TECHNOLOGY FACTSHEET

V.2

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VANADIUM REDOX FLOW BATTERY (VRB) FOR LARGE-SCALE TEMPORAL ELECTRICITY STORAGE

Date of factsheet	20-2-2020
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Sector	Electricity generation
ETS / Non-ETS	Non-ETS
Type of Technology	Storage
Description	Vanadium Redox Flow batteries (VRB) store electricity through a reversible chemical reaction. In contrast to conventional batteries, chemical energy is stored in external electrolyte tanks (Chen et al., 2009). The active material (i.e. an aqueous liquid electrolyte) is pumped from the storage tanks into the AC/DC converter where chemical energy is converted to electrical energy (discharge) or electrical energy to chemical energy (charge). Installations range between 50 kW and 1 MW, with commercial units typically between 5 and 250 kW. VRB are well suited for multiple applications (JRC ETRI, 2014). This factsheet focuses on large VRB batteries (utility or distributed systems) for bulk electricity storage, capable of supplying power for longer periods (discharge times of >1h).
TRL level 2020	TRL 9
	It represents the most mature flow batteries with multiple demonstration and deployed at MW scale (IRENA, 2015).

TECHNICAL DIMENSIONS

	Functional Unit	Value and Range		
Capacity	kWh		6,000	
		100	-	80,000

			Current			2030			2050		
Potential	Global	GWe		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 and over 10,000 cycles (IRENA, 2017)
Progress ratio	N/A
Hourly profile	No
Explanation	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, the total global grid-connected redox flow battery (both VRB and ZnBr) capacity is 46 MW - 0.03% share of utility scale storage capacity, which is dominated by pumped hydro storage with a market share of 99.1% (IRENA, 2015). Reports on lifetime vary from 5-15 years (IEA-ETSAP & IRENA, 2012) and cycle lifetime of 10,000+ cycles (IRENA, 2017).

COSTS

Year of Euro: 2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	€ / kWh		300			100			-	
		275	–	873	70	–	314	*Min*	–	*Max*
Other costs per year	€ / kWh		-			-			-	
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	€ / kWh		7.50			2.00			-	
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Variable costs per year	€ / MWh		-			-			-	
		-	–	-	-	–	-	*Min*	–	*Max*

Costs explanation	The sources used have been chosen because they are recent publications and include projections up to (at least) 2030. However, details on cost estimates are not, or only shortly, elaborated in the sources used, and estimations from other sources can vary greatly, especially from older reports. JRC ETRI (2014) lists investment costs of 180 €/kW in 2050 and up to €1,800 €/kW in 2013, with FOM costs of 2% of investment costs, and VOM costs of 2 €/MWh, however these seem to be for power applications (<1h storage) and not temporal storage applications (>1h). These costs are therefore not included in the main dataset. The main sources used for the costs expressed in this factsheet are FCH JU McKinsey (2015) and IRENA (2017).

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	–	-1.00	-1.00	–	-1.00	*Min*	–	*Max*
	Electricity	PJ		1.47			1.37			-	
			1.18	–	1.47	1.37	–	1.37	*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 68%-85% is assumed in 2020, and 73% in 2030, based on round-trip efficiencies reported by FCH JU McKinsey (2015) and 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			-			-	
		100	–	100	*Min*	–	*Max*	*Min*	–	*Max*
Charge time	Hours		N/A			-			-	
		-	–	-	*Min*	–	*Max*	*Min*	–	*Max*
Discharge time	Hours		6.00			-			-	
		2.00	–	8.00	*Min*	–	*Max*	*Min*	–	*Max*
Self discharge	% / month		0			-			-	
		-	–	-	*Min*	–	*Max*	*Min*	–	*Max*
Explanation	JRC ETRI (2014) states that the minimum time necessary to charge a unit is approximately 10 seconds.									

REFERENCES AND SOURCES

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

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

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

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IEA-ETSAP & IRENA (2012). Electricity storage technology brief

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

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