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Projecting the future levelized cost of electricity storage technologies and their future profitability

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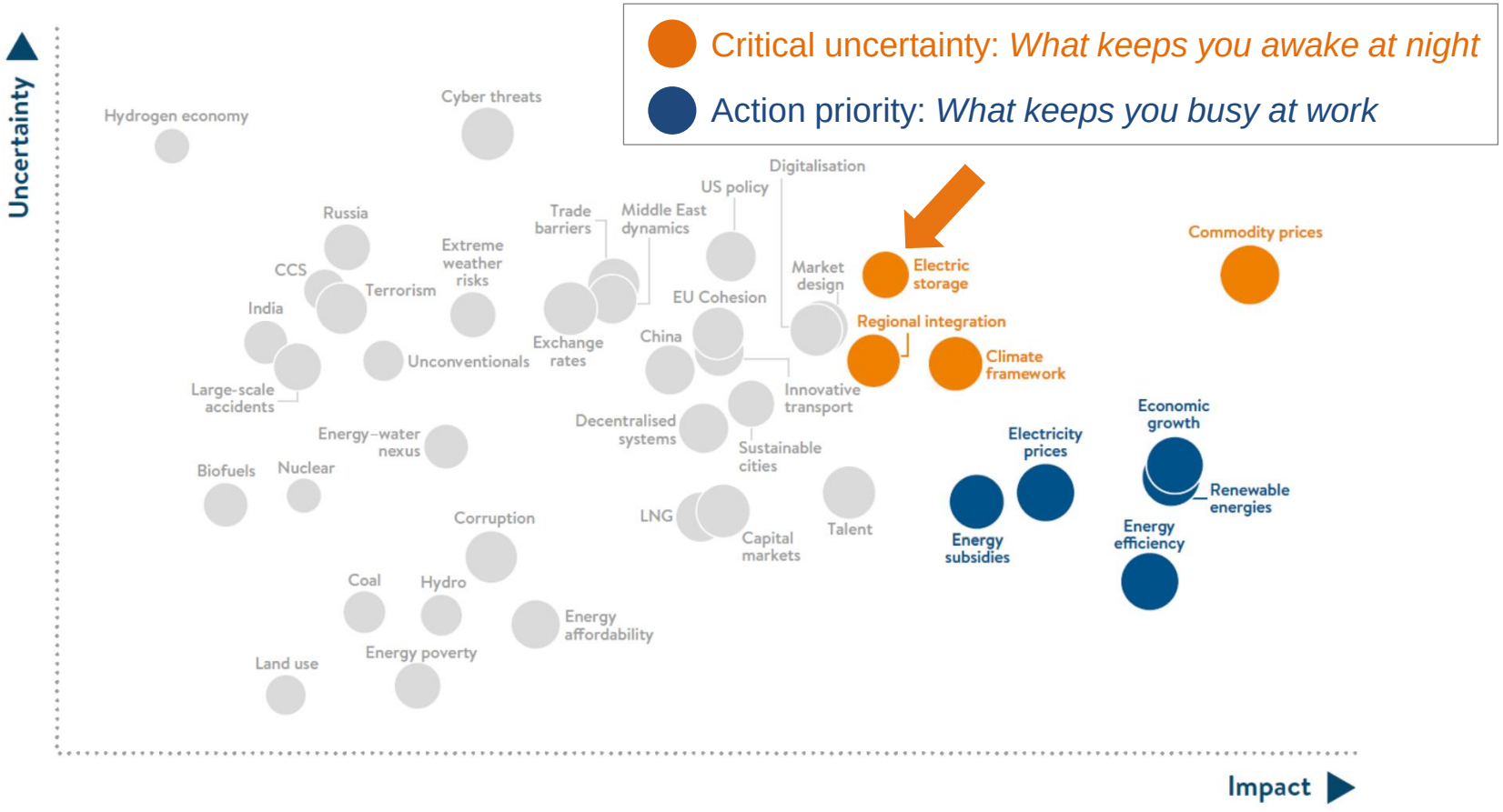
Storage could have a huge impact on the energy sector, but its future is still perceived as highly uncertain.

Problem for decision-makers



Source: World Energy Issues Monitor 2017 | Exposing the new energy realities. World Energy Council; 2017.

To reduce uncertainty on the future role of storage, three questions must be answered.

Key Questions

A Which technology will be most cost-efficient?

B How much will it cost?

C Which applications will be profitable?

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- Strategy and transaction advisory firm, cleantech only
- Team of 50 experts
- Based in Berlin, represented globally






