ENERGY STORAGE: CAN WE GET IT RIGHT?

*David Schmitt and Glenn M. Sanford**

Synopsis: Widespread adoption of energy storage has been described as the "Holy Grail" for the electricity sector because, among many of its benefits, it would allow the temporal transmission of electricity - something that has never happened before at a large scale. However, energy storage can only make such a transformative impact to the industry if proper policies are in place. This article will explore what energy storage is, the different energy storage technologies, the benefits of energy storage, the issues preventing the deployment of energy storage, and some potential paths forward. Chief among these issues are: (1) how to classify energy storage; and (2) how to value energy storage. The effects of possible answers to these two questions on other important issues facing energy storage, including transmission planning/cost allocation, jurisdiction, interconnection, double counting/double recovery, and environmental concerns, are also discussed.

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I. INTRODUCTION

Energy storage has been called the "Holy Grail" for a clean energy future.[1] It has the "potential to play a large role in the electricity system, especially as the grid ages and new infrastructure is required to maintain reliability."[2] Due in part to falling costs of energy storage technology and technological advances, there have been many advances in grid-deployed energy storage resources.[3] Many of these resources have moved into the commercialization phase of technology deployment.[4] If these technologies are widely adopted they will alter the current landscape of the electric system. Utilities are approaching energy storage as a continuation of the research and development work that they are already doing with renewables.[5] Furthermore, energy storage has "the potential to substantially ease the transition between our current centralized generation system and a mass

1. Tam Hunt, *Is an Energy Storage Tsunami About to Hit California?*, GREENTECH MEDIA, (May 5, 2014), https://www.greentechmedia.com/articles/read/is-an-energy-storage-tsunami-about-to-wash-over-california#gs.z8dnrrs (last visited May 13, 2018).

2. Dhruv Bhatnagar et al., *Market and Policy Barriers To Energy Storage Deployment: A Study for the Energy Storage Systems Program*, Sandia Report SAND2013-7606, SANDIA NAT'L LAB. 13 (Sept. 2013), https://www.sandia.gov/ess-ssl/publications/SAND2013-7606.pdf [hereinafter Market and Policy Barriers].

3. Andrew H. Meyer, *Federal Regulatory Barriers to Grid-Deployed Energy Storage*, 39 COLUM. J. ENVTL. L. 479, 480 (2014); *see also* NATIONAL HYDROPOWER ASS'N, COMMENTS OF THE NATIONAL HYDROPOWER ASSOCIATION ON THE NOVEMBER 9, 2016 TECHNICAL CONFERENCE (2016), https://www.hydro.org/wp-content/uploads/2017/08/NHA-Comments-on-November-9-2016-Technical-Conference.pdf [hereinafter Technical Conference]; *see also* Jeff McMahon, *In 5 Years, Batteries Will Blanket The U.S., Duke Executive Says*, FORBES (Oct. 22, 2017), https://www.forbes.com/sites/jeffmcmahon/2017/10/22/in-5-years-batteries-will-blanket-the-u-s-duke-executive-says/#143840206f9f (last visited Oct. 22, 2017). The price for lithium batteries for energy storage has dropped at rapid pace. It has dropped from $800 kw/hr. in 2012 to $216 Kw/hr. in 2016. The projected price decrease will continue to decrease at 9% per year. This price decline has been driven in part due to the electric car industry. The price is only projected to drop further at ever increasing rate as energy storage becomes a more mature technology. Roger Lueken et al., *Getting to 50 GW? The Role of FERC Order 841, RTOs, States, and Utilities in Unlocking Storage's Potential*, BRATTLE GRP. 3 (Feb. 28, 2018); *see also* Kerinia Cusick, *Energy Storage Misconceptions*, CENTER FOR RENEWABLES INTEGRATION 1-4 (2016) (noting that the quick decline in energy storage is due in part because of the rise of the electric car, whose growth will only continue to grow. Used electric car batteries could have a second life as grid batteries).

4. Meyer, *supra* note 3, at 480.

5. Herman K. Trabish, *Where is the U.S. Energy Storage Market Going?*, UTILITY DIVE, (Mar. 10, 2015), http://www.utilitydive.com/news/where-is-the-us-energy-storage-market-going/373479/.

distributed generation future."[6] In sum, interest in energy storage is increasing because: (1) energy "storage technologies are demonstrating increasing performance and reliability at lower costs"; (2) stakeholders are increasingly aware of the benefits that energy storage can provide; and (3) new installations are proving that energy storage can fulfill multiple needs on the grid.[7]

The electric sector is seeing numerous changes, including the growing adoption of electric transportation and the ever-increasing amount of renewable energy penetrating the grid.[8] These changes in the electric power grid are causing it to "quickly evolve into a smarter, more sophisticated delivery system that incorporates new renewable, distributed generation, end-use, and communications and control systems."[9] "These changes will provide many benefits, such as the ability to respond to public policy goals," increased "diversity of generation options," and increased consumer choice, but these changes will also present several distinct challenges that energy storage can help to alleviate.[10] These challenges, which properly implemented storage will help address, include the following: (1) increasing consumer demand for reliable, affordable, renewable power options; (2) speed of investment and deployment of variable generation; (3) ancillary services needs resulting from the fact that distributed energy resources (such as storage) create bidirectional power flow that taxes distribution systems which are reliant upon voltage regulation and protection schemes that were designed for one-way power flow; (4) "[s]mart grid designs call for additional distribution automation and sophistication, such as islanding and self-healing designs aimed at improving user reliability"; (5) "limited transmission capacity can force resources to be curtailed during their time of peak production, while the expansion of new transmission capacity poses regulatory and environmental challenges"; (6) utilities are seeking new ways to extend their capital assets and defer the costs associated with upgrades; and (7) "[u]nlike natural gas or fuel oil, electricity cannot be easily stored."[11]

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6. Heather Payne, *A Tale of Two Solar Installations: How Electricity Regulations Impact Distributed Generation,* 38 U. HAW. L. REV. 135, 179 (2016).

7. Tom Stanton, *Envisioning State Regulatory Roles in the Provision of Energy Storage*, NAT'L REGULATORY RESEARCH INST. 2 (2014) [hereinafter NRRI Energy Storage].

8. Victoria Johnston, *Storage Portfolio Standards: Incentivizing Green Energy Storage*, 20 J. ENVTL. & SUSTAINABILITY L. 26, 27 (2014); *see also* Peter Maloney, *Brattle: Wider Electrification Key to Averting Both Climate Change and Utility Death Spiral,* UTILITY DIVE, (May 24, 2017), http://www.utilitydive.com/news/brattle-wider-electrification-key-to-averting-both-climate-change-and-util/443369/.

9. ELECTRIC POWER RESEARCH INST, FUNCTIONAL REQUIREMENTS FOR ELECTRIC ENERGY STORAGE APPLICATIONS ON THE POWER SYSTEM GRID 1-1 (Nov. 9, 2011) [hereinafter *EPRI Functional Requirements*].

10. *Id*.

11. *Id*.; Lisa Wood, *Thought Leaders Speak Out: Key Trends Driving Change in the Electric Power Industry*, INST. FOR ELEC. INNOVATION, June 2016, at 3. Renewable energy share of electricity generation grew an estimated 14.1% year-on-year in 2017. This represents the largest one-year surge of the share of electricity generated by renewable energy. It has also been the dominated type of generation being built by accounting as 55% of all built out generation for a ten-year period between 2008-2010 (this also includes hydroelectric generation). In fact, from the years of 2014 through 2017, solar and wind alone counted as the majority of U.S. generation capacity that was built. BLOOMBERG NEW ENERGY FIN., 2018 SUSTAINABLE ENERGY IN AMERICA FACTBOOK, 21-23 (2018). Variable generation (i.e. either intermittent or renewable generation) refers to generation that is not controllable (dispatchable) and will vary its output due to external factors (cloud cover, low wind speed, etc.). For example, variability in solar photovoltaic and wind power output change their power output due

The electric power industry, as one of the world's most consequential and complex systems, shares a common characteristic with all other complex systems.[12] Complex systems do not have a linear progression of change, but tend to flip from one paradigm to another (this has been analogized to a phase change in material science, e.g. from solid to liquid, because they are quite instantaneous).[13] When one of these "economic phase changes" happens, it leaves vast and long lasting effects on the economy and society as a whole.[14] The energy sector has experienced these phase changes several times before, and storage could be the next key phase change.[15] Energy storage has the potential to be a phase change because it allows things to happen that were previously deemed impossible: transporting energy temporally from when it is produced to when it is needed and facilitating bi-directional flow of electricity.[16] In doing so, it would improve grid reliability and resilience, allow greater integration of renewables, and address peak demand with less overall generation capacity.[17]

While falling costs are an important factor in the economic case for energy storage, regulatory barriers and market structures may be tipping the cost-benefit scale against realizing the full potential of energy storage as a solution for today's grid problems.[18] When regulations forbid (or markets do not allow the monetization of) beneficial storage services, investment decisions are skewed away from

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to various factors and this "can lead to ramping events and unpredictable load management at the system level." These variations whether or not they are short-term (mere seconds) or longer-term (minutes) duration may create the need for additional regulation and ramping support at the system level (i.e. ancillary services). Furthermore, when excess generation is produced it is essentially wasted at this time. This has been a criticism of renewable generation and is one of the key reasons why energy storage is starting to attract interest from various stakeholders. EPRI Functional Requirements, *supra* note 9; *see also* ENERGY DIGITAL, WHY BETTER ENERGY STORAGE MATTERS (Mar. 9, 2015), http://www.energydigital.com/renewables/3746/Why-Better-Energy-Storage-Matters [hereinafter ENERGY DIGITAL]; *see also* Paul Gardner, *Who Should Be Responsible For Reliability And Resilience?*, ENERGY IN TRANSITION (Mar. 4, 2016), http://blogs.dnvgl.com/energy/who-should-be-responsible-for-reliability-and-resilience. A large increase in the increase of renewable generation can be traced to various States' Renewable Portfolio Standards (RPS). An RPS requires "that a specified minimum fraction of the electricity supplied in a state be generated from renewable energy sources, will likely result in substantial increases in the penetration of these sources on the grid in the coming 10-20 years." *See also* Stan Mark Kaplan, *Electric Power Transmission: Background and Policy Issues*, CONG. RESEARCH SERV., 1 (Apr. 14, 2009).

12. Michael Liebreich & Angus McCrone, *Electric Vehicles, It's Not Just About The Car*, BLOOMBERG NEW ENERGY FIN. 1 (Aug. 22, 2016).

13. *Id*.

14. *Id*. (giving an example of a non-energy "economic phase change" as the introduction of cellphones and eventually smartphones and how this technology has changed business, fashion, leisure, entertainment, and other industries).

15. One of the best examples of how an energy technology can institute a new way of thinking is the shale gas revolution. Steve LeVine, *Battery Powered: The Promise of Energy Storage*, 94 FOREIGN AFF. 119 (2015); *see also* Liebreich & McCrone, *supra* note 12, at 2 (stating that another example of an "economic phase change" in energy is the that the rapid uptake of renewable power has not only rendered certain conventional generation uneconomic, but has also changed how energy markets function; how "the control paradigm for the grid from base-load-and-peak to forecast-and-balance," and it is accelerating the digitization of electrical equipment).

16. Mark M. MacCracken, *Legislation spotlights building-scale energy storage*, GREENBIZ (July 25, 2013), http://www.greenbiz.com/blog/2013/07/25/legislation-shines-spotlight-building-scale-energy-storage.

17. *Id.*

18. *See generally* Trabish, *supra* note 5; *see also* Daniel Hagan & Jane Ruger, *Electric Energy Storage: Preparing for the Revolution*, BREAKING ENERGY 2 (Oct. 10, 2016).

storage options as return-on-investment calculations incorporate these facts.[19] Energy storage also faces issues of regulatory uncertainty and operator unfamiliarity with its applications, operations, and the benefits that it can offer the grid, thus creating risks for those who invest in energy storage.[20] The widespread implementation of energy storage will require the combined efforts of technology developers and utilities "to ensure that systems are designed to adequately address utility needs."[21] This means that the issues over categorization, value, interconnection, jurisdiction, transmission planning, transmission cost allocation, double counting/recovery, and environmental concerns must be addressed to ensure that storage will be able to be designed to adequately meet those needs.[22]

The rest of this paper will focus on answering two questions (or discussing two issues) that are determinative of the fact of energy storage. First, how should energy storage be classified; then, how should energy storage services be valued? Relevant to these questions are issues of jurisdiction, interconnection, transmission planning and cost allocation, double-counting/double recovery, and environmental concerns with the deployment of energy storage. These issues will also be discussed as they are important in developing the regulatory and market structures for energy storage because they can either hinder deployment or create fights over the value of energy storage. Whether storage assets are classified as transmission or generation will have significant effects on their ability to participate in markets and which regulators will control its implementation. Additionally, rules about which services storage can provide and how those can be monetized will set practical limits on its deployment. We begin by first describing energy storage and energy storage technologies as well as the history and benefits of energy storage to the extent that this background is relevant to the focus of this paper.

II. WHAT IS ENERGY STORAGE?

Unlike the storage of most commodities, the utility-scale storage of electricity does not involve the storage of electricity itself, but rather the conversion of electricity into another form of energy (kinetic, chemical, etc.) that is later converted back to electricity with minimal loss.[23] In essence, energy storage is "[a] physical system with the ability to capture energy for dispatch or for displacement of electricity use at a later time."[24] "Thus, energy storage systems have the unique

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19. *Id.*

20. Aaron Marks, *7 Key Regulatory Developments for Battery Energy Storage*, AQUION ENERGY (Feb. 4, 2014), http://blog.aquionenergy.com/7-key-regulatory-developments-for-battery-energy-storage-timeline; *see also* Andy Colthorpe, *Lack Of Experience Holding Energy Storage Back As A Non-Wires Alternative To T&D Spending*, NAVIGANT (Oct. 11, 2017), Energy Storage News, https://www.energy-storage.news/news/navigant-lack-of-experience-holding-energy-storage-back-as-a-non-wires-alte.

21. EPRI Functional Requirements, *supra* note 9, at v.

22. *Id.*

23. Penelope Crossley, *Defining the Greatest Legal and Policy Obstacle to "Energy Storage,"* 2013 RENEWABLE ENERGY L. & POL'Y REV. 268, 269 (2013); *see also* Dhruv Bhatnagar & Verne Loose, *Evaluating Utility Procured Electric Energy Storage Resources: A Perspective for State Electric Utility Regulators,* Sandia Report SAND2012-9422, SANDIA NAT'L LAB. 17 (Nov. 2012); *see also* Amy L. Stein, *Reconsidering Regulatory Uncertainty: Making A Case For Energy Storage*, 41 FLA. ST. U. L. REV. 697, 699 (2014).

24. Ethan N. Elkind et al., *The Power of Energy Storage: How to Increase Deployment in California to Reduce Greenhouse Gas Emissions*, BERKELEY LAW & UCLA LAW 5 (July 2010).

capability to be both consumers of electricity (during the charging phase) and producers of electricity (during the discharging phase)."[25] Energy storage can be thought of as a temporal sponge for electricity, soaking up excess electricity only to inject it back onto the grid when it is most useful.[26]

Energy storage is not a new technology. It has been in use for millennia.[27] For example, dams and diversions have been used to store hydraulic head for mechanical energy for thousands of years.[28] Furthermore, electricity storage has been around since the 1780's when "Galvani demonstrated 'animal electricity.'"[29] It progressed into a more familiar form when Alessandro Volta invented the modern battery in 1799.[30] "In 1836, batteries were adopted" for use to help power the telegraph network.[31] In fact, more than 120 years ago Thomas Edison's electric utility system used batteries.[32] Until the mid-1980s, the United States used energy storage to time-shift electricity generated using coal from off-peak to peak to mitigate the need for natural gas peaking plants while allowing coal units to remain at their optimum output.[33] The result was 22 gigawatts of pumped hydro storage being built.[34] The impetus for building these plants was the high price of fuels (natural gas and oil) used to power peaking power plants.[35] Currently, "about 2.5% of the total electric power delivered in the United States passes through energy storage", Europe has 10%, and Japan has 15%.[36]

The Federal Energy Regulatory Commission (FERC) defines energy storage as a "resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid."[37] "[T]his definition is intended to cover electric storage resources capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid, regardless of their storage medium (e.g., batteries, flywheels, compressed air, and pumped-hydro)."[38] For purposes of this paper, we accept the FERC's definition.

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25. Bhatnagar & Loose, *supra* note 23, at 17; *see also* Order No. 841, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, 162 FERC ¶ 61,127, 83 Fed. Reg. 9,580 (2018) (to be codified at 18 C.F.R. Part 35) (describing energy storage as having the unique ability to both inject energy and receive energy from the grid) [hereinafter Order No. 841].

26. Bhatnagar & Loose, *supra* note 23, at 17-18.

27. *Id*.

28. *Id*.

29. Abbas A. Akhil et al., *DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA*, SANDIA NAT'L LAB. xxxiii (July 2013).

30. *Id*.; LeVine, *supra* note 15, at 120.

31. Akhil et al., *supra* note 29, at xxx.

32. Wood, *supra* note 11, at 35.

33. Akhil et al., *supra* note 29, at xxxiii.

34. The build out of pumped hydro stalled due to the rise of environmental opposition combined with the changing operational needs of the electric grid, which were brought about by the deregulation and restructuring of the electric utility industry. *Id*. at 1.

35. Deborah Behles, *An Integrated Green Urban Electrical Grid*, 36 WM. & MARY ENVTL. L. & POL'Y REV. 671, 681 (2012).

36. Bhatnagar & Loose, *supra* note 23, at 17-18.

37. Order No. 841, *supra* note 25, at P 29.

38. *Id*.

III. TYPES OF ENERGY STORAGE

While all energy storage technologies store energy, they differ in the manner in which they store energy and in the implementation of stored energy.[39] It has been noted that energy storage is a catchall name for various technologies that differ in "the form in which the energy is stored, the total storage capacity, charging efficiency, discharge power, response times, maintenance costs and level of commercialization . . ."[40] The various characteristics of energy storage technologies are important to keep in mind because each has its distinct advantages and disadvantages.[41]

There are several characteristics that are used to differentiate among various storage technologies. The capital cost of energy storage is expressed through an energy component ($/MWh) and by a power component ($/MW), where energy component represents the cost of the storage medium and the power component is the costs associated with the power electronics.[42] Energy storage technologies can be distinguished by their energy capacity (MWh), power capacity (MW), round-trip efficiency, and ramping capabilities.[43]

Furthermore, energy storage is classified by the power and discharge time.[44] Discharge time or duration refers to how long the energy storage device can inject electricity back into the grid.[45] Figure 1 compares the power and discharge time of various energy storage technologies.[46] It depicts the variety of options for mid-sized, mid-range discharge speeds and the limited options for high-capacity (pumped hydro and compressed air) or fast-discharging (capacitors) storage.[47] Lastly, energy storage resources differ in the time it takes to adjust their output

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39. Meyer, *supra* note 3, at 485.

40. Crossley, *supra* note 23, at 270.

41. *See generally infra.* Figures 1, 2, and 3. These figures collectively show various storage technologies' strengths and weakness regarding operations, technology risk/maturity, and use.

42. Joyce Mclaren, *Batteries 101 Series: How to Talk About Batteries and Power-To-Energy Ratios*, NAT'L RENEWABLE ENERGY LAB. (Apr. 13, 2016), https://www.nrel.gov/technical-assistance/blog/posts/batteries-101-series-how-to-talk-about-batteries-and-power-to-energy-ratios.html (last visited May13, 2018).

43. *Id.* Energy capacity "provides an estimate of the amount of energy that can be stored." Power capacity refers to "how much power can flow into or out of the battery in any given instant." *Energy Storage Glossary*, ENERGY STORAGE ASS'N., http://energystorage.org/energy-storage/glossary/r?search= (last visited Apr. 16, 2018) [hereinafter Energy Storage Glossary]. Round-trip efficiency is defined as "[t]he amounts of energy that a storage system can deliver relative to the amount of energy injected into the system during the immediately preceding charge. (Also referred to as efficiency.)" Ramping capabilities are also called the ramp rate, which refers to how quickly the addition or subtraction of power can happen. The quicker the ramp, the quicker it can meet swings in demand. It is always less than 100% because of losses from friction, resistance, or other inefficiencies depending on the technology. Laura M. Arciniegas & Eric Hittinger, *Tradeoffs Between Revenue And Emissions In Energy Storage Operation*, ELSEVIER 2 (2017).

