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I. Introduction

Chairman Bingaman, Ranking Member Murkowski, and members of the Committee, thank you for the opportunity to speak here today. My name is Jon Wellinghoff, and I am the Chairman of the Federal Energy Regulatory Commission (FERC or Commission). My testimony addresses regulatory and technical issues related to the integration of energy storage into the electricity grid. I will begin my testimony by briefly describing the need for energy storage technology and then discuss some of the technical and regulatory issues that arise when integrating storage into the grid. I will conclude by discussing FERC's role in removing barriers to the development of grid-scale storage.

With the proliferation and adoption of renewable energy standards, the nation is showing itself increasingly committed to achieving climate change goals and a future in which clean, affordable, sustainable, and reliable energy is the everyday norm. Thirty states have adopted policies requiring fuel diversity and encouraging a move to lower-emissions energy sources, and Congress is considering a national renewable energy portfolio standard.

But greater fuel diversity and lower emissions cannot be achieved unless we ensure that the new energy resources are integrated into the transmission system in a manner consistent with reliable operation of the grid. With these concerns in mind, we at the Federal Energy Regulatory Commission are exploring our statutory authority to find ways to ensure that the reliable integration of these new energy resources reflects consumer decisions in the marketplace for electricity and meets policy goals.

One critical strategy for integrating new energy resources involves matching load and resource variations through the intelligent deployment of demand response and other distributed resources such as energy storage.

II. Use of Storage

For the most part, electricity must be produced just in time to be consumed. Energy storage offers the ability to "warehouse" electrons for consumption later or to balance the variability of some renewable resources. It alters the traditional assumption of a linear electrical network, which assumes that centralized generators send electrons through transmission and distribution systems to instantaneously match need.

Integrating large amounts of new, locationally-dispersed energy resources into the grid will require system operators to alter traditional assumptions and balance load and resources in a way that accounts for the variable nature of renewable energy resources such as wind and solar power. Storage of renewable power can provide energy when these renewable resources cannot do so directly. For example, storage can be charged or filled off-peak by renewable energy and later provide a source of power during peak demand periods or periods when the sun or wind is not available, either through direct injection of energy into the grid or by enabling demand response.

And storage can do more than just balance the variable nature of solar and wind resources. The Energy Advisory Committee on Storage, convened by the Energy Policy Act of 2005, found that storage can: improve grid optimization for bulk power production via energy arbitrage; defer the need for investments in transmission and distribution infrastructure to meet peak loads; provide backup power to buildings; and provide ancillary services directly to the grid or market operators. My testimony will focus on the ability of storage to provide ancillary services, since that is the function most frequently addressed by FERC, and the function that may be of the most value to the integration of variable resources such as wind and solar.

Ancillary services help support the reliable operation of the grid. One such ancillary service is regulation service, which resources like storage can efficiently provide. Regulation service is the micro load-following service that increases generation supply when demand or load increases, and decreases supply when demand decreases. Regulation must be provided constantly, and it is one of the most expensive services on the grid.

Ancillary services like regulation service are essential to keep the system balanced and prevent it from cascading into a blackout. The need for regulation services can dramatically increase as the amount of variable renewable resources is increased. And it turns out that local storage is among the best means to ensure we can reliably integrate renewable energy resources into the grid.

Regulation service is usually provided by combustion turbine gas-fired generators. But while such generators can generally follow the minute-by-minute variations in load to keep the system in overall balance, the frequency excursions that are the subject of Regulation service actually occur on even shorter time intervals. Indeed, it has been demonstrated that distributed resources such as storage are more efficient than central station fast response natural gas fired generators at matching load variations and providing ancillary services needed to ensure grid reliability.[1] They are faster, generally cheaper, and have a lower carbon footprint than the traditional power-plant-provided ancillary service.

