Redox Flow Battery Electrolyte Volume and Energy Density

Electrolyte energy density and tank volumes of a redox flow battery (such as vanadium) from concentration, cell voltage, state-of-charge window and energy.

Method: Faraday's law for redox flow electrolytes

Input parameters

Unit system: SI

Parameter	Value	Unit
Energy to store (discharge)	4,000.0	kWh
Active species concentration	1.6000	mol/L
Average discharge cell voltage	1.4000	V
Usable state-of-charge window	80.000	%
Electrons per active ion	1.0000	
Discharge efficiency (stack and pumps)	85.000	%

Calculated results

Parameter	Value	Unit
Charge per litre of one electrolyte (Ah/L)	34.306	
Energy density on total electrolyte (Wh/L)	20.412	
Total electrolyte volume	195.96	m³
Volume of each of the two tanks	97.982	m³

Notes for this case

• Charge per side = nFcΔSOC; energy = charge × V × η_d; positive and negative electrolytes each fill one tank, so energy density on the total electrolyte is half the per-side value. Vanadium electrolyte at 1.6 mol/L gives about 20–25 Wh/L.

Formula and method

$$q = nFc\,\Delta SOC, \quad e_{side} = qV\eta_d, \quad V_{tank} = \frac{E}{e_{side}}$$

Variables

E	Energy to store (discharge)	J
c	Active species concentration	mol/m³
V	Average discharge cell voltage	V
ΔSOC	Usable state-of-charge window	-
n	Electrons per active ion	-
η_d	Discharge efficiency (stack and pumps)	-
q	Charge per litre of one electrolyte (Ah/L)	-
e	Energy density on total electrolyte (Wh/L)	-
V_{tot}	Total electrolyte volume	m³
V_{tank}	Volume of each of the two tanks	m³

Method and standards

Flow battery sizing.

Assumptions and limits

- Average voltage; full use of the SOC window.

References

Faraday's law for redox flow electrolytes

Report details

Report reference	FCC-GPHY-08ZB (the same inputs always give the same reference)
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Calculator	Redox Flow Battery Electrolyte Volume and Energy Density
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/batteries-ups/flow-battery-electrolyte-volume

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.