44. UNIV. OF CAL. ET AL., 2020 STRATEGIC ANALYSIS OF ENERGY STORAGE IN CALIFORNIA 15 (Nov. 2011).

45. Peter Maloney, *Nearly 1/3 Of Planned Gas Peakers At Risk From Energy Storage, GTM Finds*, UTILITY DIVE (Mar. 20, 2018), https://www.utilitydive.com/news/nearly-13-of-planned-gas-peakers-at-risk-from-energy-storage-gtm-finds/519577/ [hereinafter Utility Dive: GTM Report].

46. DELOITTE, ENERGY STORAGE: TRACKING THE TECHNOLOGIES THAT WILL TRANSFORM THE POWER SECTOR 19 (2015).

47. *Id.*

and how accurately they are able to track system requests.[48] These technical requirements are important because they will determine the benefits that the storage device could provide and at what cost.[49]

Technologies	Power rating (MW)	Storage duration (h)	Cycling or lifetime	Self-discharge (%)	Energy density (Wh/l)	Power density (W/l)	Efficiency (%)	Response time
Super-capacitor	0.01-1	ms-min	10,000-100,000	20-40	10-20	40,000-120,000	80-98	10-20ms
SMES	0.1-1	ms-min	100,000	10-15	~6	1000-4000	80-95	< 100ms
PHS	100-1,000	4-12h	30-60 years	~0	0.2-2	0.1-0.2	70-85	sec-min
CAES	10-1,000	2-30h	20-40 years	~0	2-6	0.2-0.6	40-75	sec-min
Flywheels	0.001-1	sec-hours	20,000-100,000	1.3-100	20-80	5,000	70-95	10-20ms
NaS battery	10-100	1min-8h	2,500-4,400	0.05-20	150-300	120-160	70-90	10-20ms
Li-ion battery	0.1-100	1min-8h	1,000-10,000	0.1-0.3	200-400	1,300-10,000	85-98	10-20ms
Flow battery	01-100	1-0h	12,000-14,000	0.2	20-70	0.5-2	60-85	10-20ms
Hydrogen	0.01-1.000	min-weeks	5-30 years	0-4	600 (200 bar)	0.2-20	25-45	sec-min
SNG	50-1.000	hours-weeks	30 years	negligible	1,800 (200 bar)	0.2-2	25-50	sec-min

Electrical Mechanical Electrochemical Chemical

Figure 1. Representing Various Characteristics of Energy Storage Technologies[50]

A. *Centralized versus Decentralized*

Energy storage can also be separated into technologies that are centralized or decentralized.[51] Centralized energy storage includes technologies that contain hundreds of megawatts of capacity and can provide many hours of energy a day.[52] These projects are relativity large and complex.[53] These are primarily pumped hydro storage.[54] On the other end of the spectrum are distributed systems that are smaller and are generally spread throughout distribution and transmission system.[55] The Tesla Powerwall (a lithium ion battery) is an example of a consumer

48. Meyer, *supra* note 3, at 495.

49. Yuri V. Makarov et al, *Sizing Energy Storage to Accommodate High Penetration of Variable Energy Resources*, 3 IEEE TRANSACTIONS ON SUSTAINABLE ENERGY 34, 35 (2011); *see generally* Mclaren, *supra* note 42. A given energy storage technology will be often designed to excel in either the power capacity or energy capacity.

50. Deloitte, *supra* note 46, at 19.

51. Elkind et al., *supra* note 24, at 5.

52. *Id.*

53. Kaplan, *supra* note 11, at 1.

54. *Id.*; Elkind et al., *supra* note 24, at 5.

55. Elkind et al., *supra* note 24, at 5.

product that can function as a distributed energy storage system.[56] These facilities tend to be smaller but may grow larger as the technology matures and develops.[57]

IV. TECHNOLOGIES

Figure 2 shows the stages of development of various energy storage technologies.[58] Currently, the only energy storage technologies are operationally deployed at utility scale are pumped hydro storage, compressed air storage, flywheels, and some electrochemical batteries.[59] It should be pointed out that just because a technology is matured does not mean that it has high capital costs (pumped hydro storage is an example of this).[60] Figure 3 shows various technologies and some of the uses and benefits that each specific technology can provide.[61] However, it does not show all of the benefits, or all of the storage technologies.[62] Here again, the technological continuum from fast-discharging, low-capacity capacitors through mid-range technologies (i.e., fly wheels and batteries) to slow-charging, high-capacity pumped storage and compressed air projects.[63] This article, for the sake of brevity, will focus on a few storage technologies and use them to highlight the differences between various storage technologies and to illustrate the context-dependency of their usefulness.

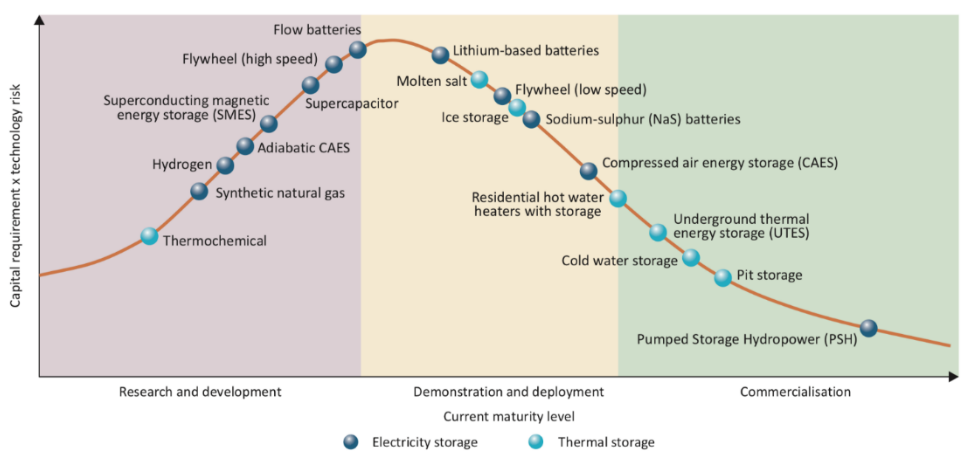

Figure 2. Showing the Capital Costs/Risk and Maturity of Energy Storage Technologies[64]

56. TESLA POWERWALL, https://www.tesla.com/powerwall (last visited Sept. 12, 2017).

57. Kaplan, *supra* note 11, at 8.

58. INTERNATIONAL ENERGY AGENCY, TECHNOLOGY ROADMAP: ENERGY STORAGE 16 (2014).

59. Bhatnagar & Loose, *supra* note 23, at 25.

60. Technology Roadmap, *supra* note 58, at 16.

61. RENEWABLE ENERGY WORLD, THE WIDE APPEAL OF BATTERIES FOR THE RENEWABLE ENERGY Market (June 5, 2014), https://www.renewableenergyworld.com/article.

62. *Id.*

63. *Id*.

64. Technology Roadmap, *supra* note 58, at 16.

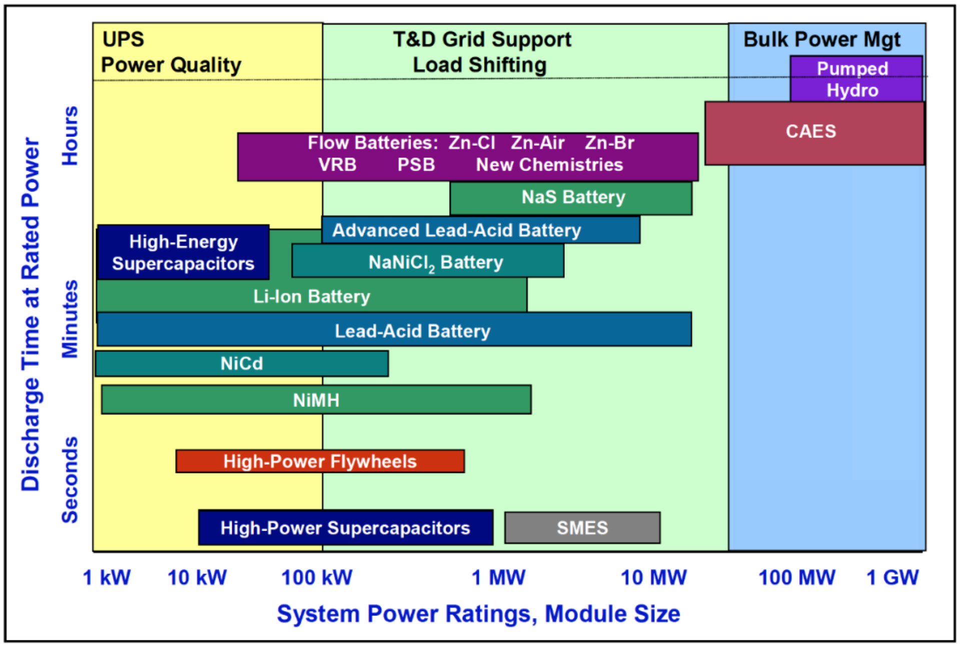

Figure 3. Showing Energy Capacity, Discharge Time, and Potential Uses of Storage Technologies[65]

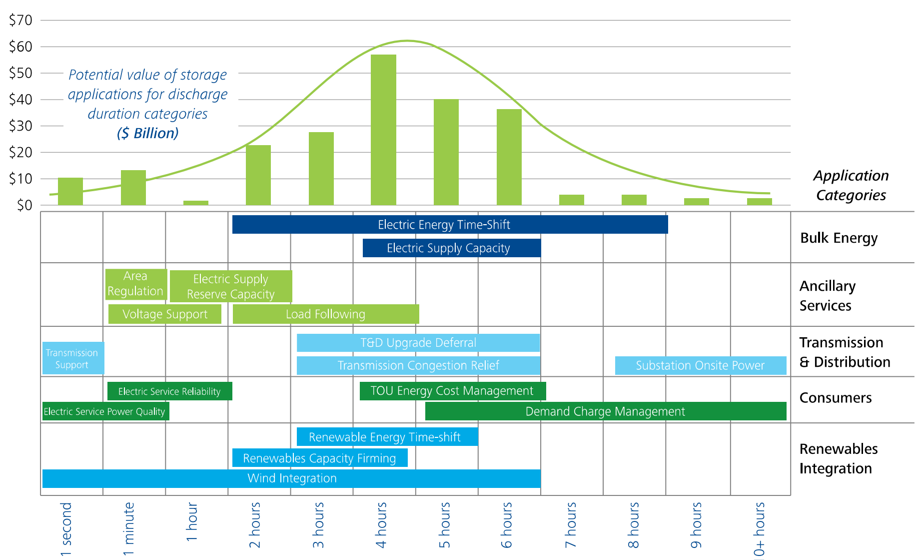

Figure 4. Plotting the Uses of Energy Storage Technologies with respect to Discharge Duration, Application Category, and Value of Services[66]

65. *Id.* at 29; *see also* Renewable Energy World, *supra* note 61.
66. Deloitte, *supra* note 46, at 6.

A. Mechanical

1. Pumped Hydro Storage

Having been around for hundreds of years, pumped hydro storage is the most mature, highest capacity, and most widely deployed commercial-scale technology.[67] It represents 95% of energy storage's share in the electric sector.[68] Because pumped hydro storage is only limited by the size of the upper and lower reservoirs, it can, at this time, have the highest capacities (up to 4,000 MW) of all storage technologies.[69] Despite its long history and widespread use, pumped hydro has several issues confronting its growth.[70] First, it is only about 76-85% efficient in storing electricity.[71] The economics of pumped hydro dictate that it be sized for storage times that exceed eight to ten hours because of the large costs of building the reservoirs, the dam, pumping equipment, and turbines.[72] Pumped hydro is also constrained geographically because it requires specific geographic criteria, namely land for the reservoirs and appropriate elevation falls for generation.[73] These plants do not tend to be located near load centers; thus doing little to relieve demands that may impact transmission and distribution networks during peak demand periods.[74] Furthermore, pumped hydro has faced controversy because of its size, its inefficiency (compared to other energy storage technologies), and its environmental effects (with resultant National Environmental Policy Act review requirements).[75]

B. Electrochemical Batteries

Batteries are one of the newest entrants in energy storage and have been getting a lot of attention due to their relatively small size, modularity, and rapidly declining costs.[76]

Perhaps the most recognizable battery is the lithium-ion battery. Lithium-ion batteries have emerged as the fastest growing stationary energy storage application for two reasons: (1) the large-scale use in consumer electronics; and (2) the use of electric vehicles.[77] This is important because as the nation moves towards the

67. Crossley, *supra* note 23, at 270; *see also* U.S. DEPT. OF ENERGY, GRID ENERGY STORAGE 16-17 (Dec. 2013) [hereinafter Grid Energy Storage Report]; *see also* Akhil et al., *supra* note 29, at 32; *see also* Stein, *supra* note 23, at 700.

68. Center for Sustainable Systems, *U.S. Grid Energy Storage Factsheet*, UNIV. OF MICH. 1 (Aug. 2018), http://css.umich.edu/sites/default/files/U.S._Grid_Energy_Storage_Factsheet_CSS15-17_e2018 [hereinafter U.S. Grid Energy Storage Factsheet].

69. Akhil et al., *supra* note 29, at 32.

70. *Id.* at 1.

71. Grid Energy Storage Report, *supra* note 67, at 16; Akhil et al., *supra* note 29, at 33; Joel A. Gallob, *In Search of Beneficial Environmental Impacts: Superconductive Magnetic Energy Storage, the National Environmental Policy Act, and an Analysis of Environmental Benefits*, 14 HARV. ENVTL. L. REV. 411, 435-36 (1990).

72. Akhil et al., *supra* note 29, at 30.

73. Stein, *supra* note 23, at 706; Akhil et al., *supra* note 29, at 32.

74. Bradford P. Roberts & Chet Sandberg, *The Role of Energy Storage in Development of Smart Grids*, PROCEEDINGS OF THE IEEE, June 2011, at 1139.

75. Stein, *supra* note 23, at 705; Meyer, *supra* note 3, at 492.

76. Hunt, *supra* note 1, at 1.

77. Akhil et al., *supra* note 29, at 96.

electrification of the transport sector, the integration of electric vehicles to the grid could be another way to store electricity and the lithium-ion batteries of electric cars can have a potential second life as grid storage batteries.[78]

Flow batteries are a newer type of battery technology; they have the potential to provide megawatt sized storage capacity without the geographic and land use constraints of pumped hydro facilities (i.e. the need to be in areas conducive to dams and the issues that surround dam construction).[79] Flow batteries use electrolytes in a liquid suspension that circulate between tanks.[80] They offer "long cycle life, flexible design, high efficiency and relatively low environmental impact."[81] Because energy capacity is independent of power capacity and is only limited by the size of the electrolyte storage tanks (which can be expanded as needed), they offer the potentially customizable energy capacity, including an option for expanding the energy capacity over time.[82]

C. Electric

1. Superconducting Magnetic Energy Storage

One advanced technology on the horizon is superconducting magnetic energy storage (SMES), whereby energy is stored in magnetic fields.[83] Because superconductivity allows a material to conduct electrons without resistance, the benefit with SMES is that electricity is stored at almost zero resistance and thereby has little to no loss of current.[84] Most SMESs have high cycle-lives and power densities, but are low in energy density, which makes them suited for providing short, rapid bursts of electricity into the system.[85] The main problem with SMES is that while they have the highest round-trip efficiency of any storage device, they are also one of the more expensive technologies to build and have been relegated to small-scale demonstration projects.[86]

V. WHAT BENEFITS CAN ENERGY STORAGE PROVIDE?

Bulk energy storage has a myriad of benefits, including relieving congestion on the transmission grid, reducing or delaying capital expenditures, improving reliability, allowing for increased integration of variable renewable sources (e.g., wind and solar), and providing ancillary services.[87] The ancillary services include operational reserves, voltage regulation, voltage support, regulation services, and

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78. Grid Energy Storage Report, *supra* note 67, at 8; Liebreich & McCrone, *supra* note 12, at 3.

79. Grid Energy Storage Report, *supra* note 67, at 18; *see also* Peter Maloney, *Lithium-Ion Domination Could Block Promising Storage Technologies, MIT Finds*, UTILITY DIVE (May 1, 2018), https://www.utilitydive.com/news/lithium-ion-domination-could-block-promising-storage-technologies-mit-find/522536/.

80. *See generally* Energy Digital, *supra* note 11.

81. Yunong Zhang, Et al, *The Benefits and Limitations of Electrolyte Mixing in Vanadium Flow Batteries*, APPLIED ENERGY, Oct. 15, 2017, at 374.

82. *Id*.

83. Grid Energy Storage Report, *supra* note 67, at 18; Gallob, *supra* note 71, at 419-20.

84. Gallob, *supra* note 71, at 412.

85. Grid Energy Storage Report, *supra* note 67, at 18.

86. *Id.* at 18-19; Bhatnagar & Loose, *supra* note 23, at 18.

87. Grid Energy Storage Report, *supra* note 67, at 21.

frequency response.[88] The fact that each technology has its own performance characteristics means that each storage system is optimized toward different sets of benefits and thus will be used in different applications and services.[89]

A. Ancillary Services

The North America Electric Reliability Corporation (NERC), whose purpose is to ensure the reliability of the grid, derives its definition of ancillary services from the FERC's Order 888-A "[t]hose services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider's transmission system in accordance with good utility practice."[90]

Conventional generators, either turbine-driven or engine-driven, have historically performed ancillary services, but energy storage technologies can also provide these services.[91] The unique attributes of energy storage are particularly appealing for ancillary services because they are the only system capable of absorbing energy when it is desirable and thus have the ability to provide capacity, energy, load, voltage and frequency regulation, and fast ramping services for the grid in a single facility.[92] In fact, storage often outperforms conventional generation in performing many of the ancillary services that are critical to grid reliability and stability purposes.[93] Ancillary service benefits are extremely important for storage to capture.[94] This is because some storage technologies, for example batteries, can only provide short-term power and at their current costs, it becomes hard to justify their construction without adding the additional value of the ancillary services.[95] However, for some ancillary services, no auction exists to sell/procure those services, thereby depriving energy storage of another revenue generating option.[96] Auctions and markets are for ancillary services are important for energy storage because they allow them to receive revenue to defray their construction operation costs.[97] The inability to monetize these services hinders the deployment of these technologies without regard for their technical effectiveness

88. *Id.* at 22.

89. *Id.*; Akhil et al., *supra* note 29, at 29.

90. North. Am. Elec. Reliability Corp., *Glossary of Terms Used in NERC Reliability Standards* (2017), http://www.nerc.com/files/glossary_of_terms.pdf (last visited June 21, 2017).

91. Meyer, *supra* note 3, at 509; Bhatnagar & Loose, *supra* note 23, at 18, 21.

92. *See generally* Figures 3 and 4, *supra* notes 65, 66. Energy storage technologies such as lithium-ion, flow batteries, and SMES would excel in providing ancillary services due to their response times. EPRI Functional Requirements, *supra* note 9, at 1-2; Bhatnagar & Loose, *supra* note 23, at 18. It should be noted that energy storage can provide ancillary services when it is acting as a generator or demand response too. *See also* Technical Conference, *supra* note 3, at 12.

93. Meyer, *supra* note 3, at 497; Market and Policy Barriers, *supra* note 2.

94. ELECTRIC POWER RESEARCH INST., MIDWEST INDEPENDENT TRANSMISSION SYSTEM OPERATOR (MISO) ENERGY STORAGE STUDY: PHASE I INTERIM REPORT 2-3 (Feb. 2012) [hereinafter EPRI Midwest].

95. *Id*.

96. Seth Mullendore, *Energy Storage and Electricity Markets: The Value of Storage to the Power System and the Importance of Electricity Markets in Energy Storage Economics*, CLEANENERGYGROUP 6 (2015).

97. Comments of Professor Paul L. Joskow on NOPR Regarding Network Access Service and Standard Market Design (FERC issued Jan. 10, 2003).

by tipping return-on-investment calculations toward other, possibly less effective, technologies.[98]

The reason why some ancillary services are market-based and others are not can be traced to the FERC's landmark Order 888, which was designed to "remedy undue discrimination in access to the monopoly owned transmission wires that control whether and to whom electricity can be transported in interstate commerce" through the elimination of remaining barriers to open access.[99] Under Order 888, public utilities:

> (1) must take transmission services (including ancillary services) for all of [their] new wholesale sales and purchases of energy under the same tariff of general applicability [i.e., open access tariffs] as do others; (2) state separate rates for wholesale generation, transmission, and ancillary services; (3) [and] . . . rely on the same electronic information network that [their] transmission customers rely on to obtain information . . . .[100]

As part of its efforts to facilitate non-discriminatory access, the FERC required transmission providers to offer the following six ancillary services under open access tariffs: "(1) Scheduling, System Control and Dispatch Service; (2) Reactive Supply and Voltage Control from Generation Sources Service; (3) Regulation and Frequency Response Service; (4) Energy Imbalance Service; (5) Operating Reserve - Spinning Reserve Service; and (6) Operating Reserve - Supplemental Reserve Service."[101] Furthermore, the FERC stated that the transmission provider must provide the first and second of these six ancillary services to the transmission customer, who must purchase these services from them.[102] The other four ancillary services must be procured by the transmission customer, and the transmission customer may elect to receive them from the transmission owner, a third party, or via self-supply.[103] The FERC has since observed that the transmission provider "is not always uniquely qualified to provide the services and customers may be able to more cost-effectively self-supply them or procure them from other entities."[104] The FERC has attempted in multiple orders post-Order 888 to ensure a competitive and well-functioning ancillary service market be expanding who can compete to provide those services most cost-effectively.[105] Energy storage's ability to access competitive markets for ancillary services will be

98. *Id*.

