

Energy Storage

Solving the Intermittency Problem

How does it work?

- “Energy” Storage because electricity can’t be stored but must be converted into a different form, stored, and reconverted into electricity when needed.
- When wind or solar is generating more power than needed, the excess energy can be stored for use when sun is down or wind isn’t blowing.
- Storage smooths out the peaks and valleys of intermittent solar and wind generation.

Large-scale batteries



Lithium-ion is dominant type

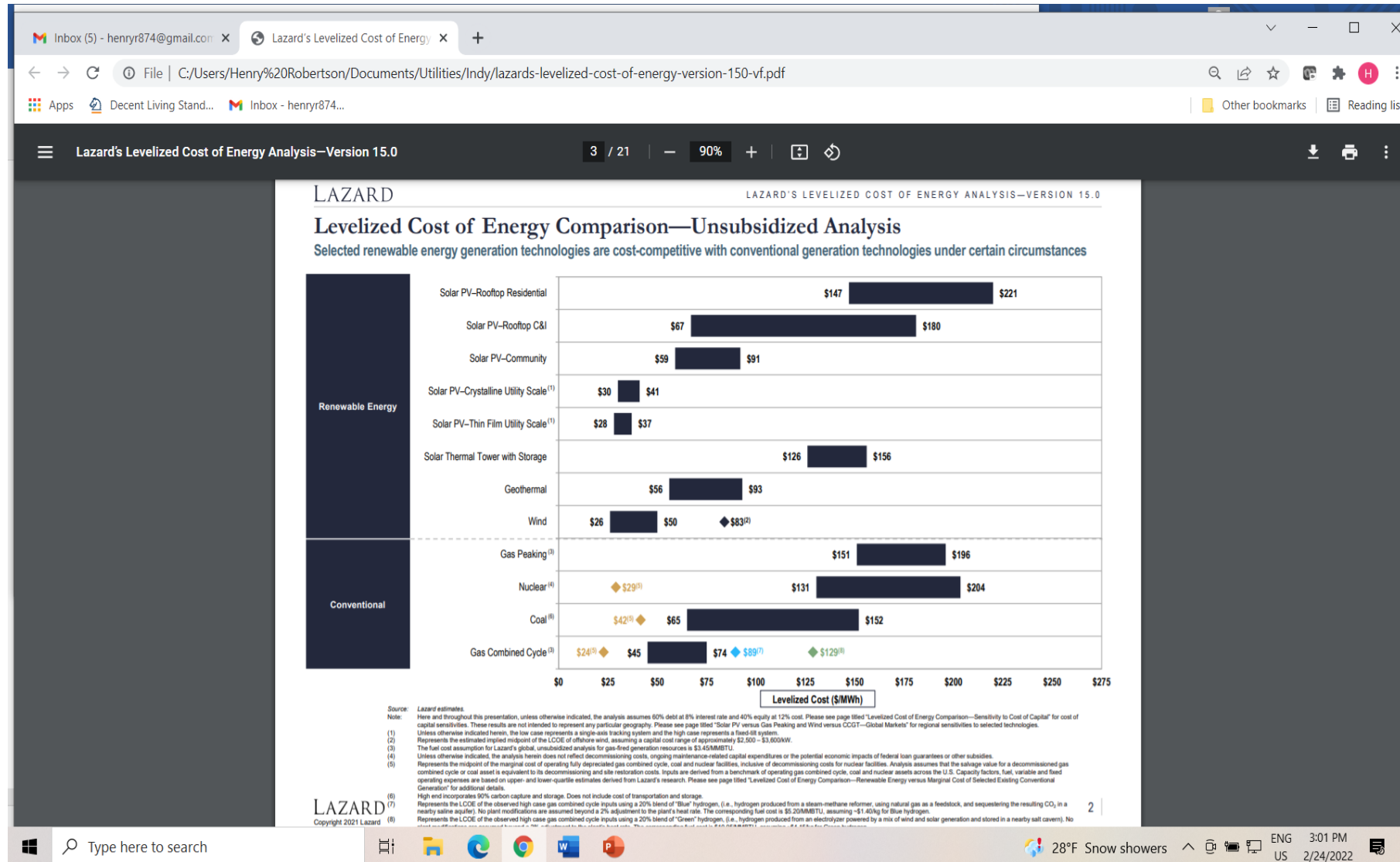
Price has fallen 90% in last decade

Research is being done on other
battery chemistries

Examples that are nearing
commercialization:

