NARUC
National Association of Regulatory Utility Commissioners

Regulator's Financial Toolbox: Resilience Technologies Brief

The National Association of Regulatory Utility Commissioners (NARUC) Center for Partnership and Innovation (CPI) Financial Toolbox series explores the types of financial tools utility regulators can use to support integration of electricity system technologies that benefit the public interest. This brief was prepared by Chris Villarreal (Plugged In Strategies) and Kerry Worthington (NARUC CPI) under DOE Cooperative Agreement # DOE-OE0000818[1] between NARUC and the U.S. Department of Energy.

On August 25, 2021, NARUC CPI hosted a webinar on Resilience Technologies, featuring opening remarks from moderator, Chair Carrie Zalewski (Illinois Commerce Commission) and presentations from Quanta Technology, Synapse Energy Economics, Sandia National Laboratory, and the California Public Utilities Commission. The speakers' biographies and presentations and August 10, 2021, recording are located at: www.naruc.org/cpi-1/electricity-system-transition/valuation-and-ratemaking/.

The webinar and this accompanying brief address:

- Defining and measuring resilience
- Types of resilience technologies
- Frameworks towards identifying benefits and measuring resilience
- Regulatory considerations and approaches
- Resources for more detailed information

Defining and Measuring Resilience

With more threats to the electricity system than ever before, due to extreme weather events, cybersecurity threats, and aging infrastructure, regulators and utilities view resilience as an important component of electricity system operations. The first task when discussing resilience is to define what a regulator (or utility) means by resilience. The Federal Energy Regulatory Commission (FERC), U.S.

[1]This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Department of Energy (DOE), Institute of Electrical and Electronics Engineers (IEEE), and others each have different definitions. At its core, resilience is the ability to withstand and recover from an incident, be it weather, cyber, or other event. Identifying the attributes of resilience, and how utility investments provide or enable those attributes will help regulators and stakeholders identify the expectations for utility investments and review utility proposals accordingly. [2]

Resilience is different from reliability, which measures availability of electricity during different periods, typically through a suite of metrics (e.g., CAIDI, SAIFI, SAIDI[3]) that regulators track to monitor system and utility performance. Professionals throughout the industry worked together to adopt these standardized metrics for reliability and are currently in the process of developing standardized metrics for resilience. Resilience, while understandable in context, has proven to be more challenging to measure and monitor.[4]

Sandia National Labs researcher Robert "Bobby" Jeffers suggests that any metric developed by a regulator should try to cover three components: convey the different impacts from an event by size, duration, and impact on customers; detail the context in which the event occurred and its impacts; and translate performance into consequence.[5]

For example, **Figure 1** shows an event and its impacts on two systems.[6] Here, improving resilience and measuring performance is framed within three components: prepare, withstand, and recover. This image also identifies the difficulties for regulators in adequately determining the cost-effectiveness of resilience for any particular investment – because the regulator may need to understand which type of response is prioritized for which areas of a service territory. A regulator may direct the utility to prepare its systems in response to certain requirements, but at the end of the day, an event is a function of the time in which it occurred and the location of its impact. Metrics can help regulators, and utilities, better understand how prepared the system is for particular events, its ability to withstand those events, and how long it may take to recover. Those metrics, however, are only as good as the data (and planning) behind it.

[2] Romero Agüero, Julio, Quanta Technology. 2021. "Resilience of Power Systems". PowerPoint presentation, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

[3] CAIDI is the Customer Average Interruption Duration Index. SAIFI is the System Average Interruption Frequency Index. SAIDI is the System Average Interruption Duration Index.

[4] One resource to measure resiliency is the Lawrence Berkeley Lab Interruption Cost Estimate Calculator (ICE Calculator) based on utility survey information, which is undergoing an update. For more information, visit: https://icecalculator.com/

[5] Romero Agüero, Julio, Quanta Technology. 2021. "Resilience of Power Systems". PowerPoint presentation at 4, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

[6] Id.

