The Storage Path to Energy Reliability

by

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BC Hydro Auditorium

Outline

- What is grid scale energy storage?
- What is the reason for requiring energy storage on a large scale?
- Major grid scale energy storage technologies?
- Different energy storage technology comparison
- Energy storage benefits for grid operation
- Case studies in grid operation

What is Grid Scale Energy Storage ?

- Large-scale storage systems supporting transmission grid operation
- Designed to store excess electricity generated from renewable energy sources such as wind and solar power.

https://www.tesla.com/blog/introducing-megapack-utility-scale-energy-storage

https://electrek.co/2018/09/24/tesla-powerpack-battery-australia-cost-revenue

The need for Large Scale Energy Storage

Electricity storage can help

- the utility grid operate more efficiently
- reduce the likelihood of brownouts during peak demand, and
- allow for more renewable resources to be built and used.

https://www.epa.gov/energy/electricity-storage

Travers Solar Project, AB, Canada

- The Project will be 465 MW in size
- 1.3 million Solar Panels solar PV
- Area covered: 3,330 Acres
- (2.59 km^2) (1.6 km x1.6 km)
- Estimated cost of 800 million dollars
- Enough to power 100,000 homes

https://www.traverssolar.com/

Travers Solar Project AB, Canada

Ocean Energy Potential in BC

- British Columbia has significant ocean energy potential.
- Over 6,000 MW of wave energy and
- Over 2,000 MW of tidal energy development opportunities have been identified to date.

https://www2.gov.bc.ca/gov/content/industry/crown-land-water/crown-land/crown-land-uses/clean-energy/ocean-energy

Grid Scale Energy Storage Technologies

- Chemical (batteries)
- Compressed Air
- Gas conversion P2G (Hydrogen, Methane)
- Weight based (Pumped Hydro, Hydro pressure, Lifted Weight)
- Heat Based (Molten Salt)

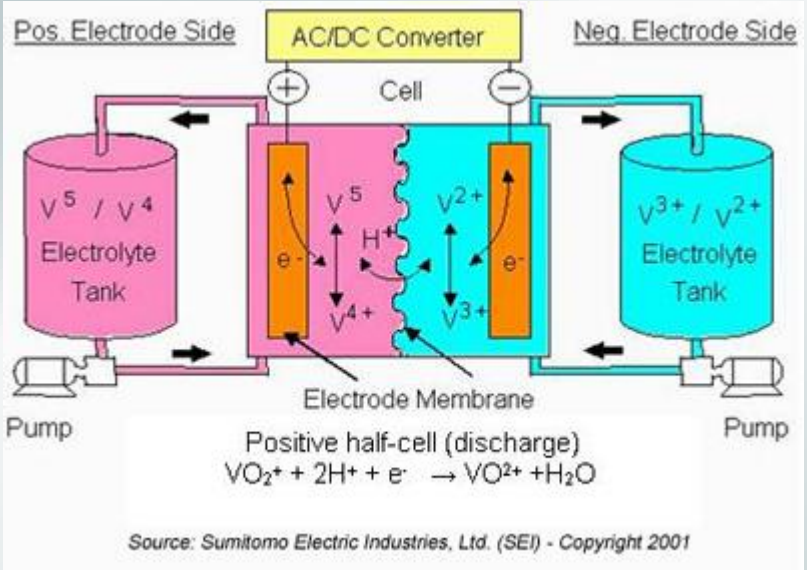
https://www.tesla.com/blog/introducing-megapack-utility-scale-energy-storage

Chemical Batteries

Grid Scale chemical batteries

- Lithium phosphate batteries (subset of Lithium Ion Batteries)
- Flow batteries

The world's largest vanadium redox flow battery was commissioned in China with 100 MW capacity and 400 MWh power



https://www.iea.org/reports/grid-scale-storage
https://www.pv-magazine.com/2022/09/29/china-connects-worlds-largest-redox-flow-battery-system-to-grid
https://energystorage.org/why-energy-storage/technologies/vanadium-redox-vrb-flow-batteries/

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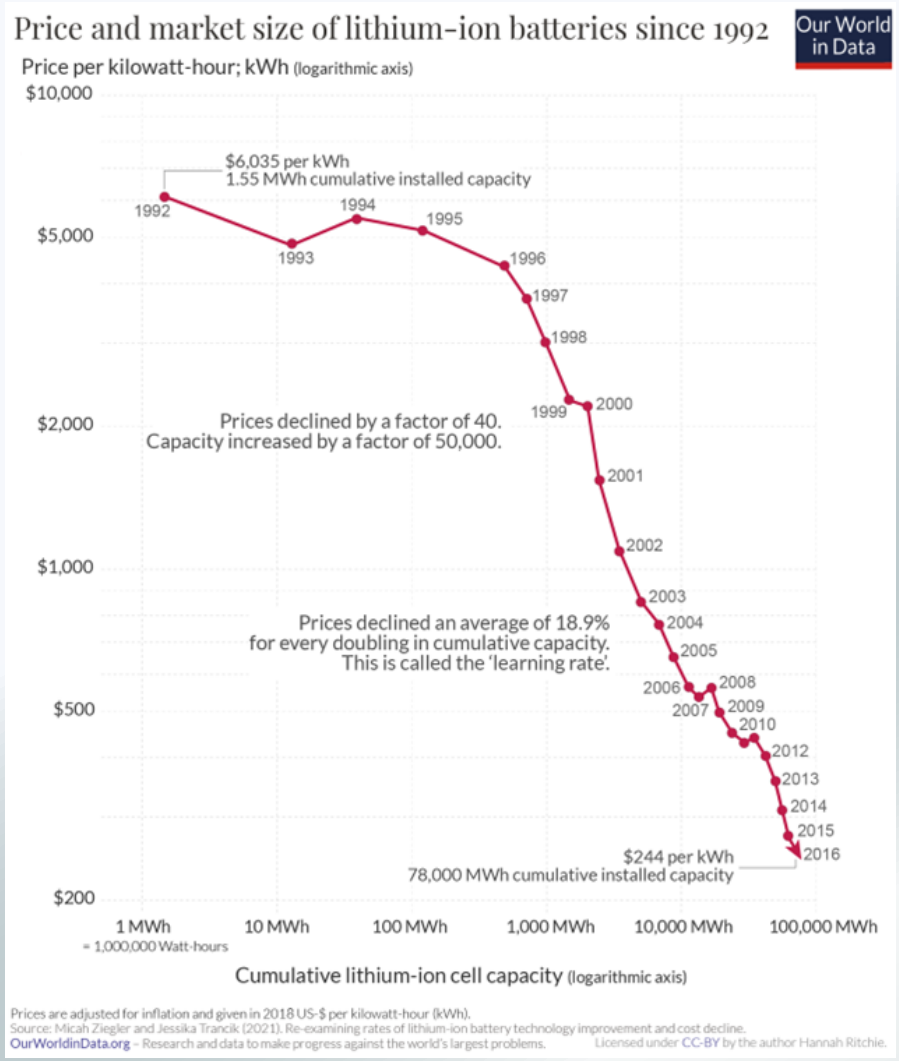
Lithium Ion Battery Price



1992 $ 6,000 /kWh

2022 $153 /kWh

https://www.energy.gov/eere/vehicles/articles/fotw-1272-january-9-2023-electric-vehicle-battery-pack-costs-2022-are-nearly#:~:text=The%20Department%20of%20Energy's%20(DOE's,least%20100%2C000%20units%20per%20year.

