

**U.S. Department of Energy**

**Workshop**

*Resilience Metrics for Energy Transmission and Distribution Infrastructure*

Offices of Electricity Delivery and Energy Reliability (OE) and  
Energy Policy and Systems Analysis (EPSA)

June, 10th, 2014

Brookhaven National Lab

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## U.S. Department of Energy

### Workshop

#### *Resilience Metrics for Energy Transmission and Distribution Infrastructure*

#### **Purpose**

- This is a follow-on workshop to the April 29<sup>th</sup> Energy Resilience Metrics workshop that was held in Washington D.C., where Sandia National Laboratories will present prototype energy infrastructure resiliency metrics and share progress to date.
- The information shared at this technical workshop will feed into the analysis conducted by the U.S. Department of Energy (DOE) and other federal agencies for the purpose of preparing the Year One Quadrennial Energy Review (QER) Report.
- To seek feedback from stakeholders on resilience metrics for energy infrastructure to transport, transmit, and deliver electric power, natural gas, and oil in the U.S., feedback on the following will be sought:
  - The overarching framework for energy infrastructure resilience metrics and problems that need to be solved
  - Examples of prototype energy infrastructure resiliency metrics for the energy sector and use cases
  - The framing of a resilience roadmap, and the implication and consequences of introducing new energy resilience metrics

(Note: “Resilience” is defined for the purposes of this workshop in Appendix A)

- The result of this workshop will lay the groundwork for policy analysis and future research and development programs within the federal government to achieve the goals of the QER, as outlined in the Presidential Memorandum of January 9, 2014.
- Outputs from this workshop are also intended to inform work of the Council on Climate Preparedness and Resilience and the Infrastructure Resilience Working Group.

#### **Background**

The initial focus for the QER will be our Nation's infrastructure for transporting, transmitting, storing and delivering energy. Elements of our current infrastructure are challenged by transformations in energy supply, markets, and patterns of end use; issues of aging and capacity; impacts of climate change; and cyber and physical threats. Any vulnerability in this infrastructure may be exacerbated by the increasing interdependencies of energy systems with water, telecommunications, transportation, and emergency response systems. High quality infrastructure can spur economic growth, attract new businesses, and enable the development of business models and

industries that are dependent on these underlying public goods. The first Quadrennial Energy Review Report will serve as a roadmap to help address these challenges and opportunities of our evolving energy system.

The DOE will take into account previous analytical work on the United States energy infrastructure as well as comments from industry, government and academia and private citizens. The public comments will inform the QER's efforts to outline specific sets and types of vulnerabilities and to define potential solutions to these vulnerabilities.

## Workshop Agenda

Time	Activity	June 10, 2014
8:30-9:00am	<b>Registration</b>	
9:00-9:15 am	<b>Workshop Purpose</b> <ul style="list-style-type: none"> <li>Welcome, Introductions, Purpose and Agenda</li> </ul> <i>Karen Wayland, EPSA</i>	
9:15 – 10:15am (1.0 hour)	<b>Energy Resilience Metric Framework</b> – Charles Hanley, Grid Modernization and Military Energy Systems Group, and Dr. Robert Jeffers, Resilience and Regulatory Effects Department <ul style="list-style-type: none"> <li>Sandia will describe a proposed framework for the development of resilience metrics that can be applied to oil, gas, and electricity energy infrastructures.</li> <li>These metrics are risk-based, including elements of Threats (e.g. Hurricane), Vulnerability or Reliability (e.g. Susceptibility of the system to damage), and Consequence (e.g. Financial devastation)</li> </ul>	
10:15 – 10:30 am	<b>Break</b>	
10:30 – 12:00 pm (1.5 hours)	<b>Presentation of Electricity Resilience Metrics in a Use-Case Context</b> – Dr. Jean-Paul Watson, Information and Cognitive Science Analytics Department <ul style="list-style-type: none"> <li>This presentation will progress through realistic but hypothetical applications of resilience metrics in the electricity sector. Actual analysis will be presented in context of how these metrics would be used.</li> <li>The presentation will pose a problem to be solved, imposing technical assumptions, analytically populate the resilience metrics, then using the populated metric, solve the problem that was posed.</li> </ul>	