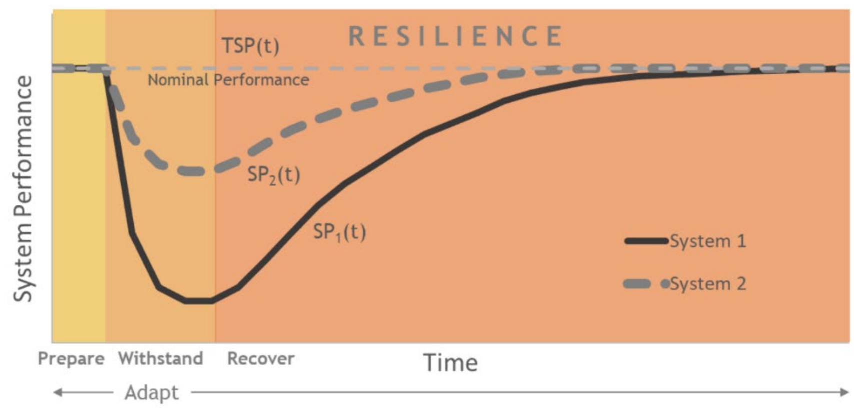

Figure 1. Measuring and forecasting resilience (Jeffers, Robert "Bobby." 2021. "A Performance-Based Approach to Equitable Resilience Planning." NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.)

Illustrating Societal Impacts

Coupled with this uncertainty is also an awareness of the societal impact of an outage: the longer an outage, the greater the impact on society. [7] **Figure 2** shows that as an outage lasts longer over time, the greater the impact and cost to society and the economy. To illustrate, if a factory loses power, then that factory cannot produce a widget for an extended period of time. The factory not only loses revenue, but, with time, workers are out of work, tax base is lost (local event), and the neighboring regions experience a shortage of the widget, and potential economic depression.

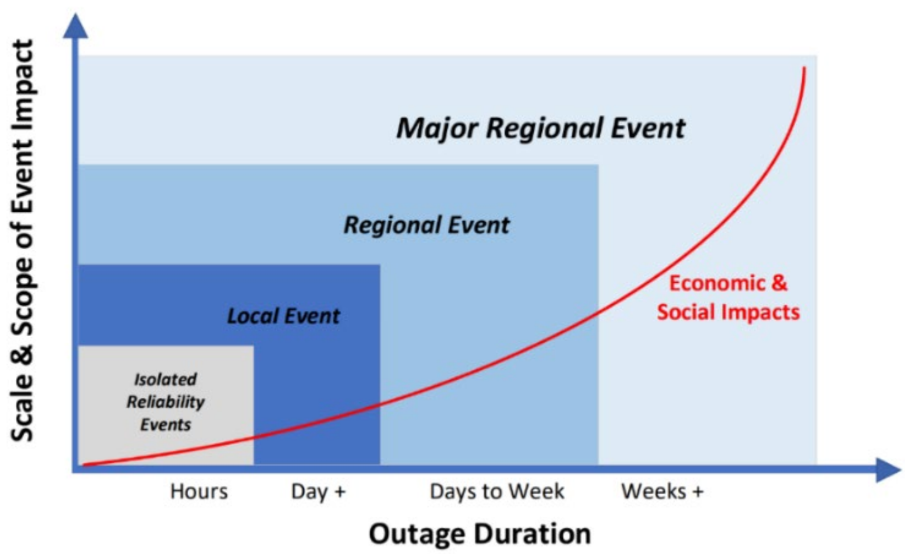

Figure 2. Reliability and resilience (Source: Romero Agüero, Julio, Quanta Technology. 2021. "Resilience of Power Systems." Slide 16, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021)

[7] Romero Agüero, Julio, Quanta Technology. 2021. "Resilience of Power Systems". PowerPoint presentation, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

Case Study: Michigan Power Grid Initiative Defines Conditions

In their ongoing MI Power Grid initiative, the Michigan Public Service Commission held a series of stakeholder meetings to better define service quality, which included defining terms for reporting outage information.[8] Under the proposed Michigan PSC definitions, normal conditions (or blue sky) result in sustained outages of less than 1% of a utility's customer base, gray sky conditions result in sustained interruptions for greater than 1% but less than 10% of a utility's customers, and catastrophic conditions (or black sky) result in sustained service interruptions for 10% or more of a utility's customers.[9] These rules are currently pending final approval.

