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An Old Technology Solves an Old Problem: Rethinking the “World’s Water Battery”

*Will Farmer**

I. INTRODUCTION

A recent poll, conducted by *The Washington Post* and the Kaiser Family Foundation, points out that a majority of Americans recognize climate change as a problem.¹ Regardless of one’s stance on this “problem,” the country’s overreliance on carbon-fuels in electricity production, which comprises roughly twenty-eight percent of America’s greenhouse gas emissions,² can be greatly reduced by a transition toward a “Renewable Energy Grid.”³

The energy grid is best thought of as the infrastructure that generates electricity and then gets that electricity to the outlet in your wall. As discussed later in this Comment, today’s energy grid is outdated and will require a shift of focus to handle the transition toward sustainable sources of energy. Today’s grid is confined by the thought processes of the past, where electricity would always be readily available because there was always more coal that could be burned.⁴

A startling truth is that the development of renewable energy resources is hindered by the fact that people, no matter the time of day, want to see the lights come on when they flip the switch.⁵ The reliability of our society’s

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1. In an assuring instance of agreement, thirty-eight percent of Americans consider climate change a crisis, while another thirty-eight percent consider it a major problem; further, “denialism is in retreat” as even sixty percent of Republicans admit that climate change is manmade. Noah Smith, *Americans Fear Climate Change and the Cost of Fighting It*, BLOOMBERG (Sept. 30, 2019, 6:30AM), <https://www.bloomberg.com/opinion/articles/2019-09-30/americans-fear-climate-change-and-the-cost-of-fighting-it?srnd=opinion>.
2. *Sources of Greenhouse Gas Emissions*, ENVIRONMENTAL PROTECTION AGENCY, <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#electricity> (Apr. 9, 2021).
3. The notion of a “Renewable Energy Grid” within this Comment refers to America’s transition toward an energy grid that can effectively supply a society while being supplied by renewable resources. As discussed throughout, this transition will not only require the development of renewable sources of electricity, but also a revamping of the grid itself, to effectively implement these new sources.
4. See Richard L. Revesz & Burcin Unel, *Managing the Future of the Electricity Grid: Energy Storage and Greenhouse Gas Emissions*, 42 HARV. ENV’T. L. REV. 139, 143 (2018).
5. David B. Spence, *Paradoxes of “Decarbonization,”* 82 BROOK. L. REV. 447, 454 (2017); Scott Nyquist, *How Energy Storage Could Change Everything*

electricity supply is underappreciated, but it is the most crucial characteristic of an electric grid.⁶ Society as a whole would likely come to a standstill if the odds that your office would have power, or whether banks could electronically transfer funds, were just a coin-flip.⁷ As a result, reliability is now the principal concern for energy providers.⁸ Coincidentally, the less desirable options for power, like fossil fuels and nuclear power, are able to consistently provide steady power.⁹ Conversely, the availability of renewable energy is sporadic, often cited as renewable energy's intermittency problem.¹⁰ This intermittency problem is exemplified by the fact that the wind is not always blowing and the sun is not always shining.¹¹ But if solar or wind power could be efficiently stored and then released to the electric grid on demand, then the practicality of renewable resources would drastically improve.¹²

The Federal Energy Regulatory Commission (FERC) defines "electric storage resource" as a "resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid."¹³ For purposes of this Comment, the terms "electric storage resource" and "energy storage" are synonymous. A 2018 survey of leading institutional investors in

About Renewables, FORTUNE (Sept. 24, 2015, 1:36PM), <https://fortune.com/2015/09/24/future-renewable-energy-storage/>.

6. The need for a reliable supply of electricity provided the foundation for public utility laws and regulation, and subsequently the growth of the electric grid. See Spence, *supra* note 5, at 454. Academics routinely stress modern society's need for a reliable supply of electricity. See, e.g., Alice Kaswan, *Energy, Governance, and Market Mechanisms*, 72 U. MIAMI L. REV. 476, 497 (2018); William Boyd, *Public Utility and the Low-Carbon Future*, 61 UCLA L. REV. 1614, 1619, 1643 (2014); Amy L. Stein, *Reconsidering Regulatory Uncertainty: Making a Case for Energy Storage*, 41 FLA. ST. U. L. REV. 697, 710–11 (2014).
7. "A productive economy requires significant amounts of electricity, and demand is only projected to increase in the future. Nearly every modern convenience—like computers, cell phones, machinery, and lights—is at the mercy of adequate electricity flows." See Stein, *supra* note 6, at 709–10.
8. *Id.*
9. *Id.*
10. See Robert Fares, *Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities*, SCI. AM. (Mar. 11, 2015), <https://blogs.scientificamerican.com/plugged-in/renewable-energy-intermittency-explained-challenges-solutions-and-opportunities/>.
11. *Id.*
12. See David Schmitt & Glenn M. Sanford, *Energy Storage: Can We Get It Right?*, 39 ENERGY L.J. 447, 451–52 (2018).
13. Non-Discriminatory Open Access Transmission Tariff, 18 C.F.R. § 35.28 (2019). For additional background on what "energy storage" is and how it came to be, see *id.*

renewable energy projects found that a majority of these investors identify energy storage as the lead attraction for investment within the next three years.¹⁴

This Comment aims to contextualize the role of energy storage in modern America and aims to promote the development of a specific form of energy storage, closed-loop pumped hydropower storage. Energy storage takes on a variety of forms, but only certain technologies can provide environmentally conscious, cost-effective and scalable energy storage; closed-loop pumped storage threads the needle for each of these characteristics.¹⁵ Further, this Comment proceeds with renewable energy resources’ intermittency problem in mind. Part II of this Comment provides additional background on energy storage, first contextualizing its complementary role with renewable energy resources and how its unique characteristics can benefit a renewable energy power grid. Part II concludes with an overview of the most prevalent energy storage technologies. Part III of this Comment focuses on closed-loop pumped storage, the most promising form of utility-scale energy storage. Part III provides a high-level technical summary of closed-loop pumped storage, an analysis of the regulatory background for the technology, and concludes with a brief overview of issues to consider when proposing closed-loop pumped storage projects. Part IV ties together each of Part III’s aspects by outlining closed-loop pumped storage’s development going forward. Part IV concludes this Comment by placing the advantages of closed-loop pumped storage, with any outstanding concerns, within the context of the technology’s benefits on renewable energy development and the power grid. Part IV further adds real-time developments and the prospects of additional development in the industry.

II. THE “GRID” AND ENERGY STORAGE

Energy storage is a balancing tool for the entire electrical system; theoretically, energy storage on a large-scale would keep the electrical grid in harmony through all likely disruptions.¹⁶ To understand how energy storage systems would do this, it is important to understand why they would need to. And for that, background on the electrical grid and renewable energy’s integration to the Renewable Energy Grid is important.

14. More than eighty-eight percent of the respondents pinpointed energy storage as the leading investment over the next three years. AM. COUNCIL ON RENEWABLE ENERGY, THE FUTURE OF U.S. RENEWABLE ENERGY INVESTMENT: A SURVEY OF LEADING FINANCIAL INSTITUTIONS 3–4 (June 15, 2018), https://acore.org/wp-content/uploads/2018/06/ACORE-Renewable-Energy-Investor-Survey_June-2018_fnl.pdf.

15. See *infra* Part III.

16. See Revesz & Unel, *supra* note 4, at 145.

The electric grid, has three main components: generation, transmission, and distribution.¹⁷ First, energy is generated by a source, whether it be thermal energy through a fossil fuel or the kinetic energy of water or wind.¹⁸ This energy is then converted into electricity and carried to consumers by high-voltage transmission lines.¹⁹ Electricity then travels directly to the consumer through lower voltage distribution lines.²⁰ Both the intermediate transmission stage and final distribution component have capacity constraints.²¹ These capacity constraints hinder the electric grid, requiring that the supply and demand of electricity always be equal.²² The imbalance of supply and demand can lead to grid failures, typically resulting in blackouts.²³ To maintain this equilibrium, grid operators are required to plan the long-term supply of electricity and also respond to demand in real time.²⁴

In the long-term, grid operators must ensure that there is enough capacity²⁵ planned and built to satisfy peak consumer demand.²⁶ But to meet the varying levels of demand throughout the day, grids must have a variety of services,²⁷ including: frequency regulation,²⁸ ramping resources,²⁹ voltage support,³⁰ and reserve capacity.³¹ For purposes of this Comment, examining the intricacies of long-term planning or each demand response service is not

17. *Id.*

18. *Id.*

19. *Id.*

20. *Id.*

21. *Id.*

22. Victoria Johnston, *Storage Portfolio Standards: Incentivizing Green Energy Storage*, 20 J. ENV'T. & SUSTAINABILITY 25, 47–48 (2014).

