記入日　2020 年 6 月 24 日

会社・団体名	日本ガイシ株式会社 英文名：NGK Insulators, Ltd.			
技術・設備名	NAS®電池（ナトリウム－硫黄電池）			
分類		（1）省エネルギー		（5）水処理
	○	（2）新エネルギー		（6）土壌汚染防止・土壌改良
	○	（3）大気汚染対策	○	（7）スマートシティ
		（4）循環経済		（8）その他
特徴（PRポイント）	独自の高度なセラミック技術により、メガワット級の電力貯蔵を世界で初めて実用化した NAS®電池は、高エネルギー密度、長寿命を特長とし、長時間にわたる高出力供給が可能です。ピークカットや非常用電源、瞬時電圧低下への対策として有用です。風力発電や太陽光発電の出力安定化用途での導入も増えており、再生可能エネルギーの普及やスマートグリッドの構築に役立てられています。また、マイクログリッド、デマンドレスポンスなど、新たなエネルギーソリューションにも対応し、その普及・発展に貢献します。			
具体的な省エネ・環境効果、経済性	1MW/6MWh の NAS®電池が再生可能エネルギーの余剰発電量（捨電）を充電、電力必要時に全量放電した場合の二酸化炭素年間削減効果： 6MWh×365 日×75%（システム効率）×0.84045（排出係数）*1=1380.5 トン *1：生態環境部発表の 2017 年度華北電網グリッド排出係数から仮定： 0.9680（EFgrid,OM,y）×75%＋0.4578（EFgrid,BM,y）×25%			
概要・原理				
実績	2002 年の商業化以来、全世界で 560MW／4,000MWh の供給実績を有する。			

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Web　URL	https://www.ngk.co.jp/product/nas/index.html

NGK INSULATORS, LTD.

NAS Battery Sales & Marketing, Power Business Group

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

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Movies about NAS batteries and the NAS battery simulator are available on our website.

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Sodium Sulfur Battery



ENERGY STORAGE SYSTEM



NGK INSULATORS, LTD.

NAS batteries are the #1 choice worldwide for large-capacity energy storage

NAS® Sodium Sulfur Battery

NGK's NAS batteries are the world leader in large-capacity energy storage.
The cumulative field experience of NAS battery systems far surpasses that of every other large-capacity energy storage system.
NGK's NAS battery systems have been deployed for over 20 years, at over 200 projects,
with total deployments of 560MW and 4.0GWh.



1MW/6MWh G
BC, Canada
Peak Shaving & Backup



1MW/7.2MWh R
Luverne, MN
Wind Integration



2MW/12MWh G
Churubusco, IN
T&D Deferral



6MW/39.6MWh G
San Jose, CA
Vacaville, CA
Peak Shaving, Backup & Ancillary



1MW/6.6MWh M
Catalina, CA
Island Grid Stability



3MW/18MWh G
Charleston, WV
Milton, WV
T&D Deferral

1MW/6MWh M
Los Alamos, NM
Microgrid



4MW/24MWh G
Presidio, TX
Power Quality & Backup





2MW/12MWh
Bluffton, OH
T&D Deferral



0.8MW/5.8MWh R
Emden,NI,Germany
Wind Integration



4.0MW/20MWh G
Varel,NI,Germany
Ancillary



1MW/6.6MWh M
Berlin, Germany
Island Microgrid



1.2MW/7.2MWh R
Dubai, UAE
PV Integration



34.8MW/250MWh G
Near Naples, Italy
Transmission Grid Stability



108MW/648MWh G
Abu Dhabi, UAE
Load Leveling & Smart Grids



1MW/7.2MWh M
Reunion, France
Renewable Integration

- R Renewables (Renewables, Power Plants)
- G Grid Solutions (Ancillary, Investment Deferral)
- C Consumers (Industrial, Commercial & Residential)
- M Microgrids (Islands, Remote Grids & Microgrids)



56MW/403MWh R
Aomori, Japan
Wind Integration



210MW/1,510MWh C M
TEPCO Area, Japan
Load Leveling, etc.



50MW/300MWh G
Kyushu, Japan
Grid Solutions

Japan
390MW/2,800MWh R G C M



Features of NAS batteries

NGK's NAS batteries are large-capacity batteries with many power grid applications.
Superior function and performance possible only from decades of research, design, testing, demonstration, advanced manufacturing and over 15 years of proven commercial operation.

Long Duration
NAS batteries are the most effective way to store large amounts of electrical energy discharging for six hours at rated output.