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Strategy Consulting

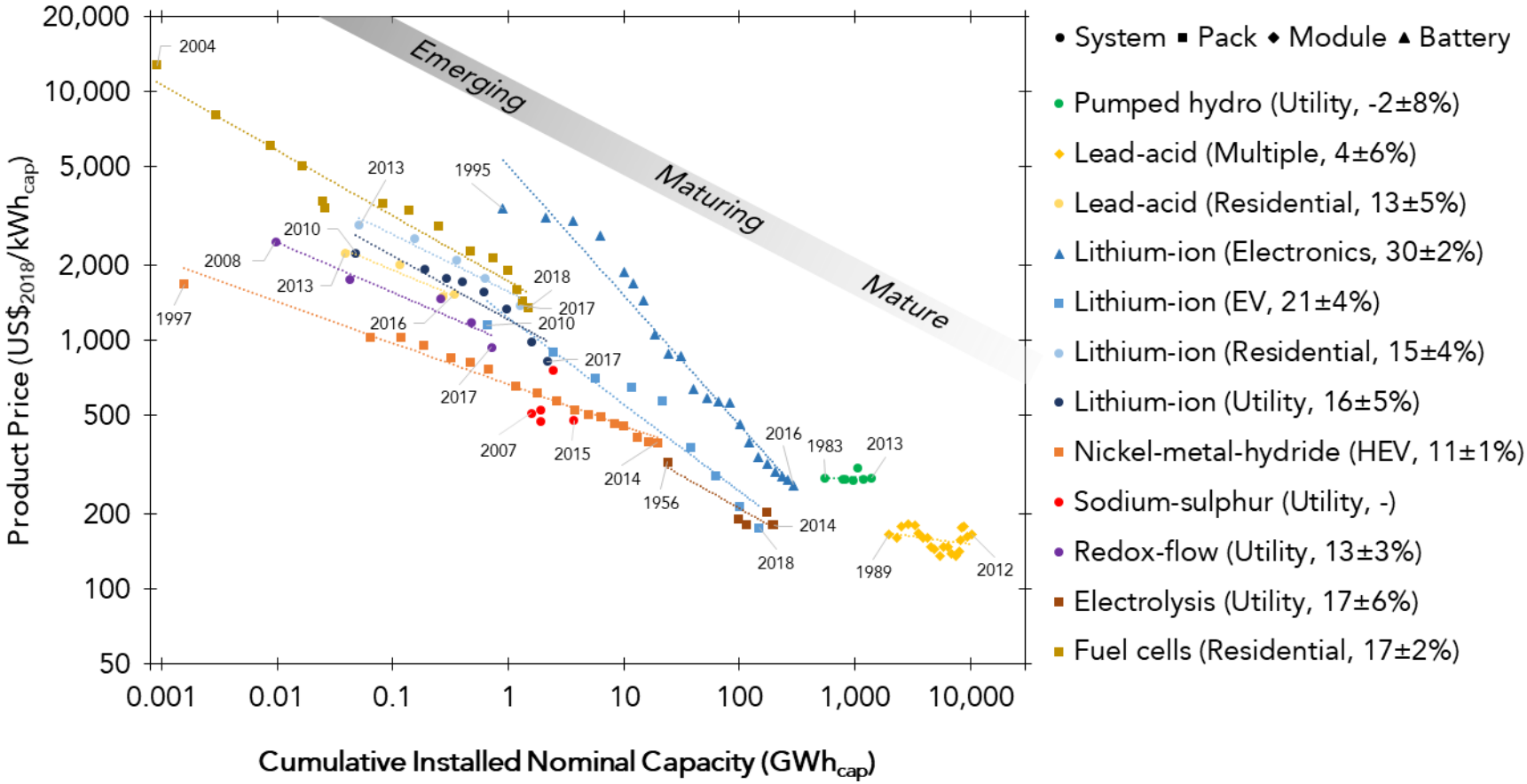
- Market entry
- Strategy review
- Internationalization

Transaction Advisory

- Fund raising / M&A
- Due diligence
- Project finance

Experience curves for storage technologies can be used to predict future investment cost.

Experience curve dataset



Source: Schmidt et al. (2017), Schmidt et al. (2018)

However, comparison of technologies must be based on lifetime cost, for example levelized cost of storage (LCOS).

Experience curve dataset

- Investment cost
- Replacement cost / interval

- Charging cost
- O&M cost

$$LCOS\left[\frac{USD}{MWh}\right] = \frac{Investment\ cost\ +\ Operating\ cost\ +\ Disposal\ cost}{Electricity\ discharged}$$

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

End-of-life cost or residual value

Levelized cost of storage (LCOS) account for all relevant cost and performance parameters and determine the discounted cost of a “MWh” discharged

Source: Apricum analysis; Annuitized capacity cost

So, let's model LCOS for 9 storage technologies in 12 power system applications up to 2050.

Applications vs Technologies

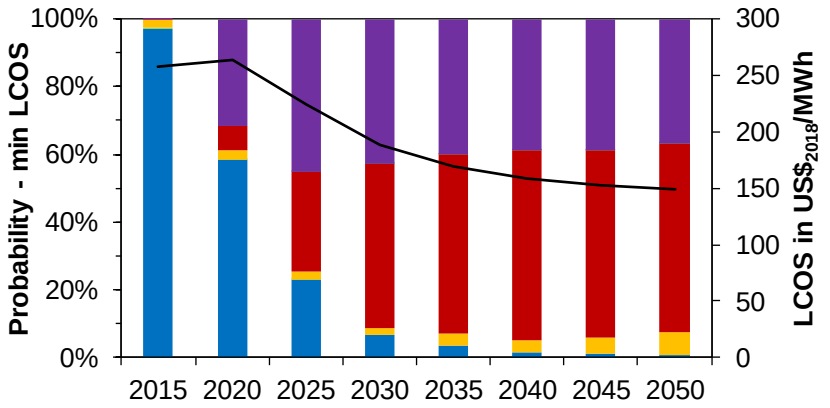
Role	Application	Pumped hydro	Comp. air	Fly-wheel	Li-ion	Sodium-sulfur	Lead-acid	Flow battery	Hydro-gen	Super-cap.
	1. Energy arbitrage	✓	✓		✓	✓	✓	✓	✓	
System operation	2. Primary response			✓	✓	✓	✓	✓	✓	✓
	3. Secondary response	✓	✓	✓	✓	✓	✓	✓	✓	✓
	4. Tertiary response	✓	✓		✓	✓	✓	✓	✓	
	5. Peaker replacement	✓	✓		✓	✓	✓	✓	✓	
	6. Black start	✓	✓	✓	✓	✓	✓	✓	✓	✓
	7. Seasonal storage	✓	✓					✓	✓	
Network operation	8. T&D upgrade deferral	✓	✓		✓	✓	✓	✓	✓	
	9. Congestion mgmt	✓	✓		✓	✓	✓	✓	✓	
Consumption	10. Bill management				✓	✓	✓	✓	✓	
	11. Power quality			✓	✓	✓	✓	✓	✓	✓
	12. Power reliability				✓	✓	✓	✓	✓	