23. *Id.*

24. Revesz & Unel, *supra* note 4, at 145.

25. “Generation Capacity” refers to the maximum output available, not necessarily what is constantly being generated. Generation capacity refers to just that, generation. However, “capacity” can also refer to other energy aspects, like storage capacity—the maximum of energy that can be stored. *U.S. Grid Energy Storage*, CTR. FOR SUSTAINABLE SYS., UNIV. MICH. (Sept. 2020), <http://css.umich.edu/factsheets/us-grid-energy-storage-factsheet>.

26. Stein, *supra* note 6, at 700–01.

27. For purposes of this article, understanding that these services give grid operators the flexibility to answer varying levels of demand is more important than knowing the nuances of each service.

28. Revesz & Unel, *supra* note 4, at 146.

29. *Id.*

30. *Id.*

31. *Id.*

a prioritized focus compared to understanding that energy storage systems offer a potential alternative to these requirements.

All of the operations of an electric grid are made more difficult with the integration of renewably generated electricity.³² Traditionally, grid operators plan the available supply of electricity to closely mirror demand.³³ In application, this means that as demand for electricity increases, powerplants (like fossil fuels and nuclear plants) generate more electricity to meet demand.³⁴ This sort of demand response is more difficult with renewable generators, like wind and solar power plants.³⁵ The reason is that renewables’ power generation can fluctuate throughout the day and doesn’t mirror demand like the less desirable alternatives—fossil fuels and nuclear.³⁶ Typically, demand for electricity is highest in the evening, but the sun is shining and wind is blowing most during the day.³⁷ This misalignment of solar and wind power’s generation with the levels of demand throughout the day results in a phenomenon known as the “Duck Curve.”³⁸

32. Sean Casten, *How Hard is it to Integrate Renewable Energy into the Electric Grid?*, ENERGY CENTRAL (July 3, 2013 8:00 PM), <https://energycentral.com/c/ec/how-hard-it-integrate-renewable-energy-electric-grid>.

33. *Id.*

34. *Id.*

35. CAL. INDEP. SYS. OPERATOR, WHAT THE DUCK CURVE TELLS US ABOUT MANAGING A GREEN GRID 4 (2016), https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf.

36. Fares, *supra* note 10.

37. Schmitt & Sanford, *supra* note 12, at 464.

38. CAL. INDEP. SYS. OPERATOR, *supra* note 35, at 1.

FIGURE 1

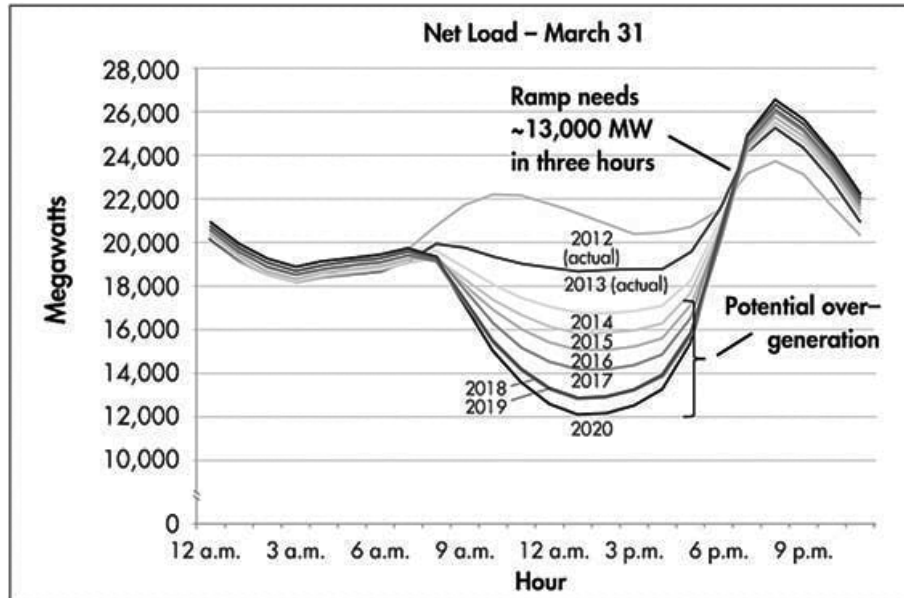


Figure 1. California Independent System Operator (CAISO) “Duck Curve” Graph.³⁹

The duck curve, represented above, outlines some of the potential issues with integrating renewable energy to the grid.⁴⁰ The graph shows the demand for electricity (y-axis) in California during each hour of an ordinary day (x-axis).⁴¹ During the daytime, when solar energy is at its peak, the demand for electricity from the grid significantly dips.⁴² This is because local solar panels throughout California are capable of meeting demand during the daytime, when electricity demand itself is relatively low.⁴³ Coincidentally, during the evening, when demand for electricity is at its highest, is when solar generation begins to tail off.⁴⁴ Both the morning’s significant dip in demand and the evening’s sharp increase creates the need for short, steep “ramps” in

39. Purvin N. Patel, *Developments in Energy Storage Could Spell the End of the Duck Curve*, POWERMAG (June 1, 2018), <https://www.powermag.com/developments-in-energy-storage-could-spell-the-end-of-the-duck-curve/>.

40. *See id.*

41. *Id.*

42. *See id.*

43. Note that this is not just a California issue. The implications of the graph are universal. California, being the pioneer for renewable energy integration, is simply the first to recognize the issue of the duck curve. *Id.*

44. CAL. INDEP. SYS. OPERATOR, *supra* note 35, at 1.

supply to match the grid’s demand.⁴⁵ These steep ramps force grid operators to quickly bring on or shut down energy generation,⁴⁶ something that massive power plants are not designed to do.⁴⁷ If grid operators do not respond to these spikes and dips in demand accordingly, they risk oversupplying or undersupplying the grid which can lead to an unstable grid resulting in black-outs or damage to the grid itself.⁴⁸ Additionally, oversupplying the grid, and subsequently curtailing generation from fossil fuel or nuclear sources, can essentially reduce all of the environmental benefits associated with solar power.⁴⁹ If grid operators were able to balance supply and demand in real time by reallocating power being generated, and use it later, the duck curve’s problems could be reduced.

Large-scale energy storage systems can balance the electric grid by optimizing the supply of electricity to mirror demand.⁵⁰ Instead of steep ramps in production, grid operators could reallocate the excess supply of energy during peak solar hours and store the energy for the peak hours of demand in the evening.⁵¹ An effective energy storage system could reduce the costs on the entire electrical system by alleviating the need for building capacity (power generation plants) and providing demand response services at a lower cost.⁵²

A. The Renewable Energy Grid

As previously mentioned, the reliability of the energy grid is the backbone of modern society.⁵³ So assuming that the transition to a renewable energy grid is inevitable, a solution to renewable resources’ intermittency issue is crucial.⁵⁴ Energy storage is that solution. Referred to by some as the “holy grail” for a clean energy future, energy storage can potentially be the “silver bullet” that balances the changing energy grid.⁵⁵ Colloquialisms aside, as a higher percentage of the grid’s electricity is generated by renewable resources—naturally providing intermittent levels of power—energy storage

45. *Id.*

46. *Id.*

47. *See id.*

48. Johnston, *supra* note 22, at 47–48.

49. *See* Patel, *supra* note 39.

50. *Id.*

51. *See id.* (describing how energy storage can alleviate intermittency problems).

52. *Id.*

53. *See supra* note 6 and accompanying text.

54. Schmitt & Sanford, *supra* note 12, at 448.

55. *Id.* at 448, 502 (describing energy storage as the “Holy Grail”) (citing 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>).

can balance the grid in real time by acting on either the supply side or demand side.⁵⁶

Effective energy storage can mitigate the reliability concerns with renewable energy's intermittency issues.⁵⁷ Energy storage enhances the reliability of a power grid, even those relying on renewable resources, by essentially providing a backup for all the power.⁵⁸ An effective energy storage system will receive excess power when the supply of electricity to the grid outweighs its demand.⁵⁹ And when demand inevitably outweighs supply, energy storage can then resupply the grid with the excess energy.⁶⁰

Energy storage provides the elegant, economically efficient solution to the issues that have always plagued the power grid. The overall generating capacity of renewable energy continues to increase⁶¹ because today's utilities and energy generators predominately focus on developing new supply resources simply to meet peaks in demand.⁶² However, in order to efficiently transition to a renewable energy grid, utilities and generators should shift their focus to developing storage systems.⁶³ As such, a growing number of investors,⁶⁴ academics⁶⁵ and politicians⁶⁶ have begun to recognize the benefits of developing additional energy storage systems.

56. U.S. DEP'T OF ENERGY, STAFF REPORT TO THE SECRETARY ON ELECTRICITY MARKETS AND RELIABILITY 73 (Aug. 2017), https://www.energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf.

