A Place for More: Three Ways to Store and Scale Renewable Energy

ENERGY INNOVATION REPORT

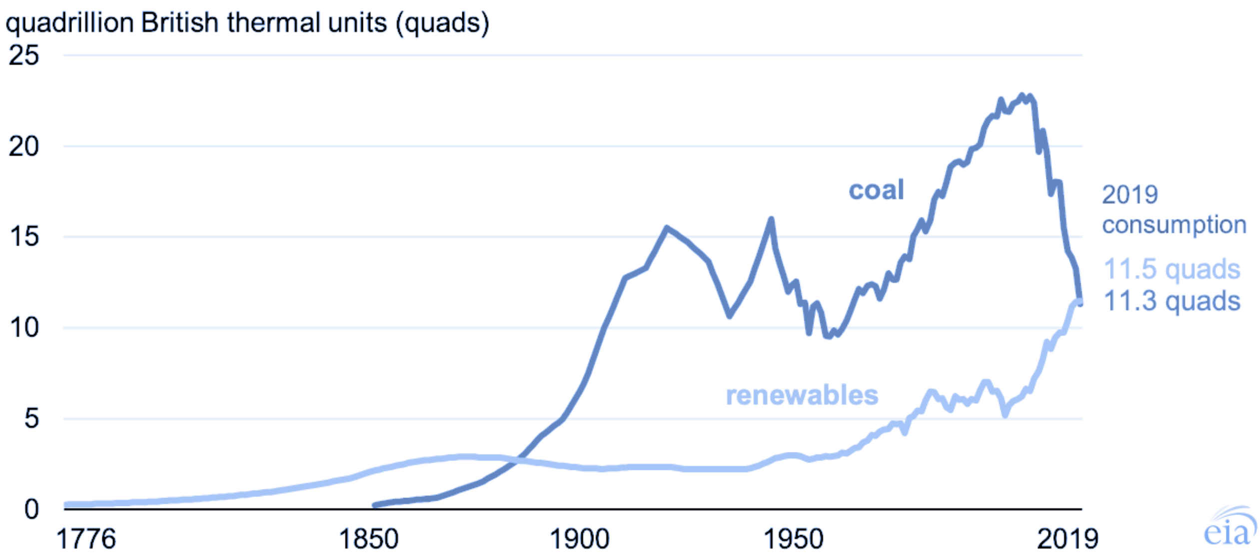
ENERGY IMPACT CENTER

Powering the world today

2020 was a unique year for energy and the COVID-19 Pandemic continues to place some uncertainty on what the future of energy looks like. Not only did global energy consumption decrease, but the International Energy Agency (IEA) estimates showed the same trend for energy demand, energy-related CO_2 emissions, and energy investment.[1] This shift may seem like a win for the climate community, but the data is misleading. Dr. Fatih Birol, IEA Executive Director, stated “Despite a record drop in global emissions this year, the world is far from doing enough to put them into decisive decline.”[2] To holistically address the emissions equation, we must consider the sources of our energy and electricity.

In 2019, annual energy consumption from renewable sources in the United States exceeded coal consumption for the first time since 1885 (Figure 1).[3] This drop globally is associated with competition from cheaper, gas-fired power generation and some renewable sources as well. Renewable energy is at the forefront in addressing global energy challenges; however, the key issue of energy storage limits how effective this solution can be.

Figure 1. U.S. Energy Consumption from Coal and Renewables (1776-2019)



Source: U.S. Energy Information Administration, Monthly Energy Review

The Main Challenge of Renewable Energy

Intermittency is at the root of the problem with renewable energy. This means, when it is not windy or sunny, wind and solar power are unreliable, causing a lack of access to power.[4] As a result, communities tend to over develop renewable energy capacity which increases costs and introduces its own set of issues to the energy grid.

This intermittency is not sustainable and scalable for society's needs. The time of demand (nighttime) is often the opposite of the peak power production (daytime). The solution to this challenge is to couple renewable energy production with various methods for energy storage.