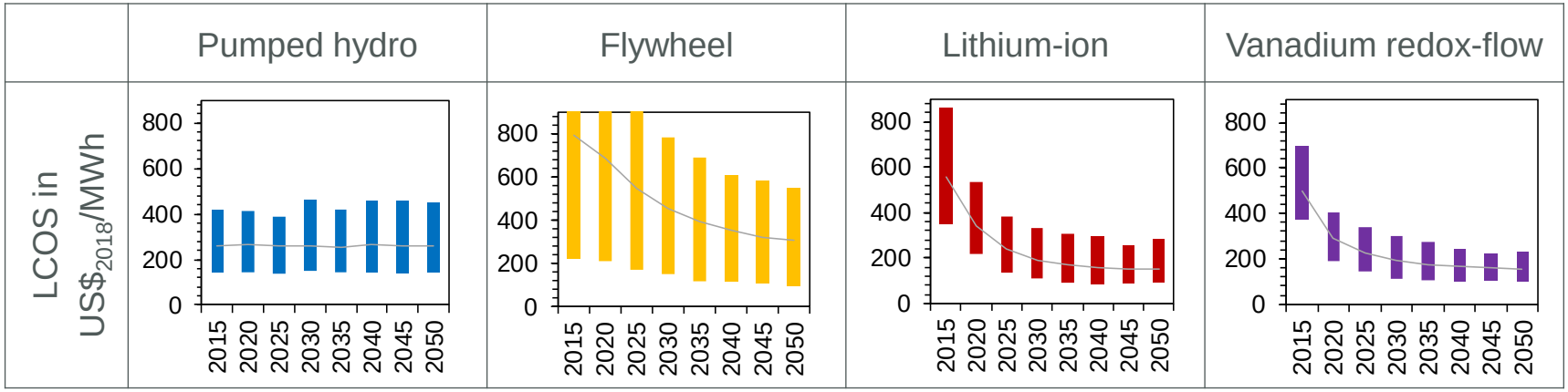
Source: Schmidt et al. (2019)

Lithium ion and vanadium redox flow will compete as most cost-efficient technologies for secondary response.

Secondary response

Power capacity	100 MW
Discharge duration	1 hour
Annual cycles	1,000
Response time	>10 seconds
Electricity price	50 USD/MWh



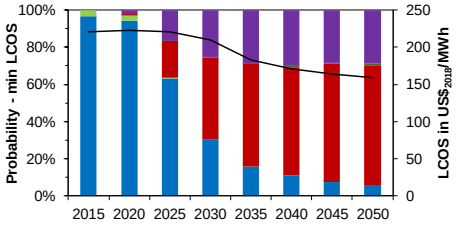


Source: Schmidt et al. (2019)

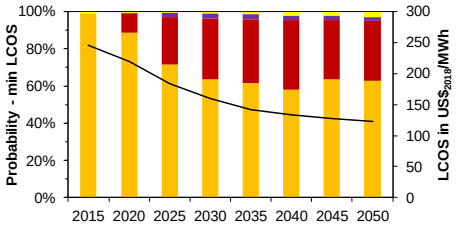
Across the 12 applications, lithium ion seems to become the dominant technology by 2030.