57. *Id.*

58. Stein, *supra* note 6, at 711.

59. *Id.* at 713–14.

60. *Id.*

61. World Energy Council, *Energy Storage Monitor: Latest Trends in Energy Storage* 4 (Nov. 5, 2019), https://www.worldenergy.org/assets/downloads/ESM_Final_Report_05-Nov-2019.pdf.

62. Schmitt & Sanford, *supra* note 12, at 468.

63. Inara Scott, *Incentive Regulation, New Business Models, and the Transformation of the Electric Power Industry*, 5 MICH. J. ENV'T & ADMIN. L. 319, 344 (2016).

64. Three-quarters of the institutional investors that responded to the survey identified energy storage scale-up as one of the top three market factors that could accelerate the growth of renewable energy. *See* AM. COUNCIL ON RENEWABLE ENERGY, *supra* note 14, at 8.

65. *See, e.g.*, Schmitt & Sanford, *supra* note 12, at 448; Revesz & Unel, *supra* note 4, at 144–45; Kaswan, *supra* note 6, at 489–90; Spence, *supra* note 5, at 456; Stein, *supra* note 6, at 697.

66. Political dissonance may be at an all-time high, but the decreasing costs associated with both renewables and energy storage has politicians from both sides of the aisle pushing for development. *See, e.g.*, Arjun Krishnaswami, *Congress*

B. Energy Storage Technologies

Just as there are a variety of parties interested in the development of energy storage, there are a variety of technologies currently being developed.⁶⁷ Energy storage takes a multitude of shapes and functionalities, but the concept remains the same; transfer electricity into energy that can be used to generate electricity in the future. The most prevalent of these technologies is pumped hydropower storage.⁶⁸

1. Pumped Hydropower Storage

Utility-scale energy storage in America is dominated by pumped hydropower storage, which accounts for ninety-five percent of all utility-scale energy storage in the United States⁶⁹ and as much as ninety-nine percent worldwide.⁷⁰ There are two forms of pumped storage systems, “open-loop” and “closed-loop,” and although the distinctions are incredibly important, the mechanics of the system are relatively the same.⁷¹ As for how the system works, the term “Pumped Hydropower Storage” is indicative, water is pumped then stored to be later used as power.⁷²

The driver of pumped storage systems is its configuration. The entire system comes down to two reservoirs at different elevations, essentially one

Charges Ahead on Energy Storage, NAT’L RES. DEF. COUNCIL (May 22, 2019), <https://www.nrdc.org/experts/arjun-krishnaswami/congress-charges-ahead-energy-storage>; Michael Grunwald, *An Unexpected Current That’s Remaking American Politics*, POLITICO (Apr. 29, 2019), <https://www.politico.com/magazine/story/2019/04/29/trump-wrong-about-wind-power-electricity-battery-storage-226755>. For further evidence on this shift, Congress has proposed a number of bi-partisan bills in an effort to promote energy storage development. See Better Energy Storage Technology Act, S. 1602, 116th Cong. (2019); Promoting Grid Storage Act of 2019, S. 1593, 116th Cong. (2019); Advancing Grid Storage Act of 2019, H.R. 1743, 116th Cong. (2019); Battery Storage Innovation Act, H.R. 1742, 116th Cong. (2019); Storage Technology for Operation Readiness and Generating Energy Act, H.R. 1744, 116th Cong. (2019); Energy Storage Tax Incentive and Deployment Act of 2019, H.R. 2096, S. 1142, 116th Cong. (2019).

67. Off. Energy Efficiency & Renewable Energy, *Pumped-Storage Hydropower*, DEP’T OF ENERGY, <https://www.energy.gov/eere/water/pumped-storage-hydropower> (last visited Apr. 9, 2021).

68. *Id.*

69. *Id.*

70. Revesz & Unel, *supra* note 4, at 152 (citing STEVE BLUME, ENERGY STORAGE COUNCIL, GLOBAL ENERGY STORAGE MARKET OVERVIEW & REGIONAL SUMMARY REPORT 2015, at 5 (2015)).

71. Off. Energy Efficiency & Renewable Energy, *supra* note 67.

72. *Id.*

higher than the other.⁷³ During “off-peak hours,” when supply of electricity is high but demand is low, the pumped hydropower storage system uses the excess supply of electricity to pump water from the lower reservoir uphill to the other.⁷⁴ The water is then stored in the upper reservoir until the electric grid requires more electricity, usually during “peak hours,” when the demand for electricity is high.⁷⁵ The water in the upper reservoir is then released back downhill through a turbine that generates electricity.⁷⁶ Both forms of pumped hydropower storage work under this basic mechanical framework, but what distinguishes the “open-loop” and “closed-loop” systems has created opportunity.⁷⁷

FIGURE 2

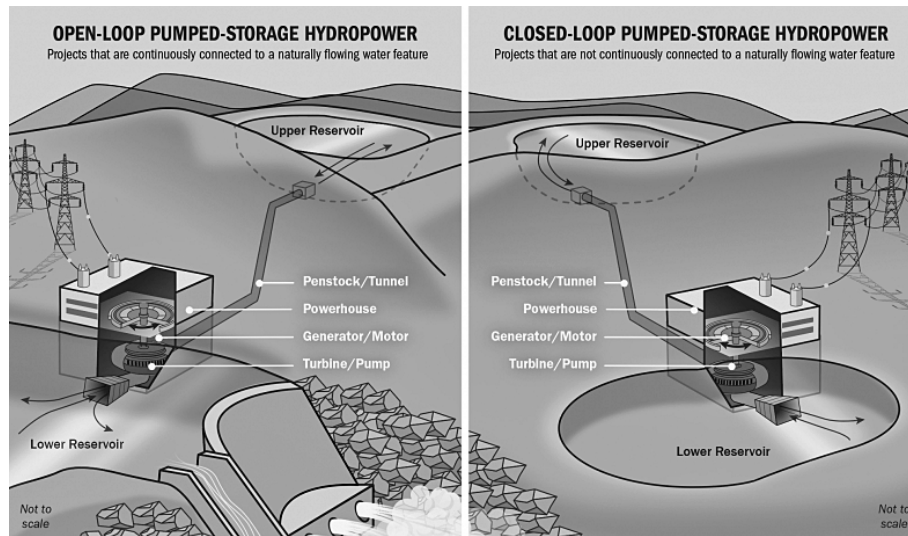


Figure 2. Open-Loop and Closed-Loop Pumped Storage Hydropower Systems.⁷⁸

73. *Id.*

74. Revesz & Unel, *supra* note 4, at 151.

75. *Id.*

76. *Id.*

77. MICHAEL MANWARING ET AL., NAT’L HYDROPOWER ASS’N, CHALLENGES AND OPPORTUNITIES FOR NEW PUMPED STORAGE DEVELOPMENT 3 (2017), https://www.hydro.org/wp-content/uploads/2017/08/NHA_PumpedStorage_071212b1.pdf.

78. Off. Energy Efficiency & Renewable Energy, *supra* note 67.

An “open-loop” pumped storage system is continuously connected to a natural water feature, like lakes and rivers.⁷⁹ The open-loop system relies on that water feature to fill and recharge its storage reservoir, because each time water is released to generate electricity it returns to the natural waterway.⁸⁰ This places a geographical constraint on open-loop systems because there must be enough land along the waterway for the reservoir at the appropriate elevation.⁸¹

Conversely, “closed-loop” is isolated from a natural waterway, utilizing reservoirs situated at other locations.⁸² A closed-loop project does not release its water back into natural waterways, only relying on natural water features or groundwater to fill the reservoirs, and the occasional recharge as needed.⁸³ Interestingly, the type of reservoirs that lend themselves to closed-loop systems are surface and underground mines.⁸⁴ As will be discussed, this creates an opportunity for energy storage development across the country.⁸⁵ Developers can essentially repurpose abandoned mines at a low cost and with little environmental disruption.⁸⁶

2. Battery Storage

Batteries are one of the world’s most recognizable energy storage systems but have only recently entered the fray for large scale energy storage.⁸⁷

79. ROGNER ET AL., INT’L HYDROPOWER ASS’N, *THE WORLD’S WATER BATTERY: PUMPED HYDROPOWER STORAGE AND THE CLEAN ENERGY TRANSITION* 4 (2018).

80. *Id.*

81. J. Daniel Skees & Robert P. Goldfin, *FERC Guidance Aims to Foster Hydropower at Mines, Dams*, LAW360 (Dec. 11, 2019), <https://www.morganlewis.com/-/media/files/document/2019/ferc-guidance-aims-to-foster-hydropower-at-mines-dams.ashx?la=en&hash=63159BF63797EB73471CE66728BC6E58B64C4528>.