Lithium Ion Battery Price

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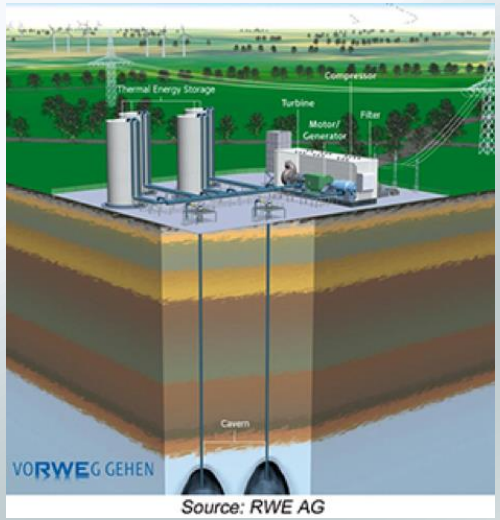
Li-Ion Battery Fire Hazard

- Tesla Megapack Australia

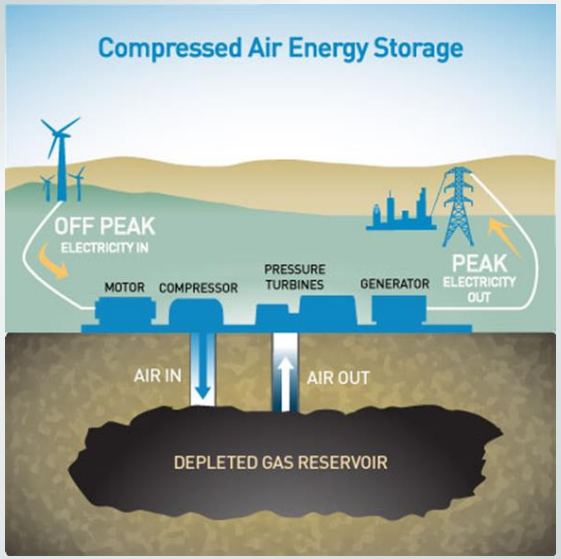
https://electrek.co/2021/07/30/tesla-megapack-caught-fire-giant-battery-project-australia/

Compressed Air Energy Storage

- Underground cavity used for compressing air by supplied power
- Discharge air and generate electricity from compressed air
- Large one installed in 1978 in Germany 290 MW
- Canadian Company HydroStore is active in this area



Source: RWE AG



https://energystorage.org/why-energy-storage/technologies/compressed-air-energy-storage-caes/
https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/compressed-air-energy-storage/compressed-air-energy-storage.page

Compressed Air CAES

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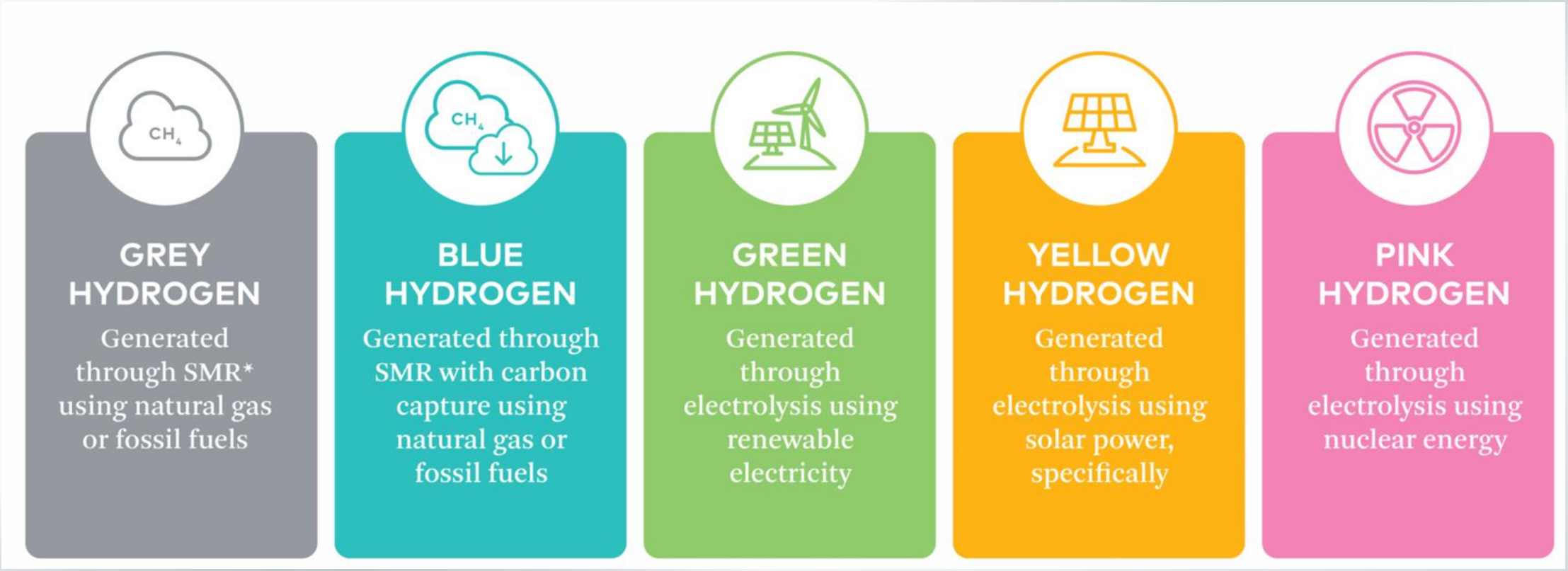
Hydrogen Energy Storage

- Hydrogen can be stored physically as either a gas or a liquid.
- Storage of hydrogen as a gas typically requires high-pressure tanks (350–700 bar [5,000–10,000 psi] tank pressure).
- Storage of hydrogen as a liquid requires cryogenic temperatures because the boiling point of hydrogen at one atmosphere pressure is −252.8°C.

https://www.tesla.com/blog/introducing-megapack-utility-scale-energy-storage

Hydrogen Color Spectrum



https://3degreesinc.com/resources/hydrogen-production-exploring-various-methods-climate-impact/