99. Order No. 888, *Transmission Open Access. Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities*, 75 F.E.R.C. STATS. & REGS. ¶ 61,080, 61 Fed. Reg. 21,540 (1996) (to be codified at 18 C.F.R. pts. 35, 101, and 385) [hereinafter Order No. 888].

100. *Id*. at p. 21,552.

101. *Id*. at p. 21,580.

102. *Id*.

103. *Id*.

104. Order No. 784, *Third-Party Provision of Ancillary Services; Accounting and Financial Reporting for New Electric Storage Technologies*, 144 F.E.R.C. ¶ 61,056 at P 6 (2013) (to be codified at 18 C.F.R. 35 and 385) [hereinafter Order No. 784].

105. *Id*.; *see generally* Order No. 755, *Frequency Regulation Compensation in the Organized Wholesale Power Markets*, 137 F.E.R.C. ¶ 61,064 (2011) [hereinafter Order No. 755]; *see generally* Order No. 819, *Third-Party Provision of Primary Frequency Response Service*, 153 F.E.R.C. ¶ 61,220 (2015) [hereinafter Order No. 819]; *see generally* Order No. 719, *Wholesale Competition in Regions with Organized Electric Markets*, 125

key for its success. As the next section will show, energy storage is capable of providing a diverse range of ancillary services. Yet, regardless of how these technologies are classified, if their services cannot be monetized, there is significantly less reason for anyone to invest in them. Their technical potential has little value in a system that has no markets or mechanisms to value those potential services.

1. Types of Ancillary Services that Energy Storage Can Provide

a. Regulation and Frequency Response

One ancillary service that energy storage is well suited to provide is regulation.[106] Regulation is the "managing [of] interchange flows with other control areas to match closely the scheduled interchange flows and momentary variations in demand within the control area."[107] "Regulation service provides secondary frequency response, which is produced from either manual or automated dispatch through automatic generation control from a centralized control system."[108] This is required to comply with the NERC's Real Power Balancing Performance and Disturbance Control Performance Standards and is also used to maintain grid frequency.[109]

Frequency response (also called primary frequency response) closely mirrors regulation, but reacts even faster to system needs (in a matter of seconds) when there is loss of a generation source or transmission line to bring the frequency back into an acceptable range, and to prevent under frequency load shedding (UFLS), generation tripping, or cascading outages.[110] In its Order 842 on primary frequency response, the FERC has observed that the electric industry has expressed concern in the decline in frequency response performance over the years.[111] As such, the FERC has required that all generation be capable of providing frequency response, including energy storage.[112] When generation, load, and losses on the grid do not net out on a moment-by-moment basis, the resulting imbalance between the load and generation will cause the frequency of the grid to drift away from the 60 Hz standard.[113] In essence, regulation service and frequency response are "the injection or withdrawal of real power' into or from the electric grid in response to fluctuations in demand for electricity."[114] Primary frequency response

F.E.R.C. ¶ 61,071 (2008) [hereinafter Order No. 719]; *see generally* Order No. 842, *Essential Reliability Services and the Evolving Bulk Power System—Primary Frequency Response*, 162 F.E.R.C. STATS. & REGS. ¶ 61,128, 82 Fed. Reg. 40,081 (2018) (to be codified at 18 C.F.R. pt. 35) [hereinafter Order No. 842] (where the FERC did not institute a market-based mechanism for the provision of Primary Frequency response, an ancillary service).

106. Grid Energy Storage Report, *supra* note 67, at 22.

107. *Id.;* Akhil et al., *supra* note 29, at 4.

108. *Indianapolis Power & Light Co. v. Midcontinent Indep. System Operator, Inc.*, 158 F.E.R.C. ¶ 61,107 at P 3 (2017), *order on reh'g,* 162 F.E.R.C. ¶ 61,266 (2018).

109. Grid Energy Storage Report, *supra* note 67, at 22; Akhil et al., *supra* note 29, at 4.

110. Akhil et al., *supra* note 29, at 14-15; Grid Energy Storage Report, *supra* note 67, at 23; Stein, *supra* note 23, at 711; Order No. 842, *supra* note 105, at P 4 ("UFLS is designed to be activated in extreme conditions to stabilize the balance between generation and load. Under frequency protection schemes are drastic measures employed if system frequency falls below a specified value.").

111. *Id*. at P 7.

112. *Id*. at P 176.

113. Stein, *supra* note 23, at 711.

114. Northwestern Corp. v. FERC, 884 F.3d 1176, 1179 (D.C. Cir. 2018).

and regulation service may be combined and sold by transmission providers through the *pro forma* Open Access Transmission Tariff Schedule 3 product, Regulation and Frequency Response Service.[115]

Historically, generation units that were online had to be ready to increase or decrease their power output depending on whether there was over or under generation.[116] However, an important consideration when using large thermal base-load generation to provide regulation services is that they will incur some wear and tear and lost efficiency as they inject or withdraw power.[117] Regulation also requires resources with fast response times to alter power output relative to other ancillary services, which can lead to limited participation by market participants and higher prices.[118] Several energy storage resources are capable of faster response times than most current system assets and are thus well suited for regulation services.[119]

Since the FERC's issuance of Order 819 in 2015, the FERC has permitted the sale of regulation services at market-based rates by sellers who have "market-based rate authority for" the sales of both energy and capacity.[120] Storage technologies may be better suited for frequency response services because the faster a resource can ramp up or down, the more accurate its response can be.[121] When storage provides regulation down (i.e., it removes power from the grid to reduce the amount of electricity in the grid to match the load), it does so by absorbing excess electricity on the grid, which requires buying energy from the market.[122] This is important because the cost of the energy absorbed might exceed the value of the regulation service, especially for storage technologies with lower efficiencies.[123] Such cost impacts limit the ability of energy storage to compete in the regulation service market.

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115. 158 F.E.R.C. ¶ 61,107 at P 4.

116. Akhil et al., *supra* note 29, at 4-5.

117. Grid Energy Storage Report, *supra* note 67, at 22.

118. Market and Policy Barriers, *supra* note 2, at 16.

119. *Id*.

120. 162 F.E.R.C. ¶ 61,266 at P 4 ("The Commission noted that, while most Balancing Authorities should be able to meet the new reliability standard using their own resources, some may nevertheless be interested in purchasing primary frequency response service from others if doing so would be economically beneficial." However, in Order 819 the Commission did not mandate that providers of primary frequency response service receive compensation for their services.).

121. Market and Policy Barriers, *supra* note 2, at 16.

122. Order No. 755, *supra* note 105, at fn. 3 (The ability to change the real output of power from a generation unit is known as "ramping" and is usually measured in megawatts per minute ("MW/min") increments (i.e., "[g]enerator[s] ramps up to produce more energy and ramps down to produce less. [S]torage device[s] ramps up by discharging energy and ramps down by charging. [D]emand response resources, in the context of the provision of frequency regulation, ramps up by consuming less energy and ramps down by consuming more.")); Akhil et al., *supra* note 29, at 5 (This highlights why managing the state of charge and who gets to control it is important for energy storage devices.); MASS. INST. TECH., ELECTRIC VEHICLE TEAM, A GUIDE TO UNDERSTANDING BATTERY SPECIFICATIONS (2008), http://web.mit.edu/evt/summary_battery_specifications.pdf (How do we categorize it and jurisdiction? The State of charge is "[a]n expression of the present battery capacity as a percentage of maximum capacity.").

123. Akhil et al., *supra* note 29, at 5. This in part due to the fact that ancillary services are not considered an arbitrage opportunity like storing wind energy at night for day use would be. ENERGY STORAGE ASS'N, FREQUENCY REGULATION, http://energystorage.org/energy-storage/technology-applications/frequency-regulation (last visited Oct. 2, 2017); Order No. 755, *supra* note 105, at fn. 124 (This is referred to as inter-temporal

b. Spinning, Non-Spinning, and Supplemental Reserves

Energy storage can also provide spinning or tertiary frequency control, (non-spinning, and supplemental reserves), too.[124] Tertiary frequency control is an ancillary service that is used to tailor scheduled unit commitment and bring the frequency on the grid back within normal tolerances when secondary frequency control cannot perform the task.[125] In other words, it "can respond within 10 seconds to 10 minutes to service frequency issues, or generation losses, or transmission outages."[126] Spinning reserves are the first resources in the queue to meet any shortfalls that occur.[127] Under current regulations, "minimum duration requirements prevent some energy storage resources from participati[ng]" in frequency response.[128] Non-spinning reserves are non-synchronized resources where "[g]eneration capacity that may be offline or that comprises a block of curtailable and/or interruptible loads and that can be available within 10 minutes[,]" while "supplemental reserves [are reserves] that can pick up load within an hour to back up any disruption to spinning and non-spinning reserves."[129]

The most important features distinguishing energy storage from traditional reserves that provide these services are their relative stand-by states and response times.[130] In order for traditional generation resources to be used in a reserve function, they must be online and operational, (i.e., at part load), but storage does not need to discharge while being a reserve capacity resource.[131] Rather, energy storage just needs to be ready and available if called upon.[132] Additionally, many emerging storage technologies can respond nearly instantaneously by adding or removing power from the grid rather than needing seconds or minutes to synchronize to the grid as injection-only participants.[133]

c. Voltage Support

Another ancillary service that is needed for reliable operations of the grid is voltage support, which is used to maintain the voltage of the grid within specified limits.[134] This is accomplished through the management of reactance, which is

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opportunity costs. Inter-temporal opportunity costs are "the foregone value when a resource must operate at one time, and therefore must either forego a profit from selling energy at a later time or incur costs due to consuming at a later time." An example of this trade-off is when energy storage would prefer to recharge when the prices are low and discharge when the prices are high. However, when energy storage provides frequency regulation, it may be required to stop charging during lower price periods and may be forced into charging during the higher price periods.).

124. Meyer, *supra* note 3, at 520.

125. *Id*. at 519.

126. Grid Energy Storage Report, *supra* note 67, at 25.

127. Akhil et al., *supra* note 29, at 7.

128. Market and Policy Barriers, *supra* note 2, at 16.

129. Akhil et al., *supra* note 29, at 8; Grid Energy Storage Report, *supra* note 67, at 25.

130. Akhil et al., *supra* note 29, at 9.

131. *Id.* at 8.

132. *Id*.

133. *Id*. at 7.

134. *Id*. at 9.

caused by grid-connected generators, transmitters, and users of the electricity.[135] A power plant is normally designated to generate volt-amp reactive power (VAR) to offset this reactance in the grid as power plants can produce both active and reactive power.[136] The power plants designated to produce VAR could be displaced by storage that is strategically located at either central locations or distributed near large loads to provide voltage support.[137] There is no market for voltage support at present because technical and geographical requirements preclude the sales of these services.[138]

B. Renewables

Some have argued that larger deployment of renewables may lead to more energy storage and a better economic case for it.[139] Because the demand for electricity does not necessarily match when the wind is blowing and the sun is shining, renewable energy suffers from an intermittency problem.[140] While the grid can handle small amounts of intermittent generation, any large-scale penetration will require the rebalancing of generation, transmission, storage, demand management, and overall regulation of the electric system.[141] The misalignment of solar and wind power with changes in demand results in a phenomenon known as the "duck curve."[142]

The issues with day-to-day integration of renewables can already be seen in several states, especially in California where the now famous duck curve has grown faster than predicted.[143] When renewables ebb, baseload fossil fuel generation must ramp up quickly to meet the demand and most baseload plants (i.e. coal

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135. Akhil et al., *supra* note 29, at 9.

136. *Id.*; Kaplan, *supra* note 11, at 11.

137. Akhil et al., *supra* note 29, at 9.

138. Mullendore, *supra* note 96, at 6; *see also* FED. ENERGY REGULATORY COMM'N, PAYMENT FOR REACTIVE POWER 2 (2014).

139. Paul Denholm et al., *The Impact of Wind and Solar on the Value of Energy Storage*, NAT'L RENEWABLE ENERGY LAB. 1 (2013); Elkind et al., *supra* note 24, at 1 (among other things, storage could help renewables with interconnecting, solving transmission and distribution issues, maintaining the frequency of the grid because renewables can increase the difficulty of maintain a functioning grid (i.e. ancillary services), and reliability); *see also* Bhatnagar & Loose, *supra* note 23, at 19; Johnston, *supra* note 8, at 28; Meyer, *supra* note 3, at 483.

140. Johnston, *supra* note 8, at 28; EPRI Functional Requirements, *supra* note 9, at 1-1; EPRI Midwest, *supra* note 94, at 2-1. For example, California's aggressive renewables and greenhouse reduction mandate will be quite difficult to meet without a large amount of renewable energy because it will be difficult to integrate more renewable energy and keeping the grid stable. Jeff St. John, *California Passes Huge Grid Energy Storage Mandate*, GREENTECH MEDIA (2013), http://www.greentechmedia.com/articles/read/california-passes-huge-grid-energy-storage-mandate.

141. MIT ENERGY INITIATIVE, MANAGING LARGE-SCALE PENETRATION OF INTERMITTENT RENEWABLES 2 (2011); Bhatnagar & Loose, *supra* note 23, at 21.

142. Diane Cardwell, *Why Home Solar Panels No Longer Pay in Some States*, NEW YORK TIMES (2016), https://www.nytimes.com/2016/07/27/business/energy-environment/why-home-solar-panels-no-longer-pay-in-some-states.html; *Infra* Figure 4 (showing the duck curve).

143. Julie Blunden, *The Case for Long-Duration Storage: Net Electricity Load in Calif. Is 5 Years Ahead of Schedule*, GREENTECH MEDIA (2015), https://www.greentechmedia.com/articles/read/california-is-already-hitting-its-2020-duck-curve#gs.OTk4Lvk.

thermal power plants) are not designed for this.[144] Figure 5 illustrates the risks of over generation in the afternoon coupled with substantial ramping requirements for dispatchable sources.[145]

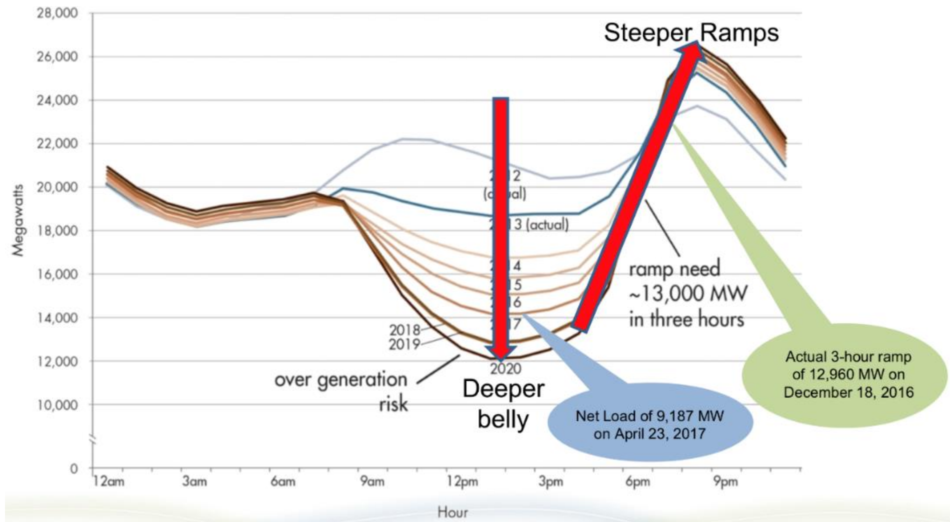

Figure 5. Showing the Duck Curve and Ramping Requirements[146]

In the Pacific Northwest with its abundant supply of renewable energy, (wind and hydro), generation often outpaces demand.[147] While exporting the excess power could be a viable solution, the ability to do so is constrained at times due to transmission congestion.[148] From a reliability perspective, this extra electricity poses a threat to the grid's balance when it cannot be exported, stored, or curtailed.[149] One way the Bonneville Power Administration (BPA) used to address the potential imbalance was to start curtailing other sources of generation, beginning with the backing down of thermal generation followed by the curtailment of wind generation without compensation.[150] The FERC held that BPA's approach of curtailing wind was impermissible and that they must find another way to determine who gets curtailed.[151] One effective method is energy storage at a utility-

144. *Id.*; Hagan & Ruger, *supra* note 18, at 6.

145. Mark Rothleder, *Renewable Integration*, CALIFORNIA ENERGY COMM'N (2017), http://www.caiso.com/Documents/RenewableIntegrationUnlockingDividends.pdf.

146. *Id*.

147. Akhil et al., *supra* note 29, at 11; Grid Energy Storage Report, *supra* note 67, at 25.

148. Emily Rietmann, Comment, *Alternative Solutions to Power Oversupply in the Pacific Northwest*, 45 ENVTL. L. 207, 212 (2015); Michael Kintner-Meyer et. al., *Energy Storage for Variable Renewable Energy Resource Integration,* 2011 IEEE/PES Power Systems Conference and Exposition, IEEE 1 (2010).

149. Rietmann, *supra* note 148, at 212.

150. *Id*.

151. *Iberdrola Renewables, Inc. v. Bonneville Power Admin.*, 137 F.E.R.C. ¶ 61,185 at P 62 (2011).

scale capacity that could absorb excess generation and deliver it when needed or when transmission capacity becomes available.[152]

Storage can assist the integration of renewables and there is "a potential synergistic relationship between renewables and energy storage."[153] One study found that installing energy storage in the UK could reduce wind curtailment by over 50% while allowing for lower-cost CO_2 reductions and potential savings on transmission investments.[154] Absent effective energy storage, the current state of the grid generally requires that electricity be used instantaneously otherwise any excess generation will be wasted and/or cause power disruptions.[155] Storage could not only smooth out these dips and climbs, but could also allow the renewable generators to access higher prices.[156] For example, in areas with high solar penetration, electrification of transportation coupled with daytime charging could help to flatten the duck curve by providing a flexible source of demand that can be coordinated with grid assets.[157] The electrification of the transport sector offers opportunities to reduce petroleum consumption; use photovoltaic solar for midday charging and absorb potentially low-value solar and wind energy during low demand periods.[158] It can also do this at lower levels of overall energy needed to balance and retain the reliability of system, even when accounting for the fact that energy storage devices lose some energy to conversion.[159] Also, it needs to be remembered that there are several supply-side and demand-side approaches to dealing with the excess electricity that is produced by renewable generation; these are basically questions economic feasibility.[160] Supply-side methods include the sharing of load and reserves, flexible generation, renewable energy curtailment, and energy storage.[161] While demand-side response include flexible loads, new demand, and energy storage.[162] Studies have shown that energy storage represents the most expensive route to deal with the lower penetrations of renewables.[163] This

152. Similar issues have happened in Texas too where the wind has stopped blowing and the local utilities had to cut service for some users for up to an hour and a half until the wind came back. David Lindley, *The Energy Storage Problem*, NATURE, Jan. 7, 2010, at 18.

153. Denholm, *supra* note 139, at 29.

154. GORAN STRBAC ET AL., STRATEGIC ASSESSMENT OF THE ROLE AND VALUE OF ENERGY STORAGE SYSTEMS IN THE UK LOW CARBON ENERGY FUTURE: REPORT FOR THE CARBON TRUST (2012), https://www.carbontrust.com/media/129310/energy-storage-systems-role-value-strategic-assessment.pdf.

155. Stein, *supra* note 23, at 713.

156. Grid Energy Storage Report, *supra* note 67, at 7; Crossley, *supra* note 23, at 269.

157. Katsen et al., *Assessing the Status of Electrification of the Road Transport Passenger Vehicles and Potential Future Implications for the Environment and European Energy System* 15 (Sept. 22, 2018), https://www.oeko.de/fileadmin/oekodoc/Assessing-the-status-of-electrification-of-the-road-transport-passenger-vehicles.pdf.

158. Denholm et al., *Co-Benefits of Large Scale Plug-In Hybrid Electric and Solar PV Deployment*, 236 J. OF POWER SERV. 350, 354 (2013).

159. Univ. of Cal., *supra* note 44, at 72.

160. *Id.* at 58.

161. *Id*. at 32-46.

162. *Id*.

