TECHNOLOGY FACTSHEET

Lithium-ion Battery for Large-scale Temporal Electricity Storage

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-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) 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	kWh		240,000.00								
			240,000.00			-			240,000.00		
			Current			2030			2050		
Potential	Global	GWh	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)	15 years (Cole and Frazier, 2020). 200-2,000 cycles (ADB, 2018)
Progress ratio	70% (JRC, 2014)
Hourly profile	No
Explanation	The reference installation is a utility-scale, 60 MW plant with 4 hour storage capacity (Fu et al., 2018), giving a storage capacity of 240 MWh. This is larger than the average project size for temporal storage (8 MWh) in SANDIA's database of existing projects (SANDIA, 2019). Larger 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 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 temporal storage is not yet clear. Reports on lifetime vary from 5-20 years (Cole and Frazier, 2020; IEA-ETSAP & IRENA, 2012). A median of 15 years has been used here (Cole & Frazier, 2020). Cycle lifetime reports vary from 0-20,000 cycles depending on the chemistry of the 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	€ / kWh	312.00			176.00			132.00		
		258.00	–	323.00	122.00	–	247.00	74.00	–	185.00
Other costs per year	€ / kWh	-			-			-		
		Min	–	Max	Min	–	Max	Min	–	Max
Fixed operational costs per year (excl. fuel costs)	€ / kWh	7.80			2.46			1.85		
		6.45	–	8.08	1.71	–	3.46	1.04	–	2.59
Variable costs per year	€ / MWh	-			-			-		
		-	–	2.61	-	–	2.61	-	–	2.61

Costs explanation	Investment costs are based on 4-hour utility scale (60 MWe) Li-ion batteries (Cole and Frazier, 2020). IRENA (2017) give larger ranges for investment costs: 175-733 €/kWh in 2016 and 67-501 €/kWh in 2030. Cole and Frazier (2020) draw from various recently published sources. The investment costs are comparable to other (older) sources such as JRC (2014) and McKinsey (2015). Li-ion batteries are experiencing rapid development and detailed cost breakdowns can be scare and difficult to obtain due to confidentiality issues (IRENA, 2017). Due to the rapid development of Li-ion batteries, the older sources have not been included in the ranges given here. Cole and Frasier (2020) show that there is a large range in O&M cost estimates, partly due to the choices made about what to include in the O&M costs. Cole and Frazier (2020) assume a VOM cost of zero for a one-cycle-per day system. With more cycles they expect the VOM to be non-zero. For FOM the authors assume 2.5% of investment costs, which is on the high side of values given in literature because it assumes degradation costs are covered in the FOM. JRC (2014) assume FOM costs are 1.4% of investment costs and VOM cost are 2.61 €/MWh.

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		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 (2014) states that minimum time necessary to charge a unit is approximately 6 minutes.									

REFERENCES AND SOURCES

1	DNV-KEMA (2013) - Systems Analysis Power to Gas (deliverable 1: Technology review)
2	IRENA (2015) - Renewables and Electricity Storage: a technology roadmap for REmap 2030
3	JRC (2014) - Energy Technology Referency Indicator (ETRI) projections for 2010-2050
4	Fu, R., Remo, T. and Margolis, R. (2018) - U.S. Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark
5	Cole, W. and Frazier, A. W. (2020) - Cost Projections for Utility-Scale Battery Storage: 2020 Update
6	IEA-ETSAP & IRENA (2012) - Electricity storage technology brief
7	SANDIA (2019) - SANDIA Energy Storage Database accessed on January 18th 2019 (http://energystorageexchange.org/)
8	Lyon projects (2019) - List of projects accessed on 29-04-2019 (https://www.lyoninfrastructure.com.au/projects/)
9	IRENA (2017) - Electricity Storage Costs
10	JRC (2014) - Energy Technology Referency Indicator (ETRI) projections for 2010-2050
11	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
12	Kessel et al. (2017) - Support to R&D strategy for battery based energy storage. Costs and benefits for deployment scenarios of battery systems (D7)
13	ADB (2018) - Handbook on battery energy storage system
14	JRC (2018) - Li-ion batteries for mobility and stationary storage applications