Grid Scale Battery Storage

An Anecdotal Review

Robert Lyman 5/30/20

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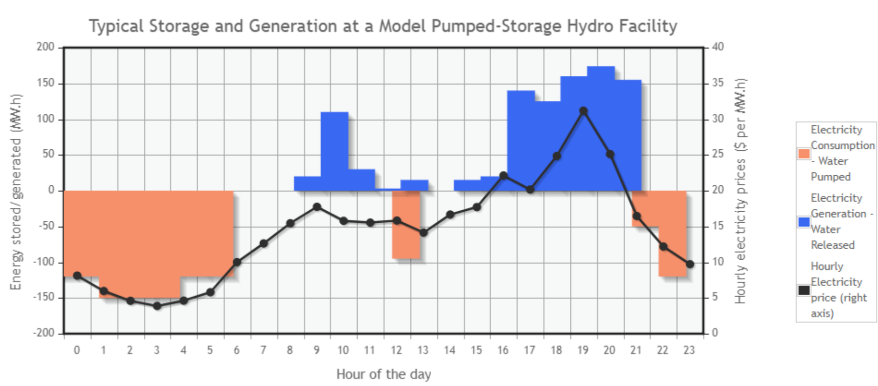
GRID-SCALE BATTERY STORAGE – AN ANECDOTAL REVIEW

One of the central claims of those who advocate “decarbonization” of the world’s economy is that in the medium-term future (i.e. by 2050) all energy services can be electrified and that the electricity generation sources can be converted from fossil fuels (mainly coal and natural gas) to renewable energy sources like wind and solar energy. Wind and solar energy, however, are intermittent sources of supply, whose production varies with the time of day and season and not in ways that match consumer demands. When skeptics point this out, the answer decarbonization advocates usually give is that new grid-scale electricity storage systems will be installed to assure security and reliability of supply. The availability and affordability of grid-scale electricity storage is stated as an article of faith, not to be challenged.

This article is intended only to offer some anecdotal evidence that takes issue with “assured storage” thesis. I leave it to those far more expert than I to explore all the technical issues.

THE PRESENT SITUATION

Storing electricity is expensive and energy intensive. The main technology used for grid-scale storage currently is “pumped hydro”, which involves pumping water to an elevated reservoir to be used to drive a turbine when electricity is needed. Canada’s only pumped hydro facility is Ontario Hydro’s Sir Adam Beck Pump Generating Station. This 174-megawatt facility pumps water from the Niagara River into a 300-hectare reservoir for energy storage. The energy required for the pumping in some cases exceeds the power ultimately generated.



Canada’s only PSH facility is Ontario Power Generation’s Sir Adam Beck Pump Generating Station. This 174 megawatt facility pumps water from the Niagara River into a 300 hectare reservoir for energy *storage. This storage capacity is greater than what currently exists in all of Canada's newer, emerging storage technologies, such as batteries.*

The United States (U.S.) has over 30 PSH facilities with a combined capacity of 22 gigawatts. U.S. facilities generate around 23 000 gigawatt hours (GW.h) per year, and consume 29 000 GW.h to operate their pumps. Despite this net loss of energy, the grid reliability provided by PSH facilities and the ability to generate when demand is strong is highly beneficial and will become increasingly important as Canada and the U.S. integrate more renewable power into their grids.

Source: https://www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/snpsht/2016/10-03pmpdstrghdr-eng.html

Globally, there are a very limited number of geographic locations suitable for construction of pumped storage facilities,[1] and projects of this kind often face public challenges due to alleged environmental effects similar to hydro dams.

This is why many environmentalists see the solution as battery storage. Euan Mearns, a geochemist and energy writer, refers to battery storage as "the Holy Grail", the technology fix that will allow wind and solar energy sources to hold larger and larger shares of a utility's generation mix. Tesla, working with extensive subsidies from U.S. federal and state governments, has been marketing battery storage in different sizes up to grid-scale. The media greets every announcement of even small developments relating to battery storage as though a historic breakthrough had occurred.

