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Written Testimony of Kiran Kumaraswamy, Market Development Director of AES Energy Storage Before the U.S. House of Representatives, Committee on Science, Space and Technology – Energy Innovation: Letting Technology Lead

Thank you, Chairman Smith, Ranking Member Johnson, Vice Chairman Lucas, Vice Ranking Member Beyer and Distinguished Members of the Committee. I am honored to testify in front of you today on the topic of energy innovation and private sector leadership in commercializing new technologies. My name is Kiran Kumaraswamy – I am a Market Development Director of AES Energy Storage, a subsidiary of The AES Corporation, a Fortune 200 global energy company headquartered in Arlington, Virginia. AES provides affordable and sustainable energy in 17 countries around the world.

Innovation can and will transform the energy sector and in turn, people's lives. Improving lives is our mission at AES and our 19,000 people around the world are energized by that mission every day. In a sector that is changing faster than ever in its history, innovation will be critical to solving society's most pressing challenges, improving the way people work and live, and providing access to cleaner electricity.

Bringing change to the industry is part of our DNA at AES and, in many ways, is what we do best. AES was founded more than 35 years ago and we continue to grow by innovating new solutions to serve emerging power sector needs. We have helped create new emissions control technologies and biomass conversions, have built new efficient power generating stations, and we have brought thousands of megawatts of wind and solar to market.

We think innovation is different from invention. Invention is a new idea. Innovation is actually doing something with the idea or applying an existing idea in a new way to drive a greater impact. That means that to AES, innovation can happen not just through

The AES Corporation
4300 Wilson Boulevard
Arlington, VA 22203
aes.com

technology, but by thinking about business models differently or modifying market structures.

AES has been successful by applying proven technologies, tailoring them for the power sector, and innovating commercial models to bring dependable, cost-effective power to our customers. It's an approach we call applied innovation. Applied innovation is about addressing a market issue with a proven technology, typically borrowed from outside of our industry. These solutions, when applied to our industry, can completely shift the dynamics within a market.

The smart application of technologies validated in other sectors removes the risk and speeds the cycle time to new and better, affordable solutions. AES leverages the capabilities of an established and proven supply chains from other industries to solve critical power system problems. Devising new applications of established technology gives AES and our customers the confidence that the technology is reliable.

Energy Storage: An Example of Applied Innovation at AES

There is no better example of our applied innovation approach than in our energy storage business. We are in the midst of a transition towards an increasingly renewable and decentralized energy system. Storage is playing a key role where it's already deployed in providing flexibility and resiliency, maximizing what our current infrastructure can deliver, and allowing us to more easily incorporate distributed generation onto the electric grid.

We've come far from where we started. Ten years ago, battery based energy storage on the grid was experimental, and did not exist as a business opportunity. Today, it is a proven solution and is operating successfully across the country and in several overseas markets. We stand at the beginning of the next big scaling up – taking this vital technology to more customers, more countries, and more grids around the world.

In the context of today's discussion and applied innovation, it's important to understand how we got here.

In 2007, AES Energy Storage was founded as a subsidiary of AES to carry forward our initial survey of advances in battery technology and power electronics. We saw the

opportunity to use these technologies to improve the flexibility and efficiency of electric grids while running power plants more efficiently. We were bullish on the potential for lithium-ion as a technology for use in the power sector, as the technology itself had been validated in other major industries, such as consumer electronics and transportation. It also had the benefit of a well-established global supply chain, which gave us confidence that we would be able to scale up supply as demand for storage solutions grew.

At the time, no one had designed a large-scale energy storage system using lithium-ion batteries. Prior experiments in deploying batteries on the power grid proved the high value of the speed and responsiveness of batteries to improve grid reliability. However, the battery technology of the time proved unable to meet the challenge, due to its limited life and high costs. The conventional wisdom of the time was that batteries could not meet the challenges of utility-scale performance. As lithium-ion technology emerged, our team believed we had found useful business cases for battery-based energy storage systems. We moved forward with designing and building the first megawatt scale lithium-ion battery energy storage project.

By 2008, our battery-based energy storage system was ready to be tested on the grid. The team connected the first grid-scale battery by integrating two large tractor trailers of batteries to the grid in Indiana. This proved that large-scale battery-based energy storage could safely connect to an electric grid, operate as a complete system, and respond remotely to instructions sent by the grid operator, a key reliability service for all power grids.

Over the next few years, we worked closely with customers and stakeholders to prove grid-scale energy storage's feasibility, making history step-by-step: delivering the first commercial lithium-ion battery storage systems in the world in Northern Chile, and expanding our deployments in the United States in Pennsylvania, Texas, California, New York, West Virginia, and Ohio. And with every project – we were driving down costs for customers, learning, and innovating.

In 2014 in California, we demonstrated that batteries could compete successfully against peaking power plants, securing the world's first Power Purchase Agreements (PPA) for energy storage to serve a utility's customers for twenty years, and still the largest contracted energy storage project in the world. To meet the needs for these

larger, long-term projects, we turned our eye towards innovating and enhancing the energy storage technologies available at the time, incorporating lessons learned and applications developed into a single battery-based energy storage platform – Advancion®.

