TECHNOLOGY FACTSHEET

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LITHIUM-ION (Li-I) BATTERY FOR LARGE-SCALE TEMPORAL ELECTRICITY STORAGE

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Sector	Electricity generation
ETS / Non-ETS	Non-ETS
Type of Technology	Storage
Description	Lithium-ion (Li-I) 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 long-term electricity storage applications with high energy capacity and discharge times of over 1 hour.
TRL level 2020	TRL 9 Li-ion batteries are one of the most used technologies for electrochemical electricity storage (IRENA, 2015). While at large-scale, as of 2014, Li-ion batteries are still considered to be at the demonstration stage of technological development (JRC ETRI, 2014). However, 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 a high TRL level by 2020.

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	kWh		22.50								
			5.00			-			40.00		
Potential	Global	GWh	Current			2030			2050		
			N/A			-			-		
			-	–	-	*Min*	–	*Max*	*Min*	–	*Max*
Market share	Global utility scale electricity storage	%	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	The typical power capacity for distributed systems is 5-10 kW (JRC ETRI, 2014). Assumed is 1-4 hours of energy storage, upper limit based on IEA-ETSAP & IRENA (2012). The estimated typical size in terms of energy storage is therefore 5-40 kWh. Projects can be scaled-up by increasing the number of batteries. SANDIA (2019) maintains a database of battery projects, including over 500 Li-ion battery projects. The average project size for temporal storage (>1h) is 8 MWh (SANDIA, 2019), however projects with a total storage capacity of up to 400 MWh are under development e.g Lyon projects (2019). The potential for all battery types is high as there are no significant space or resource constraints, instead the 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-scale electricity 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 temporal storage 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	€ / kWh	256			251			247		
		175	–	733	67	–	501	247	–	247
Other costs per year	€ / kWh	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	€ / kWh	3.58			3.51			3.46		
		3.58	–	4.00	3.51	–	4.00	3.46	–	3.46
Variable costs per year	€ / MWh	2.61			2.61			2.61		
		2.00	–	2.61	2.00	–	2.61	2.61	–	2.61

Costs explanation

While a distinction can be made between Li-ion batteries for short-term applications (<1h) and termporal 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, only specifies costs for short-term applications. For the main cost estimates, it is assumed that the costs are the same as costs for the Li-ion batteries for short-term applications. The other sources i.e. 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 on the cost estimates. Cost estimates from other sources can vary greatly, especially from older reports. Also, cost estimates for the current year (2020) differ per source: 2020 for JRC ETRI (2014), 2016 for IRENA (2017), and 2013 for FCH JU McKinsey (2015). Despite the shortcomings, these sources have been used as they are recent publications, include projections up to (at least) 2030, and similar shortcomings are also encountered in other literature.

The main reference FOM costs are calculated using the JRC ETRI (2014) assumption that they represent 1.4% of investment costs. FOM costs given in the range by FCH JU McKinsey (2015) are calculated using FOM costs of 10 €/kW and the assumption of an average storage capacity of 2.5 hours.

VOM costs are only provided for 2013 by JRC ETRI (2014) and it is assumed that they remain the same in 2020, 2030 and 2050. VOM costs are defined by JRC ETRI (2014) 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:* Electricity	PJ	-1.00			-			-		
			-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% 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			-			-
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Charge time	Hours		2.50			-			-
		1.00	–	4.00	*Min*	–	*Max*	*Min*	–	*Max*
Discharge time	Hours		2.50			-			-
		1.00	–	4.00	*Min*	–	*Max*	*Min*	–	*Max*
Self discharge	% / month		5.00			-			-
		1.50	–	6.00	*Min*	–	*Max*	*Min*	–	*Max*
Explanation	Charge and discharge times are own estimations based on literature. JRC ETRI (2014) states that 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 Referency Indicator (ETRI) projections for 2010-2050

IEA-ETSAP & IRENA 2012 - Electricity storage technology brief

SANDIA 2019 - SANDIA Energy Storage Database accessed on January 18th 2019 (http://energystorageexchange.org/)

Lyon projects (2019) - List of projects accessed on 29-04-2019 (https://www.lyoninfrastructure.com.au/projects/)

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