- Iron-air
- Sodium-sulfur (NaS)

Levelized Cost of Energy (LCOE)



Solar with Battery Storage

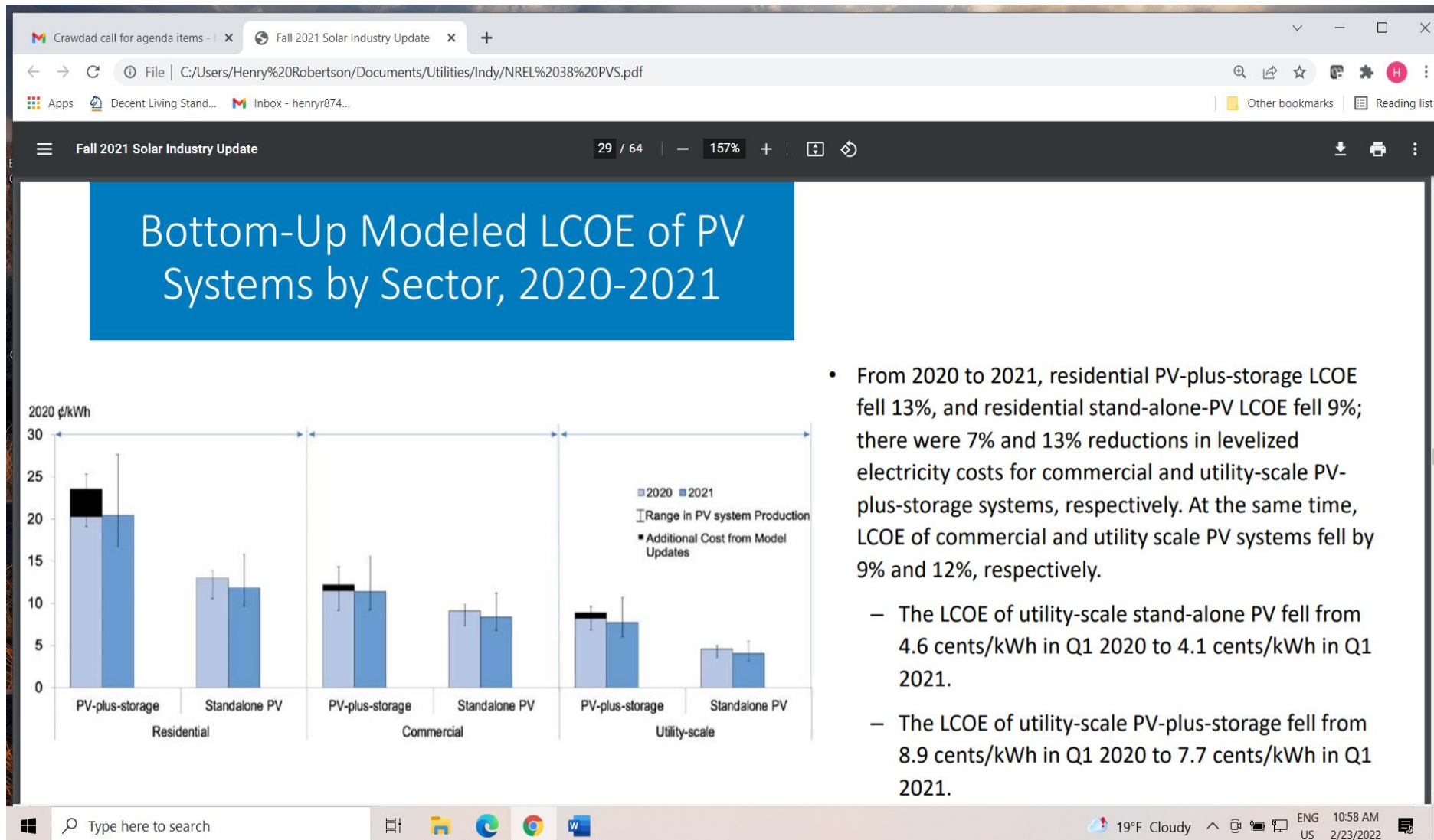
LCOE compares different technologies with a single metric: construction + O&M costs averaged over the life of the asset.

Lazard's 2021 LCOE study (previous slide) shows wind and solar have lower LCOE than combined-cycle gas.

What about solar combined with battery storage?

Building solar PC + Lithium-ion battery storage at the same site saves 8% in capital cost.