Hydrogen Color Spectrum

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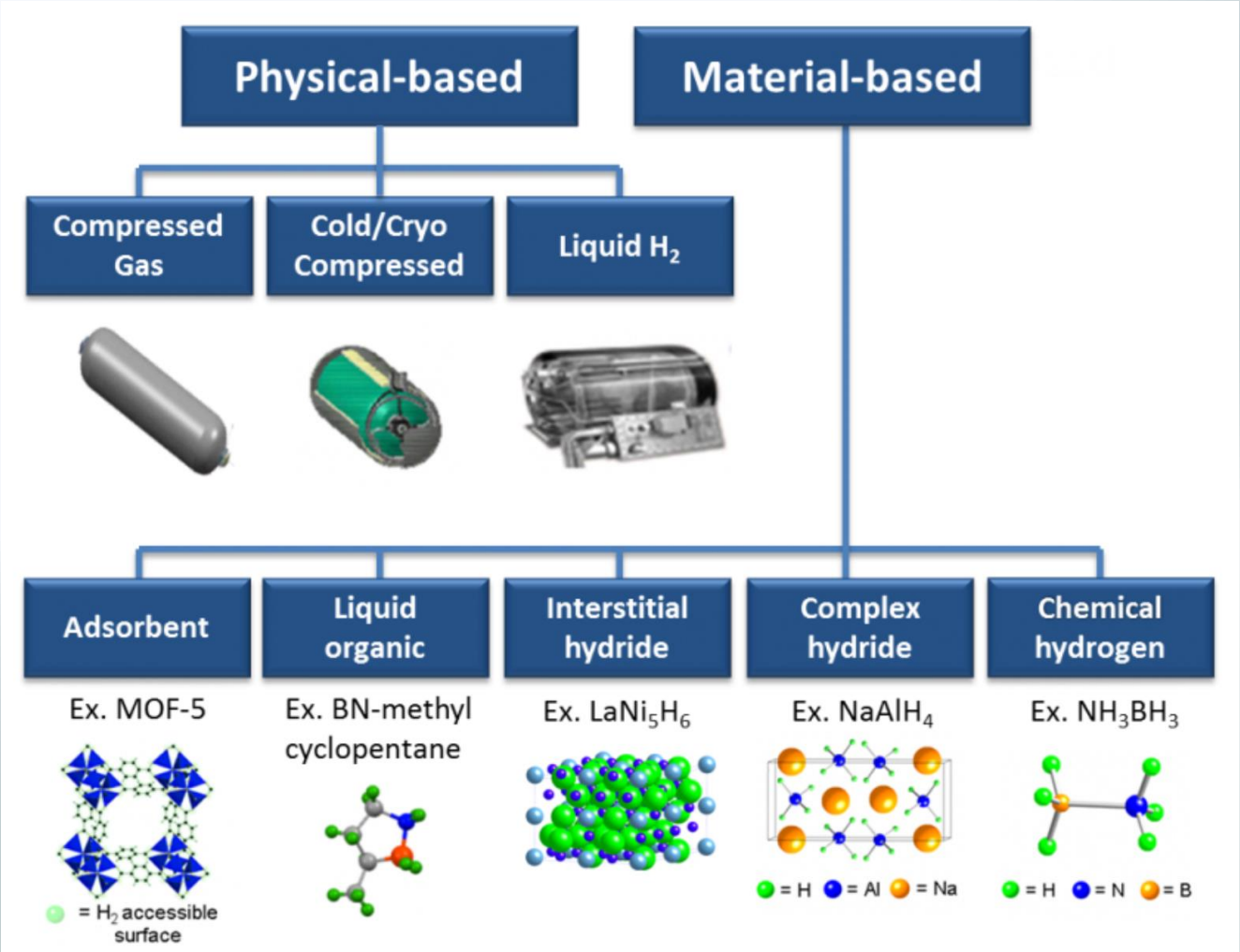
How Hydrogen is Stored



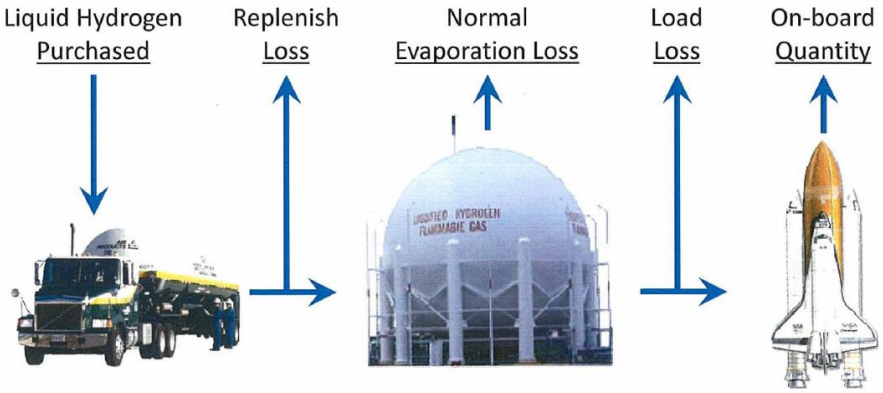
https://www.energy.gov/eere/fuelcells/hydrogen-storage

How Hydrogen Stored

Hydrogen Challenges

Kennedy Space Center
Center Operations Directorate

Historical Consumption Summary



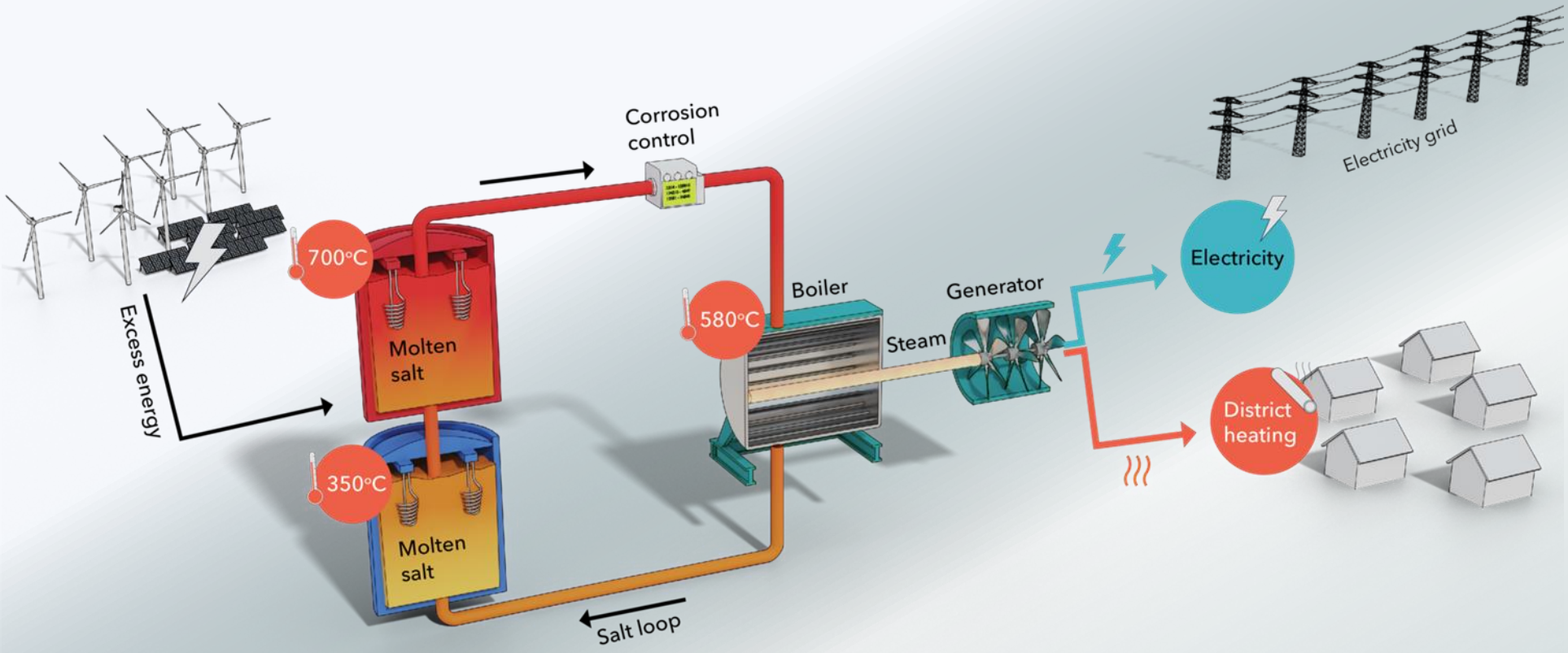
Liquid Hydrogen Consumption over Entire Space Shuttle Program

