Stationary electricity storage: daily and beyond

Paul Albertus
Associate Director, Maryland Energy Innovation Institute
Assistant Professor, Department of Chemical and Biomolecular Engineering
University of Maryland, College Park

Former US DOE ARPA-E Program Director (2015 to 2018)
Led the initiation of the DAYS program (which is focused on long duration electricity storage)

Scales of stationary storage

Battery storage:
~0.05 TWh worldwide (*growing fast*)

Tehachapi Energy Storage Project

Solar + thermal storage:
~0.04 TWh worldwide

Noor Ouarzazate III Plant

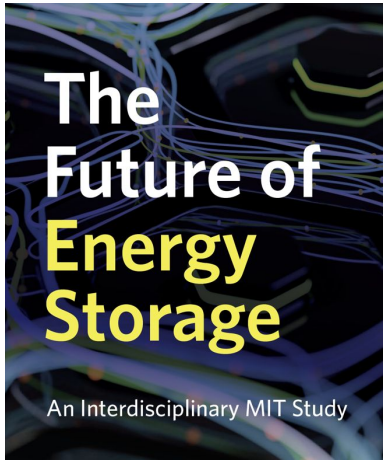
Pumped Storage Hydro:
~1.6 TWh worldwide (0.25 TWh in the US)

Bear Swamp Pumped Storage Hydro

US natural gas storage:
~1000 TWh (primary basis)

Washington 10 facility in MI, ~25 TWh

Potential future electricity storage needs:



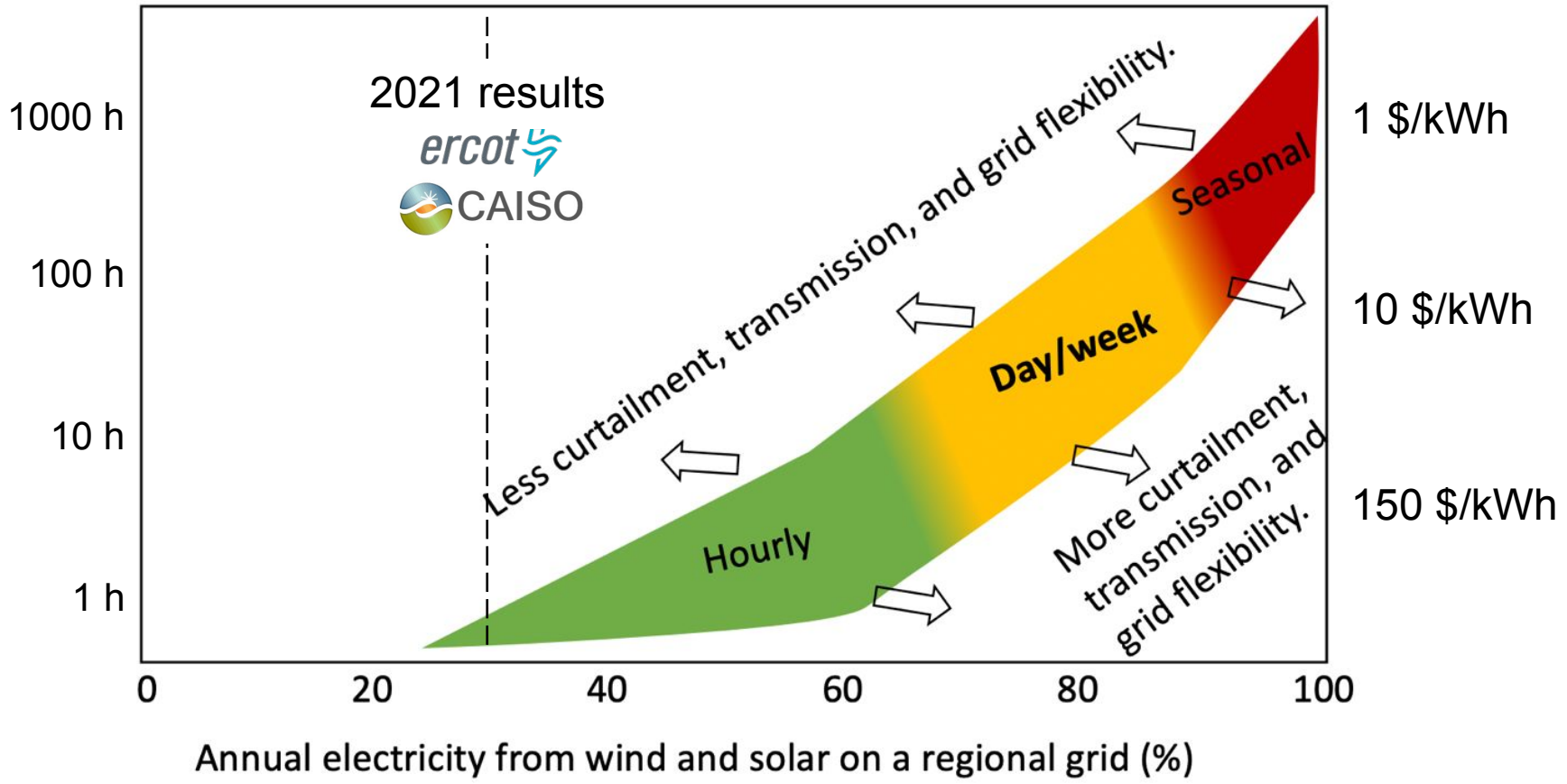
"The total energy storage capacity that may need to be deployed to fully decarbonize the U.S. electricity sector might approach 100 terawatt-hours (TWh) by 2050."

Refs: https://www.sandia.gov/ess-ssl/ldes/ https://energy.mit.edu/wp-content/uploads/2022/05/The-Future-of-Energy-Storage.pdf
Other sources

Storage duration rises as the fraction of variable generation increases

Maximum required storage duration to meet all hours of load (hours at rated power)

Approximate capital cost target ($/kWh)