III. Storage Technologies

To date, the most used bulk electricity storage technology has been pumped storage hydroelectric technology. Presently, there are 24 pumped storage projects around the nation with an installed capacity of over 19,500 MW. But new storage technologies are under development, and in some cases being deployed, that could provide substantial value to the electric grid. Building on experience with existing technology, closed-loop pumped storage uses two reservoirs that are "closed" to

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[1] See, e.g., http://www.beaconpower.com/files/PNNL_Report_Assessing_Value_Regulation_Resources_June%202008.pdf at 26 ("Experiments also showed that an average 1 MW of flywheel regulation capacity can substitute for about 2 MW of the traditional regulation mix . . .").

natural aquatic ecosystems. Other than initial filling and occasional topping off to offset evaporation or leakage losses, no natural river or stream would be used. This allows operational flexibility not available with a traditional pumped storage hydropower system, which uses natural rivers and reservoirs and must regulate flow to avoid harming local ecosystems. Currently, the Commission has issued preliminary permits for pumped storage – both traditional and closed-loop – totaling over 27,000 MW of capacity. Over one-quarter of this capacity is closed-loop.

A newer technology for providing storage for the electric grid is the flywheel, which works by accelerating a cylindrical assembly called a rotor (or flywheel) to a very high speed with low friction components, and maintaining the energy in the system as rotational energy. The energy is converted back by slowing down the flywheel. Flywheels have been successfully piloted in the U.S., and their speed is particularly useful for regulation service. For example, for the past year, ISO-NE has been conducting a pilot program to test how alternative technologies such as flywheels are able to provide regulation service.

Another promising storage technology is the grid-scale battery, which works like a giant consumer electronics battery. The battery takes energy in, and then with some small conversion losses, releases it later. Batteries for MW-scale storage have had successful pilots domestically for several applications. Like flywheels, batteries can respond more quickly and accurately than traditional generators to signals to increase or decrease the injection of energy into the grid when load changes. They can respond for short or long (multi-hour) periods of time, depending on the size and the controls of the battery. They can thus provide a variety of ancillary services or serve to defer the need for alternative transmission or distribution line investments.

The batteries onboard electric vehicles likewise can provide services to the grid. For purposes of this discussion, an electric vehicle is one that requires periodic re-charging of its propulsion battery from the electric grid. It may or may not also be a “hybrid,” additionally capable of re-charging with a fuel-driven generator or by other mechanical means.

In the future, electric vehicles can provide ancillary services, like regulation service, to the grid and serve as mobile distributed storage. The evolving nature of electric vehicles’ role and their market penetration curve create a unique set of challenges for integrating electric vehicles into electric markets as a grid service provider.

Although you may not think that a single electric vehicle could be providing an important ancillary service to the grid, researchers at the University of Delaware proved just that with a car that they parked outside of FERC headquarters that was providing regulation service to the PJM grid. More to the point here, the same researchers believe that, using this technology, parked electric cars connected and aggregated in large numbers in places like parking garages could be made available as energy storage to support grid operations, including balancing the variability of renewable resources such as wind and solar.

Each of these storage technologies – closed-loop pump storage, flywheels, batteries, and electric vehicles – are at various stages of development. Flywheels and chemical batteries have recently achieved technology maturity, and are well on the road to full scale implementation both here and abroad. Unlike flywheels and batteries, electric vehicles will not be commercially available for another year or two. Though there are several thousand electric vehicles on the road in the U.S. and abroad today, mass commercialization is expected to begin in 2010, and the U.S. has set a goal of having at least 1 million on the road by 2015.

IV. Tariff Activities Already Underway

With storage technologies at various stages of deployment, the Commission already has had several opportunities to address grid-scale storage in regions operated by regional transmission organization or independent system operators, or RTOs and ISOs.

The Commission recently accepted a proposal by the New York Independent System Operator (NYISO) to integrate energy storage devices into its day-ahead and real-time regulation service markets. (127 FERC ¶ 61,135). There we recognized that energy storage devices can help integrate wind resources, and that their integration in the regulation service market should help NYISO meet or exceed NERC control performance criteria. The Commission specifically pointed to the very fast response times of storage resources as a benefit to NYISO.

