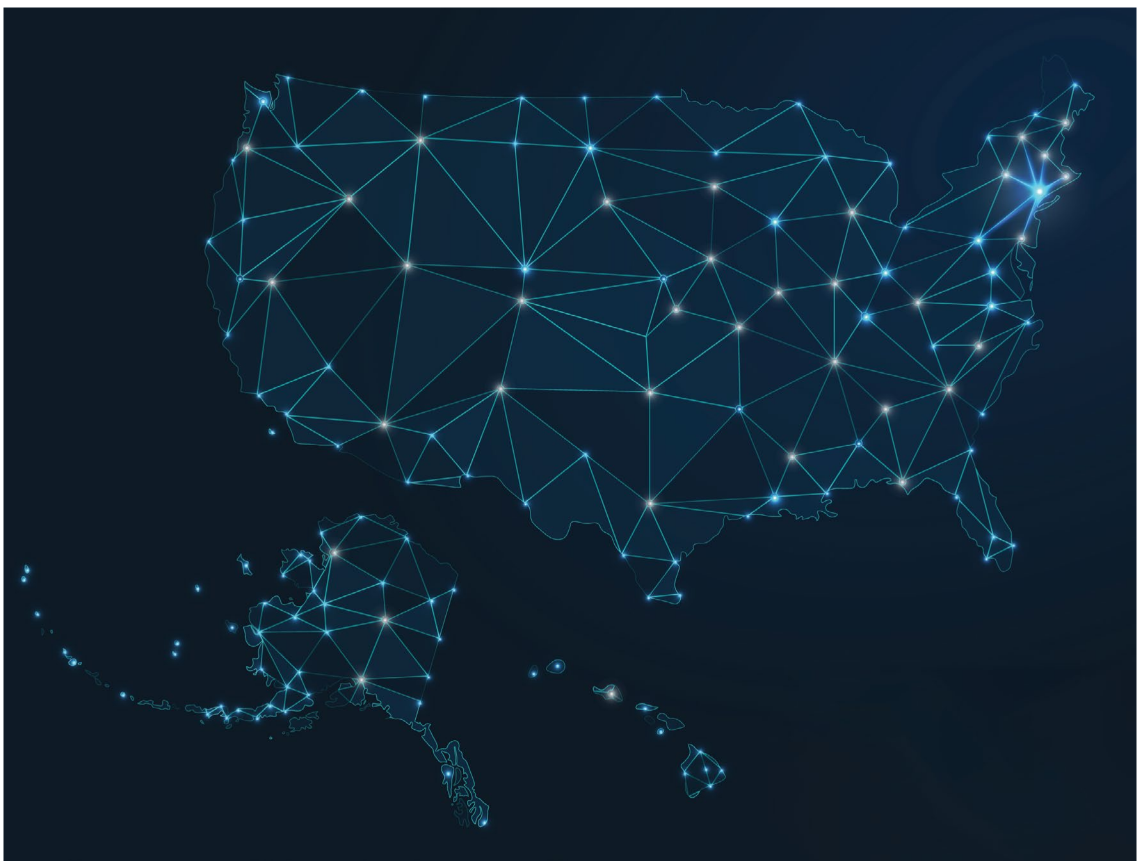
DISCLAIMER

NARUC
National Association of Regulatory Utility Commissioners

NARUC Resilience Framework



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Executive Summary

The NARUC Resilience Framework provides state regulators and other key stakeholders with a structured approach to considering policies and programs that will enhance grid resilience amid evolving technological, environmental and economic challenges. This Framework consolidates insights from nationwide workshops and peer discussions into six actionable components: (1) setting goals and objectives, (2) leveraging use cases, (3) establishing shared definitions, (4) ensuring inclusive process leadership, (5) addressing critical design questions, and (6) guiding implementation. This Framework is intended as a strategic tool for regulators to navigate resilience investments, prioritize affordability, integrate stakeholder needs, and foster collaboration across agencies, all while balancing cost-effectiveness with societal and economic resilience outcomes. By presenting a structured approach to decision-making rather than prescriptive solutions, the Framework supports nuanced, jurisdiction-specific resilience planning and is adaptable to the dynamic demands of modern energy systems.

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Disclaimer

I. Introduction

A resilient electric grid can withstand, respond to, and recover from disruptions that otherwise may have resulted in an outage or an outage of greater duration. It can also withstand new and varying threats, such as changing weather patterns, cybersecurity attacks, and changes to the composition of the electric system and the amount and diversity of equipment connected to it. Identifying and managing such threats and the risks they pose recognizes that both reliability (responding to normal operating conditions) and resilience (responding to extraordinary and dynamic conditions) are complementary goals. Contrasted to reliability, however, the focus on resilience is relatively new, especially for utility regulators.

For more discussion of both the connection and the difference between reliability and resilience, please refer to the definitions presented in Section III and Appendix 4.

Three factors make the focus on resilience timely:

- **New Risks:** The electric system is facing increasingly severe and frequent weather-related events, including extreme heat and cold, unprecedented floods, rain, regional storms, wildfires, and wind events.[1] In the face of these new and heightened risks, there is a need to consider strategies to address reliability concerns beyond those associated with the familiar risks of disruptions to the day-to-day operation of the grid.
- **New Consequences:** While the grid is facing new and heightened risks, the consequences of disruptions within the electric system have an increasing impact on society and the economy. Increased reliance on digital technologies and communication systems and the electrification of other sectors of the economy, such as transportation and building operations, means that the effects of electric system disruptions ripple well beyond the electric utility meter.
- **New Technology:** Advances in technology have created the opportunity to deploy energy resources that can provide resilience in the face of grid disruptions. The potential to deploy these technologies (such as microgrids and battery systems at customer locations) means that customers are increasingly able to invest in technologies that enhance their own resilience and that can also be leveraged as a resource for the grid. This has also increased the potential entry points for cybersecurity attacks.

In 2023, the National Association of Regulatory Utility Commissioners (NARUC) initiated a project to help state utility regulators identify and address resilience efforts in their jurisdictions. With funding from the U.S. Department of Energy's Grid Deployment Office (GDO), NARUC sought to better understand the needs of its members to respond to investment proposals to enhance and to plan for resilience within their energy systems. With facilitation help from E9 Insight, NARUC held meetings across the United States with state regulators to hear about their needs and challenges. These workshops supported the development of a needs assessment that outlined the high-level interests of regulators regarding grid resilience and the topics they wanted to address. Based on this information, NARUC established three peer-learning cohorts focused on specific topics: (1) resilience metrics, (2) valuation methodologies, and (3) regulatory mechanisms to support grid resilience.

The need for a resilience framework emerged through the work of these cohorts, where participants regularly raised questions around how decision-makers can encourage resilience planning and thoughtfully review resultant resilience plans. The idea of a framework was also informed by NARUC's prior efforts on resilience and serves as a complement to that work.

1 NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2024). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

Because there is substantial diversity in regional threats to the grid and electricity market structures in NARUC members' states and territories, there is no single prescriptive solution for addressing resilience needs. To be useful, it was clear that a resilience framework needed to be adaptable to a wide range of regulatory contexts and flexible to meet a variety of resilience applications.

From the outset, it was also clear that state utility regulators should not be the only voice in resilience conversations. State Energy Offices, state emergency management agencies, local governments, customers, and other stakeholders also play a significant role in determining appropriate resilience responses and solutions, each bringing their unique perspectives and needs.

As such, NARUC's resulting Resilience Framework expressly serves several purposes:

- **Guiding regulators:** The Framework is designed to help state agencies and public utility commissions identify questions they can ask when considering grid resilience investments and planning processes.
- **Aiding other stakeholders:** Beyond regulators, the Framework considers other state agencies and stakeholders involved in or affected by grid resilience and identifies ways they can participate in resilience-related discussions and decision-making.
- **Supporting grid and resilience planning:** The Framework aligns with NARUC's broader goal of providing resources that promote thoughtful decision-making in emerging areas of policy and technology.

Additional details of the cohort process and how the Framework was developed are provided in Appendix 6.

II. Using the Resilience Framework

The Resilience Framework supports state leaders, regulators, and other relevant state agencies to think comprehensively about the issues they need to address and the questions that may arise as they develop and advance grid resilience initiatives within their jurisdictions. It offers a structured approach to working through important questions, considerations, and processes needed to create meaningful resilience goals and roadmaps to achieve them. It can also help them be prepared for and respond to unexpected events or changes in context, such as new legislation or changes in market structures.

The Framework considers initiatives such as utility grid investment plans, customer programs, funding sources, and incentive programs related to grid resilience, but it does not propose specific approaches that states and jurisdictions should include.

Notably, this Framework is not a "how-to" guide for developing specific, actionable grid resilience plans, rules, or requirements. Rather, it strives to help gather invaluable information for decision-makers to use to generate thoughtful outcomes that meet stakeholders' needs.

The Framework is designed to help decision-makers:

- **Make grid resilience funding decisions:** Decision-makers can use this document to inform decisions related to requests for resilience funding, such as through utility resilience plans.
- **Organize grid resilience practices:** The Framework can help state agencies organize and inform their practices and oversight of grid resilience investments.
- **Understand broader impacts:** The Framework can help state agencies understand the broader impact and role of resilience beyond their own organization. It encourages consideration of how grid resilience affects other agencies, local governments, and customer groups, helping to inform cross-agency decision-making.