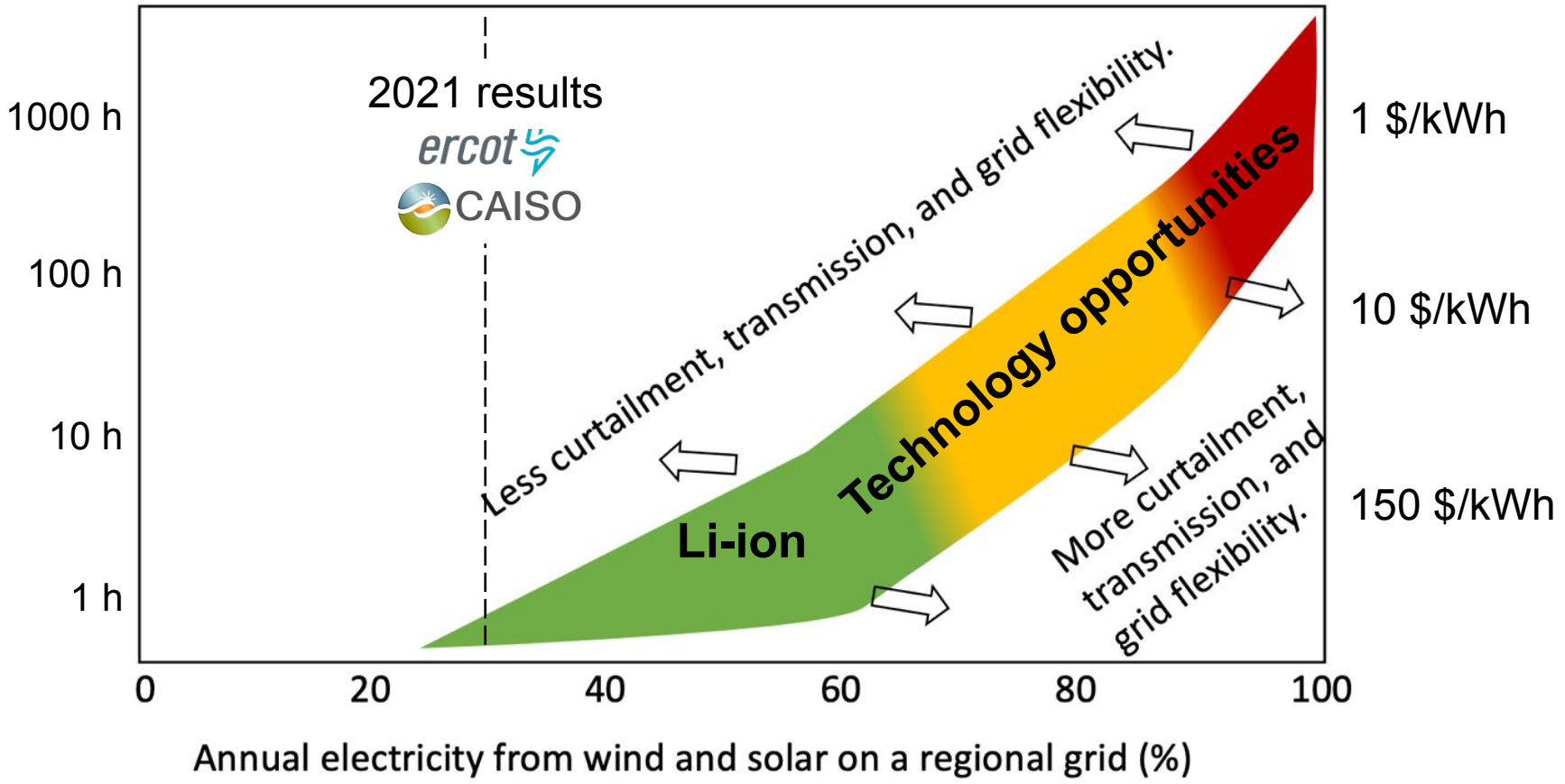


Albertus et al., Joule *4*, 21-32, January 15, 2020. Plot based on results of groups of Denholm, Caldeira, Trancik, and others.

Storage duration rises as the fraction of variable generation increases

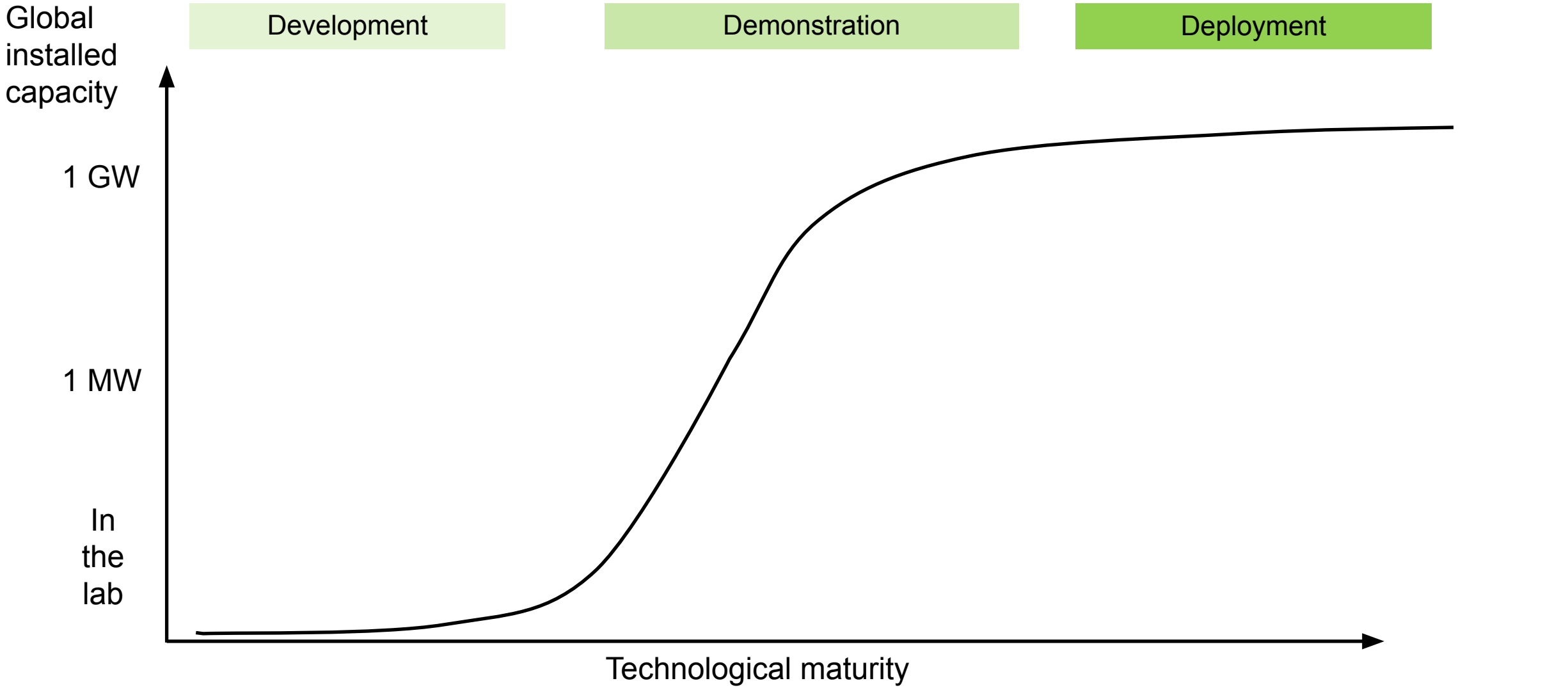
Maximum required storage duration to meet all hours of load (hours at rated power)

Approximate capital cost target ($/kWh)

