**TECHNOLOGY FACTSHEET**

# SODIUM SULPHUR (NAS) BATTERY FOR LARGE-SCALE TEMPORAL ELECTRICITY STORAGE

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| Date of factsheet | 29-4-2019 |
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| Sector | Electricity generation |
| | |
| ETS / Non-ETS | Non-ETS |
| Type of Technology | Storage |
| Description | NaS batteries store electricity through a reversible chemical reaction. The basic components are a container, electrodes, and an electrolyte. By loading the battery, the electricity is transformed into chemical energy, while during discharge, electrochemical reactions occur at the two electrodes generating a flow of electrons through an external circuit (DNV KEMA 2013). Large scale NaS batteries are usually used for energy intensive storage applications (e.g. shifting power supply of variable renewables in time, making these more dispatchable), but can also be used for power intensive storage (e.g. frequency control). The factsheet focuses on NaS batteries for temporal storage (with >1h discharge time) for large scale solutions (utility scale or for large distributed systems). |
| TRL level 2020 | TRL 9 |
| | Commercial energy storage technology (JRC ETRI 2014). |

## TECHNICAL DIMENSIONS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacity | Functional Unit | | Value and Range | | | | | | | | |
| | kWh | | 100.000 | | | | | | | | |
| | | | 7.000 | | | - | | | 245.000 | | |
| Potential | Global | GWh | Current | | | 2030 | | | 2050 | | |
| | | | N/A | | | - | | | - | | |
| | | | - | – | - | *Min* | – | *Max* | *Min* | – | *Max* |
| Market share | Global utility scale electricity storage | % | 0,28 | | | - | | | - | | |
| | | | 0,28 | – | 0,28 | *Min* | – | *Max* | *Min* | – | *Max* |
| Capacity utlization factor | - | | | | | | | | | | |
| Full-load running hours per year | | | | | | | | | | | |
| Unit of Activity | PJ/year | | | | | | | | | | |
| Technical lifetime (years) | 10 (JRC ETRI 2014). 2,500-4,500 cycles (Luo et al. 2015) | | | | | | | | | | |
| Progress ratio | 94% (JRC ETRI 2014) | | | | | | | | | | |
| Hourly profile | No | | | | | | | | | | |
| Explanation | Typical capacity refers to NaS batteries for temporal storage with a typical power rating of 1-40 MW. Discharge times are 4-10 hours (see others section below), leading to the range of energy capacities given here.<br>Potential for all battery types is high as there are no significant space or resource constraints, instead demand for storage and costs are usually determining factors when it comes to potential installed capacity. As of 2015 global grid-connected capacity is 401 MW, which is dominated by pumped hydro with a market share of 99.1% (IRENA 2015).<br>Lifetime of up to 15 years also reported in literature (IEA-ETSAP & IRENA 2012) and typical cycle lifetime of 5,000 cycles but up to 10,000 cycles reported (IRENA 2017). | | | | | | | | | | |

## COSTS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year of Euro | 2015 | | | | | | | | |
| | Euro per Functional Unit | Current | | | 2030 | | | 2050 | |
| Investment costs | € / kWh | 335 | | | 334 | | | 297 | |
| | | 230 | – | 641 | 80 | – | 334 | 297 | – | 297 |
| Other costs per year | € / kWh | - | | | - | | | - | |
| | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| Fixed operational costs per year (excl. fuel costs) | € / kWh | 5,0 | | | 5,0 | | | 4,5 | |
| | | 5,0 | – | 5,9 | 5,0 | – | 5,9 | 4,5 | – | 4,5 |
| Variable costs per year | € / MWh | 2,0 | | | 2,0 | | | 2,0 | |
| | | 0,0 | – | 2,0 | 0,0 | – | 2,0 | 2,0 | – | 2,0 |
| Costs explanation | Reference investment costs from the primary source (JRC ETRI 2014) seems high compared to own calculation based on CAPEX (per MW) and average size data (from JRC ETRI 2014 and Luo et al. 2015). JRC ETRI (2014) is still used as primary source because it has the most complete set of data, including CAPEX and FOM/VOM estimates up to 2050. Data points for the current (2020) set differ in year per source: 2020 for JRC ETRI (2014), 2016 for IRENA (2017), 2013 for JCH JU McKinsey (2015). Investment cost projections for 2020-2050 by JRC ETRI (2014) are for a generic 7.2 MW battery.<br>FOM costs calculated using JRC ETRI (2014) assumption that FOM costs are 1.5% of investment costs. It is assumed that FOM costs remain 1.5% of investment costs in 2020, 2030 and 2050. FOM costs by FCH JU McKinsey 2015 are calculated using FOM costs of 35 €/kW and the assumption of average storage capacity of 6 hours.<br>VOM costs only provided for 2013 by JRC ETRI (2014), it is assumed the VOM costs remain the same in 2020, 2030 and 2050. VOM costs are defined by JRC ETRI as production-related O&M costs that vary with electrical generation. They exclude personnel, fuel, and CO2 costs.<br>Details of the cost estimates are not or only shortly elaborated in the sources used, and estimations from other sources vary, especially from older reports. | | | | | | | | |