24/7 Power Supply
NAS batteries make 24/7 power supply feasible with solar power for 6-10 hours and a NAS battery for 14-18 hours at one-third of the rated output.

Fast Response
When used with a fast Power Conversion System (PCS), NAS systems can respond to grid commands to store or deliver electrical energy in tens of milliseconds.

Compact
NAS batteries can be flexibly deployed in smaller spaces than other battery technologies.

High Reliability
With decades of experience, NAS batteries have field-proven reliability exceeding 99%.

Safety
The safety of NAS batteries has been proven in testing by NGK and third-party authorities and from extensive field experience.

Developed for Grids
Development of NAS technology by NGK started in 1984 to provide a more flexible energy storage alternative than pumped energy storage, for the world's largest utility, TEPCO. The first NAS battery system deployment was in 1995.

System Expansion
NAS battery systems can be cascaded to any needed size (to 100s of MW or more).

Minimal Maintenance
Preventative maintenance is minimal and can be scheduled to avoid peak seasons. Maintenance can be done on partical systems while the rest of the system continues operation.

Wide Ambient Operating Range
Climates for NAS projects range from the cold of Canadian winters to the heat of Abu Dhabi.

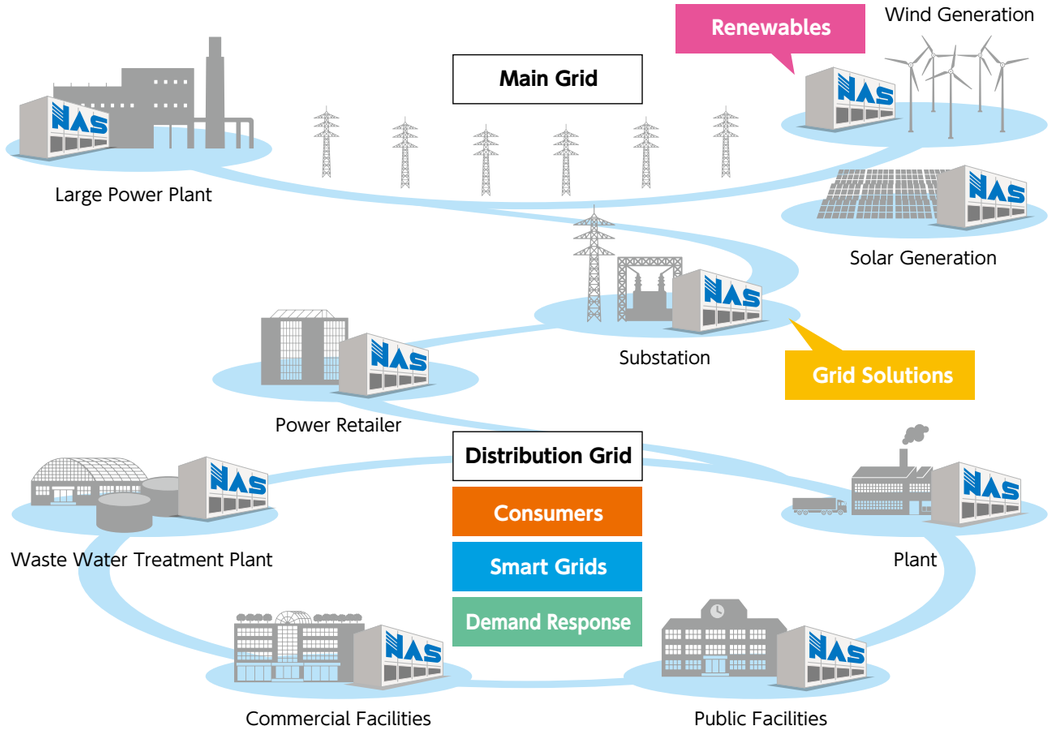
Long Lifetime
NAS batteries are rated at 4,500 full cycle discharges, or a 15-year calendar life, whichever occurs first. This lifetime is field-proven.

Plug & Play
Containerized NAS batteries, in which NAS battery modules are pre-installed, drastically reduce installation periods.

