UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Grid Resilience in Regional Transmission Organizations and Independent System Operators	)))))	**Docket No. AD18-7-000**

COMMENTS OF THE ENERGY STORAGE ASSOCIATION

In response to the Federal Energy Regulatory Commission's ("FERC" or "Commission") January 8, 2018, order in Docket No. RM18-1-000 opening Docket No. AD18-7-000,[1] the Energy Storage Association ("ESA") submits the following Comments pursuant to section 403 of the Department of Energy Organization Act.[2] As explained below, energy storage technologies are being used currently to enhance electric system resilience, as defined by FERC. ESA recommends that FERC further enhance resilience by incorporating energy storage into transmission planning processes, facilitating the participation of distributed energy resources on the grid, and defining and creating priced services for resilience and flexible market operations where warranted.

I. COMMUNICATIONS

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[1] *Grid Reliability and Resilience Pricing*, Order Terminating Rulemaking Proceeding, Initiating New Proceeding, And Establishing Additional Procedures (Jan. 8, 2018)

[2] 42 U.S.C. § 7173 (2012)

II. ABOUT THE ENERGY STORAGE ASSOCIATION

The Energy Storage Association (ESA) is the national trade association dedicated to energy storage, working toward a more resilient, efficient, sustainable and affordable electricity grid – as is uniquely enabled by energy storage. With more than 160 members, ESA represents a diverse group of companies, including independent power producers, electric utilities, energy service companies, financiers, insurers, law firms, installers, manufacturers, component suppliers and integrators involved in deploying energy storage systems around the globe.

ESA's member companies have expertise in transmission- and distribution-level grid operations relevant to energy storage, as well as firsthand knowledge of the regulatory challenges to financing and operating commercial energy storage facilities to realize full benefits to the bulk power system.

III. COMMENTS

A. ESA agrees with FERC's proposed definition of resilience. Flexibility is the fundamental attribute of the electric system that provides both reliability and resilience. Energy storage provides critical flexibility attributes that improve system resilience and reliability.

Our electric system is bound to a simple reality of physics—supply must precisely match demand at every moment, everywhere. If it does not, the result is equipment damage, service disruption, or blackouts. Reliability is the ability to maintain that match of electric supply and demand every moment every day, and to do so in the face of variable, unpredictable, and sometimes extreme system conditions. Resilience, on the other hand, as proposed by FERC, is "the ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event." ESA agrees with this definition. Moreover, *flexibility* is the necessary electric system attribute that provides both reliability and resilience, ensuring uninterrupted power is delivered to consumers whenever and wherever they need it under any variety of conditions.

Energy storage technologies enable electricity supplied from any source to be saved for use at a later time, precisely when, where, and in whatever form it is most needed. That very simple concept enables an enormous amount of capabilities for the electric grid—be it supplying back-up power, reducing peak system demands, relieving stressed grid infrastructure, filling in the gaps from variable generation sources, or maintaining the optimal function of inflexible generation sources. These capabilities are, at heart, more efficient ways to ensure that supply and demand reliably match, and to make that balance resilient to an increasing range of threats. Indeed, energy storage is the hub of an efficient, resilient, sustainable and affordable energy system that can adapt to any supply mix. And while there are a variety of energy storage technologies[3] with different operational characteristics, all do the same job of storing energy for use when it is most needed, be that across seconds, hours, or days. In effect, storage decouples the element of time from supply and demand. The discussion on resilience therefore merits accounting for the unique flexibility provided by cost-effective energy storage at all levels of the system.

[3] Electrochemical energy storage (known as a "battery") converts electricity into a reserve of potential energy by creating an electrical gradient between two terminals separated by an electrolyte; electrons can then be discharged as they separate from ions moving between the two terminals. Mechanical energy storage converts electricity into a reserve of potential energy by pressurizing a substance, accelerating the rotation of a mass, or moving a mass against gravity; the depressurizing of the substance, rotation of the mass, or falling of the mass can be harnessed to turn a generator and produce electricity. Thermal energy storage converts either electricity or heat into a large temperature differential between a mass and its surrounding temperature; that mass can then re-transfer heat to a steam turbine that turns a generator and produces electricity, or the mass can provide direct heating or cooling services. Pure electrical energy storage does not convert electrical input but rather slows the transfer of electrons within an electric field, thereby enabling discharge on demand over short intervals.

Today over 800 megawatts (MW) of battery storage are installed nationwide,[4] with megawatt-scale installations in 21 states.[5] This represents over 1,100 megawatt-hours (MWh) of energy storage available for use.[6] Battery storage technologies—primarily lithium-ion batteries—have declined rapidly in cost, dropping by 50% every 3 to 4 years,[7] and are expected to continue declining at similar rates over the next 5 years.[8] Driven by these cost declines, as well as the increasing electrification of our economy, the U.S. is forecast to quadruple installed storage capacity in just five years.[9] Of greater significance, though, is that sharp cost declines will spur ever larger sizes and longer durations for battery storage more cost-effectively, increasing their range of applications. The largest battery in the world is currently under development in the U.S. and will capable of providing 100 MW of power for four hours—enough to power 50,000 homes through the peak demands of the day.[10]

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[4] Known capacity additions prior to 2012, in addition to total from GTM Research, *U.S. Energy Storage Monitor: 2017 Year in Review*, March 2018, available at https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor

[5] DOE Global Energy Storage Database, accessed 9 Sep 2017, available at http://www.energystorageexchange.org

[6] GTM Research, *U.S. Energy Storage Monitor: 2017 Year in Review.*

[7] See, for example:

- IHS, *Future of Grid Connected Energy Storage*, Nov 2015, available at https://technology.ihs.com/512285/grid-connected-energy-storage-report-2015
- UBS, *US Battery Storage: Upstream Supply Chain Biggest Winner of EVs*, Oct 2016, available at https://neo.ubs.com/shared/d1Wg6h8EJsbg/
- McKinsey & Bloomberg New Energy Finance, *An Integrated Perspective on the Future of Mobility*, Nov 2016, available at https://www.bbhub.io/bnef/sites/4/2016/10/BNEF_McKinsey_The-Future-of-Mobility_11-10-16.pdf
- O. Schmidt et al., "The future cost of electrical energy storage based on experience rates," *Nature Energy*, Vol 2, 17110 (2017).
- B. Nykvist & M. Nilson, "Rapidly falling costs of battery packs for electric vehicles," *Nature Climate Change* 5 (2015), p 329-332.