82. “A closed-loop pumped storage project is generally defined as a pumped storage projects that utilizes reservoirs situated at locations other than natural waterways, lakes, wetlands, and other natural surface.” FED. ENERGY REGUL. COMM’N, *GUIDANCE FOR APPLICANTS SEEKING LICENSES OR PRELIMINARY PERMITS FOR CLOSED-LOOP PUMPED STORAGE PROJECTS AT ABANDONED MINE SITES* 1 (Oct. 2019) [hereinafter *FERC GUIDANCE FOR APPLICANTS*].

83. *Id.*

84. *See id.*

85. Abandoned mines can be found in almost every state. *See id.* at 2.

86. *Using Abandoned Mines for Electrical Energy Storage*, KEWEENAW REPORT (Jan. 24, 2019), <http://www.keweenawreport.com/news/local-news/using-abandoned-mines-for-electrical-energy-storage/>.

87. Alexandra Zablocki, *Energy Storage Fact Sheet*, ENV’T & ENERGY STUDY INST. 4 (Feb. 22, 2019), https://www.eesi.org/files/FactSheet_Energy_Storage_0219.pdf.

Batteries can take on a variety of forms, each of which is racing to become the commercial standard for large scale storage.⁸⁸ The leader, as of now, is the Lithium-ion battery, best known for its original use within most small-scale consumer items, like cellphones.⁸⁹ Lithium-ion batteries account for nearly ninety percent of the battery storage capacity globally,⁹⁰ or roughly twenty-two percent of non-pumped storage capacity.⁹¹ Flow batteries are a growing sect of the battery market.⁹² Flow batteries are still substantially less popular than lithium-ion batteries, but have been used in multiple energy storage projects that require storage for a longer duration.⁹³

No type of battery has been able to replicate the success on a large scale like pumped hydro storage has.⁹⁴ Battery technology has continued to grow, and encouraging developments have been made.⁹⁵ Nonetheless, batteries are still limited by their cost, size and efficiencies when applied to the large-scale storage needed to support an energy grid.⁹⁶ This raises the question of whether battery storage should be the choice technology to implement, and whether its effectiveness and low costs can truly match pumped storage on a large-scale for a long period of time.⁹⁷

3. Other – Thermal, Compressed Air, and Magnetic

Despite the battle to be the commercial standard between pumped storage and battery technologies, some other interesting developments in energy storage continue to be made and deserve to be mentioned. The use of, fly-wheels, compressed air, thermal systems and electrical storage systems are interesting technological developments.

Compressed air energy storage is an interesting type of mechanical storage, like pumped storage, and can also be used for large-scale, long-term storage.⁹⁸ Similar to closed-loop pumped hydropower storage, compressed air energy storage systems usually use underground caverns or other natural

88. *See id.*; *see also* Stein, *supra* note 6, at 707 (“[M]any other types [of batteries] are racing to the commercial finish line.”).

89. Zablocki, *supra* note 87, at 4.

90. *Id.*

91. Revesz & Unel, *supra* note 4, at 152.

92. Zablocki, *supra* note 87, at 5.

93. *Id.*

94. *Id.* at 3.

95. *Id.*

96. *Id.* at 4.

97. Andrea Immendoerfer et al., *Life-Cycle Impacts of Pumped Hydropower Storage and Battery Storage*, 238 INT’L. J. ENERGY ENV’T ENG’G 231, 235, 237, 242 (2017).

98. *See* Revesz & Unel, *supra* note 4, at 152.

reservoirs.⁹⁹ The storage system uses off-peak electricity to pump compressed air into an underground cavern, then when electricity is needed the compressed air is heated (typically using natural gas), it expands and is channeled through a turbine to generate electricity.¹⁰⁰ The system is relatively popular, constituting about forty-five percent of America’s non-pumped electric storage capacity,¹⁰¹ but is unlikely to be the answer to the energy storage problem due to its seventy percent efficiency mark.¹⁰²

Flywheels are a mechanical storage technique, like pumped storage and compressed air, but are more attuned for ancillary services, as opposed to long-term storage.¹⁰³ Flywheels store energy by running a motor that accelerates the spinning of a “flywheel,” which then uses its kinetic energy in the reverse when needed by spinning the same motor to generate electricity.¹⁰⁴ Essentially, flywheel systems utilize the kinetic energy of a wheel, typically inside a vacuum to reduce friction, to store energy and then generate energy over the short term.¹⁰⁵ These systems are efficient and can react quickly to reconcile small differences in supply and demand, but are not suited to support America’s need for long-term energy storage.¹⁰⁶

Thermal energy storage systems use temperature to store energy in a surprisingly basic but intuitive way. For example, energy is stored by heating rocks, salt or water. When energy is needed, ice or cold water will be poured onto the hot substances to produce steam which then spins turbines.¹⁰⁷ These systems can also work in the reverse, where substances are chilled when energy is stored then introduced to hot water.¹⁰⁸ Thermal energy storage doesn’t appear to be the answer for the United States’ storage needs, accounting for only 3.28%¹⁰⁹ and greatly varying in efficiency from fifty to ninety percent.¹¹⁰

Lastly, electrical storage systems offer a more direct way to store energy.¹¹¹ Unlike pumped storage or compressed air storage that hold energy indirectly, electrical storage technologies are being developed to directly

99. *Id.*

100. *Id.*

101. *Id.*

102. *See* Zablocki, *supra* note 87, at 3.

103. *See id.* at 5.

104. *Id.*

105. *Id.*

106. *See* Revesz & Unel, *supra* note 4, at 152–53.

107. *See id.* at 153.

108. *Id.*

109. *Id.* at 154.

110. *See* Zablocki, *supra* note 87, at 4.

111. Revesz & Unel, *supra* note 4, at 154.

store electricity in electrostatic or magnetic fields.¹¹² These technologies are still developing and do not yet contribute to America's storage capacity.¹¹³

All in all, interesting technological developments continue to be made in energy storage but the battle to be the market's choice energy storage technology is likely to come down to pumped storage and battery storage. More specifically, whether lithium-ion battery technology will be able to compete with the large-scale open-loop pumped storage facilities already in place, as well as the development of closed-loop pumped storage facilities.

III. LOOKING INTO CLOSED-LOOP PUMPED STORAGE

As previously mentioned, both the United States' and the world's utility-scale energy storage is dominated by pumped hydropower storage.¹¹⁴ This market domination is more impressive considering nearly half of America's pumped storage plants were built in the 1970s.¹¹⁵ The slow development of America's pumped storage systems is primarily due to developer's planning for open-loop systems,¹¹⁶ until recently.¹¹⁷

In review, open-loop pumped storage systems are incredibly difficult to build for a litany of reasons; the system is geographically constrained, capital intensive, environmentally disruptive, and hindered by regulations.¹¹⁸ The system is geographically constrained because it must find an area to build a reservoir uphill from a natural waterway, to then pump the water uphill.¹¹⁹ This is a capital-intensive process because the entire system must be built into vertical terrain along the waterway.¹²⁰ As a result of all these difficulties, open-loop systems are typically situated near dams, and are often cited as a comparable environmental nuisance.¹²¹ These environmental issues have given rise to the strict permitting and licensing of pumped storage systems, akin to dam regulations.¹²²

Conversely, closed-loop systems avoid complex aquatic systems and are more geographically agnostic because they are completely isolated systems

112. *Id.*

113. *Id.*

114. Off. Energy Efficiency & Renewable Energy, *supra* note 67.

115. See Fred Mayes, *Most Pumped Storage Electricity Pumped Storage Electricity Generators in the U.S. were Built in the 1970s*, ENERGY INFO. ADMIN. (Oct. 31, 2019), <https://www.eia.gov/todayinenergy/detail.php?id=41833>.

116. *Id.*

117. *Id.*

118. Schmitt & Sanford, *supra* note 12, at 457.

119. *Id.*

120. See Mayes, *supra* note 115.

121. *Id.*

122. *Id.*

that only need topography that contains a height differential.¹²³ Because closed-loop systems present minimal impacts to existing aquatic systems,¹²⁴ closed-loop systems have recently been afforded the opportunity to expedite the permitting and licensing process.¹²⁵ This expedited process greatly reduces the administrative costs associated with a pumped storage project as well as the regulatory uncertainty, all without compromising any environmental protections.¹²⁶ Additionally, closed-loop systems offer another improvement on open-loop systems by being more geographically agnostic.¹²⁷ Closed-loop projects only require that the system’s two reservoirs be at different heights.¹²⁸ This opens up the possibility of closed-loop systems across the country, from abandoned mines to more conventional topographic features like mountains.¹²⁹ Combining the closed-loop system’s innovative technology,¹³⁰ the ability to locate projects where needed, and the lower regulatory costs, closed-loop pumped storage is quickly becoming a commercially viable technology.¹³¹ In summation, despite being the standard energy storage system for most of America’s history, pumped storage is not without its shortcomings.¹³²

A. Technical and Practical Background

Closed-loop pumped hydro storage facilities are able to minimize the shortcomings of traditional open-loop pumped storage, while also emphasizing pumped storage technology’s effectiveness.¹³³ A closed-loop system

123. MANWARING ET AL, *supra* note 77, at 1, 9.

124. *Id.*

125. See Expedited Licensing Process for Qualifying Non-Federal Hydropower Projects at Existing Nonpowered Dams and for Closed-Loop Pumped Storage Projects, 18 C.F.R. § 7 (2019); see generally America’s Water Infrastructure Act of 2018, Pub. L. No. 115-270, § 3004, 132 Stat. 3765, 3867 (2018).