Liquid Hydrogen Purchased	100.0%	54,200,000 lb
Replenish Loss	12.6%	6,800,000 lb
Normal Evaporation Loss	12.2%	6,600,000 lb
Load Loss	20.6%	11,200,000 lb
On-board Quantity	54.6%	29,600,000 lb

February 25, 2011 7

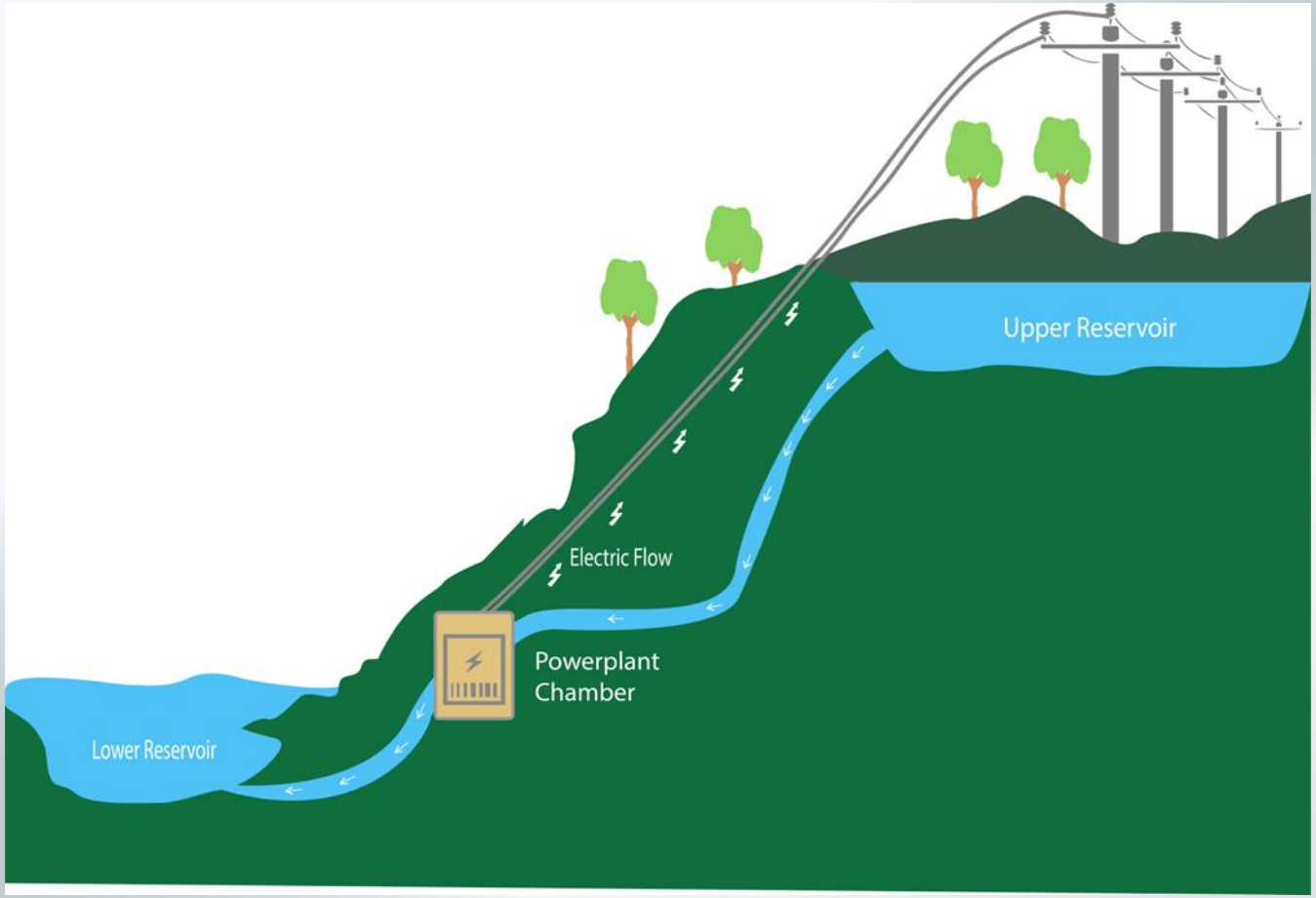
https://ntrs.nasa.gov/api/citations/20110008561/downloads/20110008561.pdf

Molten Salt



https://www.pv-magazine.com/2022/02/08/storing-solar-power-with-grid-scale-molten-hydroxide/