[8] GTM Research, *U.S. Front-of-the-Meter Energy Storage System Prices 2018-2022*, Feb 2018, available at https://www.greentechmedia.com/research/report/us-front-of-the-meter-energy-storage-system-prices-2018-2022

[9] GTM Research, *U.S. Energy Storage Monitor: Q3 2017*, Sep 2017, available at https://www.greentechmedia.com/research/subscription/u-s-energy-storage-monitor

[10] Assumes 6 hours of consumption (5 PM to 11 PM) and average household consumption of 1.23 kW, per 2015 EIA data on annual residential electricity consumption, available at https://www.eia.gov/tools/faqs/faq.php?id=97&t=3

Battery storage is uniquely flexible among all grid resources. *First*, storage is the only resource promoting reliability in every part of the grid: co-located with generation, connected to the high-voltage transmission system, placed on the lower-voltage distribution grid, and located in buildings and other end-user facilities, as well as in microgrids. It is modular and can be scaled to any size, from a home system of a few kilowatts to a central facility 10,000 times larger. *Second*, storage provides value to all power sector participants: utilities, independent providers, and consumers can all own and operate storage for a variety of reliability services and other cost-saving applications. *Third*, storage is the only grid resource that operates as both supply and demand: supply when discharging and demand when charging, giving it effectively twice the operating range of conventional generation and the unique flexibility to mitigate oversupply as well as undersupply conditions. *Fourth*, storage is capable of near-instantaneous response and precise control, able to ramp its output to charge or discharge at full power in milliseconds. It is that precise control that allows storage to efficiently provide essential reliability services of frequency response, voltage control and ramping, as well as enhance resilience during sudden disruptions.[11] *Fifth*, storage can provide a diversity of functions for the bulk power system, the distribution grid, and end-users, including providing multiple services interchangeably over time to meet the greatest need in any given moment. *Sixth*, storage can be deployed quickly, with build times for MW-scale installations at less than 6 months.[12] Importantly, storage is agnostic to the supply of electricity, and its flexibility can be used to optimize grid functions for any supply mix. It makes non-dispatchable generators dispatchable; it makes inflexible generators flexible; and it makes inefficient cycling generators more efficient.

[11] For example, storage can synchronize to the grid and maintain appropriate frequency with even greater fidelity than the mechanical governor devices common to conventional generation that have historically been required in generator interconnection agreements.

[12] J. Pyper, "Tesla, Greensmith, AES Deploy Aliso Canyon Battery Storage in Record Time," *Greentech Media*, 31 Jan 2017, available at https://www.greentechmedia.com/articles/read/aliso-canyon-emergency-batteries-officially-up-and-running-from-tesla-green

Nuclear, coal, gas, wind, solar, hydro, demand response and system efficiency—storage enhances all resources' utilization.

As the Department of Energy's 2017 *Staff Report on Electricity Markets and Reliability* noted, storage currently provides most essential reliability services, flexibility attributes, and other reliability characteristics.[13] The flexibility of storage enhances both reliability and resilience in a diversity of applications along the entire delivery infrastructure, with several examples captured below:

- *Storage maintains power quality and provides on-site backup power to keep businesses, homes, and industrial facilities resilient to service disruptions.* On-site storage can maintain electric service following hurricanes, as happened in Florida last year when homeowners[14] and sheltering sites[15] kept their lights on with solar-paired storage. This is also why storage companies have installed battery storage systems recently in Puerto Rico, which are powering hospitals and fire stations while the electric grid is rebuilt following Hurricane Maria.[16] On-site storage is also especially important for local critical infrastructures affected by electric service disruptions serving its citizens. For example, Irvine Ranch Water District in California is installing 7 MW of batteries at its critical water treatment and pumping infrastructure to ensure continuity for public health.[17] Similarly, New Jersey has installed storage at critical facilities, such as schools, to use as shelter from hurricanes.[18] Microgrids integrating energy storage are demonstrating their capability to operate in island mode, isolated from the larger grid, to maintain service.

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[13] See Figure 4.13, "Mapping Reliability Attributes Against Resources," in U.S. Department of Energy, *Staff Report on Electricity Markets and Reliability*, Aug 2017, available at https://energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf

[14] P. Kelly-Detwiler, "After Irma: Solar Plus Storage - A Small Beacon Of Light In A Sea Of Darkness," *Forbes*, 17 Sep 2017, available at https://www.forbes.com/sites/peterdetwiler/2017/09/17/after-irma-solar-plus-storage-a-small-beacon-of-light-in-a-sea-of-darkness/

[15] J. Dean, "Solar power helped shelter shine through Irma," Florida Today, 24 Sep 2017, available at http://www.floridatoday.com/story/news/2017/09/24/solar-power-helped-shelter-shine-through-irma/694322001/

[16] A. Peters, "During Puerto Rico's Blackout, Solar Microgrids Kept The Lights On", *Fast Company*, 24 Apr 2018, available at https://www.fastcompany.com/40562660/during-puerto-ricos-blackout-solar-microgrids-kept-the-lights-on. See also B. Chappell, "Tesla Turns Power Back On At Children's Hospital In Puerto Rico," *NPR*, 25 Oct 2017, available at https://www.npr.org/sections/thetwo-way/2017/10/25/560045944/tesla-turns-power-back-on-at-childrens-hospital-in-puerto-rico.

[17] P. Maloney, "Tesla, AMS ink 34MWh storage deal with California water system," *Utility Dive*, 29 Sep 2016, available at http://www.utilitydive.com/news/tesla-ams-ink-34mwh-storage-deal-with-california-water-system/427202/

[18] H. Trabish, "New Jersey makes first awards in energy storage program to boost grid resiliency," *Utility Dive*, 24 Mar 2015, available at http://www.utilitydive.com/news/new-jersey-makes-first-awards-in-energy-storage-program-to-boost-grid-resil/378490/

Batteries combined with onsite generation projects are allowing remote communities like Kodiak Electric Association[19] and island campuses like that of the University of Hawaii to be almost entirely self-sustaining without fuels.[20] Military installations like U.S. Army Garrison Kwajalein[21] and Ft. Bliss in Texas[22] have incorporated storage into their microgrids to enable islanding and mission assurance in the event of electric and fuel supply disruptions. And that option is increasingly available in environments where end-users already have access to an extensive electric grid—for example, utility Ameren recently islanded its Champaign, Illinois microgrid for 24-hours relying solely on wind, solar, and batteries.[23]