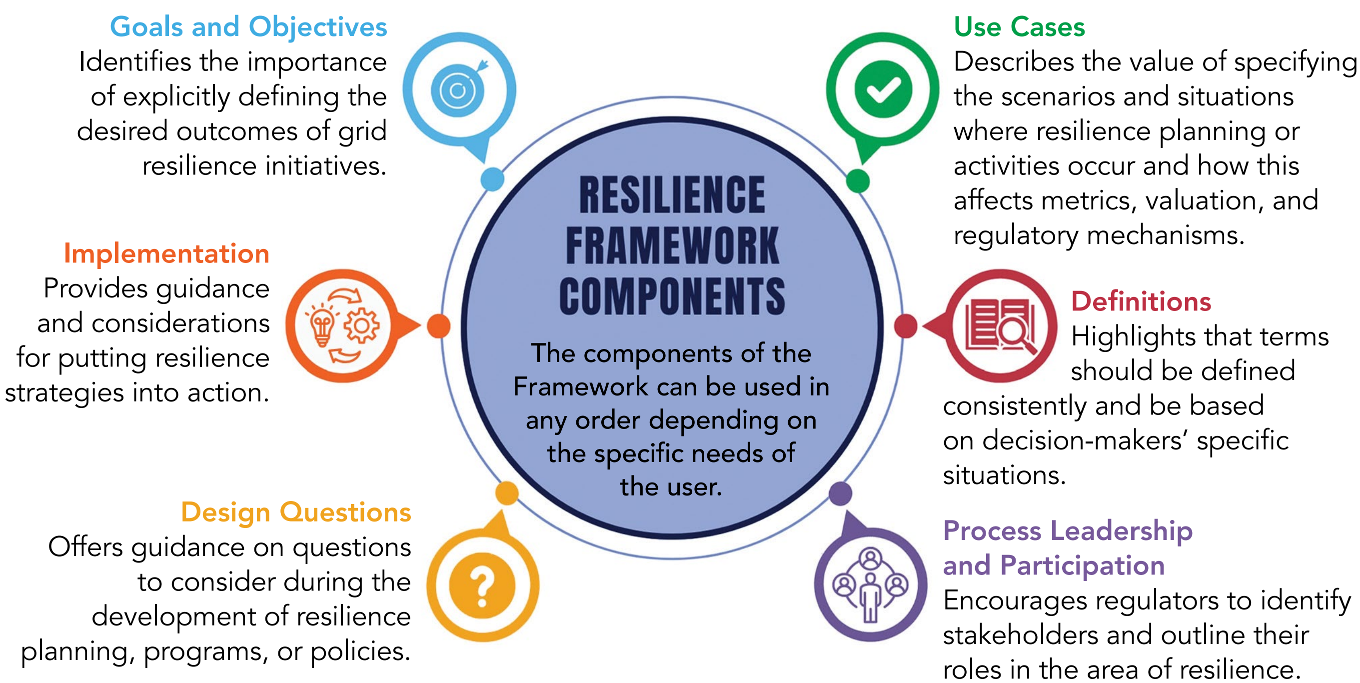
As different state agencies tackle resilience within their respective contexts, the Framework can be used by different entities to address their specific resilience decision-making needs yet retain focus on the state's overall resilience goals. For example, a regulator may want to apply the Framework to help assess a utility's grid investment plan. A state or local emergency services agency may want to apply it to address the risk-reduction benefits of different resilience technologies. A State Energy Office may want to determine which risk-reduction programs will be most impactful. The Resilience Framework is adaptable and flexible to meet these differing needs and applications and combined to present a holistic statewide approach.

Lastly, the Framework also anticipates that the decision-maker is not on this journey alone; rather, it recognizes that this is a journey with shared responsibilities. Those responsibilities may be shared with other state agencies, local or municipal authorities, customers, utilities, and technology companies. Decision-makers should recognize the opportunities that this provides and use the Framework to identify and act on them.

Resilience Framework Components

The Framework is organized into six key components and outlines the importance of addressing each of them as part of the resilience-related planning, investment, and implementation processes. Where appropriate, the Framework includes examples that may be relevant or instructive.

The Six Components of the Resilience Framework



The components of the Framework can be used in any order depending on the specific needs of the user. Rather than providing definitive answers, the Framework helps users contextualize resilience plans, investments, and solutions within the scope of their projects or needs.

Resilience Framework Applications

Following the Needs Assessment, the cohorts organized themselves into groups to consider how the Framework could apply to and support three specific resilience-related topics: establishing resilience metrics, developing methodologies to value resilience, and regulatory mechanisms that support resilience-focused efforts and outcomes. These are described briefly below. In addition, the description of each Framework component in the following section includes one or more application-specific examples or considerations drawn from the cohorts' work. Appendix 1 contains the results of the relevant cohorts applying the Framework to resilience metrics and resilience valuations. Because each cohort focused its efforts on different subsets of the Framework components based on those it felt were most relevant to its topic, the level of detail and approach to each Framework component will vary across the two application examples. The cohort that focused on regulatory mechanisms took a different approach, producing a detailed taxonomy of mechanisms and their application to resilience topics. This appears in Appendix 4.

Metrics
Discussions in this cohort identified the need for new ways to measure resilience and yielded three categories of potential metrics. In the first category, existing metrics (those focused on reliability, for example) might be expanded or modified to be applicable to resilience outcomes. In the second category are existing data sets or sources that are not currently applied to resilience but that could be. For example, smart meter data could be used to support metrics related to outages at a high-level of spatial and temporal detail. Third, there may be a need to create new data sets to address aspects of resilience that have not previously been measured. For example, some states historically have not collected information on the number of homes or facilities that have backup power systems, which could be an important data point in resilience planning. Appendix 2 contains examples of resilience metrics.

Valuation
Regulators and other decision-makers may need to establish methods to value the benefits and outcomes of resilience investments or programs, whether during rate cases or investment approval dockets, to support planning, or to coordinate resilience efforts across multiple entities.

Regulatory Mechanisms
Workshop and participant discussions also highlighted tension between traditional cost recovery strategies associated with utility investments and the increasing role of distributed energy and customer investments in supporting resilience. It is increasingly the case that resilience planning includes a broad diversity of investments made by the utility, the customers they serve, and the communities in which they operate. This requires that regulators consider regulatory mechanisms beyond those predicated on relying on ratepayer capital for all (or nearly all) infrastructure investments, as well as to realize that new approaches may have implications that go far beyond the scope of this process and Framework.

III. The NARUC Resilience Framework

This section describes each Framework component and includes examples of how the questions and considerations posed in each might be answered by decision-makers. The examples are purely informative; each jurisdiction will need to determine the use and outcomes itself based on existing laws, practices, and procedures.

Because regulators and other stakeholders may begin engaging in resilience-related activities from a number of entry points, the Framework Components can be used in any order or combination. As regulators gather more experience in reviewing resilience proposals, conducting resilience planning, and collecting information about programs, technologies, and expected results, they may choose to use the Framework in a more linear fashion. This will likely look different in each jurisdiction based on its unique circumstances, but the overarching concept for this Framework remains that grid resilience is a journey, and these Components can be helpful wherever one is on that journey.

1. Goals and Objectives

This section addresses the importance of articulating the desired outcomes from actions related to grid resilience. Cohort participants noted that state regulators and energy offices may have been reviewing resilience proposals in a vacuum, either due to time constraints or lacking appropriate context for the proposals. They recognized that having a set of goals and objectives is an important piece of their process that may have been lacking or not adequately expressed prior to making decisions. As a result, success was more difficult to recognize, and measurements of progress were difficult to contextualize because there were few to no points of reference for progress, success, or failure.

To help decision-makers address grid resilience, it may be helpful to clarify and agree on the ultimate vision for a resilient grid in the state as well as the milestones on the journey to that future. For this Framework, the vision or "destination" is characterized as a resilience goal or set of goals. Resilience objectives are milestones along the journey that can be used to mark progress towards the ultimate destination.

Goals and objectives should be representative of the jurisdiction, including its broader policy goals, laws, and statutes. Starting points for developing resilience goals and objectives can be existing laws and statutes or other instances where state agencies have stated a policy goal, objective, or preference. These help identify specific resilience goals and objectives and provide additional context for resilience. For example, a jurisdiction may have a law that requires electricity costs to be no greater than the average of neighboring states. This could result in a constraint on the cost of pursuing resilience objectives. Alternatively, a jurisdiction may favor specific resources as part of the electricity system. Here, the goals and objectives need to be aligned with the resources that will be used to meet demand.

Goals are desired outcomes that are aligned with policies, laws, and statutes. They may be legally binding or aspirational.

Objectives are targets and activities that help achieve one or more goals. They may inform the tasks or steps necessary to reach goals and should be tangible and measurable.

Goals

Goals for a resilient electric system may be determined in part by a state's existing legislative mandates or utility regulations to the extent they reflect the operation of the state's grid. Regardless, regulators and stakeholders might begin by asking, "What would make for a resilient grid?"

Resilience goals may address a range of outcomes, examples of which are listed below. Because resilience has value beyond the immediate operation of the electric system (e.g., providing critical public safety services), regulators might keep in mind relevant goals that are beyond their typical reach. This is not meant to be comprehensive but is intended to prompt conversation.

- System requirements (e.g., the capabilities of the system)
- Policy mandates (e.g., legislative requirements for power resilience)
- Cost-effectiveness (e.g., methods and thresholds for benefit-cost analyses of resilience solutions)
- Consumer benefits (e.g., the value of resilience to different types of consumers)
- Economic benefits (e.g., local and statewide economic value of increased resilience)
- Environmental impacts (e.g., changes in local and global emissions)

Objectives

After resilience goals have been determined it can be useful to define a set of objectives that can provide a "roadmap" for the journey to a resilient system. Objectives should be actionable and measurable to facilitate assessing progress towards goals. The following identifies several types or categories of objectives that can act as a starting point, as well as a tangible example for each.

- Situational awareness (e.g., the percentage of distribution lines with SCADA equipment)
- Infrastructure hardening (e.g., the percentage of distribution lines undergrounded)
- Technology deployment (e.g., the percentage of commercial customers with access to a microgrid)
- Operational criteria (e.g., average restoration times for downed lines)
- Emissions (e.g., the percentage of energy used as backup power that is low- or zero-emissions)
- Regulatory and market structures (e.g., all utility investments consider DER alternatives)

Developing Goals and Objectives

One way that regulators and other decision-makers can develop goals and objectives is through a process of asking questions, preferably to all involved stakeholders. Some questions developed by the metrics and valuation cohorts are provided below as examples that may provide useful information and guidance; these only begin to address the enormous range of topics that could be considered.

- Are there existing metrics that could be used to measure progress towards the jurisdiction's resilience goals and objectives?
- What types of data are necessary to develop new metrics that can inform development of goals and objectives and measure progress?
- What are the objectives for a resilience valuation formula?
- Which resilience goals most affect the calculation of resilience value?

