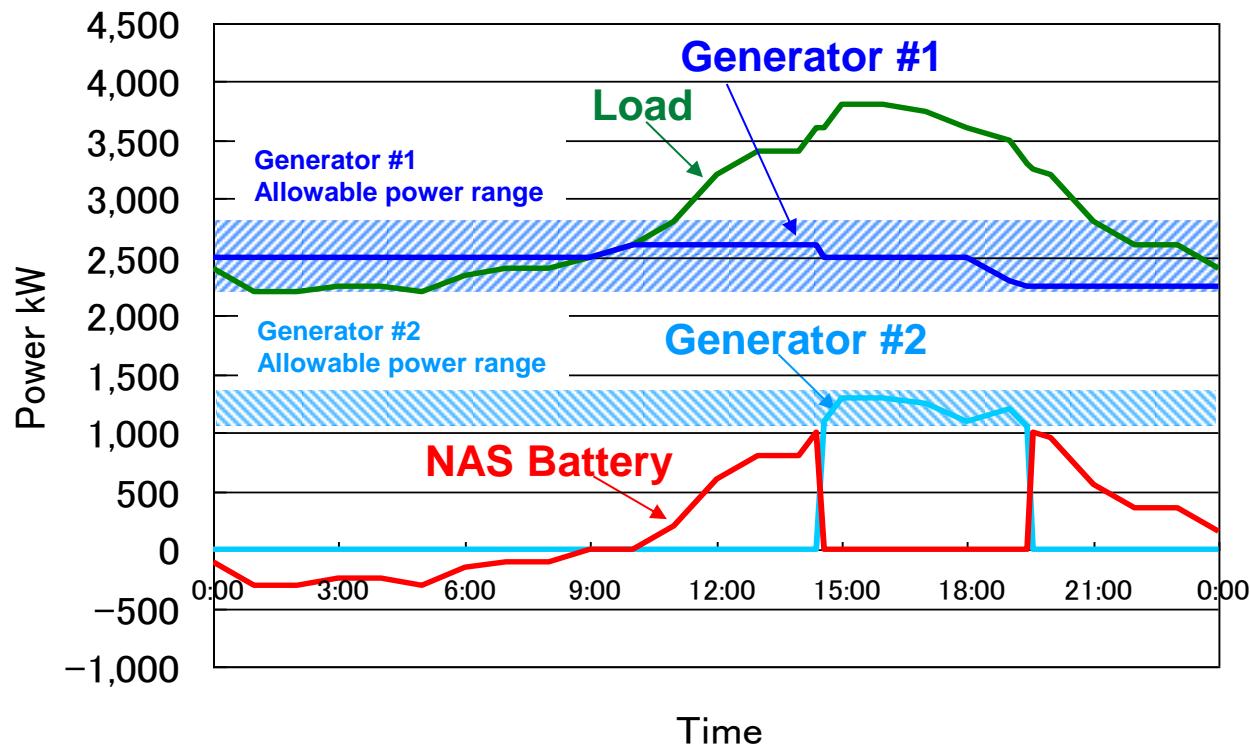
Frequency Control and Energy Time Shift

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



High Efficiency Operation of Diesel Generator

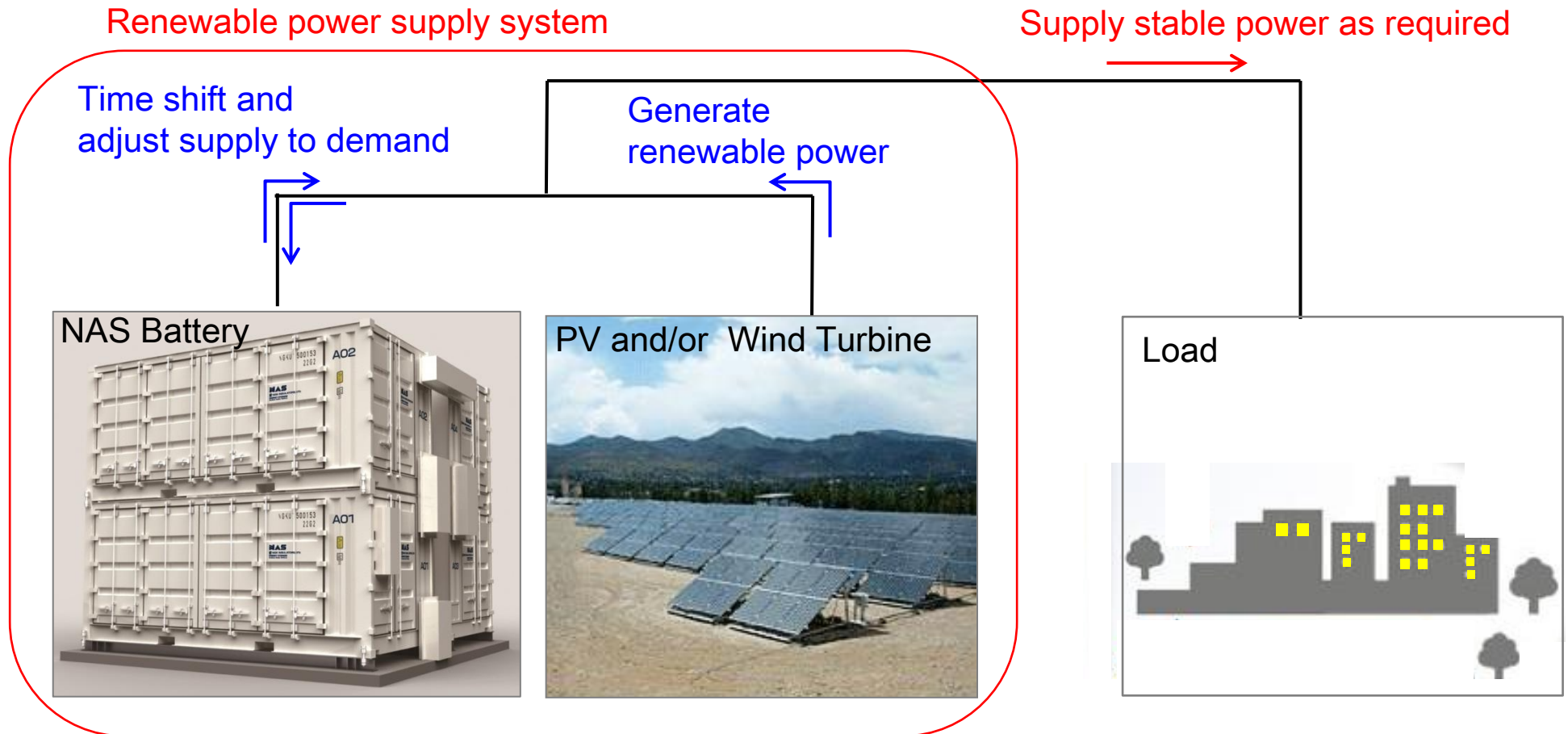
- NAS Battery can **enhance the efficiency of diesel generators** and reduce the air pollutants and greenhouse gases by the following schemes.
 - a) **increase renewable generators** with adjusting demand and supply by NAS battery
 - b) **run the diesel generator at the highly efficient power range** with absorbing the fluctuation of demand by NAS Battery
- NAS Battery in Catalina Island is used to minimize the environmental impact by the above scheme b).



Owner: Southern California Edison
System Size: 1 MW
Commissioning Operation Date: August, 2011




Renewable Power Supply System at Off-grid

- Utilizing NAS battery with renewable power source (PV, Wind turbine, etc.), renewable power will be available for 24 hours/day.



