NAS® Battery for Stationary Energy Storage

Santiago de Chile, 2024

BASF
We create chemistry

NAS® Battery for Long Stationary Energy Storage

We are your local support

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BASF Group:
Facts & figures

BASF at a glance

- Our chemistry is used in almost all industries.
- We combine economic success, social responsibility and environmental protection.
- **Sales 2022: €87,3 billion**
- **EBIT before special items 2022*: €6,9 billion**
- Employees (as of December 31, 2022): 111,481
- 6 Verbund sites and 232 other production sites
- Around 90,000 customers from various sectors in almost every country in the world

BASF’s segments

Chemicals

Petrochemicals

Intermediates

Materials

Performance Materials

Monomers

Industrial Solutions

Dispersions & Pigments

Performance Chemicals

Surface Technologies

Catalysts

Coatings

Nutrition & Care

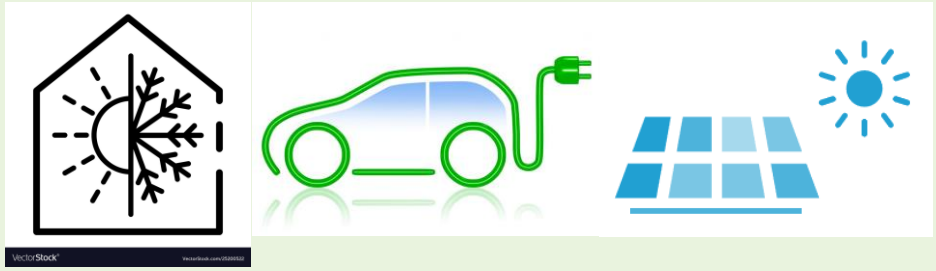
Care Chemicals

Nutrition & Health

Agricultural Solutions

BASF contribution to climate protection

Products for avoiding and reducing greenhouse gas emission



- Thermal insulation materials
- N_2O decomposition catalysts
- Materials for Li-ion batteries
- Materials for wind turbines
- Molten salt for solar thermal plants

…and many others

Carbon management R&D programme

- Emission-free hydrogen production
- World`s 1st electric heating concept for steam cracker
- CO_2-free synthesis pathway for olefins

BASF climate target 2030: CO_2 neutral growth

- Reduction of CO_2 emission from production by improving energy and process efficiency
- Increasing share of RE in our global power supply

Sodium-sulfur battery (NAS® Battery): Strategic cooperation NGK/BASF

- NGK Insulators: experience in manufacturing and deployment of NAS® Batteries, 20 years` track record

+

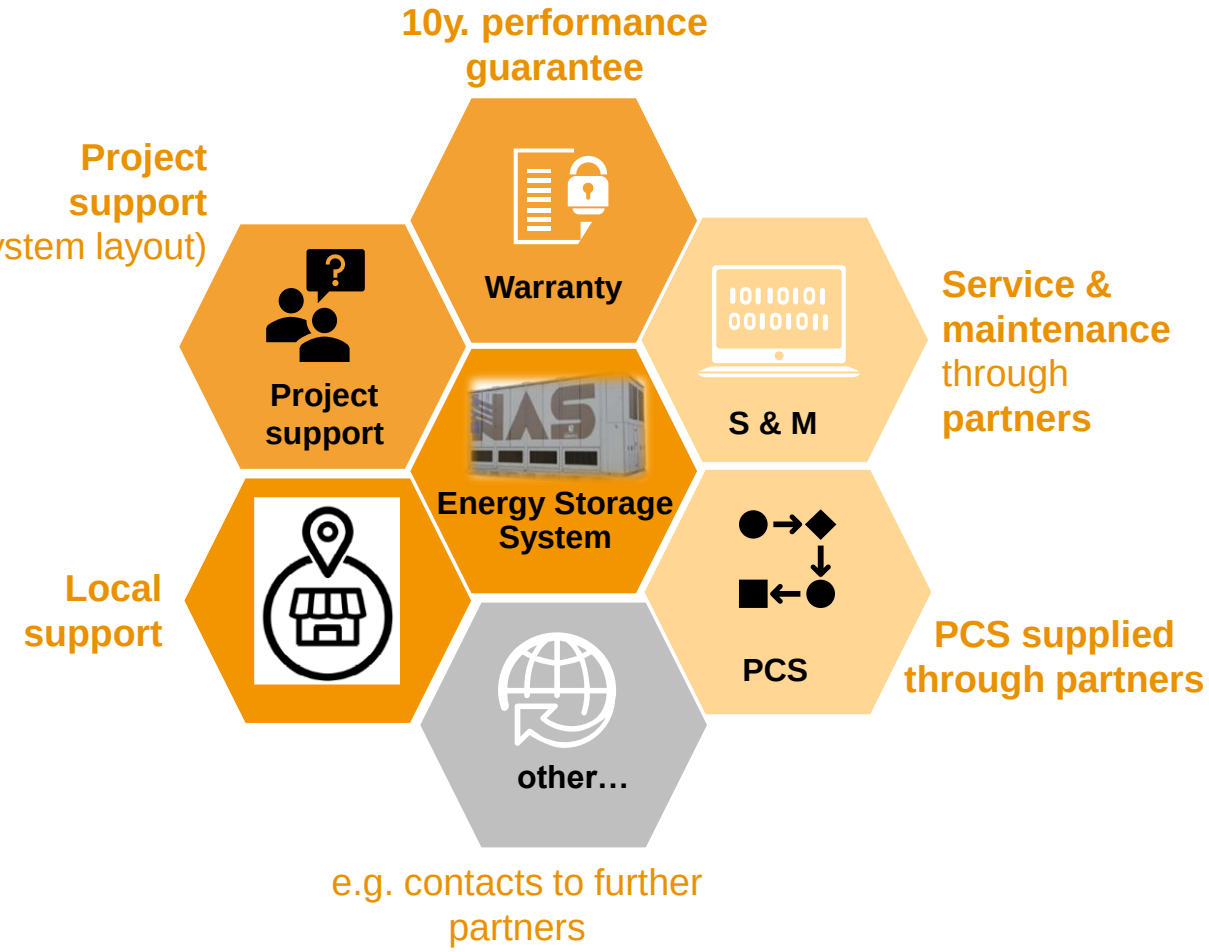
- BASF: years of R&D on sodium-sulfur battery technologies, global organization & worldwide sales network