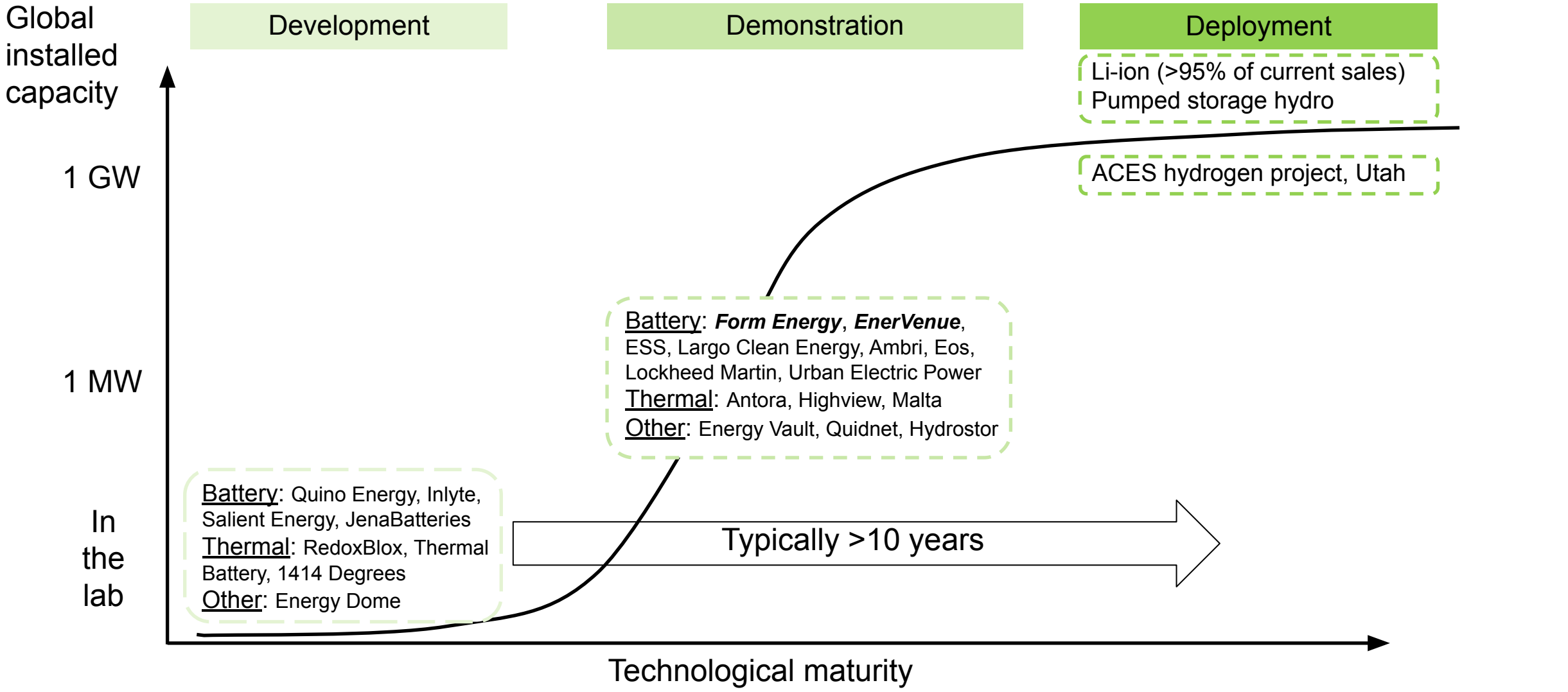


Albertus et al., Joule *4*, 21-32, January 15, 2020. Plot based on results of groups of Denholm, Caldeira, Trancik, and others.

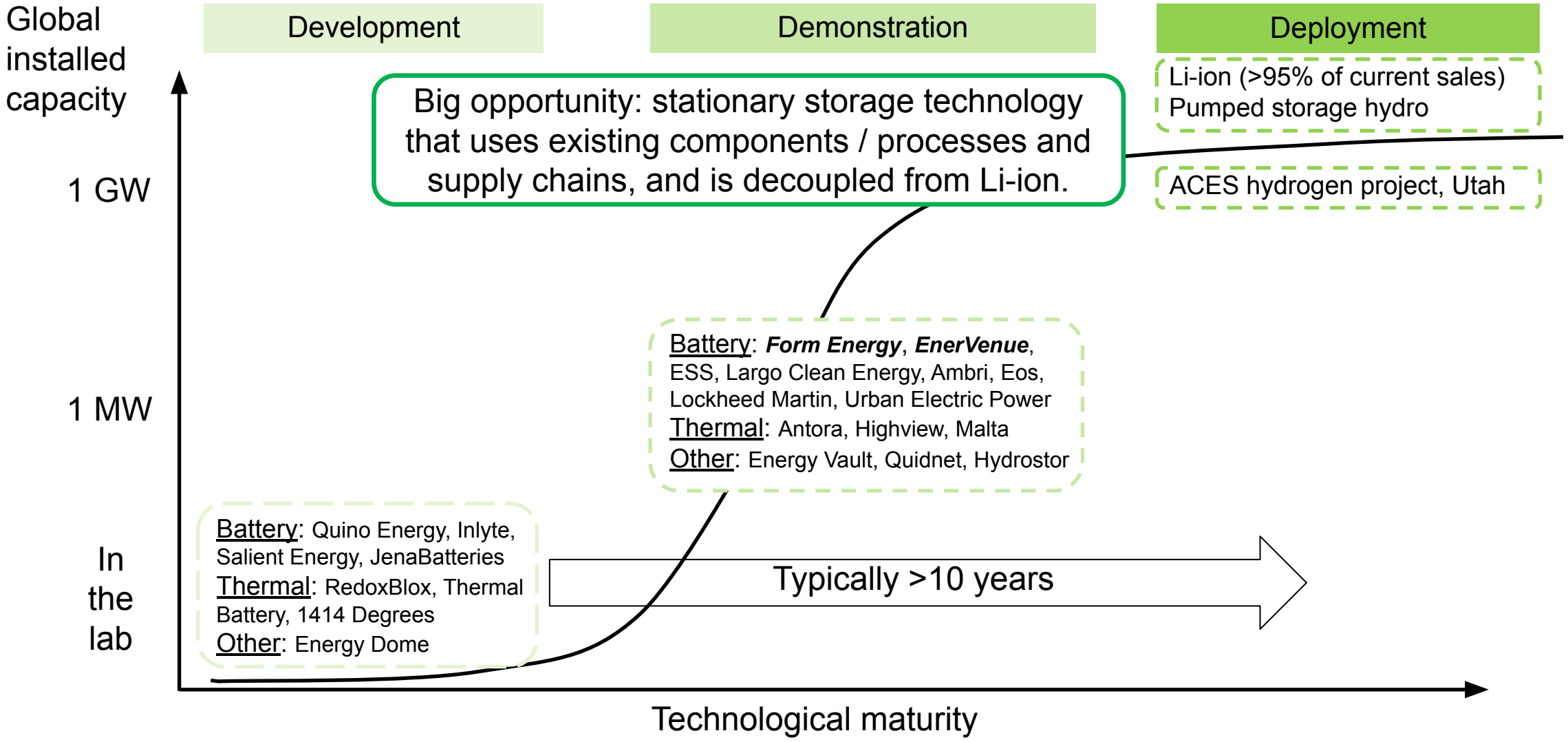
New stationary storage technologies on the S curve