- *Storage is increasingly distributed throughout the grid to enhance reliability and resilience.* For example, during heat waves last summer in California, aggregated energy storage relieved peak demands across the grid, responding with just minutes notice and doing so repeatedly.[24] Similarly, building chillers and water heaters are being increasingly aggregated and deployed as reliable demand response, another form of market-based energy storage. Utilities like Hawaii's HECO are increasingly working with customers who own storage to utilize their assets for distribution grid reliability.[25] By distributing these assets throughout the grid, aggregations of storage are reducing risk of failure of any single, central grid resource. And the advent of battery electric vehicle fleets will push still further in this direction. For example, utility ConEdison is piloting a fleet of mobile batteries that can unplug from one substation and move to another, allowing a grid that can reconfigure around evolving system conditions.[26]

- As an example of the recovery aspect of resilience, *storage provides blackstart capability, which restores the grid after system blackouts and enables other generators to*

[19] "Younicos installs 3 MW energy storage system on Kodiak Island," Electric Light & Power, 16 Nov 2017, available at https://www.elp.com/articles/2017/11/younicos-installs-3-mw-energy-storage-system-on-kodiak-island.html

[20] "College among first with 100 percent renewable energy generated on-site," Johnson Controls website, accessed 7 May 2018, available at http://www.johnsoncontrols.com/insights/2018/buildings/features/uhcc

[21] "Johnson Controls partners with U.S. Army to provide needed energy upgrades to U.S. Army Garrison Kwajalein," Johnson Controls website, 8 Feb 2018, available at http://www.johnsoncontrols.com/media-center/news/press-releases/2018/02/08/johnson-controls-partners-with-us-army-to-provide-needed-energy-upgrades-to-us-army-garrison-kwajalein

[22] J. St John, "The Military Microgrid as Smart Grid Asset," *Greentech Media*, 17 May 2013, available at https://www.greentechmedia.com/articles/read/the-military-microgrid-as-smart-grid-asset

[23] "S&C and Ameren conduct successful 24-hour islanding test on microgrid," PennEnergy, 18 Aug 2017, Available at http://www.pennenergy.com/articles/pennenergy/2017/08/microgrid-s-c-and-ameren-conduct-successful-24-hour-islanding-test-on-microgrid.html

[24] "Stem Energy Storage Network Delivers Emergency Grid Relief in California Heat," *BusinessWire*, 26 June 2017, available at http://www.businesswire.com/news/home/20170626005354/en/

[25] J. Spector, "Stem Pilot Marks a Step Forward for Commercial Energy Storage in Hawaii," *Greentech Media*, 2 Feb 2017, available at https://www.greentechmedia.com/articles/read/stem-tests-model-for-networked-commercial-energy-storage-in-hawaii-solar

[26] P. Maloney, "How ConEd's mobile battery REV demo could build a new storage business model," *Utility Dive*, 7 Mar 2017, available at http://www.utilitydive.com/news/how-coneds-mobile-battery-rev-demo-could-build-a-new-storage-business-mode/437364/

turn on again. Imperial Irrigation District installed a 33 MW battery precisely for this role and has successfully restarted its natural gas generators from outage conditions.[27]

- *Storage provides faster, more efficient and cost-effective response to short-run grid fluctuations*, which avoid unexpected outages from system imbalances. In the mid-Atlantic PJM market and in the Electric Reliability Council of Texas (ERCOT) system, fast-responding energy storage is modulating output at every second to maintain a stable grid frequency more efficiently, reducing the need for more Regulation reserves. In the Midcontinent Independent System Operator (MISO), Indianapolis Power & Light is similarly using battery storage to provide fast frequency response,[28] arresting deviations to grid stability from unexpected losses of power plants faster than generators—functionality that United Kingdom[29] and Australian[30] grid operators are increasingly taking advantage of. Particularly in systems where asynchronous generation is increasing or where grids are small, such as islands, such response capability is increasingly valuable. Figure 1 illustrates how battery storage facilities in the Dominican Republic stayed online during Hurricane Irma in 2017 even as conventional generators and large loads tripped off the system, with the batteries riding through low voltages and correcting significant and recurring frequency deviations.

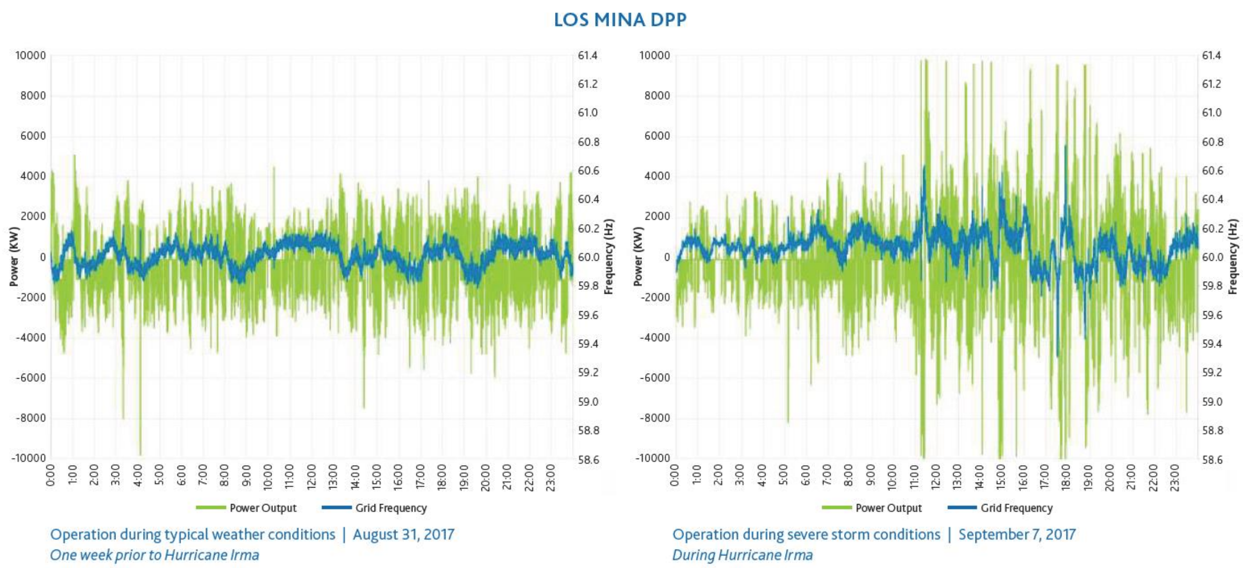
[27] P. Maloney, "California muni IID completes first US demonstration of black start battery capability," *Utility Dive*, 19 May 2017, available at http://www.utilitydive.com/news/california-muni-iid-completes-first-us-demonstration-of-black-start-battery/443099/

[28] "IPL Announces Commercial Operation of Battery-Based Energy Storage Array During White House Summit on Renewable Energy and Storage," *BusinessWire*, 16 June 2016, available at http://www.businesswire.com/news/home/20160616006603/en/IPL-Announces-Commercial-Operation-Battery-Based-Energy-Storage