Pumped Hydro

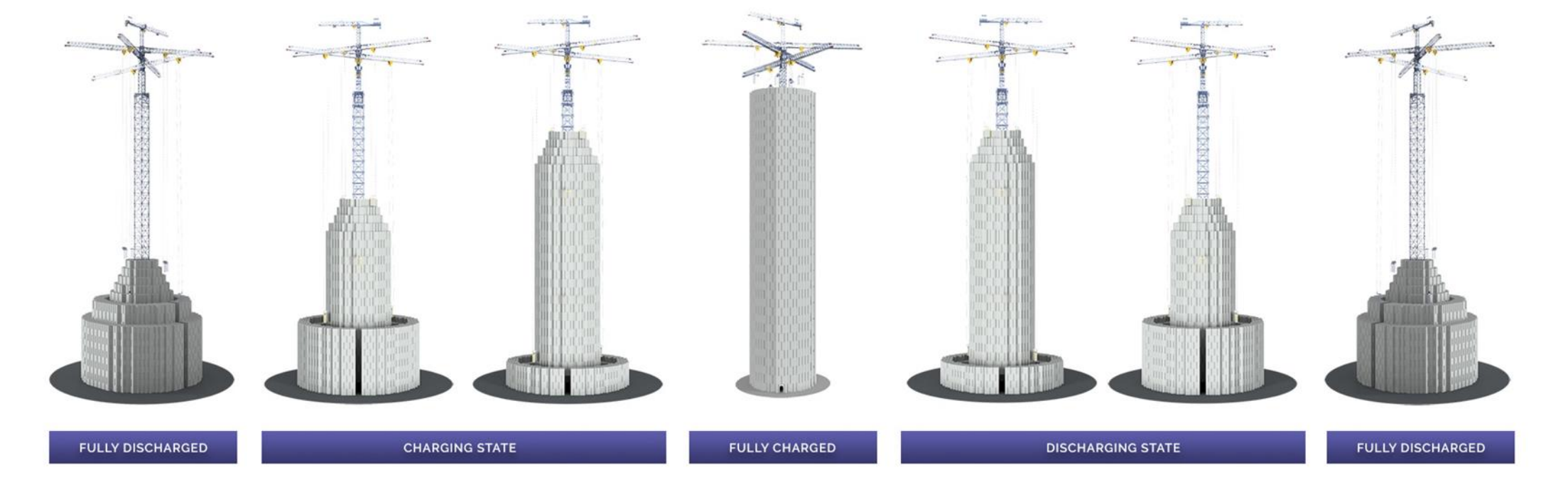


https://www.tesla.com/blog/introducing-megapack-utility-scale-energy-storage

Lifted Weight

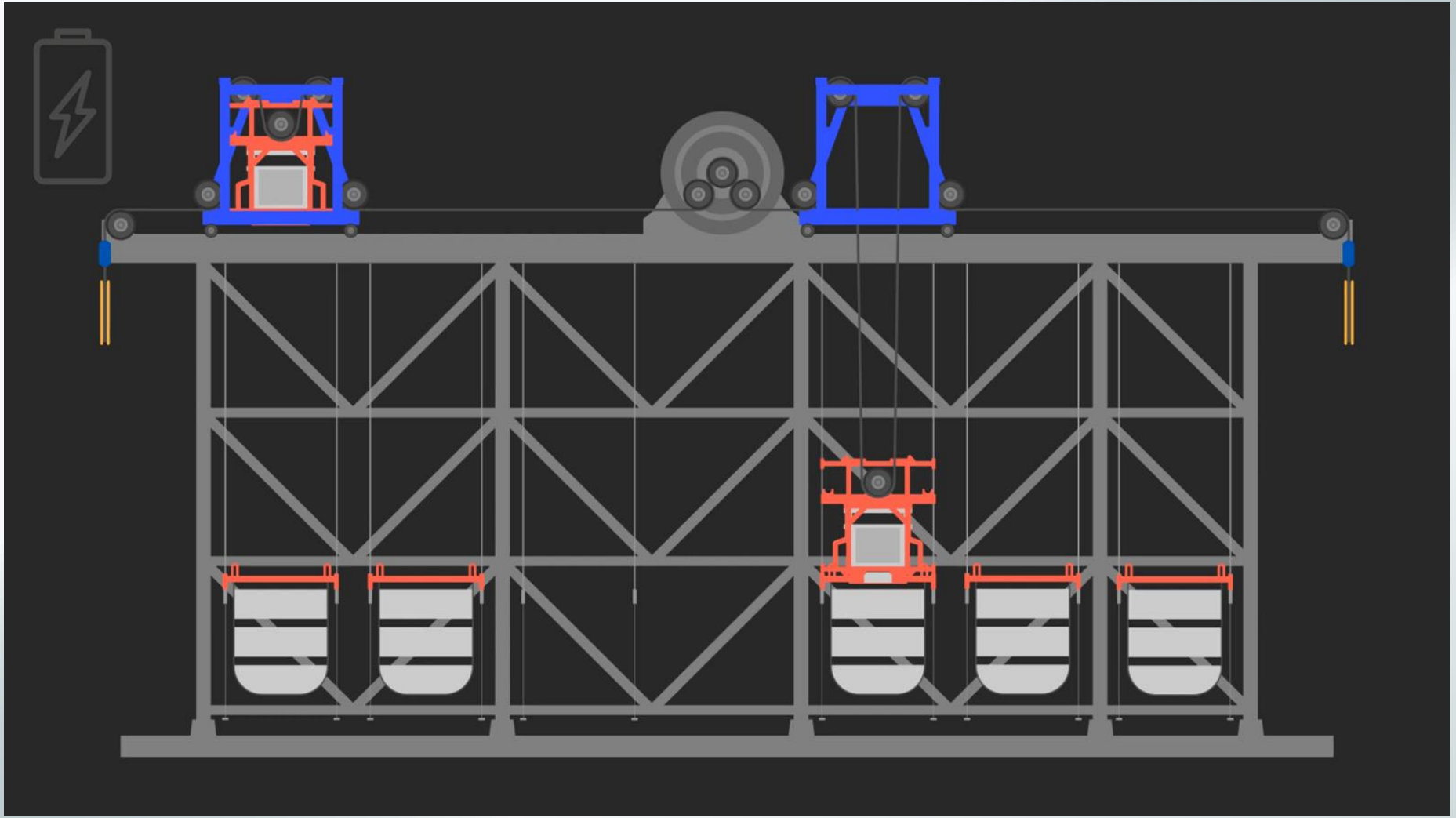
Power System Energy Storage Technologies,
Editor(s): Paul Breeze,
Power Generation Technologies (Third Edition), Newnes, 2019