Types of Resilience Technologies

Utilities leverage a variety of technologies and programs to help the grid be more resilient in the face of existing and future threats. Investments can range from capital-intensive -- like energy storage, transmission, substations, generation, and microgrid systems -- to other types of technologies that include hardware and software, to human resources. Customer-side resilience measures may also be considered by the regulator and utility for potential investments. Other examples of utility resilience investments include installing better monitoring equipment on utility infrastructure to receive near-real-time and real-time information on system operations and use those data to then proactively identify potential weak-spots on the system.

A familiar program is vegetation management, such as tree trimming. Utilities implement tree trimming so that when a weather event comes through a utility's service territory, the utility has successfully minimized the impacts of vegetation to reliability that may be caused from trees falling (or branches falling from the trees) onto utility poles, wires, and equipment, and creating an outage or service disruption.[10, 11]

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[8] "Grid Security and Reliability Standards Workgroup Staff Final Report: Service Quality and Reliability for Electric Service," Michigan Public Service Commission, Case No. U-20629 (December 15, 2020). https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t000000HwK3nAAF

[9] *In the matter, on the Commission's own motion, to establish a workgroup to review the service quality and reliability standards for electric distribution systems and to recommend potential improvements to the standards*, Order and Notice of Hearing, Case No. U-20629, Exhibit B (November 4, 2021). Available at: https://mi-psc.force.com/sfc/servlet.shepherd/version/download/0688y00000102drAAA

[10] More information on state-of-the-art vegetation management please see CPI Innovation Webinar: Smart Vegetation Management: New Approaches to an Age-Old Problem https://pubs.naruc.org/pub/AF3BB39F-1866-DAAC-99FB-5779B80D71FB

[11] Some utilities, such as PG&E and Florida Power and Light (FPL), have adopted "Right Tree, Right Place" programs to improve the placement of trees in the community. PG&E's is located at: https://www.pge.com/en_US/safety/yard-safety/powerlines-and-trees/right-tree-right-place/right-tree-right-place.page FPL's program is located at: https://www.fpl.com/reliability/trees/tree-location.html

Figure 3 shows a topical list of resilience categories that a utility may use to guide its planning and investment strategy.[12] Inside each category are a variety of reliance attributes and technologies. For example, for "Advanced Automation and Control," potential technologies and attributes include (but are not limited to)[13]:

- Smart protective and switching devices (e.g., smart reclosers/switches, self-resetting interrupters, etc.);
- Advanced reclosing (single-phase reclosing, pulse reclosing, etc.);
- Fault Location, Isolation and Service Restoration (FLISR); and
- Substation automation.[14]

Sophisticated technologies located on the distribution system that can support resilience include intelligent switches, remote fault indicators, and line sensors. These technologies are used by the utility to not only to identify when an outage occurs, but where the outage occurred and take immediate steps to minimize the extent and duration of the outage. Some technologies may be able to act autonomously (typically based on pre-