New stationary storage technologies on the S curve

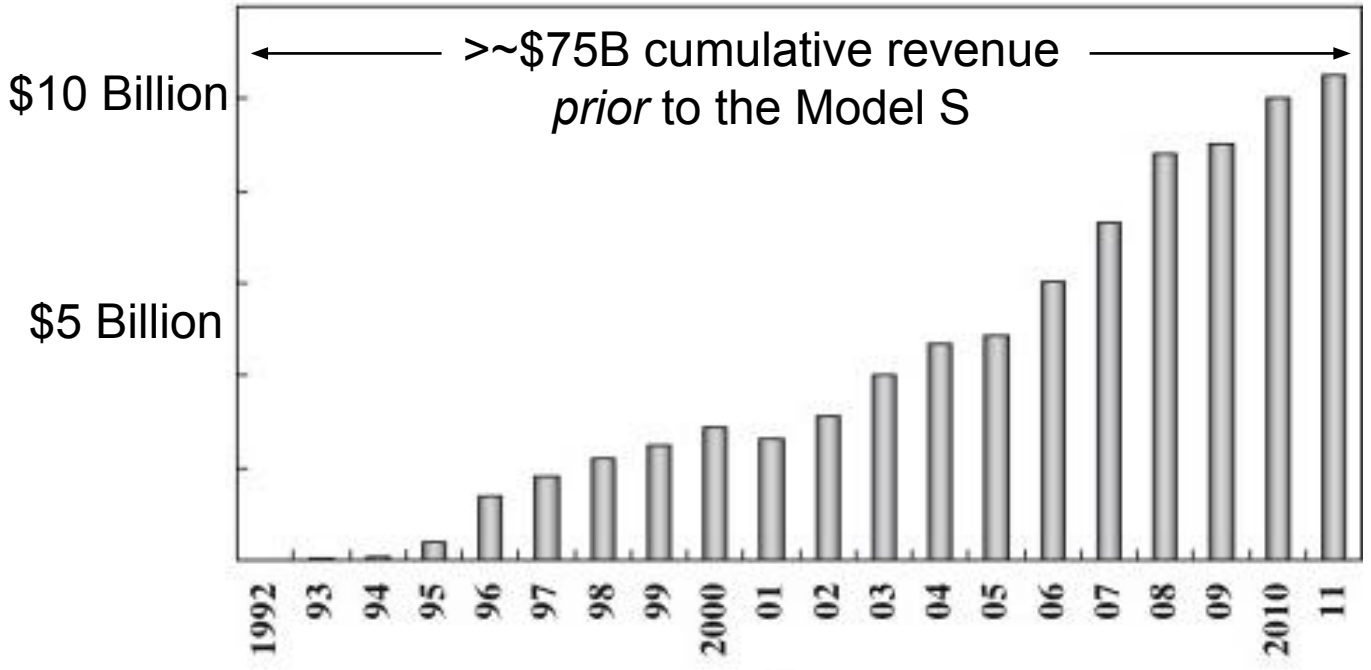


New stationary storage technologies on the S curve



Li-ion grew with large markets outside grid, and government support

Li-ion annual revenue by year



2012

2014

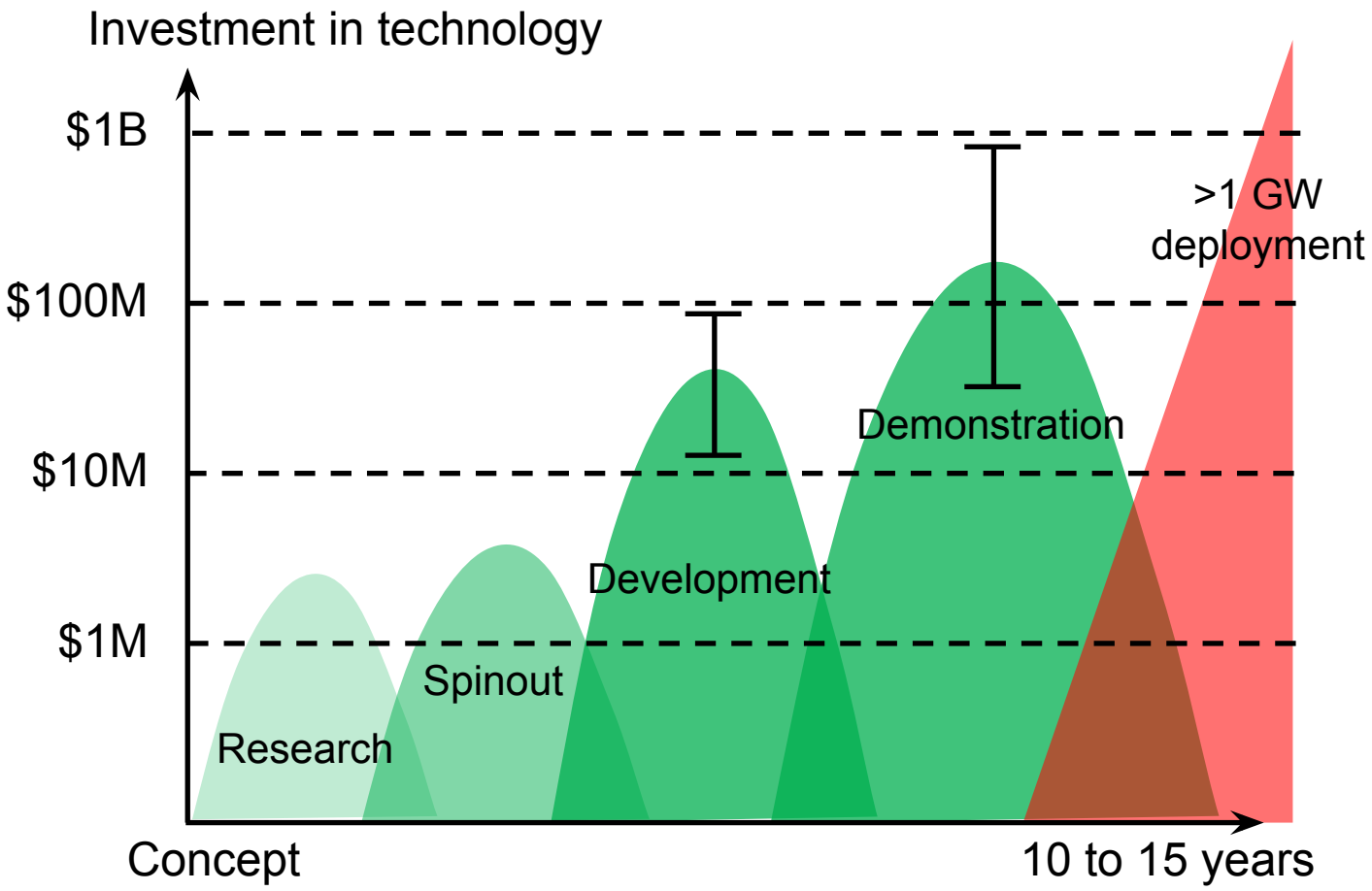
Tesla Model S

Tehachapi Energy Storage Project

- 8 MW, 32 MWh
- Automotive Li-ion cells from LG
- Utility owned (SoCal Edison)
- Multiple use cases
- DOE/SoCal Edison funded

Li-ion revenue figure: Yoshino, Lithium-Ion Batteries, “1– Development of the Lithium-Ion Battery and Recent Technological Trends,” 2014, pp. 1-20.

