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RELIABILITY TECHNICAL CONFERENCE

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Thank you for the opportunity to share information with you on electricity reliability research I have conducted relevant to the focus of this panel on the 2016 State of Reliability. My comments will focus on the third topic listed for this panel: metrics. The research I will draw upon was funded by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability. Hence, my comments will build from and provide more details on those that have already been provided on this panel by Patricia Hoffman. That said, I wish to clarify that the opinions and perspectives I express are my own and do not necessarily reflect those of the Department of Energy or of the Lawrence Berkeley National Laboratory.

I. The Importance of Reliability Metrics and The Need for Improvements to Them

The often-used management dictum that one can't manage what one can't measure provides the organizing rationale for the use of reliability metrics. To this starting point, we must further qualify this rationale by distinguishing between—and separately taking account of—the aspects of reliability that one can, in fact, manage (such as storm hardening) from the aspects that one cannot manage (such as the frequency and intensity of storms). And, finally, along these lines, it is essential that we acknowledge a quote attributed to Albert Einstein: "Not everything that counts can be counted, and not everything that can be counted counts."

The reliability of the electric power system has long been a focus of analysis. Many highly mature metrics are in widespread use. They have been developed to assess specific aspects of reliability considered from a variety of perspectives. The purposes they serve, by and large, remain important today and so reliance on them is expected to continue for some time. Still, there are opportunities for improvements and expansion upon existing metrics. These opportunities have been created by new uses for and increased importance of information on the reliability of the power system.

Existing metrics for electricity reliability can be divided into two types: lagging metrics and leading metrics.

Lagging metrics measure what *has happened*, such as how long or how often electric service has been interrupted. They include System Average Interruption Duration Index (known as SAIDI) and System Average Interruption Frequency Index (known as SAIFI), both of which are widely used by distribution utilities. They also include reporting on individual large events, such as those that are reported to the North

American Electric Reliability Corporation (or NERC) following Standard EOP-004 and to the Department of Energy using Form OE-417; these metrics are thought to be relevant mainly for use by transmission system operators. Finally, lagging metrics also include metrics specifically related to the restoration of electric service following power interruptions, such as restoration time. These are used by both transmission and distribution utilities.

Leading metrics measure aspects of the state of the power system *prior* to the occurrence of the events that cause power interruptions. They are used to help assess how well the power system is prepared for these events. For the transmission system, NERC further divides these into metrics associated with resource adequacy (such as reserve margin – both planning and operating) and operational security (such as N-1 planning).

With respect to lagging metrics, there are two major areas where improvements are needed. First, there is a need to expand traditional metrics on interruptions to allow for explicit consideration of the economic impacts of interruptions on customers. SAIDI and SAIFI, for example, are system-wide averages that do not, by themselves, tell us anything about the actual experiences of customers during interruptions, such as how long a customer is without power or how frequently. More importantly, they do not, by themselves, distinguish among customers. Yet, we know prima facie that the economic impacts of power interruptions can vary by many orders of magnitude depending on the type of customers affected and how long or how widespread is the interruption.

Second, there is a need to better align the measurement of reliability—or rather the sources or causes of reliability events (that is, unreliability)—with the institutional

structures we rely on to manage and oversee reliability. Specifically, reliability metrics must evolve to distinguish between and enable more precise state-led regulation of distribution reliability separately from federal regulation of transmission reliability.

With respect to leading metrics for reliability, the principal area for improvement lies with taking more explicit account of uncertainty in prospective assessments and with formal recognition of (and incorporation of) risk management techniques to address these uncertainties in decision-making.

II. Early Successes and the Path Forward Toward Future Improvements in Reliability Metrics

Fortunately, thanks in part to support provided by the Department of Energy, especially the Office of Electricity Delivery and Energy Reliability, progress is being made on all of these fronts.

With respect to more granular information on customer's individual experiences with power interruptions, the Department of Energy's Grid Modernization Lab Consortium has initiated a major research project to develop enhanced reliability metrics (along with other grid metrics) that will seek to capture this information in future complements to traditional SAIDI and SAIFI.

In addition, as part of the Smart Grid Investment Grant program, the Department of Energy has developed the Interruption Cost Estimate (or ICE) Calculator that allows utilities to factor in the cost of interruptions by customer class, duration, and timing into economic assessment of reliability enhancing improvements, such as undergrounding

distribution lines. The tool is based on the collective results of 37 value of lost load surveys conducted by U.S. utilities over the past 20 years. The tool is publicly available online via a website hosted by my laboratory and its use is free of charge. We know that the tool is being used to support regulatory filings for distribution system investments in several state jurisdictions. Moreover, the Department of Energy is sponsoring additional research to make the tool more useful in estimating the economic costs to customers associated with long-duration, widespread interruptions of power.

With respect to improving the availability of SAIDI and SAIFI, and better aligning the information they provide with state vs. federal oversight of reliability, the Department of Energy has worked with the Energy Information Administration (or EIA) to collect and publish SAIDI and SAIFI metrics from all utilities. Importantly, the EIA data collection requires utilities to report these metrics separately for the loss of supply, which provides a first-order proxy for distinguishing between interruptions originating from *within* the distribution system and interruptions originating from outside or "upstream of" distribution systems in the sub-transmission and transmission system. More work will be required to fully align these classifications with FERC's oversight of the bulk electric system; still, this is a very promising start. In this regard, we are excited to have begun collaborative work with NERC to enhance existing reliability metrics, concentrating first on the potentially changing interface between the distribution and bulk electric systems.

Finally, with respect to the treatment of uncertainty in prospective assessments of and management approaches for reliability, the Department of Energy is supporting academic and national laboratory research on advanced techniques to incorporate these

concepts into power system planning. There is no shortage of promising approaches. The challenge is to engage stakeholders by demonstrating these techniques side-by-side against current deterministic approaches and, thereby, begin charting the path toward more formal adoption by incorporating the insights they provide into current decision making processes.

This concludes my prepared remarks.