Application overview

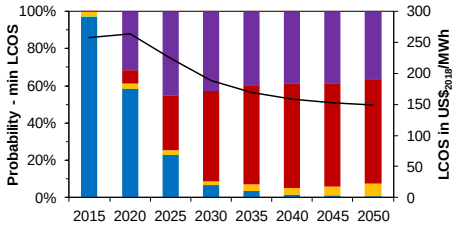
1 Energy Arbitrage



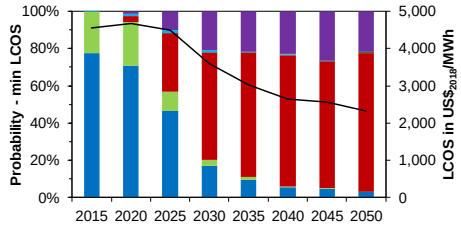
2 Primary Response



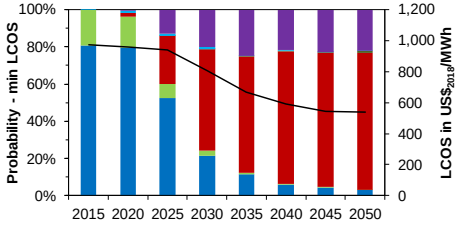
3 Secondary Response



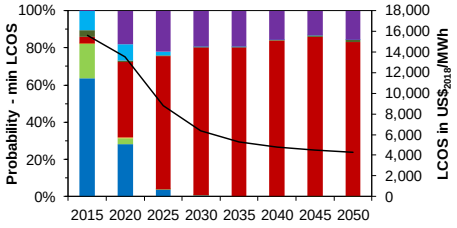
4 Tertiary Response



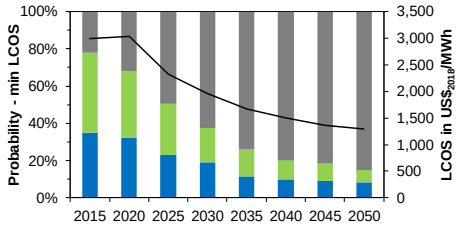
5 Peaker Replacement



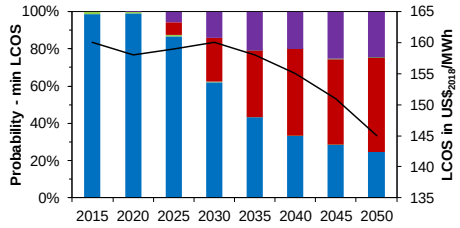
6 Black Start



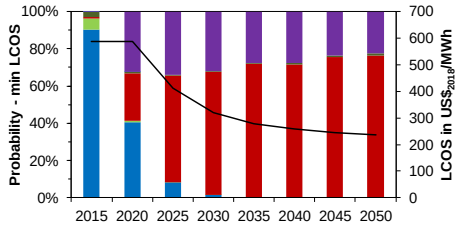
7 Seasonal Storage



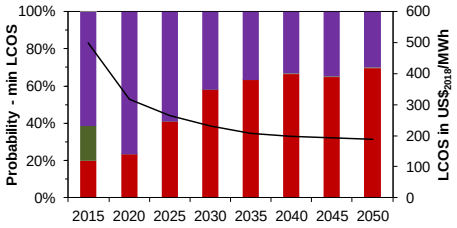
8 T&D Inv. Deferral



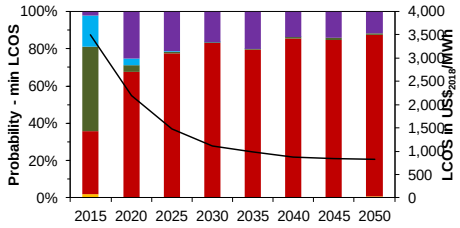
9 Congestion mgmt



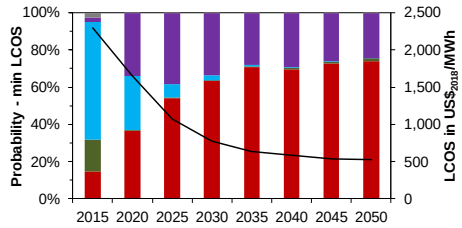
10 Bill management



11 Power quality



12 Power reliability

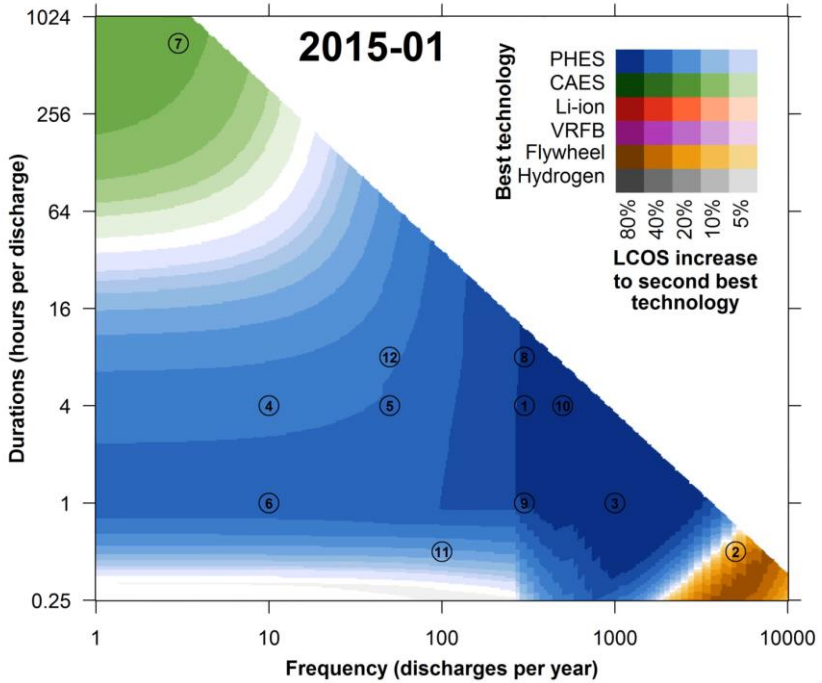


Overall, pumped hydro and compressed air seem to give way to lithium ion and hydrogen.

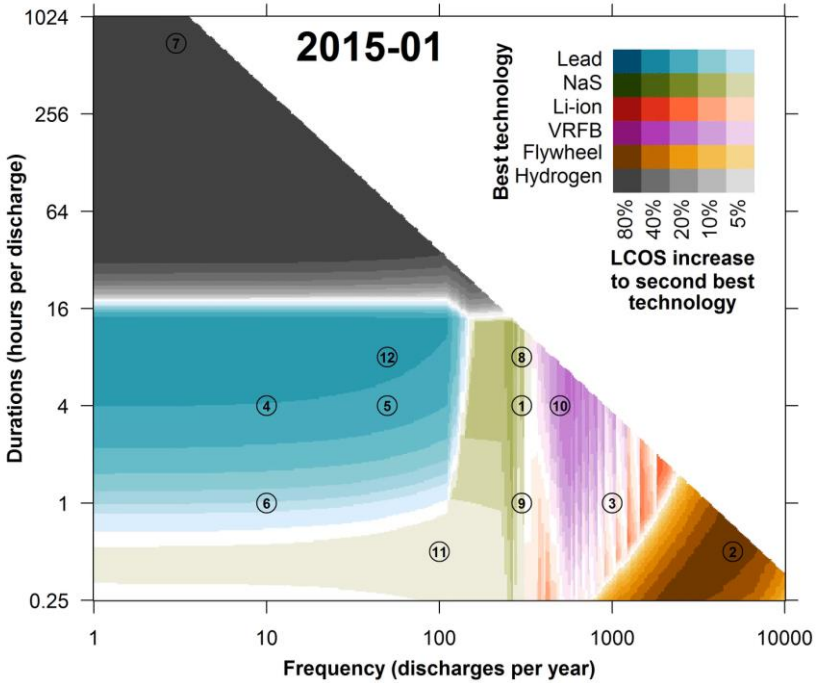
Most cost-effective technology for energy services