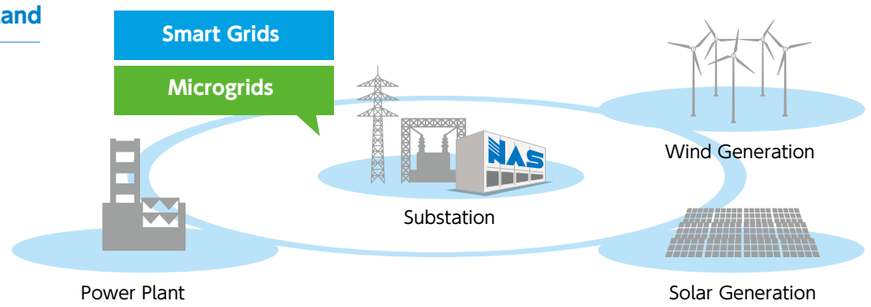
NAS Battery Energy Storage System

Large-capacity NAS batteries play a vital role in various scenes of electric power grids.

Renewables	Avoiding Suppression Output・Renewable Stabilization
Grid Solutions	System Stabilization・Load Leveling
Consumers	Reduction of Electric Bill・Emergency Power Supply・Prevention of Instantaneous Voltage Drop
Microgrids	Remote Islands・Regional Power Grids・Microgrids
Smart Grids	Efficient Energy Management・Increasing Reliability and Resilience of Grids
Demand Response	Behind-the-Meter・Interactive Load Adjustment



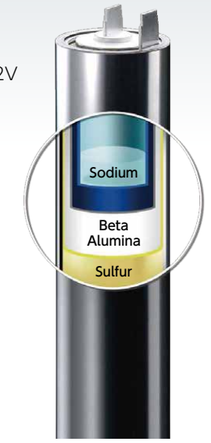
Remote Island



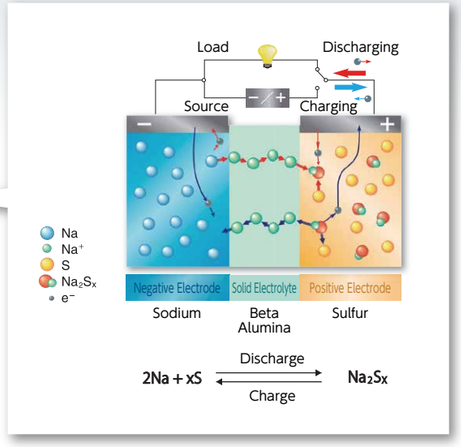
Structure of Battery Cell

- Weight: 5.3kg
- Capacity: 1,200Wh
- Average Discharge Voltage: Approx. 2V

A battery cell has a sodium (Na) negative electrode and a sulfur (S) positive electrode separated by a ceramic solid electrolyte.