↓

  - Joined forces for market development of long duration stationary batteries
  - Joint development of next generation of sodium-sulfur batteries

NAS® Battery @ BNB: our offer to our customers

- Safe and reliable battery system
- Project development support (initial technical layout and system configuration of battery system)
- Performance guarantee for 10 years if desired by customers
- Recommendation for matching PCS solution through established partnerships with suppliers
- Service & maintenance through our partners
- Local support through our offices worldwide



NAS® Battery: Key features

NAS® Battery: key features

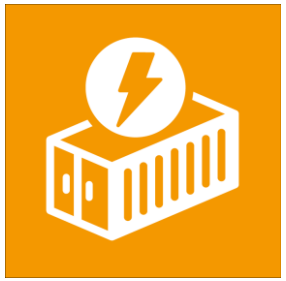
6-10 hr duration

life time ~ 20y

safe & reliable

environmentally benign

high energy density



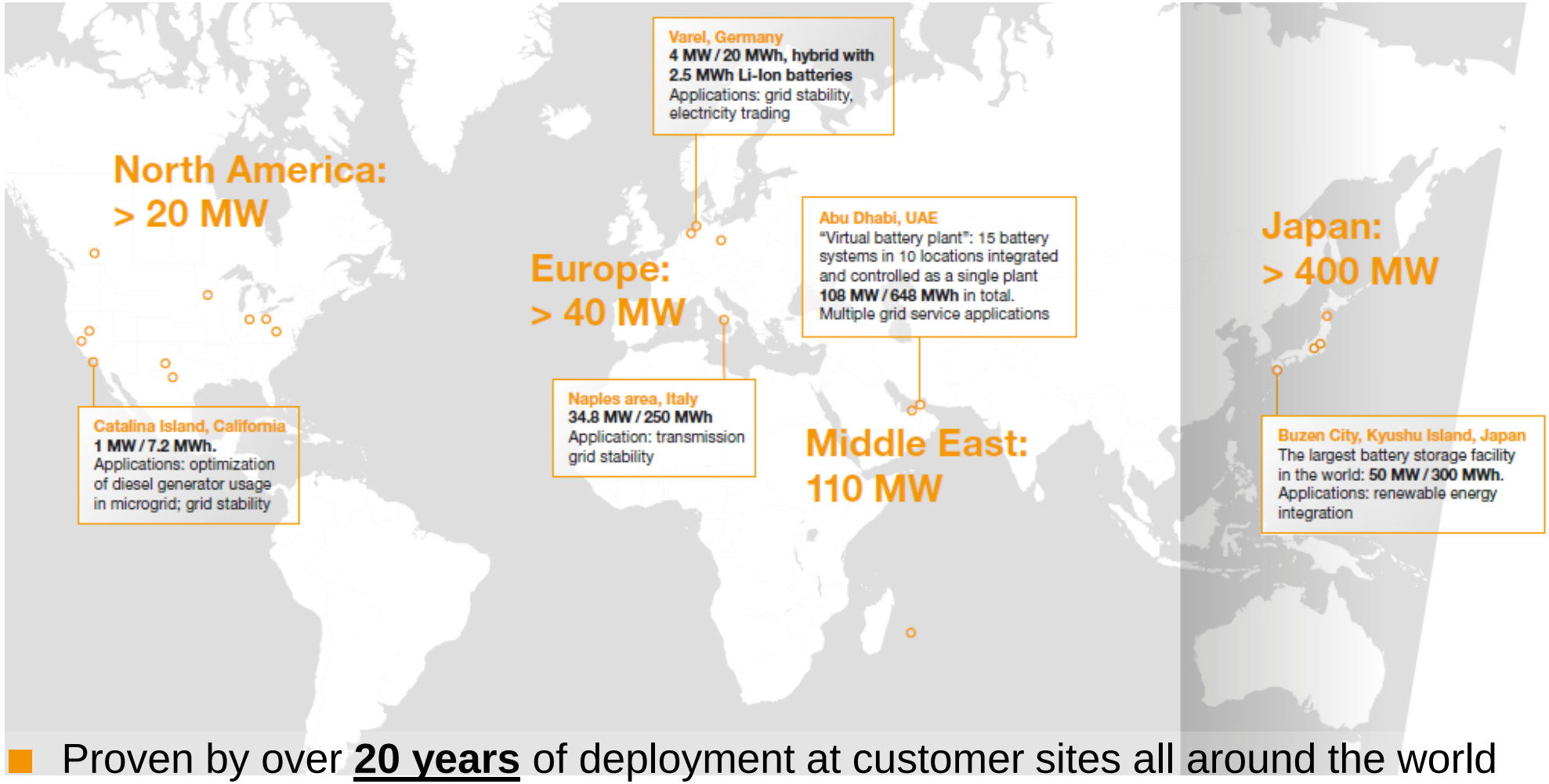
fast response

climate resilient

low maintenance

NAS® Battery: References

NAS® Battery: installation record

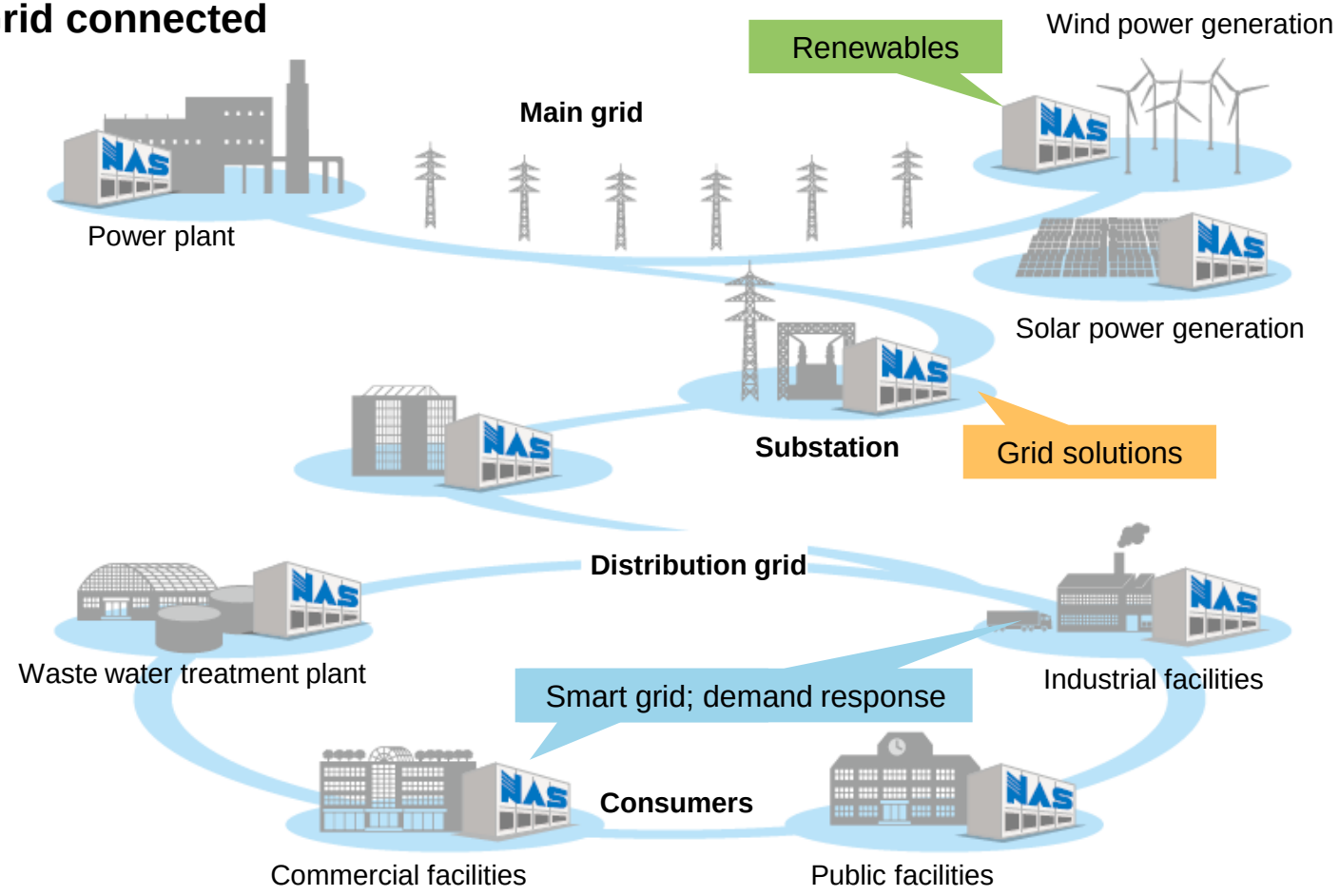


- Proven by over **20 years** of deployment at customer sites all around the world
- More than **200 projects** with a total output exceeding 680 MW / 4,8 GWh