163. *Id*. at 34-46.

does not consider the other benefits of energy storage: ancillary services, transmission deferral, congestion management, or economic.[164] Energy storage is one way to help with the intermittency issue, the duck curve, and seasonal over-generation or under-generation of renewables.[165]

C. Reliability

Energy storage can also ensure reliability of the grid. For example, in Texas, the Public Utility Commission of Texas (PUCT) approved the use of a NaS battery to ensure grid reliability in Presidio, Texas.[166] The battery was needed to increase the reliability of the grid, because the grid had suffered numerous outages caused by transmission losses (i.e. transmission line outages stemming from weather or other events).[167] Storage systems can also provide the ancillary service known as black start services, which aid in reliability since black start services are used "to energize transmission and distribution lines and provide station power to bring power plants on line after a catastrophic failure of the grid."[168] Energy storage would able to do this if "the storage system is suitably sited and there is a clear transmission path to the power plant from the storage system's location."[169] However, no auction currently exists for these services thereby lowering the economics of energy storage.[170]

D. Economics/Arbitrage/Capacity

A productive economy requires significant amounts of electricity to run, and access to cheaper electricity is even better for the economy.[171] The price of electricity can vary depending on the time of use, higher prices occur when there is an increased demand for electricity.[172] Energy storage's ability to traverse time to access electricity when it is cheapest is another primary benefit.[173] This is referred to as energy shifting which is where energy storage is used to level the net load on the system by charging during low-demand (low-cost) periods and discharging during high-demand (high-price) periods.[174] The benefit of storage in this regard

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164. Univ. of Cal., *supra* note 44, at 34-46.

165. Shelley Welton, *California Creates First State Energy Storage Mandate*, CLIMATE LAW BLOG (Oct. 19, 2013), http://blogs.law.columbia.edu/climatechange/2013/10/19/california-creates-first-state-energy-storage-mandate/.

166. *Scope of Competition in Electrical Markets in Texas, Public Utility Commission of Texas*, Report to the 82[nd] Texas Legislature. 19 (Jan. 14, 2011), http://www.puc.texas.gov/industry/electric/reports/scope/2011/2011scope_elec.pdf [hereinafter Presidio Battery Order].

167. *Id.*; Technical Conference, *supra* note 3, at 19-21 (describing the Presidio Battery was used to ensure reliability of the grid and add incremental capacity to the transmission infrastructure instead of rebuilding the transmission line).

168. Akhil et al., *supra* note 29, at 10.

169. *Id*. at 9-10.

170. Mullendore, *supra* note 96, at 6.

171. Stein, *supra* note 23, at 709.

172. *Id*. at 712.

173. *Id*. at 712-14.

174. Denholm, *supra* note 139, at 2; Akhil et al., *supra* note 29, at 2; Grid Energy Storage Report, *supra* note 67, at 20.

is highly dependent on the cost differential between off-peak and on-peak prices.[175]

Another economic benefit of energy storage is for customers to use it in conjunction with a demand response program or to manage their demand charges.[176] Demand response gives system operators control over large power users and aggregated small users (i.e. water heaters and HVAC units) to manage the demand side of the power supply equation by lowering demand during critical peak times.[177] The FERC defines demand response as "a reduction in the consumption of electric energy by customers from their expected consumption in response to an increase in the price of electric energy or to incentive payments designed to induce lower consumption of electric energy."[178] This is opposed to the traditional focus of only managing the supply of electricity.[179] For example, energy storage could be charged at the distribution level and then discharged back onto the distribution grid during usage peaks on the transmission grid.[180] Customer-sited energy storage can also limit the demand for electricity the customer puts on the grid during times of high demand.[181] This type of billing is often used with commercial and industrial customers that have to pay a charge, known as a demand charge, which is based on their peak demand for electricity in a given period.[182] This is known as peak shaving.[183] Thus, a single storage asset could be used to arbitrage off-peak-to-peak prices, limit the demand of a facility (lowering demand-charge prices), and provide power reliability when the grid nears its capacity limits.[184]

E. Efficiency

Another reason why utilities are interested in energy storage is the nature of the power demand they have to meet.[185] Demand can be separated into peak demand, which is when there is a high demand for electricity, and baseload demand, typically during the night where demand can decrease by half of the daytime demand.[186] To meet peak demand, peak power comes from generation output that can be varied, but some generation, i.e., baseload nuclear and coal, do not possess or have a limited ability to ramp up or down and thus need to run continuously

175. Denholm, *supra* note 139, at 2.

176. Mullendore, *supra* note 96, at 6, 12-14.

177. *Id*. at 6. Demand response also ensures that large investments in electric generation or transmission lines are not built to only serve a limited number of hours that happen to be the peak of the peak. Energy Storage will also ensure the efficient use of electric assets. *Infra* efficiency and transmission planning and cost allocation discussions.

178. Order No. 745, *Demand Response Compensation in Organized Wholesale Energy Markets*, 134 F.E.R.C. ¶ 61,187 at P 2 fn. 2 (2011).

179. Mullendore, *supra* note 96, at 6.

180. *Id*.

181. *Id*. at 12.

182. *Id*.

183. *Id*.

184. Mullendore, *supra* note 96, at 12.

185. Gallob, *supra* note 71, at 434-35.

186. *Id*.

(the hydroelectric dams in the Pacific Northwest are an example of this issue).[187] Any excess power that is produced is wasted.[188] By removing this historical limitation of instantaneous use, energy storage allows the grid to become more efficient and to be able to use the power that once was lost.[189]

As discussed, energy storage has unique attributes that allow power generated during off-peak times to be used during on-peak times.[190] Using this ability, energy storage can promote system-wide efficiency by allowing generation plants to operate at their most efficient level irrespective of the particular demand load.[191] Although peak periods are only a relatively small fraction of the grid's life cycle, resource planners must plan generation, transmission, and the distribution system around the few hours a year when peak demand exists.[192] This need to plan for peak demand has traditionally meant constructing peaking plants for use when called upon to serve those few hours of peak demand.[193] This construction represents an inefficient use of capital because these plants operate infrequently.[194]

Depending on the circumstances in the electric system, energy storage could be used to operate generation assets and the system more efficiently.[195] Energy storage would allow thermal plants the ability to continue to operate at optimum efficiency levels removing the need to startup or shutdown in response to demand.[196] This is a well-understood advantage of energy storage.[197] Furthermore, because storage technologies, particularly flywheels and batteries, are modular they can be scaled to the appropriate level, thereby ensuring that ratepayers are not paying for excess capacity.[198] However, this typically comes at the cost of a higher capital cost per installed kW due to their smaller size.[199] Storage in this regard also minimizes the need for infrastructure only dedicated to meeting peak demand.[200] It would allow the system to move somewhat away from operating in a pre-contingency manner to a more post-contingency manner because energy storage can operate at near instantaneous speeds thereby allowing grid operators the ability to wait see if something will happen before they act to mitigate it.[201] This

187. *Id*. at 435; Rietmann, *supra* note 148, at 208, 212; *see generally* Kintner-Meyer, *supra* note 148.

188. Gallob, *supra* note 71, at 435.

189. Stein, *supra note 23*, at 700; Gallob, *supra* note, 71, at 435.

190. Bhatnagar & Loose, *supra* note 23.

191. *Id*.

192. Stein, *supra* note 23, at 712.

193. *Id*. at 698-99, 712-13; Technical Conference *supra* note 3, at 16-18.

194. Utility Dive: GTM Report, *supra* note 45. The GTM report found that energy storage could displace up to 32% of new gas peaker capacity could be at risk due to the falling costs of 4-hour capacity energy storage by 2027. How quickly the change from using natural gas turbine to energy storage for peaking will be governed by low costs for long duration energy storage. While lower costs will help speed the deployment of energy storage duration will be important because it will determine if it could be used to replace peaker plants. *Id*.

195. Akhil et al., *supra* note 29, at 3.

196. Denholm, *supra* note 139, at 2; Crossley, *supra* note 23, at 269.

197. Denholm, *supra* note 139, at 2; Crossley, *supra* note 23, at 269.

198. Bhatnagar & Loose, *supra* note 23, at 18.

199. *Id*.

200. Elkind et al, *supra* note 24, at 11.

201. Technical Conference, *supra* note 3, at 13-14.

represents a new paradigm in managing the grid from a speculatively-proactive to an informed-reactive manner.

Furthermore, energy storage may also lower system costs better than other technologies.[202] An analysis of demand response costs demonstrates that in some cases batteries combined with pumped hydro can compete favorably with combined cycle turbine installations.[203] While analyses are fact-dependent, pumped hydro's advantage of becoming more cost efficient as the discount rate decreases is a result of its long life cycle and lack of interim capital costs (e.g. no need for replacement batteries).[204] While traditional demand response value comes from having a large capacity to respond to peak loads, batteries can be either a load or a generator, thereby potentially altering their value to the grid as they provide additional ancillary services outside of demand response.[205] Focusing on batteries solely as demand response ignores a range of services that the batteries can provide (e.g. time-shifting energy from renewables, frequency regulation, etc.).[206]

F. Environmental

Storage technologies may also have several environmental benefits from their ability to reduce emissions from high-emitting, peaking gas power plants and emissions associated with generators having to ramp up and down.[207] They may also reduce greenhouse gases by minimizing the need to build conventional generation to serve as backup to grids using an increased amount of renewable energy.[208] As the electricity sector seeks options to reduce its carbon footprint while meeting the demand for electricity, this potential zero-carbon resource ability will only grow to be more important.[209] Additionally, when fossil fuel plants are used to meet ancillary service needs they operate in a less efficient manner (e.g., ramping up and down to match demand) and thereby produce more emissions.[210] The release of excess emissions happens because generation is being operated in a manner less than its designed or rated output (this is referred to as "part load operation"), thus increasing the plant's heat rate, fuel cost, and emissions.[211] Energy storage can minimize these inefficiencies and provide zero-emissions-based services when coupled with renewable energy.[212] However, there are some instances

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202. Kintner-Meyer, *supra* note 148, at 7.

203. *Id*.

204. *Id*.

205. *Id*.

206. Meyer, *supra* note 3, at 524; Bhatnagar & Loose, *supra* note 23, at 26.

207. Bhatnagar & Loose, *supra* note 23, at 19.

208. Elkind et al., *supra* note 24, at 10.

209. Kintner-Meyer, *supra* note 148, at l. For example, if Massachusetts meets its energy storage goals of 1.78 gigawatts. It would result in a carbon emissions reduction of more than one million metric tons of carbon dioxide over ten years. That is the equivalent of taking over seventy thousand cars off the road. Andrew Kaplan, *Monetizing Energy Storage Massachusetts Case Study*, PUBLIC UTILITIES FORTNIGHTLY 46-47 (Dec. 2016).

210. Bhatnagar & Loose, *supra* note 23, at 20; P. Saha et al., *New High Energy Density Mg Battery Concepts for Electrical Energy Storage*, 3 (2011); NRRI Energy Storage, *supra* note 7, at 4.

211. Akhil et al., *supra* note 29, at 3.

212. Bhatnagar & Loose, *supra* note 23, at 20; Johnston, *supra* note 8, at 28; Denholm, *supra* note 139, at 1. While there is an increase in the value of storage as the penetration of renewables increases, any significant

where energy storage may raise or contribute to environmental problems itself, particularly when a storage option with low round-trip efficiency is paired with fossil fuel generation.[213]

G. Transmission/Distribution

The development of transmission infrastructure is increasingly facing challenges involving "who pays for" and "who owns" new transmission capacity in part due to the high capital cost, and difficulties in siting transmission infrastructure due to environmental impacts, costs, and aesthetic concerns.[214] Debate over the state of the transmission infrastructure and the need to upgrade it has given way in previous years to restructuring and the evolution of the wholesale market.[215] Thus, the transmission grid still needs to update existing critical points, particularly those that are currently limiting the expansion of renewable energy.[216] Here again, an advantage that storage provides in the transmission/distribution context is that it can be built in a matter of months, instead of the long lead times involved in developing a transmission project.[217]

Energy storage can become an alternative to building new lines and/or power plants and help increase the throughput of electricity in existing lines by reducing congestion and unhelpful electric effects, such as voltage issues, thermal overloads, or providing reactive power to the grid.[218] Energy storage does this by being positioned downstream from the transmission constraint and being charged when the demand for electricity is low (i.e., nighttime).[219] By bringing storage closer to the load, it may also help alleviate high line-congestion and line-loss rates that occur during times of peak demand.[220] This reduces the need for new transmission projects and extends the life of the existing system.[221] Prolonging the operational

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economic benefits and carbon reduction do not occur until a very high penetration of renewables is achieved (i.e. 40% wind).

213. Arciniegas & Hittinger, *supra* note 43, at, 2; *see also infra* Part VI(G): Environmental Concerns with Storage.

214. Bhatnagar & Loose, *supra* note 23, at 19; Stein, *supra* note 23, at 713; David Schmitt, *How are we Splitting the Bill: A Solution to the Transmission Cost Allocation Problem*, 11 TEX. J. OIL GAS & ENERGY L. 381, 382-83 (2016).

215. Bhatnagar & Loose, *supra* note 23, at 21.

216. *Id*.

217. Technical Conference, *supra* note 3, at 16.

218. Bhatnagar & Loose, *supra* note 23, at 19; Deloitte, *supra* note 46, at 11; Technical Conference, *supra* note 3, at 8-9 (noting that in Western Grid, the FERC approved the use of a battery to provide voltage support and thermal overload protection for transmission facilities). The concept of using energy storage or other technologies to defer transmission investment is called a Non-Transmission Alternative (NTA) or Non-Wires Alternative (NWA). Tom Stanton, *Getting the Signals Straight: Modeling, Planning, and Implementing Non-Transmission Alternatives*, NAT'L REGULATORY RESEARCH INST. 1 (2015) [hereinafter NRRI NTA].

219. Bhatnagar & Loose, *supra* note 23, at 19; Grid Energy Storage Report, *supra* note 67, at 8.

220. *Id*.; Stein, *supra* note 23, at 713.

221. Grid Energy Storage Report, *supra* note 67, at 8. Only 50 percent of the transmission system is utilized in the U.S. because of the significant grid constraints that exist during the peak period times. Energy storage can help make better use of the existing infrastructure, and thereby reduce the need for near-term investment in transmission upgrades. *Wood*, 2 INST. FOR ELEC. INNOVATION, at 36. When transmission Planners plan the grid, they are faced with a choice of solving for the planning horizon, or for the life of the transmission project. Energy

life of transmission and distribution assets is especially important now because a significant portion of the grid is in need of replacement due to age.[222] Energy storage could help customers of municipalities, rural electric cooperatives ("Co-ops"), and investor-owned utilities achieve substantial cost savings by deferring transmission upgrades.[223] There are several ways that energy storage can help strengthen the transmission and distribution grid.

1. Transmission

a. Transmission Upgrade Deferral

Even a small amount of energy storage can help postpone transmission investment and, in some cases, avoid it entirely.[224] For example, consider a transmission system where the peak load is approaching the line load-carrying capacity. If storage is installed downstream from the nearly overloaded node, this would delay the need to upgrade the line for at least a couple of years.[225] Also, by decreasing the load on transmission components, the life of these components can be extended perhaps by a few years.[226] The key consideration in this scenario is that by using energy storage to defer the construction of the transmission infrastructure it: (1) reduces the overall costs passed to ratepayers; (2) improves utilization of utility assets; (3) allows capital to be directed to other priorities, (4) reduces the financial risk associated with the transmission investments, and (5) reduces the need to construct infrastructure to meet the highest load, which may only happen for a few hours a year.[227] Energy storage can also be used to lower or eliminate transmission upgrades needed for interconnection of generation by managing the amount of electricity injected into the grid at a given moment.[228] Furthermore, because it can be added in scalable blocks, it can lower the chances of stranded

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storage gives the Transmission Planners the option of solving transmission issues that are in the planning phase, and thus give planners more flexibility. Technical Conference, *supra* note 3, at 19-20.

222. DEPARTMENT OF ENERGY, TRANSFORMING THE NATION'S ELECTRICITY SYSTEM: THE SECOND INSTALLMENT OF THE QER 1-22 to 1-23 (Jan. 2017) [hereinafter 2nd QER]; Joshua D. Rhodes, *The old, dirty, creaky US electric grid would cost $5 trillion to replace. Where should infrastructure spending go?*, THE CONVERSATION (Mar. 16, 201), https://theconversation.com/the-old-dirty-creaky-us-electric-grid-would-cost-5-trillion-to-replace-where-should-infrastructure-spending-go-68290; Grid Energy Storage Report, *supra* note 67, at 8.

223. The benefits of deferral can be seen in comparing Co-ops and Investor Owned Utilities (IOUs) on their customers and revenue per mile of transmission line. Nationally, Co-ops have an average of 7.4 customers per mile and collect revenue of $15,000 per mile. IOUs, however, have 34 customers per mile and receive $75,500 in revenue per transmission line. Thus, Co-ops put greater emphasis on mitigating of feeder congestion and voltage support. However, both Co-ops and IOUs could use energy storage to defer substation capacity buildout and to address transmission issues. Akhil et al., *supra* note 29, at 131.

224. Akhil et al., *supra* note 29, at 15.

225. *Id*. at 16.

226. *Id*.

227. *Id*.

228. Current rules in many RTOs require a generation interconnection customer to pay for transmission upgrades when interconnecting if their generation would cause a line to carry more electricity than it is designed for (overloading). Herman K. Trabish, *Utilities Take Note: Hybrid Renewables Projects Are Coming*, UTILITY DIVE (Apr. 3, 2018), https://www.utilitydive.com/news/utilities-take-note-hybrid-renewables-projects-are-coming/520319/ [hereinafter Utility Dive Hybrid].

assets and lower the risks associated with uncertainty by allowing for more timely and flexible deployment.[229] In essence, it allows grid planners to become more reactive and less speculatively proactive during transmission planning by allowing them to address peaks on a shorter future horizon.[230] This is especially true when looking at the modularity of many energy storage technologies.[231]

b. Transmission Congestion Relief

Storage can also help ease the amount of transmission congestion on the grid. Transmission congestion occurs when the least-cost electricity cannot be delivered.[232] This happens when transmission upgrades do not keep pace with the demand for electricity and bottlenecks form.[233] These bottlenecks lead to increased congestion costs or higher locational marginal prices (LMPs) on the wholesale electricity market.[234] By placing storage downstream from the congestion points on the grid, it could be charged when congestion is not present and discharged during times of high demand, thereby minimizing the effects of congestion on the grid. [235]

2. Distribution

The distribution portion of the grid can also benefit from energy storage. The distribution system is the portion of the system that carries the electricity to homes and business, while transmission is the portion of the system that carries electricity over long distances.[236] Distribution upgrade deferral is similar to transmission upgrade deferral in that it uses storage to avoid or delay investment in the distribution grid.[237] Examples of that investment include replacing or augmenting distribution transformers and substations or the need to use a heavier wire on the distribution lines than would otherwise be need be necessary to meet the requirements to serve all loads.[238] When a transformer is being replaced, it is sized to accommodate future load growth on a fifteen to twenty year planning horizon.[239] This creates two practical issues: (1) equipment is underutilized through a large portion of its useful life and (2) ongoing risk that the predicted growth may not appear.[240]

229. Technical Conference, *supra* note 3, at 73-74.

230. *Id*.

231. Akhil et al., *supra* note 29, at 16.

232. Congestion on the line causes the grid operator to curtail generation to keep the lines from overloading. This curtailment prevents generators from selling electricity and customers from having access to the cheapest electricity available. Schmitt, *supra* note 214, at fn. 95.

233. Akhil et al., *supra* note 29, at 17; Schmitt, *supra* note 214, at 394.

234. Akhil et al., *supra* note 29, at 17.

235. *Id*.

236. ENERGY INFO. ADMIN., ELECTRICITY EXPLAINED HOW ELECTRICITY IS DELIVERED TO CONSUMERS (Aug. 31, 2017), https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery.

237. *Id*.

238. Akhil et al., *supra* note 29, at 19; Grid Energy Storage Report, *supra* note 67, at 26.

239. Akhil et al., *supra* note 29, at 19-20.

240. Grid Energy Storage Report, *supra* note 67, at 26; Akhil et al., *supra* note 29, at 20.

Energy storage can also help extend the life cycle of equipment by ensuring the peak periods do not overtask the grid.[241] Storage can help reduce the investment needed to serve load when it is at its highest peak for a few hours.[242] Furthermore, if the storage system is containerized, it can be moved to another substation when the one it is currently supporting is upgraded.[243] This could allow system planners greater flexibility to see whether load materializes at a given location.[244] Additionally, a storage system that was used to defer distribution upgrades could simultaneously provide ancillary services such as voltage support on the distribution line even with no market available to or for it.[245] Being able to control voltage is especially important on long radial lines or when one of the customers uses arc welders or has a residential PV system, because these may cause unacceptable voltage excursions onto neighboring customers.[246] Storage can help to dampen these voltage fluctuations with minimal draw of real power from the storage system.[247]

H. Smart Grid and Building Tomorrow's Grid With Energy Storage

Energy storage will be a key component of the smart grid and the grid of tomorrow.[248] As previously mentioned, the grid of the future will be smarter with two-way power flows.[249] This is driven not just on the supply side by technologies such as renewables, but also on the demand side by technologies such as the electric vehicles (EV).[250] The growth of rooftop solar and EVs will stress the infrastructure by putting more demands on it.[251] Smart grids combined with energy storage will help smooth the troughs and spikes that happen in the electric system on a day-to-day basis.[252] Some have even said that storage is one of the key components necessary to move us towards a smarter grid.[253] Energy storage allows a smarter grid because it gives the other smart grid technologies the flexibility they need.

