P-14889 Pump Storage Hydro Fact Sheet

1. Until the mid-1980s energy storage was viewed by the electric utilities as a means to time shift energy produced by coal and nuclear units during off-peak hours to displace energy that would be produced from other more expensive fuels during on-peak periods. Since then, the re-introduction of no-brake flywheel generators and introduction of new applications for chemical batteries has forever changed the way energy storage is now used.

2. U.S. DOE/EPRI Electricity Storage Handbook (2013) describes eighteen services and applications in five umbrella groups, as listed below. The services and applications identified below show that energy storage can be used to support generation, transmission, and distribution, as well as customer-side-of-the-meter needs of the grid.

Bulk Energy Services
Electric Energy Time-Shift (Arbitrage)
Electric Supply Capacity
Ancillary Services
Regulation
Spinning, Non-Spinning and Supplemental Reserves
Voltage Support
Black Start
Other Related Uses

Transmission Infrastructure Services
Transmission Upgrade Deferral
Transmission Congestion Relief
Distribution Infrastructure Services
Distribution Upgrade Deferral
Voltage Support
Customer Energy Management Services
Power Quality
Power Reliability
Retail Electric Energy Time-Shift
Demand Charge Management

3. New pump storage hydro (PSH) makes economic sense for certain applications like energy management, backup and seasonal reserves, and regulation service if equipped with variable speed pumps. This point is sometimes overlooked given the emphasis on mandates, subsidies for some storage projects, and noneconomic or tough-to-measure economic rationales for storage (such as resilience and insurance against power outages).

4. It is commercially viable to use PSH to augment power management and frequency regulation. PSH and power monitoring software have combined to be an alternative method of providing spinning reserve or curtailment which could improve the efficiency of infrastructure and reduce greenhouse gas emissions caused by wasteful excess capacity and lowered heat-rates associated with excessive plant cycling.

5. PSH can reduce the need for major new transmission grid construction upgrades as well as augment the performance of existing transmission and distribution assets. DOE estimates that 70% of transmission lines are 25 years or older, 70% of power transformers are 25 years or older, and 60% of circuit breakers are more than 30 years old. Extending the capability of the transmission grid—for example by pre-positioning

storage on the load side of transmission constraint points—makes the grid more secure, reliable, and responsive. Additionally, distributed storage can reduce line-congestion and line-loss by moving electricity at off-peak times, reducing the need for overall generation during peak times. By reducing peak loading (and overloading) of transmission and distribution lines, storage can extend the life of existing infrastructure.

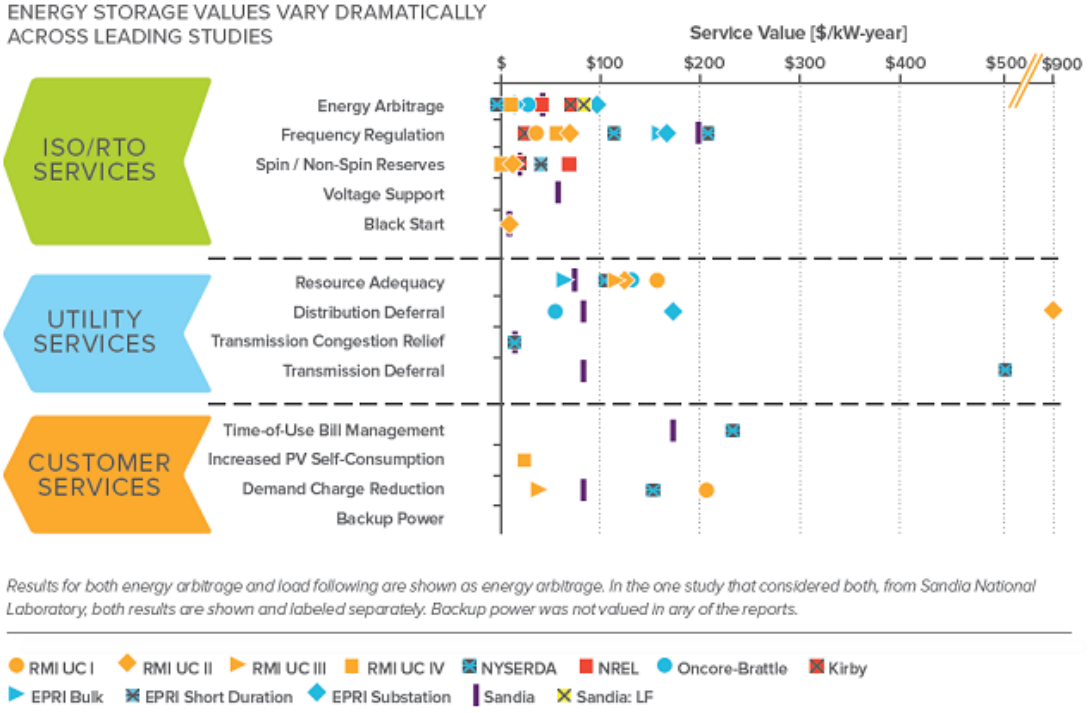
6. As the U.S. moves towards the electrification of the transportation sector, energy storage for vehicles, and the integration of energy between vehicles and the grid, will be critical.