Solar + Storage



Solar + Storage PPA

PPA = Power Purchase Agreement

Prices have been as low as 4¢ per kilowatt hour.

How is this possible when storage by itself costs more? For the explanation, see:

[Battery storage at US\\$20/MWh? Breaking down low-cost solar-plus-storage PPAs in the USA - Energy Storage News \(energy-storage.news\)](#)

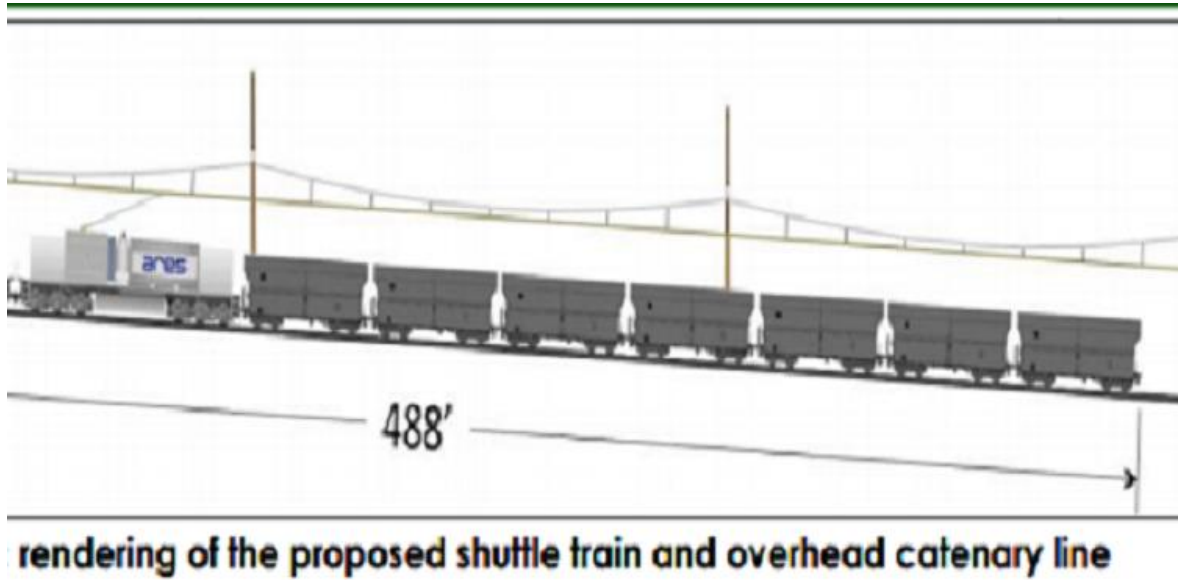
Thermal Energy Storage

Stores heat that can be used to generate electricity

Examples:

- heated bricks or concrete blocks, used to make steam to run a turbine generator;
- molten salt;
- ice tanks for air conditioning

Gravity storage



Examples of gravity storage

- Concrete blocks: raised and lowered by crane
- Loaded railroad cars running downhill with generative brakes
- Underground pumped water storage

In short, there are lots of storage technologies out there!

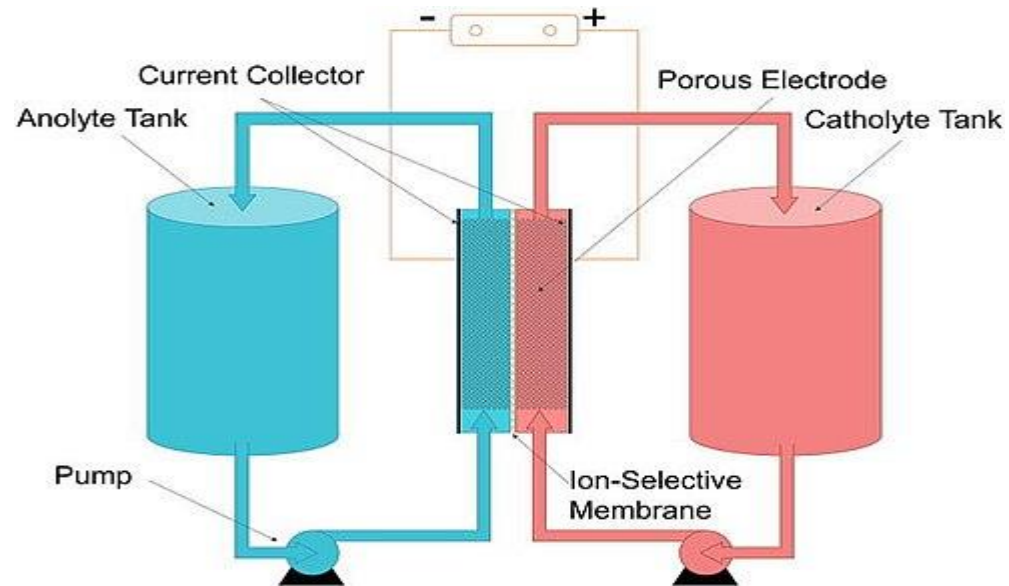
Long duration energy storage (LDES)