2. Use Cases

Use cases are scenarios that define the context in which stakeholders develop grid resilience plans or programs or make decisions on grid resilience investments. Cohort participants noted that the inclusion of use cases and example scenarios in this Framework would help them apply these concepts to their jurisdictions and specific circumstances. They also suggested examples of high priority use cases pertinent to their state, jurisdiction, or agency. By considering possible scenarios, stakeholders can apply the Framework to a specific context and outline potential needs and pathways to reach relevant goals or decisions.

The example use cases below are organized into several categories and are intended to capture some of the priorities articulated by cohort participants. They only begin to touch on the variety of use cases that may be relevant in a particular jurisdiction.

- Policy development (e.g., implementing legislation through state programs and/or regulations)
- Long-term Planning (e.g., using resilience value methodologies to make planning decisions or to compare options in other contexts (e.g., renewable portfolio standards)
- Grants for community solutions (e.g., state and local funding for microgrids or other infrastructure)
- Utility programs focused on customer-oriented solutions (e.g., microgrid incentive programs, resilience-as-a-service tariffs) or utility investments (e.g., tree trimming programs, grid hardening proposals)

3. Definitions

The process of developing resilience programs or conducting planning for resilience can benefit greatly from establishing a set of shared definitions for resilience terminology early in the process. The changing nature and use of the electric system and the need to educate new stakeholder groups and communities that may rely on the electricity grid to support their policies, highlights the importance and value of a common set of terms and definitions.

This Framework does not propose authoritative definitions of these terms across all contexts. Rather, it focuses on definitions of concepts and terms that states may find useful. Because states are at different stages on their resilience journey, terms and their definitions may vary from state to state. The following definitions are provided as starting points for discussion.

Resilience

During the past decade, several definitions of resilience have been proposed for the electricity sector or for public utilities in general. While regulators and other stakeholders may have their own, the following definition from the National Resilience Strategy includes the major common components:

> *Resilience is defined as 'the ability to prepare for threats and hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions.'*[2]

Additional definitions can be found in NARUC's Energy Resilience Reference Guide, Chapter One.[3] Further context for resilience is also provided in Appendix 5.

Resilience vs. Reliability

It is important to distinguish between resilience and reliability. The latter is usually defined as the ability of the system to respond to normal, rather than abnormal or extraordinary, operating conditions. Put another way, reliability addresses high-frequency, low-impact events while the resilience addresses low-frequency, high-impact events. Currently, infrastructure resilience is essentially a "built-in" externality of adhering to established planning and operating practices designed to achieve a reliable system. The electricity grid is particularly demonstrative of this, as it is operated around reliability standards that require enough reserve capacity to maintain service to customers, even if the single largest component (transmission line or power plant) fails. The ability of reliability standards to ensure resilience is changing as the type and extremity of events affected the grid increase.

When considering how to define resilience for your jurisdiction, consider focusing on the following:

- Extraordinary, low probability events
- Significant impacts to individuals and communities
- Performance characteristics that describe recovery from and minimization of frequency, duration, scale, and severity of outages.

Resilience Solutions Categories

Resilience solutions—actions that promote and enhance resilience, whether infrastructure, policy, or planning decisions—can be organized into one or more categories based on the aspects of an event that are being addressed. An example scheme used to distinguish the benefits of different resilience solutions is:[4]

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2 *National Resilience Strategy. The White House. Washington, DC. January 2025.*

3 McCurry, W., & Nethercutt, E. (2022) *Energy Resilience Reference Guide: Chapter One: Developing a Shared Definition of Energy Resilience. Washington, DC: National Association of Regulatory Utility Commissioners.*

4 Connecticut Public Utilities Regulatory Authority Docket No. 17-12- 03RE08: *PURA Investigation into Distribution System Planning of the Electric Distribution Companies - Resilience and Reliability Standards and Programs. August 31, 2022.* https://www.dpuc.state.ct.us/2nddockcurr.nsf/8e6fc37a54110e3e852576190052b64d/4bcecc163d47d814852588af005bca09/$FILE/171203RE08-083122.pdf

- **Mitigation:** Infrastructure hardening, automation, on-site back-up generation, microgrids, system redundancies, etc.
- **Preparedness:** Coordinating with other responders, developing response plans, conducting training and exercises, etc.
- **Response:** Enacting mutual aid agreements, pre-staging resources, activating incident command, control room operations, etc.
- **Recovery:** Restoration activities, after-action reports, lessons-learned, etc.

Event Severity Level

Distinguishing between different event severities or conditions can be useful when evaluating the reliability and resilience of a system. One classification system uses the terms "blue sky", "gray sky", and "black sky," as defined below.[5]

- **Blue sky:** Normal, routine conditions for an energy system.
- **Gray sky:** Conditions that pose reliability concerns to an energy system and that may result in outages, but where utilities and emergency response organizations still have access to critical communication services.
- **Black sky:** Severe, catastrophic events that compromise both reliability and the ability to respond and restore service.

For an alternative classification system, see the Valuation Application section of Appendix 1.

Priority Zones

Some state resilience planning efforts and programs may designate specific geographies or "zones" as higher priority for improved grid resilience. Some examples of these priority zones include:

- Disadvantaged communities (DACs) or low-moderate income (LMI) communities
- Environmental justice (EJ) communities
- High event risk or frequent outage geographies (e.g., wildfire risk)
- High impact areas (e.g., clusters of critical facilities)

Defining Priority Zones for Resilience Metrics

Resilience metrics may be used to define priority zones, for example by historical event risk data or historical outage data. Alternatively, decision-makers may wish to define metrics that assess resilience in zones defined using other characteristics. In some cases, particularly with smaller utilities, it can be difficult to gather data to support these definitions and metrics. This Framework does not require that priority zones for resilience planning or programs be defined by data that may be of limited availability.

Resilience Service Level

In measuring and valuing resilience solutions, it can be useful to define the quantity resilience or "how much" resilience is being provided. This may be implicit in the design of resilience metrics and programs, but for quantifying the benefits and devising valuation formulas, a more explicit definition of the parameters is needed.

The concept of a Resilience Service Level is a combination of parameters into a metric or number that could be used in a contract, a rate case, program requirements, etc. Example parameters could include:

- Loads or customers receiving resilience benefits or being made resilient (e.g., critical loads, specific buildings or neighborhoods)

5 Stockton, Dr. Paul, "Resilience for Black Sky Days; Supplementing Reliability Metrics for Extraordinary and Hazardous Events," NARUC, Feb. 2014, p. 4. https://pubs.naruc.org/pub.cfm?id=536F42EE-2354-D714-518F-EC79033665CD.

- Effectiveness in prevention (e.g., the severity of events that can be withstood)
- Response time (e.g, how quickly is backup power provided or power restored)
- Duration (e.g., for what period of time can backup power be provided)
- Emissions (e.g., the emissions profile of resources providing backup power)

Example Resilience Service Level definitions

For a large battery system providing backup power to a substation in the event of a transmission outage, the following could be a set of relevant Resilience Service Level definitions.

- Load: entire substation, up to 20 MW of load
- Effectiveness: provides backup power in the event of transmission line outage but not in the case of a natural disaster affecting the substation itself
- Response time: backup power provided in under 1 second
- Duration: backup power can be provided for four hours at full discharge (80 MWh)

4. Process Leadership and Participation

A key feature of regulatory development is the nature of the process itself. With changing risks, new communities leveraging the electric grid, new resources being added, and multiple government agencies in play, it will be increasingly important to understand the roles and responsibilities of the entities that should be involved. When an outage happens, multiple state and local authorities play a role in providing services for the community, and state policies may identify a specific agency as the lead agency on certain topics. For example, disaster and emergency response may be managed by an agency that only focuses on rebuilding and restoring service as soon as possible and may not prioritize issues and topics that drive utility regulatory discussions and decisions.

The importance of process leadership and participation is also applicable within a public utility commission. Accurately and specifically identifying which division should lead a proceeding and which staff members should be consulted can ensure that the process being implemented by the commission includes the internal voices that have roles to play in the resilience discussion. Among the parties that could lead or participate in resilience proceedings or discussion are:

- Utility commission
- State Energy Office
- Utility companies
- Emergency management agency
- Military entities
- State environmental agency

Lastly, the process itself may warrant consideration. Commissions conduct different types of proceedings. A commission could decide to address resilience in a focused, open proceeding or technical session, to address resilience or consider it as part of a larger contested proceeding focused on general rates, distribution system planning, or integrated resource planning. Furthermore, proceedings that come with statutory restrictions may not be the optimal place to address resilience. In most contested cases the commission must ensure that an accurate record is developed and that all actions and decisions be justified by that record. Regulators should consider these factors in creating a process and venue for resilience discussions. Among the options are:

- Stakeholder workgroups
- Workshop series
- Formal regulatory proceedings
- Staff research or study projects
- Consultant contracts
- Utility company internal studies
- Inter-agency workgroup or taskforce

Assessing Options for Process and Participation

Cohort participants identified a number of questions that regulators and other stakeholders might ask while determining how to develop an effective process and ensuring all relevant stakeholders are included. These are examples and may not be reflective of the circumstances in all jurisdictions.

- Are these issues appropriately before this agency?
- Do agencies have an interest in or jurisdiction over topics raised in this proceeding or effort?
- Does the commission have appropriate staff to run the proceeding?
- What customer groups should be participating in this proceeding?
- Are there other sources of information or perspectives that would be useful in this proceeding?

5. Design Questions

Policy and program development can be organized as a set of design questions that leaders and stakeholders work to answer. Articulating these questions can help guide the process and generate outcomes that support the agreed-upon goals and objectives. This will also help define the scope for any process or proceeding and guide the development of an appropriate record, if necessary. It has the added benefit of ensuring that the effort stays focused on the goals and objectives and does not lose focus in the face of new technologies, new needs, new outcomes, and new ways of pursuing resilience.

High level design questions that can apply across any resilience planning or program context include:

- What types of events or incidents will be considered in this use case and how will these events be defined in terms of severity of impact?
- How will the state define geographies that have a higher priority for improved grid resilience?
- How, if at all, will resilience policies and programs distinguish or prioritize between customer classes and facility types?

Below we provide a number of potential design questions in the areas of establishing resilience metrics, developing valuation formulas, and creating regulatory mechanisms. More detailed questions are found in the individual Applications sections in Appendix 1.

