STATEMENT OF
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Chairman Bingaman, Senator Murkowski, and members of the Committee, thank you for the opportunity to participate in today's hearing on the role of grid-scale energy storage in meeting energy and climate goals. My name is Ralph Masiello. I am senior vice president of energy systems consulting at KEMA and I am responsible for innovation management within the company. I have been engaged in a number of energy storage-related activities while at KEMA including serving on the U.S. Department of Energy "Energy Advisory Committee" and the Smart Grid and Storage subcommittees.

KEMA is an independent, global provider of business and technical consulting, operational support, measurement and inspection, and testing and certification for the energy and utility industry. We have over 1,400 professionals worldwide with 600 in the United States. KEMA, Inc. serves energy clients throughout the Americas and Caribbean. We have offices in 13 states, including Arizona, Michigan, North Carolina, and Oregon, and operate the only independent high voltage power apparatus testing lab in the United States.

KEMA has been actively engaged in projects across the energy storage value chain, ranging from technology development and evaluation to the advancement of large-scale storage applications. KEMA has worked to expand understanding of energy storage capabilities by developing analytic tools needed to plan for its use. We have been performing storage consulting and testing activities for manufacturers, developers, utilities, and the U.S. Army and the U.S. Navy via NATO for some time. While we are generally true believers in the many benefits that storage can bring to the electric power industry, we have no vested interest in any particular technologies or solutions.

Today, I will provide a brief overview of what storage is and how it relates to the electricity industry, including potential benefits of storage and current barriers. First, I will discuss storage's role in the electricity system. Then, I will provide an overview of storage technologies and applications. Finally, I will briefly discuss policy issues to consider regarding storage.

Energy and Storage – What It Is and Where We Are

At the turn of the 20th century, early electric power developers used batteries as part of the electricity generation and delivery infrastructure. However, batteries were quickly surpassed by other generation, transmission, and distribution technologies. For the past 100 years, electricity has been the only major commodity that is not stored anywhere in the value chain. As such, the electricity industry has been operating under a just-in-time delivery system, where power is produced on demand as energy consumers need it and where all that is produced is delivered. To maintain operations, grid operators must balance generation to match load in real-time.

The lack of storage in the electricity industry has led to relatively low capacity utilization throughout the production and delivery of electricity – capacity is built and maintained to support peak needs with adequate reserves against contingencies. Overall utilization may be as low as 30% for some parts of the system. In the case of production, peaking resources are often the most expensive and their use just a few hours a year leads to very high spot prices of electric power in the wholesale markets. Were we able to store electricity effectively, this expensive model of planning and operation could be much more efficient.

In addition to improving system efficiency, storage could help address grid management challenges stemming from the integration of variable resources. Unlike traditional fuel-based generation, many renewable resources are variable over time and are not easily controlled. With relatively small amounts of variable generation, load has been the main source of variability. However, as renewable penetration increases, grid operators will need to account for larger variability in supply. The current system has a certain degree of flexibility which it uses to balance demand and supply in real-time. Additional sources would help the system absorb increasing amounts of renewables. Storage, in particular, is one potential source of flexibility that acts as a bridge, buffer, and reliability component.

Storage Future: Changing the Game

Renewables Resources

The industry is beginning to conclude that some increase in the use of ancillary services will be necessary to integrate renewable resources. Pacific Northwest National Labs, KEMA, and others have conducted studies on the impact of high levels of renewables on system operations and the results more or less agree on this point. While ancillary services traditionally have been provided by fossil-based generation, new sources are beginning to contribute. According to the results of a recent KEMA study with the California Independent System Operator (CAISO), a fast battery is two to three times as effective as a combustion turbine at providing regulation and ramping services. In addition, even where traditional generation sources are used for ancillary services, storage appears to be beneficial. Virtual power plants which integrate storage and production could supply ancillary services more efficiently. This enables a plant to supply regulation or reserves even while running near peak output.

Smart grid also offers ways to manage the demand side of the equation – whether by demand response programs controlled by the grid operator or via dynamic pricing schemes that induce consumer behavioral change or both. Though they are valuable resources, it is likely that demand response and dynamic pricing will not suffice at certain renewable penetration levels.

Storage can offer additional benefits for renewable generation beyond integration. With storage, producers of renewable energy could time-shift production from periods of low demand to higher demand when it is more valuable to the producer. Also, storage allows remote (and often renewable) resources to escape curtailments due to transmission congestion with the attendant cost exposure. Financially, the benefits of storage may be considerable in such applications. Today, storage is already proving itself economical for some of these applications in market environments, to the extent that the markets are correctly valuing the services. It is therefore likely to be economic in regulated environments as well. Nevertheless, due to high upfront costs, the challenge of investing in storage can compound existing challenges for renewable investment.