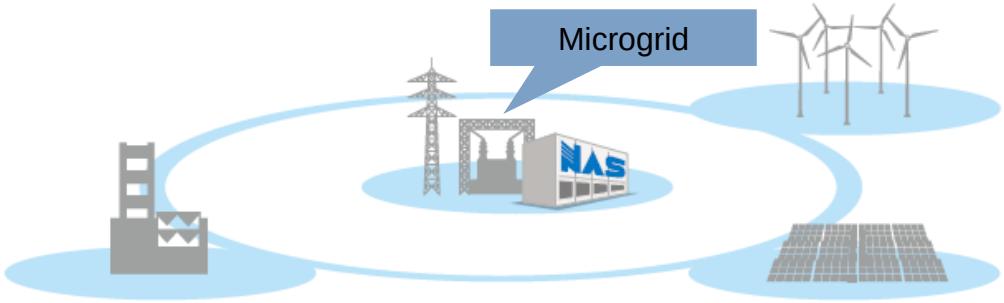
NAS® Battery: Applications

NAS® Batteries role in the power chain

Grid connected



Remote island



NAS® Batteries applications in various energy market segments

Power generation

- Renewable stabilization
- Fossil fuel peaker plants replacement

Grid solutions

- Investment deferral
- Ancillary services

Consumers

- Peak shaving
- Time of use shift
- Back up power and resilience
- Demand response

Microgrids

- Optimization of fossil fuel use
- 24/7 power supply with solar
- Further functions

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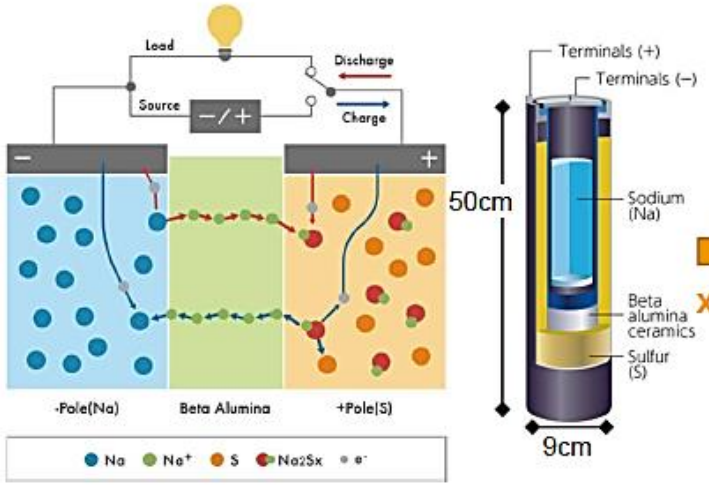
NAS® Battery: System design

NAS® Battery system design

Battery cell



- 1.2kWh / 5.3kg
- ~2V
- C-rate 1/6 (0.17)
- Max. t-range: 290°C – 360°C
- No memory effect
- Life time: **7300** cycles or **20** years

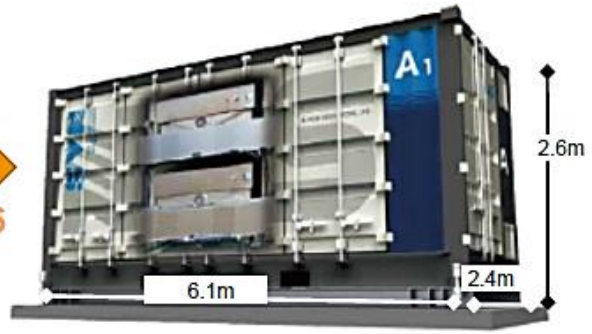
x192

Battery module

- **33kW / 242kWh (max 42kW*)**

x6

Battery container (single unit)



- 20 feet container / 21 ton
- **max. 250kW*/ 1.45MWh**
- **DC-DC RTE: 80-85%****

x4

Battery system (stacked)

- 4x 20 feet container
- **max 1000kW*/ 5.8MWh**

*limited by max. temperature and max. current of the system
** depending on load profile.

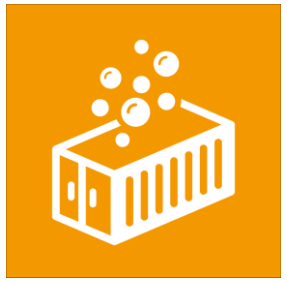
NAS® Battery: enhanced safety features

Fire exposure

890°C for 35 min.

