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A CASE STUDY OF HYDROPOWER AS A WHOLESALE STORAGE RESOURCE

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INTRODUCTION

The proper role of electricity regulation is to facilitate competition for generation services. However, in many cases, existing regulatory regimes suppress competition from energy storage resources and undervalue grid services where these resources hold comparative advantages. This has a particularly constraining effect on hydropower, which comprises the vast majority of deployed storage resources and holds large untapped potential.1 Regulatory reform is essential to allow all storage resources to compete on a level playing field and to drive voluntary innovation and deployment of cost-efficient resources.

Hydropower's ability to participate as a storage resource faces unusually high artificial barriers to entry in wholesale power markets. These stem primarily from inadvertently discriminatory wholesale market rules and lengthy and ambiguous permitting processes. Considering the value of storage services is on the rise, reducing artificial barriers should have a potent effect on market outcomes.

GROWING ECONOMIC VALUE OF ENERGY STORAGE

The value of storage in wholesale markets is rapidly evolving. The largest drivers are growth in variable energy resources (VERs)—like wind and solar power—and the retirement of conventional power plants. Storage excels at providing flexible balancing services and essential reliability services (ERSs)[2] that grow in importance as the generation mix evolves.[3] VERs also have greater geographic constraints than most conventional generators, which creates greater value for storage technologies that avoid costs from transmission expansion or upgrades.

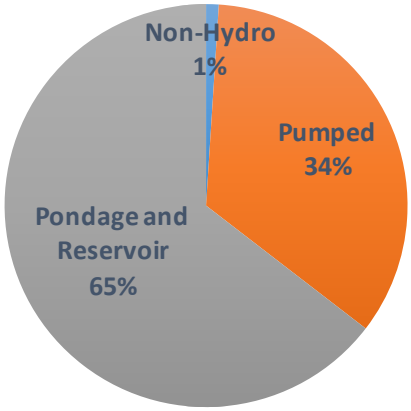
Various energy storage technologies are approaching the threshold for commercial viability. Rapid cost reductions, along with the increased value of storage services, has spurred intense interest in policy reforms to ensure market access and market-based compensation for energy storage resources. Although the costs of storage technologies continue to decline rapidly, many remain uneconomic beyond niche wholesale applications.[4] For example, even lower-end cost projections of battery storage remain too high to support large-scale investment in the wholesale market in the near term.[5]

In contrast, storage applications for hydropower have commercial potential to expand at large scale immediately. Pumped hydropower has been commercially viable for decades, and the Energy Department estimates potential for another 36 gigawatts.[6] Other forms of hydropower have use limitations, which result from physical limitations or environmental restrictions on operations, that mimic characteristics of other use-limited resources in the storage class. At the same time, run-of-river hydropower has operational characteristics akin to VERs, which becomes more valuable as storage economics improve.

Hydropower dominates existing storage capacity, which will be the primary near-term beneficiary of improving market access and compensation for storage resources. Grid operators traditionally used pumped hydropower to absorb oversupply from central station plants during periods of low demand.[7] Given the aforementioned changes in the generation mix plus the rise of distributed resources, to ensure market mechanisms capture the value of storage is very important for existing and prospective hydropower.

A new report by the Brattle Group finds that to increase the operational flexibility from existing hydropower could provide great value through the reduction of need for new investments.[8] However, they find that existing hydropower cannot or does not provide these full benefits because of a lack of market access, operational flexibility, wholesale market rules that limit participation and insufficient valuation of avoided transmission and distribution system costs.[9] While

FIGURE I: STORAGE CAPACITY IN RTO/ISO AREAS



SOURCE: derived from analysis by The Brattle Group of SNL and other data.

this paper addresses wholesale market limitations to hydropower storage resources, retail-level reforms are especially important to address valuation of storage services for avoided distribution system costs and certain end-use customer benefits.