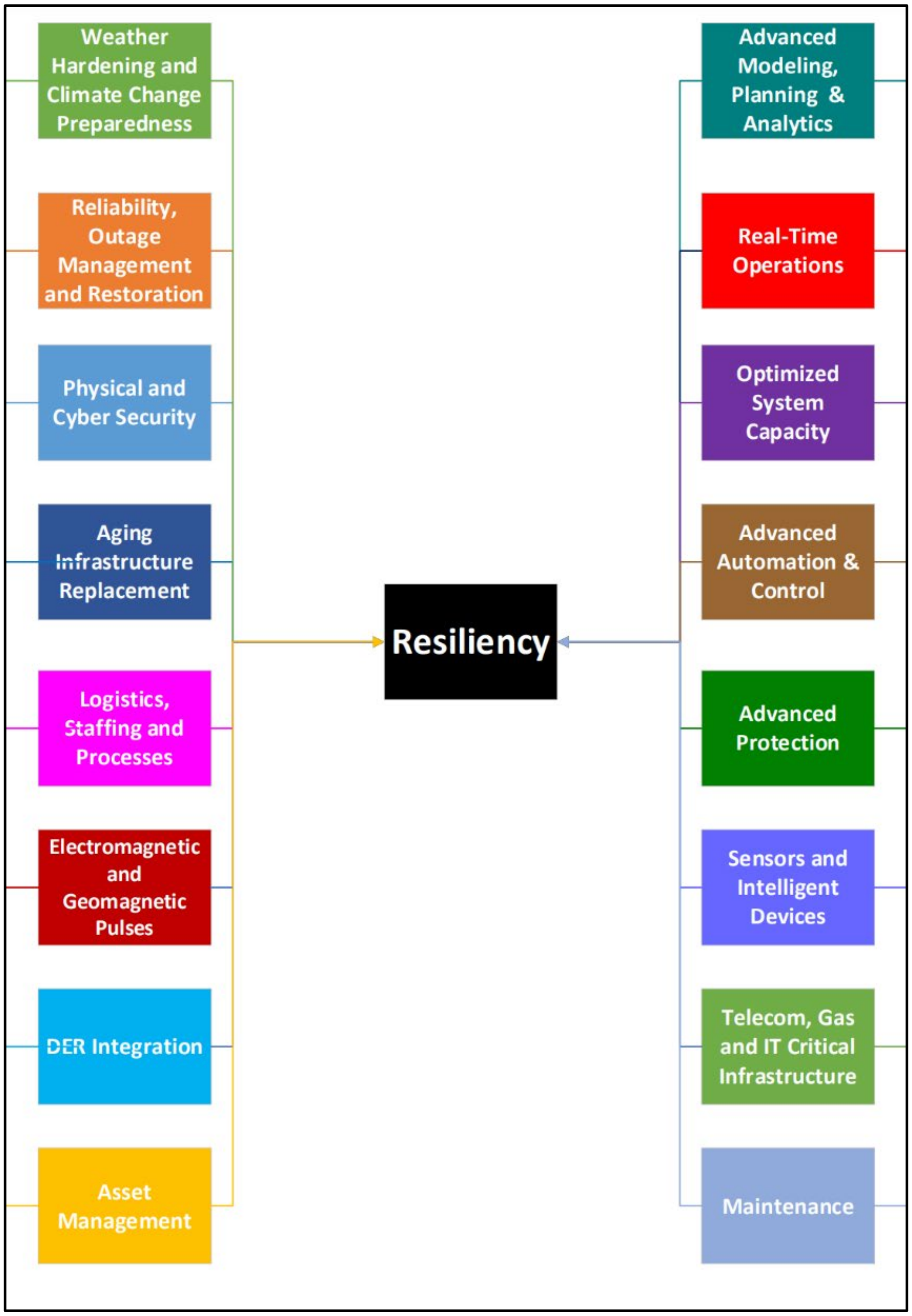

Figure 3. Types of Resilience Improvement Solutions (Source: Romero Agüero, Julio, Quanta Technology. 2021. Resilience of Power Systems, Slide 16. NARUC webinar, August 25, 2021)

[12] Romero Agüero, Julio. 2021. "Resilience of Power Systems. PowerPoint presentation, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.
[13] Id.
[14] Id.

determined settings), or the utility will dispatch a technology to provide electricity during times of need.

A component in the determination of which attributes and technologies to pursue in accordance with each category is a function of the threats and regulatory structure in which the utility operates. For example, a utility located near the Gulf of Mexico would prioritize resilience investments targeted towards hurricanes, while a utility in the northern plains might focus on winter storms and tornadoes. Not all technologies or attributes may be applicable to every utility across the country; the purpose of these technologies are dependent upon the risks and regulatory structure of the state.