- no material leakage
- no fire inside
- no cell damage

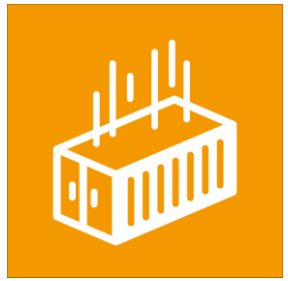
Submerge



3 days in water

- no material leakage
- no fire
- no cell damage

Module drop



2.3to from 3.1m

- deformation at point of contact
- module enclosure damaged but no cell damage
- no material leakage
- no fire

Short circuit

6.4kA

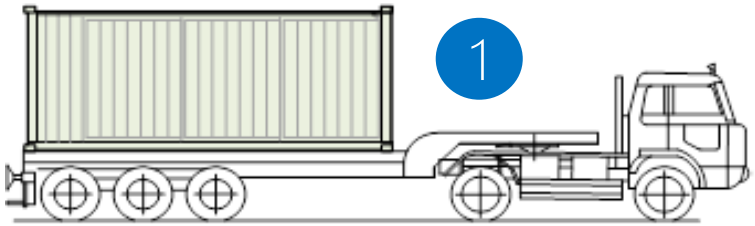
- internal fuse activated within 800ms
- no material leakage
- no fire
- no cell damage

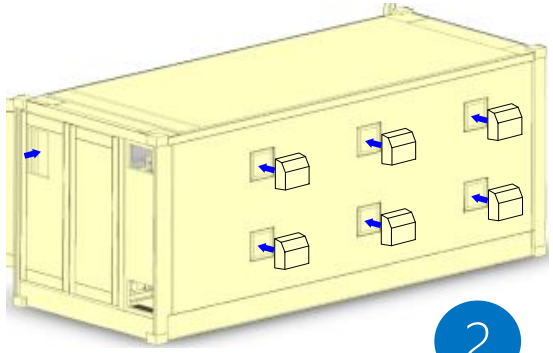
Self-extinguish

one cell ignited

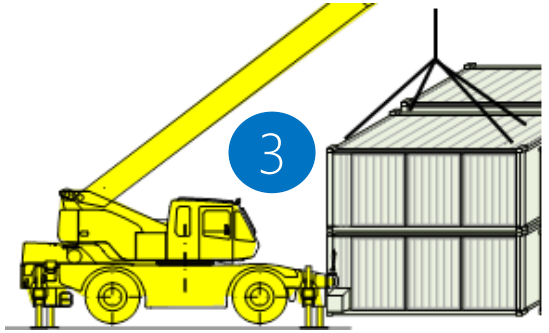
- fire constrained to the ignited cell only, no spread to adjacent cells
- no material leakage
- no fire

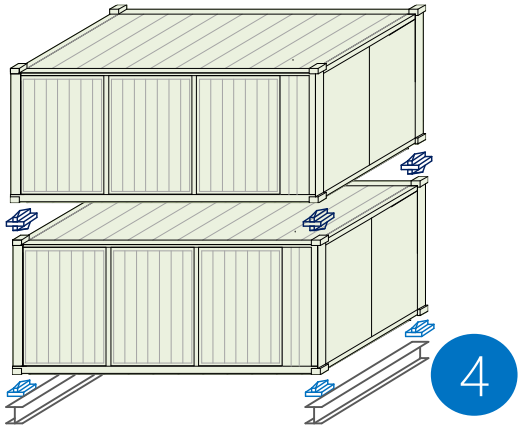
Containerized NAS® Battery: installation



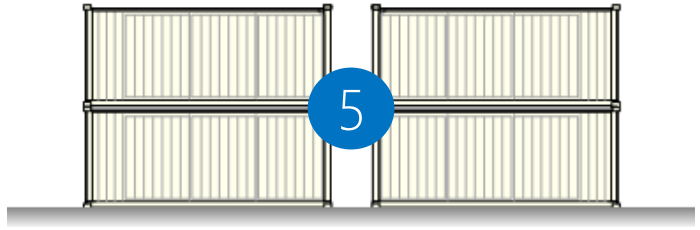


- assemble air outlet hood
- remove cushion materials for transportation above and under battery modules





- twist lock
- bottom stacker
- H-steel for the base



- external DC wiring
- communication with PCS
- air-conditioning for control room

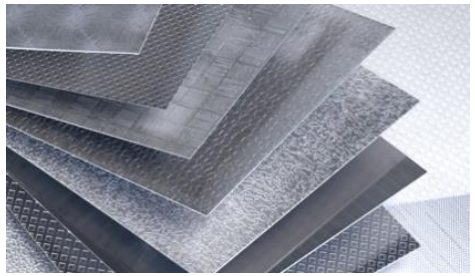
NAS® Battery: environmentally friendly technology

ceramic: aluminium, oxygen, sodium

sodium

sulfur

steel and aluminium



carbon

silica-based materials

fully recyclable or reusable

metals & slag

➢ abundant materials, stable prices

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NAS® Battery: total costs of ownership

CAPEX

- Battery system
- Installation costs

OPEX

- No air conditioning
- Low maintenance costs

Long life time

- Very low degradation
  → life time up to 20 years

End of life

- Recyclable or reusable raw materials

Initial investments are compensated by low OPEX, and paid off over long lifetime

NAS® Battery: Deployment examples

The largest NAS® Battery systems in the world

Photo: courtesy of NGK

location	Buzen City, Fukuoka, Kyusyu, Japan
capacity	50MW / 300MWh
containers	252
footprint	100 x 140 (m)
construction	6 months
commission	march 2016
grid connection	66kV
main purpose	renewable energy