	<ul style="list-style-type: none"> <li>The intent of this presentation is to better articulate use of the metrics rather than to endorse the analytic methodology used, which is a subject of further R&amp;D.</li> </ul>
<b>12:00-1:00pm</b>	<b>Lunch</b> (On Your Own)
<b>1:00 – 2:00 pm</b> (1.0 hour)	<p><b>Presentation of Oil Resilience Metrics in a Use-Case Context</b> – Dr. Tom Corbet, Policy and Decision Analytics Department</p> <ul style="list-style-type: none"> <li>This presentation will progress through realistic but hypothetical applications of resilience metrics in the oil sector. Actual analysis will be presented in context of how these metrics would be used.</li> <li>The presentation will pose a problem to be solved, imposing technical assumptions, analytically populate the resilience metrics, then using the populated metric, solve the problem that was posed.</li> <li>The intent of this presentation is to better articulate use of the metrics rather than to endorse the analytic methodology used, which is a subject of further R&amp;D.</li> </ul>
<b>2:00 – 3:00 pm</b> (1.0 hour)	<p><b>Presentation of Gas Resilience Metrics in a Use-Case Context</b> – James Ellison, Electric Power Systems Research Department</p> <ul style="list-style-type: none"> <li>This presentation will progress through realistic but hypothetical applications of resilience metrics in the gas sector. Actual analysis will be presented in context of how these metrics would be used.</li> <li>The presentation will pose a problem to be solved, imposing technical assumptions, analytically populate the resilience metrics, then using the populated metric, solve the problem that was posed.</li> <li>The intent of this presentation is to better articulate use of the metrics rather than to endorse the analytic methodology used, which is a subject of further R&amp;D.</li> </ul>
<b>3:00 – 3:15 pm</b>	<b>Break</b>
<b>3:15 – 4:45 pm</b> (1.0 hour)	<p><b>Framing of a Resilience Roadmap: Implications and Consequences of Introducing New Energy Resilience Metrics</b> - Ross Guttromson, Electric Power Systems Research Department, and Charles Rath, Resilience and Regulatory Effects Department</p> <ul style="list-style-type: none"> <li>The QER needs to articulate technical needs, policy needs, and envisioned benefits of a national effort for energy resilience. Per the Presidential Directive for the</li> </ul>

	<p>QER, “a comprehensive and integrated energy strategy must be developed, which must include elements of our nation’s energy infrastructure resilience.</p> <ul style="list-style-type: none"> <li>• This session will seek feedback to establish motivations for such a strategy, and attempt to articulate the high level research, commercial, and policy needs to achieve them.</li> <li>• Additionally, this conversation will seek feedback on how new resilience metrics could be implemented in resilience-focused policies and what potential reactions might emerge from energy sector stakeholders (e.g. Utilities, regulators, emergency planners, municipalities, etc).</li> </ul>
<p><b>4:45- 5:00 pm</b> <b>(15 mins)</b></p>	<p><b>Wrap–Up/Review of Group Discussion:</b></p> <ul style="list-style-type: none"> <li>• Discussion of next steps: <i>Karen Wayland, EPSA</i></li> </ul>
<p><b>5:00 pm</b></p>	<p><b>Adjourn</b></p>

## Expected Outputs

The technical workshop on resilience metrics will provide DOE staff with significant information that will inform the critical analysis being conducted to write the first QER Report.

Key outputs from this technical workshop will include the following:

- Identify the types of energy-sector resilience metrics that have been developed and are most commonly used,
- Discuss and reach agreement on the adequacy of existing metrics, both quantitative and qualitative,
- Identify options for improved metrics, working towards the establishment of a common taxonomy for characterizing energy sector resilience, and
- Solicit input from participating experts on the above topics, and identify areas for further refinement.

## Principal participant roles:

- *Sandia National Laboratories* will present prototype metrics and their progress to-date on developing a long-term roadmap on resilience metrics for electric power, gas, and oil infrastructure and their proposed uses.

## Location

The session will be held on June 10th, 2014 at:

Brookhaven National Labs in Upton, New York

## Contact Information

Technical Workshop Logistics:

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## Appendix A

Resilience can mean many different things to people, so to provide consistency for our basic dialogue, we make the following definitions and clarifications.

This workshop will use the PPD-21 definition of resilience as a basis for resilience metric development. Many different options have been proposed, and rather than add a new definition to the mix, we will use the PPD-21 definition as a foundation and customize it for energy infrastructure.

*PPD-21: “The term ‘resilience’ means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.”*

During the workshop, resilience, adaptation, and other key terms mean in the context of resilience will be defined. A description of metrics for quantifying the resilience of energy infrastructure will be provided and, facilitators will walk through how these could be used in a set of test cases.

- Infrastructure: Work will be focused on energy infrastructure, including electric power, oil, and natural gas infrastructure. Additionally, focus will be given to resilience at a systems level, rather than at individual components (e.g., a transformer or natural gas compressor).
- Disruptive events: Events of concern are relatively low probability but with potentially high consequences. These events include hurricanes, earthquakes, intentional attacks, etc. There will not be attention provided to more common events that are already planned for (e.g., N-1 contingencies in the electric power sector.) Discussion on disruptions will be limited to “acute events” that occur over a relatively short time period (hours to weeks at most). This excludes disruptions that occur over years or decades (e.g., reduced demand for electricity due to economic downturns).
- Metrics: there are many different aspects to resilience that can be explored. Our discussion will be restricted to the formulation and application of metrics that can be used to characterize and inform on the resilience of energy infrastructure.