Design Questions for Resilience Metrics

Design questions can help the regulator identify specific items of interest in the development of metrics. Design questions might address the following types of issues:

- The availability of existing metrics
- The technology needed to collect data for new and existing metrics
- The required level of temporal and spatial granularity in metrics data and definitions

Design Questions for Resilience Valuation and Methodologies

For the use case considered by the Valuation cohort, design questions were answered in the form of setting the initial set of definitions for:

- Event Severity Level
- Priority Zones
- Value Factors and Parameters
- Resilience Service Level

Design Questions for Regulatory Mechanisms in Support of Resilience

When determining the appropriate regulatory mechanisms for grid resilience, the following questions may be considered. Refer to Appendix 4: Regulatory Mechanisms Examples for a detailed taxonomy of available regulatory mechanisms, including examples relevant to resilience planning, programs, and policies.

- What are the regulatory mechanisms currently in effect that advance resilience objectives?

- Are there effective mechanisms to evaluate resilience investments proposed by utilities?
- Are there requirements or incentives to encourage utility or customer investments in resilience solutions?
- Are there barriers to implementing new regulatory mechanisms?
- Which entities or stakeholders might be positively or negatively affected by changes in regulatory mechanisms?
- Are there state, agency, or jurisdictional goals that have been established regarding resilience? If so, could new regulatory mechanisms help achieve these goals?

6. Implementation

This component addresses the decisions and guidance a decision-maker may consider when implementing resilience-related regulatory changes and programs. This may include, for example, developing timelines for meeting goals and objectives, using alternative options for reviewing and determining cost-effectiveness, or scheduling future reviews of resilience investments. Regardless of how implementation proceeds, there should be a clear pathway for ongoing review of investments, metrics, and programs to ensure that relevant goals and objectives are being met.

As noted earlier, this Framework is designed so that users can refer to any of the individual components that apply to their needs and in any order. That said, proceeding to implement resilience solutions will generally come after at least some of the actions described in the preceding sections have occurred. Ideally, implementing design decisions made through a relevant process to fit the use case and achieve the goals and objectives is the final step.

Some initial implementation questions include:

- What key decisions remain before implementing the design decisions or resilience solution, and who are the decision-makers?
- What data needs to be collected to support implementation? Who will collect the data and by which processes?
- What actions and processes are required by state agencies? What, if any, legislative action is required?
- How do the solutions and design decisions relate to existing programs, regulatory procedures, policies and guidance?
- What is the cadence of updates or reporting regarding the solutions?
- What public facing information will be provided after implementation?

Implementing Metrics for Resilience Planning

In anticipation of a final decision on metrics for a future resilience plan, the regulator will need to decide how its requirements will be implemented and how reporting on metrics will occur. Questions a regulator may ask to determine appropriate next steps might include:

- What is the timeline for new technology that could provide useful or necessary information to support the metrics?
- At what time and with what frequency should the utility report on metrics? Annually? As part of rate cases or distribution system planning proposals?
- What is the process for modifying or updating metrics?
- How should metrics be aligned with other related proceedings?

IV. Conclusion

The Resilience Framework is intended for use by regulators and other stakeholders to help identify resilience outcomes and develop robust resilience strategies, goals, and objectives for achieving them. It is not intended as a prescriptive "how-to" guide but rather as one tool among many within the broader landscape of resilience resources. As new challenges and insights emerge, approaches to resilience necessarily will ne reexamined and refined. The Framework provides the structure, flexibility, and adaptability to support current and future efforts. Peer learning remains a cornerstone of this process, allowing stakeholders to benefit from each other's experiences and knowledge. The authors are confident that additional work to explore these critical resilience issues will be undertaken to hasten the collaborative journey toward resilience that is essential to meet the evolving needs of our energy systems.

Concise summary of considerations for using this Framework

In general, when using this Framework, consider the following:

- The **environment** of your state, agency, utilities, and customers. This Framework is intended to be adaptable for your needs.
- The **needs** of your state, agency, utilities, and customers. What needs have these groups and stakeholders expressed?
- The **intention** – why is grid resilience being addressed? What do you want to get out of using this Framework?

If using this Framework to address grid resilience ***metrics***, consider the following:

- Are there existing metrics that are already being collected that could be used for assessing resilience?
- What technologies are available to collect additional information about system performance to inform existing metrics or create new ones?
- Are relevant data and metrics available from sources other than the utility, such as from DERs, state or local government agencies, or customers?
- Can metrics rely on publicly available and shareable data and information to enhance transparency?
- What levels of data granularity and availability are needed to support the metrics?

If using this Framework to address ***resilience valuation***, consider the following:

- What is the context in which a resilience value is needed? Is it to compare resilience solutions to one another or to set a threshold above which a resilience solution is accepted?
- Which existing statutes and regulatory precedents affect how the state and other stakeholders value and prioritize resilience?
- What resilience metrics being measured today will be relevant to valuation?
- What mechanisms or policies are in place to value benefits that are hard to quantify?

If using this Framework to address ***regulatory mechanism***s for grid resilience, consider the following:

- What is the jurisdictional authority of your agency or other agencies engaged in resilience planning, programs, or policies?
- Which regulatory mechanisms are currently used in your jurisdiction? Mandates? Incentives? Market structures?

APPENDICES

1. Applications: Metrics and Valuation

2. Metrics Cohort: Metrics Examples

3. Valuation Cohort: Resilience Valuation Resources

4. Regulatory Cohort: Taxonomy of Regulatory Mechanisms

5. Resilience Context

6. Overview of Framework Development Process

7. Relevant Resources

Appendix 1. Framework Application Examples

Each of NARUC's three cohorts focused its efforts on different subsets of the Framework components based on those they felt were most relevant to their topics. As a result, the level of detail and approach to each component will vary across the application examples. Furthermore, the Regulatory Mechanisms cohort summarized their work in the form of detailed taxonomy and the application of each mechanism to a relevant resilience solution, policy, program, or planning effort. Appendix 4 presents this output; there is no detailed application of the six Framework components to Regulatory Mechanisms in this appendix.

Application: Resilience Metrics

This section applies the Framework to the development of resilience metrics. This is an example to help decision-makers take steps to identify and adopt resilience metrics. In this hypothetical situation, a decision-maker is developing a resilience strategy for its jurisdiction that will be used to inform utility proposals. The adopted metrics will be used by the utility in its resilience plan submissions. They may also be used by the decision-maker in other circumstances, such as rate cases or other proceedings where the utility is seeking cost-recovery.

1. Goals and Objectives

In determining appropriate goals and objectives, the decision-maker would look to existing goals and objectives identified in state statute, existing policies, and other relevant goals as determined by the user. These goals may be varied and, in some cases, may even appear to be contradictory. It is useful to categorize the goals so that the regulator can then appropriately identify those goals and objectives that are more pertinent to their needs. Example categories include:

- Implement public policy
    - Reduce length and duration of outages
    - Focus on underserved areas of electric system
- Achieve customer benefits
    - Reduce outages
    - Ensure that investments are cost-effective
    - Enable opportunities for customer sited resources
- Enhance system resilience
    - Utilize DERs to provide local resilience needs
    - Invest in new technology to provide more data to system operator

Once goals are identified, the decision-maker may then identify objectives that can mark progress or enable goals to be reached. Some objectives may apply to multiple goals. Example objectives include:

- Deploy needed technology to provide necessary visibility and data to the utility
- Increase options for low-income customers or neighborhoods that experience worse performance than others areas
- Identify areas where alternative resources may be used to off-set utility capital investments

2. Use Cases

Use cases can be helpful to identify specific examples or situations where the regulator or other stakeholders have a particular interest. This allows for the regulator or stakeholder(s) to run through a scenario and identify a variety of options to support the purpose of the use case. A decision-maker may consider one or multiple use cases depending on the needs and goals of the initiative.

Metrics that may be applicable to a use case of enhancing resilience in a particular neighborhood or geographic region might include the following:

- Frequency and duration of outages in the target neighborhood or geographic region
- Utility spending on infrastructure serving these neighborhoods or regions
- Average usage per customer for these neighborhoods or regions

3. Definitions

Differences in usage and definitions related to resilience can be a source of disagreement between stakeholders. Decision-makers might find it useful to identify common terms and adopt definitions for use in the proceeding or engagement.

- The terms below may be useful to define in the development of metrics. This framework does not attempt to define these terms, as that will ultimately be determined by the laws and statutes of the jurisdiction.
- Resilience - This term may already be identified by the regulator or in statute but ensuring that all stakeholders understand the definition is critical.
- Low-income or "underserved" - In the context of the use case, understanding how low-income or underserved is defined will provide clarity and allow the utility and other stakeholders to be more precise in their focus on the actions needed to address resilience for these customers.
- Distribution - While this may sound simple, it is important to identify the voltage levels being discussed for the project. In some cases, projects may not be appropriate for high distribution voltage levels. In others, old distribution lines may have insufficient voltage to support certain options.
- Data – Both grid data and customer usage data are increasingly important sources of information to help the utility, customers, and other providers support decisions on resilience. References to data should clarify the source, ownership, and extent of the data.

4. Process Leadership and Participation

As the regulator considers its options in developing requirements for a resilience plan, with a focus on enhancing resilience of low-income/underserved neighborhoods, they will want to ensure that the proceeding is being led by the appropriate staff or agency. This includes recognizing the extent of its jurisdiction beyond the regulated utility. It may be that the commission has authority but wants to ensure that there is sufficient and relevant participation from affected customer groups. Questions a regulator may ask include:

- Are these issues appropriately before this agency?
- Does the commission have appropriate staff to run the proceeding?
- Are there other agencies that may have an interest in topics raised in this proceeding?
- What customer groups should be participating in this proceeding?
- Are there other sources of information that would be useful in this proceeding?

5. Design Questions

Here, the regulator can set the stage for actions it intends to take during the proceeding and the expectations for topics it wants to address. In the context of developing metrics to support a resilience plan, the design questions can be broad but should lead to specific outcomes.

- Are the metrics tied to specific goals or objectives?
- Do the metrics address costs, benefits, community, or specific utility investments?
- Are the metrics informative or tied to performance or an incentive?
- Are the metrics tied to specific data sources or technologies?

- Are the data sources available, and are they public or confidential?
- Is the metric measurable?
- How often is the metric reported?
- How will confidential or private information be handled?