MARKET DESIGN CHANGES FOR ENERGY STORAGE

The rules that govern wholesale electricity markets emanate from a period when few storage resources were economical at large scale. This has resulted in market designs that inadvertently discriminate against energy storage resources by imposing artificial barriers to entry and suppressed market-based compensation. Recognizing this, in 2018, the Federal Energy Regulatory Commission (FERC) issued Order No. 841 to remove barriers to the participation of storage resources in wholesale electricity markets.[10] In particular, the order required wholesale market administrators and operators, also known as Regional Transmission Organizations (RTOs) or Independent System Operators (ISOs), to establish a participation model that facilitates the participation of storage resources.[11] This model must:

1. Ensure participating storage resources are eligible to provide any energy, capacity and ancillary services they are technically capable of providing;

2. Ensure participating storage resources can be dispatched and set the market-clearing price;

3. Account for the physical and operating characteristics of storage resources (e.g., establish rules governing bidding parameters); and

4. Establish a minimum size requirement that does not exceed 100 kilowatts (kW).[12]

Order No. 841 takes a principles-based approach that leaves room for different RTO/ISO-specific compliance pathways. This permits a degree of regional experimentation that uniform prescriptions negate, and this provides value when best practices are unclear. At the same time, it creates opportunities for wide variance in implementation quality across RTO/ISOs. For example, rules governing bidding parameters may treat opportunity costs and offers from resources with zero marginal fuel costs very differently, but still comply with the spirit of Order No. 841.

How RTO/ISOs implement the order will directly affect the market value of storage.[13] As noted by one storage practitioner, implementation of the order is where the "rubber meets the road."[14] Another practitioner noted the resistance of incumbents to rule changes in RTO/ISO stakeholder processes that allow new technologies to compete.[15] This corroborates a paper by the Vermont Law School commissioned by the R Street Institute on how the RTO/ISO stakeholder processes affect market efficiency.[16]

A particular implementation area to watch is the treatment of storage as a capacity market resource. Concepts for capacity accreditation for storage resources remain a work in progress and will increase in importance as net revenues from energy markets decline in an era of inexpensive natural gas and increasing VER penetration.[17] Deep methodological challenges may create capacity compensation uncertainty that could escalate investment risk. This is evident in the United Kingdom, where abrupt rule changes recently de-rated capacity accreditation for a category of storage resources by 80 percent.[18]

Order No. 841 implementation is likely to better account for characteristics of commercially available storage resources and hydropower's operating features have a comparatively higher degree of technological maturity and industry understanding. Furthermore, any participation challenges for small resources under the order's minimum size threshold will likely impact other storage resources more than hydropower. Although some pumped storage concepts fall under the 100 kW threshold, these projects will likely connect at the distribution, rather than the bulk transmission or wholesale level.[19]

Generally, existing rules create fewer market access and integration problems for pumped storage than other storage resources because RTO/ISOs developed them around existing resources. In some cases, rules for pumped storage offered the only pathway to participation for all storage resources (as in New England). Efforts to tailor rules to pumped hydropower's unique characteristics actually helped provide a template to treat new unconventional resources. Much improved utilization of pumped hydropower could even occur under existing market rules. For

example, the Brattle Group estimates that storage revenues could increase two to five times with improved market participation strategies and equipment upgrades.[20]

Still, existing rules do not account for all unique aspects of hydropower storage resources. For example, new adjustable-speed pumped storage technology has more operational flexibility than considered by rules crafted around traditional pumped storage capabilities. As such, thorough compliance with Order No. 841 should substantially improve market valuation of hydropower storage resources and move it more in line with its full wholesale economic value. Altogether, given the relative economic advantages of hydropower to most other storage resources, even incremental increases to their revenue streams could have more market impact than proportionately greater revenue stream enhancement to less economic storage resources.

CO-OPTIMIZING GENERATION AND TRANSMISSION PROCESSES

FERC considered incorporation of storage resources in transmission planning to be outside the scope of Order No. 841.[21] As such, the rule did not address the ability for storage to serve as, or substitute for, a transmission resource. This remains an important area to examine as storage can serve as a generation, demand and transmission resource. Although generation and transmission have long served as complements and substitutes, each has its own planning and procurement process largely detached from the other.

FERC Order No. 1000 intended to give non-transmission alternatives, including storage, comparable consideration in regional transmission planning processes.[22] The RTO/ISOs have implemented the Order in various ways, but none effectively facilitate competition from non-transmission alternatives.[23] Improvements may come, however, from a new FERC rulemaking or through piecemeal compliance filings.

