Cost assessment for bulk storage technologies

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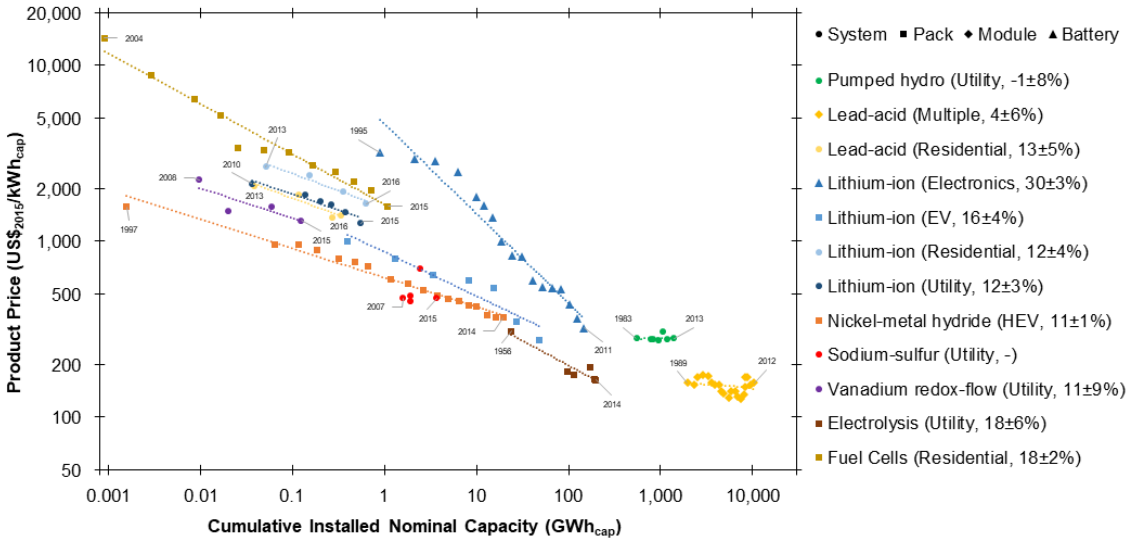
Focus on investment cost is insufficient for storage technology cost assessment

Problem

Investment cost reduction for storage technologies



- Application-specific ☐
- Installed system cost ☑
- All performance and cost parameters ☐

Appropriate cost assessment is application-specific, refers to full system, and considers all cost and performance factors relevant in storage lifetime

Source: O. Schmidt, A. Hawkes, A. Gambhir & I. Staffell. The future cost of electrical energy storage based on experience rates. Nature Energy 2, 17110 (2017) [Open Access: http://rdcu.be/t5h8]

Levelised cost of storage (LCOS) quantify discounted cost of discharged electricity

Method

- Investment cost
- Construction time
- Replacement cost
- Replacement interval

- Charging cost
- O&M cost

$$LCOS\left[\frac{\$}{MWh}\right] = \frac{Investment\ cost\ +\ Operating\ cost\ +\ Disposal\ cost}{Energy\ throughput}$$

- Energy basis: $\frac{\$}{MWh}$
- Power basis: $\frac{\$}{MW_{yr}}$

- Round-trip efficiency
- Depth-of-discharge
- Annual cycles
- Cycle / Calendar life
- Degradation