Storage and Emissions

Overall, the potential of storage to improve system efficiency and to facilitate renewables integration means that it can significantly reduce emissions as compared to ancillary provision from fossil generation. As noted earlier, storage's ability to quickly absorb the variable output of renewable generation makes it a strong integration tool for renewables. By any means, storage is able to provide a service – storing and dispatching energy – with fewer emissions than any comparable generation device. Examples of these savings are seen in the one of the more prominent applications of storage today, frequency regulation. A study by KEMA has shown that when replacing traditional fossil-fuel generation, storage technologies such as flywheels and fast-response storage systems can greatly reduce carbon dioxide emissions compared to the incumbent technologies.

Storage could feasibly reduce emissions associated with backup generation as well. KEMA recently performed a study for the California Energy Commission in which it was determined that 3,800 MW of backup generation, if replaced by battery storage, would result in reduction of the annual emissions attributable to backup generation of as much as 40%. Here, emissions associated with the backup generation of non-residential customers outweigh those associated with the grid-based portfolio powering replacement batteries.

While it is becoming clear that storage can offer reductions in emissions associated with the electricity system, further research is needed to better define potential reductions across the host of storage applications. Such reductions are likely to be specific to the region and the storage technology, as emissions associated with storage depend on the portfolio of generation used to power it and on the efficiency of the technology.

Storage Technologies and Applications

Storage Characteristics

Many electric storage technologies are available today and more are forthcoming. Advanced lead-acid batteries, large format Lithium Ion, and grid-scale Sodium Sulfur batteries are all commercially available. There are many more emerging battery technologies from numerous established and start-up manufacturers around the country. DOE has awarded R&D Energy Frontier Research Centers funding and smart grid demonstration funding to a number of these.

No single storage technology fits every application and technologies have varying capabilities. However, advancements in storage technology are resulting in characteristics that increase the applicability of storage as a whole. These include:

- Fast Response: For regulation and some other ancillary services as well as transmission reliability applications, the storage device must be able to respond to control signals and change its charge / discharge power level near instantaneously; some technologies easily support this.
- Cycle durability: Some technologies can provide multi-thousand range cycles, allowing them to be used for longer periods of time in applications that require frequent use.
- Duration: In some applications, storage devices must be able to sustain full charging or discharging power levels for 2 to 6 hours. Shifting the diurnal production cycles of wind production typically requires durations in this range, for instance.
- Transportability: Where devices are somewhat mobile, the range of possible applications increases and re-use becomes more feasible. Substation batteries used for reliability and peak load management can be moved once station capacity expansion is justified and re-used at another substation, for instance.
- Scalability: The ability of a technology to maintain its characteristics regardless of size makes designing its use more flexible.

As storage technology evolves, storage will likely have many applications. Each technology will likely have its own niche depending on which combination of the above characteristics define the device. Performance and cost ultimately determine which type of storage is right for which applications.

Application Areas for Advanced Electricity Storage

In addition to the generation-related applications of storage noted above, electricity storage can provide value at the transmission, distribution, and end-use levels of the electricity system. Currently, developers and utilities are aggressively pursuing storage for ancillary services provision, localized transmission reliability, and community or utility-side backup reliability as well as more traditional backup power applications.

Distribution

In many parts of the United States, distribution reliability is such that consumers can expect to be without power an hour or more each year – this significantly lags behind other countries, including Japan and most of Europe. It is more than an inconvenience for someone working at home and leads to consumers acquiring backup generators. Storage, however, is a tool that could help improve reliability. In particular, at the substation, storage can provide local ride-through if sub-transmission failures limit service to the station. Substation-based storage could also provide contingency coverage in the event of transformer failures at peak load. This allows deferral of transformer upgrade or replacement and avoids load curtailment.

On the feeder, storage can provide the same benefit at either primary or secondary voltage – providing power to customers that would be without service as a result of a feeder outage. This can be a tremendous benefit, given that distribution feeder outages are the greatest source of power outages. System average interruption duration index (SAIDI) can be reduced dramatically by community energy storage system. Storage out on the feeder can also be a way to temporally provide extra capacity during load roll-over to alternate feeder configurations – a way of enhancing reliability or deferring expansion.

The Community Storage concept as envisioned by AEP, a national electricity generator and transmission system owner, would re-use electric vehicle batteries (or other technologies) to provide one or two hours of service to homes clustered around each distribution transformer. This potentially has favorable impacts on the cost of ownership of electric vehicles and is of interest to the automotive community as well.