6. Implementation

In anticipation of a final decision on metrics for a future resilience plan, the regulator will need to decide how its requirements will be implemented and how reporting on metrics will occur. It is also possible that the regulator will conclude that a metric should not be adopted because data or information are unavailable, insufficient or of poor quality, uncollectable, or deemed confidential. Nevertheless, simply identifying and adopting metrics is not the end of the journey. Questions a regulator may ask to determine appropriate next steps include:

- What is the timeline for new technology that could provide useful or necessary information to support the metrics?
- At what time and with what frequency should the utility report on metrics? Annually? As part of rate cases or distribution system planning proposals?
- What is the process for modifying or updating metrics?
- How should metrics be aligned with other related proceedings?

Application: Resilience Valuation

This section provides a hypothetical example of how the Framework could help with the task of establishing a valuation methodology for use in state resilience planning, policies, and programs. This scenario is not a recommendation for how to calculate value in this use case. It is an example of the process that staff at state agencies could undertake and a selection of possible choices they could make. The context of this hypothetical scenario is a state developing a valuation methodology to support a grid resilience grant program.

1. Goals and Objectives

Before working on a specific use case, state agencies that are involved with electrical system resilience coordinate on identifying and specifying an initial set of goals and objectives for resilience in their state. The primary agencies involved here are the State Energy Office (SEO) and the public utilities commission (PUC).

The first step in setting goals is establishing a timeframe. In this hypothetical application of the Framework, 10 years is the timeframe for achieving the goals. Agencies involved may also adopt an overall Vision Statement that includes several types of goals. For example: "Within 10 years, 100% of critical facilities, at least 75% of residential buildings, and at least 50% of commercial buildings in state designated Priority Zones will have low- or zero-emissions backup power in the case of a grid outage.

The agencies may then articulate further goals in the same 10-year timeframe:

- System goal: All distribution utilities have real-time communications with all microgrids deployed in their territory, including both customer-sited and community microgrids.
- Consumer Benefits: All medical baseline customers have sufficient low- or zero-emissions backup power for their critical medical equipment for at least 1 hour.
- Economic Benefits: Commercial districts in Priority Zones have sufficient power to keep streets and stores open for 8 hours.
- Environmental: All sewage treatment facilities have sufficient backup power to operate at full capacity for 8 hours.

Agencies can then create a series of Objectives for policy and market conditions to reach the Goals. Some example Objectives are listed here, in a rough timeline:

- Within one year, the state has defined Resilience Priority Zones, conducted studies on the existing grid, and published maps of the Zones
- Within 18 months, the state has defined the standard backup solution for medical baseline customers and each utility has launched an incentive program
- Within three years, costs and timelines for interconnecting critical facility microgrids have been reduced by 50%
- Within four years, a resilience program for residential buildings has deployed backup power to 10% of targeted single-family homes and 15% of multi-family buildings
- Within six years, all sewage treatment facilities at historically high risk of outages have installed or begun construction of a system to provide 8+ hours of backup power

2. Use Cases

Valuation Use Cases are scenarios where a method of calculating resilience value is needed to make decisions. This example the use case is the design of a grant program where a methodology is needed to compare resilience project proposals against one another. It could also be used to report projects results in the form of benefits associated with funded projects.

3. Definitions

To establish a valuation methodology for a grant program, the state agencies involved should begin by establishing definitions and shared terminology relevant to the calculation of resilience values and benefits. The Valuation Cohort developed the following list of definitions that might be applied to the design of a valuation methodology.

- Event Severity Level: Event Severity Level definition are defined using examples from resilience proceedings in Connecticut.6 The severity level that a resilience proposal could withstand will be included in the valuation formula.
- Resilience Solution Categories: Adopt the definitions of mitigation, preparedness, response, and recovery from Connecticut. The grant program will provide funding focused on mitigation solutions.
- Resilience Hub: A building that provides resilience benefits to the surrounding community in addition to the regular occupants and users of the building. The valuation formula for Resilience Hub proposals will include the benefits to the surrounding community.
- Priority Zones: Use state designated low- and moderate-income communities as Priority Zones. Additional value will be assigned to projects that provide resilience benefits to a Priority Zone.
- Resilience Service Level: The major attributes of a RSL for this program include:
  - The types of loads that are provided backup power
  - Effectiveness in preventing against different event severity levels
  - Response time and duration of backup power

  Using these definitions, a proposal for a large battery system providing backup power to a substation in the event of a transmission outage could describe their solution as:

  - Load: entire substation, up to 20 MW of load
  - Effectiveness: provides backup power in the event of transmission line outage but not in the case of a natural disaster affecting the substation itself

6 Connecticut Public Utilities Regulatory Authority Docket No. 17-12- 03RE08

- Response time: backup power provided in under 1 second
- Duration: backup power provided for four hours at full discharge (80 MWh)

The Resilience Valuation cohort also introduced two new definitional concepts: Value Factors and Value Parameters.

A *Value Factor* is a resilience benefit that would be included in a resilience valuation formula. Examples include:

- **Customer loss-of-load:** e.g., avoided burden to a home / business
- **Community benefits**: e.g., avoided local healthcare costs
- **Local economy:** e.g., avoided impact on local GDP
- **Grid benefits:** e.g., reduced costs for restoration or utility staffing for events
- **Environmental benefits:** e.g., avoided local emissions from backup generation

A *Value Parameter* is an attribute of a Value Factor that, if included in a valuation formula, meaningfully affects that value calculation. This might include:

- **Benefits timescale**: Choices include short, medium and long-term benefits, e.g., a formula could limit consideration to benefits realized within 1 year
- **Zones & customer types**: Resilience value can vary based on geography as well as customer type, e.g., critical facilities
- **Temporal:** Resilience value can vary based on time of day or season of the year
- **Risk assessment:** Resilience value often depends on type, frequency and severity of outrages
- **Discount rate:** Choice of discount rate makes a significant difference in the calculation of the net present value of a valuation solution
- **Effectiveness:** Different resilience service levels provided by resilience solutions can determine the value of those solutions
- **Approach or solution category:** The value of a resilience solution can depend strongly on the Resilience Solutions Category (defined above) it addresses: mitigate, prepare, respond, or recover.
- **Update frequency:** For reach value factor, the formula establishes how often that factor is updated for use in calculations.

The Valuation Cohort provided an example application of Value Factors and Value Parameters, considering the application of a valuation formula designed for a resilience grant program to a proposal for a microgrid located at a water treatment plant.

- Value Factors could include:
  - Replacement Power: the avoided cost of running backup generators
  - Public health and safety: replacement cost of providing clean drinking water
  - Environmental: Avoided local emissions compared to an on-site generator
- Value Parameters specific to the environmental factor could include:
  - Timescale: Short term benefits of reduced local air pollution
  - Priority Zones: Air pollution benefits vary by geography, with higher value in communities with greater public health burdens
  - Temporal: Value does not vary by time or season
  - Risk Assessment: Value is higher in regions at higher risk of major outages

- Discount rate: Limited effect of discount rate on short-term benefit calculation
- Update frequency: Valuation factors updated each time grant program pricing is adjusted

4. Process Leadership & Participation

While a resilience grant program might be managed by a single agency (e.g., the State Energy Office), other state agencies and stakeholders might agree the resilience valuation formula used in the program should be consistent with valuation methodologies used in other resilience use cases in the state. Thus, the process of developing the formula for this program should also involve other entities such as:

- Public Utilities Commission
- Utilities
- Emergency management agency
- State environmental agency

The primary process will be a stakeholder working group created and managed by the SEO and with representatives from each of the above agencies. In developing a formula, the working group could recommend any needed changes to the policies and programs at the other state agencies. It may also be necessary for those changes to be implemented before establishing the formula for the grant program.

5. Design Questions

The Valuation Cohort discussed design questions relevant to designing resilience valuation formulas and methodologies.

- What value factors and parameters will be included in the valuation formula? (Detailed information on these is provided in the definitions section, above.)
- What tools and methods will be used to calculate or estimate a dollar amount for each value factor? (Appendix 3 presents a number of resources that may be useful in developing resilience valuation methods.)
- For each use case, what, if any, new authorization is needed to include the chosen value factors in regulatory decisions?

6. Implementation

While the state agencies have worked on being consistent with their resilience valuation methodologies, official adoption of the resilience valuation formula for the 40101(d) grant program does not depend on legislative or regulatory action.

Therefore, implementation of the new formula would likely only need the approval of the Department of Energy Grid Deployment Office before being used in practice.

Appendix 2. Metrics Examples

This appendix presents a number of metrics that users might consider as they determine how to measure resilience. Due to the emerging nature of this topic, resilience metrics are still being developed and are not as robust and standardized as metrics for reliability. As such, the metrics included here may need further development or detailing depending on the need and jurisdiction. Lastly, jurisdictions should consider the following when developing metrics. Notably, metrics should be:

- **Measurable**
- **Available:** The data to support the metric are or could be available to the entity calculating the metric.
- **Repeatable:** The measurement and results should be repeatable by others using the same methodology and should produce consistent results over time given the same inputs.
- **Public:** Metrics should rely on publicly available information as much as possible, and it should be feasible and appropriate to report the metric publicly without privacy concerns.
- **Leverage existing technology and process:** The data and reporting should utilize information and technology already available and consider new uses for existing technology and process.

With more technology being deployed by utilities, customers, and others, new data sources may become available over time. As such, jurisdictions should consider what role technology can play to inform existing metrics and in the development of new metrics.

A starting point for jurisdictions may be to consider existing metrics associated with reliability and consider whether information from those metrics, or modifications to existing metrics, may also help in measuring resilience.

- System Average Interruption Duration Index (SAIDI) measures the total number of minutes of interruption the average customer experiences.
- System Average Interruption Frequency Index (SAIFI) measures the number of outages per customer.
- Momentary Average Interruption Frequency Index (MAIFI) measures the average number of momentary, short outages per customer.
- Customer Average Interruption Duration Index (CAIDI) measures the average time required to restore service.[7]

DOE's Grid Modernization Laboratory Consortium (GMLC) produced a resource that provides significant insight into the development of metrics.[8] It described two types of resilience metrics:

- Multi-criteria decision analysis, which addresses the question "what is the current state of resilience of the electric system, and what are the options to enhance its resilience over time?"
- Performance-based analysis, which addresses the question "how would an investment impact the resilience of my system?"