126. 2018 Pumped Storage Report, NAT’L HYDROPOWER ASS’N 10 (Apr. 2018), <https://www.hydro.org/wp-content/uploads/2018/04/2018-NHA-Pumped-Storage-Report.pdf>.

127. Skees & Goldfin, *supra* note 81.

128. *Id.*

129. Hydroelectric Licensing Regulation Under the America’s Water Infrastructure Act of 2018, 84 Fed. Reg. 17,064 (Apr. 24, 2019) (to be codified at 18 C.F.R. pt. 7).

130. See *infra* Part III.A.

131. See Brian Murray, *Just Add Water: How Retired Coal Assets Could Help Power a Low-Carbon Future*, FORBES (Feb. 7, 2020, 8:16 AM), <https://www.forbes.com/sites/brianmurray1/2020/02/07/just-add-water-how-retired-coal-assets-could-help-power-a-low-carbon-future/#25a39011496c>.

132. Schmitt & Sanford, *supra* note 12, at 457.

133. Skees & Goldfin, *supra* note 81.

functions the same as an open-loop system, except it simply recirculates the same water from one reservoir to another, as opposed to open-loop system's use of a natural waterway to act as one of the reservoirs.¹³⁴ Often referred to as "off stream" pumped storage, closed-loop systems can be located anywhere that an upper and lower reservoir can be used or created, and then a tunnel (of sorts) can be used or created to move water between the two reservoirs.¹³⁵

Because of this simplistic outlay, closed-loop systems have been proposed in a number of different terrains, most interestingly of them all is in abandoned mines.¹³⁶ Abandoned mines offer a ready-made closed-loop pumped storage system through the deep underground pit, acting as the lower reservoir, and the shafts to the surface acting as the tunnel between the lower reservoir and the upper reservoir created on the surface.¹³⁷ Additionally, these mines are equipped with transmission infrastructure, minimizing the need to site and permit costly powerlines.¹³⁸

Pumped storage is effective because of its flexibility in responding to the energy grid's needs. Pumped storage technology has developed over time to allow facilities to offer both balancing and ancillary services to the grid.¹³⁹ Balancing services refer to larger-scale transfers of energy to meet supply and demand over long periods of time; conversely, ancillary services refer to more response-based solutions that meet the smaller variances in real time supply and demand.¹⁴⁰ Both of these services allow pumped storage facilities to respond to the varying and intermittent nature of renewable resource generation.¹⁴¹ Further, pumped storage technology has evolved, specifically the turbines it uses, to better respond.¹⁴² More specifically, the traditional "fixed-speed" turbine is used for large-scale supply and demand and is exactly what it sounds like, the turbines spin at a fixed-speed and transmit the same level of energy during generation.¹⁴³ In the 1990s, Japan developed variable speed pump-turbines to better respond to varying levels of generation from renewable resources.¹⁴⁴ These variable speed pump-turbines can act in both balanc-

134. *Id.*

135. *Id.*

136. *See Murray, supra* note 131.

137. *Id.*

138. *Id.*

139. ROGNER ET AL., *supra* note 79, at 1, 6.

140. *Id.*

141. *Id.*

142. *Id.*

143. *Id.*

144. *Id.*

ing and ancillary services as a result.¹⁴⁵ Similarly, ternary pumped storage technology is a recent technology that uses wholly separate machines as the pumps and turbines.¹⁴⁶ This allows the ternary pumped storage system to offer even quicker response times for ancillary services, and thereby greater flexibility to the grid as a whole.¹⁴⁷

Due to closed-loop systems being located off of natural waterways, closed-loop projects can be appropriately placed to efficiently complement intermittent renewable resource generation. Additionally, energy storage generally increases transmission efficiency, meaning energy storage usually requires less building of costly transmission infrastructure.¹⁴⁸ Further, closed-loop pumped storage systems can even better utilize transmission facilities already in place, like those from abandoned coal mines¹⁴⁹ or sources of renewable energy generation.¹⁵⁰

B. Regulatory Background

Pumped storage has a unique regulatory background, especially closed-loop pumped storage. Recently, closed-loop storage systems have been promoted, and their regulatory landscape has changed as a result.

1. Permits and Licenses

Nearly half of the pumped storage capacity in operation was built in the 1970s.¹⁵¹ The difficulties of obtaining approval for a pumped storage facility is mostly to blame, along with the geographical restrictions, on traditional pumped-storage technology.¹⁵²

Again, by opting to build a pumped storage project “off-stream” you are creating a closed-loop system that has minimal interaction with aquatic systems, thereby minimizing the need for a lengthy permitting and environmen-

145. See ROGNER ET AL., *supra* note 79 at 6.

146. *Id.*

147. *Id.*

148. David G. Victor et al., *Pumped Energy Storage: Vital to California’s Renewable Energy Future*, SAN DIEGO WATER CNTY. AUTH. 11 (May 21, 2019), <https://www.sdcwa.org/sites/default/files/White%20Paper%20-%20Pumped%20Energy%20Storage%20V.16.pdf>.

149. Murray, *supra* note 131.

150. SW. RSCH. INST., *Optimizing West Texas Wind & Solar Energy Generation Using Closed-Loop Pumped Storage Hydropower 2*, https://www.swri.org/sites/default/files/brochures/closedloop-pumped-storage-hydropower_1.pdf (last visited Apr. 9, 2021).

151. Mayes, *supra* note 115.

152. *Id.*

tal review process.¹⁵³ Similarly, the ability to build near existing transmission infrastructure further reduces the need for the siting and permitting of powerlines for closed-loop projects.¹⁵⁴

Recognizing closed-loop projects' low risk of adverse environmental effects, a number of organizations asked the FERC for an expedited licensing process to increase the number of closed-loop pumped storage projects.¹⁵⁵ In response, Congress passed America's Water Infrastructure Act, instructing the FERC to create this expedited process.¹⁵⁶ The FERC obliged, issuing Order No. 858 in April 2019.¹⁵⁷ Order No. 858 created an expedited licensing process for qualifying facilities at non-powered dams and for closed-loop pumped storage projects.¹⁵⁸ The FERC's goal for this expedited process was to issue final decisions on licenses "no later than two years after the Commission receives a completed license application."¹⁵⁹ This goal represents an overwhelming success for closed-loop pumped storage because it greatly reduces the administrative costs of each project, while simultaneously decreasing the timeline for a project's profits.¹⁶⁰

Imperative to the success of the expedited licensing process is how the FERC chooses to define a qualifying "closed-loop pumped storage project."¹⁶¹ The definition of a "closed-loop" system is imperative for the expedited licensing process because it acts as the proverbial sorting hat for the entire process, directing each proposed project through the correct licensing process.¹⁶² When creating this expedited process, the FERC and interested parties wanted to be certain that projects in need of a deeper environmental

153. Vladimir Koritarov et al., *Modeling and Analysis of Value of Advanced Pumped Storage Hydropower in the United States*, ARGONNE NAT'L LAB'Y 2-2 (June 2014), https://energyexemplar.com/wp-content/uploads/ANL-DIS-14-7_Advanced_PSH_Final_Report.pdf.

154. *Id.*

155. *See, e.g.*, NAT'L HYDROPOWER ASS'N, *supra* note 126, at 1, 10.

156. America's Water Infrastructure Act of 2018, Pub. L. No. 115-270, §§ 300304, 132 Stat. 3765 (2018).

157. Hydroelectric Licensing Regulation Under the America's Water Infrastructure Act of 2018, 84 Fed. Reg. 17,064 (Apr. 24, 2019) (to be codified at 18 C.F.R. pt. 7).

158. *Id.*

159. *Id.*

160. *2018 Pumped Storage Report*, *supra* note 126, at 1, 10.