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241. Akhil et al., *supra* note 29, at 19-20.

242. Grid Energy Storage Report, *supra* note 67, at 26; Akhil et al., *supra* note 29, at 20.

243. Grid Energy Storage Report, *supra* note 67, at 26-27.

244. *Id*.

245. Akhil et al., *supra* note 29, at 20; Grid Energy Storage Report, *supra* note 67, at 27; Mullendore, *supra* note 96, at 6; FEDERAL ENERGY REG. COMM'N, COMMISSION STAFF REPORT: PAYMENT FOR REACTIVE POWER (April 22, 2014).

246. Akhil et al., *supra* note 29, at 20; Grid Energy Storage Report, *supra* note 67, at 27.

247. Akhil et al., *supra* note 29, at 20; Grid Energy Storage Report, *supra* note 67, at 27.

248. MASSACHUSETTS INST. OF TECH., THE FUTURE OF THE ELECTRIC GRID 20 (2011) ("While uses of the term [smart grid] vary throughout industry, government, and the public, it is perhaps best described as the expanded use of new communications, sensing, and control systems throughout all levels of the electric grid.").

249. 2nd QER, *supra* note 222, at 1-23 to 1-25.

250. Roberts & Sandberg, *supra* note 74, at 1139.

251. Some have predicted that EV's alone could add substantial peak demand growth and even change the load profiles. Gavin Blade, *CEC: California EV chargers will add 1 GW of peak demand by 2025*, UTILITY DRIVE (2018), https://www.utilitydive.com/news/cec-california-ev-chargers-will-add-1-gw-of-peak-demand-by-2025/519517/; Roberts & Sandberg, *supra* note 74, at 1141.

252. Lindley, *supra* note 152, at 18-20; Roberts & Sandberg, *supra* note 74, at 1141.

253. J. Michael Barrett, *Challenges And Requirements For Tomorrow's Electrical Power Grid*, LEXINGTON INST., 15 (2016).

VI. WHAT ISSUES ARE CONFRONTING ENERGY STORAGE?

There are many regulatory and market issues that inhibit energy storage from playing a more robust role in the electricity market. This is in large part due to the regulatory framework that was developed over the last century combined with the limited experience working with these new technologies, besides pumped hydro storage.[254] The FERC has observed that "market rules designed for traditional generation resources can create barriers to entry for emerging technologies."[255] The FERC has responded by promulgating rules that recognize the operational characteristics of non-traditional resources such as variable energy resources and demand response."[256] Additional potential barriers to storage are competing policy proposals (e.g., demand response, energy efficiency, distributed generation, etc.) and the need to balance energy storage with these polices.[257] Finally, market issues arise concerning how to capture the value (or return on investment) of energy storage installations.[258] These issues are exacerbated when regulatory frameworks artificially limit the types of value energy storage installations can capture based on outdated regulatory classifications.[259] There are many issues that will need to be solved, and some technologies have more issues than others.

A. The Issues of Newness

While energy storage is not new, e.g. pumped hydro storage, it has not yet been widely deployed on the grid.[260] This creates numerous challenges for grid operators; notably, market rules were not developed with energy storage in mind and are not aligned with its unique physical and operational characteristics, which differ from traditional generation.[261] The FERC has recognized these issues and has recently devoted considerable resources to ensure that energy storage can operate in the market.[262] Examples of the FERC's efforts in facilitating integration of energy storage can be seen in Order 841 and Order 842.[263] As earlier noted, Order 842 requires that energy storage be able to provide (primary) frequency response.[264] It compelled energy storage operators to identify "particular operating circumstances when electric storage resources will not be required to provide pri-

254. Bhatnagar & Loose, *supra* note 23, at 23.

255. Notice of Proposed Rulemaking, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, [2016 Proposed Regs.] F.E.R.C. STATS & REGS. ¶ 61,121, Fed. Reg. 9,580 (2016) [hereinafter Energy Storage NOPR].

256. *Id*. at P 9.

257. Univ. of Cal., *supra* note 44, at 112.

258. *Id*.

259. *Infra* Value and Classification.

260. While many RTOs have had experiences working with Pumped hydro storage for many years with it bidding into eh electricity markets, other types of energy storage, such as lithium-ion and flywheels, are now appearing in energy markets. Order No. 841, *supra* note 25, at P 7.

261. Order No. 842, *supra* note 105, at P 176.

262. *See generally* Order No. 841, *supra* note 25; *see also* Order No. 842, *supra* note 105.

263. *See generally* Order No. 841, *supra* note 25; *see also* Order No. 842, *supra* note 105.

264. Order No. 842, *supra* note 105, at P 176.

mary frequency response, and the inclusion of energy limitations in the list of exemptions from the requirement to provide primary frequency response."[265] Other issues are that current tariffs that address energy storage are designed around one particular technology and limit small energy storage assets to demand response programs.[266] Another issue facing energy storage is that the current grid modelling and simulation software are not able to model the complexities of energy storage such as its ability to deliver multiple services simultaneously.[267]

B. How Do We Categorize Energy Storage?

A major challenge facing more robust integration of energy storage is that there is no universally accepted system for classifying energy storage into the traditional categories of generation and transmission.[268] Establishing a legal definition is important because investment recovery cases require an operational definition and that the goals of implementing energy storage to be defined.[269] The issue is that energy storage and its inherent complexity differs from traditional resources in that it cannot be reduced to a single functional definition.[270] Storage can be generation (injecting energy into the grid or providing ancillary services), load (withdrawing energy from the grid), or transmission (transporting energy through time), and therein lies the crux of the problem.[271] Energy storage does not fit neatly into the "holy trinity" that the industry has been accustomed to or the framework design around the ideas of separate generation, transmission, and distribution.[272] While assets have been traditionally defined by their function (generation or transmission), energy storage can perform both functions.[273]

On more than one occasion, the FERC has observed "electricity storage devices . . . do not readily fit into only one of the traditional asset functions of generation, transmission or distribution. Under certain circumstances, storage devices can resemble any of these functions or even load."[274] The result is that energy storage does not fit neatly into these rigidly defined federal or state jurisdictional

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265. *Id*. at P 177.

266. Order No. 841, *supra* note 25, at PP 11-12, 19.

267. *See generally* Colthorpe, *supra* note 20.

268. Crossley, *supra* note 23, at 269; Bhatnagar & Loose, *supra* note 23, at 26.

269. Bhatnagar & Loose, *supra* note 23, at 26.

270. Crossley, *supra* note 23, at 274.

271. Meyer, *supra* note 3, at 524. Depending how energy storage is classified it can mean the awarding tax credits, as the IRS in a ruling allowed a wind farm to claim a thirty percent investment tax credit on energy storage batteries because the devices were not treated as transmission for regulatory purposes. Stein, *supra* note 23, at 717; *see also PJM Interconnection, L.L.C.*, 149 F.E.R.C. ¶ 61,185 (2014), *reh'g denied*, 151 F.E.R.C. ¶ 61,231 (2015) (holding that energy storage in the PJM market would be required to pay wholesale distribution charges even though the FERC has classified storage as generation in some context).

272. Technical Conference, *supra* note 3, at 5.

273. *Id.*

274. *Western Grid Dev. L.L.C.*, 130 F.E.R.C. ¶ 61,056 at P 44 (2010); *see also Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery*, 158 F.E.R.C. ¶ 61,051 at P 2 (2017) [hereinafter Energy Storage Policy Statement] (noting that energy storage may fit into numerous tradition asset functions of generation, transmission, and distribution.); *see also* Order No. 845, *Reform of Generator Interconnection Procedures and* Agreements, 163 F.E.R.C. ¶ 61,043 at P 278 (2018) (noting that, in certain circumstances, energy storage can be a transmission asset, generation facility, or both).

categories, nor traditional ratemaking categories.[275] Problems arise because the FERC's jurisdiction often hinges on the resource's classification and energy storage blurs the categorization of the historical system.[276] Yet, it is because energy storage can transcend traditional categories by both withdrawing and injecting electricity into the grid that it can improve the efficiency and stability of the grid.[277] To fully capture the potential commercial value of energy storage systems, regulations must be developed to allow single systems to be valued for the generation, transmission, and ancillary services that they provide.[278]

Because electric storage resources do not readily fit into one of the traditional asset functions, the FERC has addressed the classification of energy storage devices on a case-by-case basis.[279] This case-by-case approach has two primary effects on investment in energy storage: (1) it is not competing on a level playing field in a FERC-jurisdictional market as the regulatory lag impedes progress; and (2) it picks winners and losers because winners receive the support of financial incentives (i.e., return on investment) and this will chill the research and commercialization of the losers.[280] Stakeholders criticize the resulting uncertainty that surrounds the fundamental classification issue, which, in turn stifles investments in energy storage.[281] There are several arguments on why it should be classified as generation or transmission.[282] How one classifies it can even affect whether the FERC or the states have jurisdiction over energy storage.[283]

1. Generation

Technically, utility scale energy storage does not currently store electricity; instead, it converts the electricity into kinetic, potential, mechanical, chemical, or thermal energy for storage and then back into electricity at discharge.[284] From an operational perspective, classifying storage as generation would be appropriate if it is intended to perform energy and ancillary services functions that support generation facilities, especially in organized markets.[285] The financial side of such a scenario would require market-based sales of electricity to pay for the energy storage project.[286] This means that the energy storage device would have to receive all the revenue from the arbitrage of power prices (i.e., based on what price it buys power and the price it receives for injecting power) and by providing market-based

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275. Michael J. Allen, *Energy Storage: The Emerging Legal Framework (And Why It Makes a Difference)*, 30 NAT. RESOURCES & ENV'T 20, 21 (2016); Meyer, *supra* note 3, at 484.

276. Meyer, *supra* note 3, at 524; Bhatnagar & Loose, *supra* note 23, at 26.

277. Hagan & Ruger, *supra* note 18, at 3; Akhil et al., *supra* note 29, at 27.

278. Hagan & Ruger, *supra* note 18, at 3; Akhil et al., *supra* note 29, at 27.

279. 130 F.E.R.C. ¶ 61,056 at P 15.

280. Meyer, *supra* note 3, at 484; Crossley, *supra* note 23, at 269.

281. Stein, *supra* note 23, at 702-03, 718.

282. *Id.* at 702.

283. *Id.* at 716-717.

284. *Id*. at 718-19.

285. Meyer, *supra* note 3, at 525.

286. Ramteen Sioshansi et al. Economics of Energy and Environmental Policy, Market and Policy Barriers to Deployment of Energy Storage, 1 ECON. OF ENERGY & ENVTL. POL'Y 47, 56 (2012).

ancillary services.[287] If the energy storage is only classified as transmission, it is limited in the ability of capturing value from the transmission and distribution benefits and the non-market ancillary services that energy storage can provide.[288]

However, there are several arguments against the classification of energy storage as generation. First, the traditional characteristics of generation are that it sends power one way, while energy storage requires two-way power flows to charge and discharge.[289] There are those who also argue that an entity can only qualify as generation if it provides a net increase of electricity being injected into the grid, but energy storage merely converts electricity into something else to later be reconverted back to electricity, and thus provides no net increase in electricity.[290] Beyond this, energy storage technologies do not offer 100% efficiency during charging and discharging resulting in a net consumption of energy.[291] Furthermore, the FERC itself has noted that energy storage is "not a new source of energy [,]" rather "it takes unused off-peak electricity, and stores it for peak energy use. It is a supply management system which enhances the value of existing energy resources."[292] Based on this rationale, the economic benefits of energy storage are more analogous to the economic benefits of transmission in that it provides cheaper access to electricity.[293]

Another issue with calling energy storage generation is that in some states if generation is being built, then a Certificate of Public Good and Necessity (CPGN) will need to be acquired and storage may not qualify in some jurisdictions.[294] For an energy storage device to obtain a CPGN, operators need to show that it is a prudent investment and is in the public interest.[295] Energy storage may have difficulty in meeting these standards, particularly when regulations do not allow the storage installation to capture the value of all of the benefits it provides. Furthermore, under the Public Utilities Regulatory Act (PURPA), the FERC has held that energy storage does not qualify as a small power producer on its own merit—it is not a primary generating source, it charges with electricity generated elsewhere.[296]

287. *Id*.

288. *Infra* Part VI(D): Valuing Energy Storage.

289. Akhil et al., *supra* note 29, at 112.

290. Stein, *supra* note 23, at 719.

291. Opinion No. 192, *Power Auth. of the State of N.Y.*, 25 F.E.R.C. ¶ 61,084, at p. 61,266 (1983).

292. *Id*. at p. 61,265.

293. Schmitt, *supra* note 214, at 394-95 (noting that transmission provides economic benefits by allowing the access of cheaper electricity).

294. *See generally* Presidio Battery Order, *supra* note 166, at 4 (opponents of the NaS battery arguing that it needs a certificate of need and necessity).

295. Adrienne L. Tompson, *Preparing for the Energy Future by Creating It: What State Public Utility Commissions Can do to Promote Sustainable Energy Policies*, 7 GEO WASH. J. ENERGY & ENVTL. L. 215, 220 (2016). The public interest test is used to show that the investment furthers the underlying polices that the CPGN are issued under. To satisfy this test a utility must "demonstrate that the power from the new source is needed and that the resource being considered is the most economical or at least it is a part of an overall least cost plan. In addition, the utility must demonstrate that the timing is reasonable." Bangor Hydro–Electric Co. v. Pub. Utilities Comm., 589 A.2d 38, 40 (Me. 1991).

296. *Luz Dev. and Fin. Corp.*, 51 F.E.R.C. ¶ 61,078, at p. 61,172 (1990). How energy storage fits within PURPA will be an ongoing issue that the FERC will need to resolve going forward as PURPA developers have started to look at adding energy storage to their Qualify Facility projects. Robert Walton, *Franklin Energy Asks FERC to Reverse Idaho Decision on PURPA Energy Storage Contracts*, UTILITY DIVE (Jan. 17, 2018),

2. Transmission

The FERC has found that energy storage meets the definition of transmission "by addressing reliability concerns on the transmission grid through provision of voltage support and remaining revenue neutral in the [organized] markets. By contrast, generation is built almost exclusively to produce electricity and has limited shared characteristics with transmission."[297] A transmission asset can either transmit electricity or aid in the reliability of the grid by providing voltage support, frequency regulation, or other load leveling functions.[298] Furthermore, a transmission designation can be important under the FERC's recent Order 1000 because it requires transmission planners to consider public policy requirements established under state and federal law and non-transmission alternatives in transmission planning and this can include storage (transmission planning and energy storage is discussed *infra*).[299]

The FERC has also held that storage devices are transmission assets in the electricity and natural gas context. For example, the FERC has long held that capacitors, a type of energy storage, are categorized as part of the transmission infrastructure because they increase the capacity (or transfer capacity) of transmission lines and help keep the system reliable.[300] Additionally, the FERC's natural gas jurisprudence not only mandates that storage is considered a part of transmission, it requires that shippers of natural gas must have title to the gas when it is held in storage.[301] Furthermore, there are several reasons why the FERC thought that the pipelines with storage had superior rights compared to gas merchants without storage that closely mirror some of the benefits of energy storage. The pipeline with storage can arbitrage the price of gas during peak and off-peak times, and this can be used to supplement transmission capacity; and to flexibly manage third party supply and demand.[302]

An illuminating case of energy storage being classified as a transmission asset on the state level comes from the Public Utility Commission of Texas' (PUCT) decision regarding a sodium sulfur (NaS) battery installation in Presidio, Texas.[303]

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https://www.utilitydive.com/news/franklin-energy-asks-ferc-to-reverse-idaho-decision-on-purpa-energy-storage/514910/. The FERC gave notice that it did not intend to act on Franklin Energy's PURPA complaint. *See generally Franklin Energy Storage*, 162 F.E.R.C. ¶ 61,110 (2018).

297. 130 F.E.R.C. ¶ 61,056 at P 52. The battery in question was not selected in the end by Cal-ISO. CAL. INDEP. SYS. OPERATOR CORP., ISSUE PAPER STORAGE AS A TRANSMISSION ASSET: ENABLING TRANSMISSION CONNECTED STORAGE ASSETS PROVIDING REGULATED COST-OF-SERVICE-BASED TRANSMISSION SERVICE TO ALSO ACCESS OTHER MARKET REVENUE STREAMS 6 (2018) [hereinafter Cal-ISO Storage Issue Paper].

298. Stein, *supra* note 23, at 724.

299. *Id*. at 727.

300. *See, e.g., Newmont Nev. Energy Investment LLC v. Sierra Pacific Power Co.*, 147 F.E.R.C. ¶ 61,030 (2014); *American Electric Power Serv. Corp.*, 101 F.E.R.C. ¶ 61, 211 at P 13 (2002); *Southern. Co. Serv's, Inc.*, 80 F.E.R.C. ¶ 61,318 (1997); *Niagara Mohawk Power Corp.*, 124 F.E.R.C. ¶ 61,021 at P 35 (2008) (stating that the Commission was asserting jurisdiction over capacitor banks because it was relieving congestion on the transmission grid thus increasing the transfer capability of the transmission system).

301. Due to the similarities between the Federal Power Act and the Natural Gas Act, both are considered to be mirror images of each other. David Schmitt, *supra* note 214, at fn. 43; *In re Entergy New Orleans, Inc*., 122 F.E.R.C. ¶ 61,219 at PP 4-5 (2008).

302. 122 F.E.R.C. ¶ 61,219 at P 9.

303. *See generally* Presidio Battery Order, *supra* note 166.

At the heart of the PUCT's decision is an acknowledgement that the classification of an energy storage system is dependent upon the services it will provide.[304] In this case, the PUCT granted transmission status (and allowed cost recovery) to the portion of the battery that provided reactive power, but classified its back-up service as a distribution asset (with the need for a wholesale transmission rate schedule).[305]

Not only does the PUCT decision provide a look at classifying energy storage systems based upon the services they provide, it also provides a lesson in how the language of energy storage may differ from that of traditional grid assets.[306] Among the PUCT's findings of facts was the claim that "the battery does not generate electric power by converting another source of energy into electricity."[307] This finding is incorrect because all electrochemical batteries (of which NaS batteries are but one example) operate by converting chemical energy to electrical energy as they discharge, just as they convert electrical energy to chemical energy when they are charged.[308]

Notably, the PUCT acknowledges that while the battery adds power to the grid, without power from the grid, it cannot be charged.[309] In essence, the PUCT found that though the battery will provide power, it is not producing the power as a generation asset.[310] Rather, it is time-shifting power that was generated and added to the grid by another asset.[311] Setting aside the technical details of battery charging and discharging, based on this mode of operation, the PUCT decided that this battery was a transmission asset for improving reliability rather than a generation asset designed to add power to the grid for commercial sales.[312]

However, being designated as a transmission asset can limit the market and ownership of energy storage.[313] The FERC has expressed concern over energy storage as transmissions as this could affect the independence of RTO's and competition in the market.[314] For example, energy storage would be prohibited by current market rules from participating in wholesale energy and ancillary services markets if classified as transmission.[315] Wholesale energy and ancillary services markets have been the province of generators to maintain the independence of grid

304. *Id*. at 2.

305. *Id*.

306. *Id*.

307. Presidio Battery Order, *supra* note 166, at 2.

308. *See generally supra* notes 49-69 and accompanying text.

309. Presidio Battery Order, *supra* note 16, at 2.

310. *Id*.

311. *Id*.

312. *Id*.

313. Stein, *supra* note 23, at 728; *see also* Technical Conference, *supra* note 3, at 4 (noting that its approval of the storage facility in *Western Grid* was in part due to the energy storage owner forgoing the ability to operate as a market participant and thereby maintaining an independent RTO). This would mean that the energy storage owner would be forgoing revenue that could be needed to make the project economic and that the system would not be obtaining the full benefits if the system.