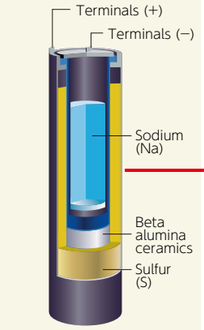


Operating Principle



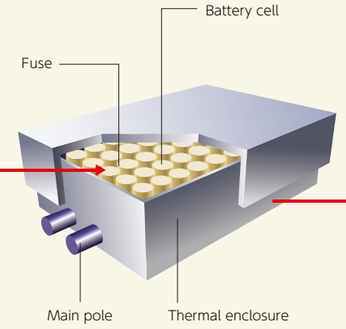
NAS Battery System

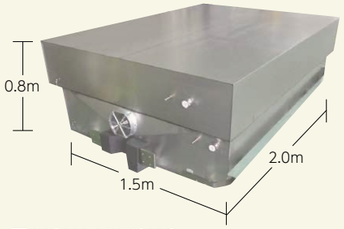
Battery Cell





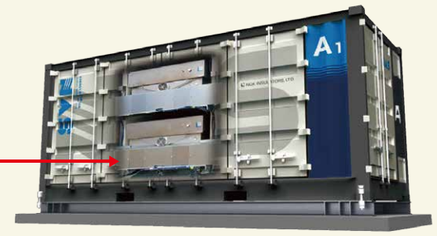
Battery Module





■ 33kW / 200kWh

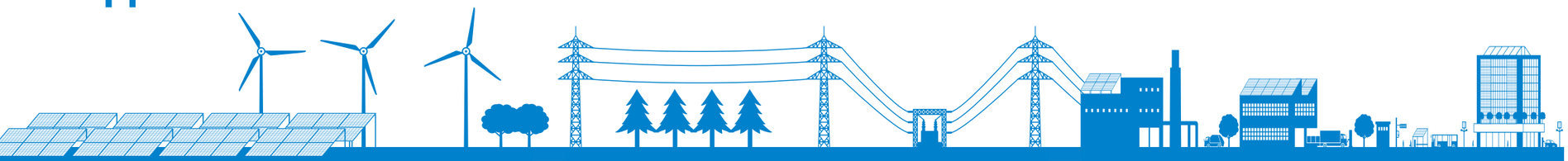
Battery Container





■ 200kW / 1,200kWh

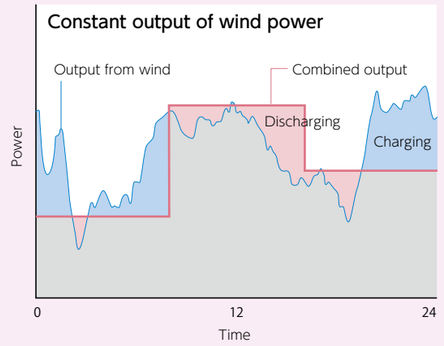
Applications

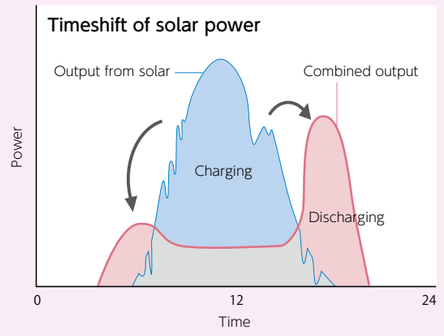


Renewables
Renewables / Power Plants

Renewable Stabilization

By absorbing fluctuating renewable energy such as wind and solar during off-peak times, NAS batteries can provide additional power during periods of peak demand.





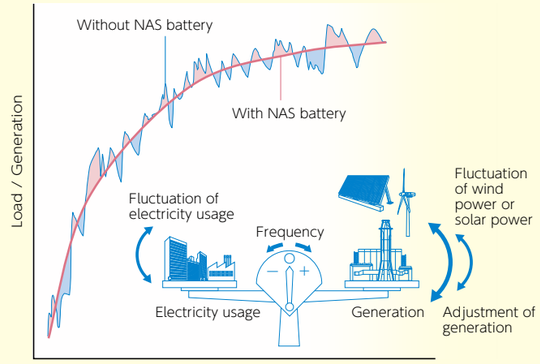
Fossil Fuel Peaker Plant Replacement

NAS batteries can provide resource adequacy capacity of six hours or more per day, providing a green alternative to fossil fuel peaker plants. Moreover, NAS batteries can also provide on-peak/off-peak price arbitrage, frequency regulation, ramping services, VAR support and other grid functions.

Grid Solutions
Ancillary / Investment Deferral

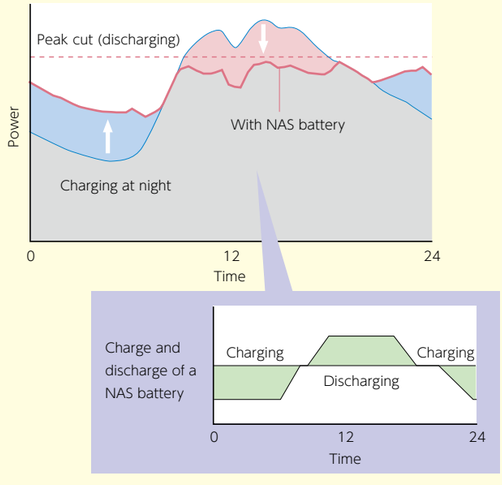
Ancillary Services

Imbalance between demand and supply could cause frequency fluctuation. NAS batteries can achieve minimization of frequency fluctuation by utilizing their high-speed response.



Investment Deferral

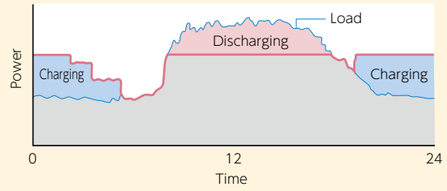
NAS batteries can defer or eliminate the need for transmission and distribution upgrades. Power can be imported into a transmission constrained area when loads are light, charging NAS batteries that are positioned nearby. During peak load, NAS batteries are discharged to supplement the power from the at-capacity transmission lines.



Consumers
Industrial / Commercial & Residential

Peak Shaving

NAS batteries can reduce peak demand automatically by simply setting the desired peak threshold. This can be used to reduce demand charges for users with fluctuating loads.