Facilitating competition from non-transmission alternatives is particularly valuable for resources that developers can locate near demand centers. This generally lends more importance to technologies with few siting restrictions, such as batteries, than conventional hydropower, which is geographically constrained. However, unconventional forms of hydropower, such as conduit systems, have potential to be located closer to heavily populated areas. As with Order No. 841, the relative economic advantages of hydropower to other storage resources could make improved transmission planning competition especially advantageous for hydropower applications. As evidence, the hydropower industry sees considerable value in a market structure that recognizes the value of storage to provide transmission benefits.[24] In particular, the industry suggests the inclusion of storage in regional transmission planning processes under FERC Order No. 1000.[25]

GROWING VALUE OF ANCILLARY AND ESSENTIAL RELIABILITY SERVICES

Incomplete ERS markets and underdeveloped ancillary service markets cause market signals to undervalue resources that would otherwise provide them in a competitive context.[26] Energy storage is particularly well-suited for providing these services, with hydropower standing out for both the breadth of service capabilities and quality (e.g., long duration storage). In particular, hydropower offers a robust suite of service offerings that include regulation and frequency response, ramping and flexibility reserve, spinning reserve, non-spinning (supplemental) reserve, voltage support, and reactive power and black-start service.[27]

Potential shortfalls in ERSs include voltage control, frequency response and generation ramping,[28] which may justify the need for dedicated procurement strategies. In theory, market mechanisms would provide the most cost-effective option and with better innovation incentives than a standards-driven approach.[29] Conceptual market design for ERSs remains a work in progress. If enacted, it would probably result in specialized procurement that expands revenue streams to storage resources. In contrast, a standards-driven approach would likely procure services inefficiently without sending a clear signal of service value to resource developers.[30]

HYDROPOWER LICENSING REFORMS

Improvements in market design and transmission planning are insufficient to remove the critical mass of artificial barriers to entry and continued operations that currently face hydropower resources. Lengthy and ambiguous permitting processes create excessive barriers that render many hydropower projects difficult to finance.[31] An R Street Institute study that reflected input from several industry consultants and former hydropower regulators found that Congress and the Trump administration should prioritize the reduction of delays and uncertainties in hydropower licensure, which mostly result from poor dispute resolution, duplicative processes and lack of schedule discipline.[32]

The study recommended seven executive actions and five joint Congressional and executive actions.[33] Most of these apply to hydropower generally, however, some actions may target storage applications. In particular, storage applications often have minimal ecosystem effects,[34] and thus would benefit from reforms that exclude *de minimis* projects from licensing and exemption requirements and "right-sizing" default regulatory treatment of projects with low, incremental environmental impact.

CONCLUSION

Electricity policy should remain technology-neutral and facilitate free competition among all technologies. However, regulatory and legislative reforms may necessarily come piecemeal and specific to a technology class. Altogether, beneficial reforms will enhance market performance by using efficient incentives to drive voluntary resource investment decisions by the private sector. Consistent with this framework, this report finds the following with respect to hydropower as a storage resource:

1. FERC must remain vigilant that RTO/ISOs implement Order No. 841 efficiently, which will have a large effect on the market value of storage overall and hydropower in particular.

2. FERC should revisit how Order No. 1000 facilitates competition from non-transmission alternatives through a rulemaking or by signaling an interest that induces petitioners to initiate a complaint.

3. FERC should examine the creation of fuel- and technology-neutral ERS markets, consistent with the Energy Department's 2017 technical staff report.35

4. Congress and the Trump administration should pursue reforms that reduce delays and uncertainties in hydropower licensure, especially for projects with minimal environmental impact.

Streamlining permitting processes, improving market access and ensuring market-based compensation for hydropower as a storage resource provides an insightful case study on the benefits of regulatory reform. The speed and quality of legislative and regulatory responses will determine whether this produces a success story or an example of regulatory morass strangling an otherwise productive resource. Bipartisan interest in hydropower reform in Congress, comments from the Trump administration and actions at FERC indicate political will may suffice to achieve the deep reforms needed to unleash the full benefits of the most valuable form of energy storage today.[36]

ABOUT THE AUTHOR

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ENDNOTES

1. See, e.g., *Hydropower Vision: A New Chapter for America's 1st Renewable Energy Source*, U.S. Dept. of Energy, 2016. https://energy.gov/sites/prod/files/2016/10/ f33/Hydropower-Vision-10262016_0.pdf.