Transmission

Congestion relief, stability enhancement and capital deferral are some of the benefits storage can offer the transmission system. Storage can relieve congestion by time-shifting the energy in location as well – taking production off peak and storing it near the load center – downstream of the congestion point instead of at the generator. In market environments, congestion costs are applied in principle to the entire load in the congested zones or nodes. In this case, the benefit of storage can be leveraged several times the value of the direct megawatt shifted.

When the peak load in the congested area exceeds the production available plus the production transmitted in, storage can serve as a way to meet peak load and thus can be a means to defer transmission expansion. (Generation expansion in many congested areas is impractical for siting reasons as congestion points typically occur in dense, urban areas).

The congestion problem will usually show up first as a contingency limit, not a direct lack of transmission capacity. Storage is a way to mitigate these contingency limits, with the fast storage picking up the load before the generation can be started. Furthermore, it is especially cost effective, as it avoids having to build transmission to provide redundancy, and it provides emission benefits, as it allows the use of downstream, uneconomic resources only after a contingency has occurred.

Finally, in some specialized problem areas, where stability concerns impose transfer limits that are more restrictive than the inherent transmission capacity limits, fast storage can be used as a stability enhancement device to relieve these stability constraints. The value of this in a particular instance is potentially very great and this application is worthy of serious engineering analysis and study.

End User

When storage is a more economical way to provide ancillaries, it reduces costs for everyone in the market. If enough storage is present to affect the clearing price, it reduces the price for all suppliers of the particular product. Similarly, by time-shifting lower cost generation to peak periods, it reduces the need for expensive peaking generation and reduces peak power prices. When storage reduces congestion this is inherently a market benefit.

The ability of storage to perform in certain applications is not limited to utility-scale devices. Generally, electricity storage is unique in the ease with which the technologies can be scaled. Whether the device is packaged as a kilowatt-scale application or a megawatt-scale application, the performance characteristics of the device can stay the same. For example, the same batteries that are being used in utility-scale megawatt devices are being used in today's electric vehicles.

Policy issues and actions for consideration

Beyond the technical and economic hurdles that a new technology in a new application has to overcome, there are a number of storage-specific policy issues worth considering. As storage becomes more versatile and commercially available, fitting storage into the existing policy framework becomes more challenging. For example, how best to classify storage, as a regulated or unregulated asset, is a primary concern as the classification can determine how to allocate costs and benefits. In addition, state utility commissions have to determine appropriate depreciation schedules and prudent expenditures for regulated distribution assets. The difficulty lies in the fact that a single device can serve multiple functions, and may at times play the roles of a regulated asset and an unregulated one.

Classifying the Type of Application

As noted above, storage can be used for many applications throughout the value chain – from generation to transmission and distribution to end-use. As such, a single storage asset can play the roles of what are currently distinct regulated and unregulated assets. Specifying the rules of engagement, in part to allocate costs and revenues, must therefore account for function as well as ownership. The example below discusses a case where transmission-based storage can serve multiple purposes.

Example: Transmission Storage – Multiple Services

When storage is used for transmission congestion relief by shifting energy in both time (off peak to peak) and location (remote to congested zone near the load), the storage increases the energy's value by both displacements. In essence, storage sets the marginal energy clearing price. If the storage is financed and operated as a purely merchant asset then the pricing, revenue sources, and cost allocations are clear. In this case, the primary regulatory concern would be whether the storage has undue pricing power or market concentration and must be subject to the same treatment as a “reliability must run” (RMR) unit.

If the storage asset is proposed as a transmission asset with a regulatory rate of return to the transmission owner then the question of the allocation of the profits from time and location shifting are very real. In effect it is allowing the transmission owner a share of the congestion rents that the storage device can garner. This is familiar ground to the industry; the new wrinkle here is that the storage device could also easily access ancillary markets as well as congestion. Storage deployed to relieve congestion is almost a perfect merchant transmission asset. There are no questions of loop flows or free rider usage. If the congestion relief economically justifies storage then the best regulatory role might be to provide some level of incentives or guarantees rather than to construct it as a regulatory asset.

However, the conundrum is that the most advantageous solution overall may be a level of storage deployment that reduces congestion costs to the level needed to justify the storage investment and no more. Whether market entrants will deploy the last increments of storage against diminishing returns is always unclear. If storage capital costs are on a decreasing curve it could be expected that new entrants might drive out existing facilities as is normal with high technology assets. That argues that merchant investors will want faster economic depreciation recovery rather than standards imposed by regulators. What is clear is that large-scale storage offers the first real opportunity for a kind of merchant transmission in a way that is environmentally and economically benign – and that we need the right regulatory and market solutions to facilitate it and not create a new form of regulated monopoly.