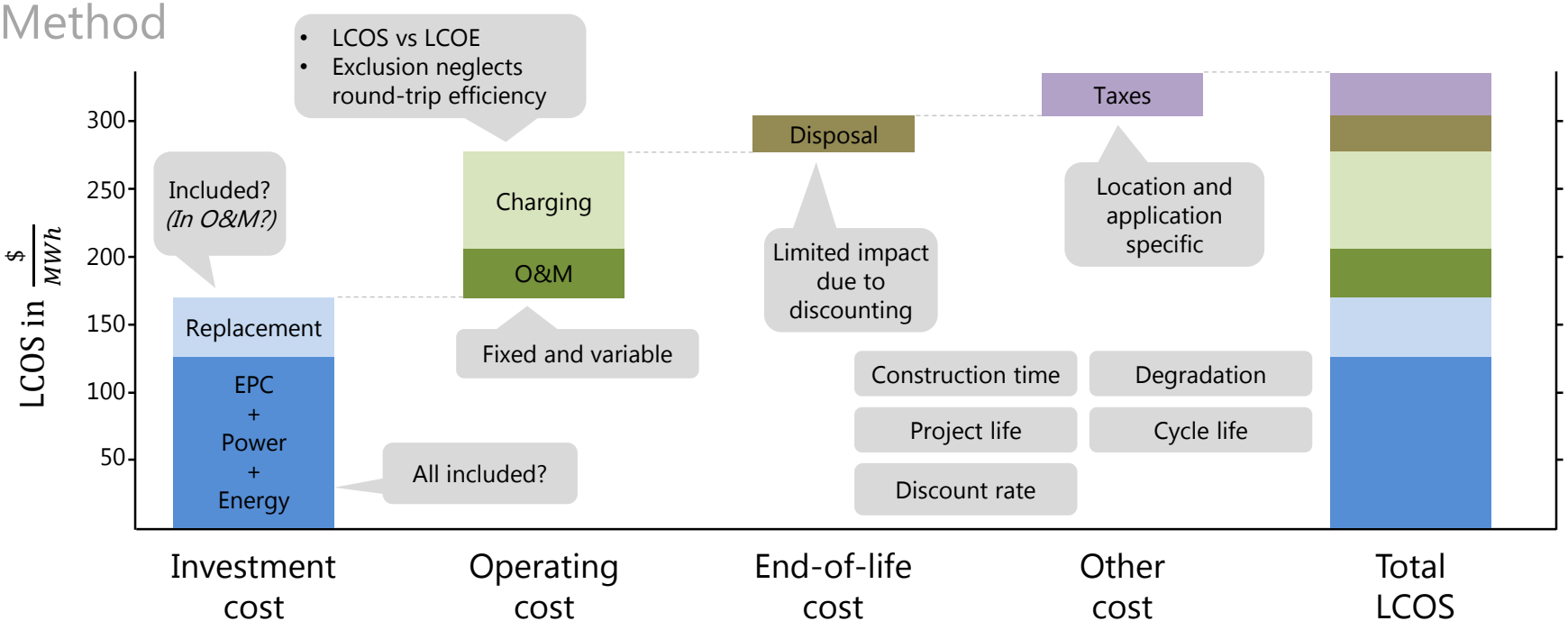
- Disposal cost or residual value

Application-specific LCOS are an appropriate metric to compare electricity storage investment options for particular applications

Source: Mayr, F. & Beushausen, H. How to determine meaningful, comparable costs of energy storage (2016). www.apricum-group.com
Lazard's Levelized Cost of Storage Analysis—Version 3.0 (2017). www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf

Best-practice LCOS approach is not yet established

Method



Check and challenge LCOS methodology and inputs

Source: Mayr, F. & Beushausen, H. How to determine meaningful, comparable costs of energy storage (2016). www.apricum-group.com
Lazard's Levelized Cost of Storage Analysis—Version 3.0 (2017). www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf

Input parameters are the substance of any LCOS analysis

Input

Application Data	Bulk storage
Discharge	8 hours
Size	MWh
Annual cycles	330 #
Charging cost	30 $/kWh

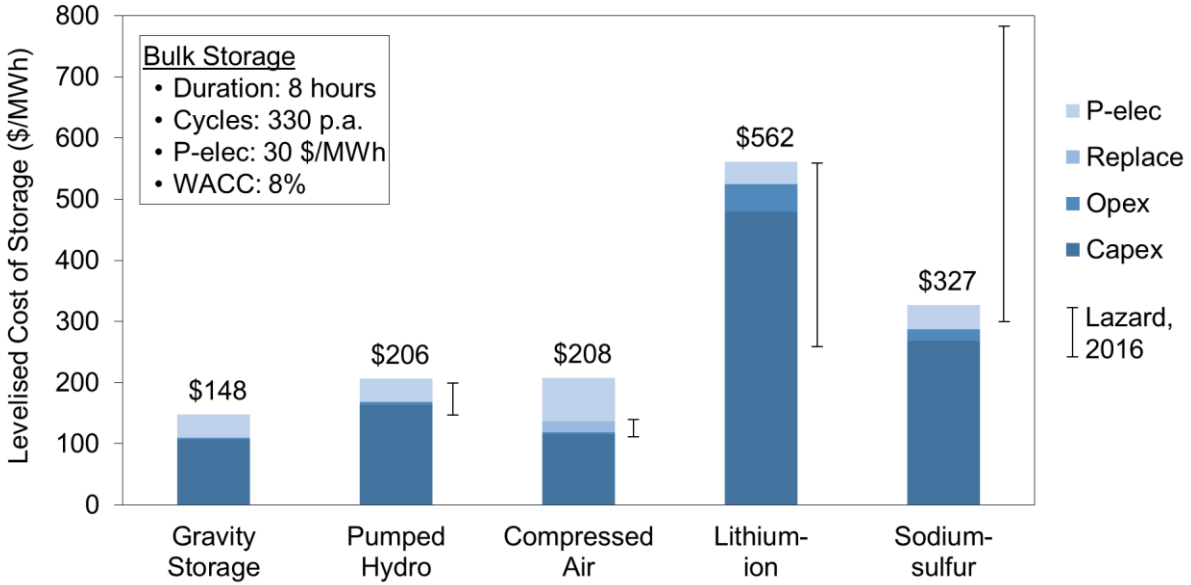
Technology Data		Gravity Storage[1]	Pumped Hydro[2]	Compr. Air[2]	Lithium-ion[3]	Sodium-sulfur[2]
Nominal capacity	MWh	8,000	9,600	1,088	35	720
Discharge duration	hours	8	8	8	8	8
Capex - energy	$/kWh	148	93	17	538	298
Capex - power	$/kW	579	1,950	825	615	490
Replacement - energy	$/kWh	-	-	-	538	298
Replacement - power	$/kW	25	112	90	615	490
O&M	%	0.30%	0.31%	0.36%	1.38%	0.88%
Disposal cost	$/kWh	-	-	-	-	-
Depth of discharge	%	100%	100%	100%	80%	80%
Round-trip efficiency	%	80%	80%	42%	81%	75%
Degradation	% pa	0%	0%	0%	-3%	-2%
Construction time	years	5	5	5	1	2
Cycle life	#	19,800	21,900	14,600	3,500	5,500
Shelf life	years	60	60	40	10	15
Replacement interval	years	10	20	4	10	15
Discount rate / WACC	%	8%	8%	8%	8%	8%

