NARUC
National Association of Regulatory Utility Commissioners

Advancing Electric System Resilience with Distributed Energy Resources: Key Questions and Resources

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About SEIN

The Solar Energy Innovation Network (SEIN) assembles diverse teams of stakeholders to research solutions to real-world challenges associated with solar energy adoption. This paper is written as input to a broader project by the National Association of Regulatory Utility Commissioners under SEIN. NARUC's SEIN project focuses on the value of resilience and its use in state policymaking. NARUC has previously explored the topic of resilience as it relates to electricity regulation.[1] NARUC has also explored opportunities for improved electric grid resilience in the face of "black sky" hazards that can cause long-duration power interruptions.[2] In parallel, NARUC has developed a manual for state utility regulators on rate design and compensation models for distributed energy resources (DERs).[3] NARUC's SEIN research builds on these previous efforts by investigating whether and how current state DER policies support resilience objectives. Concurrently, Converge Strategies LLC, as a member of NARUC's SEIN team, published a report covering valuation methodologies for resilience. The overall goal of the NARUC SEIN project is to provide state regulators with guidance for taking resilience into account when evaluating investments in the distribution system.

Disclaimer

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1 Miles Keogh and Christina Cody, NARUC, "Resilience in Regulated Utilities," November 2013: https://pubs.naruc.org/pub/536F07E4-2354-D714-5153-7A80198A436D.

2 Paul Stockton, NARUC, "Resilience for Black Sky Days: Supplementing Reliability Metrics for Extraordinary and Hazardous Events," February 2014: https://www.sonecon.com/docs/studies/Resilience_for_Black_Sky_Days_Stockton_Sonecon_FINAL_ONLINE_Feb5.pdf.

3 NARUC Staff Subcommittee on Rate Design, "Distributed Energy Resources Rate Design and Compensation," November 2016: https://pubs.naruc.org/pub/19FDF48B-AA57-5160-DBA1-BE2E9C2F7EA0.

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Overview

State energy regulators have a clear interest in improving the resilience of the electricity distribution system. System disruptions are costly, inconvenient, and can be devastating, depending on the duration. The vast majority of service interruptions are located in the distribution system; unfortunately, these interruptions are increasing in frequency and pose severe threats to the provision of reliable electricity service.[4] While regulators are familiar with monitoring and regulating system reliability – defined by the North American Electric Reliability Corporation (NERC) as the electric system's ability to (a) supply adequate power to meet demand and (b) withstand sudden disturbances or unanticipated loss of components[5] – resilience is a newer term that lacks a universally accepted definition and metrics. FERC defines resilience as the ability of the system to anticipate, absorb, adapt to, and/or rapidly recover from disruptions,[6] while NARUC defined resilience in a 2013 paper as "robustness and recovery characteristics of utility infrastructure and operations, which avoid or minimize interruptions of service during an extraordinary and hazardous event."[7] While state energy regulators have generally not yet arrived at state-specific definitions of resilience, they are paying increasing attention to how resilience can be incorporated into the regulatory process by exploring how to ensure utility and customer investments achieve resilience benefits when possible.

To date, distribution-level investments have not been put through rigorous analysis by commission staff to document resilience benefits. A review of regulatory proceedings conducted by Converge Strategies LLC for NARUC found three examples of resilient distributed energy resources (DERs) projects[8] coming to commissions for approval; none included a quantified value of resilience.[9] The lack of metrics and valuation methodologies for resilience prevents commissions from fully and accurately analyzing and comparing the impacts that proposed investments will have on resilience, thereby limiting a commission's ability to adequately review the cost effectiveness of a project.

However, NARUC anticipates the continuation of two trends: (1) threats to electric distribution system resilience will grow more frequent and severe, and new catastrophic threats will emerge with the potential to cause widespread and/or long-term outages, and (2) regulated utilities will propose investments to regulators that will have an impact on system resilience. Therefore, it is critical for regulators to apply economic analysis methods to resilience investments and to treat resilience as a desired outcome similar to other objectives, such as reliability, emissions goals, and other public policy preferences depending on the state.

State energy regulators are not the only state-level entities with influence over the electric distribution system; state legislatures, energy offices, and other agencies and officials can shape the environment in which commissions operate and the scope of commissions' authority. However, in recognition of commissions' unique role overseeing distribu-

4 Alison Silverstein, Rob Gramlich, and Michael Goggin, Grid Strategies, "A Customer-Focused Framework for Electric System Resilience," May 2018: https://gridprogress.files.wordpress.com/2018/05/customer-focused-resilience-final-050118.pdf.