1st – NGK; Japan 2016 300MWh

2nd – NGK; Japan 2008 245MWh

3rd – NGK; UAE 2018 240MWh

4th 129MWh

Source : DOE Global Energy Storage Database 12.09.2018

Renewable energy integration

Rokkasho, Japan

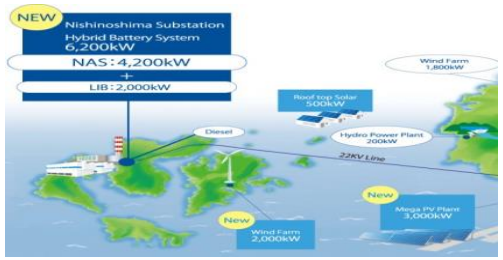
- August 2008
- 34MW/244.8MWh
- 51MW wind
- meet desired dispatch
- store excess wind power

Luverne, MN, US

- October 2008
- Xcel Energy demo
- 1MW/7.2MWh
- 11MW wind farm
- frequency regulation

Miyako Island, Japan

- October 2010
- 4MW/28.8MWh NAS + 100kW/200kWh li-ion
- solar fluctuations
- frequency stabilization



Oki Islands, Japan

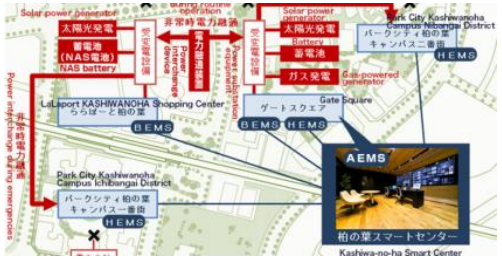
- September 2015
- 4.2MW/25.2MWh NAS + 2MW/0.7MWh li-ion
- maximisation of renewable energy on islands

Photos and pictures: courtesy of NGK

Grid service applications

Presidio, TX, US

- April 2010
- 4MW/32MWh
- 97km 69kV overhead line
- transmission deferral
- prevention of power outage
- flattening voltage fluctuations

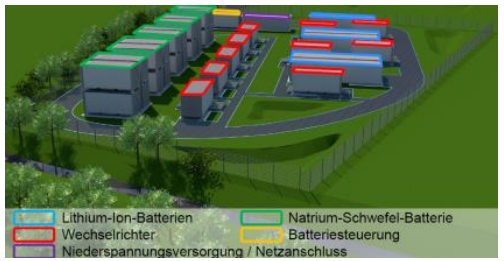


Kashiwa, Japan

- January 2015
- 1.8MW/12.96MWh
- load balancer between residential and commercial
- renewable fluctuations
- backup (natural disaster)

Abu Dhabi, UAE

- Jan 2010 to Dec 2017
- 108MW/648MWh in 10 locations = “smart grid”
- investment deferral
- daily time-shifting
- frequency control
- spinning reserve



Varel, Germany

- October 2018
- 4MW/20MWh
- hybrid with 2.5MWh Li-ion
- demonstration project
- electricity trading: reference for regulation, etc.

Photos & pictures: courtesy of NGK

Microgrid applications

La Réunion, France

- December 2009
- 1MW/7.2MWh
- reduce diesel costs
- allow high renewable penetration rate

Catalina Island, CA, US

- August 2011
- 1MW/7.2MWh
- diesel load at min. 80%
- voltage regulation
- island system stability

Los Alamos, NM, US

- September 2012
- 1MW/6MWh
- power balancing
- level out photovoltaic fluctuation

Photos: courtesy of NGK

NAS® Battery: Key messages

Summary – key messages

- **We offer you**
  - **NAS® Battery system for long duration stationary storage**
    - High energy
    - Long lifetime
    - Safe & reliable
    - Environmentally benign
    - Proven by 20 years deployment at customer sites all over the globe
  - **Extended warranty: 10 years performance guarantee**
  - **Service & Maintenance over project lifetime**
  - **Initial project development support**: technical layout and system configuration
  - **Support through our local offices worldwide**

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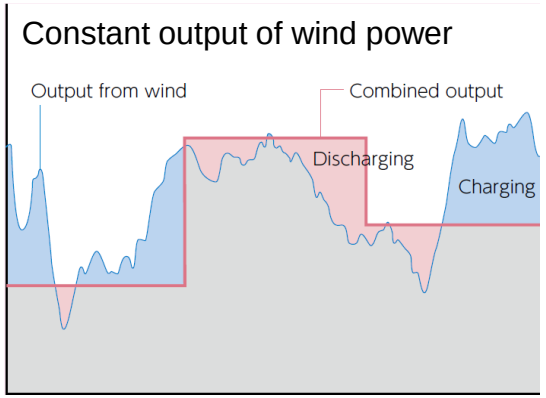
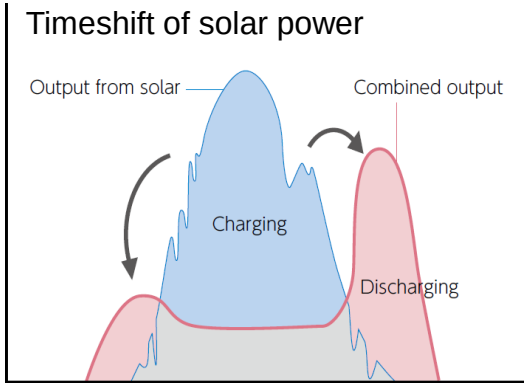
BACK UP