2. "Essential Reliability Services," North American Electric Reliability Corporation, December 2016, pp. iv-v. http://www.nerc.com/comm/Other/essntlrlbltysrvcstsk-frcDL/ERSWG_Sufciency_Guideline_Report.pdf.

3. This occurs because VERs cause periods of supply excess and undersupply, and do not provide the same level of ERSs as conventional generators.

4. See, e.g., Roger Lueken et al., "Getting to 50 GW? The Role of FERC Order 841, RTOs, States, and Utilities in Unlocking Storage's Potential," The Brattle Group, Feb. 28, 2018, p. 16. http://files.brattle.com/files/13428_13366_getting_to_50_gw_study_2_22_1811.pdf.

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8. Ibid.

9. Ibid.

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11. Ibid., p. 7

12. Ibid., pp. 8-9.

13. Lueken et al., p. 8.

14. Peter Maloney, "FERC order opens 'floodgates' for energy storage in wholesale markets," UtilityDive, Feb. 20, 2018. https://www.utilitydive.com/news/ferc-order-opens-floodgates-for-energy-storage-in-wholesale-markets/517326.

15. Ibid.

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17. Devin Hartman, "Enhancing Market Signals for Electric Resource Adequacy," *R Street Policy Study* No. 123, December 2017, p. 10. http://2o9ub0417chl2lg6m43em6psi2i.wpengine.netdna-cdn.com/wp-content/uploads/2017/12/Final-123.pdf.

18. David Pratt, "Major blow for UK energy storage in Capacity Market following de-rating rule," *Energy Storage News*, Dec. 4, 2017. https://www.energy-storage.news/news/major-blow-for-uk-energy-storage-in-capacity-market-following-de-rating-rul.

19. "Comments of National Hydropower Association on the November 17, 2016 Notice of Proposed Rulemaking," Docket Nos. RM16-23-000 and AD16-20-000, p. 10. https://www.hydro.org/wp-content/uploads/2017/08/NHA-Comments-on-FERC-2016-Energy-Storage-NOPR.pdf.

20. Lueken et al., p. 23.

21. "Electric Storage Participation in Markets," p. 209. https://www.ferc.gov/whats-new/comm-meet/2018/021518/E-1.pdf.

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25. Ibid., p. 7.

26. See, e.g., "Wholesale Electricity Markets in the Technological Age," p. 12. https://www.rstreet.org/wp-content/uploads/2016/08/67.pdf.

27. Hydropower Vision, pp. 41-42. https://energy.gov/ sites/prod/files/2016/10/f33/Hydropower-Vision-10262016_0.pdf.

28. "Essential Reliability Services," pp. iv-v. http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSWG_Sufciency_Guideline_Report.pdf.

29. "Enhancing Market Signals for Electric Resource Adequacy," p. 2. http://2o9ub0417chl2lg6m43em6psi2i.wpengine.netdna-cdn.com/wp-content/uploads/2017/12/Final-123.pdf.

30. See, e.g., arguments in FERC Order No. 842 on a standards-based approach for primary frequency response versus creating a market product. https://www.ferc.gov/whats-new/comm-meet/2018/021518/E-2.pdf.

31. "Quadrennial Energy Review Transforming the Nation's Electricity System: The Second Installment of the QER," U.S. Dept. of Energy, January 2017, pp. 3-18. www.energy.gov/sites/prod/files/2017/02/f34/Quadrennial%20Energy%20Review-Second%20Installment%20%28Full%20Report%29.pdf.

32. Devin Hartman and Tom Russo, "Ebbing the Flow of Hydropower Red Tape," *R Street Policy Study* No. 105, August 2017, p. 2. http://2o9ub0417chl2lg6m43em6psi2i.wpengine.netdna-cdn.com/wp-content/uploads/2017/08/105.pdf.

33. Ibid.

34. For example, take closed-loop pumped hydropower, which presents limited potential impact to ecosystems.

35. "Staff Report to the Secretary on Electricity Markets and Reliability," U.S. Dept. of Energy, August 2017, p. 126. https://www.energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf.

36. For example, bipartisan bills on hydropower reform have advanced in the last two Congresses and the Trump administration has made public statements in favor of reducing regulatory burdens on hydropower.