Storage Examples

Batteries

Over the last several years, breakthroughs in battery technology have made them a viable option for renewable energy storage. Prices for lithium-ion batteries have dropped 76% since 2012.[5]

Companies like Tesla, LG Chem, and BYD Auto have developed massive production facilities for lithium-ion batteries with an 80% storage capacity. These batteries are mostly used for electric vehicles, but can also be used to power homes, businesses, and utility-scale systems.[6] In 2017, Tesla installed a 100 gigawatt-hour power pack system in Australia, the Hornsdale Power Reserve near Adelaide, and recovered one-third of its costs in its first year of production. It is expected that these costs will continue to lower as more plants are built.[7]

Once batteries have run their optimal use in electric vehicles, they can then be repurposed for grid storage for an additional 20-30 years. Grid storage is also predicted to go down in cost which would cause battery systems to come close to cost parity with gas peaker plants.[8]

Another option is the redox flow battery. These batteries have a liquid anode and cathode (a container of positively charged and a container of negatively charged liquid) that flow together through oxidation into a fuel cell and create electricity. In charging the battery, the electricity in the fuel cell feeds ions into the separate solutions. To make these bigger, all one would have to do is add more solution or fuel cells to produce more power. They also operate at a 95% efficiency rate. The main downside, however, is that inside the redox flow batteries solutions is an element called Vanadium. This is a scarce element in the world and would cause hurdles in the scalability of this renewable energy storage source.[9]

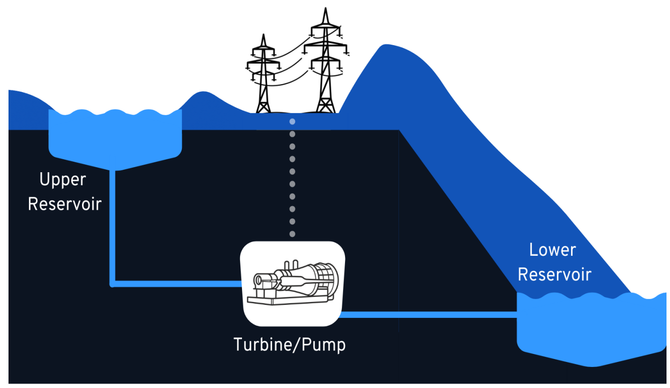
Pumped Hydropower

Even though batteries have grown in popularity and usage, the most common method of renewable energy storage is pumped-storage hydropower. It accounts for 96% of energy storage worldwide.[10]

Hydropower is produced by creating a dam on a natural source of flowing water. The dam creates pressure from the built-up water and when the water is eventually released, it turns turbines that produce energy.

Pumped hydropower uses two reservoirs, one at a higher elevation and one at a lower elevation, with a pipeline connecting the two (Figure 2). When there is excess energy, such as solar power during the day, that energy is used to pump water from the lower reservoir to the upper reservoir, which stores a mass of that water as potential energy. When extra energy is needed at night, when solar power is no longer available, the water is released from the upper reservoir to the lower reservoir. This causes the facility's turbines to turn and produce energy.[11]

Figure 2. Pumped Hydropower Storage System



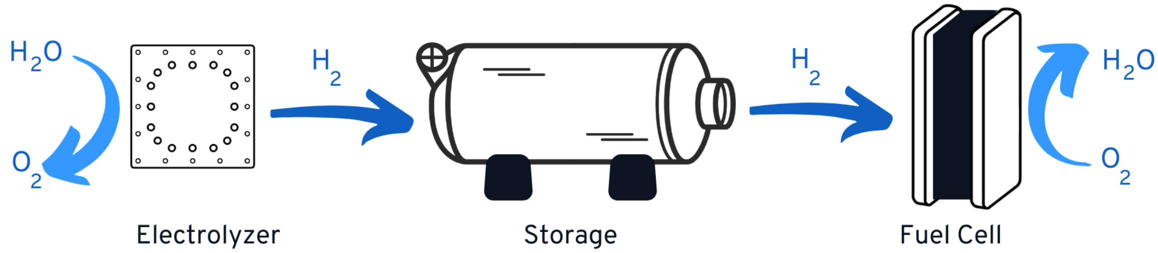
There are already 69 pumped hydropower facilities worldwide that have more than one gigawatt hour of capacity with 37 more being built by 2025. To put that figure into perspective, the world's total hydropower capacity was 1,308 gigawatts and 16% of global electricity production in 2019, including 158 gigawatts of pumped storage.[12]