Rendering of 100 MW/400 MWh (Energy Storage) Alamitos Energy Center Under Contract and Expected to be Completed in 2021 in Long Beach, California

We then offered the Advancion® platform to other utilities and developers, and in less than six months from contract signing, delivered the world's largest system of its kind in San Diego, California.

Today, Advancion® is one of the world's leading energy storage platforms. With 20 projects and 398 MW deployed and awarded across seven countries, we've helped ensure more customers in more locations benefit from energy storage. AES has deployed the most comprehensive and proven fleet of battery-based energy storage systems in the world, which have delivered more than 3.5 million megawatt-hours of service to-date.

20 MW Harding Street Advancion® Energy Storage Array in Indianapolis, Indiana

Energy storage is critical for the grid's transformation to a new energy network – one that can meet the needs of our rapidly changing energy landscape and accelerate a cleaner energy future. Global demand for grid-connected energy storage is rapidly expanding. To answer that demand and transform the grid, we need to continue to drive down costs by scaling energy storage up, further and faster.

Just last week Siemens and AES announced we will join forces to create Fluence, a new global energy storage technology and services company that unites the scale, experience, and reach of its two parent companies. Subject to customary regulatory approvals, the 50/50 joint venture between Siemens and AES will deliver both the AES Advancion® and Siemens Siestorage energy storage platforms and continue to develop new storage solutions and services reaching customers in more than 160 countries.

Fluence will fill a major gap in the market by bringing together two of the industry's leading power and storage companies to create a new company that will have the power, breadth, people and footprint to continue transforming the energy landscape.

Combined, the companies deployed or have been awarded 48 projects in 13 countries with a total capacity of 463 MW.

The energy storage market is at a point similar to what we saw with the solar industry in 2007 or 2008. Solar was at the cusp of a tremendous period of growth and the energy storage industry will follow a similar trajectory, with significant expected growth over the next 10 years. Several forecasts anticipate the global market size of grid-connected storage at more than 28 GW by 2022, and could possibly go higher if places like India achieve their renewable energy targets.

With the market at an inflection point, what did we, as a private company, learn about commercializing next generation technologies in the power sector?

First, the existing power market is not designed to reward innovators and many of the needs reside within the network without any capability for remuneration. Many of the rules in the current power markets were put in place for traditional generation and do no fully account for technical, performance characteristics of advanced technologies like energy storage. The entire infrastructure of the existing centralized power and ancillary service markets were designed for the operating characteristics of traditional generation only. One notable example of the inability of the current market to accommodate a more efficient and valuable lithium-ion battery is the IPL Advancion® Energy Storage Array. Due to various issues, including an inability by the regional grid operator (Midwest Independent System Operator, MISO) to fully utilize the storage system and limitations in dispatch modeling, the device is continuously providing valuable service to the grid, but is not compensated for doing so.

It is important to remedy these regulatory concerns as soon as possible, so that storage can provide key grid services to regional markets. The Federal Government has an important role to play here, to ensure markets are fully competitive and have the policy in place to catch up with the technology – otherwise, market rules set up several years ago become an unintended roadblock for commercializing energy storage. The Federal Energy Regulatory Commission (FERC) currently has a Notice of Proposed Rulemaking (NOPR) related to removing barriers for storage participation in wholesale power markets. These types of efforts that include reforming market regulations to enable storage to compete in markets should be accelerated.

By making the challenges and needs of the power system consistently more visible, technologies and the capital to fund them can be mobilized to address these needs. For example, the earliest instances of energy storage were based around resolving frequency management in large power systems such as the Mid-Atlantic PJM Regional Transmission Organization Power Market. This was made possible due to the fact that this market had made the need for frequency management a known need through a defined market service. In other parts of our electric sector, where we do not have organized markets, this need remains obscured. Whereas energy storage has emerged to lower the cost, improve reliability, and reduce emissions associated with frequency regulation in the organized markets, these technologies have not yet been applied in more closed power systems.

Second, on the topic of battery chemistry research we believe that lithium ion is mature and private capital from large battery manufacturing companies are moving it forward at incredible speed and investment. . The Government should continue funding R&D on other early stage battery chemistries that have the potential to achieve greater capabilities.

Third, the national labs through the Department of Energy (DOE) are doing a great job in advancing the modeling and visualization of benefits that energy storage brings to the grid. These are complex analytic simulations that require the use of state of the art power market models and a high degree of computational rigor; the Government should encourage and increase investments in the DOE and national labs, to continue this work and to share analytical methods with utilities, wholesale market operators, and other stakeholders responsible for planning, operating and maintaining the electric system. This is a critical piece of commercialization because it provides the analytic support for comparing the costs and benefits of deploying energy storage for specific applications.

Finally, the Government should continue to provide technical assistance to storage project deployments, particularly for states and utilities that are considering their first projects but may be constrained by lack of technical experience. Through our experience, we have found that deploying projects in the field is the best way to enhance learning among all stakeholders – utilities, grid operators and state regulators alike.

Mr. Chairman, thank you again for the opportunity to testify today – I would like to invite you and the other Members of the Committee to visit any of our storage facilities in the United States. I am happy to take any questions.

Thank you.

The AES Corporation
4300 Wilson Boulevard
Arlington, VA 22203
aes.com