For performance-based analysis, the GMLC describes the need to identify the consequence of an event and how to measure that consequence, as shown in the following table.

7 https://www.eia.gov/electricity/annual/html/epa_11_01.html

8 Grid Modernization Metrics Analysis (GMLC1.1) – Resilience," Dept. of Energy, Grid Modernization Laboratory Consortium, Reference Document Volume 3 (April 2020). https://gmlc.doe.gov/resources/grid-modernization-metrics-analysis-gmlc11-resilience

Table 4.2: Example of Consequence Categories for Consideration in Grid Resilience Metric Development

Consequence Category	Resilience Metric
Direct	
Electrical Service	Cumulative customer-hours of outages Cumulative customer energy demand not served Average number (or percentage) of customers experiencing an outage during a specific period
Critical Electrical Service	Cumulative customer-hours of outages Cumulative customer energy demand not served Average number (or percentage) of citical loads that experience an outage
Restortoration	Time to recover Cost of recovery
Monetery	Loss of utility revenue Cost of grid damages (e.g. repair or replace lines, transformers) Cost of recovery Avoided outage cost
Indirect	
Community Function	Critical services without power (e.g. hospitals, fire stations, police stations) Critical services without powerfor more than *N* hours (e.g. *N* > hours of backup fuel required)
Monetery	Loss of assets or perishables Business interruption costs Impact on Gross Municipal Product or Gross Regional Product
Other Critical Assests	Key production facilities without power Key military facilities without power

This example provides a starting point for jurisdictions to start discussing the types of metrics necessary for their jurisdiction. Furthermore, this process is consistent with the Framework discussed above. The Framework can help jurisdictions answer the questions raised by GMLC around need and purpose. For example, if a jurisdiction is considering a utility investment that may enhance system resilience, it must also identify the events, risks, or hazards that the investment can mitigate to enhance resilience.

Developing metrics is on-going as practices and policies to address resilience continue to evolve and mature. Regulators can use this opportunity to utilize information and guidance to chart their own path to support resilience in their jurisdiction.

Appendix 3: Resilience Valuation Resources

Valuation Methods and Tools

In developing the Framework, high level research was conducted to identify existing valuation methods and tools in these categories. This did not include a comprehensive review of the literature or deep investigation into relevant regulatory proceedings.[9]

The resilience valuation cohort grouped resilience Valuation Factors into several categories, as follows.[10]

- **Customer Loss-of-Load** (aka Value of Lost Load)

  Customer Damage Function Calculator Tool – NREL
  https://cdfc.nrel.gov

  Interruption Cost Estimator 2.0 Tool - LBNL, EEI: https://icecalculator.com/home

- **Community Benefits**

  FEMA Benefit-Cost Analysis Tool - FEMA: Provides quantitative values for lost emergency services, such as police, fire, and emergency medical response.
  https://www.fema.gov/grants/tools/benefit-cost-analysis

  Sandia National Lab Social Burden Method
  https://energy.sandia.gov/wp-content/uploads/2022/12/Social-Infrastructure-Burden-White-Paper_Final.pdf

- **Local Economy**

  Power Outage Economics Tool (POET) - LBNL, ComEd
  https://energy.lbl.gov/publications/power-outage-economics-tool-prototype

For the two remaining categories, Grid Benefits and Environmental Benefits, examples of valuation methods or tools in actual use were not found.

State Regulatory Proceedings

The following state proceedings and regulatory documents provided useful examples of the treatment of resilience valuation in regulatory decisions.

California Public Utilities Commission Order Instituting Rulemaking on Microgrids R.19-09-009
https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M516/K162/516162719.PDF

California Public Utilities Risk Based Decision Making Framework R.20-07-013
https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M520/K706/520706014.PDF

State of Connecticut VALUE OF DERS 2020 Report
https://www.dpuc.state.ct.us/DOCKCURR.NSF/8e6fc37a54110e3e852576190052b64d/56d151da9f6343af852585980063329d?OpenDocument

9 For a current literature review, please see "Measuring and Valuing Resilience: A Literature Review for the Power Sector" (NREL 2023). Full citation appears in Appendix 6.

10 Most of these examples are drawn from the NARUC publication, "The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices" (2019). Full citation appears in Appendix 6.

State of Connecticut Distribution System Planning - Resiliency and Reliability 17-12-03RE08 - 8/31/2022 Final Decision
https://www.dpuc.state.ct.us/2nddockcurr.nsf/8e6fc37a54110e3e852576190052b64d/4bcecc163d47d814852588af005bca09/$FILE/171203RE08-083122.pdf

State of Florida, Florida Power & Light Storm Protection Plan 20220051-EI
https://www.floridapsc.com/pscfiles/library/filings/2022/06043-2022/06043-2022.pdf

State of Florida Department Environmental Protection Duke Storm Protection Plan 20220050-EI
https://www.floridapsc.com/library/filings/2022/11122-2022/11122-2022.pdf

Hawaii Investigation into Integrated Grid Planning 2018-0165 Resilience Working Group Report
https://www.hawaiianelectric.com/a/7883

Hawaii Electric Company, Inc Grid Resilience Application
https://hpuc.my.site.com/cdms/s/puc-case/a2G8z0000007f18EAA/pc20323?tabset-a3299=3

Appendix 4: Regulatory Mechanisms Examples

The following Taxonomy of Regulatory Mechanisms was developed by the Regulatory Mechanisms Cohort.

Mandates can require utilities to adhere to specific standards or actions to enhance grid resilience. Existing mandates may be built upon to incorporate resilience components.	
Integrated Grid Planning and Integrated Resource Planning	Integrated planning mandates can require utilities to incorporate resilience considerations into long-term grid planning through processes like Integrated Grid Planning (IGP) or Integrated Resource Planning (IRP). *Example: A mandate requires utilities to include microgrids in their IGP to provide backup power to critical facilities during outages, strengthening overall grid resilience.*
Planning Studies	Mandates for planning studies might require utilities or other agencies to assess grid vulnerabilities and identify areas that need resilience enhancements, especially in high-risk regions. These studies help prioritize resilience-focused projects and can aid commissioners and commission staff in their determination of the prudency of utility proposals. *Example: A mandate requires utilities to conduct a vulnerability assessment to assess where grid resilience investments and traditional hardening investments are needed at a more granular level.*
Technology Deployment	Technology deployment mandates might require utilities to consider and implement a certain amount of a technology or specific resilience-enhancing technologies, such as automatic switches, sensors, or energy storage. Specific technologies might be chosen to align with existing state energy goals. *Example: A mandate requires utilities to install a certain capacity (in MW) of battery energy storage systems to be deployed by critical facilities during an extreme weather event by a certain date.*
Distribution System Planning	Mandates for distribution system planning (DSP) might focus on enhancing grid resilience within local grid networks to withstand and quickly recover from disruptions. These mandates might require utilities to reinforce distribution lines, upgrade substations, or invest in flood-resistant infrastructure. *Example: A requirement within resource planning and distribution system planning processes that incorporates an assessment of customer resources (such as energy storage devices and microgrids) that complement and enhance utility-led investments.*
Incentives encourage utilities and customers to invest in resilience measures by offering financial rewards, cost recovery options, or direct funding for resilience-enhancing projects.	
Tariffs	Tariffs can allow utilities to collect dedicated funds from customers to support grid resilience investments. *Example: A standardized tariff structure for energy exports from customer-owned or independently developed resilience resources, such as battery systems and microgrids.*
Direct Funding	Direct funding provides financial support for utilities to undertake resilience projects without requiring cost recovery from customers. This funding can come from federal, state, or shareholder sources and enables more rapid deployment of resilience measures. *Example: A government grant directly funds the investments in grid modernization that can enable the integration of additional local resources.*
Customer Incentives	Customer incentives encourage end-users to adopt resilience-enhancing technologies, such as solar-plus-storage systems that provide backup power. By offering rebates or tax credits, customers are motivated to invest in technologies that support resilience. *Example: A utility offers rebates for residential battery systems, allowing homes to maintain power during grid outages and easing demand on restoration efforts during high-stress events.*

Enhanced Cost Recovery	Enhanced cost recovery allows utilities to recoup the costs of resilience investments more quickly, encouraging them to undertake essential projects with less financial strain. *Example: A utility is granted enhanced cost recovery to rapidly fund the replacement of aging transformers that are vulnerable to storm damage.*
Securitization	Securitization enables utilities to finance large projects by issuing bonds, spreading costs over a longer period and reducing the immediate rate impact on customers. This mechanism can be useful for costly, long-term projects like undergrounding power lines or building flood-resistant substations. *Example: A utility issues bonds to finance the installation of a resilient microgrid in a high-risk area, using securitization to make the project financially viable and minimize customer rate increases.*
Performance-Based Ratemaking: *Performance Incentive Mechanisms*	Performance-based ratemaking with performance incentive mechanisms (PIMs) can tie a portion of utility revenue to achieving specific resilience goals, such as reducing outage frequency or minimizing recovery times. This structure incentivizes utilities to prioritize resilience improvements that directly benefit customers. PIMs can also be utilized to help achieve a variety of other goals, such as ensuring a certain number of investments are made in targeted communities. *Example: A commission awards a utility financial rewards for meeting or exceeding benchmarks related to faster power restoration after major events, encouraging them to invest in resilience technologies.*
Market Structure mechanisms shape the regulatory and operational environment in which utilities and other grid stakeholders operate. By defining how utilities earn revenue, invest in resilience, and introduce new services, market structures influence the prioritization of resilience.	
Cost of Service	Cost of service regulation, the status quo, allows utilities to recover the cost of providing service plus an approved rate of return on investments. Under this model, utilities are able to pass the costs of investments directly to customers, provided they demonstrate the necessity of the investments. *Example: A utility applies for commission approval to include costs for storm-hardening infrastructure within its rate base.*
Performance Based Ratemaking: *Multi-Year Rate Plans*	Multi-year rate plans provide utilities with revenue stability over several years and can include incentives to improve performance and resilience. These plans encourage utilities to invest in resilience projects without needing frequent rate adjustments. *Example: A utility uses a multi-year rate plan to fund ongoing grid modernization efforts while maintaining performance targets over the rate period.*
Grid Services Markets	Market structures that include grid services allow utilities or third-party providers to offer services such as demand response and energy services, which support grid resilience by improving grid flexibility and stability. *Example: A utility incentivizes customers to participate in demand response programs, enabling faster response times and better grid management during disruptions.*
New Service Offerings	New service offerings allow utilities to introduce resilience-oriented services, such as backup power options, microgrid services, or resilience-as-a-service packages, providing customers with direct access to resilience resources. These offerings help to decentralize resilience, empowering customers to maintain power independently during outages. *Example: A utility offers a subscription-based service that provides backup power through a community microgrid.*