Discount rate: 8%
Electricity price: 50 USD/MWh

All Technologies



Excluding PHES and CAES



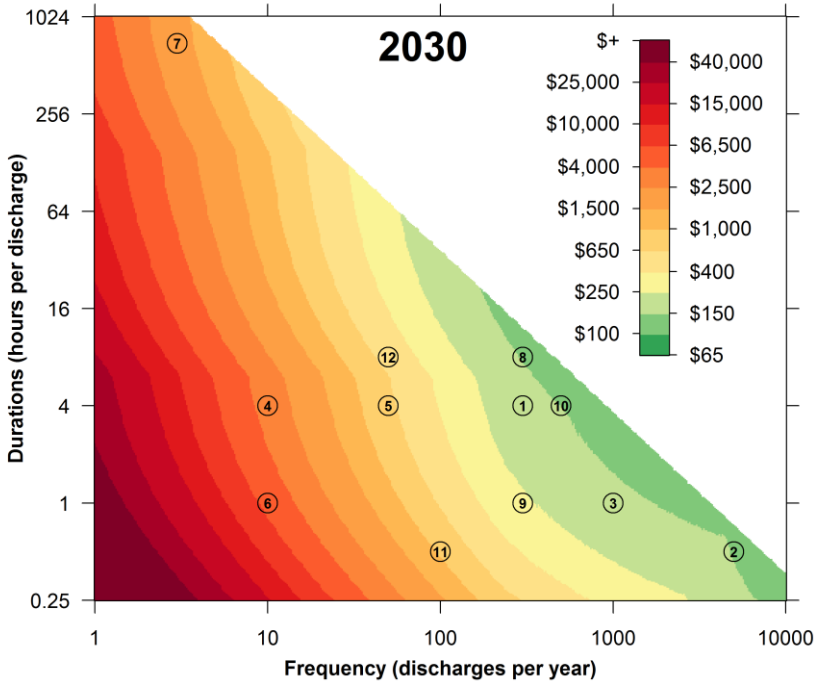
Based on lifetime cost, lithium ion is likely to outcompete all alternative storage technologies in applications that require less than 8 hours discharge duration

Future storage cost highly depend on discharge duration and annual cycles required by each application.

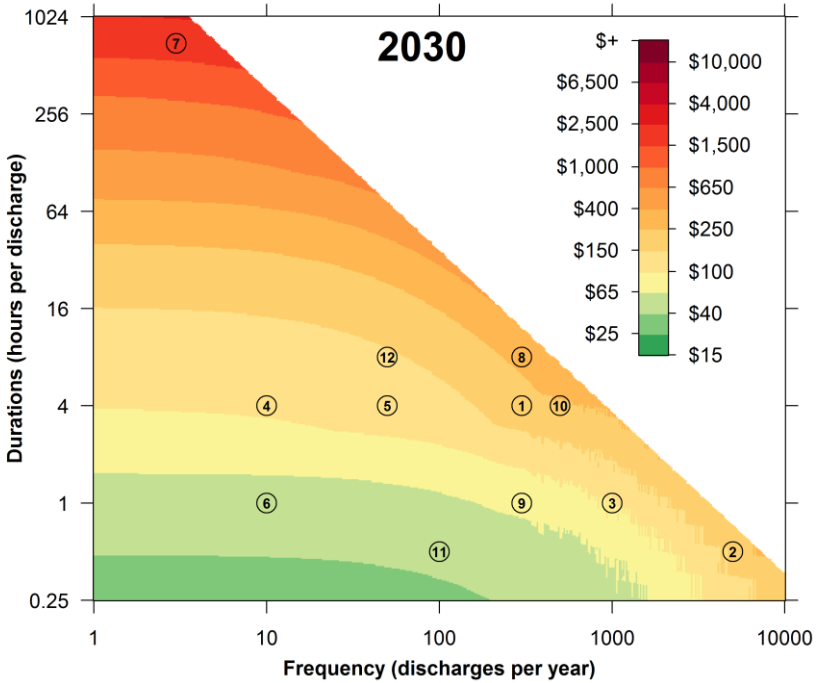
Future cost of electricity storage

Discount rate: 8%
Electricity price: 50 USD/MWh

Levelized cost of storage [USD/MWh]



Annuitized capacity cost [USD/kW-year]



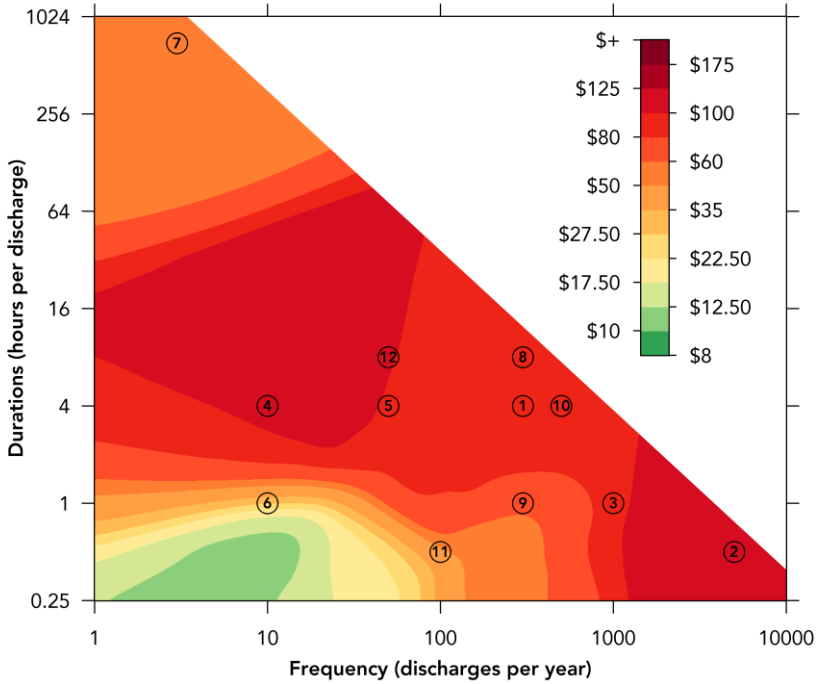
Driven by falling investment cost, lifetime cost will fall to 50–100 USD/MWh (LCOS) and 40–65 USD/kW-year by 2030