Lifted Weight

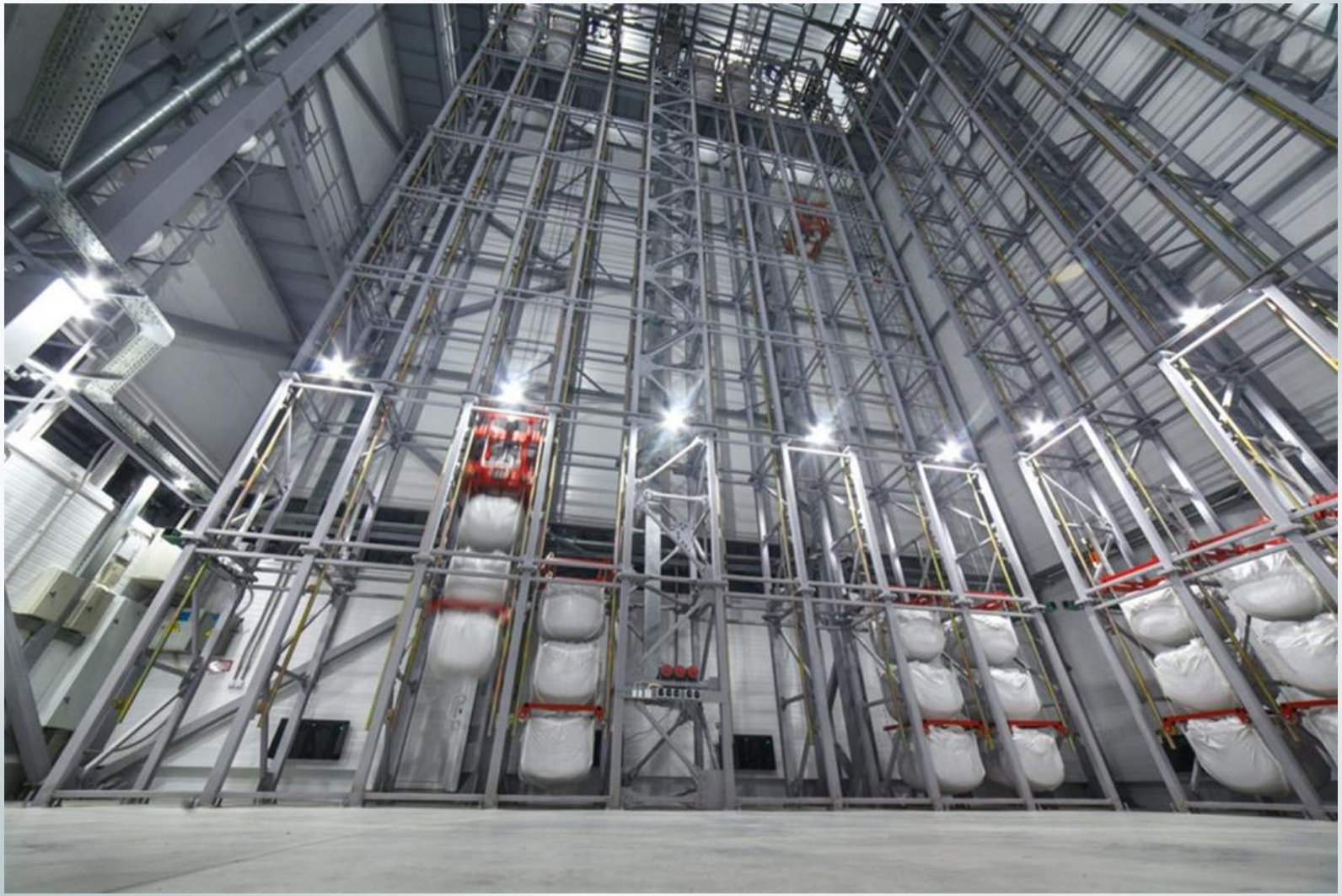


https://366solutions.com/14-/01-/2021/136-gravity-based-energy-storage-system/

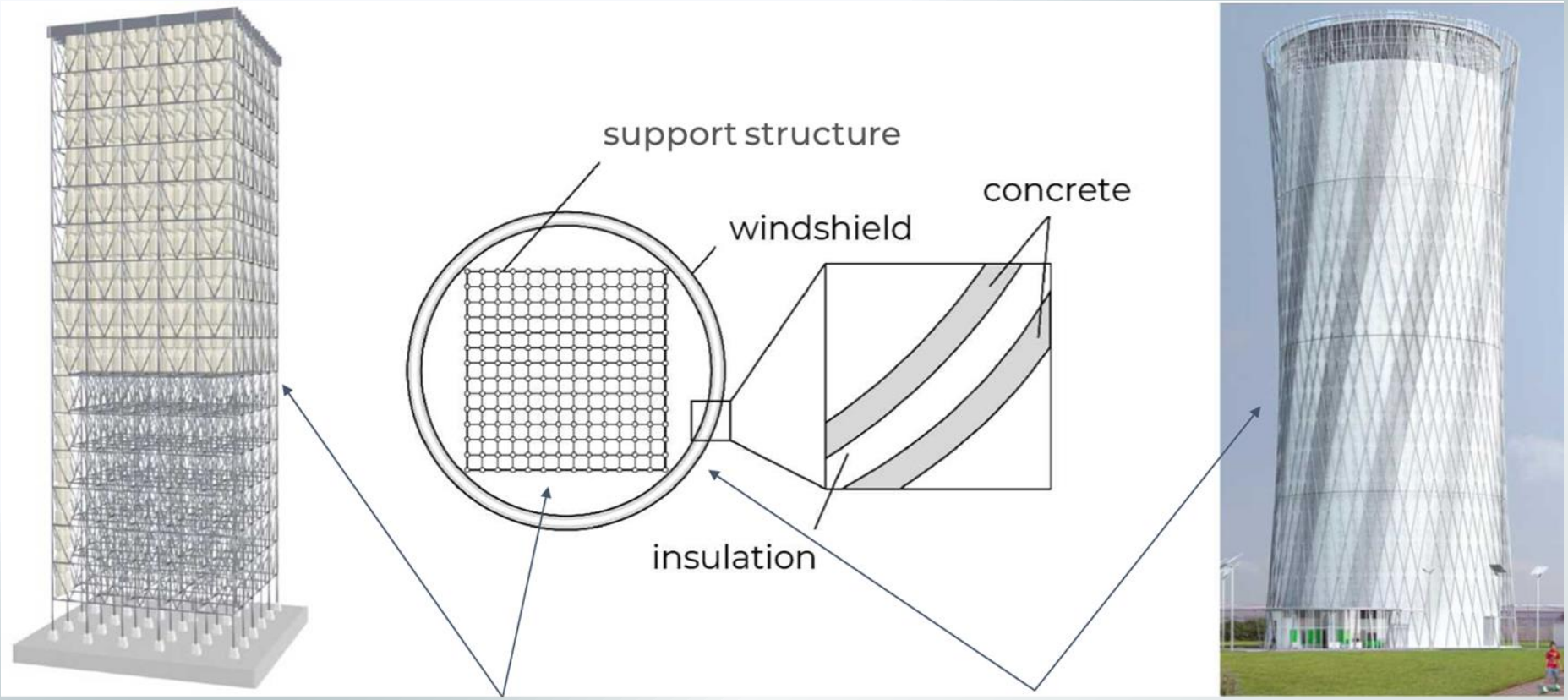
Lifted Weight



Lifted Weight



Lifted Weight Energy Storage



Comparison LWS vs. Site C

Capacity 1100 MW 5,100 GWh

- Area needed 1.5 km2 (~1.5 km in diameter)
- and 200 m in height
- Volume: 0.28 km^3 (~650 m cube)
- No large area environmental impact
- Estimated Cost $500 million

- Area flooded 7000 acres (28 km2) or about 5.3 km x 5.3 km
- Water volume: 2,310 Million m3 (a 13.2 km size cube)
- Large area environmental impact
- Estimated Cost 16 Billion