Technology Example

Figure 4 shows an example of the types of technologies that might be installed across the distribution system to provide more information about operations down to the end user.[15] This home has solar panels connected to the distribution system where a variety of technologies provide data about operations and are located behind the meter and attached to utility infrastructure. Technologies, such as an advanced inverter and line sensor, can provide information about the real-time or near-real-time operations of the solar installation, which can be used by the utility to operate its system more efficiently by knowing how much electricity is flowing onto the distribution system or if there are any issues occurring on that line.

Information from the types of technologies identified in **Figures 3 and 4** can help the utility be more resilient. This is done through several means -- having information about DER can avoid overloading distribution circuits; can identify any overloaded circuits or transformers due to changes in end-use customer demand or introduction of DER at a location; can leverage DER to bring power on more quickly at a location; and can help in the identification of any imminent infrastructure failures due to age, vegetation incursions, or other events.

[15] Romero Agüero, Julio, Quanta Technology. 2021. "Resilience of Power Systems. PowerPoint presentation, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

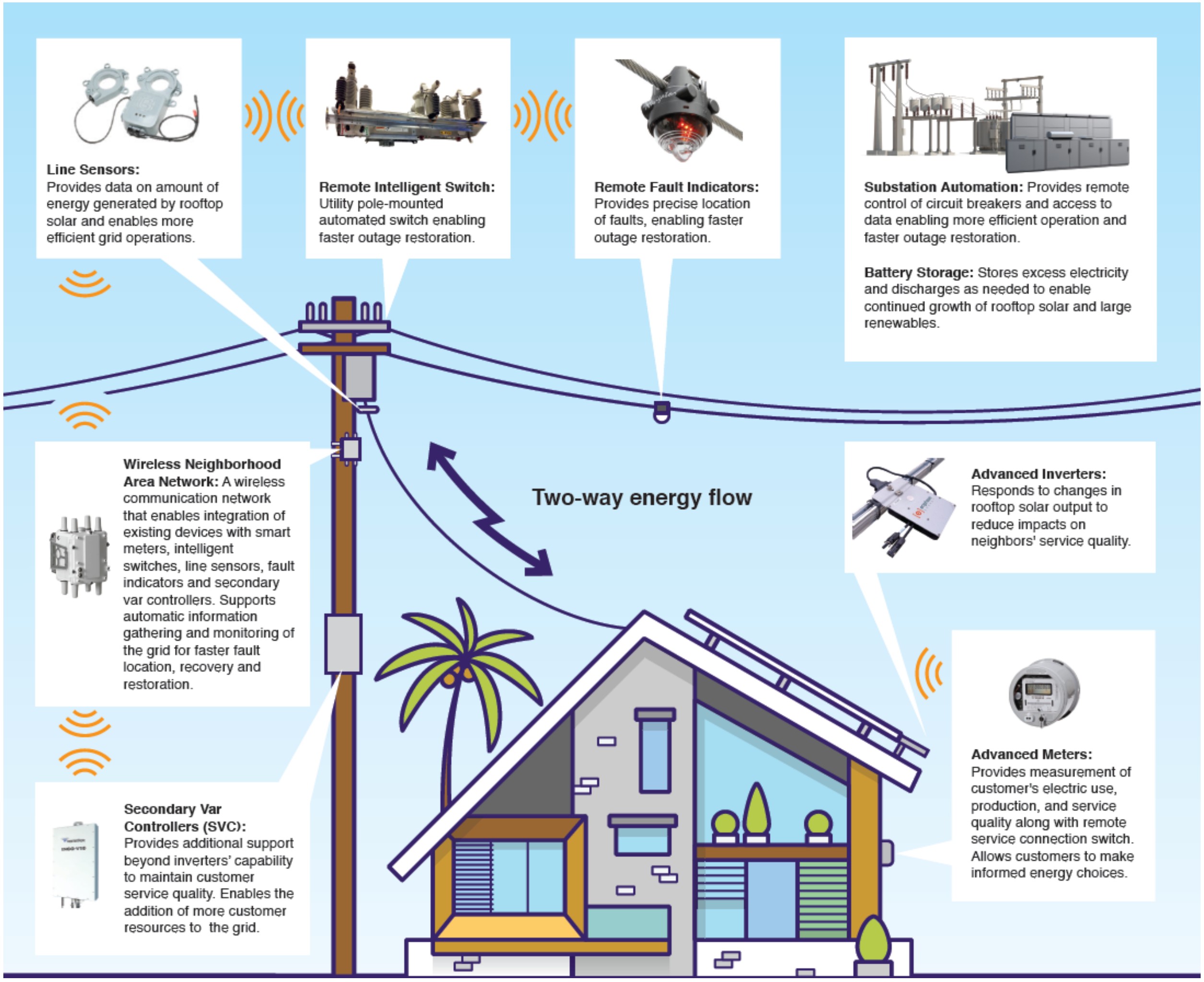

Figure 4. Examples of Solutions - Advanced Technology (Source: Romero Agüero, Julio, Quanta Technology. 2021. "Resilience of Power Systems. NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.)

Frameworks Towards Identifying Benefits and Measuring Resilience

Similar to producing a definition for resilience, measuring resilience may also be a challenge. As noted by IEEE, "it is not possible to have simple, industry-accepted resilience metrics addressing all possible events."[16] Therefore, having a framework to understand resilience, potential threats and hazards, and the metrics to measure resilience and the impacts of those threats and hazards can help regulators and utilities better plan and measure their path towards a more resilient system. This can also help balance short-term economic and investment pressures (pressure to act is high and uncertainty is low) compared to the long-term economic and investment pressures (pressure to act is low and uncertainty

[16] "Resilience Framework, Methods, and Metrics for the Electricity Sector," Technical Report PES-TR83, IEEE Power & Energy Society Industry Technical Support Leadership Committee Task Force at 1 (October 2020). https://resourcecenter.ieee-pes.org/publications/technical-reports/PES_TP_TR83_ITSLC_102920.html