Investment scales and timelines for new stationary storage technology



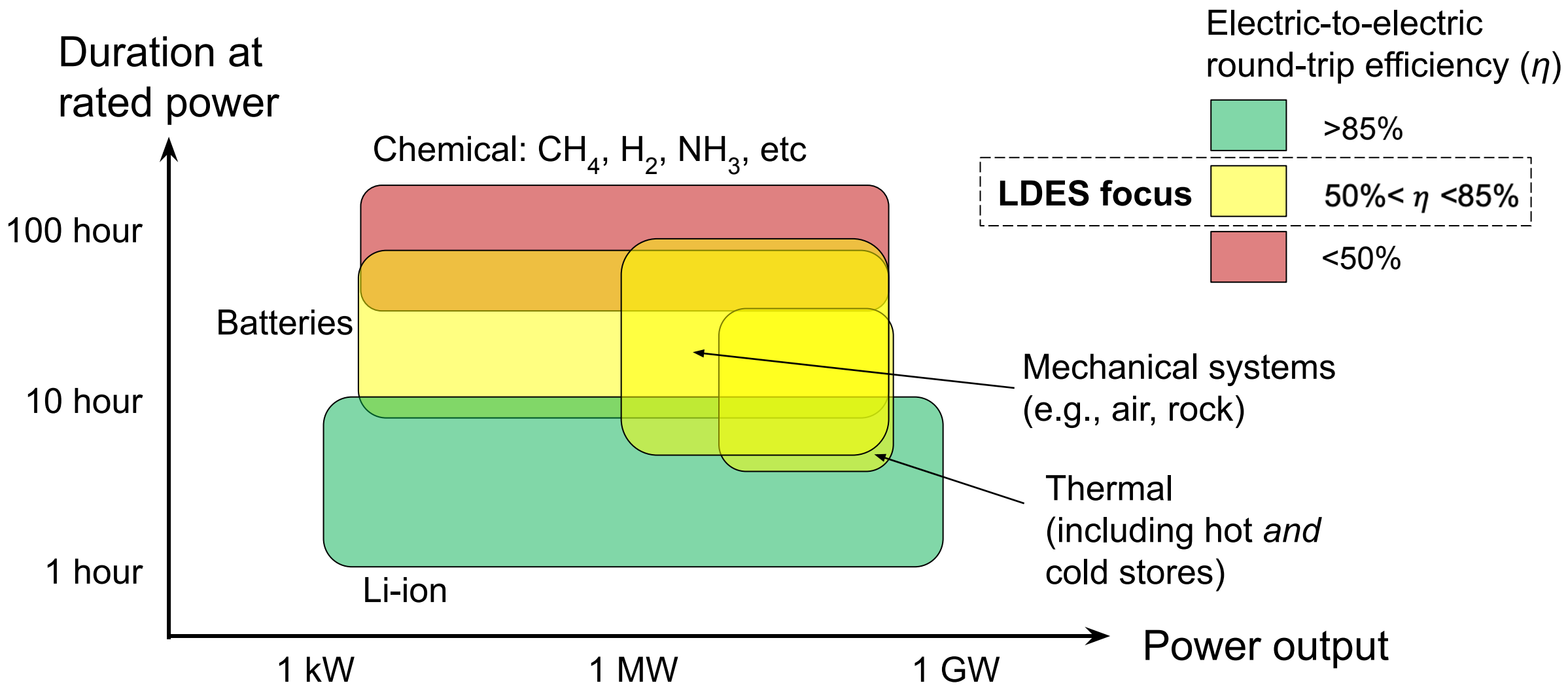
The electricity sector poses unique challenges for technology scaling and business development. Key questions:

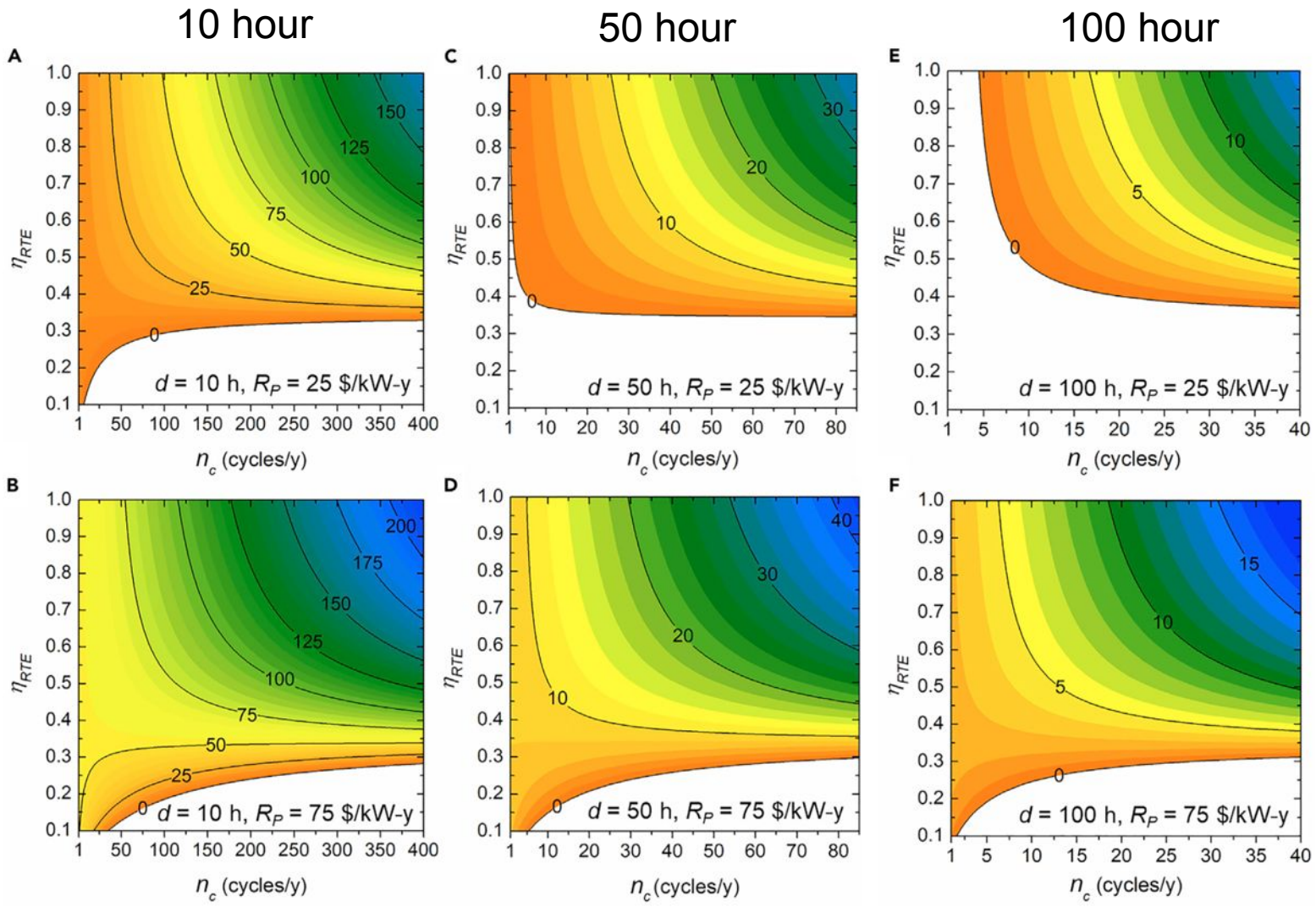
- Support for many large (10s to 100s of MW) demonstration projects.
- Support for a multi-year pipeline of deployment projects to solidify manufacturing and business activities.