7. Healthy margins are likely to accrue to companies like FreedomWorks that make use of grid based energy storage and load-profile data. The unique characteristics of individual customers will favor tailored approaches, including the development of algorithms that find and extract the greatest value. Strong customer relationships are required to access relevant data and to deliver the most economical solution as regulations and technologies evolve.

8. How to use storage to reduce system-wide costs will require some thought by regulators. Examples include new FERC Rule 841, price signals that are correlated with significant deviations in power generation and consumption, rules that reward the provision of storage to serve multiple sites in close proximity, and tariffs that favor self consumption (or load shifting) of renewable electricity.

9. Rocky Mountain Institute analysis shows the following ISO/RTO service category values assigned by various studies. Energy arbitrage, frequency regulation, spinning reserves, voltage support and black start all have values to the ISOs and RTOs.

FIGURE ES1
ENERGY STORAGE VALUES VARY DRAMATICALLY ACROSS LEADING STUDIES



Results for both energy arbitrage and load following are shown as energy arbitrage. In the one study that considered both, from Sandia National Laboratory, both results are shown and labeled separately. Backup power was not valued in any of the reports.

10. The most important implication is this: the large-scale deployment of energy storage could overturn business as usual for many electricity markets. In the U.S., central or bulk generation traditionally has been used to satisfy instantaneous demand, with ancillary services helping to smooth out discrepancies between generation and load. Energy storage is certainly well suited to provide such ancillary services. However, it can also provide more and more power to the grid, displacing plants. Energy storage has the potential to upend the industry structures, both physical and economic, that have defined power markets for the last century.

11. A climate paradox exists for long-term use of natural gas to firm high penetrations of renewable energy. The climate paradox is that as system-average emissions fall, the climate benefit of each new gas-fired generation plant falls. Because, although emissions from NG are 60% less than coal, they are still significant at ~875 lbs/MWh (~400 kg/MWh). So, as each NG and renewable energy plant replaces a shuttered coal plant, each new NG plant displaces fewer and fewer GHG emissions, until eventually U.S. power sector emissions begin to increase once again. Last year, U.S. power system-wide average GHG emissions declined to 992 lbs/MWh (~450 kg/MWh); only 15% more than the emission intensity of natural gas. If the U.S. power market continues on the current ~50/50 renewable energy-to-natural gas generation trend line for new power generation, NG will begin to increase U.S. GHG emissions in less than 10 years. As a result, PSH provides a cost effective viable alternative to NG, and an indispensable low-emission resource type, to firm renewable energy beyond 30% penetration on the grid.

12. Currently, there are 188 Wind Farms and roughly 175,000 solar installations in PJM and MISO seam areas. In 2018, the average wind power available in any hour in PJM, alone, is a maximum of 4700 MWs and minimum 2100 MWs. This data does not include wind energy available in MISO seam areas. PJM anticipates between new 4400 and 6700 additional MWs of wind in PJM and an additional new 8400 MWs in MISO, will come on-line by 2025. PJM recently estimated 83 hours/11,200 GWh annual of 100%RE supplied energy storage would enable reduction of nearly 900 Mt CO2e in annual GHG emissions.

13. In 2015, 3.12 GWs of new 100%RE-offset corporate PPAs were signed. In 2016, 7,900 GWh of RE was consumed by corporate PPAs in 210 agreements. In 2017, an additional an additional 15,500 GWh of corporate PPAs were signed. In 2018, a record 5 GWs of new 100%RE-offset corporate PPAs were signed. Rocky Mountain Institute anticipates an additional 70,000 GWh of 100%RE-offset corporate PPAs will be signed before 2020.

Additional reading:

A. https://thinkprogress.org/renewable-energy-lowers-carbon-emissions-eace037beec6/
B. https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage
C. https://www.energy.gov/sites/prod/files/2014/09/f18/Grid%20Energy%20Storage%20December%202013.pdf
D. https://www.rmi.org/wp-content/uploads/2017/03/RMI-TheEconomicsOfBatteryEnergyStorage-FullReport-FINAL.pdf
E. https://www.hydro.org/wp-content/uploads/2017/08/NHA_PumpedStorage_071212b1.pdf
F. http://www.irena.org/publications/2015/Jun/Renewables-and-Electricity-Storage
G. http://www.irena.org/publications/2018/Jan/Renewable-power-generation-costs-in-2017
H. http://mailchi.mp/322807f12e95/north-dakota-overtakes-denmark-in-use-of-wind-energy-wind-passes-natural-gas-in-system-wide-ghg-reductions-offshore-wind-developments-and-more