Appendix 5: Resilience Context

Balancing Resilience and Reliability

The basic concept of resilience is generally well-understood as a part of our common experience, either in one's daily life or in response to unpredictable events. It relates to how quickly one can recover from a shock or impact. It recognizes the need to identify risks and the ability to mitigate those risks, especially when they are uncommon. Within utility commissions, resilience is a relatively new concept. Regulators have traditionally focused on reliability, which in some respects can be easy to measure: electricity is either being delivered to customers or it is not, and the causes and risks are often relatively easy to identify. For example, utility poles must be able to remain standing at certain wind speeds or infrastructure must be able to operate at certain temperatures. If a car hits a pole or a transformer, a distribution line goes down, or a power plant trips off-line and a power outage results, these causes are generally identifiable and measurable. So, too, is how long the power is out and how long it takes to re-establish service. Reliability addresses the known risks to the normal operating conditions of the grid.

Standard reliability metrics related to reliability include:

- **SAIDI** - System Average Interruption Duration Index measures the total number of minutes of interruption the average customer experiences.
- **SAIFI** - System Average Interruption Frequency Index measures the number of outages per customer
- **MAIFI** - Momentary Average Interruption Frequency Index measures the average number of momentary, short outages per customer
- **CAIDI** - Customer Average Interruption Duration Index measures the average time required to restore service.

These measures inform utility investments in infrastructure and planning and inform regulatory decision-making on those investments. With increased attention to creating a more resilient electricity system, investments in reliability may not be the same as the investments required to increase the resilience of the system. The workshops and information gathered in this initiative revealed that regulators are seeking ways to better understand how to assess and evaluate new investment options. The regulator's role in approving utility plans, costs, and cost recovery through customer rates shows why this concept is becoming so pervasive and important in the context of utility operations and infrastructure planning of the grid.

In essence, what was previously a discussion solely within the electric industry is now evolving to include a much wider range of government, business, and community stakeholders. As a result, it has become increasingly important to distinguish between the traditional concept of "reliability" and a more expanded notion of "resilience" regarding the electric system. In other words, recognizing that resilience and reliability are different outcomes and occur under different circumstances will ensure that policies are appropriately focused on resilience and that proposals will benefit resilience.

In this context, regulators must also balance a range of potential investments and how ratepayer capital can be most effectively deployed. As with all utility investments, regulators must consider both the costs and anticipated benefits. For example, investments in grid hardening such as burying powerlines may support resilience outcomes that benefit customers but also burden customers with higher bills.

A Paradigm Shift: Reliability to Resilience

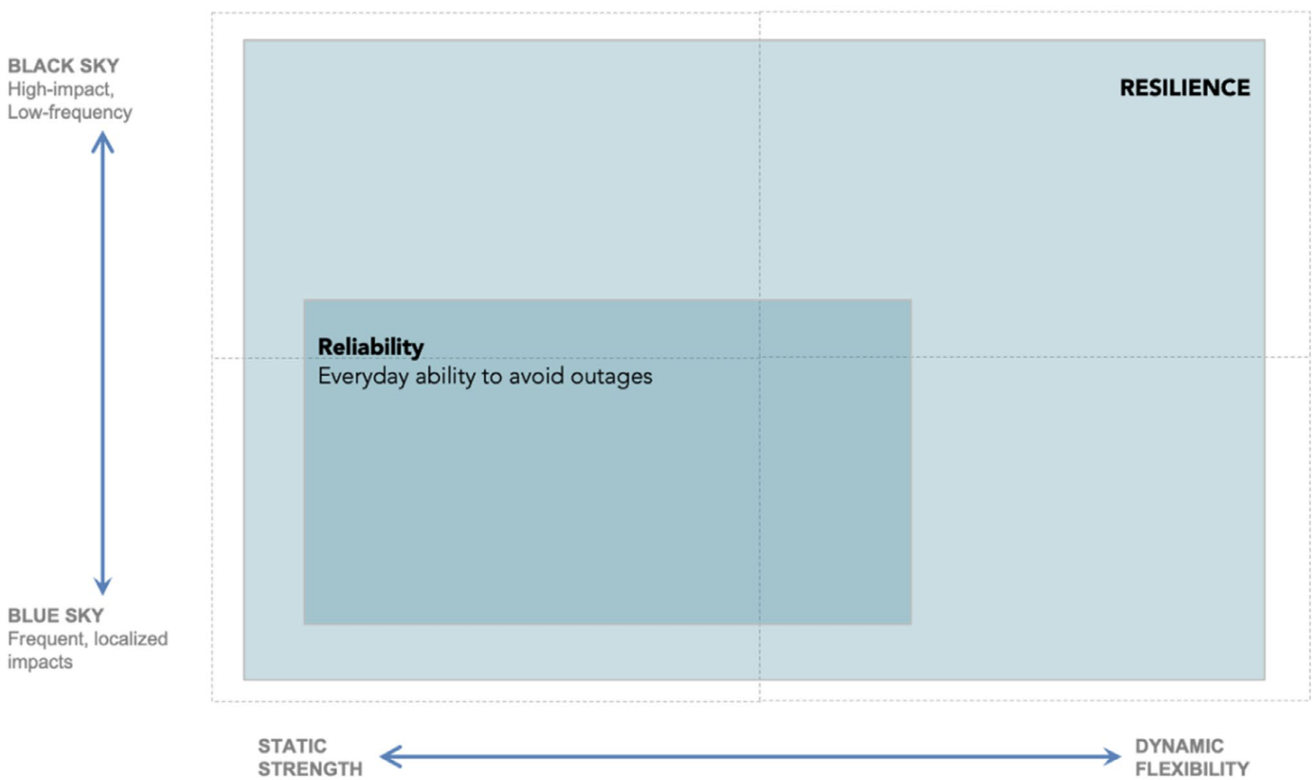
In the workshops and discussions with regulators and other stakeholders as part of this initiative, three factors were repeatedly noted that distinguished resilience from reliability:

- **Extreme Events:** Where reliability focuses primarily on the anticipated risks associated with normal operating conditions ("blue sky" days), resilience expands the scope to consider how the electricity system can respond to the less frequent, but more severe, impacts of extreme events ("black sky" days).
- **Flexibility:** Resilience considers a variety of strategies that rely on increased flexibility in demand and energy resources. Strategically located microgrids, for example, may be alternatives to upgrading or hardening distribution infrastructure.
- **Customer Solutions:** New technologies allow resilience solutions that rely on on-site and distributed energy resources. In many cases, these involve investments made by customers directly or by community entities and are not solely reliant on utility ratepayer investments.

While these factors address the operation of the grid, it should also be noted that the effects are felt by customers. This includes the use of (or ability to use) resources located across the grid, regardless of whether they are owned by the utility. Grid resilience planning may consider the availability and usability of all available resources, provided they are known and can be integrated into the operation of the electric system. As noted above, distributed energy resources will inevitably play an increasing role in emerging resilience strategies and state regulators need to consider the impacts of these investments on customers, electrification efforts, and the relationship with the regulated utility.

The figure below was used in workshops and cohort discussions to help illustrate these concepts. The graph represents how resilience builds from and expands beyond traditional notions of reliability in two key dimensions – consideration of "black sky" events and the need for flexibility. The more expensive landscape occupied by resilience also involves the deployment of both utility-led and customer-led resilience solutions that are enabled by new, advanced technologies.

Resilience and Reliability



Appendix 6: Overview of Framework Development Process

A. Regional Workshops

The initial step of this initiative was to convene meetings across the NARUC footprint in order to meet with and bring state regulators together to discuss issues on a regional basis. To help further understand this need, NARUC organized meetings with regulators across the five NARUC regions (Western, MARC, SEARUC, MACRUC, and NECPUC) to allow regulators a forum to discuss these issues, but also to better understand the needs and drivers of grid resilience in these regions. These meetings also were used to inform a resilience Needs Assessment. Workshops were held throughout 2023, typically coinciding with regional NARUC meetings.

Two of the workshops were held in person (Western and MARC) while the other workshops were held virtually. The final workshop was an opportunity for anyone who had been unable to attend their regional meeting to participate and provide comments on the needs of their jurisdiction.

At each workshop, a representative from the region provided introductory remarks about how grid resilience is being considered before their commission, the threats facing their region, and the regional benefits of resilience. The meeting also included an introductory framework that was presented to help drive conversations about the role and importance of resilience across the electric system. This proposed framework offered a conceptual model for how to think about resilience in the context of regulatory decision-making. This model allowed regulators to respond to the idea of a model to help with decision-making but also helped to identify regulatory challenges and needs to address resilience.

B. Needs Assessment

This first phase of the project led to the development of a Needs Assessment. This Needs Assessment identified a series of topics, projects, and policies raised by state regulators regarding resilience. Three of these—metrics, resilience valuation, and regulatory mechanisms—formed the foundation for the next phase of the project, in which regulators formed cohorts to more fully discuss these topics.

The Framework offered here emerged from the overall objective of this initiative to find common tools that span across broad topics that resilience encompasses and across multiple areas of regulatory practice. As part of the effort to develop this Framework, beginning in 2023, multiple meetings and workshops with regulators were held to provide a forum to identify which aspects of resilience were most relevant and pressing for state commissions, recognizing that there is a wide range of needs and experiences across the country.

Topics that were identified by commissions and public agencies as opportunities to expand expertise and guidance include:

- Coordination with various state and federal agencies pertaining to funding and resilience planning in general
- Definitions of grid resilience that are actionable and unique to jurisdictions

- Vulnerability and threat assessments
- Third-party solutions (e.g., technology)
- Cost-benefit analyses and calculations
- Regulatory mechanisms and how to approach investments
- Accessible tools and clear guidance on how to use them to successfully advance grid resilience planning.