is high).[17] In other words, resilience planning is based on the time horizon for action and implementation.

A few frameworks for valuing resilience are gaining traction in the industry. Different frameworks may serve different objectives, such as understanding the impact of an event that happened, forecasting future events, and planning investments. A general goal (and challenge) of developing a metric is to be simple, even if comprehensive.

Performance-Based Methods: Attribute-Based and Performance-Based

DOE and Sandia National Laboratory have developed two performance-based methods for constructing resilience metrics: multi-criteria decision analysis (MCDA or attribute-based) and performance-based. Either approach can be retrospective or forward-looking; power-focused or consequence focused; threat-informed or threat-agnostic.[18]

The first is multi-criteria decision analysis (MCDA), or attribute-based, which calculates a resilience index (RI) for ~1,200 attributes grouped into 350 categories. These attributes measure features that make a system more resilient and identify metrics that apply to an aspect of resilience, such as robustness and adaptivity.[19] RI inputs are qualitative and become quantitative with analysis.

The second are performance-based metrics which quantify system consequences during events and are suitable for investment planning.[20] Performance-based metrics look at how components of the system, and the system as a whole, performed during an event.[21] These inputs are quantitative and are countable.

IEEE PES Distribution Resilience Working Group

Another method, developed by the IEEE Power & Energy Society (PES) Distribution Resilience Working Group, focuses on the first twelve hours beginning when the customer loses power. The aim of this method is to develop a threshold for non-storm, gray sky days (GSD).[22]

Resilient Community Design Framework & Social Burden

The DOE-funded "Designing Resilient Communities" project, led by Sandia National Lab, is developing a four-phased resilience planning framework, validating it through data, surveying and modifying / simplifying the model, and applying it. An implementation challenge is understanding the impacts of resilience on different populations inside a utility service territory.

In the framework illustrated in **Figure 5**, there are roles for cities, utilities, and regulators for each of the four phases. First, these groups would consider the threats with which they are concerned. Then, they

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[17] Id. at 9-10.

[18] Jeffers, Robert "Bobby," Sandia National Labs. 2021. "A Performance-Based Approach to Equitable Resilience Planning." PowerPoint, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

[19] Id.