There are two major obstacles to the broader adoption of pumped hydropower storage. It does require a mountainous terrain (two reservoirs at different elevations) and a large initial investment due to steep construction costs. However, if these are met, these facilities could potentially be worth their cost because they have the ability to operate for decades at nearly 80% efficiency.[13]

Hydrogen Energy Storage

Hydrogen energy storage is the process by which hydrogen is taken out of water through electrolysis and stored in high-pressure storage facilities. To produce electricity, this hydrogen is then passed through a fuel cell (Figure 3).[14]

Figure 3. Hydrogen Production, Storage, and Transformation Cycle



Hydrogen energy has the potential for high scalability. Compressed hydrogen can be stored in a multitude of different sizes of pressurized vessels that have the capacity to power cars or entire cities.

This energy can also be stored in solid metal hydrides or nanotubes to compress even more energy to an even smaller space. Depending on the storage vessels, there is the potential for the hydrogen energy to be stored in underutilized spaces with huge capacities like underground caverns, depleted aquifers, and abandoned mines. A 500,000 cubic meter cavern can hold around 100 gigawatts of stored energy.[15]

For example, the Chevron Phillips Clemens Terminal in Texas has 30,000,000 cubic meters of storage and could therefore hold 6,000 gigawatts of stored energy.[16]

Although there is great potential for massive scale, hydrogen energy storage does not have a very high overall process efficiency when compared to other storage methods.

Conclusion

Aside from 2020 being an outlier year, all indicators show that global temperatures are still on the rise. According to the IEA, the world needs 266 gigawatt hours of storage by 2030 in order to keep global warming below the 2°C tipping point.[17] The examples mentioned above offer ways to increase the storage capacity of renewable energy, but these options, along with others, must be implemented much faster to not only slow climate change, but to hopefully reverse it.

Endnotes

Further information, references, and hyperlinks

1. IEA (2020). *World Energy Outlook 2020.* IEA. https://www.iea.org/reports/world-energy-outlook-2020.
2. Ibid.
3. U.S. Energy Information Administration. (2020, May 28). *U.S. renewable energy consumption surpasses coal for the first time in over 130 years.* Today in Energy. www.eia.gov/todayinenergy/detail.php.
4. Fares, R. (2015, March 11). *Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities*. Scientific American. www.blogs.scientificamerican.com/plugged-in/renewable-energy-intermittency-explained-challenges-solutions-and-opportunities/.
5. Scott, J. (2019, December 16). *7 Ways To Store Renewable Energy*. Youtube. www.youtube.com/watch?v=kAB3-IzxvkE.
6. Scott, J. (2019). *7 Ways to Store Renewable Energy.*
7. Thornhill, J. (2020, February 27). *Two Years On, Elon Musk's Big Battery Bet Is Paying Off in Australia.* Bloomberg. www.bloomberg.com/news/articles/2020-02-28/two-years-on-musk-s-big-battery-bet-is-paying-off-in-australia.
8. U.S. Energy Information Administration (2020). *U.S. renewable energy… 130 years.*
9. Scott, J. *7 Ways to Store Renewable Energy.*
10. Ibid.
11. Ibid.
12. Ibid.
13. Ibid.
14. Ibid.
15. Ibid.
16. Ibid.
17. IEA (2020). *World Energy Outlook 2020.*

energyimpactcenter.org

ENERGY IMPACT CENTER