Participants emphasized the importance of understanding different customers' resilience thresholds, expectations and the fact that these needs cut across customer classes. For example, a residential customer with medical needs will have different backup power requirements, thus a different customer threshold, than an industrial facility. These differences may result in different expectations of need, value, and cost. Commissions may consider a variety of options to promote increased stakeholder participation, including workshops, informal proceedings and meetings, and holding meetings across the state or utility service area.

The Needs Assessment identified over a dozen potential topics for further investigation using a cohort model. In consultation with GDO, NARUC organized three peer-learning cohorts focused on:

1. Metrics - *What are existing or emerging methods for measuring progress against a baseline goal?*
2. Valuation - *What tools or methodologies are required to properly value grid resilience instruments and assets?*
3. Regulatory Mechanisms - *What is the full range of options available to commissions and other state authorities to facilitate and enhance grid resilience?*

These cohorts, and the work developed by them, form the basis of this Framework.

C. Cohorts

After completion of the Needs Assessment, NARUC, with support from GDO and in collaboration with the National Association of State Energy Offices (NASEO), convened three cohorts: Resilience Metrics, Valuation Frameworks, and Regulatory Mechanisms for Grid Resilience. These topics were deemed most relevant to state utility regulators. NASEO also convened cohorts to address risk mitigation strategies, risk assessment approaches, and grant implementation.[11] for more information). Members of NARUC and NASEO were invited to participate in each cohort.

Cohorts met regularly over the course of 2024 and were run in parallel with each other. Each of the NARUC cohorts held four individual meetings. NARUC and NASEO cohorts also met together during an in-person meeting in July 2024.

For each NARUC cohort meeting, outside speakers were invited to present on a specific issue related to the topic at hand. For example, for the Metrics cohort, presenters included staff from commissions to discuss the development of metrics, which helped inform the discussion on how to create metrics. Discussions then typically included breakout sessions to allow small group discussions on a series of questions or tasks. The cohorts were designed to encourage conversation and sharing of information with other attendees. It is from these conversations across the cohorts that NARUC and the E9 team identified the value of a framework to help regulators organize their processes to address questions on resilience. A draft Framework was prepared for the in-person meeting held July 31 - August 1, 2024, in Detroit, Michigan.

D. In-Person Workshop

Participants in the cohorts, members of NARUC and NASEO, as well as consumer advocates and state emergency services were invited to attend the in-person workshop. Attendees were tasked with utilizing the

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11 See www.naseo.org/issues/electricity/resilience.

Framework to address the development of resilience metrics, identification of appropriate resilience valuation methodologies, and contextualize these within relevant regulatory contexts. This meeting provided substantial insights and perspectives into the completion of this Framework.

Attendees indicated that they found the Framework useful and that it would be valuable in their review of resilience proposals and helpful as a mechanism to imbue resilience into regulatory processes.

Appendix 7: Relevant Resources

The following list of resources pertains to the topics of resilience valuation, grid resilience metrics, and regulatory mechanisms for grid resilience. This is not an exhaustive list but consists of resources that the authors recommend and have utilized.

NARUC Resources

The topic of resilience is not new to NARUC and its members. In recent years, NARUC has issued a variety of reports and led initiatives to engage the regulatory community about resilience.

- NARUC (2022-2023). Energy Resilience Reference Guide for State Utility Regulators.
  - https://pubs.naruc.org/pub/1C098515-1866-DAAC-99FB-3FBA6FA3AB0B
  - (2022). Chapter One: Developing a Shared Definition of Energy Resilience.
    https://pubs.naruc.org/pub/45491EC6-FF05-559F-2B1D-85D1FC8E7042
    Addresses challenges related to differing definitions of resilience across sectors and encourages state public utility commissions to establish a shared understanding and language for energy resilience.
  - (2023) Chapter Two: Developing a Shared Framework to Value Resilience Investments.
    https://pubs.naruc.org/pub/458600D2-913F-CBF6-B8F3-BBF1A796F00E
    Outlines core principles for creating frameworks to value resilience investments and highlights state-level efforts to incorporate such frameworks in regulatory practices.
  - (2023) Chapter Three: Climate Resilience Strategies for Regulators.
    https://pubs.naruc.org/pub/45930E31-AD27-1228-C5A0-3FFCFD9DAD95.
    Discusses regulatory approaches for addressing specific climate-related threats to energy resilience, with an emphasis on tailoring strategies to distinct climate risks.
- (2019). Regulating for Resilience Workshop Presentation.
  https://pubs.naruc.org/pub/6A146D0E-B6A2-89F8-1469-484C2B6E8FFE
  A workshop presentation that addresses the regulatory frameworks and approaches to enhancing grid resilience, featuring strategies and best practices discussed in an interactive format.
- (2013). Resilience in Regulated Utilities.
  https://pubs.naruc.org/pub/536F07E4-2354-D714-5153-7A80198A436D
  Investigates how regulators can define and integrate resilience into regulated utility frameworks, particularly in response to emerging hazards like cyber threats and large-scale natural disasters. Advocates for resilience to be a focused area of investment alongside reliability and proposes a foundation for evaluative methodologies that can support resilience-focused decisions by public utility commissions.

Other Selected Resilience Resources

- Connecticut Public Utilities Regulatory Authority (2022). Decision on Utility Resilience and Grid Modernization, Docket No. 17-12-03RE08.

https://www.dpuc.state.ct.us/2nddockcurr.nsf/8e6fc37a54110e3e852576190052b64d/4bcecc163d47d814852588af005bca09/$FILE/171203RE08-083122.pdf
Decision outlines Connecticut's framework for electric distribution companies to enhance system resilience and reliability, directing companies to submit resilience-focused capital plans. Emphasizes the importance of data-driven, cost-effective investments to meet state reliability and resilience objectives, including guidelines for emergency response planning and addressing climate change vulnerabilities.

- Federal Energy Management Program, Pacific Northwest National Laboratory, National Renewable Energy Laboratory (n.d.). Technical Resilience Navigator.
  https://trn.pnnl.gov/about
  The Technical Resilience Navigator, a tool for identifying and mitigating risks to critical energy infrastructure, offering guidance for resilience-focused planning.

- Grid Strategies (2018). A Customer-Focused Framework for Electric System Resilience.
  https://gridprogress.files.wordpress.com/2018/05/customer-focused-resilience-final-050118.pdf
  Presents a resilience framework centered around customer needs, suggesting that resilience efforts should prioritize customer service continuity and reliability enhancements.

- Lawrence Berkeley National Laboratory (2023). Strategies for Valuing and Prioritizing Resilience Investments and Measuring Progress.
  https://eta-publications.lbl.gov/sites/default/files/larsen_20231130.pdf

  Explores strategies for evaluating resilience investments and tracking progress, providing a methodology for prioritizing resilience initiatives based on economic and operational impacts.

- Lawrence Berkeley National Laboratory (2023). The Value of Sharing and Consolidating Critical Community, Electricity, and Natural Hazard Information.
  https://emp.lbl.gov/publications/value-sharing-and-consolidating
  Examines the benefits of integrating community, utility, and hazard information to improve resilience planning and response, providing insights into multi-sectoral data consolidation for more informed decision-making.

- Lawrence Berkeley National Laboratory (2024). Alternative Ratemaking Treatments for Grid Resilience Programs.
  https://emp.lbl.gov/publications/alternative-ratemaking-treatments
  Discusses alternative ratemaking methods to incentivize resilience investments, exploring various economic frameworks that utilities and regulators could consider to support resilience-oriented grid improvements.

- Lawrence Berkeley National Laboratory (2024). Grid Resilience Plans: State Requirements, Utility Practices, and Utility Plan Template.
  https://emp.lbl.gov/publications/grid-resilience-plans-state
  "Reviews the regulatory landscape, where 14 states and one city mandate resilience planning by utilities. The report offers a template that includes vulnerability assessments, resilience programs, cost projections, and rate impact estimates. While focused on extreme weather events, it also addresses other threats such as cyber and physical attacks and seismic risks."

- Lawrence Berkeley National Laboratory (2024). State Requirements for Electric Distribution System Planning.
  https://emp.lbl.gov/publications/state-requirements-electric
  Analyzes state-specific requirements for distribution system planning, focusing on how various jurisdictions incorporate resilience considerations into electric distribution planning mandates.

- National Association of State Energy Offices and National Governor's Association (2021). State Governance, Planning, and Financing to Enhance Energy Resilience.
https://www.nga.org/wp-content/uploads/2021/12/Resilience_Guide_21Dec2021.pdf
Highlights governance strategies, planning processes, and financing mechanisms that states can use to enhance energy resilience, emphasizing inter-agency collaboration and funding opportunities.
- National Renewable Energy Laboratory (2023). Applications of Measuring and Valuing Resilience in Energy Systems.
https://www.nrel.gov/docs/fy23osti/83841.pdf
- National Renewable Energy Laboratory (n.d.). Customer Damage Function Calculator.
https://cdfc.nrel.gov/
Provides a tool to quantify the economic impacts of power outages on customers, helping utilities and regulators to better assess and value resilience investments based on customer impact.
- Sandia National Laboratories (2023). Designing Resilient Communities: A Consequence-Based Approach for Grid Investment.
https://www.osti.gov/servlets/purl/2204268
Proposes a consequence-based planning approach that prioritizes resilience investments based on potential impacts to community infrastructure, offering guidance on targeting investments for maximum community benefit.
- Sandia National Laboratories (2021). Regulatory Mechanisms to Enable Investments in Electric Utility Resilience.
https://www.osti.gov/biblio/1808934
Examination of regulatory strategies to enhance electric utility resilience by aligning investments with regulatory, community, and stakeholder priorities, utilizing approaches such as performance-based regulation, tariffs, and cost recovery mechanisms, and includes case studies for practical insight.
- Siemens, Hawaiian Electric Company, et al. (2020). Resilience Working Group Report for Integrated Planning.
https://www.hawaiianelectric.com/a/7883
Evaluates the resilience of Hawaii's electrical grid against natural hazards, offering strategies to enhance system robustness and ensure reliable service.

NARUC

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