Comparing revenue potential (power) and annuitized capacity cost reveals…

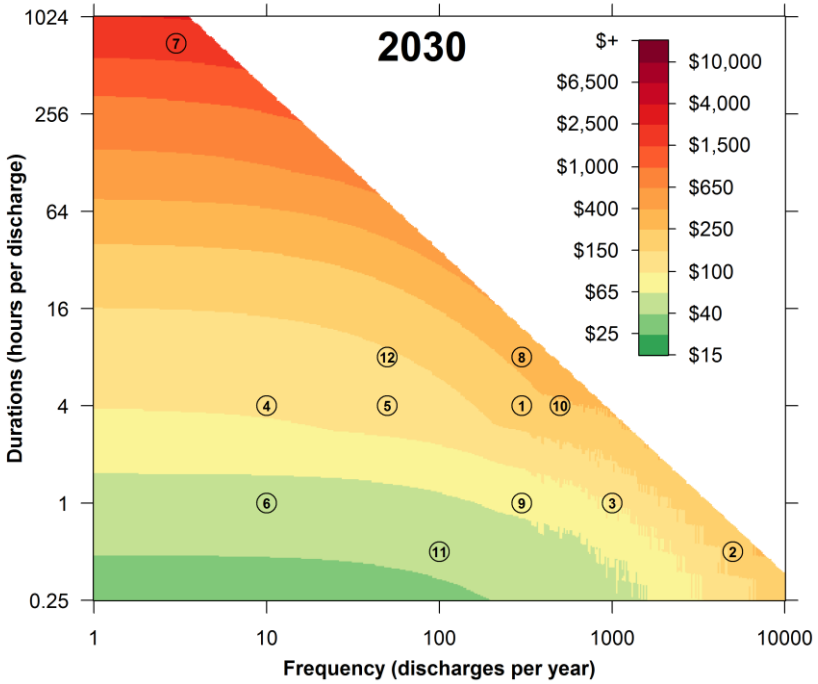
Revenue potential – power capacity [USD/kW-year]

Discount rate: 8%
Electricity price: 50 USD/MWh

Revenue potential (power)



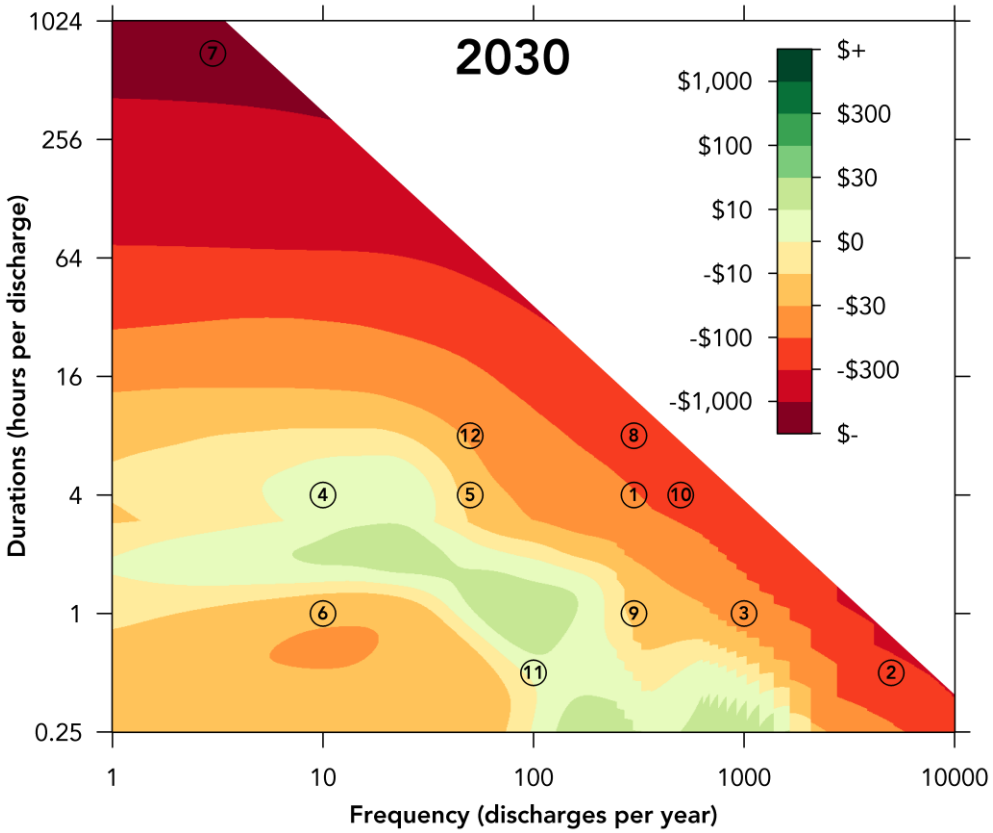
Annuitized capacity cost



… two application categories for potential business cases.