Power supply applications

- **Renewable Stabilization:**
  - fluctuations of renewable energy are leveled out by absorbing excess energy during off-peak times and providing power during demand peaks
- **Fossil Fuel Peaker Plants Replacement:**
  - NAS battery provides resource capacity of six hours or more per day and thus can serve as a green alternative to fossil fuel peaker plants
- **Other use cases:**
  - on-peak/off-peak price arbitrage, frequency regulation, ramping services, VAR support and other grid functions



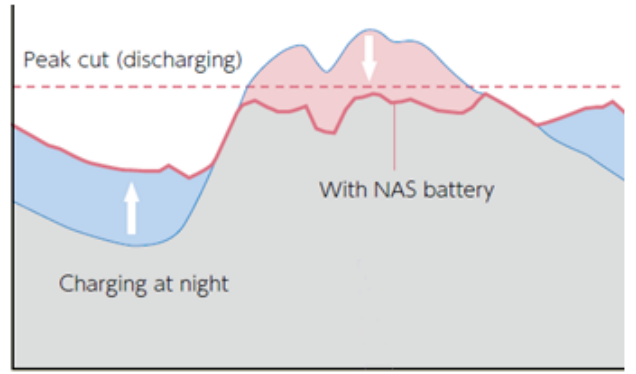


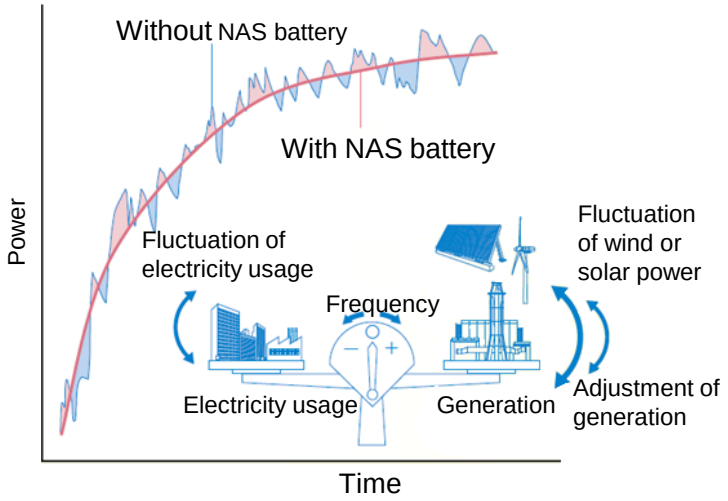
Grid solution applications

- **Investment deferral:**
  - Transmission and distribution upgrades can be deferred or even eliminated by deploying NAS batteries:

    → at times of light loads→ charge and store excess energy
    → at times of peak load → discharge and supply power to grid

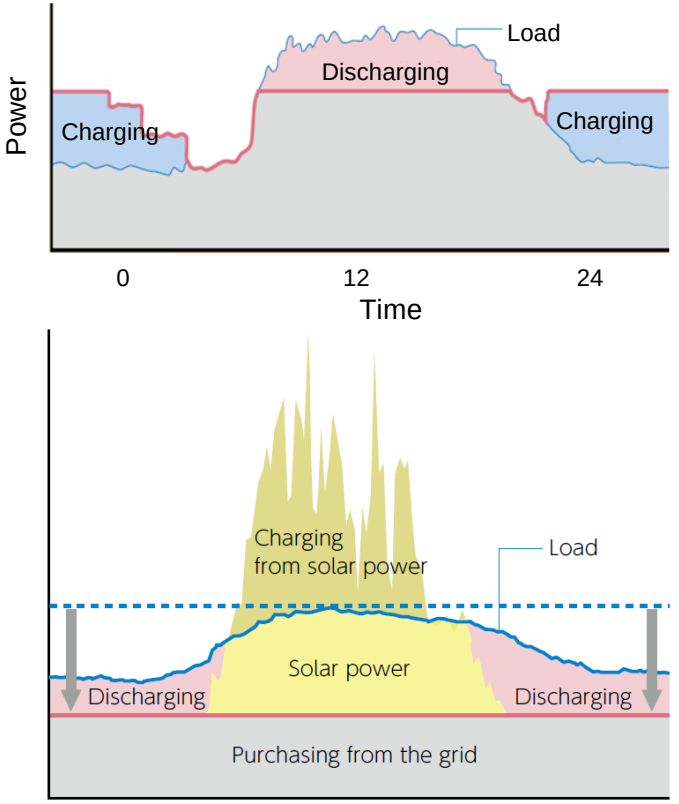
- **Ancillary services:**
  - Thanks to its fast response, NAS batteries can reduce imbalances between demand and supply to stabilize the grid