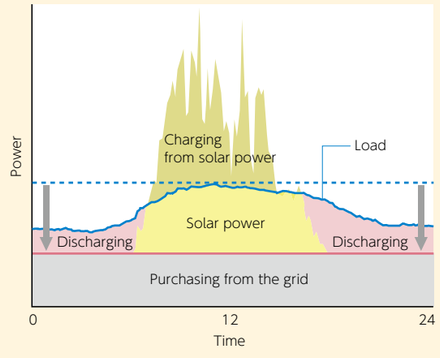


Backup Power and Resilience

NAS batteries can provide continuous power to critical loads for six hours or more in the event of grid outages. In addition to providing multi-hour backup, NAS batteries can also provide other functions, including peak shaving, demand charge reduction, solar power storage, and management of power quality. With solar or other local power generation, additional resilience can be provided by using NAS batteries in a microgrid configuration with islanding (self sustaining) capability.

Storage of Local Solar Power

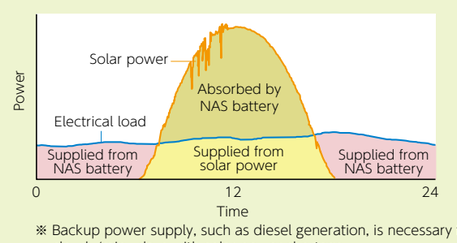
The rapidly declining cost of solar power has led to widespread deployment of solar power generation by end users. NAS batteries can reduce or eliminate grid power usage by timeshifting excess solar power from daytime to nighttime, and can also cut grid costs for end users by simultaneously providing solar power storage, peak shaving and demand charge reduction.



Microgrids
Islands / Remote Grids & Microgrids

24/7 Power Supply with Solar Power for Microgrids

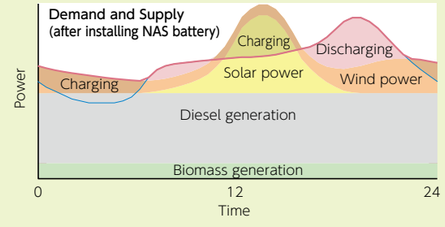
On sunny days, four to five times maximum solar power output against average load and NAS battery with capacity of two-third against solar power are required to cover the most of the load for 24/7. Battery storage needs to discharge for 14-18 hours to shift the surplus solar energy to nighttime and early morning. NAS batteries can discharge for six hours at rated output, but they can discharge for a much longer duration by lowering the output. Roughly speaking, the discharge duration will be increased up to 18 hours if a NAS battery discharges at one-third the rated output. Only proven long-duration energy storage like NAS batteries could be expected for this application. As an example, for a 200kW load, 24/7 power supply could be achieved by utilizing 1,000kW of solar power and 600kW (3,600kWh) of power from a NAS battery. This will enable higher penetration of solar power, optimum use of solar power including its surplus energy and reduction of non-environmentally friendly and costly diesel generator operation, which will lead to a greener society.



※ Backup power supply, such as diesel generation, is necessary for cloudy/rainy days with solar power shortage.

Microgrids

NAS batteries can provide essential functions for smaller grids, such as microgrids, island grids and grids in remote locations. These functions include support for higher levels of renewables, timeshifting and stabilization of wind and solar, voltage support, frequency regulation, protection against frequency collapse during contingencies, black start energy and backup power. Furthermore, NAS batteries allow fossil fuel and biomass generators to be operated at a fixed output setting that minimizes fuel use and emissions.



Reference Installations

Installations for Various Applications

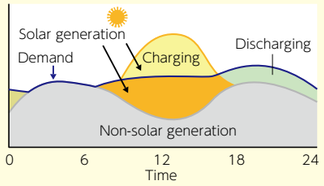
Balancing Supply and Demand Using Long-Duration Energy Storage Systems

50MW/300MWh NAS battery system at the Buzen storage battery substation
Kyushu Electric Power Co., Inc. (supplied through Mitsubishi Electric Corporation)

Fukuoka, Japan
Operation since 2016



Solar power generation is expected to exceed power demand especially during the daytime in spring and autumn when power demand is low. This NAS battery system optimizes the balance of supply and demand of power by absorbing excess solar power to avoid limiting solar power output.



Mitigation of Transmission Congestion and Losses

Total 34.8MW/250MWh NAS battery systems at three substations
Terna S.p.A.

Campania Region, Italy
Operation since 2015



This is the first large-scale battery project directly operated by TSO (Transmission System Operator) in order to manage transmission line congestion caused by variable renewable energy generated in the south. Grid congestion is mitigated by activation of the charging phase. The energy storage function also integrates renewables by balancing supply and demand.



Stabilization of a Huge Wind Farm

34MW/244.8MWh NAS battery system alongside 51MW wind farm
Futamata Wind Development Co., Ltd.