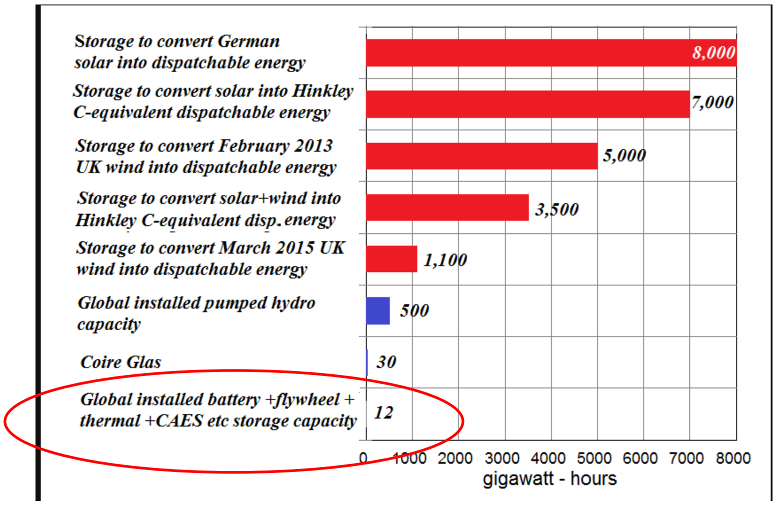
> *A recent Telegraph article claims that storage battery technology is now advancing so fast that "we may never again need to build 20th Century power plants in this country, let alone a nuclear white elephant such as Hinkley Point" and that the "Holy Grail of energy policy" that will make this solution economically feasible – a storage battery cost of $100/kWh – will be reached in "relatively short order". This brief post shines the cold light of reality on these claims by calculating battery storage costs based on the storage requirements for specific cases estimated in previous Energy Matters posts. It is found that installing enough battery storage to convert intermittent wind/solar generation into long-term baseload generation increases total capital costs generally by factors of three or more for wind and by factors of ten or more for solar, even at $100/kWh. Clearly the Holy Grail of energy policy is still a long way off.*
>
> ***First a simple calculation. $100/kWh = $100,000/MWh = $100 million/GWh = $100 billion/TWh….** (Note that all the costs listed in this post are in US dollars unless otherwise specified).*
> ***Source:*** http://euanmearns.com/the-holy-grail-of-battery-storage/

[1] https://www.greentechmedia.com/articles/read/why-norway-cant-become-europes-battery-pack

THE PROBLEMS OF SCALE

Roger Andrews, writing in the blog Energy Matters,[2] stated that:

"installed world battery +CAES+flywheel+thermal+other storage capacity amounts to about 12 GWh, enough to fill global electricity demand for all of fifteen seconds. Total global storage capacity with pumped hydro added works out to only about 500 GWh, enough to fill global electricity demand for all of ten minutes".



Steve Goreham, a frequent commentator on energy and climate issues, wrote in 2019[3] that:

"Pumped storage provides about 97% of grid power storage in the United States today. But less than one in every 100,000 watts of US electricity comes from pumped storage. In 2018, US power plants generated 4.2 million GH-hours of electrical power. Pumped storage capacity totaled about 23 GW-hours. Battery storage provided only about 1 GW-hour of capacity. Less than one-millionth of our electricity is stored in grid-scale batteries."

Mark Mills, in his article, "*The Math Behind the New Energy Economy*",[4] wrote:

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[2] Roger Andrews, *The cost of wind and solar, batteries included*, Energy Matters, November 22, 2018

[3] Steve Goreman, *An Infinitesimally Small Part of Electrical Power*, Wattsupwiththat essay, June 29, 2019

[4] Mark Mills, *Inconvenient Energy Realities*, Economics 21, July 1,2019

"For security and reliability, an average of two months of national demand for hydrocarbons are in storage at any time. Today, barely two hours of national electricity demand can be stored in all utility-scale batteries plus all batteries in one million electric cars in America.