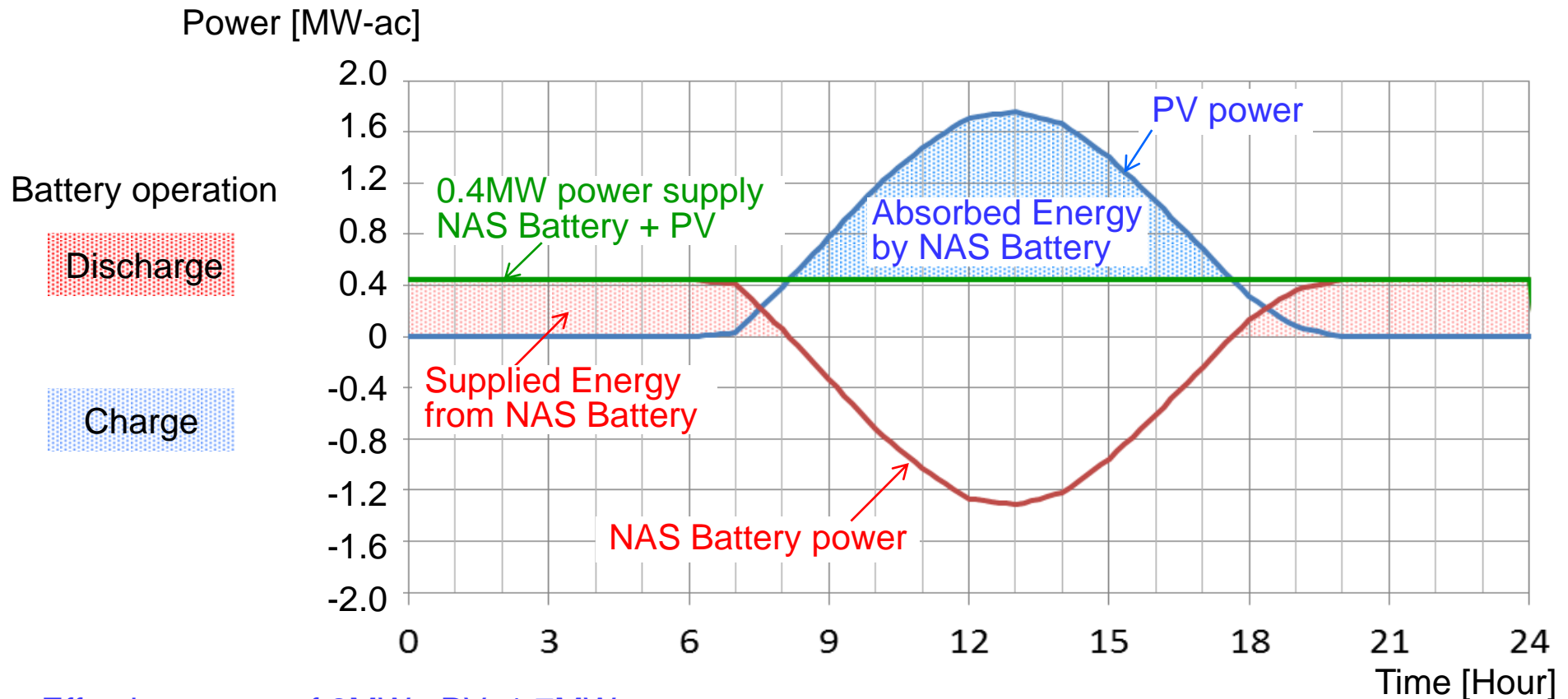
Simulation of power supply system at off-grid, assumed system

- Following three cases of power supply systems at off-grid is simulated.
- All the Cases are intended to supply about 0.4 MW constantly.

	NAS Battery 	Solar PV 	Diesel Generator (DG) 
Case 1 DG	n/a	n/a	0.4MW
Case 2 DG + PV	n/a	0.2MWp	0.4MW
Case 3 DG +PV +NAS	1.2 MW	2MWp	0.4MW

Simulation of power supply system at off-grid, operation

- Constant 0.4MW power supply for 24 hours could be achieved by 2 MWp PV and 1.2MW NAS Battery.