5 NERC, "Definition of 'Adequate Level of Reliability'," December 2007: https://www.nerc.com/docs/pc/Definition-of-ALR-approved-at-Dec-07-OC-PC-mtgs.pdf.

6 FERC, "Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures," Docket Nos. RM18-1-000 AD18-7-000, January 8, 2018: https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf.

7 Kiera Zitelman, NARUC, "Advancing Electric System Resilience with Distributed Energy Resources: A Review of State Policies," April 2020.

8 The utilities bringing these projects to the commissions for approval used the term "resilient" in the proposals and specifically cited resilience benefits.

9 Wilson Rickerson, Jonathan Gillis, and Marisa Bulkeley, Converge Strategies, "The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices," NARUC, April 2019: https://pubs.naruc.org/pub/531AD059-9CC0-BAF6-127B-99BCB5F02198.

tion-level investments and the importance of the distribution system in improving resilience, commissions should be prepared to consider resilience investments ranging from traditional distribution grid hardening measures, to advanced rate designs that incentivize socially beneficial DER installations, to optimal utilization of DERs, including non-utility-owned technologies.

This resource has two complementary parts:

I: A list of questions that offers an initial starting point for state public utility commissions (commissions) to frame how they review proposed utility investments and considerations that could offer resilience benefits The questions are divided into three categories: (a) initiating a public utility commission conversation about system resilience, (b) considering particular projects or investments, and (c) understanding the broader resilience landscape.

II: A list of relevant resources to improve a regulator's ability to oversee resilience investments and obtain the best possible solutions for customers. The list of resources includes a synopsis of relevant topics covered in each resource.

This document is not intended to offer a complete picture of resilience literature, but instead suggests strategies for state regulators to convene conversations and make decisions to achieve better resilience outcomes for customers. It is meant to serve as a starting point for commissions to understand and incorporate resilience into regulatory processes. The list of questions and resources will not be perfectly suited to the particular needs of each commission. As the resilience conversation advances, regulators will need to take advantage of available resources to build their capacity to assess resilience risks, compare investment options, and evaluate performance.

I. Resilience Questions for State Energy Regulators

A. Initiating a Public Utility Commission Conversation about Distribution System Resilience

To arrive at an improved understanding of resilience and to incorporate resilience into the regulatory process, regulators will likely want to start with broad questions first. The questions in this section are based on conversations with commissioners, commission staff, and federal experts about the current resilience landscape and gaps or challenges faced by commissions.

The questions that follow help commissions to assess the landscape in their states, consider the most productive roles for the commission and other stakeholders, and understand the scope of the commission's authority as it relates to system resilience.

Goals and Definitions

- What does resilience mean to my state? Does my commission or state have goals related to resilience? If not, should it?
- Which stakeholders should be involved in developing a definition and metrics for distribution system resilience? How will we reach them?

Roles and Approaches

- What should be the commission's role? Convener (gathering parties together)? Moderator (synthesizing feedback from diverse stakeholders)? Leader (shaping and managing the conversation)? Participant (joining the discussion)?

Threats and Benefits

- What threats are responsible for service interruptions currently? What natural and human threats should we be trying to mitigate in the future? At what level(s) and/or location(s) on the system are these threats pertinent?
- What are the potential impacts and durations of resilience threats? How much certainty do we have around these predictions? What level of risk are we willing to accept?
- What resilience benefits can we reasonably quantify (e.g., decreased outage duration)? Where do we lack data or understanding of possible benefits (e.g., improved access to emergency services during an outage)? What benefits are outside the typical or statutorily defined scope of the commission (e.g., air quality benefits, health and safety benefits)? How should we communicate the challenge of quantifying such "out of scope" benefits?
- What resilience costs can we reasonably quantify (e.g., infrastructure upgrade costs, software costs for monitoring sensors, intentional redundancy)? Where do we lack data or understanding of possible costs (e.g., interoperability costs)? What costs are outside the typical or statutorily defined scope of the commission (e.g., environmental costs, health and safety costs)? How should we communicate the challenge of quantifying such "out of scope" costs?

Options

- What avenues can the commission use to explore valuation methodologies for resilience (e.g., public workshops, formal dockets, other stakeholder engagement processes)?
- How can the commission encourage prudent investments in resilience? How do we know when those investments are just and reasonable? In what cases, if any, are we willing to accept investments that are otherwise not prudent for the sake of resilience?
- How can DERs enhance or detract from resilience in my state?
- What examples of resilient DERs[10] already exist that may be applicable to my state?
- What types of investments have historically been proposed by the utilities to improve resilience? How do DERs compare to these traditional investments when considering resilience impacts and values?
- How can a utility utilize resources owned by customers, third parties, or other entities to support resilience? Are there adequate procurement or compensation models that can value and compensate others for the resilience benefits from these resources?