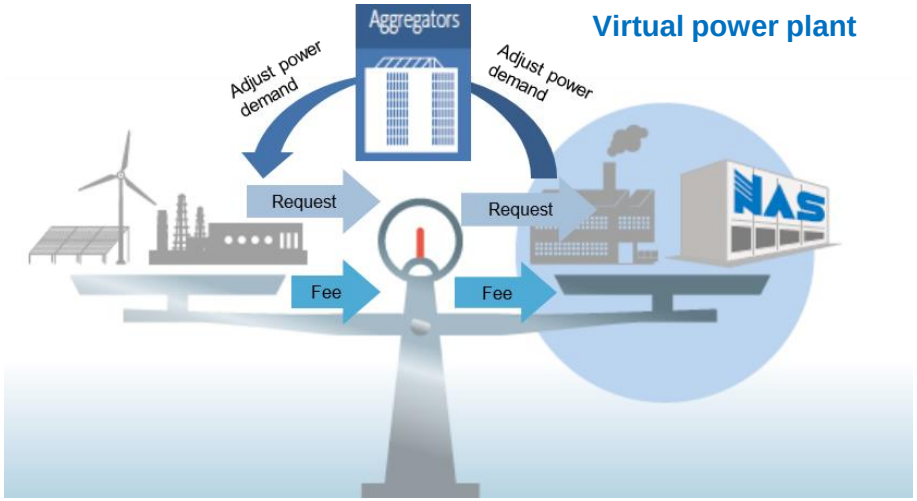
Behind-the-meter applications

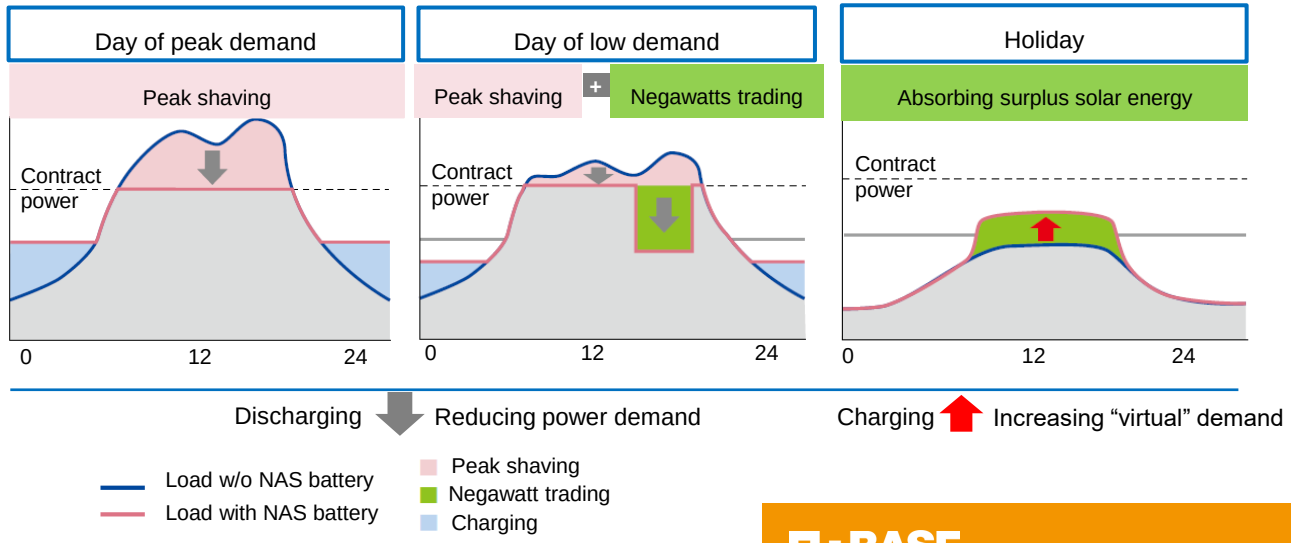
- **Peak shaving:**
  - Reduce demand charges by covering peak demand with NAS battery
    → NAS battery will be charged at low demand times and discharged during peak time, supplementing power supply from the grid
- **Time of use shift:**
  - Costs of power supply from the grid can be reduced
    → excess power (e.g. solar) can be stored and its usage shifted from high-tariff times to low tariff time
- **Back up power and resilience:**
  - continuous power supply for six hours or more in the event of grid outages



Virtual power plant applications

- **Demand response:**
  - supply-demand balance maintained by aggregation and re-distribution of unused power from multiple consumers, from private to large scale
  - Benefits:
    - Front-of-the-meter: no dedicated investment needed, existing systems are utilized for reserve capacity and balancing services; reduced or no penalties for supply shortage
    - Behind-the-meter: effective utilization of (renewable) power sources; compensation for reduced power demand





Microgrid / Island grid applications

- **Reliable power supply from renewable sources**
  - Combine solar or wind power generation with NAS battery to achieve reliable power supply and optimize costs
- **Autonomous power supply with solar power**
  - excess power is stored by NAS battery in the daytime and used at nighttime → power supply from grid is thus reduced or even eliminated
- **Minimization of fossil generators usage**
  - Reduce energy costs and CO2 emission by combining NAS battery with a diesel or biomass generator
- **Additional resilience to local power generation**