Thank you

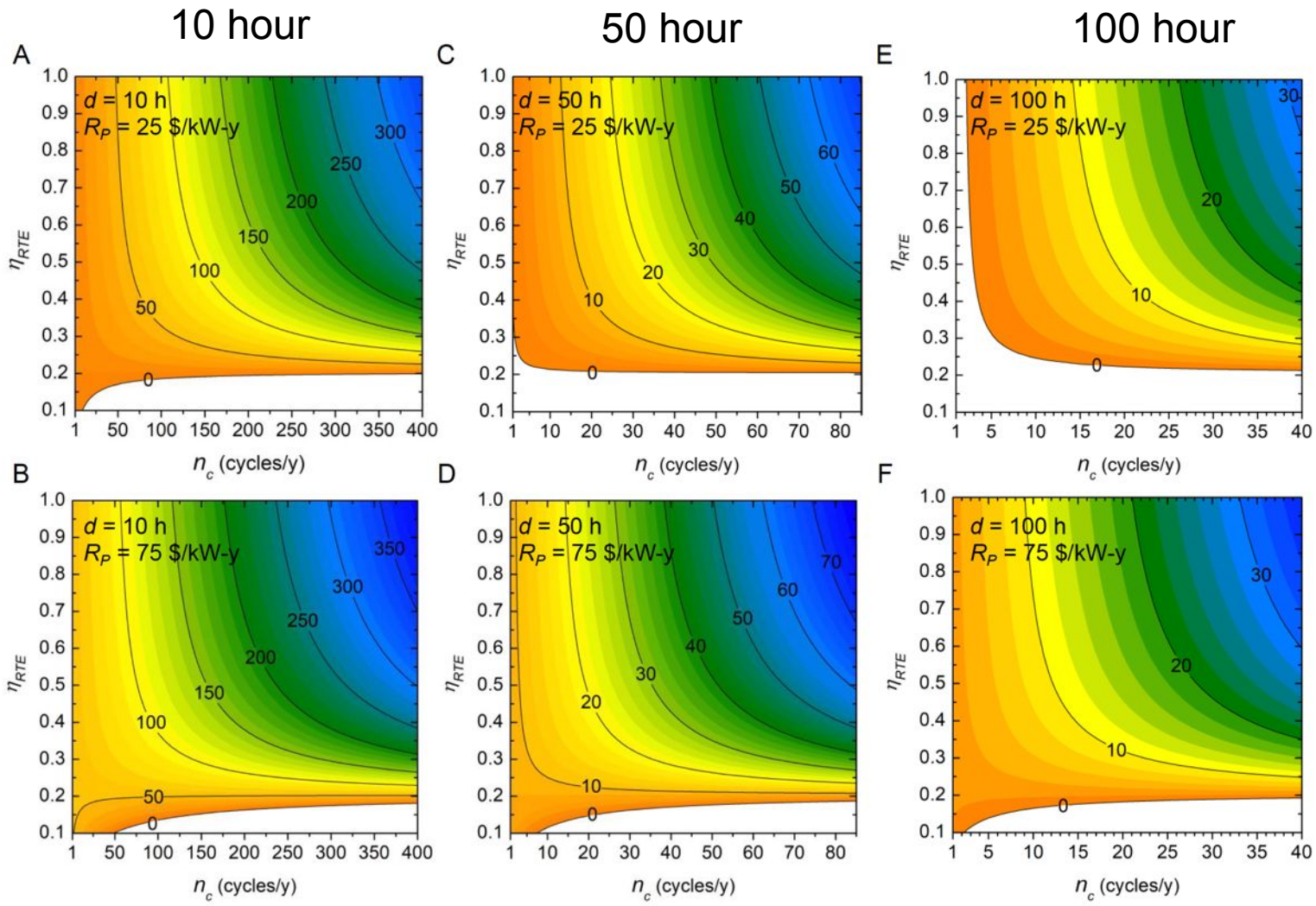
Contact: albertus@umd.edu

Technologies potentially suitable for LDES



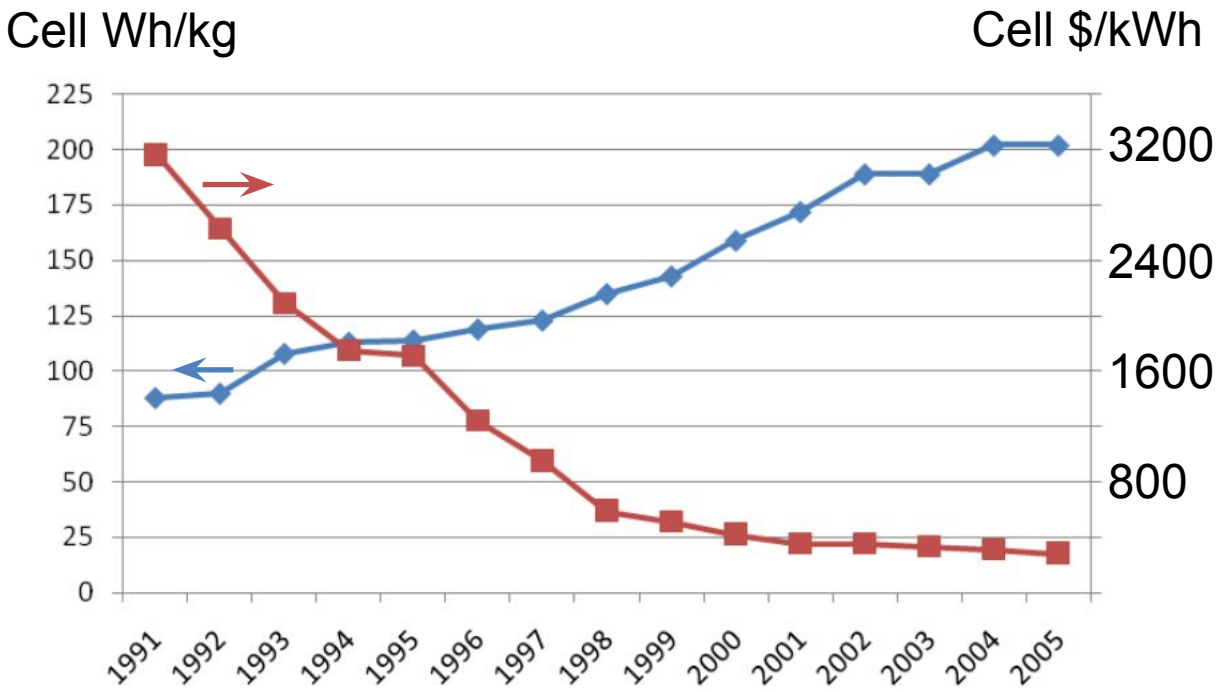


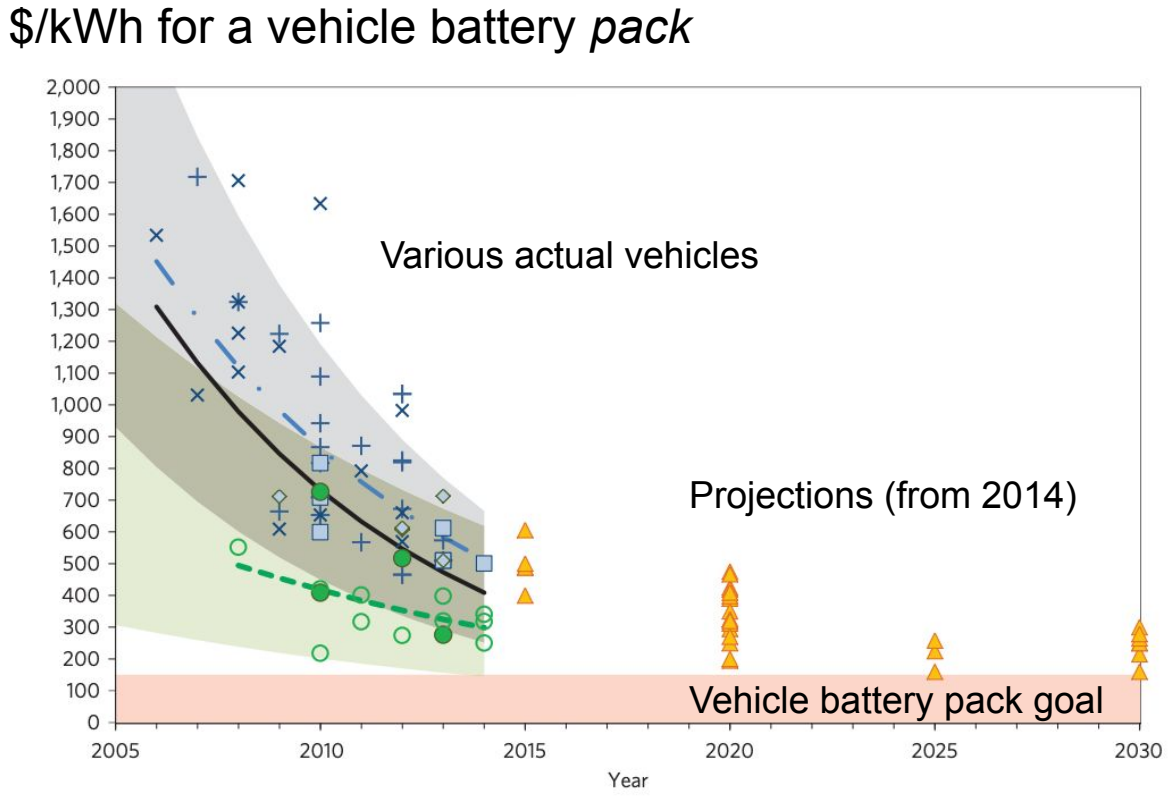
Albertus et al., Joule *4*, 21-32, January 15, 2020.



Albertus et al., Joule *4*, 21-32, January 15, 2020.