[29] D. Pratt, "50MW of Enhanced Frequency Response batteries go online in Britain from VLC Energy," *Energy Storage News*, 8 Jan 2018, available at https://www.energy-storage.news/news/50mw-of-enhanced-frequency-response-batteries-go-online-in-britain-from-vlc

[30] Australian Energy Market Operator, *Initial operation of the Hornsdale Power Reserve Battery Energy Storage System*, April 2018, available at https://www.aemo.com.au/-/media/Files/Media_Centre/2018/Initial-operation-of-the-Hornsdale-Power-Reserve.pdf

Figure 1 Example of battery storage frequency stabilizing operations during Hurricane Irma[31]



- *Storage is also being deployed to help transmission and distribution infrastructure adapt to changing conditions*, maintaining reliability during multi-year upgrades, and deferring or altogether avoiding costly upgrades. For example, utility AEP's Presidio project in Texas and Balls Gap project in West Virginia used batteries to maintain reliable service while transmission upgrades were completed.[32] Storage has also been deployed to increase the capabilities of the distribution system. For example, the utility Arizona Public Service has deployed a set of 2 MW batteries at its substations to enable reliable service and avoid wires upgrades—both to enhance rural grid reliability and integrate more customer-sited solar power systems.[33] In Massachusetts, Eversource has received regulatory approval to procure one 5 MW battery and one 12 MW battery, both of which enable the utility to defer or avoid upgrades to existing transmission and distribution facilities.[34] National Grid has proposed a 6 MW, 48 MWh battery for Nantucket, Massachusetts, to delay the need for the construction of another submarine cable to bring

[31] Fluence, *Advancion Case Study: Storm Resilience*, 2017, available at https://info.fluenceenergy.com/hubfs/Collateral/AES%20ES%20Case%20Study%20-%20Storm%20Resilience.pdf

[32] Edison Electric Institute, *Transmission Projects at a Glance – American Electric Power*, available at http://www.eei.org/ourissues/ElectricityTransmission/Documents/Trans_Project_A-D.pdf#4 and "AEP Milton NaS Battery Energy Storage System," DOE Global Energy Storage Database, available at http://www.energystorageexchange.org/projects/268

[33] "APS, AES bring energy storage to Arizona customers," APS press release, 8 Dec 2016, available at https://www.aps.com/en/ourcompany/news/latestnews/Pages/aps-aes-bring-energy-storage-to-arizona-customers.aspx. See also, "APS Brings Battery Storage to Rural Arizona," APS press release, Aug 2017, available at: https://www.aps.com/en/ourcompany/news/latestnews/Pages/aps-brings-battery-storage-to-rural-arizona.aspx

[34] See pages 489-495 of Massachusetts Department of Public Utilities, *Order Establishing Eversource's Revenue Requirement*, Docket No. 17-05, 30 Nov 2017, http://170.63.40.34/DPU/FileRoomAPI/api/Attachments/Get/?path=1705%2f1705_Final_Order_Revenue_Requi.pdf

electricity to support the island's growing demand.[35] New York's Con Edison is deferring a $1.2 billion substation upgrade through its non-wires alternative program, the Brooklyn-Queens Demand Management Program, by contracting for 52 MW of demand reductions and 17 MW of distributed resource investments, including energy storage.[36]

- *Storage meets the peak demands of electric grids, contributing to resource adequacy.* Large pumped hydro resources such as Michigan's Ludington Pump Storage Plant have traditionally met this role, charging off-peak to provide eight hours of generation at peak capacity. As costs decline across the industry, a broader array of storage technologies is also fulfilling this role. Lithium-ion batteries are now providing four or more hours at peak capacity to meet utilities' resource adequacy needs,[37] with those durations expected to increase as prices fall—indeed, grid battery storage units with 8- and 10-hour durations have now been bid in competitive solicitations for early 2020s.[38] Flow batteries[39] and molten salt storage[40] are proving capable of more than six hours of peak capacity on the bulk system today.

- *Storage is being deployed to respond quickly to broader infrastructure failures.* After the Aliso Canyon gas storage facility unexpectedly shut down, over 90 MW of battery storage facilities were built in less than six months to make up local capacity shortfalls[41]—a stunning achievement given that it would have taken two or more years for a gas turbine to be deployed.[42] The arrival of "just-in-time" capacity additions offers grid planners not just flexibility to deal with uncertain forecasts of future needs, but also

[35] National Grid Press Release, 6 November 2017, National Grid Develops Innovative Solution for an Island's Community's Unique Energy Challenges, available at: https://news.nationalgridus.com/2017/11/nationalgriddevelops-innovative-solution-island-communitys-unique-energy-challenges/

[36]Con Edison, Distributed System Implementation Plan (DSIP), 30 June 2016, available at: https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energyprojects/ceconydsip.pdf?la=en

[37] J. Pyper, "Tesla, Greensmith, AES Deploy Aliso Canyon Battery Storage in Record Time," *Greentech Media*, 31 Jan 2017, available at https://www.greentechmedia.com/articles/read/aliso-canyon-emergency-batteries-officially-up-and-running-from-tesla-green

[38] Xcel Energy, *Public Service Company of Colorado 2017 All-Source Solicitation 30 Day Report*, 28 Dec 2017, available at https://www.documentcloud.org/documents/4340162-Xcel-Solicitation-Report.html

[39] "National Grid Distributed Energy Storage Systems Demonstration - Vionx Energy," from website of DOE Global Energy Storage Database, accessed 28 Sep 2017, available at http://www.energystorageexchange.org/projects/26

[40] P. Fairley, "A Tower of Molten Salt Will Deliver Solar Power After Sunset," *IEEE Spectrum*,21 oct 2015, available at https://spectrum.ieee.org/green-tech/solar/a-tower-of-molten-salt-will-deliver-solar-power-after-sunset

[41] D. Ola, "How California pulled off the world's fastest grid-scale battery procurement - Part II," *Energy Storage News*, 3 May 2017, available at https://www.energy-storage.news/blogs/how-california-pulled-off-the-worlds-fastest-grid-scale-battery-procurement. See also J. Pyper, "Tesla, Greensmith, AES Deploy Aliso Canyon Battery Storage in Record Time," *Greentech Media*, 31 Jan 2017, available at https://www.greentechmedia.com/articles/read/aliso-canyon-emergency-batteries-officially-up-and-running-from-tesla-green

[42] Slide 21 of J. Lin, "Energy Storage: Power System Game Changer," presentation at Minnesota Energy Storage Summit 2015, 14 July 2015, available at http://energytransition.umn.edu/wp-content/uploads/2015/06/Energy-Storage-Power-System-Game-Changer-by-Janice-Lin-.pdf#21

the ability to respond to infrastructure failures. Similarly, as discussed previously energy storage has been deployed at fire stations and hospitals in post-disaster environments like Puerto Rico to make power available while grid infrastructure is rebuilt.

