TECHNOLOGY FACTSHEET

Lithium-ion Battery for Power Applications

Date of factsheet	2-8-2021
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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) and have in recent years become the most installed battery for stationary applications (JRC, 2018; Kessel et al., 2017).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	kW		2,000.00								
			1,000.00			-			20,000.00		
Potential	Global	Gwe	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	1.00
Full-load running hours per year	
Unit of Activity	PJ/year
Technical lifetime (years)	10 years (JRC, 2014). 200-2,000 cycles (ADB, 2018).
Progress ratio	70% (JRC, 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, 2014) with utility scale systems of 6-40 MW operational (Luo et al., 2015). Typical storage capacity is 0.5-1.2 MWh (JRC, 2014), and ranges up to 20 MWh (Luo et al., 2015). More recent studies consider utility-scale systems of up to 100 MW (EPRI, 2018; Cole and Frazier, 2020; Feldman et al., 2021). 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 2016, Li-ion batteries have 0.6% of the utility-scale electricity storage market share at 829 MW, which is dominated by pumped hydro at 99% market share (Kessels et al., 2017). From the battery energy storage systems, Li-ion is the dominant technology with a market share of >65% (Kessel et al., 2017). 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 5-20 years (Cole and Frazier, 2020; IEA-ETSAP & IRENA, 2012) and cycle lifetime from 0-20,000 cycles depending on the type of Li-ion battery (IRENA, 2017). The reference chemistry used here for cycle lifetime is Lithium Iron Phosfate (LiFePO4 or LFP), currently the most commonly used chemistry for stationary applications.

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	€ / kW	363.00			192.00			145.00		
		363.00	–	844.00	134.00	–	269.00	80.00	–	203.00
Other costs per year	€ / kW	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	€ / kW	5.08			2.69			2.03		
		5.08	–	21.10	1.88	–	10.00	1.12	–	5.08
Variable costs per year	€ / MWh	2.60			2.60			2.60		
		-	–	2.60	-	–	2.60	-	–	2.60

Costs explanation	The reference is utility scale Li-ion batteries (10-60 MW) with 0.5 hour storage capacity. The investment costs include the Li-ion battery, battery inverter, balance of systems (BOS), installation labour costs, taxes and fees (Feldman et al., 2021). Costs of only the Li-ion battery are about 100 €/kW in 2020 (Feldman et al., 2021). Current investment costs for systems with 1h storage capacity are within the range given here: 422-760 €/kW (EPRI, 2018). Note that the storage capacity (in hours) and the choice for reporting investment costs in €/kW or €/kWh, has a significant effect on cost comparisons (Cole and Frazier, 2020). Investment costs decreases towards 2030 and 2050 are based on the analysis by Cole and Frazier (2020) for a 60 MW, 4-hour Li-ion battery. Fixed O&M costs taken to be 1.4-2.5% of investment costs (JRC, 2014; EPRI, 2018; Cole and Frazier, 2020). The higher estimate (2.5%) includes costs for counteracting degradation (Cole and Frazier, 2020). Variable operation & maintenance (VOM) costs are defined by JRC (2014) as production-related O&M costs that vary with electrical generation. They exclude personnel, fuel, and CO2 costs. JRC (2014) only specify VOM costs for 2013. It is assumed the VOM costs remain the same in 2020, 2030 and 2050. Cole and Frazier (2020) do not include VOM, under the assumption that all O&M costs are included in the FOM.

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	1.18			-			-		
			1.18	–	1.18	*Min*	–	*Max*	*Min*	–	*Max*
		PJ	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
		PJ	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Energy in- and Outputs explanation											

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	%	80.00			-			-		
		80.00	–	80.00	*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	5.00			-			-		
		1.50	–	6.00	*Min*	–	*Max*	*Min*	–	*Max*
Explanation	Charge and discharge times are own estimations based on literature. JRC (2014) states that the minimum time necessary to charge a unit is approximately 6 minutes.									

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