10 Kiera Zitelman, NARUC, "Advancing Electric System Resilience with Distributed Energy Resources: A Review of State Policies," November 2019.

B. When Considering Particular Projects (e.g., DERs, Microgrids)

After commissions have a state-specific concept of distribution system resilience defined, they can then apply those concepts to specific investments. Questions in this section are designed to help state regulators review proposed projects that come before commissions for regulatory approval.

Project Characteristics

- What technology or combination of technologies is being proposed? What attributes of resilience does the project exhibit (e.g., dispatchability, islanding capability, siting at critical loads/locations, fuel security, quick ramping, grid services, decentralization, flexibility)?
- Where in the system does this project improve resilience (e.g., bulk power system, distribution system, individual facility)? At what scale and against which threats?
- What is the owner and/or operator structure proposed for this project?
- Does this project leverage all available sources of funding (e.g., green bank funding, federal or state grants)?

Benefits and Costs

- Does my commission have the capacity to evaluate the resilience benefits of this project? Do we need to invest in new capabilities or training for existing staff and/or commissioners?
- How will we measure success when implementing this project? What data do we need to collect to determine if the project is producing the benefits projected?
- What data can we collect? What gaps can we anticipate?
- How will the costs of this project be recovered? Is this in the best interest of customers? Which customer classes will benefit from this investment?
- How can we manage the risk of shifting costs to customers who will not benefit from this investment? How can the commission manage financial risk to customers and avoid stranded assets?
- Does the project's owner and/or operator structure make sense in light of the proposed use, financing, and benefits? Are there alternative procurement models (e.g., public private partnerships, shared service agreements) that are needed? Are there alternate ownership or procurement structures that minimize costs or cost-shifting to customers without negatively impacting resilience?

Analysis and Alternatives

- Is the project a cost-effective way to improve resilience? Is a cost-benefit analysis (weighing costs and benefits of different options without setting a target outcome) or a cost-effectiveness analysis (setting a specific goal and comparing costs of various ways of reaching it) more appropriate to conduct when considering this project?
- What is the life of the resource? How often will it have to be replaced?
- What other benefits can this project offer (e.g., social, environmental, economic)?

- Do the resilience benefits of this project (e.g., back-up power) preclude it from offering other services (e.g., ancillary services)?
- Can we scale or replicate this solution? If so, how and when will we decide?
- Based on what we know today, will this investment mitigate vulnerability to future threats?
- Is this project the right size/configuration to solve the specific problem at hand? How can the commission prevent "gold plating" (i.e., overbuilding a project to maximize utility returns beyond what is prudent) and ensure that the scale and cost of the project is appropriate?
- Is the resource deferring traditional grid hardening solutions or will this project replace the traditional solutions?

C. On the Broader Resilience Landscape

Beyond specific projects, commissions may want to ask additional questions and envision their ideal future role in a more holistic regulatory landscape for resilience, including how they may interact with other federal, state, and local policymakers and regulators. Questions in this section position commissions to think about their role alongside other stakeholders in regulating resilience and how electric distribution system resilience interacts with resilience in other sectors.

Organizational Roles

- Who is in charge of critical infrastructure security and energy assurance at the state level? What is the relationship between these entities and the commission?
- What role does aggregation of DERs play in resilience? How can individual DERs be strategically grouped to deliver increased resilience benefits to individual owners and/or the broader distribution system? How might recent and ongoing FERC rulemakings impact DER aggregation and participation in both wholesale and retail markets? Are non-wires alternatives an option?

Decision Making

- How can we apply what we know about customer behavior to resilience investments?
- How can we prioritize resilience investments? How can we identify optimal locations?

Funding Options

- How can the commission work with the public, utilities, independent system operators, regional transmission organizations, the legislature, governmental agencies, technology vendors, and others to identify, prioritize, and advance resilience projects?
- What funding streams exist to help invest in resilience beyond ratepayer funding?

Customer Needs

- How should the benefits of resilience investments be allocated, particularly when a project is funded partially by ratepayers and partially by other resources?
- What other strategies are needed to facilitate resilience investments? Can the state rely upon and share resilience obligations with non-utility stakeholders?
- What do customers (broadly defined) want? How do we rank customer needs (e.g., prioritizing service to military, local critical facilities [hospitals, police stations, prisons, and elder care facilities], private businesses)?
- In what ways can current efficiency programs be leveraged? Does it make sense to develop a new efficiency program to explicitly support resilience goals?

