TECHNOLOGY FACTSHEET

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LITHIUM-ION BATTERY FOR POWER APPLICATIONS

Date of factsheet	29-4-2019
Author	Sam Lamboo
Sector	Electricity generation
ETS / Non-ETS	Non-ETS
Type of Technology	Storage
Description	Lithium-ion (Li-ion) 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). Li-ion batteries can be used for a variety of applications in large-scale energy storage such as frequency regulation, temporal storage and integrating renewables into the grid (making them more dispatchable). This factsheet focuses on power applications (<1 hour discharge time) such as power balancing and frequency regulation.
TRL level 2020	TRL 9
	Li-ion batteries are one of the most used technologies for electrochemical electricity storage (IRENA 2015). While large scale, as of 2014, Li-ion batteries are still considered to be at a demonstration stage of technological development (JRC ETRI 2014), but the recent rapid development of Li-ion storage technology (including in both the telecommunications and automotive industry), leads to the expectation that Li-ion batteries for large-scale electricity storage will achieve high TRL levels by 2020.

TECHNICAL DIMENSIONS

	Functional Unit	Value and Range		
Capacity	kW	2,000		
		1,000	-	20,000

			Current			2030			2050		
Potential	Global	GWe	N/A			-			-		
			-	–	-	Min	–	Max	Min	–	Max
Market share		%	See explanation			-			-		
			-	–	-	Min	–	Max	Min	–	Max

Capacity utlization factor	
Full-load running hours per year	
Unit of Activity	PJ/year
Technical lifetime (years)	10 years (JRC ETRI, 2014). Up to 20,000 cycles (IRENA, 2017).
Progress ratio	70% (JRC ETRI, 2014)
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. Typical power capacity refers to project level capacity, not individual battery capacity. For power based applications, the typical capacity is 1-3 MW (JRC ETRI, 2014) with utility scale systems of 6-40 MW operational (Luo et al. 2015). Typical storage capacity is 0.5-1.2 MWh (JRC ETRI, 2014), and ranges up to 20 MWh (Luo et al., 2015). The 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, Li-ion batteries have 0.2% of the utility storage market share, which is dominated by pumped hydro at 99% market share (IRENA 2015). The market share is not included in the data set because it covers all utility-scale storage applications (both temporal and power applications) and the market share of Li-ion batteries for power applications is not yet clear. Reports on lifetime vary from 8-15 years (IEA-ETSAP & IRENA, 2012) and cycle lifetime from 0-20,000 cycles depending on the type of Li-ion battery (IRENA, 2017).

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	€ / kW	170			140			140		
		130	–	200	110	–	170	110	–	160
Other costs per year	€ / kW	-			-			-		
		Min	–	Max	Min	–	Max	Min	–	Max
Fixed operational costs per year (excl. fuel costs)	€ / kW	2.38			1.96			1.96		
		1.82	–	10.00	1.54	–	10.00	1.54	–	2.24
Variable costs per year	€ / MWh	2.60			2.60			2.60		
		2.00	–	2.60	2.00	–	2.60	2.60	–	2.60

Costs explanation	While a distinction can be made between Li-ion batteries for short-term applications (<1h) and temporal storage (>1h), these distinctions are not always clearly made in literature. In the case of Li-ion batteries, obtaining cost estimates is particularly difficult because while Li-ion batteries are experiencing rapid development, detailed cost breakdowns are often scarce and difficult to obtain due to confidentiality issues (IRENA, 2017). JRC ETRI (2014), the main source used for costs, specifies costs for short-term applications. The other sources, IRENA (2017) and FCH JU McKinsey (2014), do not make a clear distinction between short-term and temporal storage solutions and do not, or only shortly, elaborate the cost estimates. Cost estimates from other sources can vary greatly, especially from older reports, Chen et al. (2009) report CAPEX cost of up to 4,000 USD/kW. Despite the shortcomings, these sources have been used because they are recent publications, include projections up to (at least) 2030, and similar shortcomings are also encountered in other literature. Cost estimates for the current (2020) set differ in year per source: 2020 for JRC ETRI (2014), 2016 for IRENA (2017), 2013 for FCH JU McKinsey (2015). Reference fixed operation & maintenance (FOM) costs are calculated using JRC ETRI (2014) with the assumption that FOM costs are 1.4% of investment costs. Variable operation & maintenance (VOM) costs are 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.

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:*	PJ	-1.00			-			-		
	Electricity		-1.00	–	-1.00	Min	–	Max	Min	–	Max
	Electricity	PJ	1.11			-			-		
			1.11	–	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 input for 1 PJ of electricity output is calculated. A roundtrip efficiency of 90% is assumed based on JRC ETRI (2014).										

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	%	80			-			-		
		80	–	80	Min	–	Max	Min	–	Max
Charge time	Hours	0.55			-			-		
		0.10	–	1.00	Min	–	Max	Min	–	Max
Discharge time	Hours	0.50			-			-		
		0.25	–	0.75	Min	–	Max	Min	–	Max
Self discharge	% / month	5			-			-		
		2	–	6	Min	–	Max	Min	–	Max
Explanation	Charge and discharge times are own estimations based on literature. JRC ETRI (2014) states that the minimum time necessary to charge a unit is approximately 6 minutes.									

REFERENCES AND SOURCES

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

IRENA (2015). Renewables and Electricity Storage: a technology roadmap for REmap 2030

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

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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