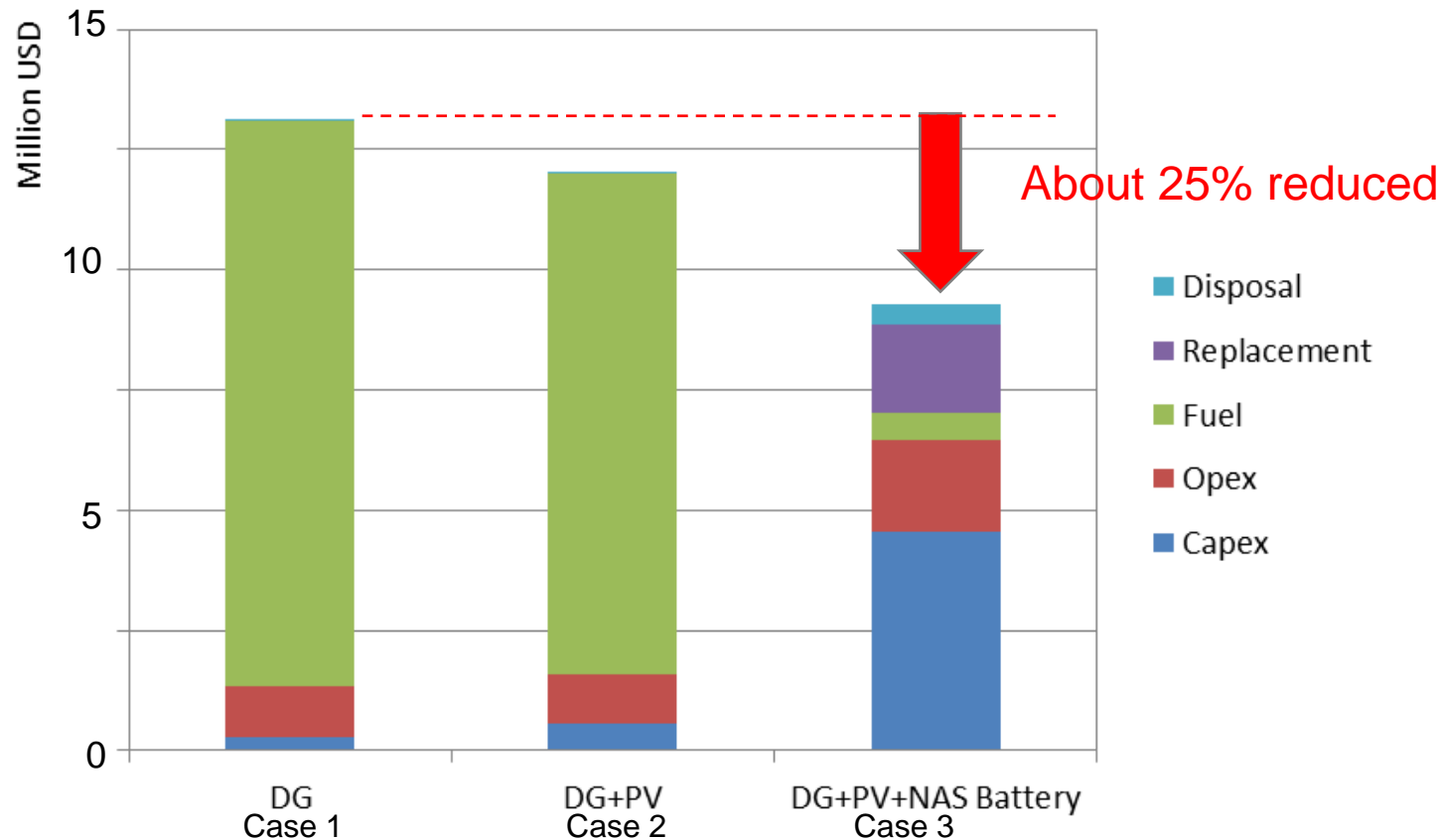


Effective power of 2MWp PV: 1.7MW-ac

Capacity of NAS Battery: 1.2W-ac / 7.2MWh-ac

Simulation of power supply system at off-grid, total cost

- For the three Cases, the total costs to supply electricity about 0.4MW constantly for 25 years are calculated.
- The total cost of Case 3 (DG+PV+NAS Battery) will be the lowest according to the calculation.