314. Technical Conference, *supra* note 3, at 4.

315. Stein, *supra* note 23, at 728.

operators and avoid the potential concern for any real or perceived market manipulation.[316] The other issue is that ownership of storage will be limited in restructured regimes as companies owning transmission and distribution assets are required to be separated from those that own generation assets.[317] Opponents of classifying storage as transmission worry that the characterization of energy storage as transmission will be a "back-door attempt to socialize the fixed costs of generation."[318] The concern is that it would also allow energy storage projects to receive "a guaranteed revenue stream. . .that would create an undue preference for [these energy storage projects] compared to these other similarly situated [projects]."[319] Because energy storage "would provide its transmission service by participating in the energy market, it would not exclusively be a transmission asset."[320] The result could be an increase in rates without any benefits.

Another concern with the independence of energy storage to other market participants is "the level of control in the operation of an electric storage resource by an RTO/ISO that could jeopardize its independence from market participants."[321] As, "[c]oordination between the RTO/ISO and the electric storage resource owner or operator will be necessary for electric storage resources that concurrently provide services compensated through cost-based rates and services compensated through market-based rates."[322] To understand this concern it is worth reviewing the history of how the competitive market was brought about and the rise of the RTOs under the FERC. This concern derives from the regulation of RTOs and ISOs by the FERC and the potential conflicts of interest regarding market participants.[323] The FERC is concerned with "'the principle of independence [because it] is the bedrock upon which the ISO must be built" and emphasized that this principle must apply to all RTOs both in reality and perception.[324] The purpose of and concern over the independence standard of RTOs is to ensure that an RTO provides transmission service and operates the grid in a non-discriminatory manner.[325] Equal access requires RTOs to be independent.[326] Accordingly, the question arises from whom should the RTO be independent? The FERC holds that RTOs should be independent from market participants.[327] This prohibition

316. *Id*.

317. *Id*.

318. *Id*.

319. *Id*. at P 83.

320. Sioshansi, *supra* note 286, at 8.

321. Energy Storage Policy Statement, *supra* note 274, at P 13; *Nevada Hydro Co.*, 122 F.E.R.C. ¶ 61,272 at P 82 (2008) (stating that the FERC disagreed with Nevada Hydro that it would be appropriate for CAISO to assume any operation control of a pumped hydro facility).

322. Energy Storage Policy Statement, *supra* note 274, at P 25. Chief among these concerns is the management of the state of charge.

323. *See generally* Order No. 2000, *Regional Transmission Organizations*, 89 F.E.R.C. ¶ 61,285, 65 Fed. Reg, 810 (1999) (to be codified at 18 C.F.R. Pt. 35) [hereinafter Order No. 2000].

324. *Id*. at 842.

325. *Id.*

326. *Id.* at 850.

327. *Id*.

against economic interests stretches from the RTO to its employees and independent directors.[328] The independence directive only works when the independence is both actual and perceived; otherwise, market participants could have reasons to believe that the RTO may favor a market participant, including itself.[329]

While it is true that RTOs are independent of market participants, they are not independent of the market itself because the RTO has certain required obligations (e.g. supplier of last resort for ancillary services and procuring these services efficiently and in a competitive manner).[330] "Given this possible conflict, [the FERC] will require that all RTOs must propose an objective monitoring plan to assess whether the RTO's involvement in these markets favors its own economic interests over those of its customers or members."[331] Commissioner LaFleur in her dissent to the FERC's Policy Statement regarding energy storage echoed these concerns when she noted that the policy statement dismissed concerns that multiple streams of revenue could have on market competition and RTO independence.[332]

C. *Who Has Jurisdiction Over Energy Storage?*

How assets are classified determines whether they fall under federal or state regulatory authority.[333] To make things even more complicated, the jurisdiction of energy storage could depend on how the company is structured and where storage is located on the grid.[334] The FERC can assert its jurisdiction over storage when it is deemed either "the transmission of electric energy in interstate commerce [or] to the sale of electric energy at wholesale in interstate commerce."[335] Energy storage would fall under the first part of the FERC's jurisdiction if it is either transmission services or the facilities used to effectuate transmission services.[336] The arguments for why storage can be classified as transmission and thereby subject to the FERC's regulation, or generation and thereby within the purview of the state, were discussed above.[337] "Sale for resale" is another option for the FERC to assert jurisdiction over energy storage, it is deemed a wholesale sale in interstate commerce.[338] This is the approach that the FERC took in asserting its jurisdiction under Order 841.[339]

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328. Order No. 2000, *supra* note 323, at 850.

329. *Id*.

330. *Id*. at 851.

331. *Id*. at 852.

332. Energy Storage Policy Statement, *supra* note 274, at 24 (LaFleur, C., dissenting); *see also* Indianapolis Power & Light, *supra* note 108, at P 69 (further discussing this process of creating multiple streams of revenue – known as "value stacking.").

333. *See generally* DAVID E. POMPER, *Pausing the Speed of Light: Rethinking the Basis for Federal Jurisdiction over Storage Services*, ELECTRICITYPOLICY.COM 6 (2011), http://www.spiegelmcd.com/files/Pomper_merged_2011_11_15_02_26_56.pdf (last visited May 13, 2018).

334. *Id*.

335. 16 U.S.C. § 824(b)(1), (f) (2017). However, the FERC does not regulate state (e.g. municipals) and federal power agencies (e.g. Tennessee Valley Authority).

336. New York v. FERC, 535 U.S. 1, 20 (2002); Pomper, *supra* note 333, at 2.

337. *See generally* 16 U.S.C. § 824.

338. Order 841, *supra* note 25, at P 289.

339. *Id.* at P 30.

One of the lead cases relying on the "sale for resale" distinction is *Norton Energy Storage LLC* wherein the FERC asserted that it had jurisdiction over a compressed air energy storage (CAES) facility and the rates it would pay to charge itself.[340] The FERC found that it had jurisdiction over CAES given the analogous nature of CAES and pumped hydro (over which the FERC had previously asserted its jurisdiction).[341] The FERC stated:

> The fact that pumping energy or compression energy is not consumed means that the provision of such energy is not a sale for end use that this Commission cannot regulate. Rather . . . we find that deliveries of compression energy . . . as part of energy exchange transactions employing the conversion/storage cycle are wholesale transactions subject to our exclusive authority under the FPA.[342]

In addition to finding that the CAES was not a retail energy transaction, the FERC found the CAES would not fall under the rubric of station power, as "station power is consumed, and is not converted and stored as pumping energy and compression energy are."[343] This implies that the FERC can have jurisdiction over energy storage because it is a wholesale transaction, rather than relying upon its transmission jurisdiction.[344] The issue with basing jurisdiction on classifying storage as a sale for resale is that it would be easy for a company to structure a transaction that would not be a sale for resale of power and thereby leave a gap in jurisdiction.[345] For example, an energy storage owner could discharge only for retail sales if it is a vertically integrated utility.[346] Alternatively, transactions could be structured similar to natural gas storage, where the storage facility never takes title to the energy.[347]

Another jurisdictional issue is that of storage located on the distribution grid and whether the state or the FERC should regulate it.[348] In Order 841, the FERC stated that it has "exclusive jurisdiction over the wholesale markets and the criteria for participation in those markets, including the wholesale market rules for participation of resources connected at or below distribution-level voltages."[349] According to Order 841, the FERC announced that the states would still have the authority to regulate retail services and the distribution grid.[350] The FERC also stated that nothing in the Order should be construed to affect the "responsibilities of distribution utilities to maintain the safety and the reliability of the distribution system or their use of electric storage resources on their systems."[351]

340. *Norton Energy Storage, LLC.*, 95 F.E.R.C. ¶ 61,476, at p. 62,702 (2001).

341. *Id*. at p. 61,701-02.

342. *Id*. at p. 61,702.

343. *Id*. at p. 61,703.

344. Pomper, *supra* note 333, at 5.

345. *Id*. at 6-7.

346. *Id*. at 6.

347. *Id*.

348. Order 841, *supra* note 25, at P 26.

349. *Id.* at P 35. The Commission also observed that this exclusive jurisdiction extended to other areas such as demand response and energy efficiency.

350. *Id*. at PP 26, 32, 38.

351. *Id*. at P 36.

On the issue of jurisdiction, the FERC's Order 841 relied in part on its decision in *Advanced Energy Economy* and *FERC v. Electric Power Supply Ass'n*.[352] In *Advanced Energy Economy*, the FERC said that it had exclusive jurisdiction over energy efficiency resources that participate in the wholesale market and that relevant electric retail regulatory authorities (RERRAs) "may not bar, restrict, or otherwise condition the participation of EERs [Energy Efficiency Resources] in wholesale markets unless [FERC] expressly gives RERRAs such authority."[353] The decision about jurisdiction was also based in part on the United States Supreme Court decision in *FERC* v. *Electric Power Supply Ass'n* where the Court upheld Order 745, which allowed aggregators of third party demand response to bid into the wholesale market.[354] The FERC in the Rehearing Order in *Advanced Energy Economy* rejected the argument that its interpretation of *Electric Power Supply Ass'n* was overboard because while the Demand Response Order was an exercise in cooperative federalism, the FERC's ability to regulate was well with the boundaries of its exclusive jurisdiction.[355]

There are several issues with the FERC's assertion of exclusive jurisdiction over energy storage on distribution grids.[356] The FERC in the *Advanced Energy Economy* Order stated that any effects of the wholesale energy efficiency on the RERRA-controlled system would be incidental and not substantial.[357] As, the FERC noted, "[u]nlike demand response resources, EERs are not likely to present the same operational and day-to-day planning complexity that might otherwise interfere with an [Load Serving Entity's] day-to-day operations."[358] However, because energy storage may involve the buying and selling of electricity at both the wholesale and retail level, it will not be incidental, nor minimal, but of much greater significance than that of even demand response.[359] Thus, energy storage is at least closer to the FERC's jurisdiction over demand response, where the FERC gave the states an ability to opt-out of wholesale demand response.[360] Furthermore, unlike demand response where "whatever the effects at the retail level, every aspect of the regulatory plan happens exclusively on the wholesale market and governs exclusively that market's rules," energy storage at the customer level will have an effect at the retail level because the electricity would comingle in the battery.[361]

Assume that a customer-sited energy storage installs meters as directed by Order 841 (though how many need to be installed could be in question). [362] If it

352. *Id*. at P 92.

353. *Advanced Energy Econ.*, 161 F.E.R.C. ¶ 61,245 at PP 57, 59, 61 (2017) (Order granting in part and denying in part Advanced Energy's Petition for Declaratory Order).

354. FERC v. Electric Power Supply Ass'n, 136 S.Ct. 760, 763 (2016).

355. *Advanced Energy Econ.*, 163 F.E.R.C. ¶ 61,030 at PP 39-40 (2018) (Order denying rehearing and granting clarification in part).

356. *Id.* at P 6.

357. 161 F.E.R.C. ¶ 61,245 at P 63.

358. *Id*.

359. *Id*. at P 36.

360. *Electric Power Supply Ass'n*, 136 S.Ct. at 778-80.

361. *Id*. at 776.

362. Order 841, *supra* note 25, at P 317.

discharges into the wholesale market, it gets the wholesale price.[363] However, if it discharges to the customer, it would be entitled to the retail rate.[364] Energy cannot be traced from grid through storage and back to the grid.[365] There is no way to know precisely which electrical energy was used for which purpose as it has become comingled.[366] Because we cannot assume traceability and identity of energy in energy storage, the meters could tell us how much electricity was stored, consumed, and injected into the grid, but upon discharge they cannot differentiate discharged energy by original source.[367]

While a "First-In, First-Out" (FIFO) or "First-In, Last-Out" (FILO) could be used to delineate the electricity in question, it then begs the question, who chooses which method to use? This issue of determining what is wholesale versus resale versus self-generated would only grow in complexity if distributed generation was also involved.[368] Thus, energy storage sited on the distribution grid should be governed under an opt-out provision. Storage on the transmission grid is the FERC regulated and should be treated as such.[369] This approach has many of the same benefits that the co-federalism approach as contemplated in Order 719, which was upheld in *FERC v. EPSA*.[370]

Thus, turning to Order 719 which was the heart of *FERC v. EPSA* is a particularly illuminating example of how the jurisdictional boundaries between the FERC and state PUC's should lie with regard to energy storage.[371] A portion of Order 719 dealt with demand response.[372] The FERC has noted that demand response provides: "competitive pressure to reduce wholesale power prices; increases awareness of energy usage; provides for more efficient operation of markets; mitigates market power; enhances reliability; and in combination with certain new technologies, can support the use of renewable energy resources, distributed generation, and advanced metering."[373] By allowing its participation in wholesale markets, it enables demand-side resources to improve "the economic operation of electric power markets by aligning prices more closely with the value customers place on electric power."[374]

As the Commission has expressed "well-functioning competitive wholesale electric markets should reflect current supply and demand conditions," and that "the wholesale electric power market works best when demand can respond to the wholesale price."[375] The pertinent part of Order 719's requirements regarding demand response and the opt-out provision is where it notes that if the FERC did not

363. *Id.* at P 304.
364. *Id*.
365. Clare Hatcher, *Law Society's Gazette*, BUTTERWORTHS 87.39(19) (1990) (UK).
366. *Id*.
367. Order 841, *supra* note 25, at P 48.
368. *Id.* at P 312.
369. *Id.* at P 294.
370. *Electric Power Supply Ass'n*, 136 S.Ct. at 780.
371. *Id*.
372. Order 719, *supra* note 105, at P 3.
373. *Id*. at P 16.
374. *Id*.
375. *Id*. at PP 16, 18.

allow the opt-out, Order 719 may "have unintended consequences, such as placing an undue burden on the relevant electric retail regulatory authority."[376] The only requirement that the Commission placed on Relevant Electric Regulators who choose to opt-out was that "their decision or policy should be clear and explicit so that the RTO or ISO is not tasked with interpreting ambiguities."[377]

Energy storage has many similarities with demand response. Energy storage, like demand response, can be used to alter the demand on the grid.[378] In fact, when it is charging the FERC has described it as a dispatchable demand asset, because it can take energy off the grid.[379] Demand response can also provide similar benefits to energy storage in terms of economics, efficiency, reliability, and renewable integration.[380] Thus, this can create a dilemma where if energy storage decides to be a demand response it may run the risk that it cannot participate in the energy market if a RERA used its authority under Order 719's opt-out provision, but under Order 841 it could participate in wholesale markets.[381] Even though energy storage injects power back onto the grid, it is clear that given the similarities between demand response and energy storage, the State PUC's need at the very least an opt-out option in allowing energy storage to bid into the wholesale market.[382]

D. Valuing Energy Storage

Valuing energy storage appropriately, especially when it provides multiple benefits, is a unique challenge facing storage.[383] The FERC has observed that "new resources may have difficulty creating momentum for the market rule changes necessary to facilitate their participation and may thus need to spend considerable time and effort to gain entry to the organized wholesale electric markets" and this is especially true with new technologies such as storage, demand response, and variable energy resources.[384] This means that storage has to (at least in the beginning for newer technologies) operate within existing market rules that were designed primarily around a generation portfolio of central stations that were almost exclusively fueled by fossil fuels.[385] For example, pumped hydro storage has

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376. *Id*. at P 155.

377. Order No. 719-A, *order on reh'g*, 128 F.E.R.C. ¶ 61,059 at P 50 (2009).

378. As previously mentioned, the FERC allows energy storage to participate in demand response programs. Order No. 841, *supra* note 25, at P 56. The FERC further stated in its definition that it was not extending Order 841's definition of energy storage to behind the meter energy storage that does not inject electric energy back onto the grid because the FERC considers that to be a demand response resource. *Id*. at 322. As the FERC has stated, it does not matter whether the method is behind the meter generation, lowering electricity use, or some other method, the grid still sees it as a reduction of demand. *ISO New England Inc.*, 138 F.E.R.C. ¶ 61,042 at P 76 (2012), *reh'g denied*, 139 F.E.R.C. ¶ 61,116 at P 5 (2012).

379. Order No. 841, *supra* note 25, at P 125.

380. Order No. 719, *supra* note 105, at P 16.

381. Order No. 841, *supra* note 25, at P 12.

382. *Id.* at P 30.

383. Kaplan, *supra* note 11, at 21.

384. Energy Storage NOPR, *supra* note 255, at P 2.

385. Allison Clements, *FERC Affirms Support for Removing Market Barriers to Energy Storage, Other Clean Energy Resources*, ENERGY COLLECTIVE 1-2 (Feb. 28, 2014), http://theenergycollective.com/nrdcswitchboard/346136/ferc-affirms-support-removing-market-barriers-energy-storage-other-clean-enery; Energy Storage NOPR, *supra* note 255, at P 2.

had to bid into RTOs as a generator.[386] However, the increased presence of renewables, demand response, distributed generation, energy storage, and energy efficiency has rendered the current rules outdated and even discriminatory because energy storage cannot play on a level playing field.[387] The FERC has tried to level the field through Order 841's requirement of a participation model for energy storage that takes into account its eligibility to "provide all capacity, energy, and ancillary services that it is technically capable of providing, including services that the RTOs/ISOs do not procure through an organized market."[388] However, there are still many issues to work through about how to value the benefits of storage.

An example of this is Indianapolis Power and Light's (IPL) complaint against Midcontinent Independent System Operator (MISO) arguing that its battery provides primary frequency response, thereby contributing to MISO's compliance with NERC Reliability Standard BAL-003-1.1, but MISO does not compensate IPL for this service.[389] Although the FERC rejected several of IPL's claims, the FERC's finding that the MISO tariff was "unjust, unreasonable, and unduly discriminatory or preferential because it unnecessarily restricts competition by preventing energy storage resources from providing all the services that they are technically capable of providing, which could lead to unjust and unreasonable rates . . ." represents a significant step forward on properly valuing storage.[390] However, the FERC did not find that it would be appropriate to require MISO to adopt a market approach for primary frequency regulation, even if energy storage and other resources could do it better.[391]

The FERC has recognized that energy storage has the ability "to charge and discharge electricity and can provide a variety of grid services to multiple entities (e.g., RTO/ISOs, transmission and distribution utilities) or in multiple markets.[392] In addition, these resources are able to provide multiple services almost instantaneously and can switch from providing one service to another almost instantaneously."[393] Accordingly, the FERC has posited that "[e]nabling electric storage

386. Order No. 841, *supra* note 25, at P 7.

387. Clements, *supra* note 392; 158 F.E.R.C. ¶ 61,107 at P 69.

388. Order 841, *supra* note 25, at P 76. Some have argued that if the participatory model, if applied to all generation, load, and even some transmission, may represent a better way of thinking and operating the wholesale market in a more efficient and effective matter. Mark Ahlstrom, *Blog: The Universal Market Participation Model*, ESIG (Apr. 5, 2018), https://www.esig.energy/blog-the-universal-market-participation-model/.

389. 158 F.E.R.C. ¶ 61,107 at P 8. The FERC found that IPL had not proven that MISO's tariff was unjust, unreasonable, and unduly discriminatory or preferential regarding the failure to compensate providers of primary frequency response. *Id*. at P 33. The FERC also found that Indianapolis Power and Light had not meet its burden in proving how MISO operated its Storage Energy Resource (SER) Tariff harmed its battery storage unit. *Id*. at P 65. Similar issues are playing out in PJM where complaints against PJM alleging that changes to their Reg-D Frequency Regulation signal is unreasonable and unduly discriminatory because it changed the operating parameters of the dispatch signal and these changes will cause energy storage operators to operate well outside the parameters were designed for, thus ultimately reducing expected service life of the energy storage. *Energy Storage Ass'n v. PJM Interconnection*, 162 F.E.R.C. ¶ 61,296 at PP 2-10 (2018).

390. 158 F.E.R.C. ¶ 61,107 at P 69.

391. *Id*.

392. Energy Storage Policy Statement, *supra* note 274, at P 2.

393. *Id.* These services can be broken down into transmission, distribution, wholesale market, or customer located. The only storage services that do not fall under the FERC's purview is distribution and customer services. *See also* Technical Conference, *supra* note 3, at 1-2.

resources to provide multiple services (including both cost-based and market-based services) ensures that the full capabilities of these resources can be realized."[394] This maximizes energy storage's efficiency and value to the system and thus to customers.[395] This is called "value-stacking" because it is combining multiple value streams into a single system.[396] The cost of current energy storage represents a financial risk that will persist until technologies are able to monetize all of their benefits through a cost recovery mechanism that is able to accurately price the stacked benefits.[397]

Consistent pricing for energy storage benefits does not exist and this inhibits investments because energy storage lacks an established revenue-generating model.[398] Historically, the value of storage has been priced as the differential between light-load hours and the higher price during the high-load hours in the wholesale market on the assumption that the primary value of storage was economic arbitrage.[399] However, this fails to recognize the value associated with the provision of ancillary services transmission and/or distribution deferment, and other benefits, and ignores the uniqueness of storage, its advantages as a resource with quick response times, the bi-directional capabilities, and the fact that it produces minimal emissions.[400] In fact, some studies have found that "30–40% of the total system-wide benefits of storage investments are associated with reliability, transmission, and distribution functions that are not reflected in wholesale market prices and, therefore, cannot be captured by merchant storage investors."[401]

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394. Energy Storage Policy Statement, *supra* note 274, at P 2; Sydney P. Forrester et al., *Policy and Market Barriers to Energy Storage Providing Multiple Service*, ELEC. J., 50, 51 (Nov. 2017).