161. *Id.*

162. Note that the FERC has three different licensing processes for pumped storage projects. *See* FED. ENERGY REGUL. COMM'N, *Licensing Process*, <https://www.ferc.gov/industries/hydropower/gen-info/licensing/licen-pro.asp> (last visited Apr. 9, 2021).

review would not slip through the cracks.¹⁶³ In their final rule, the FERC astutely chose to revise their definition of a “closed-loop pumped storage project” to address the project’s “use of surface waters or groundwater rather than on its physical, hydraulic connection” to water features.¹⁶⁴ Additionally, the FERC further revised the definition to require that a proposed closed-loop project demonstrate that it “will cause little to no change to existing surface and groundwater flows and uses, and is unlikely to adversely affect” federally protected species.¹⁶⁵ The crucial aspect of the definition is the project’s use of water. Under the revised definition, water can only be used for the initial fill, or “charge” of the reservoir, and then for periodic fills to replace loss of water through leakage and evaporation.¹⁶⁶ Although these revisions correctly address the “closed-loop” definition in the broadest sense with little risk of a project that adversely effects water features qualifying for the expedited process,¹⁶⁷ the revised definition does raise the question of how to qualify a proposed closed-loop project’s projected use of water.

More specifically, how will the FERC regulate a project’s “periodic recharges,” and how will the Commission go about enforcing this rule? In recent guidance, the FERC addressed this issue by stipulating that each license application should include the water source and amount used for initial fill and recharges and also the frequency of recharges going forward.¹⁶⁸ The guidance is instructive, but it does little to clear up the ambiguity of the “recharge.” Did the FERC purposefully leave the “periodic recharge” requirement ambiguous to best adjudicate on a case-by-case basis? And for those projects that abuse the leniency of the “periodic recharge,” how will the FERC look to penalize the project owners? It is unlikely that the Commission would look to posthumously revoke the license of an active pumped storage facility, but agency fines have a mixed bag of results.¹⁶⁹ Depending on the circumstances, agencies’ issuing of fines lends itself to bankruptcy sentencing for many beneficial projects or a minor slap on the wrist.¹⁷⁰

163. Hydroelectric Licensing Regulation Under the America’s Water Infrastructure Act of 2018, 84 Fed. Reg. at 17,064, 17,068.

164. *Id.* (addressing the definition within 18 C.F.R. § 7.1(b)(3)).

165. *Id.*

166. *Id.* at 17,068–69.

167. *Id.*

168. FERC GUIDANCE FOR APPLICANTS, *supra* note 82, at 1, 13.

169. *All Civil Penalty Actions – 2019*, FED. ENERGY REGUL. COMM’N, <https://www.ferc.gov/enforcement-legal/enforcement/civil-penalties/all-civil-penalty-actions-2019> (last visited Apr. 9, 2021).

170. *Id.*

2. Categorizing “Energy Storage” Within Regulations

The lack of growth in electricity storage can also be attributed to the inability to categorize what exactly it is.¹⁷¹ The FERC has delineated that electricity storage projects “do not readily fit into only of the traditional asset functions of generation, transmission or distribution.”¹⁷² The Commission has routinely reiterated this sentiment, noting that energy storage projects can function within distribution, generation or transmission, or even all three.¹⁷³ As a result, the Commission typically addressed the classification of energy storage devices on a case-by-case basis.¹⁷⁴

Energy storage’s indeterminate classification makes it like fitting a square peg in a round hole, unable to be easily placed into any federal or state jurisdictional categories.¹⁷⁵ Further, energy storage does not comply with traditional ratemaking categories, which can further devalue the versatility of energy storage projects.¹⁷⁶ Essentially, energy storage projects would be typecast as either a “generation” or “transmission” facility by the FERC, the implications of each has benefits but mostly inhibits the profitability of storage system’s versatility.¹⁷⁷ Energy storage projects categorized as “generation” facilities are reduced to receiving revenue through arbitrage power prices alone—meaning its revenue is limited to the difference between what it pays for power (to store energy) and the price it sells it for.¹⁷⁸ Conversely, even if “transmission” seems the more appropriate category,¹⁷⁹ it essentially dooms the economics of an energy storage project by prohibiting the operator to act as a market participant.¹⁸⁰ The FERC’s current legal framework prohibits transmission assets from participating in wholesale energy and ancil-

171. Schmitt & Sanford, *supra* note 12, at 476.

172. W. Grid Dev., LLC, 130 FERC ¶ 61,056 para. 44 (2010), 2010 WL 198394.

173. *See, e.g., Reform of Generator Interconnection Procedures and Agreements*, 163 FERC ¶ 61,043 para. 278 (2018), 2018 WL 1896449 (to be codified in 18 C.F.R. pt. 37) (“The Commission previously has found that, in certain situations, electric storage resources can function as a generating facility, a transmission asset, or both.”); *Utilization of Electric Storage Resources for Multiple Services When Receiving Cost-Based Rate Recovery*, 158 FERC ¶ 61,051 para. 2 (2017), 2017 WL 368068 (“[E]lectric storage resources may fit into one or more of the traditional asset functions of generation, transmission, and distribution.”).

174. W. Grid Dev., LLC, 130 FERC ¶ 61,056 para. 44. The FERC has routinely reiterated this sentiment.

175. Schmitt & Sanford, *supra* note 12, at 476–77.

176. *See id.*

177. *Id.*

178. *Id.* at 477.

179. *See Stein, supra* note 6, at 724.

180. Schmitt & Sanford, *supra* note 12, at 480 n.313.

lary services. This is out of concern that such ability would adversely affect market’s competition, as well as the independence of Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs).¹⁸¹ The ideology is that transmission assets transmit electricity and address reliability concerns in the grid and as a result are thought to be “revenue neutral” within organized markets.¹⁸² So when labeled as a “transmission” asset, energy storage projects are prohibited from open markets to minimize any incentive for market manipulation.¹⁸³

Although energy storage can fit into each traditional category, all of the capabilities of energy storage systems are not properly incentivized.¹⁸⁴ More specifically, the value-add of balancing the electric grid, by being able to pull and place power within the grid on both a large scale and as an ancillary service, is not properly valued for energy storage systems.¹⁸⁵

Due to the FERC addressing this classification on a case-by-case basis in the past, projects were essentially hand-picked by the Commission as the winners or losers of financial incentives.¹⁸⁶ You don’t have to be Warren Buffett to realize that this regulatory risk increases investor uncertainty to a level that discourages investment.¹⁸⁷ Thus, the FERC looked to mitigate some of the regulatory inhibitors to energy storage systems by requiring RTOs and ISOs to address the barriers to participation in their wholesale markets.¹⁸⁸

FERC Order No. 841 was intended to be a boost to the energy storage industry by rectifying the variety of regulations that inhibited storage system’s participation in various markets, opening up new revenue streams for storage operators as a result.¹⁸⁹ Although some markets recognized electric storage’s uniqueness, most energy storage systems were hindered under a

181. *Id.* at 480. RTOs and ISOs are entities that were formed under the FERC’s recommendation to regulate and administer multi-state electric grids. *See RTOs and ISOs*, FED. ENERGY REGUL. COMM’N (July 13, 2020), <https://www.ferc.gov/industries-data/electric/power-sales-and-markets/rtos-and-isos>.

182. Schmitt & Sanford, *supra* note 12, at 479.

183. *Id.* at 480–81.

184. *See* Revesz & Unel, *supra* note 4, at 173.

185. *See id.*

186. Schmitt & Sanford, *supra* note 12, at 477.

187. *See id.*

188. *See* Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, 83 Fed. Reg. 9,580, 9,583 (Mar. 6, 2018) (to be codified at 18 C.F.R. pt. 35).

189. Matthew Bandyk, *FERC’s Order 841 ‘Essential’ for Energy Storage to Cut Emissions, Attorneys General Argue*, UTILITY DIVE (Feb. 11, 2020), <https://www.utilitydive.com/news/fercs-order-841-essential-for-energy-storage-to-cut-emissions-attorneys/572050/>.

transmission-like label and were prohibited from participating in wholesale markets.¹⁹⁰ By forcing all RTOs and ISOs to restructure their market participation models to accommodate electric storage resources unique characteristics, the FERC expects markets to optimize all of the beneficial characteristics that energy storage systems have to offer.¹⁹¹

Order No. 841's recognition of energy storage's versatility, specifically as a generation asset, and subsequently leveling its playing field within the open market is a step in the right direction.¹⁹² Nonetheless, progress has been relatively slow since the FERC issued its final rule;¹⁹³ grid operators (RTOs and ISOs) waited until the end of 2018 to file their proposed plans,¹⁹⁴ and have only recently received approval,¹⁹⁵ and even one grid operator's request for delay was recently approved.¹⁹⁶ Perhaps more concerning for Order No. 841's success are the recent filings in the D.C. Circuit Court of Appeals, challenging Order No. 841 as an overreach of federal authority into state affairs.¹⁹⁷ The lawsuit is in response to Order No. 841 at large, but more, specifically the FERC's denial of a state-by-state opt-out provision.¹⁹⁸

The regulatory risks and uncertainties associated with closed-loop pumped storage continue to diminish through both an expedited licensing process and the FERC releasing energy storage from traditional regulations'

190. Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, 83 Fed. Reg. at 9,580–83.