Aomori, Japan
Operation since 2008



This NAS battery system makes wind output dispatchable by charging from excess wind power and discharging so as to meet desired dispatch levels. Immediate smoothing and timeshifting can both be provided.



Installations for Various Applications

Load Leveling

Total 108MW/648MWh NAS battery systems at several substations
Abu Dhabi Department of Energy

Abu Dhabi, UAE
Operation since 2010



These NAS battery systems deployed at several distribution substations (4-40MW/site) level the load curve, thereby reducing the use of high-cost and peak-load thermal generation.



Maximization of Renewable Energy Installations

4.2MW/25.2MWh NAS battery system
The Chugoku Electric Power Co., Inc.

Oki Islands, Shimane, Japan
Operation since 2015



This NAS battery system absorbs large fluctuations in solar and wind power, which helps the owner add more renewables to their grid.



Peak Shaving and Backup Reserve

1MW/6MWh NAS battery system
BC Hydro and Power Authority

Yoho National Park, British Columbia, Canada
Operation since 2013



This NAS battery system supplies clean backup power to a remote area in the Canadian Rockies in the event of a power outage and reduce system load during periods of high demand.



Standard Containerized NAS Battery System

NAS battery systems have a plug-and-play design that enables integration of battery and control equipment into one container. Their newly designed high-power battery module uses less auxiliary power. Containerized NAS batteries can be replicated in parallel for larger deployment.
The containerized design expedites transportation and installation and helps minimize installation costs.





Inside

Advantage of the Containerized NAS Battery System

- Reduction of construction period
- Reduction of construction cost
- Highly flexible and capable of being deployed for various applications
- Easy transportation

Quick Installation



1. Loading battery modules
2. Inland transportation
3. Ocean transportation
4. Unloading containers
5. Installation of battery containers
6. Completion

Six steps from factory to site

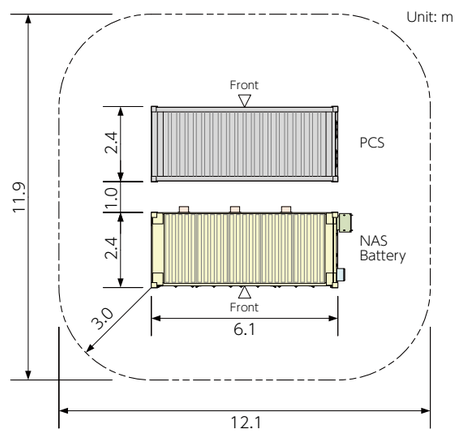


Picture: Buzen storage battery substation of Kyushu Electric Power Co., Inc.

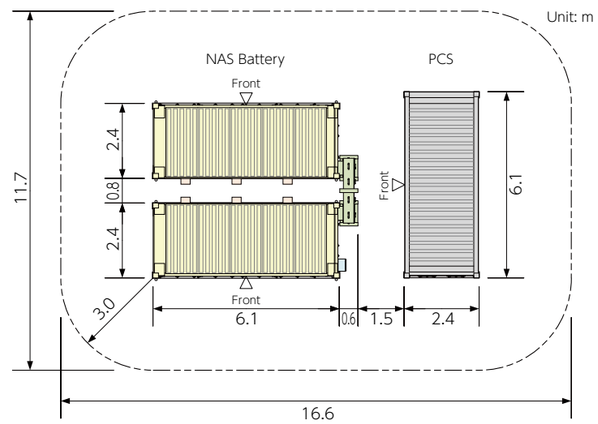
A containerized NAS battery has a rating of 200kW. Up to four units can be connected in series.

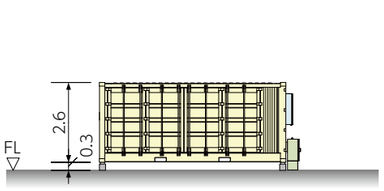
Typical Layout of NAS Battery Systems

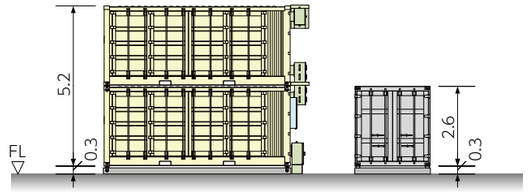
Typical layout of 200kW NAS Battery System