Revenue potential – power capacity [USD/kW-year]

Discount rate: 8%
Electricity price: 50 USD/MWh



In summary…

- Lifetime cost account for all relevant cost and performance parameters of electricity storage technologies and should be used for comparison and profitability assessment

A Based on lifetime cost, lithium ion is likely to outcompete all alternative storage technologies in applications that require less than 8 hours discharge duration

B Driven by falling investment cost, lifetime cost will fall to 100–150 USD/MWh (LCOS) and 40–65 USD/kW-year by 2030

C There is a range of applications where electricity storage is or will become profitable

- However, this is a high-level analysis based on average revenue and cost data

- At Apricum, we dive into the details and can help you understand the business cases in specific markets

Let’s discuss how we can help you.

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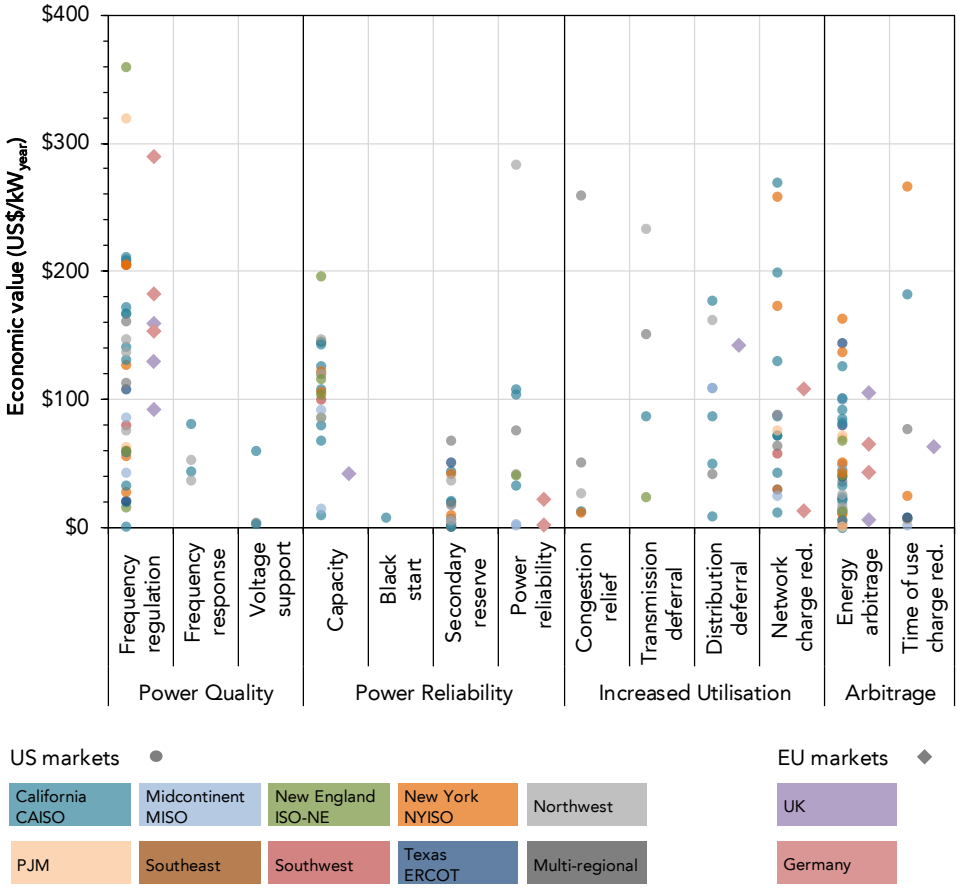
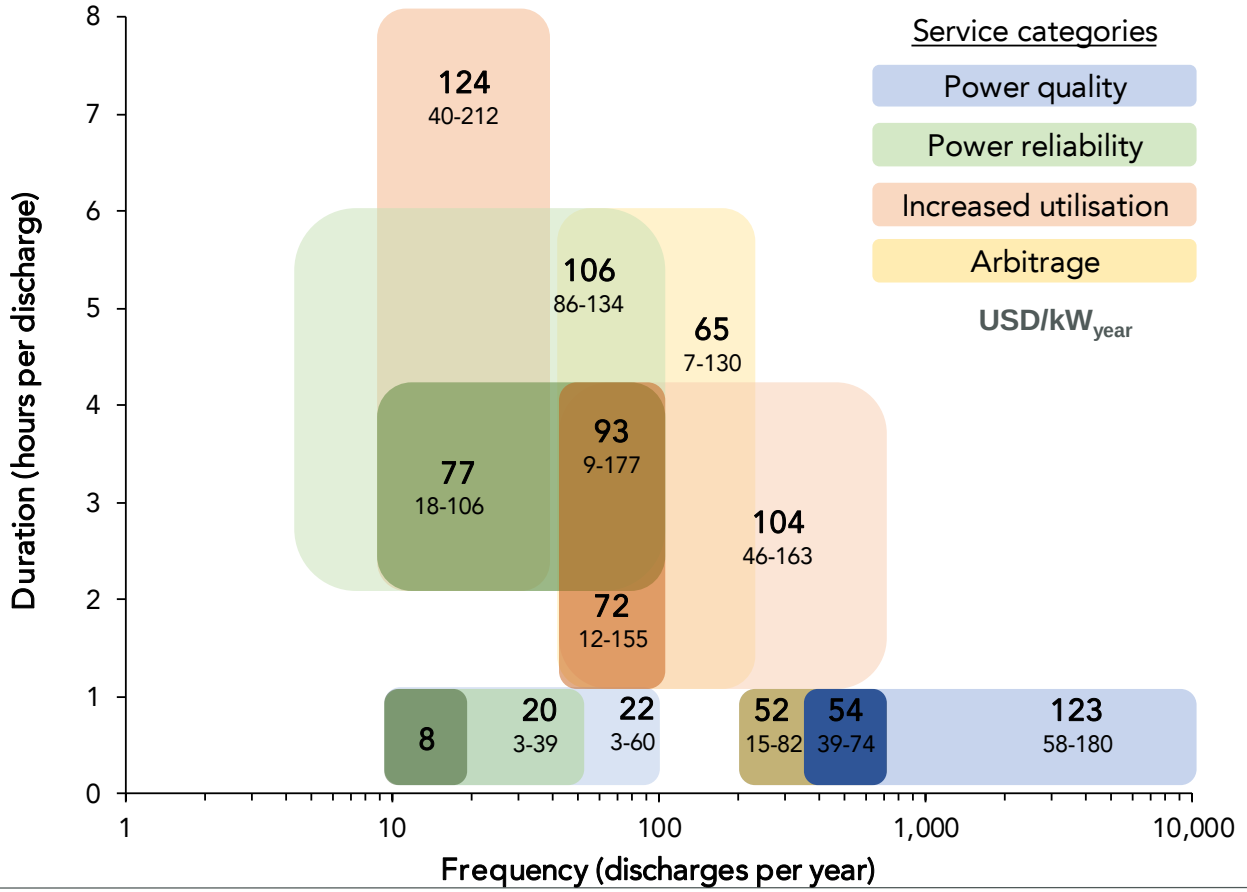
Wide spread of revenue potential for electricity storage in common applications.