Energy Storage vs. Site C

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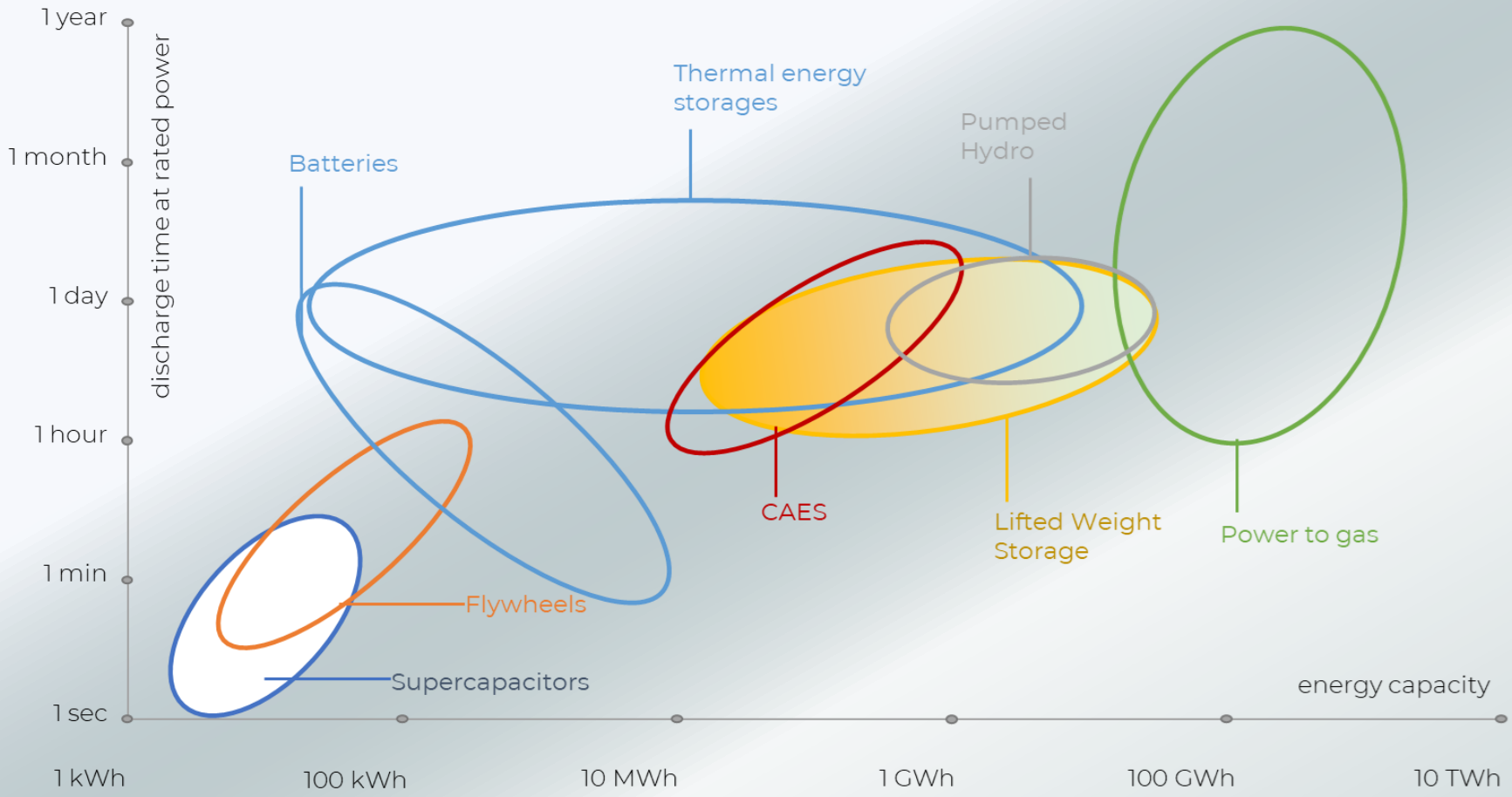
Energy Storage Comparison



Energy Storage comparisons

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Comparison of Grid Scale Energy Storage Technologies

	Lifted Weight Storage	Pumped Hydro Storage	Li-ion Battery	Hydrogen	Compressed Air
Environmental impact	ecologically friendly	affects large area ecosystem	toxic substances	explosive substance	Medium (underground cavities
Hazard	No	Environmental hazard	Fire Hazard	Fire and explosion hazard	Pressurized equipment
Lifetime	40 - 50 years	40 - 50 years	10 -15 years	20 years	50 years
Standardized design	yes	no	yes	no	no
Capacity Range	40 MWh to 1200 MWh (one unit)	800 MWh to 60 GWh	Up to 730 MWh	1 MWh to 10 MWh	10 MWh to 1 GWh
Roundtrip lifetime efficiency	80% - 83%	73% - 79%	79% - 95%	max 45%	45 to 70 %
Deployable	any location	relief and water sources	any location	Locations suitable to store hydrogen	At suitable locations only
Area	medium	large	medium	medium	medium
Flexibility	Seconds (zero to peak 3.5 sec)	minutes	seconds	minutes	seconds
Service	Fast (100 millisecond), easy, uninterrupted	slow, hard, interrupted	fast, easy, interrupted	Slow (minutes)	Fast, easy interrupted

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Grid Operation Improvements

Demand Response — Wholesale	Manages high wholesale price or emergency conditions on the grid by calling on users to reduce or shift electricity demand
Energy Arbitrage	Storage of inexpensive electricity to sell later at higher prices
Frequency Regulation	Provides immediate (four-second) power to maintain generation-load balance and prevent frequency fluctuations
Resource Adequacy	Provides capacity to meet generation requirements at peak loading
Spinning/ Non-Spinning Reserves	Maintains electricity output during unexpected contingency events (e.g., outages) immediately (spinning reserve) or within a short period of time (non-spinning reserve)
Distribution Deferral	Provides extra capacity to meet projected load growth for the purpose of delaying, reducing or avoiding distribution system investment
Transmission Deferral	Provides extra capacity to meet projected load growth for the purpose of delaying, reducing or avoiding transmission system investment
Demand Response — Utility	Manages high wholesale price or emergency conditions on the grid by calling on users to reduce or shift electricity demand
Bill Management	Allows reduction of demand charge using battery discharge and the daily storage of electricity for use when time of use rates are highest
Backup Power	Provides backup power for use by Residential and Commercial customers during grid outages