- *Storage is a key resource for supplementing the natural variability of wind and solar resources* as they reach higher levels of installations. Projects like the Hawaii co-op Kauai Island Utility Cooperative solar and storage projects[43] and Texas generator E.ON's wind and storage projects[44] are increasingly common. That said, storage provides this value regardless of where on the grid it is located. For example, standalone storage is increasingly providing ramping services in grids like CAISO, which must efficiently maintain system reliability as gigawatts of solar power steadily come off the system over a short period each evening.[45]

- *Storage can enable greater flexibility of nuclear and coal plants and drive higher efficiency in gas plants.* Much of the over 20,000 MW of pumped hydro storage facilities in the U.S. were built in the latter half of the 20th century to avoid ramping up and down inflexible nuclear power plants and maintaining high capacity factor in coal plants, storing generation during periods of lower demand for use during peak times. In addition, natural gas-fired power plants can operate more efficiently when energy storage reduces the need for cycling those plants, which is why General Electric has introduced the first gas turbine-battery hybrid unit in the world and other turbine and engine makers, like Wärtsilä and Siemens, have acquired or merged energy storage businesses. Power companies have co-located storage at conventional plants as well, like the AES Tait gas-fired generator in Ohio and their Warrior Run coal-fired generator in Maryland.

The above examples are indicative of the flexibility storage provides for reliability and resilience. In addition, as greater parts of the economy electrify, such as transportation and heating, the need for flexibility will only increase—and with it, the deployment of energy storage to enhance the capabilities of grid infrastructure. ESA notes that storage technologies other than batteries, like pumped hydro storage, compressed air storage, molten salt storage, and hydrogen

[43] G. Bade, "Hawaii co-op signs deal for solar+storage project at 11¢/kWh," *Utility Dive*, 10 Jan 2017, available at http://www.utilitydive.com/news/hawaii-co-op-signs-deal-for-solarstorage-project-at-11kwh/433744/. See also R. Walton, "Tesla's dispatchable solar+storage project in Hawaii brought online," *Utility Dive*, 13 Mar 2017, available at http://www.utilitydive.com/news/teslas-dispatchable-solarstorage-project-in-hawaii-brought-online/437858/

[44] P. Maloney, "E.ON to build nearly 20 MW of battery storage at Texas wind farms," *Utility Dive*, 2 Mar 2017, available at http://www.utilitydive.com/news/eon-to-build-nearly-20-mw-of-battery-storage-at-texas-wind-farms/437211/

[45] P. Maloney, "California ISO approves proposals to bolster storage and demand response," *Utility Dive*, 4 Feb 2016, available at http://www.utilitydive.com/news/california-iso-approves-proposals-to-bolster-storage-and-demand-response/413365/

storage are expected to increase in capabilities and decrease in cost over time, lending characteristics well suited to meeting grid flexibility needs at large sizes and durations.

B. As a first step toward long-term resilience planning, FERC should direct RTOs/ISOs to establish methods for evaluating energy storage as a solution to transmission needs as a part of transmission planning processes. RTO/ISO planning processes should also make data on transmission asset utilization available to stakeholders to enable effective consideration of transmission needs.

Electric system resilience needs stem primarily from the failure of electric delivery infrastructure. In recent years, extreme weather accounted for over 95% of all hours of major electric service interruption, with generation inadequacy and fuel supply emergencies accounting for less than 0.01% of all hours of major electric service interruption.[46] Extreme weather generally leads to failures of transmission and distribution infrastructure, not failures of generators or disruption of fuel supplies. When major U.S. electric system disruptions occur for reasons other than extreme weather, infrastructure tends to be of central concern, rather than fuel supply. For example, the 2003 Northeast Blackout was caused by a cascading failure of voltage controls and transmission lines.[47]

For this reason, ESA strongly supports a focus on transmission planning to enhance resilience and agrees with statements expressed by PJM and MISO on this subject:

- PJM: "resilience efforts will require changes to transmission and infrastructure planning…the Commission could provide assistance to RTOs by requiring them to plan for and address resilience, and confirm that resilience is a component of regional transmission system planning…Robust long-term planning, including developing and incorporating resilience criteria into the [Regional Transmission Expansion Plan], can also help to protect the transmission system from threats to resilience."[48]

[46] *See* T. Houser, et al., "The Real Electricity Reliability Crisis," *Rhodium Group* website, Oct 3, 2017, available at http://rhg.com/notes/the-real-electricity-reliability-crisis

[47] *See* U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, April 2004, available at https://www.ferc.gov/industries/electric/indus-act/reliability/blackout/ch1-3.pdf

[48] *Comments And Responses Of PJM Interconnection, L.L.C.*, Docket No. AD18-7-000, 9 Mar 2018, available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838232, pages 11, 69, 50

- MISO: "Continued industry dialogue on more effectively identifying, valuing, and incorporating resilience attributes in transmission planning processes will help the Commission identify further opportunities to support and advance grid resilience.[49]

As one step toward enhancing the resilience of electric infrastructure recommended via transmission planning, ESA recommends that FERC direct RTOs/ISOs to establish methods for evaluating energy storage as a solution to transmission needs as a part of transmission planning processes, so as to address the most common threats to the bulk electric power system. Energy storage serving in a transmission resilience function can, for example, mitigate and ride through anomalous power flows on transmission lines resulting from sudden events, provide active and reactive power in post-fault operating states, and increase deliverability of critical supply in the face of temporary transmission constraints. In addition, storage can serve a traditional transmission reliability role, such as mitigating congestion, avoiding thermal overload of existing transmission lines, and otherwise meeting system deliverability needs. Presently, only CAISO has studied energy storage as a transmission solution as a regular part of transmission planning, both in system-wide studies of transmission reliability needs[50] and in narrower studies of specified line upgrades.[51] Each RTO/ISO should have a clearly identified methodology for evaluating storage proposals as a solution to reliability, economic, or public policy needs. This is currently not the case, depriving the grid of an important tool for resilience.

Consideration of storage in transmission planning processes involves evaluating storage resources as a transmission asset and *not* solely as a non-transmission alternative. The latter

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[49] *Responses Of The Midcontinent Independent System Operator, Inc*, Docket No. AD18-7-000.