191. *See id.* at 9,583–84.

192. Derya Eryilmaz et al., *Energy Storage as a Transmission Asset in Regional Markets*, LAW360 (Jan. 22, 2020, 4:34 PM), <http://www.crai.com/sites/default/files/publications/Energy%20Storage%20As%20A%20Transmission%20Asset%20In%20Regional%20Markets-Law360-January-2020.pdf>.

193. Thomas N. Russo, *Pumped Storage Hydro: Reliable Choice for the New Electric Storage Era*, NAT. GAS & ELEC., Sept. 2019, at 25, 26.

194. *Id.*

195. *See, e.g.*, Paul Ciampoli, *FERC Accepts Part of NYISO Storage Plan*, AM. PUB. POWER ASS'N (Jan. 2, 2020), <https://www.publicpower.org/periodical/article/ferc-accepts-part-nyiso-storage-plan>; Paul Ciampoli, *FERC Accepts Storage Order Filings Made By CAISO, MISO, and ISO-NE*, AM. PUB. POWER ASS'N (Nov. 25, 2019), <https://www.publicpower.org/periodical/article/ferc-accepts-storage-order-filings-made-caiso-miso-and-iso-ne>; Paul Ciampoli, *FERC OKs SPP, PJM Compliance Filings for Storage Order*, AM. PUB. POWER ASS'N (Oct. 17, 2019), <https://www.publicpower.org/periodical/article/ferc-oks-spp-pjm-compliance-filings-storage-order>.

196. Sw. Power Pool, Inc., 170 FERC ¶ 61,164 para. 1 (2020), 2020 WL 968066.

197. Bandyk, *supra* note 189.

198. *See id.*; Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, 167 FERC ¶ 61,154 para. 30 (2019), 2019 WL 2147234.

inhibitors.¹⁹⁹ For energy storage, specifically closed-loop pumped storage, to be placed on a level playing field with all other forms of electricity generation, and in turn be a tool for an efficient energy grid, the categorization of energy storage needs to be rectified with its unique characteristics.²⁰⁰ To ensure that energy storage is properly categorized, the actions that the FERC have undertaken must continue and challenges against it should be dismissed.²⁰¹

C. Other Issues – Legal, Cultural, Environmental

Closed-loop pumped storage has been shown to be distinguishable from open-loop on both a technical and regulatory basis.²⁰² As a result of these differences, closed-loop pumped storage is capable of penetrating the electricity market by providing an efficient, low-risk and non-invasive pumped storage system;²⁰³ essentially ending America’s dearth of energy storage development.²⁰⁴ Notwithstanding closed-loop’s advantages, the concept still has unaddressed issues, as well as issues unique to itself.²⁰⁵

As previously mentioned, the use of water plays an integral role in the licensing process for closed-loop pumped storage projects.²⁰⁶ Further, a closed-loop project’s proposed location relies heavily on water availability—project’s relying solely on groundwater and rainwater would likely be too small scale—and the subsequent water rights surrounding that location.²⁰⁷ In order to find the right source of the initial fill, and subsequent recharges, an investigation into local water rights is required.²⁰⁸ This challenging mix of

199. See *supra* Part III.B.

200. See Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, 83 Fed. Reg. 9,580, 9,583–84 (Mar. 6, 2018) (to be codified at 18 C.F.R. pt. 35).

201. See Bandyk, *supra* note 189.

202. See Off. Energy Efficiency & Renewable Energy, *supra* note 67; Sw RSCH. INST, *supra* note 150, at 4.

203. See Bandyk, *supra* note 189.

204. See Mayes, *supra* note 115.

205. See, e.g., FERC GUIDANCE FOR APPLICANTS, *supra* note 82, at 8–13.

206. See *supra* note 166 and accompanying text.

207. See Botterud et al., *Pumped Storage Hydropower: Benefits for Grid Reliability and Integration of Variable Renewable Energy*, ARGONNE NAT’L LAB 4 (Aug. 2014), <https://publications.anl.gov/anlpubs/2014/12/106380.pdf>; Brandi A. Antal, *Pumped Storage Hydropower: A Technical Review*, DEPT. OF CIVIL ENG’G, UNIV. COLO. DENVER 42 (May 2014), <https://pdfs.semanticscholar.org/588d/c5f863dda656e030f9567550647bbbc78be6.pdf>.

208. Antal, *supra* note 207, at 22.

issues to identify the feasibility of a closed-loop project is not a part of an open-loop project's consideration.²⁰⁹

After identifying a feasible location, in terms of water availability, the project company must still consider the overall quality of the water to be used.²¹⁰ The quality of the water affects projects in two ways: (1) environmental and water pollution; and (2) operational effects.²¹¹ Closed-loop projects must be conscientious of the potential effects on groundwater and any potential leakage that may come from the project.²¹² This is of paramount concern when utilizing an abandoned mine as the project's reservoirs.²¹³ Abandoned mines can lead to three forms of drainage damage: (1) acid mine drainage (the most prevalent); (2) alkaline mine drainage; and (3) metal mine drainage.²¹⁴ Each of these forms of drainage can create highly toxic fluids, harming all aspects of the environment when flooded from an abandoned mine.²¹⁵

Similarly, the quality of the water can affect operational characteristics of the project.²¹⁶ More specifically, the water's contents can influence the operation's set-up, typically to account for the salinity of the water.²¹⁷ The contents of the water can deteriorate and damage the pumps and turbines within the project.²¹⁸ Notably, this problem has been diminished with the development of projects that use seawater.²¹⁹ As such, it is feasible that a closed-loop system could use the recycled water from frac fluids operations, a big development for the efficient use of West Texas drilling operations.²²⁰

There are several other, lesser, considerations that must be accounted for when developing a closed-loop pumped storage project.²²¹ A problem that plagues most energy infrastructure projects is the land use and aesthetics.²²²

209. *See id.*

210. *Id.*

211. *See id.*; *Abandoned Mine Drainage*, ENV'T PROT. AGENCY (Feb. 14, 2018), <https://www.epa.gov/nps/abandoned-mine-drainage>.

212. *See* FERC GUIDANCE FOR APPLICANTS, *supra* note 82, at 14.

213. *Id.* at 8–9.

214. *Abandoned Mine Drainage*, *supra* note 211.

215. *See id.*

216. *See* SW. RSCH. INST., *supra* note 150, at 12.

217. *See id.* at 10, 12.

218. *See id.* at 10.

219. *See id.*

220. *See id.* at 12.

221. *See* FED. ENERGY REGUL. COMM'N, HYDROPOWER PRIMER: A HANDBOOK OF HYDROPOWER BASICS 14–16, <https://www.ferc.gov/sites/default/files/2020-05/hydropower-primer.pdf> (last visited Apr. 9, 2021).

222. *Id.* at 14–15.

These issues may seem inapplicable for a closed-loop project, especially one that uses an abandoned mine, but anything that may be visible on other lands or invade into other lands raises both land use and aesthetic concerns.²²³ Perhaps the most obscure consideration is specific to projects using abandoned mines.²²⁴ Some mines are regarded as “heritage sites,” while also operating as museums or historic sites.²²⁵ It’s an interesting concept to address, because each potential site is not necessarily as conspicuous as it would seem.²²⁶

All in all, the issues that plague closed-loop pumped storage projects are certainly surmountable. Even with some of these unique issues, the minimized environmental effects promote the development of new closed-loop pumped storage projects.²²⁷ Coincidentally, advances in technology and adjustments in regulation have created an environment that interests a wide-range of investors; subsequently, an increase in closed-loop pumped storage projects.²²⁸

IV. GOING FORWARD – WHERE DOES CLOSED-LOOP PUMPED STORAGE GO?

A number of states and investors, including Bill Gates,²²⁹ view closed-loop pumped storage as the solution to renewables’ intermittency problem.²³⁰ The technology needed to create efficient closed-loop pumped storage projects is developing rapidly, even winning awards from the U.S. Department of Energy as a result.²³¹ Following the rules promulgated by the FERC,

223. *See id.*

224. *See Using Abandoned Mines for Electrical Energy Storage, supra* note 86.

225. *Id.*

226. *See id.*

227. *See Skees & Goldfin, supra* note 81.