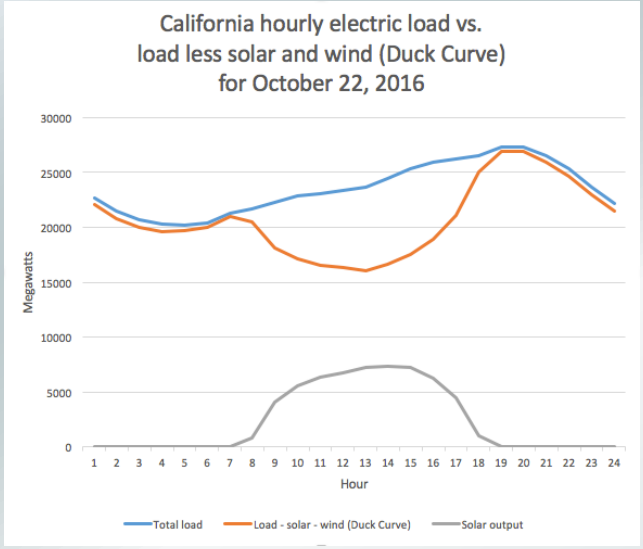
https://en.wikipedia.org/wiki/Duck_curve#/media/File:Duck_Curve_CA-ISO_2016-10-22.agr.png

Case Study: Nuclear Power Plant Operation

- Managing excess power
- Storing generated energy until needed.
- Smaller size power plants are needed.
- Emergency Backup
- Cold Start backup

Grid Operation Reliability Improvement

- Evens out peaks and valleys in power demand and generation availability
- Integrating renewable generation efficiently
- Large islanding is possible
- Arbitrage (Buying cheap and selling at peak price time)



https://en.wikipedia.org/wiki/Duck_curve#/media/File:Duck_Curve_CA-ISO_2016-10-22.agr.png

Case study: UBC Point Grey Campus

- Supplied by 69 kV transmission lines
- Peak demand for 6 hours during the day
- Extra transmission line costs 30 million dollars
- Main need is 6 hours during the day operating heat pumps
- Chemical batteries explored, but did not work well
- Energy storage charged during the night
- Energy storage discharged during the day when power is needed

UBC Point Gray Campus

https://www.tesla.com/blog/introducing-megapack-utility-scale-energy-storage

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Case Study: Vancouver/Lower Mainland

- Supply are from two main corridors
- Ice storm withstand 1 in 100 year and some 1 in 200 year probability
- Restoration time in an ice storm for at least 72 hours
- Large scale energy storage can supply Lower Mainland until some restoration is complete

Vancouver /Lower Maniland

https://www.tesla.com/blog/introducing-megapack-utility-scale-energy-storage

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Case Study: Vancouver Downtown

- Cable supply to Downtown Vancouver is vulnerable to earthquakes
- In case of earthquake 6 months outage is projected
- Recharging cars in Downtown area
- Grid scale Energy Storage is one possible solution to provide basic power to downtown

Case Study: Brownout prevention

- Vancouver Island has small generation capability
- Vancouver Island Peak load in winter heating
- Summer Air Conditioning paeak load
- December 21, 2022, BC Hydro Peak load 10,900 MW (highest ever)
- Large scale energy storage can provide required energy without major transmission investment

https://www.bchydro.com/news/press_centre/news_releases/2022/extreme-cold-leads-to-record-breaking-electricity-demand-for-a-s.html

Cold Start of the Grid

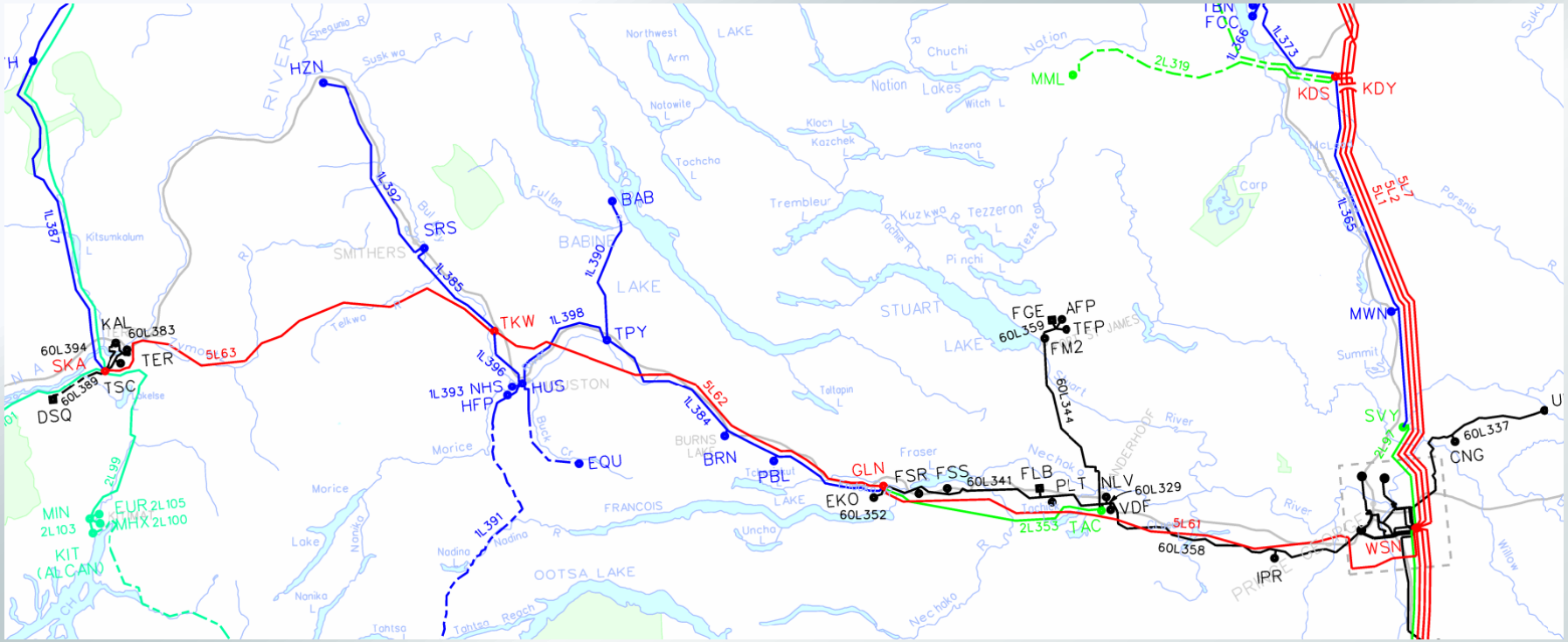
- Burrard Thermal acted as a cold start backup (Decommissioned in 2016)
- Similar capacity 960 MW energy storage can provide environmentally friendly cold start backup

Industrial Plant Operations

- Short term peak electrical demand
- High Cost of Electricity
- Buy energy at low cost and use it as needed
- Integrating local green energy sources to plant operation

Radial Line Reliability improvement

- Single source supply to an area combined with energy storage
- Significant improvement in reliability
- BC North 500 kV radial line



https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/suppliers/transmission-system/maps/transplt-Default-001.pdf

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Summary

- Grid scale energy storage technologies are becoming available and cost effective
- Grid scale energy storage can provide significant system operation benefits
- Integrating renewable environmentally friendly energy generation to the grid requires large scale energy storage

https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/suppliers/transmission-system/maps/transplt-Default-001.pdf

Questions?

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