## ENERGY IN- AND OUTPUTS

| | Energy carrier | Unit | Current | | | 2030 | | | 2050 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy carriers (per unit of main output) | *Main output:* Electricity | PJ | -1,00 | | | - | | | - | | |
| | | | -1,00 | – | -1,00 | *Min* | – | *Max* | *Min* | – | *Max* |
| | Electricity | PJ | 1,25 | | | - | | | - | | |
| | | | 1,25 | – | 1,25 | *Min* | – | *Max* | *Min* | – | *Max* |
| | | PJ | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| | | PJ | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| Energy in- and Outputs explanation | The required amount of electricity input for 1 PJ of electricity output is calculated. Roundtrip efficiency of 80% assumed based on JRC ETRI (2014). | | | | | | | | | | |

## MATERIAL FLOWS (OPTIONAL)

| | Material | Unit | Current | | | 2030 | | | 2050 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Material flows | | | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| | | | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| Material flows explanation | | | | | | | | | | | |

## EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)

| | Substance | Unit | Current | | | 2030 | | | 2050 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions | | | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| | | | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| | | | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| | | | - | | | - | | | - | | |
| | | | *Min* | – | *Max* | *Min* | – | *Max* | *Min* | – | *Max* |
| Emissions explanation | | | | | | | | | | | |

| OTHER | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **Current** | | | **2030** | | | **2050** | | |
| Depth of discharge | % | 100 | | | - | | | - | | |
| | | 100 | – | 100 | *Min* | – | *Max* | *Min* | – | *Max* |
| Charge time | Hours | 6 | | | - | | | - | | |
| | | 4 | – | 8 | *Min* | – | *Max* | *Min* | – | *Max* |
| Discharge time | Hours | 4 | | | - | | | - | | |
| | | 4 | – | 10 | *Min* | – | *Max* | *Min* | – | *Max* |
| Self discharge | % / month | 30 | | | - | | | - | | |
| | | 2 | – | 100 | *Min* | – | *Max* | *Min* | – | *Max* |
| Explanation | Charge time for 0.5-50 MW system (DNV KEMA 2013).<br>Discharge time for 1-35 MW systems (IEA-ETSAP & IRENA 2012, Luo et al. 2015, JRC ETRI 2014). | | | | | | | | | |

**REFERENCES AND SOURCES**


JRC 2014 - Energy Technology Referency Indicator (ETRI) projections for 2010-2050

IRENA 2015 - Renewables and Electricity Storage: a technology roadmap for REmap 2030

IEA-ETSAP & IRENA 2012 - Electricity storage technology brief

IRENA 2017 - Electricity Storage Costs

FCH JU McKinsey (2015) - Commercialisation of energy storage in Europe

Sauer et al. (2007). Detailed cost calculations for stationary battery storage systems. Second International Renewable Energy Storage Conference (IRES II) Bonn, 19.-21.11.2007

DNV-KEMA 2013 - Systems Analysis Power to Gas (deliverable 1: Technology review)