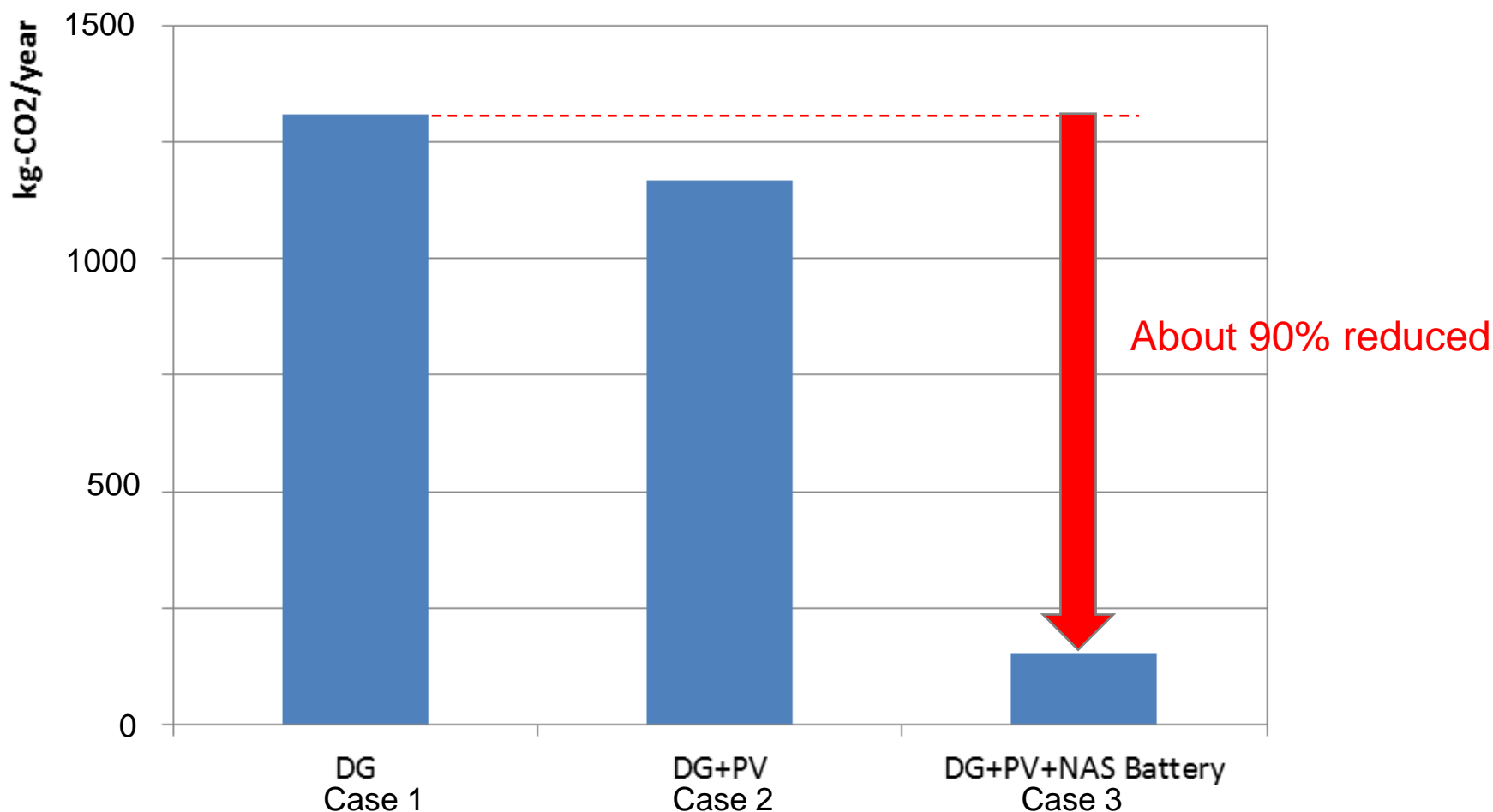


Notes:

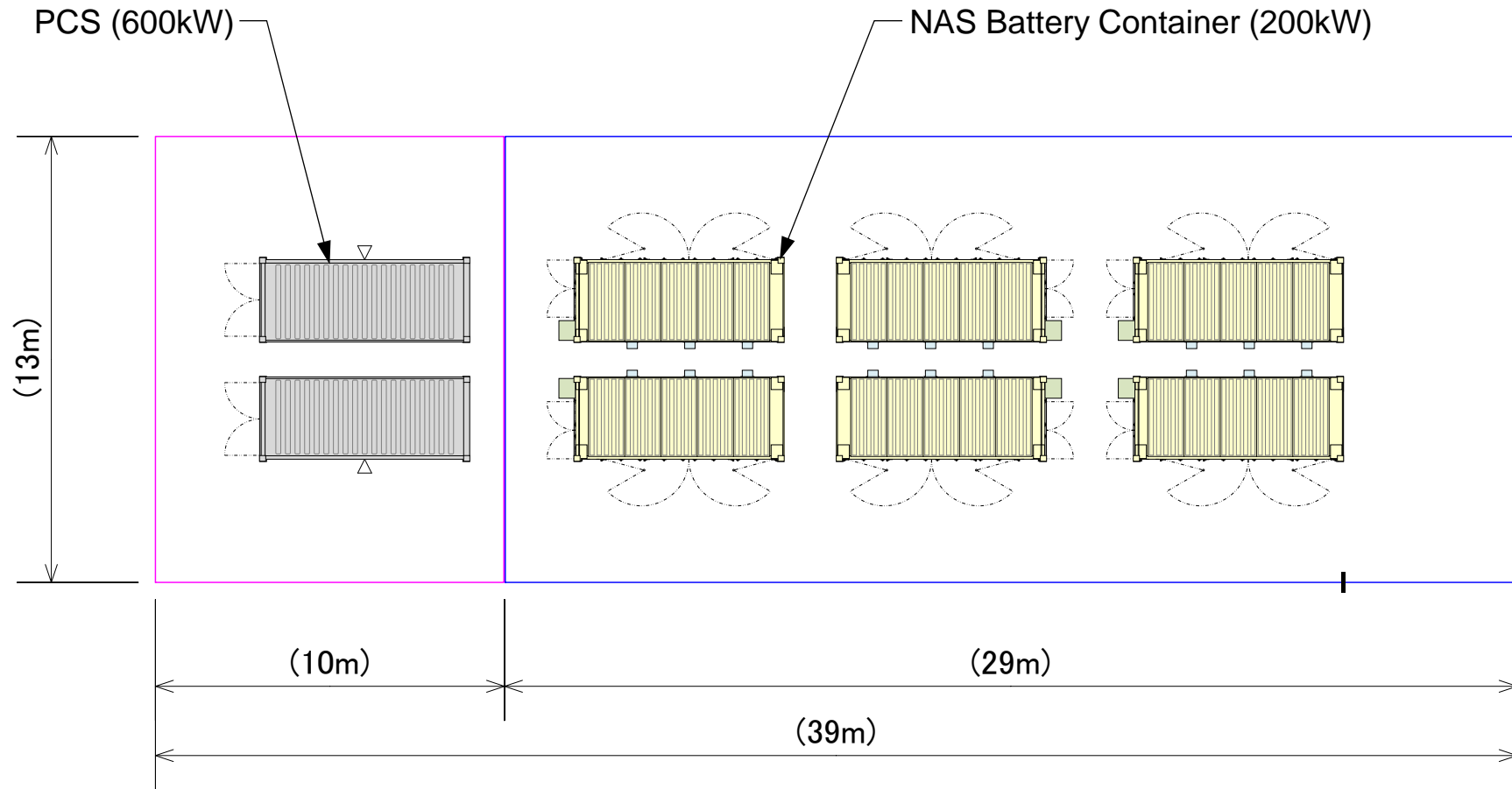
(he above data are rough estimation. To enhance the accuracy of the data, detailed feasibility study should be implemented.

