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## Increased Grid Flexibility From Energy Storage Technologies

Variability exists today on the electric grid in various forms such as loads which routinely deviate from forecasts, and generation sources such as wind and solar which rely on variable resources and are subject to forecast errors. To manage variability, grid operators require flexibility, which also already exists in various forms including dispatchable generation and controllable loads. As variability is bound to increase with increasing proportions of renewable generation, energy storage resources offer a new source of flexibility to the grid. There is no doubt that this additional flexibility is welcome and can serve to help manage increased variability. We presently face challenges in exactly how to accept this enhanced flexibility through existing and future market mechanisms.

Today flexibility is largely managed through existing ancillary services markets. Regulation smoothes moment-to-moment imbalances between load, generation, and unscheduled interchange by dispatching generators up or down within the short-term limits of their ramp rates in order to maintain a stable system frequency. Advanced energy storage technologies possess certain properties that result in superior performance in this application than traditional generators. The fast response speed of advanced energy storage technologies offers digital control of resources – the ability to demand injections or withdrawals of energy at precise megawatt levels, and for those levels of output or absorption to be instantaneously met. This superior response speed can essentially serve as an “ACE eraser” for the grid operator, instantly reducing the need for slower regulation resources to respond, resulting in system and customer benefits through reduced fuel use (and associated emissions), reduced O&M burden on the generation fleet, and increased generator life. By rapidly withdrawing and injecting energy from the system, high efficiency advanced energy storage resources effectively recycle excess energy for use moments later when it is again needed. These two properties of digital control and high efficiency enable advanced energy storage technologies to provide regulation to the grid in a manner that is better, faster, and cleaner than it is provided today, while offering the much-needed flexibility to enable the integration of renewable resources.

Contingency reserves offer another form of flexibility to the grid by keeping a set of operating generators available to ramp up their output in the case of a system contingency such as a sudden loss of a generator or transmission line. In this application, advanced energy storage technologies provide an advantage through their property of programmatic response. Being able to specify the shape of a resource’s contingency response through software controls allows that resource to provide an ideal response to system contingencies, rather than simply the response a generator may provide as a function of its droop settings or ramp rate. Load shedding has proven to be somewhat effective in this area. Energy storage has the potential to be even more effective since the response can be programmed and shaped in the ideal way to help restore grid stability, and can do so while avoiding the economic cost of load curtailments and the opportunity cost of under-utilized generation. AES is developing a commercial-scale energy storage project in this application in Latin America. We have been working with the system operator there on the ideal response to grid contingencies, and working with our suppliers to develop and program the algorithms involved, with a focus on a response to rapidly decaying system frequency. This has given us the exciting opportunity to introduce “self healing” properties to the grid. Existing U.S. spinning reserve markets do not yet have a widespread mechanism to value the operational and reliability

benefits of programmatic response, but the opportunity exists to incorporate such concepts in the near future as our sources of flexibility expand.

With increased wind penetration grid operators are going to be facing, and already are in some places, a level of variability that challenges the flexibility offered by the existing generation fleet's ramp rates. The relative scarcity of high-performance flexibility necessary to compensate for these large and rapid ramps calls for innovation in how flexibility is offered and valued. An opportunity exists when discussing system ramping requirements to draw upon lessons from existing ancillary services, including lessons learned about the flexibility-enhancing properties of advanced energy storage technologies. Taking advantage of the digital control and programmatic response capabilities of energy storage when addressing the challenges of system ramping requirements holds significant potential to provide the flexibility demanded by high RPS and low carbon scenarios being proposed today.

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