[50] For example, see *ISO 2016-2017 Transmission Planning Process Supplemental Sensitivity Analysis: Benefits Analysis of Large Energy Storage*, 4 Jan 2018, available at http://www.caiso.com/Documents/SupplementalSensitivityAnalysis-BenefitsAnalysisofLargeEnergyStorage.pdf

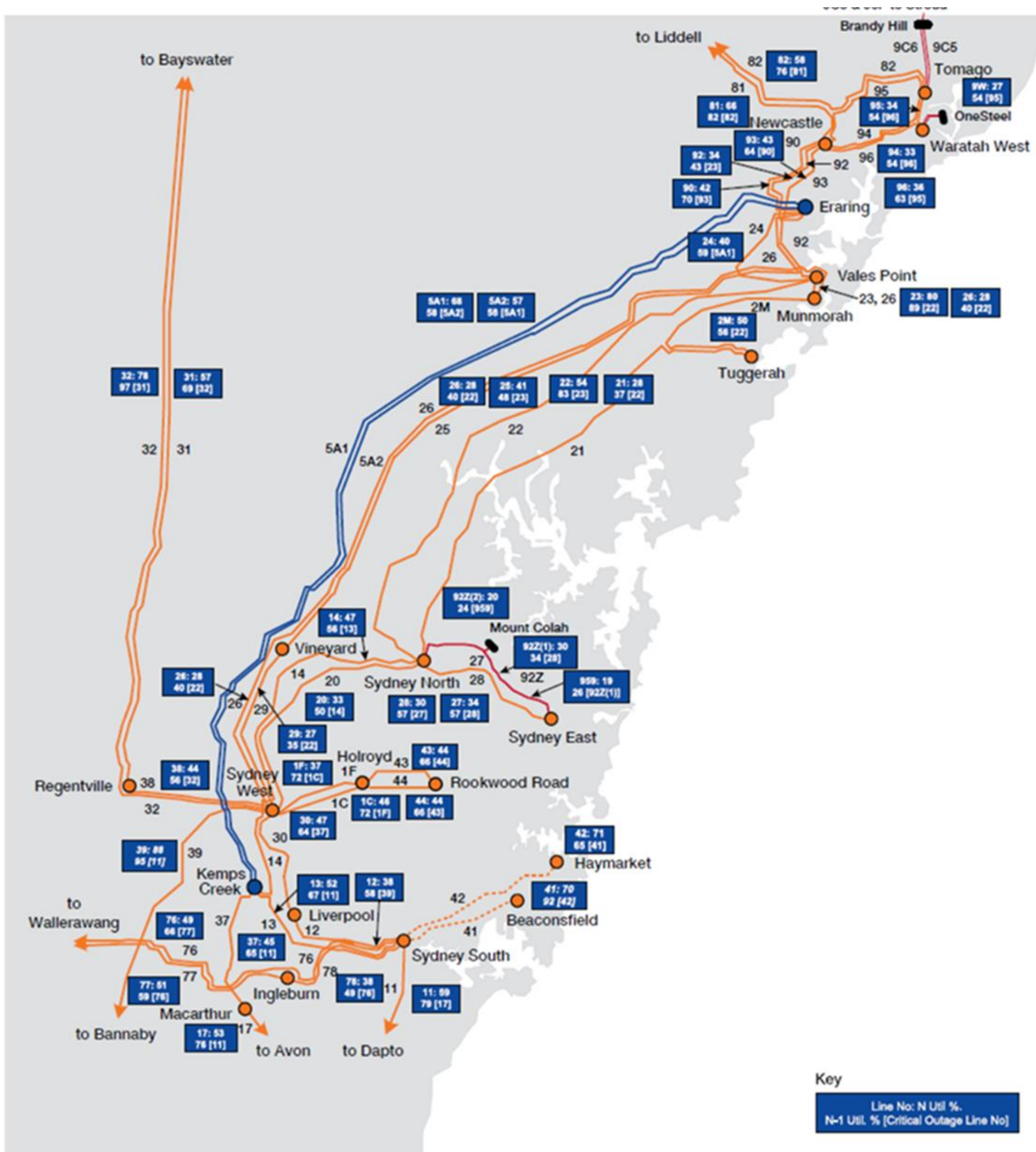
[51] For example, see "Less than $50 Million Projects and Preliminary Economic Assessment Results," presentation at 2017-2018 Transmission Planning Process Stakeholder Meeting, 16 November 2017, available at http://www.caiso.com/Documents/Presentation_2017-2018TransmissionPlanningProcessMeeting_Nov162017.pdf

construct, while useful for the purposes of economic efficiency, relies only on assets not operated by a transmission provider. ESA emphasizes that RTOs/ISOs should be required to consider energy storage as a transmission asset. As an example of this distinction, MISO staff and stakeholders have previously discussed storage as a "non-traditional transmission alternative" subject to transmission cost-allocation rules[52]—which is a more appropriate manner for inclusion in transmission planning.

Additionally, ESA recommends that RTO/ISO transmission planning processes make data on transmission asset utilization available to stakeholders with appropriate safeguards. Doing so would allow transmission providers to devise optimal energy storage transmission solutions and help grid operators and relevant government agencies to better understand grid resilience needs. As an example, Figure 2 below presents a map from the Australian transmission company Transgrid showing network utilization on all transmission lines under normal (N-0) and contingency (N-1) conditions. At present, ESA is unaware of comparable publicly available data or maps for the U.S. transmission system.

[52] MISO, "Non-transmission Alternatives," presentation at MISO Planning Subcommittee, 19 April 2016, available at https://cdn.misoenergy.org/20160419%20PSC%20Item%2002%20Non%20Transmission%20Alternatives94481.pdf. Note that proposal for a non-traditional transmission alternative distinction was ultimately deferred—see MISO, "NTAs and NTTAs," presentation at MISO Planning Subcommittee, 14 June 2016, available at https://cdn.misoenergy.org/20160614%20PSC%20Item%2002%20Non-Transmission%20Alternatives94486.pdf

Figure 2 Example of Transmission Utilization Map[53]



Additionally, making such information available upon request by stakeholders in transmission planning processes, and subject to any appropriate and relevant confidentiality

[53] See "Appendix 3: Line Utilization Report" in *New South Wales Transmission Annual Planning Report 2017*, Transgrid, 30 June 2017, available at https://www.transgrid.com.au/news-views/publications/transmission-annual-planning-report/Documents/Transmission%20Annual%20Planning%20Report%202017.pdf

restrictions, can identify potential needs for network upgrades in advance of generator retirements and avoid or greatly reduce reliance on reliability-must-run (RMR) contracts. Market participants can give as little as 90 days' notice in some RTO/ISO regions regarding retirement of generators. When transmission network upgrades are necessary to maintain system reliability due to retirements, an RMR contract may be implemented to provide out-of-market payments to generators to remain operational for the months or years before upgrades are completed. Better access to information in transmission planning processes is the first step to reducing reliance on RMRs. While such RMRs are for conventional transmission reliability concerns, ESA notes that potential use of RMRs for transmission resilience concerns may similarly be addressed through better information availability.