II. Resources for State Energy Regulators to Scope, Prioritize, and Answer Questions about Resilience

The following table presents resources from NARUC, DOE, national labs, and other stakeholders that may be helpful to commissions in answering the questions put forward in Section I. Resources are presented in chronological order from most to least recent.

				Relevance to Questions		
Date	**Author**	**Title**	**Key Questions Addressed**	**A**	**B**	**C**
April 2020	Kiera Zitelman, NARUC	Advancing Electric System Resilience with Distributed Energy Resources: A Review of State Policies	• How do distribution-level investments interact with system resilience? • What is a resilient DER? What characteristics do they exhibit? • Do strategies that commissions have implemented to expand DER deployment simultaneously improve resilience? How can commissions better align DER regulatory structures with resilience goals?	✓	✓	✓
September 2019	John Agan, Brooke Holleman, Sapna Gheewala, DOE	How Distributed Energy Resources Can Improve Resilience in Public Buildings: Three Case Studies and a Step-by-Step Guide	• How can DOE DER modeling tools (e.g., Distributed Energy Resources Customer Adoption Model [DER-CAM], Renewable Energy Integration and Optimization [REopt]) assist facility managers in using DERs to maintain power during grid outages? • How have DOE Better Buildings Challenge partners utilized DER-CAM and REopt to enhance energy resilience? • How do energy efficiency measures complement the use of DERs for energy resilience?		✓	✓

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Date	**Author**	**Title**	**Key Questions Addressed**	**A**	**B**	**C**
June 2019	Eliza Hotchkiss and Alex Dane, NREL	Resilience Roadmap: A Collaborative Approach to Multi-Jurisdictional Resilience Planning	• How have states and cities advanced community resilience planning? • What stakeholders are important to involve in resilience planning? • What are the phases of resilience planning and where can commissions add value?			✓
April 2019	Organization of MISO States, National Rural Electric Cooperative Association, Edison Electric Institute, National Association of State Utility Consumer Advocates for Lawrence Berkeley National Lab	Future Electric Utility Regulation Report Series No. 11: Utility Investments in Resilience of Electricity Systems	• What level and scope of resilience is needed and how much and who will pay for it? • Who is responsible for resilience, and how should other entities coordinate with utilities when there are mutual benefits? • What types of utility investments have the most impact on improving resilience, and how can utilities and regulators tell whether utility investments in resilience are impactful? • Should utilities take more proactive approaches to investments in resilience? • How can decision-making about resilience investments be improved?	✓	✓	✓
April 2019	Wilson Rickerson, Jonathan Gillis, and Marisa Bulkeley, Converge Strategies	The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices	• How are commissions currently approaching resilience? • Have commissions defined or quantified resilience? • What have non-commission state policy and regulatory entities done to define and quantify resilience? Are these approaches replicable by commissions?	✓		✓
November 2018	Wilson Rickerson, Michael Wu, Meredith Pringle, Converge Strategies for Association of Defense Communities	Beyond the Fence Line: Strengthening Military Capabilities Through Energy Resilience Partnerships	• How does the U.S. military approach energy assurance and resilience? What are the policies and structures of each branch? • What solutions have the military relied on in the past, and why are these solutions ill-suited to modern and emerging resilience threats? • How can military energy resilience assets provide value to surrounding communities? • In what ways does the military work with communities, utilities, state regulators, and other entities to build partnerships to achieve improved energy resilience?	✓	✓	