Batteries produced annually by the Tesla Gigafactory (world's biggest battery factory) can store three minutes' worth of annual U.S. electricity demand.

To make enough batteries to store two days' worth of U.S. electricity demand would require 1,000 years of production by the Gigafactory."

In short, based on the anecdotal evidence, there is an immense gap between the currently available grid-scale battery storage and the amount that would be needed to provide secure electricity supply needed to avoid the likelihood of significant and repeated electricity brownouts and blackouts.

THE COST OF BATTERY STORAGE

So, with current technology, what would it cost to partially fill that gap?

The current costs of grid-scale battery storage fall into a range.

The U.S. Energy Information Administration, in a May, 2018 report,[5] estimated that the total installed cost of large scale battery storage in the U.S. varied by the duration of the storage required. The median cost for medium duration (undefined) storage was about U.S. $1,100 per kilowatt-hour (kWh) and that for long duration (also undefined) batteries was about U.S. $650 per kWh.

Between 2014 and 2016, the largest battery storage facilities with energy storage capacities of less than 10 MWh were built in Germany at costs of about 1,000 Euros (Cdn $1,500) per kWh. In August, 2017, a 16 MWh plant was inaugurated in Germany at a cost of 10 million Euros, which corresponds to 625 Euros (Cdn $938) per kWh. Larger modular units reportedly are being built at a cost of 1,000 Euros (Cdn $1,500) per kWh. At 1,000 Euros per kWh, the cost of storing one terawatt hour would be one trillion Euros. To deal with a 10-day

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[5] *U.S. Battery Storage Market Trends*, Energy Information Administration, May 21, 2018

lull in the wind in winter in Germany, when sunlight levels are low, batteries would be needed to store 16 TWh.

In a recent Friends of Science article on decarbonization ("Shocking Reality: Electrification and Decarbonization"), a Canadian industry power generation expert was quoted in describing how much battery power Alberta would need on one winter day:

"*How much storage would we need to replace all our thermal generation? On February 4, 2019, we would have needed to replace 225,000 MWh. Given that storage is only about 90% efficient, we would need to install 250,000 MWh. In addition, the system would need to be sized to cover the peak thermal production of 9,800 MW.*

How much would all this storage cost? Recent estimates for utility-scale storage show battery costs of around Cdn $650 for the system plus Cdn $250/kWh for the actual batteries. The cost to provide enough storage for one cold winter day in Alberta would be $69 billion. Unfortunately, this wouldn't be nearly enough. We would need weeks, if not months, of storage to maintain a reliable grid. The costs would be in the hundreds of billions, if not trillions, of dollars."

So, the costs of the energy storage alone (i.e. not counting the costs of replacing coal and gas-fired generation with more expensive wind and solar generation) are much, much higher than staying with the present systems in most of North America. The costs are so high that, if added to residential, commercial and industrial electricity's bills, they would drive most economic activity to jurisdictions outside of the one that imposed such costs.

CONCLUSIONS

The current scale of battery storage is several orders of magnitude below that which would be required to assure security of electricity supply in a decarbonized electricity grid, even without the electrification of all economic sectors that decarbonization advocates foresee.

The cost of current battery technology is also far too high for any but exceptional uses. Jurisdictions that impose such costs on their utilities and electricity ratepayers will face severe economic consequences.

Energy and climate policies should be based on facts, not fantasies.

About the Author

Robert Lyman is a former public servant of 27 years and a diplomat for 10 years. Lyman's bio can be read [here.]

About Friends of Science Society

Friends of Science Society is an independent group of earth, atmospheric and solar scientists, engineers, and citizens that is celebrating its 18th year of offering climate science insights. After a thorough review of a broad spectrum of literature on climate change, Friends of Science Society has concluded that the sun is the main driver of climate change, not carbon dioxide (CO_2).

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