C. To bolster grid resilience across all locations and critical infrastructures, ESA respectfully recommends that FERC develop rules to enable the greater participation of distributed energy resources in wholesale markets.

While distributed energy resources ("DERs") are connected to the distribution system, they can contribute to bulk system resilience. Specifically, DERs can provide continuity of service to loads at specific locations, by responding to outages of specific transmission wires or generators via islanding. Additionally, since most electric service disruptions originate in distribution infrastructure, DERs can play a role in mitigating the adverse impact of distribution service disruptions on bulk system operations. Finally, DERs can sustain linked critical infrastructures, such as telecommunications and emergency responder facilities, whose continuity is critical for bulk power system resilience.

As a step to better ensuring that DERs may contribute to electric system resilience, ESA requests that FERC continue to advance discussion on the role of DERs in wholesale markets. Docket No. RM18-9-000 has initiated an exploration of numerous topics associated with the participation of DER aggregations in wholesale markets, and ESA encourages FERC to identify issues appropriate for a Notice of Proposed Rulemaking that would facilitate DER contributions to grid resilience.

D. FERC and RTOs/ISOs should identify and quantify discrete resilience needs, and seek to meet those needs by improving price formation associated with resilience services of all resources.

As mentioned in previous comments in Docket No. RM18-1-000, ESA agrees with the recent recommendations from DOE to improve price formation associated with resilience services. For example, in its August 2017 *Staff Report on Electricity Markets and Reliability* ("DOE Staff Report"), DOE recommended improving valuation of and compensation for essential reliability services:[54]

> "Valuation of Essential Reliability Services (ERS): Where feasible and within its statutory authority, FERC should study and make recommendations regarding efforts to require valuation of new and existing ERS by creating fuel-neutral markets and/or regulatory mechanisms that compensate grid participants for services that are necessary to support reliable grid operations. Pricing mechanisms or regulations should be fuel and technology neutral and centered on the reliability services provided. DOE should provide technical and policy support that strengthen and accelerate these efforts."

Aligned with DOE's recommendations, ESA urges FERC to consider means to value and compensate all inadequately compensated or uncompensated resilience services for their cost-effective provision. The DOE Staff Report cites PJM to identify several other resilience attributes that are inadequately compensated or uncompensated that are of particular relevance to energy storage:[55] essential reliability services like frequency response, voltage control, and ramp; flexibility attributes like short minimum run times and fast start; and other attributes, such as ability to run without environmental restrictions. Of the total 13 attributes listed, only two—

[54] *See* U.S. Department of Energy, *Staff Report to the Secretary on Electricity Markets and Reliability*, Aug 2017 ("DOE Staff Report") at 126.

[55] DOE Staff Report at 86.

regulation and contingency reserve—are directly compensated as priced market products, and a third—black start capability—is compensated through RTO/ISO procurement.

Electric storage resources can provide electric system resilience solutions that are inadequately compensated or uncompensated. For example:

- Ramp services are uncompensated or incomplete in many RTOs/ISOs. For example, load-following products compensate flexible resources forced to ramp up or down uneconomically to meet demand when a larger, inflexible resource must operate at a minimum output level.[56] PJM's own description of a load-following product—which has not yet been proposed in PJM—states that it "would provide enhanced opportunities for flexible resources, including new technologies, <u>such as energy storage resources</u>, to receive compensation for the value of their flexibility."[57] (emphasis added) To meet system ramp needs, California ISO ("CAISO") and Midcontinent ISO ("MISO")[58] both have introduced ramp products, and New York ISO ("NYISO") and CAISO both have instituted multi-period dispatch,[59] with varying levels of success in providing ramp capability and avoiding uplift payments.[60] PJM and ISO New England ("ISO-NE") have no such mechanisms to value ramp.

- Frequency response is uncompensated in all RTOs/ISOs. While CAISO previously discussed a potential PFR market product in stakeholder processes, it has been put on hold with the issuance of Order 842, which requires new supply resources to demonstrate PFR capability as a condition of interconnection. PJM's stakeholder process on PFR briefly included discussion on potential compensation mechanisms but has proceeded to consider only cost-of-service approaches.[61] As ESA has noted previously, markets products for performance-based PFR exist in the United Kingdom and other markets.[62]

[56] The figure cited in the DOE Staff Report incorrectly states storage is not capable of load following, which is one of several ramp services that is an essential reliability service. Storage is entirely capable of such activities—which are called for over a varying number of 5-minute dispatch intervals--as exemplified in its participation as a ramping resource for CAISO flexible capacity needs.

[57] *See* PJM Interconnection L.L.C., *Energy Price Formation and Valuing Flexibility*, June 15, 2017, at 4-5, available at http://www.pjm.com/~/media/library/reports-notices/special-reports/20170615-energy-market-price-formation.ashx

[58] ESA notes that storage resources are presently prohibited by rule from participation in MISO ramp product.

[59] *See* ISO-NE, *Procurement and Pricing of Ramp Capability*, Sep 20, 2017, available at https://www.iso-ne.com/static-assets/documents/2017/09/20170920-procurement-pricing-of-ramping-capability.pdf

[60] *See* FERC, *Staff Analysis of Uplift in RTO and ISO Markets*, Aug 2014, available at https://www.ferc.gov/legal/staff-reports/2014/08-13-14-uplift.pdf

[61] PJM Interconnect, *Primary Frequency Response (PFR) Senior Task Force Charter*, 28 July 2017, available at http://pjm.com/-/media/committees-groups/task-forces/pfrstf/20170725/20170725-item-03-pfrstf-charter-post-meeting.ashx

[62] See National Grid UK's Frequency Responsive Services information at http://www2.nationalgrid.com/uk/services/balancing-services/frequency-response/. Also, see TenneT's Primary

- Fast response capabilities are generally uncompensated in RTOs/ISOs. Fast frequency response arrests deviations more quickly than conventional primary frequency response, thereby reducing the headroom reservations needed for frequency response;[63] yet frequency response is not compensated. Only PJM has a fast frequency regulation market product, which has reduced the overall regulation reserve requirement by 30%.[64] No contingency reserve products specify any value for faster response.