▶ Input data based on literature review

Source: [1] – Anticipated by Heindl Energy GmbH, [2] - DOE/EPRI 2013 electricity storage handbook in collaboration with NRECA, Sandia National Laboratories., [3] - M. Kleinberg (KEMA, Inc.), Battery Energy Storage Study for the 2017 IRP, PacifiCorp, 2017.

Gravity Storage most cost-effective at anticipated cost and performance

Result

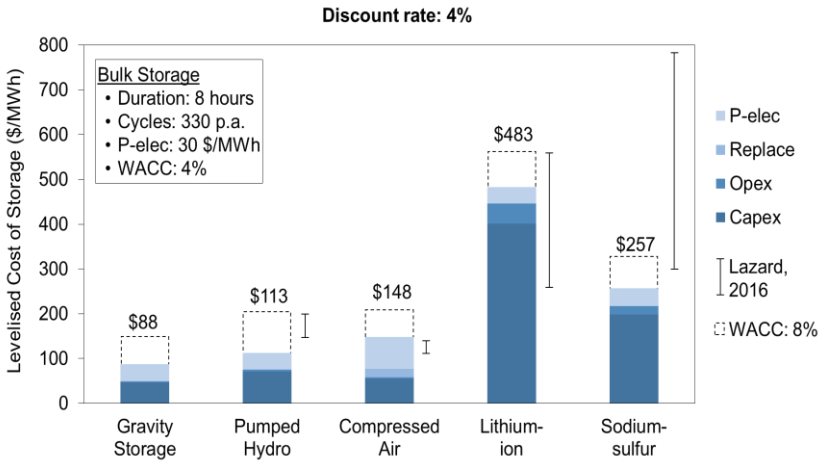


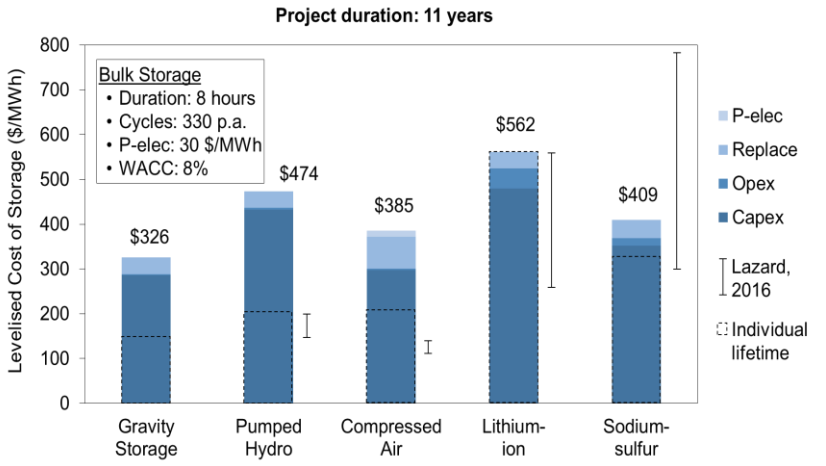
Combination of low specific energy cost and moderate specific power cost represent key advantage for Gravity Storage

Source: Schmidt, O. Levelised Cost of Storage – The Case of Gravity Storage. Imperial College Consultants and Storage Lab (2017). https://www.storage-lab.com/levelized-cost-of-storage

Discount rate and project duration have significant impacts on LCOS

Sensitivity





Lower discount rate could push Gravity Storage LCOS below 100 $/MWh

Source: Schmidt, O. Levelised Cost of Storage – The Case of Gravity Storage. Imperial College Consultants and Storage Lab (2017). https://www.storage-lab.com/levelized-cost-of-storage