Simulation of power supply system at off-grid, CO2 emission

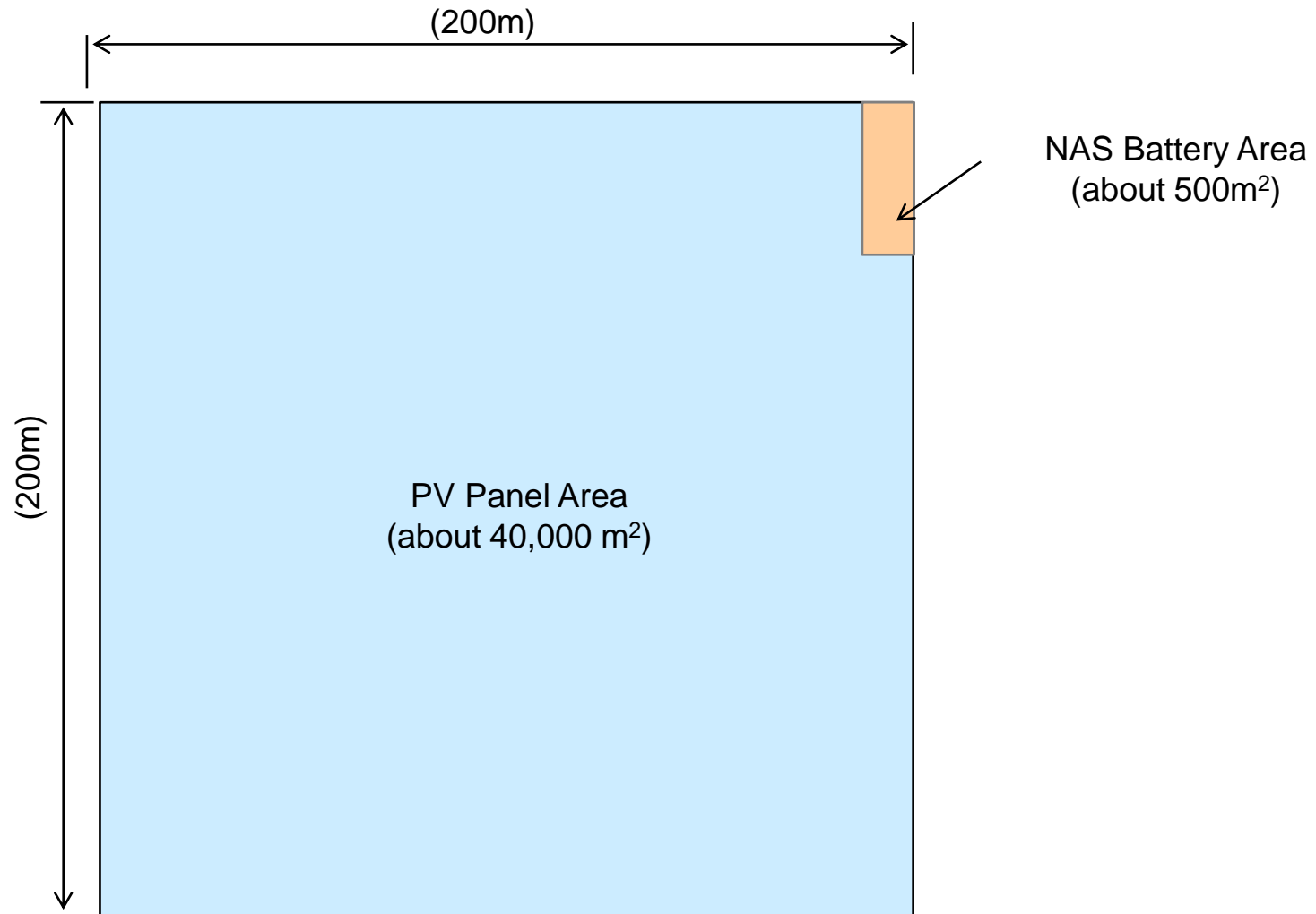
- CO2 emission can be reduced about 90% changing the power supply system from Case 1 (DG) to Case 3 (DG+PV+NAS Battery) according to the calculation.



Example of NAS Battery System Layout (1.2MW)



Example of NAS Battery System(1.2MW) + PV (2MWp)Layout



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 for the distribution network at off-grid.



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