Some have argued that time shifting or locational storage uses more environmentally unfriendly resources; it is also as likely that storage fills in for intermittent renewable supplies. An interesting study would examine these empirical trade-offs. Because grid-scale storage will involve utility interconnection requests and technical requirements, these aspects have to be monitored carefully – and may prohibit the co-existence of regulatory and merchant assets in the same congestion zone. Another interesting corollary is the value of additional transmission when new renewable generation resources in addition to storage are sited. Does storage compete directly with transmission or is it the combination of renewables and storage that may obviate transmission benefits? Have we skirted the issue of benefits allocations through transmission upgrades or merely postponed it?

Is there an Industry Precedent?

The gas transmission industry offers one precedent which would not necessarily be attractive to today's merchant storage entrepreneurs. The storage asset is a regulated asset which earns a regulated rate of return based on a tariff for gas stored. The energy shipper/trader that contracts to use the storage pays a reservation fee and a storage fee based on usage with penalties for over or under scheduling; the time arbitrage gains on the stored gas are the profit or loss for the shipper/trader. This model neatly separates the questions raised by asset classification raised above. However, in this model it is not clear what the electricity industry economics would be for the storage investor. And as noted, the merchant electric storage operators today would find this discouraging.

One aspect of the natural gas industry which bears examination relative to electricity storage is the use of storage as part of transportation to meet just in time delivery needs. Independent marketers have more efficiently used both storage and pipeline capacity to deliver fuel to generators. Storage operators and transmission purchases can be bundled with energy to provide load. For the gas industry, this has contributed to price volatility as weather or outages have put pressure on local gas prices.

Other Barriers

The biggest challenge that faces adoption and deployment of storage is lack of routine methodologies about how to incorporate storage into system planning and operations. At the transmission level, this is largely within FERC's purview. At the distribution level, it is a matter for the states, of course.

NIST is developing standards for the interconnection of storage with the grid and its smart grid interoperability. KEMA assisted the ISO RTO Council in preparing the draft wholesale standards for storage this fall. Beyond these standards, we need standards developed for the description of storage in terms of efficiency, performance, life cycles, and the like. Manufacturers are asking us to test their new products in our laboratories in Pennsylvania and in Europe; most storage testing standards have been developed for electronic devices, back up power, and the like – and not for grid connected storage.

Tools to incentivize storage devices must be considered carefully. An Investment Tax Credit for storage, for example, likely has limited incentive for merchant developers and start ups as they cannot exploit these themselves because they have little or no income to offset. Rather, they arrange sale-leaseback with financial institutions that can utilize the tax credits. The number of financial institutions interested in these arrangements, however, is somewhat reduced right now. Loan guarantees might be a more effective tool for such markets.

Careful consideration of how to allocate the emissions benefits of storage is also important. Right now, when a regulated utility's storage investment leads to emission improvements, the credit will flow to the power production sector. Attribution of reliability improvements is also complicated, but would serve to help spur reliability-related storage investments.

Conclusion

The electricity grid is in the midst of historic transformation—modernizing its technologies and changing its generation mix to include a larger percentage of renewable resources. In the meantime, KEMA has observed that advanced electricity storage technologies have drawn attention from utilities, developers, governmental agencies, and consumers across the globe. Additional factors, such as the rapid growth in renewable generation investments and the increasing penetration of electric vehicles and plug-in hybrid electric vehicles, have increased the need for information that can help individuals navigate the wave of attention being placed on storage to address grid-related changes.

In the long-term, the implications of widespread, mass deployment of electricity storage across the power system are profound. It holds promise of dramatically increasing capacity utilizations of the generation and transmission and distribution system—essentially enabling a deferral of capital spending. Storage also can help significantly improve reliability, especially at the distribution level.

KEMA is heavily involved in expanding the understanding and capabilities of storage technologies by grid simulation. Through our studies on the business of storage and electrical vehicle integration in the grid, our knowledge of storage technology and its potential, our testing facilities for small-scale storage systems like batteries, our Flexible Power Grid Laboratory for grid integration of storage systems, and our knowledge of safety, environmental and customer aspects – we have been involved in formulating the key questions around the economy and efficacy of storage, and in developing the analytical and economic tools necessary to plan for its use. The level of industry interest in electricity storage is increasing very rapidly, and the policy sector is taking up the need for and design of incentive and regulatory structures for storage development.

Thank you for the opportunity to present electricity storage. I appreciate the Committee's interest in this topic and I look forward to answering your questions.