Typical layout of 800kW NAS Battery System







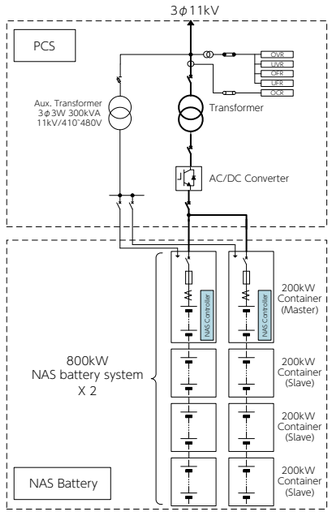
Rated Output(1) [kW]	200	400	600	800
Energy Capacity(1) [kWh]	1,200	2,400	3,600	4,800
Weight(2) [t]	21	42	63	84
Numbers of Containerized NAS Batteries Connected in Series	1	2	3	4
DC Nominal Voltage [V]	192	384	576	768
Footprint(3) Width X Depth Area	6.1 X 2.4 [m] 15 [m²]	6.1 X 2.4 [m] 15 [m²]	6.1 X 5.6 [m] 34 [m²]	6.1 X 5.6 [m] 34 [m²]
Footprint(3) Assumed Arrangement				

(1) AC output base. PCS conversion efficiencies from AC to DC and vice versa are assumed to be 96%.
(2) Weight of battery unit alone.
(3) PCS and maintenance spaces are excluded. Containers are assumed to be stacked in two steps.

System Configuration

A NAS battery is connected to the grid through a Power Conversion System (PCS). When the NAS battery is charging, the PCS converts the grid's AC energy into DC energy, which is stored in the NAS battery. When the NAS battery is discharging, DC energy is converted into AC energy by the PCS and supplied to the grid. Interactions with the grid are through an integrated control system, which manages the NAS battery and PCS, resulting in safe and efficient operation.

Typical Single-Line Diagram for 1.6MW NAS Battery System



NAS Battery Simulator



NAS batteries offer optimal solutions to your energy management.
Simulator is available!

Japanese	https://www.ngk.co.jp/product/nas/simulator/index.html
English	https://www.ngk-insulators.com/en/product/nas/simulator/

Flow of simulation

Registration

Registration is required to use the simulator.
URL of the simulator will be sent to the registered e-mail address.

Entering the power demand of the candidate site

Entering the power demand every 30 minutes (or 1 hour) from 0:00 to 24:00.

Select the type of NAS battery and its operation mode

This simulator will calculate the benefit of a NAS battery and show the results in a chart.

Safety

In designing the NAS battery, NGK placed safety in paramount importance. The safety of NAS batteries has been proven in testing by NGK and third-party authorities and from decades of field experience. NAS batteries also comply with CE Marking requirements which are essential for exportation to Europe.

Test	Test Result
Fire exposure	**<Put module in fire>** No leakage. No fire. Safety confirmed.
Submerge	**<Submerge module at operational temp>** No leakage. No fire. Safety confirmed.
Drop	**<Drop module at operational temp>** Module enclosure was damaged but no damage to battery cells. No leakage. No fire. Safety confirmed.
Short circuit	**<Short circuit module>** Circuit was opened by internal fuses. No leakage. No fire. Safety confirmed.
Self-extinguish	**<Ignite one battery cell inside module>** No expansion of fire to adjacent battery cells. No leakage. No fire. Safety confirmed.

Expected Lifetime

15 years or 4,500 cycles (at 100% DoD or equivalent), whichever occurs first.

Environmental

NAS battery cells are hermetically sealed and there are no emissions from their operation.

Installation Process

NGK can provide professional support that complies with local laws and regulations for NAS battery installations. This includes installing, connecting and energizing NAS battery systems.

Operation and Maintenance

Appropriate maintenance is recommended to achieve stable operation for a long period of time.

Routine check	Checking for abnormalities
	Cleaning up
	No need for suspending operation
Periodic check (fee-based service)	Every four years
	Replacement of consumable parts
	Functional tests

NGK-NAS Call Center (fee-based service)

The NGK-NAS Call Center provides timely solutions and further relief to customers.

24/7 remote monitoring of customer's system
Technical support via call or email

Warranty

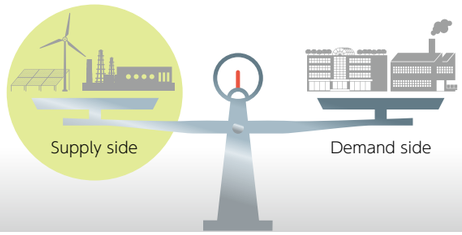
Two year warranty standard. Extended warranty available.

New Application "Demand Response"

Demand response adds more value to NAS batteries.