100+ hours, for times when the wind is still or skies cloudy for days on end.

U.S. Department of Energy goal: reduce price 90% by 2030.

Examples:

- Iron-air batteries
- Flow batteries
- Liquid air
- Concrete blocks



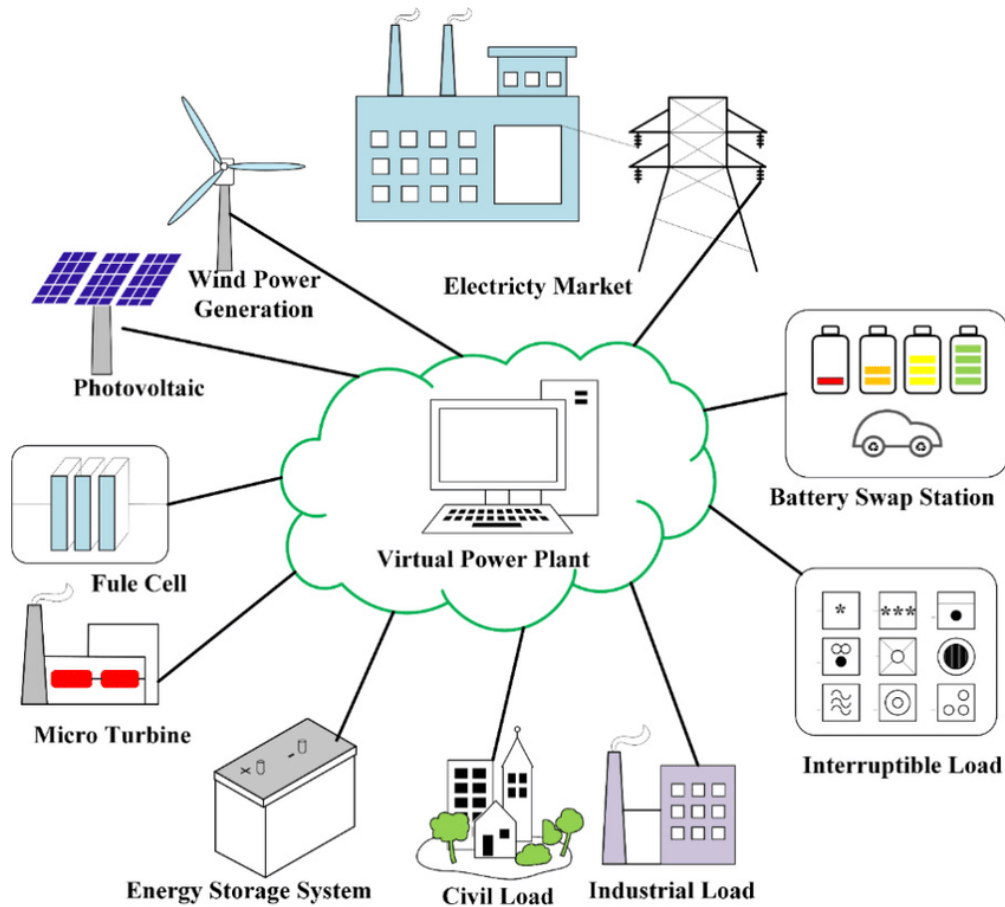
Demand Management

Smoothing out the peaks and valleys of intermittent generation by reducing demand, especially peak demand.

Example: Time-of-Use rates

- Offer customers the incentive of lower rates for using energy in off-peak hours.
- Especially important with more electric vehicles. Owners need to recharge overnight, not during evening or daytime peaks.

Virtual Power Plant



- Aggregate rooftop solar, storage batteries, EV batteries, voluntary load reductions.
- Can be dispatched to grid, earning money on the wholesale market.