> Regulated services are compensated through a charge across utility customer bills with regulatory approval (i.e., rate-basing), while market-revenue services are compensated through revenues from competitive markets. For many investors, cost recovery via rate-basing is attractive due to its stable cash flows. However, cost recovery from the competitive market can prove to be more lucrative and flexible, allowing storage owners to take advantage of momentary, daily, seasonal, annual, and multi-year fluctuations in the value of services and electricity.

395. Energy Storage Policy Statement, *supra* note 274, at P 2; Forrester et al., *supra* note 394, at 50 ("[i]f only considered for a single service, energy storage often costs more when compared to traditional infrastructure such as thermo-electric generators" and thus is often not considered a valid economic choice).

396. Forrester, *supra* note 394, at 54; Sky Stanfield et al., *Charging Ahead: An Energy Storage Guide for State Policymakers*, INTERSTATE RENEWABLE ENERGY COUNCIL 8 (April 2017).

397. Univ. of Cal. et al., *supra* note 44, at 106; Stanfield et al., *supra* note 396, at 25.

398. Grid Energy Storage Report, *supra* note 67, at 31; Order No. 755, *supra* note 105, at 79 n.122 (The FERC has explained that when "a storage resource that is only allowed to participate in the frequency regulation market has no opportunity costs related to the energy market, unlike a traditional generator. Therefore, the storage resource's capacity payment could be lower than the generator's capacity payment. These payments send inefficient signals to market participants.").

399. ECOFYS, ENERGY STORAGE OPPORTUNITIES AND CHALLENGES 1, 44 (APRIL 4, 2014).

400. *Id*. Furthermore, some of the benefits that energy storage can provide do not have auction markets to provide a source of revenue for the energy storage operator and thereby lowering the economics of energy storage. Mullendore, *supra* note 96, at 6.

401. Judy Chang et al., *The Value of Distributed Electricity Storage in Texas Proposed Policy for Enabling Grid-Integrated Storage Investments*, BRATTLE GRP. 2 (2014). Consider several overnight hours where energy prices are zero and renewables are curtailed during the hours of 1 A.M and 4 A.M and a high price of $50/MWh during peak times of 4 till 7 P.M. Let us also suppose that a 300 MW storage plant is replacing a 300 MV high price peaker plant that bids in at $50/MWh in the late afternoon. Thus, the storage plant could eliminate $45,000 of operational costs (300 MW * 3 hour * $50/MWh). If there were enough storage to absorb all the curtailed

The FERC has recognized that the current rules may hinder energy storage from providing all services it is capable of, including the rules already in place for its operation.[402] There are several factors that prevent energy storage from obtaining all the benefits it produces: (1) owing to the complexity of the grid and the fact-specific nature of any energy storage installation, there is not an approach that will work for energy storage all of the time; thus, there is always some uncertainty in describing and documenting the benefits of the storage; (2) there is a division of the benefits of storage between the owners, ratepayers, and the grid with the owner unable to capture enough of the benefits value to make it a good investment decision; (3) there is the issue of the ability of storage to respond quickly (often measured in fractions of cycles) is both its strength and weakness in estimating its value; and (4) there is the issue of stacking, where storage provides multiple benefits at once.[403] This happens because energy storage may be able to provide ancillary service during the charging cycle and discharging cycles.[404] This creates the potential for storage to obtain multiple streams of revenue, thereby making it economically viable.[405] The value stack of a given energy storage project will be dependent upon its location and the technology used.[406] Thus, the valuing of the stacked services requires careful planning and should be considered on a case-by-case basis.[407]

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renewable energy and displace the generation from the peaking unit, then it would change the marginal prices for electricity. Thus, the storage when charging will charge at a higher rate (assume $20/MWh) and not $0/Mwh, even if it was charged from what was curtailed electricity from renewable energy. The opposite is true with the peak period as it experiences a drop in the marginal price because the storage plant displaces the high cost (assume now that the price is $37.5/MWh, the price of generation from a combine cycle gas turbine). Under these assumptions, assuming a $75% round-trip efficiency, the storage plant would pay $24,000 to charge (300 MW * 4 hours * $20/ MWh) and receive $33,740 dollars (300 MW * 3 hours * $37.5 MWh) in revenue for net revenue of $9,750 but provide $45,000 in benefits by reducing the operating costs of the system. Denholm, *supra* note 139, at 25.

> In an extreme case, a storage plant could change the net load to the point where on-- and off--peak prices are the same, and while the storage plant could provide significant value it could actually lose money in a market setting. The same general phenomenon could also occur for a storage device providing reserves.

402. Order No. 841, *supra* 25, at P 14, 56 (noting that energy storage resources are not precluded from operating as demand response resources).

403. Matthew Deal et al., *Electric Energy Storage: An Assessment of Potential Barriers and Opportunities*, CAL. PUB. UTIL. COMM'N, July 9, 2010, at 5; Akhil et al., *supra* note 29, at 112. When the market acknowledges speed and accuracy of resource, it ensures the proper levels of ancillary services are procured. Order No. 784, *supra* note 104, at P 111; Order 784 required among other things that transmission operators reward technologies, such as energy storage, that can quickly and accurately dampen disturbances in frequencies. This order boosted storage systems' competitiveness versus traditional power generation that is slower and less accurate in responding to these imbalances. After Order 719's implantation, PJM saw a reduction of 30% in the need for overall regulation reserve requirements because more fast-responding resources have cleared the market. Behr, *supra* note 218; William Tokash, Navigant Research Blog, *Overcoming Hurdles to Monetizing Value Streams from Energy Storage Systems*, NAVIGANT RESEARCH BLOG (Aug. 19, 2016), https://www.navigantresearch.com/blog/overcoming-hurdles-to-monetizing-value-streams-from-energy-storage-systems.

404. EPRI Midwest, *supra* note 94, at 2-4.

405. Grid Energy Storage Report, *supra* note 67, at 21.

406. *Id*.

407. *Id*.

Furthermore, a given valuation method must have a sufficiently reliable and long-term mechanism to provide a return on capital investments for the projects to receive financing.[408] "Without sufficient proof that a given business model and technology combination can capture diffuse revenue streams, modernize the grid, and reduce greenhouse gas emissions, regulators are unlikely to take the time to consider classifying storage within the generation or distribution market structure or pursuing other methods to deploy storage."[409] For storage, this is even more pressing because "[h]istorically, the lines between a transmission asset and generating asset were clearly defined" with their own distinct cost recovery mechanism."[410] As a result of the original separation between these categories, "cost recovery for transmission versus market-based resources was clear and fairly well defined."[411] Figure 6 shows the historical method of delineating generation which receives market revenue, capacity payments and

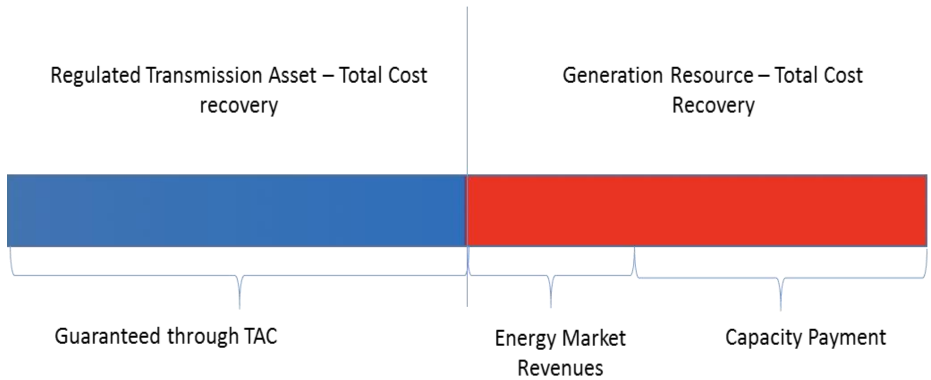

Figure 6. Representing the Traditional Model of Separating Transmission and Generation[412]

transmission, which is a cost-based recovery.[413] That is recovered through transmission access charges, such as the transmission access charge (TAC) in CAISO.[414] When energy storage is required to use participation models that were designed for a different set of resources it is forced to choose to be on the transmission or generation side and forgo the revenue on the other side of the divide.[415] Thus, pigeonholing energy storage to this model fails to account for its unique operational characteristics and ability to provide energy capacity, ancillary services for the wholesale market, and transmission related benefits.[416] This is in part

408. Univ. of Cal. et al., *supra* note 44, at 111.
409. *Id*. at 111-12.
410. Cal-ISO Storage Issue Paper, *supra* note 297, at 9.
411. *Id*.
412. *Id*. at 10.
413. *Id*.
414. *Id*. at 3.
415. Order No. 841, *supra* 25, at PP 19-20.
416. *Id*.

due to current tariffs that do not recognize energy storage's operational characteristics, thus limiting its ability to participate in the organized wholesale electric markets and/or force it to operate inefficiently by not allowing it to provide all the services of which it is capable.[417] Furthermore, energy storage blurs the traditional boundaries of the electricity market and leads to questions about how to value it.[418] In some instances price signals do not exist for energy storage, nor can the size of the benefit be verified.[419] An example of this is (primary) frequency response where energy storage may be superior to traditional methods of providing the service.[420] In Order 842, the FERC did not mandate compensation for providers of frequency response or institute a market for such services.[421] The FERC rejected requests for compensation for primary frequency response for four reasons: (1) only the operational capabilities of providing primary frequency response are being mandated; (2) the economic efficiencies of a primary frequency market may not overcome the costs and time of development of the markets in RTOs or bilateral purchases; (3) Order 755's requirements were inapposite to the Order at hand because it dealt with existing compensation structure for frequency regulation; and (4) generation resources that already produce inertia do so automatically by rotating mass generation and do not suffer from operational losses from providing it.[422] By not allowing a competitive market for all providers of frequency response, the FERC has not allowed energy storage to fully capture its value even when it may be the better situated resource to provide frequency response.[423]

The FERC's policy statement on energy storage states that an energy storage project can obtain both market-based rates (for the generation benefits it provides) and cost-based recovery (for the transmission benefits it provides); thus, creating two paths for energy storage to receive payment for the benefits it provides.[424] Figure 7 shows what would happen if energy storage was solely rate based as a transmission asset, with any market revenue it received being credited against the transmission revenue requirements.[425] This would reduce the amount of payments

417. *Id*.

418. Deal et al., *supra* note 403, at 9.

419. Bhatnagar & Loose, *supra* note 23, at 25.

420. *Id*. at 39.

421. Order No. 842, *supra* note 105, at P 119.

422. *Id*. at PP 122-24; *see also* Order No. 755, *supra* note 101 (dealing with frequency regulation compensation by RTOs and ISOs). It should be noted that energy storage does suffer from efficiency losses due to its operation. Ecofys, *supra* note 399, at 28.

423. While the FERC has not expressly mandated compensation or a market for frequency response, market participants are able to procure frequency responses from "primary frequency response pools, self-supply of primary frequency response, and transferred primary frequency response markets . . . through [the] contracts for frequency response service under Order No. 819, and . . . Frequency Response Sharing Group under Reliability Standard BAL-003-1.1." Order No. 842, *supra* note 105, at P 125.

424. *See generally* Policy Statement, *Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery*, 158 F.E.R.C. ¶ 61,051 (2017).

425. Cal-ISO Storage Issue Paper, *supra* note 297, at 11.

received through a cost-of-service rate.[426] It would also maintain the rigid separation between generation and transmission assets.[427] This mechanism has had at least tacit endorsement from the FERC in *Western Grid* and its policy statement.[428]

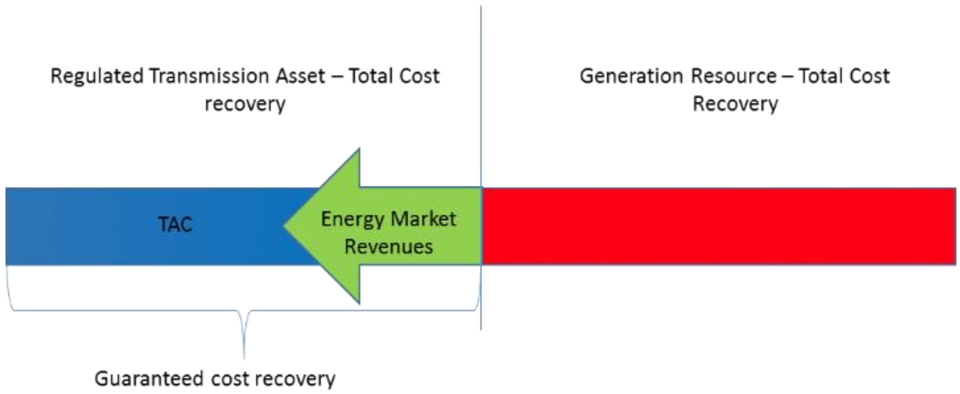

Figure 7. Updating the Traditional Separation of Transmission and Generation to Include Crediting Market-based Revenue Toward Cost Recovery[429]

Figure 8 shows another approach to compensating energy storage where energy storage is partially rate based and the owners take on the upside and downside risk of recovering a portion of the costs from the market.[430] This would represent an entirely new model for transmission assets and according to some it would inject more complexities and risks.[431] The risks and complexities arise from the ability of owners to speculate on how much value the energy storage assets can capture in the market.[432] The benefit is it values the energy storage asset based upon its actual benefits the transmission grid and incentivizes the owner to pursue as much market value as possible.[433]

426. *Id*.

427. *Id*.

428. Energy Storage Policy Statement, *supra* note 274, at P 16; 130 F.E.R.C. ¶ 61,056 at P 52. In other areas, the Commission has expressed a preference for revenue crediting to deal with double recovery. Opinion No. 501, *Golden Spread Electric Cooperative, Inc.*, 123 F.E.R.C. ¶ 61,047 at P 93 (2008) (stating that the Commission prefers revenue crediting for opportunity sales).

429. Cal-ISO Storage Issue Paper, *supra* note 297, at 11.

430. *Id*.

431. *Id*. at 12.

432. *Id*.

433. *Id*.

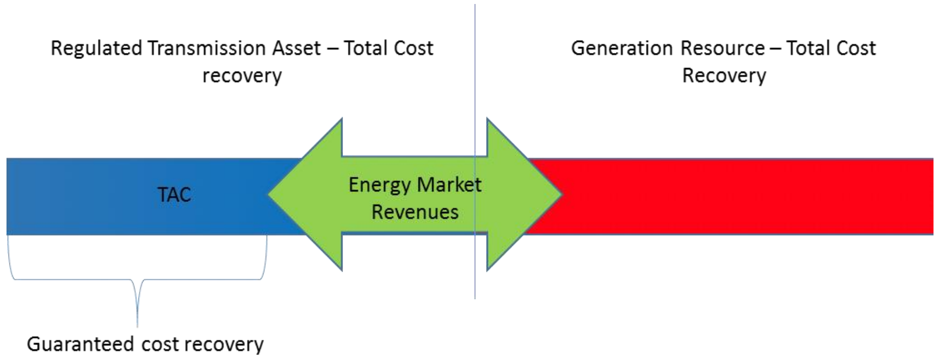

Figure 8. Updating the Traditional Separation of Transmission and Generation to Include Market-based Revenue Risks and Benefits[434]

1. The Problem With Double-Counting Benefits

Associated with the issue of valuing storage, there is the concern over double-counting of benefits and thereby allowing double recovery for storage.[435] "An electric storage resource receiving cost-based rate recovery for providing one service may also be technically capable of providing other market-based rate services."[436] The two primary issues with double counting/double recovery that energy storage raises are:

> (1) the potential for combined cost-based and market-based rate recovery to result in double recovery of costs by the electric storage resource owner or operator to the detriment of cost-based ratepayers; (2) the potential for cost recovery through cost-based rates to inappropriately suppress competitive prices in the wholesale electric markets to the detriment of other competitors who do not receive such cost-based rate recovery. . .[437]

The concern is that by receiving cost-based rates storage would possess an unfair advantage over other competing technologies and thereby unjustly enrich its shareholders.[438] Moreover, this unfair advantage over competitors would come at the expense of captive wholesale customers.[439] The FERC summarized its concern by stating "[t]he Commission has sought to prevent the subsidization of public utility shareholders at the expense of their captive customers."[440]

The FERC noted that "[i]n some cases, an electric storage resource may only be cost competitive for the cost-based service if expected market revenues are considered in the evaluation of the electric storage resources."[441] "Such market revenues can be used to offset the electric storage resource's costs for providing the

434. Cal-ISO Storage Issue Paper, *supra* note 297, at 12.
435. *Id*. at 13.
436. Energy Storage Policy Statement, *supra* note 274, at P 11.
437. *Id.* at P 13.
438. *Id*. at P 12.
439. *Id*. at P 13.
440. *Id*. at P 16.
441. Energy Storage Policy Statement, *supra* note 274, at P 12.

cost-based rate service."[442] To solve these issues the FERC has required that entities credit the approximate amount of market revenues to captive wholesale customers to prevent the subsidization of utility shareholders by captive customers.[443] Further, the FERC has noted that it has not required any other measures to address potential competitive impacts of market rates on other competitors.[444] Moreover, if having dual recovery undermines competitors, then public utilities in restructured states that own both transmission assets (cost-based recovery) and generation assets (market-base recovery) would need to be revisited.[445]

The FERC believes that any market suppression could be addressed when the FERC reviews rates under the "just and reasonable" standard.[446] The FERC has confronted the issues of double recovery/double counting before on a case-by-case basis, addressing concerns about the cross-subsidization by customers to stakeholder.[447] Thus, the FERC has had much practical experience in weeding out activities "that result in a transfer of benefits from [ratepayers] to [shareholders]" in a variety of contexts.[448] By using either of the approaches illustrated in Figures 6 and 7, the FERC could nearly eliminate the chances of double counting/double recovery because they would either use the market revenues to offset the transmission access charge or limit the transmission access charge to the transmission benefits it provides.[449]

E. Interconnecting Energy Storage

Energy storage projects go through similar interconnection procedures that generation goes through, even though energy storage has different operating and technical characteristics (i.e. storage cannot operate at full capacity continuously owing to recharge requirements and it does not add net energy to the grid).[450] Utility-scale storage must go through the interconnection study process, pay any required network upgrade costs "to ensure deliverability of energy, and negotiate an interconnection agreement."[451] This process can take twelve to thirty months.[452] This puts some energy storage at a disadvantage because the longer interconnection process artificially reduces the advantages storage has in its speed of deployment, as it can be built and put in commercial operation quicker than traditional

442. *Id*.

443. *Id*. at P 16.

444. *Id*.

445. *Id*. at P 22.

446. Energy Storage Policy Statement, *supra* note 274, at P 23 fn. 38.

447. *See generally Heartland Energy Services, Inc*., 68 F.E.R.C. ¶ 61,223 (1994) [hereinafter *Heartland Order*] (affiliate abuse); *Golden Spread Electric Coop. v. Sw. Pub. Serv. Co.*, 115 F.E.R.C. ¶ 63,043 (2006) (affiliate abuse); *Northwest Pipeline Corp.*, 98 F.E.R.C. ¶ 61, 352 (2002) (subsidizing pipeline expansion by existing customer).

448. Heartland Order, *supra* note 447, at p. 62,065.

449. Cal-ISO Storage Issue Paper, *supra* note 297, at 11-12.

450. Buck Enderman et al., *Energy Storage Handbook*, K&L GATES 44 (2017).

451. *Id*.