228. *See* David R. Baker, *In Quest for Bigger Batteries, California Mulls Century-Old Idea*, BLOOMBERG L. (June 6, 2019, 7:53AM), <https://www.bloomberg.com/news/articles/2019-06-06/in-quest-for-bigger-batteries-california-mulls-century-old-idea>; Mayes, *supra* note 115.

229. Bill Gates has sponsored a number of companies, most notably “Quidnet,” which developed a new form of pumped storage that is completely geographically agnostic. Bill Gates, *A Critical Step to Reduce Climate Change*, GATES-NOTES (May 14, 2019), https://www.gatesnotes.com/Energy/A-critical-step-to-reduce-climate-change?WT.mc_id=05_14_2019_10_Energy-Storage_BG-LI_&WT.tsrc=BGLI.

230. *See* Baker, *supra* note 228; Julian Spector, *Montana Developer Ready to Build Modern-Day Pumped Hydro Storage*, GREENTECH MEDIA (Aug. 13, 2019), <https://www.greentechmedia.com/articles/read/montana-developer-ready-to-build-first-us-pumped-hydro-storage-in-years>.

231. *See* Off. Energy Efficiency & Renewable Energy, *Funding Selections Announced for Innovative Design Concepts for Standard Modular Hydropower*

the reinvigorated pumped storage market has been filled with new closed-loop projects to instigate the development of a renewable energy grid.²³² These proposals have popped-up across the country, with at least sixteen closed-loop projects being granted a preliminary permit,²³³ including in states like Arizona,²³⁴ California,²³⁵ Montana,²³⁶ New York,²³⁷ and Pennsylvania.²³⁸ This correlates well with the FERC's intent²³⁹ as well as the overall economic viability of closed-loop pumped storage projects.²⁴⁰ As of today, developing low-impact closed-loop pumped storage projects is more advantageous than simply relying on environmental damaging open-loop projects,²⁴¹ as well as any new technologies, like batteries.²⁴²

Comparing pumped storage, let alone closed-loop systems, to batteries is difficult for a multitude of reasons, from batteries ever-evolving technol-

and Pumped Storage Hydropower, DEP'T OF ENERGY (Apr. 1, 2019), <https://www.energy.gov/eere/articles/funding-selections-announced-innovative-design-concepts-standard-modular-hydropower>.

232. "Many of these proposed projects can be classified as using a closed-loop system." See *Pumped Storage Projects*, FED. ENERGY REGUL. COMM'N (June 10, 2020), <https://www.ferc.gov/pumped-storage-projects>.
233. *Preliminary Permits*, FED. ENERGY REGUL. COMM'N (June 20, 2020), <https://www.ferc.gov/industries-data/hydropower/licensing> (follow "Active Preliminary Permits" hyperlink).
234. Kavya Balaraman, *Proposed 2.2 GW Storage Project Plans to use Navajo Coal Station Power-Lines*, UTILITY DIVE (Jan. 21, 2020), <https://www.utilitydive.com/news/2200-mw-storage-project-navajo-coal-facility-power-lines/570720/> (massive proposed closed-loop project in Arizona).
235. See Baker, *supra* note 228 (California performs research on a number of pumped storage projects, including closed-loop projects); Sammy Roth, *Environmental Disaster or Key to a Clean Energy Future? A New Twist on Hydropower*, L.A. TIMES (Mar. 5, 2020, 6:00 AM), <https://www.latimes.com/environment/story/2020-03-05/is-hydropower-key-to-a-clean-energy-future>.
236. Spector, *supra* note 230 (proposed closed-loop project in Montana).
237. Baker, *supra* note 228.
238. *FERC Issues Preliminary Permit for 400-MW Packer-Banks Pumped Storage Project in Pennsylvania*, HYDRO REVIEW (Nov. 13, 2019), <https://www.hydroreview.com/2019/11/13/ferc-issues-preliminary-permit-for-400-mw-packer-banks-pumped-storage-project-in-pennsylvania/#gref>.
239. See *supra* Part III.B.
240. See William Driscoll, *Pumped Hydro with Better Financing Can Compete with Batteries*, PV MAG. (May 14, 2019), <https://pv-magazine-usa.com/2019/05/14/pumped-hydro-with-better-financing-can-compete-with-batteries/>.
241. See *supra* Part III.A.
242. Victor et al., *supra* note 148, at 17.

ogy to the issues with evaluating new closed-loop projects.²⁴³ The key factors for determining whether an energy storage technology is commercially viable are the technology’s life-cycle cost and overall performance.²⁴⁴ It is difficult to analyze these factors completely, but with the evidence available, it seems that closed-loop projects are a more desirable option.²⁴⁵ Closed-loop pumped storage projects typically perform at a lower efficiency than batteries but are able to perform at a much higher scale.²⁴⁶ This creates a sort of trade-off, because today’s battery technology is simply unable to compete with the scale of pumped storage projects.²⁴⁷ Similarly, the life-cycle costs of pumped storage projects are surprisingly less than the life-cycle costs of batteries.²⁴⁸ This is in large part due to the average pumped storage project’s life-cycle being four-times that of today’s best batteries.²⁴⁹ It is also important to note batteries’ inherent issue, deterioration and decommissioning; a battery’s power naturally declines as it ages, and it will eventually need to be disposed of in an environmentally conscious way because the battery’s materials deteriorate into hazardous waste.²⁵⁰ Along those lines, some initial research has shown that the global warming potential of battery storage over a lifetime akin to pumped storage could be twice that of pumped storage.²⁵¹ Further muddying this analysis is the fact that most of the research takes into account massive capital expenditures and environmental impacts through the lens of an open-loop pumped storage project, as opposed to a closed-loop project which greatly diminishes *both* of those negatives.²⁵²

Notwithstanding the advantages of closed-loop pumped storage, there remain concerns about how it will be regulated and administered into the energy grid.²⁵³ If Congress’ and the FERC’s efforts to promote energy stor-

243. *Id.*

244. U.S. DEP’T OF ENERGY, STAFF REPORT TO THE SECRETARY ON ELECTRICITY MARKETS AND RELIABILITY 73 (2017), https://www.energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf.

245. *See* Murray, *supra* note 131.

246. Victor et al., *supra* note 148, at 17; Zablocki, *supra* note 87, at 3.

247. *See* Zablocki, *supra* note 87, at 3.

248. Gabriel Hurtado & Sasaenia Paul Oluwabunmi, *Battery Storage and Pumped Storage Power: The Perfect Synergy*, ELEC. ENERGY ONLINE (Sept. 9, 2020), <https://electricenergyonline.com/energy/magazine/1142/article/Battery-Storage-and-Pumped-Storage-Power-The-Perfect-Synergy.html/>.

249. Immendoerfer et al., *supra* note 97, at 237.

250. *Id.* at 235, 237, 242.

251. ROGNER ET AL., *supra* note 79, at 9–10.

252. *See, e.g.,* Victor et al., *supra* note 148, at 17–18; Immendoerfer et al., *supra* note 97, at 231.

253. *See supra* Part III.B.

age and closed-loop pumped storage continues, it will certainly benefit the energy grid.²⁵⁴ Nonetheless, there are concerns about possible abuse²⁵⁵ and the overall regulation of this new form of pumped storage.²⁵⁶ As it stands, the geographical diversity,²⁵⁷ low environmental impact,²⁵⁸ large-scale capabilities,²⁵⁹ and proven technology²⁶⁰ imputes that closed-loop pumped storage offers the most viable option for energy storage development in the world.²⁶¹

254. See Peter Maloney, *As Grid Operators File FERC Order 841 Plans, Storage Floodgates Open Slowly*, UTILITY DIVE (Dec. 11, 2018), <https://www.utilitydive.com/news/as-grid-operators-file-ferc-order-841-plans-storage-floodgates-open-slowly/543977/>; Skees & Goldfin, *supra* note 81.

255. See Schmitt & Sanford, *supra* note 12, at 481.

256. See *supra* Part III.B.

257. See MANWARING ET AL., *supra* note 77, at 9.

258. *Id.*

259. Pumped storage makes up over ninety-five percent of America's energy storage capacity. Revesz & Unel, *supra* note 4, at 152 (citing STEVE BLUME, GLOBAL ENERGY STORAGE MARKET OVERVIEW & REGIONAL SUMMARY REPORT 2015, ENERGY STORAGE COUNCIL 5 (2015)).

260. Victor et al., *supra* note 148, at 17.

261. There are seemingly countless locations that are apt for closed-loop pumped storage projects. See Emiliano Bellini, *More than a Half-Million Pumped-Hydro Sites for a World of 100% Renewables*, PV MAG. (Apr. 2, 2019), <https://pv-magazine-usa.com/2019/04/02/more-than-a-half-million-pumped-hydro-sites-for-a-world-of-100-renewables/>.