TECHNOLOGY FACTSHEET

SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) FOR POWER APPLICATIONS

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Sector	Electricity generation
ETS / Non-ETS	Non-ETS
Type of Technology	Storage
Description	Superconducting magnetic energy storage (SMES) systems store electricity in a magnetic field generated by superconducting magnets working at cryogenic temperature (IEA ETSAP & IRENA, 2012). Key features of SMES include relatively high power density, fast response time, very quick full discharge time, depth of discharge, high cycle efficiency and long lifetime (Luo et al., 2015). The main drawbacks are its high capital cost and high daily self-discharge rates (Luo et al., 2015). Existing SMES projects can provide high power for short periods of time, making them suitable for voltage and power quality applications (Chen et al., 2009). High energy capacity (100 MWh+) SMES could become available in the next decade (Luo et al., 2015), but these are not considered in the current factsheet.
TRL level 2020	TRL 8 Some demonstration projects have been launched (Luo et al., 2015). SMES devices in the range of 0.1-10 MW have been used commercially (Luo et al., 2015).

TECHNICAL DIMENSIONS

Capacity	Functional Unit		Value and Range								
	kW						5,000				
				100			-			10,000	
Potential	Global	GWe		Current			2030			2050	
				N/A			-			-	
			-	–	-	Min	–	Max	Min	–	Max
Market share	0	%		-			-			-	
			Min	–	Max	Min	–	Max	Min	–	Max

Capacity utlization factor	
Full-load running hours per year	
Unit of Activity	PJ/year
Technical lifetime (years)	20+ years and 100,000+ cycles (Chen et al., 2009). >30,000 cycles according to IEA (2009).
Progress ratio	N/A
Hourly profile	No
Explanation	kW is used as functional unit because the amount of power a battery can deliver for short periods of time is more relevant for power applications than the amount of energy that can be stored in the battery. SMES systems can deliver high power for short periods of time, leading to large MW/MWh ratios. The typical capacity is 2 MJ (0.56 kWh), but projects go up to 7.3 MJ (2 kWh) (Luo et al., 2015). Discharge times are milliseconds up to 8 seconds (see the 'Other' section below).

COSTS

Year of Euro	2015								
	Euro per Functional Unit		Current			2030		2050	
Investment costs	€ / kW		200			-		-	
		160	–	440	Min	–	Max	Min	–	Max
Other costs per year	€ / kW		-			-		-	
		Min	–	Max	Min	–	Max	Min	–	Max
Fixed operational costs per year (excl. fuel costs)	€ / kW		17			-		-	
		17	–	17	Min	–	Max	Min	–	Max
Variable costs per year	€ / MWh		0.90			-		-	
		0.90	–	0.90	Min	–	Max	Min	–	Max
Costs explanation	Costs are for typical systems of 1-10 MW with discharge time in the range of seconds.								

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		1.05			-			-	
			1.03	–	1.11	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 to obtain 1 PJ of electrical output, based on roundtrip efficiencies of 90-97% (Luo et al., 2015; IEA 2009; DNV-KEMA 2013).										

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			-			-	
		Min	–	Max	Min	–	Max	Min	–	Max
Charge time	Minutes		N/A			-			-	
		-	–	-	Min	–	Max	Min	–	Max
Discharge time	Seconds		2.00			-			-	
		1.00	–	8.00	Min	–	Max	Min	–	Max
Self discharge	% / day		12.50			-			-	
		10	–	15	Min	–	Max	Min	–	Max
Explanation	Chen et al. (2009) state that the discharge time at full power is milliseconds up to 8 seconds.									

REFERENCES AND SOURCES

IEA-ETSAP & IRENA 2012 - Electricity storage technology brief

Luo et al. (2015) - Overview of current development in electrical energy storage technologies and the application potential in power system operation

Chen et al (2009) - Progress in electrical energy storage system: A critical review

IEA (2009). Prospects for large-scale energy storage in decarbonized power grids. International Energy Agency, working paper

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