Current Situation

Supply-demand balance is maintained by adjustment of generation on the supply side.



Challenges on the Supply Side

Reserving and balancing power are required for stable power supply.
❶ Maintaining backup power plants is required.
❷ Renewal of old power plants is required.

Needs on the Supply Side and Demand Side



・Avoiding limitation of grid connection and curtailment of renewable energy



・More countermeasures during power supply shortage
・More efficient investment for stable power supply



・Reducing the penalty cost charged when electricity retailers cause a shortage of power supply to planned power demand
・Suppressing procurement cost of electric power



・Creation of new market
・Useful balancing of power

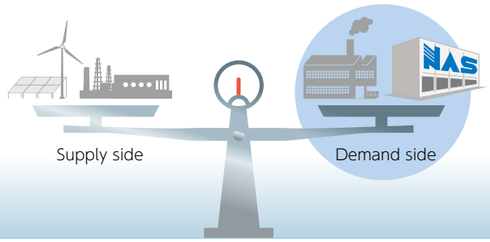


・Utilizing surplus capacity of NAS batteries during off-peak time
・Increasing income through optimum use of NAS batteries

*An aggregator is a control tower that generates demand response at the request of its client.

New Application "Demand Response"

Balancing on the demand side

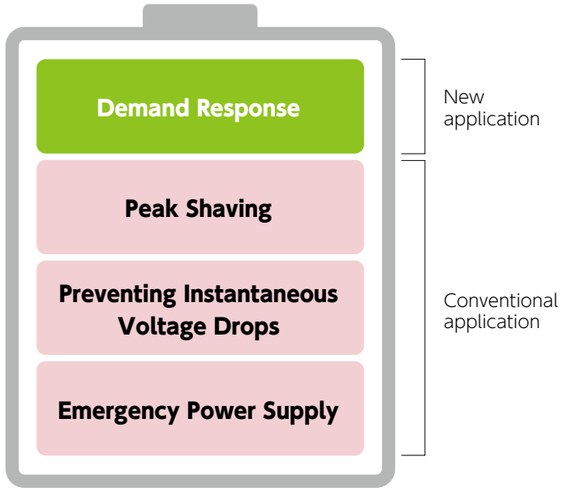


New Method of Utilization

Utilizing off-peak unused portion for external needs

Conventional Application + **Demand Response**

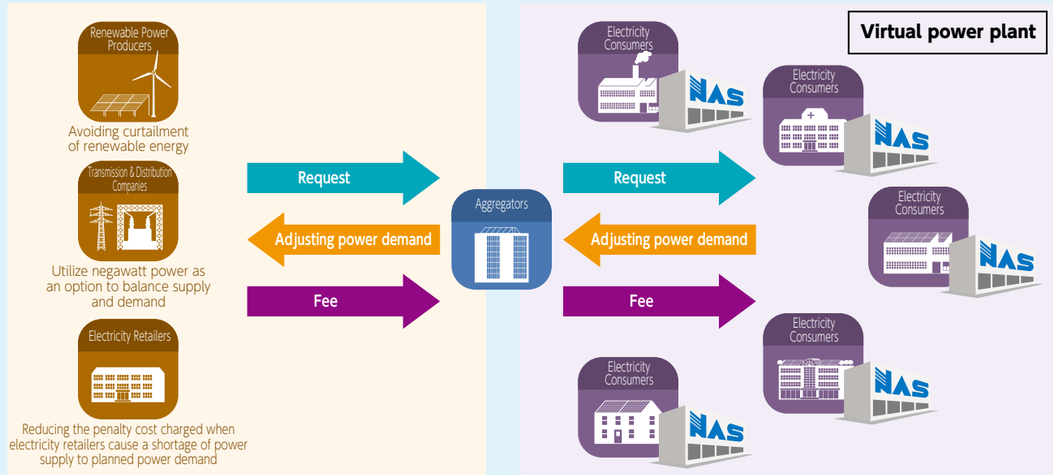
Expanding value of NAS batteries



Demand response extends the possibilities for new applications. Meeting needs on the supply side through optimum use of NAS batteries' large capacity and long-duration storage.

Utilizing large-capacity NAS batteries provides benefits to both sides.

Mechanism of Demand Response



Benefit of supply side
Aggregate consumer's energy resources to utilize them for reserve capacity and balancing services

Benefit of demand side
・Receive compensation for reducing power demand when supply-demand balance is tight
・Effective utilization of surplus power from renewable energy

Receiving power in case of participation in demand response