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Date	**Author**	**Title**	**Key Questions Addressed**	**A**	**B**	**C**
November 2018	Anne Hoskins, SunRun	Solar + Batteries: A Resiliency Solution	• How were solar + storage installations applied in Puerto Rico and Florida following severe hurricanes? • What services and values do distributed solar + storage projects provide? • How can regulators enable distributed resilience solutions?		✓	✓
May 2018	Alison Silverstein, Rob Gramlich, and Michael Goggin, Grid Strategies	A Customer-Focused Framework for Electric System Resilience	• What are the threats to energy resilience and where in the system do they generally occur? • How can we develop new metrics that reflect the consequences of electric service interruptions? • Given recent data on energy system performance, what should customers, regulators, and utilities prepare for? • In what types of resources and where in the system should commissions prioritize for resilience investment?	✓		✓
January 2018	Joyce McLaren and Seth Mullendore, Clean Energy Group	Valuing the Resilience Provided by Solar and Battery Energy Storage Systems	• How is resilience defined? • What types of data are needed to arrive at a comprehensive definition of energy resilience? • How does solar PV contribute to resilience? • What metrics are available to describe resilience? • How does establishing a value for resilience contribute to the economic case for solar + storage?		✓	✓
October 2016	Peter Larsen, Lawrence Berkeley National Laboratory	A Method to Estimate the Costs and Benefits of Undergrounding Electricity Transmission and Distribution Lines	• When is undergrounding transmission and distribution lines a cost-effective strategy to improve reliability and resilience? • How can an analysis framework be applied to decision-making?		✓	
September 2016	DOE, Office of Energy Policy and Systems Analysis	Climate Change and the U.S. Energy Sector: Guide for Climate Change Resilience Planning	• How do utilities assess vulnerabilities to climate change and extreme weather? • How do utilities arrive at a portfolio of resilience solutions?	✓	✓	
July 2016	DOE, Office of Energy Policy and Systems Analysis	Climate Change and the U.S. Energy Sector: Guide for Assessing Vulnerabilities and Developing Resilience Solutions to Sea Level Rise	• Given the high concentration of coastal energy infrastructure, what are the potential impacts of sea level rise and storm surge? • What are strategies that owners and operators of energy assets can deploy to be resilient to these threats?	✓	✓	

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Date	**Author**	**Title**	**Key Questions Addressed**	**A**	**B**	**C**
June 2016	Judy W. Chang, et al., Brattle Group for Natural Resources Defense Council	Advancing Past 'Baseload' to a Flexible Grid: How Grid Planners and Power Markets Are Better Defining System Needs to Achieve a Cost-Effective and Reliable Supply Mix	• What is the relationship of baseload power to resilience and reliability? • How does flexibility interact with resilience? • How can market operators design compensation mechanisms for flexibility and resilience?	✓		✓
May 2016	DOE, Office of Energy Policy and Systems Analysis	A Review of Climate Change Vulnerability Assessments: Current Practices and Lessons Learned from DOE's Partnership for Energy Sector Climate Resilience	• How are utilities identifying vulnerabilities from extreme weather and climate change? • What data and analysis is feeding into vulnerability assessments? • What resilience solutions are identified?	✓		
October 2015	DOE, Office of Energy Policy and Systems Analysis	Climate Change and the U.S. Energy Sector: Regional Vulnerabilities and Resilience Solutions	• How do impacts to the energy sector differ across regions? • What are the expected impacts of climate change and extreme weather on various types of electric infrastructure? • What is the most pressing vulnerability in each region?	✓		
September 2015	Jean-Paul Watson , et al., Sandia National Laboratories	Conceptual Framework for Developing Resiliency Metrics for the Electricity, Oil and Gas Sectors in the United States	• How can probability density functions be applied to resilience? What are the benefits and drawbacks of this approach? • What data and analysis are needed to deploy this approach? • What steps should decision-makers follow to improve resilience?	✓	✓	
August 2015	Seth Mullendore, Clean Energy Group	Energy Storage and Electricity Markets: The Value of Storage to the Power System and the Importance of Electricity Markets in Energy Storage Economics	• What resilience benefits does energy storage offer throughout the entire power system? • What barriers remain to storage deployment? • How does energy storage participate in electricity markets? • What new market mechanisms can emerge to compensate storage for additional value streams?		✓	
March 2015	Lew Milford and Seth Mullendore, Clean Energy Group	Solar + Storage 101: An Introductory Guide to Resilient Solar Power Systems	• What are the components of a resilient solar + storage installation? • From the customer's perspective, what factors influence the decision to install solar + storage as opposed to other resilience solutions? • How do solar + storage systems operate in practice?	✓	✓	

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Date	**Author**	**Title**	**Key Questions Addressed**	**A**	**B**	**C**
2015	Rand Corporation for DOE	Measuring the Resilience of Energy Distribution Systems	• On a nationwide scale, what metrics exist to describe resilience? • What role does the federal government have in a resilience strategy? • How do resilience metrics differ among electricity, oil, and gas distribution infrastructure?	✓		
November 2013	Miles Keogh and Christina Cody, NARUC	Resilience in Regulated Utilities	• How does resilience fit into regulatory structures to achieve reliability? Are reliability frameworks equipped to tackle resilience? • What terms need to be defined for state regulators to advance resilience in their states? • What else is needed to create evaluation frameworks for resilience investments at the commission level?	✓		