Revenue data



Source: Balducci et al. (2018)

Revenue potential varies with application requirements.

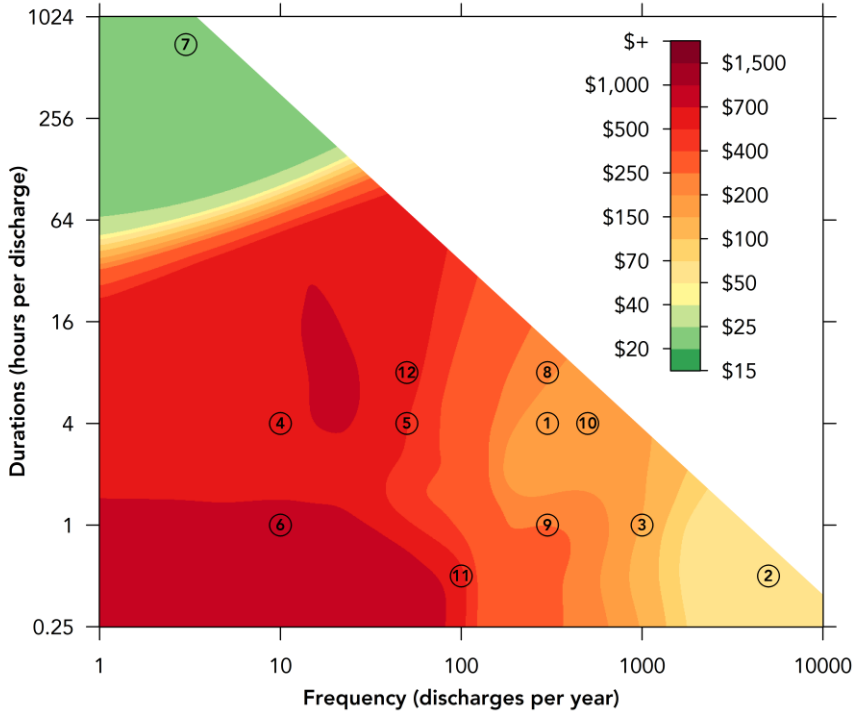


Comparing revenue potential (energy) and levelised cost of storage suggests…

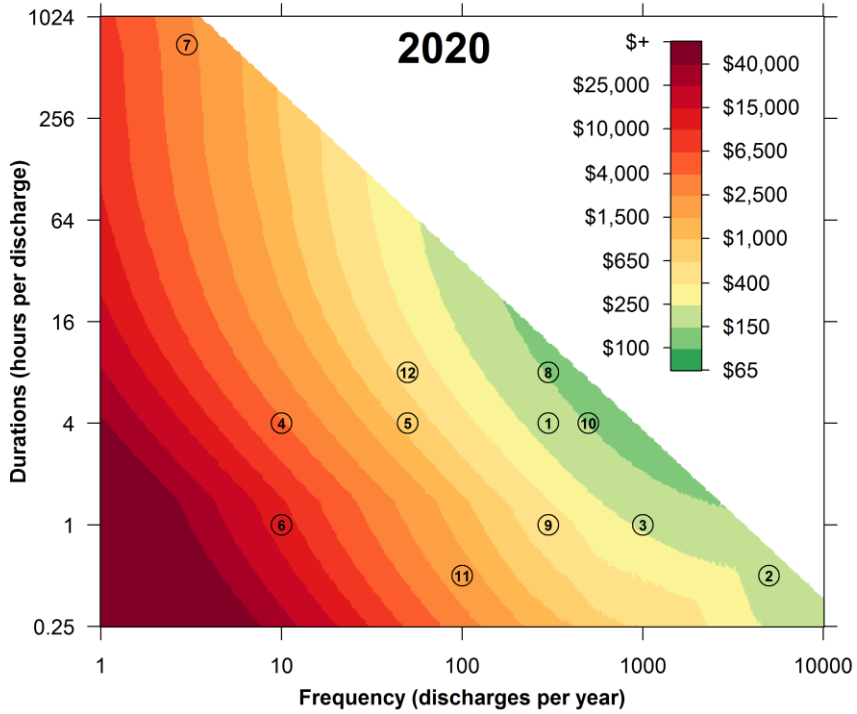
Revenue potential – energy capacity [USD/MWh]

Discount rate: 8%
Electricity price: 50 $/MWh

Revenue potential (energy)



Levelised cost of storage



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…potential business cases for applications with>300 cycles and >1 hour discharge.

Revenue potential – energy capacity [USD/MWh]