452. *Id*.

resources.[453] A possible way to fix this is to use a first-ready, first-served approach instead of the first-in-time method that is presently.[454] This change would reward those who can get to the starting line quicker instead of the first to submit for a queue spot.[455]

To assist in the interconnection of energy storage, the FERC also made changes to the Small (Under 20 MW) and Large Generation Interconnection Processes (over 20 MW) (GIPs) and Generation Interconnection Agreements (GIAs) to ensure that they interconnect in a nondiscriminatory, just and reasonable manner.[456] Energy storage may avail itself of either the small or large GIP or GIA so long as it meets their threshold requirements.[457] One change is that the SGIAs/LGIAs explicitly mentions storage now.[458] The FERC has also given guidance with injections by energy storage stating, "the Transmission Provider should generally assume that the capacity of the storage device is equal to the maximum capacity that the particular device is capable of injecting into the Transmission Provider's system."[459] However, this does not "preclude a Transmission Provider from studying the effect on its system of the absorption of energy by the storage device and making determinations based on the outcome of these studies."[460] Furthermore, an interconnection customer can specify a lower amount than the maximum if the transmission owner agrees and equipment such as power relay or control systems are put in place to ensure that excess power is not put on the grid.[461]

One of the biggest concerns for storage in the context of the LGIP is in its modeling during the LGIP.[462] These controversies may also rise when storage is added to existing interconnections, which may require a restudy because of the change from synchronous to inverter energy when a turbine is fully replaced with an inverter-based technology as there is less experience with interconnecting them to the grid.[463] This aspect of the interconnection process will be important to storage because hybrid connections where storage is combined with another generator (i.e. variable renewables) may represent a portion of storage's interconnection requests.[464] Thus, the FERC maintains that grid operators may perform additional studies to check for safety and reliability concerns at the maximum output of the

453. Notice of Proposed Rulemaking, *Reform of Generator Interconnection Procedures and Agreements* [2016-18 Proposed Regs.] F.E.R.C. STATS & REGS. ¶ 61,212, 83 Fed. Reg. 21,342 at P 25 (2016).

454. *Id*. at P 18.

455. *Id*.

456. Order No. 792, *Small Generator Interconnection Agreements and Procedures*, 145 F.E.R.C. ¶ 61,159 at P 203 (2013) [hereinafter Order No. 792]; Order No. 845, *supra* note 274, at P 135.

457. Order No. 792, *supra* note 456, at P 203; Order No. 845, *supra* note 274, at P 279.

458. Order No. 792, *supra* note 456, at P 228; Order No. 845, *supra* note 274, at P 275.

459. Order No. 792, *supra* note 456, at P 229; Order No. 845, *supra* note 274, at P 367 (stating that there are similar requirements under the LGIA).

460. Order No. 792, *supra* note 456, at P 229; Order No. 845, *supra* note 274, at P 368 (stating that RTOs still retain tools to ensure reliability, even with the changes to the LGIA).

461. Order No. 792, *supra* note 456, at P 17; Order No. 845, *supra* note 274, at P 367.

462. The requirements of modeling energy storage were not extended by the FERC to the SGIP. Order No. 845, *supra* note 274, at PP 548-49.

463. Enderman et al., *supra* note 450, at 45-46; Order No. 845, *supra* note 274, at P 544.

464. *See generally* Utility Dive Hybrid, *supra* note 228; Order No. 845, *supra* note 274, at P 382.

generation when confronted with hybrid interconnections.[465] There is also the issue of modeling the energy storage asset for the interconnection process and whether to model storage as "a single asset, as opposed to separate generation and load assets, and based on their intended use."[466] The FERC noted that modeling it as a single asset has some merit because it "could streamline the interconnection of electric storage resources, save costs, and avoid modeling the charging of electric storage resources the same as other unpredictable, non-controllable load resources."[467] However, the FERC did not mandate a particular way to model energy storage assets as RTO's do not have experience in modeling the effects of many types of energy storage due to their newness.[468]

Lastly, the practice of First-in, First-out of the generation interconnect process needs to be replaced with a first-ready, first-served approach.[469] As was mentioned, a project could can take twelve to thirty months to go through the entire process.[470] One of the benefits of energy storage is that it can be built quickly where it is urgently needed.[471] Making energy storage wait in a long queue deprives it of one of its advantages. The FERC's Order 2003 laid the groundwork for the interconnection process "to standardize the agreements and procedures related to the interconnection of large generating facilities."[472] One of the keys was to institute a queue management process.[473] Order 2003 also mandated a first in time approach for queue position.[474] The issue with the first-in-time approach in filling the queue is that it rewards those who get in line first, but may not be ready to build thus prolonging the queue process for everyone.[475] Given that technologies like energy storage can be deployed rather quickly, a first-ready, first-served approach might give everyone a chance to move through the process quicker. [476] An example of how quick storage can be built is that Tesla constructed a lithium-ion battery in Australia in 100 days that was 100 MW and was designed to help with preventing blackouts.[477]

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465. Order No. 845, *supra* note 274, at P 383.

466. *Id.* at P 544.

467. *Id*.

468. *Id.*

469. *Id*. at 14, 550.

470. Enderman et al., *supra* note 450, at 45.

471. *See generally* i*nfra* discussion regarding the transmission and distribution benefits of energy storage.

472. *Interconnection Queuing Practices*, 122 F.E.R.C. ¶ 61,252 at P 2 (2008).

473. *Id*.

474. Order No. 2003, *Standardization of Generator Interconnection Agreements and Procedures*, 104 F.E.R.C. ¶ 61,103 at P 35 (2003). Queue Position is used to determine the order of performing the various Interconnection Studies and the assignment of cost responsibility for the construction of facilities necessary to accommodate the Interconnection Request.

475. 122 F.E.R.C. ¶ 61,252 at P 15.

476. *Id*. at P 18 (noting that a first serve, first benefits approach might be a workable solution that aligns with the goals of Order 2003 and might not suffer from the drawbacks of the first in time approach).

477. Julian Spector, *Tesla Fulfilled Its 100-Day Australia Battery Bet. What*'*s That Mean for the Industry?*, GREENTECH MEDIA (Nov. 27, 2017), https://www.greentechmedia.com/articles/read/tesla-fulfills-australia-battery-bet-whats-that-mean-industry#gs.SpukFvI.

F. Energy Storage and Transmission Planning and Cost Allocation

The way the transmission grid is planned and paid for can have profound impacts on whether energy storage can reach its full potential.[478] Because transmission planning affects transmission and interconnection costs, it in turn impacts the cost and value of energy storage.[479] Transmission planning also governs how congestion is managed on the grid and whether energy storage can receive cost recovery for helping to mitigate congestion.[480] Storage "does not fit neatly into traditional utility planning, or current regulatory and financing structures, which have approached power system needs with central station power plants and large transmission projects."[481] Part of the problem is that storage can be a Non-Transmission Alternative (NTA), which is defined as "any combination of equipment and operating practices that is capable of deferring or replacing the need for a specific electric power transmission project, by reliably alleviating transmission congestion in a specific area."[482] NTAs allow a better transmission system to be built by using NTAs at key locations to provide needed relief and maximize the efficiency of grid assets.[483] NTAs, including storage, are not only a cheaper and faster process to address transmission issues, but also come without the same need for rights-of-way or other environmental considerations.[484] Using an NTA in this manner prevents ratepayers from paying for an oversized system.[485] The FERC has realized that NTAs may not have been given adequate consideration and thus required their consideration in Order 1000.[486]

The FERC stated that a "transmission planning region must also consider proposed non-transmission alternatives on a comparable basis" to transmission.[487] "When evaluating the merits of such alternative transmission solutions, public utility transmission providers in the transmission planning region also must consider proposed non-transmission alternatives on a comparable basis."[488] Order 1000

478. Schmitt, *supra* note 214, at 411; Kaplan, *supra* note 11, at 17.

479. Univ. of Cal. et al., *supra* note 44, at 84. Energy Storage and other advance transmission technologies (i.e. distributed generation, controllable loads, etc.) are to be considered during the planning process too. Order No. 890, *Preventing Undue Discrimination and Preference in Transmission Service*, F.E.R.C. STATS. & REGS. ¶ 61,119, 72 Fed. Reg. 12,266 (2007) (to be codified at 18 CFR pts. 35, 37) [hereinafter Order No. 890].

480. Univ. of Cal. et al., *supra* note 44, at 84. Order 890 set out 8 principles plus a cost allocation principal that RTOs must following during planning. They are: coordination, openness, transparency, information exchange, comparability, dispute resolution, regional participation, and congestion studies. Order 1000 added that RTO's also plan for public policy requirements too. Order No. 890, *supra* note 479, at 426; Order No. 1000, *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, 136 F.E.R.C. ¶ 61,051 at P 148, 76 Fed. Reg. 49,842 (2011) (to be codified at 18 CFR pt 35) [hereinafter Order No. 1000].

481. Kaplan, *supra* note 11, at 17.

482. NRRI NTA, *supra* note 218, at 1.

483. KIRAN KUMARASWAMY, *The Days of All-or-Nothing Transmission Planning Are Over*, ADVANCED ENERGY ECONOMY (Apr. 5, 2017), https://blog.aee.net/the-days-of-all-or-nothing-transmission-planning-are-over; Technical Conference, *supra* note 3, at 51-53.

484. Kumaraswamy, *supra* note 483.

485. *Id*.

486. Meyer, *supra* note 3, at 537.

487. Order No. 1000, *supra* note 480, at P 148.

488. *Id*.

also requires public policy goals be taken into account during the transmission planning process.[489] While the FERC was in part likely referring to state renewable portfolio standards and federal incentives, storage can assist in bringing these to market and some states (e.g. California) have made increasing energy storage a state policy.[490] The expansion of energy storage may depend on whether or not transmission planners and the FERC adopt a favorable view of public policy considerations and push for inclusion of NTAs into the planning process.[491]

Order 890 and Order 1000 also dealt with another important issue that affects energy storage—the controversies over transmission cost allocation.[492] Transmission cost allocation deals with how costs for transmission are split between various beneficiaries and can be quite contentious.[493] In Order 1000, the FERC stated that this is an important issue because storage can compete as a solution against or alongside transmission and other technologies.[494] However, the FERC stated in Order 1000 that the "issue of cost recovery for non-transmission alternatives is beyond the scope of the transmission cost allocation reforms . . . which are limited to allocating the costs of new transmission facilities."[495] Accordingly, how the costs are divided and whether the solution qualifies for cost allocation may influence the selection of one solution over another.[496] For example, under a socialization approach to cost allocation (also known as postage stamp,) costs are broadly spread out to the entire region, as it classifies everyone in the RTO as a beneficiary.[497] While beneficiary pays is a much narrower approach, a pure socialization approach may give a transmission project an advantage because a storage project may have to be paid for by a narrower customer base given that the FERC has not given guidance on how NTAs could obtain cost-recovery for their alleviation of the transmission problem.[498]

G. Environmental Concerns with Storage

Lastly, there may be some environmental issues with the operation of energy storage. Pumped hydro is one energy storage technology that has environmental concerns due to its similarities to hydroelectric projects.[499] Also, there exists a "somewhat complex relationship between energy storage and emissions. On the one hand, energy storage is not 100% efficient and, in general, represents an additional load on the system that can result in increased emissions."[500] "The three main factors that affect storage-related emissions are: the marginal emissions of

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489. Meyer, *supra* note 3, at 537-38.
490. *Id*.
491. *Id*. at 539.
492. Order No. 890, *supra* note 479, at P 557-61; Order No. 1000, *supra* note 480, at PP 482-733.
493. Schmitt, *supra* note 214, at 382-83.
494. Akhil et al., *supra* note 29, at 14.
495. Order No. 1000, *supra* note 480, at P 779.
496. Schmitt, *supra* note 214, at 411.
497. *Id*. at 407-412.
498. *Id*. at 407, 414.
499. Akhil et al., *supra* note 29, at 1.
500. Ecofys, *supra* note 399, at 28.

the generator that charged the device, the marginal emissions of the displaced generator when storage discharges, and the round-trip efficiency of the storage."[501] Studies have shown that the presence of storage during low-load hours presents additional load that coal power plants can serve at times they could have been curtailed.[502] The issue is that

> unless off-peak generation is sufficiently cleaner than the peak generation, accounting for the energy losses that will occur from charging and discharging the device (e.g. a 75% round-trip efficient storage device needs to charge with off-peak generation that is at least 33% cleaner than peak generation to prevent adding emissions to the grid)."[503]

The same studies also showed that while levels of carbon emissions rose in the baseline scenario, there was also quantifiable reduction in a high renewable energy build out scenario.[504] It should be pointed out that the increase in CO_2 is not an attribute of storage, but rather an attribute of the operation environment in which the storage is deployed.[505] Thus, the environmental benefits of energy storage largely derive from how the system is constructed (higher penetration of renewables mean lower CO_2, larger amount of fossil fuels may mean higher CO_2 levels).[506]

VII. Getting Energy Storage Right

If the proper regulations are put in place, energy storage can vastly improve the entire system by enhancing the economics, efficiency, and reliability of the system. It needs to be remembered that energy storage provides both regulated and market services to the electricity grid.[507] The current process is undertaken on a "case-to-case basis, [and] current regulations allow owners of energy storage facilities to draw revenue from only a single asset classification."[508] The case-by-case approach "leaves most storage assets both undervalued and underutilized."[509] This presages underinvestment in storage, thereby reducing system efficiency and increasing costs.[510] The best way to ensure that storage can be fully valued and ensure proper utilization is for it to be classified as a transmission asset that can also receive market revenue.

Starting with a rebuttable presumption that storage is a transmission asset that can also receive market revenue would be a significant first step. Storage by its nature is more analogous to transmission assets than generation as it does not add net energy to the grid but merely transports it through time, as traditional transmission transports energy through space.[511] Transmission in the economic context

501. Arciniegas & Hittinger, supra note 43, at 2.
502. Ecofys, supra note 399, at 28.
503. Arciniegas & Hittinger, *supra* note 43, at 2.
504. Ecofys, supra note 399, at 28.
505. Arciniegas & Hittinger, *supra* note 45, at 10.
506. *Id*. at 2, 10.
507. Forrester et al., *supra* note 394, at 50.
508. *Id*. at 51.
509. *Id*. at 2.
510. *Id*.
511. Forrester et al., *supra* note 394, at 51.

allows electricity to reach customers that it would not otherwise have access to.[512] Storage is doing the same thing by moving electricity through time until there is demand for it.[513] Storage can also provide benefits to the electric system that are similar to those that other transmission assets do, i.e., reliability, economic, and public policy benefits.[514] Furthermore, treating energy storage as transmission would allow it to be treated like capacitors, which enhance the flow of electricity throughout the system, something that energy storage does.[515] Treating energy storage as a rebuttable transmission asset that can receive market revenue would also ensure that it could be properly valued as an NTA in the transmission planning process. While the FERC policy statement allowing storage to receive both market and cost rates is a start, there is still the question of how the FERC would allocate the costs of an NTA.[516] To do this, the FERC would also need to institute a rule-making on how NTA's would have their costs properly allocated. The FERC has stated in regards to the natural gas storage that:

> [a]s a general matter, gas in storage can be analogized to money in a bank. The customer injecting gas into storage is acting like a depositor putting money into a bank. The customer, as a "depositor", may withdraw its gas from the pipeline when it wants. (Of course, the customer's right to withdraw gas from storage is subject to operational constraints.) But the pipeline, just as a bank, may use the "deposited" gas to serve another customer in the meantime.[517]

Thus, if this rule was adopted for electricity storage, a storage operator could use the stored energy in the ancillary service market, so long as they could meet the demands of the owner of the electricity and the grid operator's requirements. The RTOs could put further qualifications on the energy storage assets that are trying to become rebuttable transmission assets by requiring them to go through transmission planning or a similar process. This would allow the transmission planner to quantify what the actual transmission congestion and deferral benefits are and when they would be used. It would also allow the energy storage operator to know when the battery would have to be fully charged and be ready to be used in a transmission context. In such a scenario, when the RTO/ISO needed to take control of the asset it could post the times in advance on OASIS, as this should be predictable and known in advance based on the information established during the qualifying process. When the storage is finished completing its transmission role, it can be returned to the asset owner in the way it was originally given. Furthermore, by having energy storage's transmission benefit being checked in every planning cycle, it would ensure that the energy storage would still be providing the benefits that it is suppose too. Ideally, the transmission deferral benefits would decrease over time as future load growth becomes clearer and investments in relieving transmission congestion become more pronounced in later transmission studies or the assumptions do not pan out in reality.

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512. *Id*.
513. Akhil et al., *supra* note 29, at xxxiii.
514. Forrester et al., *supra* note 394, at 51.
515. *Id*.
516. Deal et al., *supra* note 403, at 2.
517. 59 F.E.R.C. ¶ 61,030, at p. 97 fn. 139 (1992).

Furthermore, by requiring the energy storage owner to obtain a part of its revenue through the competitive market it would incentive the energy storage owner to play an active role in the market. Having the energy storage device receive recovery as a transmission asset and refund the market revenues to transmission customers would not only have the potential to disincentivize the storage device from actively seeking as much revenue from the market as possible (thereby making the system less efficient). It could also promote inefficiency because the energy storage asset may only be used a limited amount of time as a transmission asset foregoing potentially unprofitable generation activities. At the limit, a storage device, under the refunding market revenue scenario, could theoretically sit idle until it was needed as a transmission asset and not provide any other benefits, but still fully recover its costs in whole.

A possible example of where energy storage may not meet the rebuttable presumption would be where the energy storage is located areas with low congestion. Storage connected to or near generation could also face challenges to its presumptive classification as a transmission asset. Under the proposed rebuttable presumption, these assets would be most likely to fail the rebuttable transmission test because energy storage connected with or near generation would be primarily used to smooth out the generation or allow it to run more efficiently and would provide less transmission benefits given its location. Storage in low congestion areas will not produce as many transmission benefits because they are situated in areas that will not experience the need for congestion relief.

There are several other things that regulators should remember. Energy storage by itself is agnostic to how it is charged, so if promoting environmental and renewable energy goals is important to developers and regulators, particular attention needs to be paid to the resources that are used to charge energy storage. Also, because deployment of large amounts of energy storage is new, many of the ways the industry operates the grid and interconnect with it must be examined to ensure that it does not unnecessarily impede energy storage where it is needed and useful.[518] A first-in-time approach to determine queue position would allow technologies like energy storage that can be deployed quicker to linger in limbo for months and eliminate one of their competitive advantages—their speed of deployment.[519]

VIII. CONCLUSION

"Energy storage carries electricity through time, just as transmission lines carry it through space—without it, electrical energy must be used at the instant it is generated."[520] Energy storage mediates between the variable generation and variable load.[521] Electric energy storage is akin to the Strategic Petroleum Reserve in storage tanks, natural gas pipelines and underground storage.[522] It can unlock invaluable opportunities by shifting energy through time until it has greater value,

518. Order No. 841, *supra* note 25, at P 7.

519. *See generally* Spector, *supra* note 477.

520. Meyer, *supra* note 3, at 480-81.

521. Akhil et al., *supra* note 29, at xxxiii.

522. *Id*.

provide fast response and ramping capabilities to serve the ancillary market, help integrate renewables, increase reliability, and enhance the transmission and distribution system.[523]

The electrical grid is in a midst of modernization in an effort to help the United States meet the challenges posed by issues such as climate change and obtaining more energy from renewable sources, while maintaining a robust and real-time electric system that will have to meet 4-5 teraKWh of electricity demand by 2050.[524] Storage exemplifies the disruptive changes that are happening in the electric market.[525] Tomorrow's system with "two-way flow of energy and communications would open up access to information, participation, choice, and empower consumers with options from using electric vehicles to producing and selling electricity."[526] The presence of energy storage is necessary to meet this future of energy.[527]

However, storage faces many barriers to its integration in the grid.[528] The regulatory valuation of storage, especially in restructured markets may prevent it from reaching its full potential and thus inhibit deployment by suppressing the return on investment relative to the benefits provided.[529] While energy storage faces some technological barriers, these are quickly being confronted with the reduction of costs for energy storage.[530] Nonetheless, the policy barriers can stifle and progress by depriving energy storage of markets for its most beneficial uses by limiting its monetization to a subset of its benefits.[531] Chief among these policy issues are the proper classification of storage and the appropriate valuation of the services it can provide.[532] Ensuring fair treatment for storage is of particular importance now as energy infrastructure is being built in part by independent power producers who lack utility-rate-based cost recovery and must rely on market-based rates to recover their costs.[533] It is important to signal the eventual resolution of these issues because investors will be hesitant to invest (or will not invest) capital where returns are uncertain (i.e., regulatory uncertainty reduces investment by creating conditions of uncertain return).[534] This "Holy Grail" could be unlocked by clarifying energy storage as a rebuttable transmission asset that can obtain market revenue and allowing it to recover both cost and market based recovery separately.

523. *Id*. at 115; Grid Energy Storage Report, *supra* note 67, at 7, 9; EPRI Midwest, *supra* note 94, at 1-2; EPRI Functional Requirements, *supra* note 9, at ix.

524. Grid Energy Storage Report, *supra* note 67, at 7.

525. William Pentland, *Are Battery Boosters Risking A Blowback?*, FORBES (Feb. 11, 2015), http://www.forbes.com/sites/williampentland/2015/02/11/are-battery-boosters-risking-a-blowback/print/.

526. *Id*.

527. Wood, *supra* note 11, at 61.

528. Denholm, *supra* note 139, at 16.

529. *Id*. at 29.

530. Deal et al., *supra* note 403, at 3.

531. *Id*. at 2.

532. Stein, *supra* note 23, at 701-02.

533. *Id*. at 734.

534. *Id*.