Early markets supported high Li-ion cell and vehicle pack prices



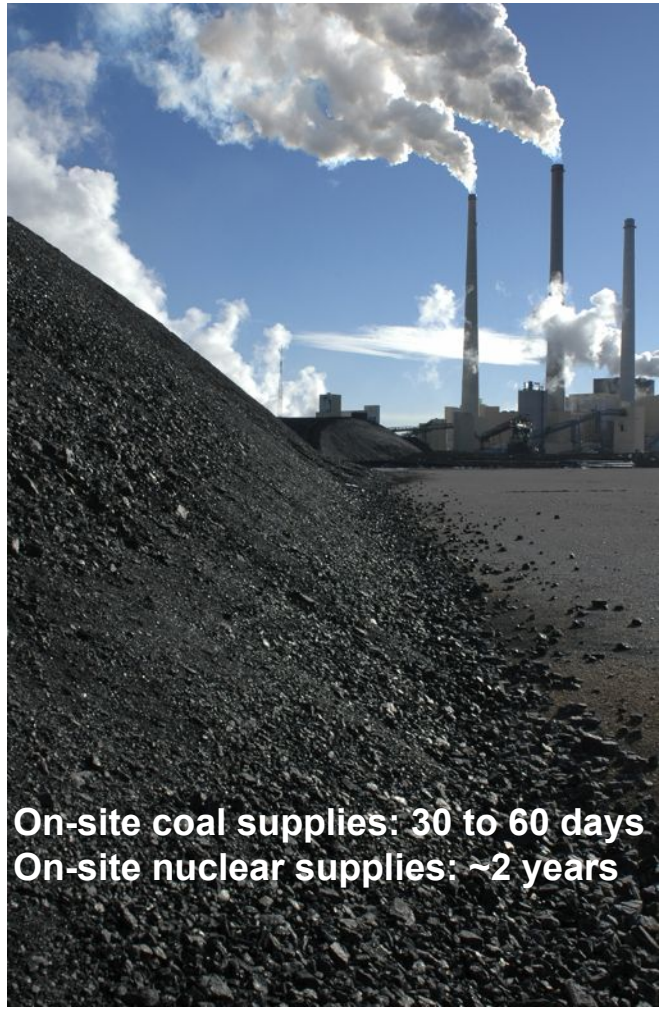


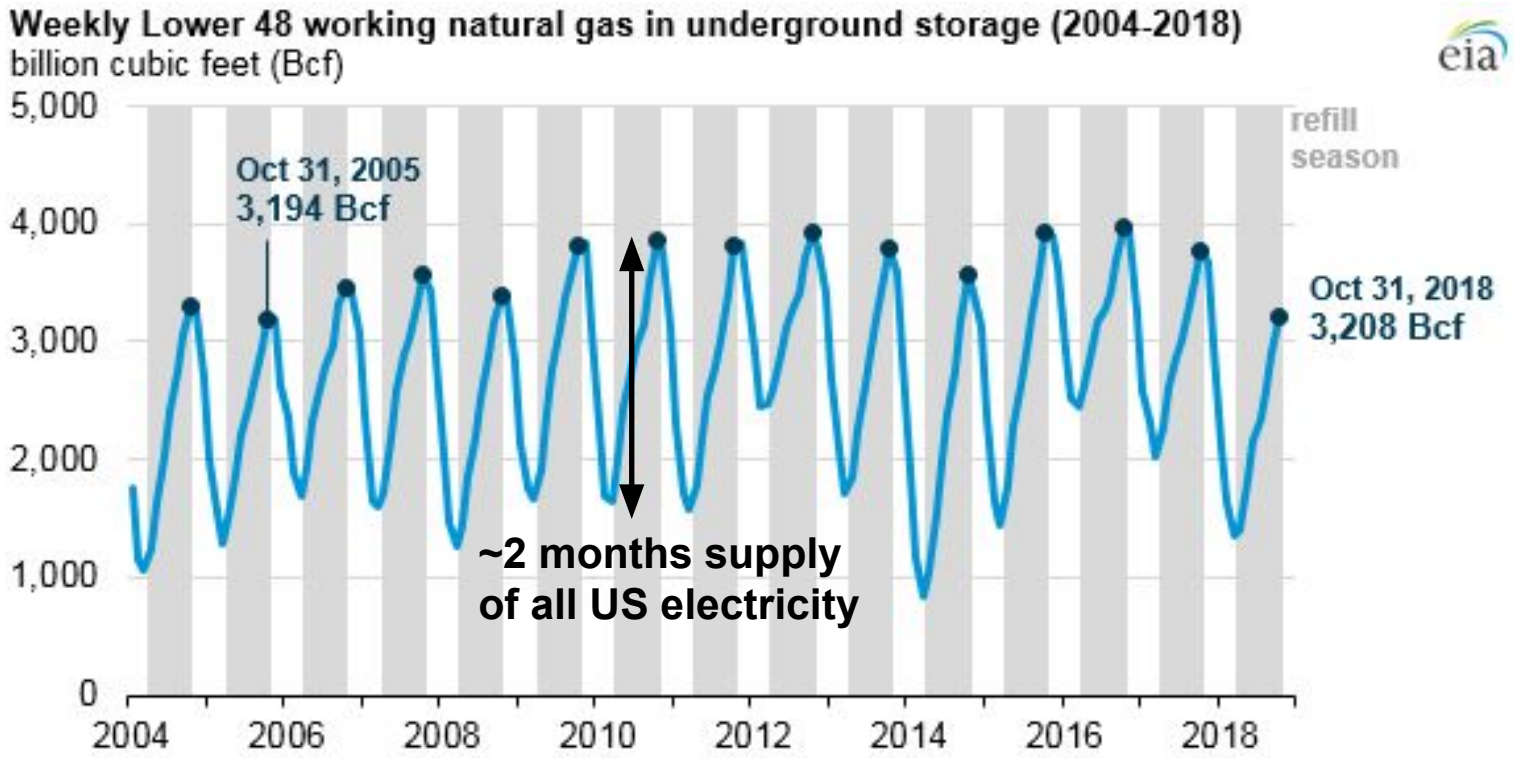
Grid Li-ion had significant consumer first markets in both small cells (portable electronics) and large packs (vehicles), and has benefited from cross-sector government subsidies (federal EV subsidies drove down prices for grid projects).