FERC currently is considering a proposal to better accommodate stored energy resources in the Midwest ISO markets. The Midwest ISO tariff revisions would allow short-term energy storage devices to enter, in a limited fashion, the frequency regulation market.

In the Northeast, ISO New England (ISO-NE) has recently sought to extend a pilot project for testing the ability of different storage technologies to participate in the regulation market. The pilot pays storage based on the speed of its response.

In the Mid-Atlantic, PJM Interconnection (PJM) has allowed a storage device to enter into the frequency regulation market with no tariff or technical manual revisions. AES installed a 1 MW battery at PJM headquarters to provide frequency regulation. PJM bundles that battery with the batteries of three electric cars, each of which purchase electricity at retail rates. The batteries then sell into the frequency regulation market. PJM has stated that it expects larger batteries to be able to enter other ancillary service markets or energy markets without significant tariff revisions.

Other areas of the country are examining the potential of demand response and other distributed resources to reliably integrate renewable energy resources into the grid. For example, this summer, the CAISO issued a white paper that identified storage as one technology solution to facilitate renewable integration.

V. FERC Efforts

Beyond the case-specific applications just described, we at FERC are already looking at methods to remove regulatory barriers to the adoption of storage technology. In October, I provided Congress with the Commission's

Strategic Plan for FY2009-2014 and committed to take additional steps to address possible barriers to development of renewable resources, including the implementation of tools like storage to support reliable integration of renewable resources. And earlier this year, the Commission adopted a policy statement on the smart grid, which included storage as a key functionality of the smart grid. It is the Commission's expectation that this policy statement, which seeks greater interoperability and functionality of smart grid technologies through the adoption of standards, will help accelerate the development and promulgation of newer storage technologies.

And FERC will continue to monitor the development of storage technologies to ensure that they receive tariff treatment comparable to other resources and receive compensation commensurate with the value of the services they provide to wholesale markets and the grid.

Regarding compensation, some storage technologies appear able to provide a nearly instantaneous response to regulation signals, in a manner that is also more accurate than conventional resources. These two characteristics can reduce the size, and hence overall expense, of the regulation market. Most existing tariffs or markets do not compensate resources for superior speed or accuracy of regulation response, but such payment may be appropriate in the future as system operators gain experience with the capabilities of storage technologies. In the meantime however, the unique characteristics of storage technologies could require different market bidding parameters and telemetry requirements for providing energy and ancillary services than those established based on the characteristics of traditional generators. Furthermore, the potential interaction and synergies of renewable resources, storage and demand response resources call for new ways to operate the electric system to take advantage of these resources for cost-effective, reliable, cleaner and more efficiently produced electricity. This would ensure that consumers have access to the lowest cost resources needed to provide electricity service.

As for transmission tariffs, some tariffs may not yet allow storage technologies to enter wholesale markets in a manner comparable to generation or to use storage as a substitute, or complement, to transmission investment. FERC will monitor these developments and, when appropriate, ensure best practices for development and use of storage for all of its various purposes.

VI. Conclusion

In conclusion, at FERC, our challenge as regulators is to remove barriers that impede the vast potential of energy storage to support our national energy goals. With the appropriate compensation and tariff treatment, storage resources will have the opportunity to proliferate. While energy storage offers ample benefits just in improving grid operation and efficiency, it can also make integration of renewable energy resources not only reliable, but efficient and cost-effective as well. Fully opening wholesale electric markets to resources like storage will make it easier to meet renewable energy standards by efficiently matching renewable energy resources and demand resources with distributed storage resources to smooth variations in resource output. In this way, these resources can complement each other to ensure a stable and reliable grid. FERC can strive to ensure that regulatory barriers are removed and compensation and tariff treatment are appropriately gauged to match the value of the services that storage provides.