For these reasons, ESA supports consideration of mechanisms to adequately compensate resilience services. Some of those services may include: increasing generator deliverability via congestion relief resulting from external disruptions; post-contingency operational capabilities, which can compensate for unexpected loss of units; and fast deployment as network upgrades, which can shorten grid planning lead times and avoid potential reliability-must-run contracts.

In some cases, FERC or RTOs/ISOs could identify specific resilience services not contemplated in existing market products. For example, fast deployment and interconnection of capacity, which can shorten grid planning lead times and avoid potential reliability-must-run contracts, could be turned into a formal service. The fast replacement of lost capacity from the Aliso Canyon Gas Facility in CAISO represents the kind of situation where such a service would

Reserve market information at http://www.tennet.org/english/operational_management/system_data_preparation/primary_reserve.aspx

[63] Fast frequency response arrests deviations faster, reducing overall reserves required and increasing in value as inertia decreases on the system. See Everoze, *Batteries: Beyond the Spin*, Oct 2017, available at http://s2.q4cdn.com/601666628/files/doc_presentations/2017/Everoze-Batteries-Beyond-the-Spin.pdf See also page 10 of S. Newell et al. "Cost-Benefit Analysis of ERCOT's Future Ancillary Services (FAS) Proposal." Prepared by the Brattle Group for ERCOT. Dec 21, 2015. Available at http://www.brattle.com/system/news/pdfs/000/000/982/original/Cost-Benefit_Analysis_of_ERCOT's_Future_Ancillary_Services_%28FAS%29_Proposal.pdf?1450901946. See also ERCOT Staff's "Future Ancillary Service Team (FAST) and Technical Advisory Committee (TAC) Workshop #2" presentation to the ERCOT Technical Advisory Committee on Aug 25, 2014, available at http://www.ercot.com/content/meetings/fast/keydocs/2014/0825/FAST-TAC%208-25-14%20Workshop.ppt and ERCOT Future Ancillary Service Team's "Primary Frequency Response (PFR) / Fast Frequency Response (FFR) Assessment" presentation on Mar 28, 2014, available at http://www.ercot.com/content/meetings/fast/keydocs/2014/0328/PFR_FFR%20Assessment_FASTworkshop_03282014.pdf

[64] See PJM's report, *Performance Based Regulation: Year One Analysis*, submitted on October 16, 2013 in Docket No. ER12-1204.

be useful. As an example of such a service, Australia's wholesale market operator runs a Reliability and Emergency Reserve Trader program that enables the grid operator to purchase options on capacity with varying lead times for deployment.[65] Other examples of potential resilience services could include increasing generator deliverability and resource adequacy contribution through congestion relief, or post-contingency operational supply and reactive power resources. These are all concepts that can be turned into products or procurements that attach a price signal for their provision.

Moreover, market products that reward performance and flexibility also contribute to resilience. Market designs like the fast regulation product PJM has introduced and the flexible capacity construct that CAISO has introduced can ensure reliability assets also provide specific resilience values, such as quick response and flexibility during sudden, large-magnitude changes to net load. Similarly, market products could be created for services like reactive power provision or fast frequency response, both of which contribute to system resilience in addition to their role in reliability. ESA encourages FERC to consider price formation and market designs that value and compensate flexibility as a means to better ensuring it is also available for resilience. Indeed, as MISO states in their comments in the instant docket, "Resilience should include the ability of the grid to provide sufficient flexibility to accommodate resource portfolio changes over time driven by economics, technology advances, and energy policy."[66] ESA commends NYISO and suggests to FERC that efforts to conduct a "comprehensive review of the

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[65] AEMO, *RERT: Reliability And Emergency Reserve Trader*, June 2017, available at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Emergency_Management/2017/RERT-Information.pdf

[66] *Responses Of The Midcontinent Independent System Operator, Inc*, Docket No. AD18-7-000, 9 Mar 2018, available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14837872

NYISO's existing market products and operational practices" to ensure flexibility could be similarly instituted in other RTOs/ISOs.[67]

E. *While ESA broadly agrees with PJM's emphasis on price formation to provide flexibility and resilience services, ESA cautions that energy price formation must effectively incent flexibility.*

PJM's response in the instant docket rightly emphasizes using price signals as an effective means to value and compensate identified flexibility and resilience needs of the bulk power system. ESA has previously asked FERC to eliminate out-of-market payments such as uplift, which PJM is also seeking to do. However, ESA expresses caution to FERC that efforts to enhance price formation must effectively incent flexibility. The energy price formation proposals advanced by PJM and under discussion in their stakeholder processes at present would replace uplift with locational marginal pricing that allows inflexible units to set clearing prices—effectively transferring the costs of generator inflexibility to load without any corresponding incentive for generators to provide flexibility. This does not actually contribute to resilience since the fundamental mismatch between grid needs and generator inflexibility remains.

The goal in price formation should be to meet system needs for flexibility and resilience. Uplift payments signal that the grid has greater needs for flexibility than can be provided by some generators. Solutions should therefore consider ways to reduce uplift that enable better meeting of system needs. For example, rather than insulate inflexible generators from system demands by increasing costs to load, generators themselves could be asked simply to respond to dispatch signals sent by the grid operator and bear the costs of inflexibility, creating incentives to manage their own risks of non-performance through use of technologies that enable more flexible operations. PJM asks for FERC to establish a deadline for filing on this subject that

[67] *Response of the New York Independent System Operator, Inc.*, Docket No. AD18-7-000, 9 Mar 2018, available at https://elibrary.ferc.gov/IDMWS/common/opennat.asp?fileID=14838205

could bring stakeholder processes to conclusion sooner. ESA recommends that FERC at minimum make clear to PJM the basis on which it will entertain such energy price formation in the context of resilience.

IV. CONCLUSION

As explained above, energy storage technologies are an important tool for enhancing grid resilience. While FERC and RTOs/ISOs should ascertain the best mechanisms to address unmet resilience needs, actions to enhance flexibility of the electric system will be of value in any range of future supply mixes and extreme situations. Indeed, for both reliability and for resilience, flexibility will continue to be of critical importance for the electric system. ESA encourages FERC to focus on no-regrets changes to transmission planning, resource participation, and price formation and market design to ensure sufficient flexibility in the system to meet electric system resilience needs.

Respectfully submitted,

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Dated: May 9, 2018

CERTIFICATE OF SERVICE

I HEREBY certify that I have this day caused the foregoing document to be served, via electronic mail, upon each person designated on the Official Service List compiled by the Secretary in these proceedings.

Dated in Boston, MA this 9th day of May 2018

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