From David L. Anderson, Masters Thesis, 2009, Link.

Nykvist and Nilsson, Nature Climate Change, 5, 2015, pp. 329-332.

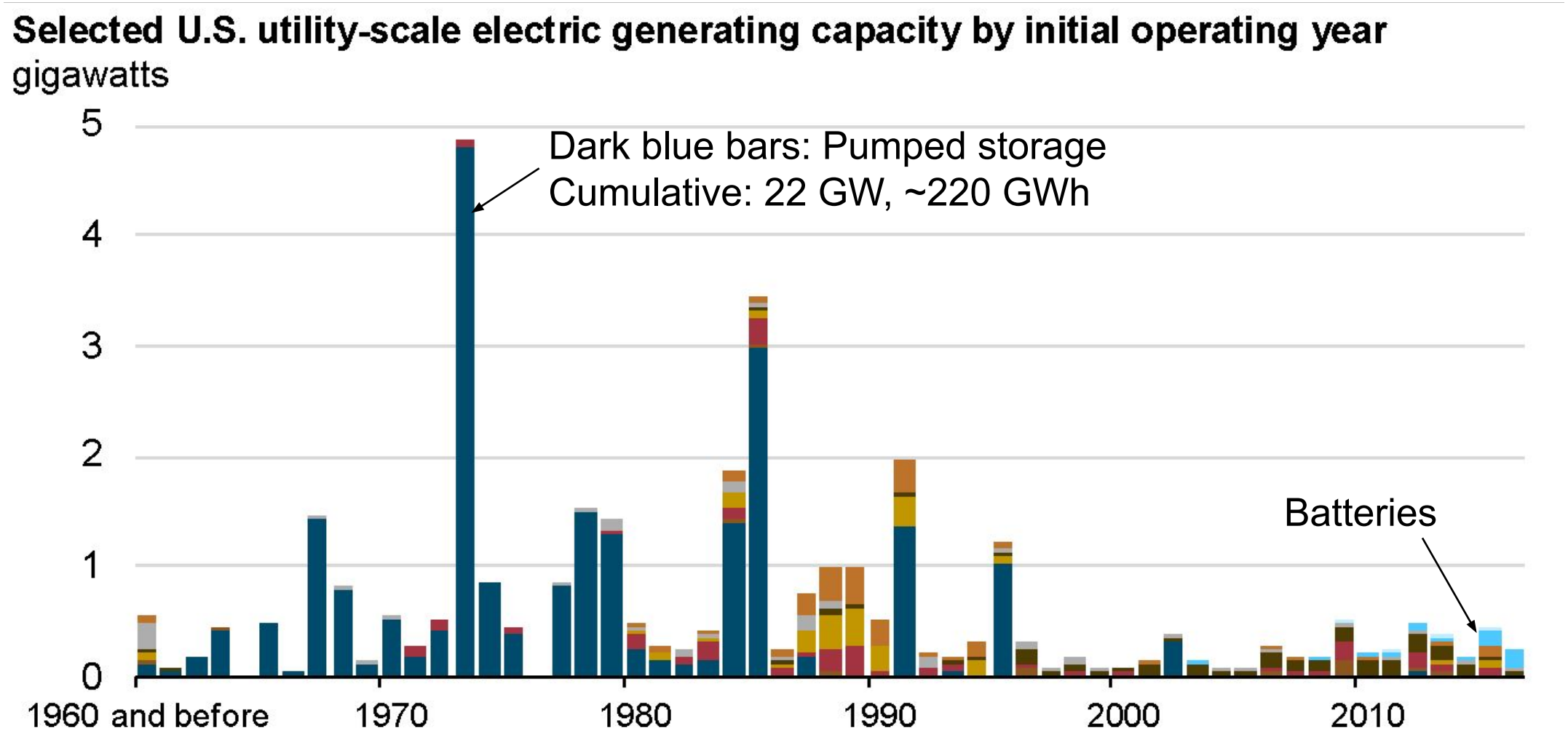
We do have extensive long-duration *fuel* storage today





https://www.eia.gov/todayinenergy/detail.php?id=37512

Pumped storage deployments have essentially stopped



https://www.eia.gov/todayinenergy/detail.php?id=31372