[20] Romero Agüero Julio. 2021. "Resilience of Power Systems. PowerPoint presentation, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

[21] Jeffers, Robert "Bobby," Sandia National Labs. 2021. "A Performance-Based Approach to Equitable Resilience Planning." PowerPoint, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021

[22] Romero Agüero Julio. 2021. "Resilience of Power Systems. PowerPoint presentation, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

would run a baseline analysis with the performance-based analysis in mind and consider the threats they are likely to experience. Then, the groups would consider their alternatives for improving their resilience including policy, market, and technology options. Finally, the groups would evaluate and implement from the suite of alternatives. These phases may sound familiar to planning professionals; the Designing Resilient Communities project maps the roles with these phases for integrated planning.

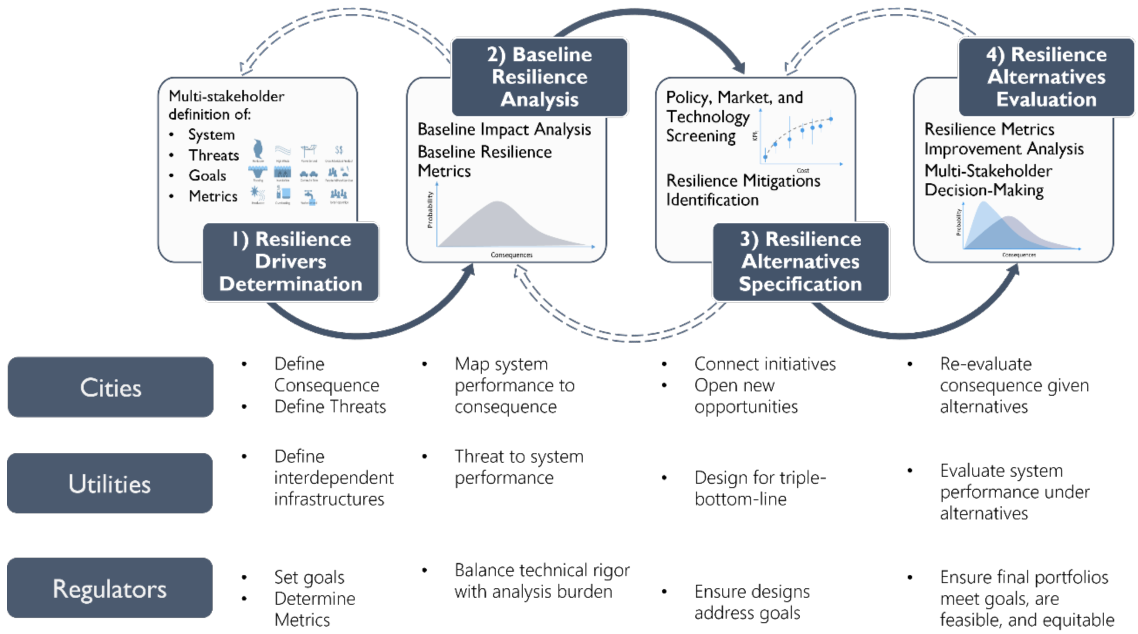

Figure 5. Resilient Community Design Framework (Source: Jeffers, Robert "Bobby," Sandia National Labs. 2021. "A Performance-Based Approach to Equitable Resilience Planning." PowerPoint, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021)

Social Burden

A separate report, also produced by Sandia, looks at the social burden for meeting basic needs as a metric for resilience.[23] This methodology would help identify not only the effects of an outage on a community, but which communities would suffer most under an outage. By identifying those communities and their needs, a regulator and utility could then prioritize investments in resilience to those communities most at risk.

A strategy built upon better information may help regulators and stakeholders in determining not only appropriate utility investments but identify the benefits and approaches to realize those benefits. Developing maps that identify areas of a system already at risk or subject to poor resilience may help identify areas to upgrade in advance. Looking at where outages are happening and how to improve the social impacts can be a place to start to address equity. A forward-looking metric for measuring resilience and equity based on "effort" (resources spent to achieve basic human needs, via microgrids, for example) and "ability" (leveraging predictor such as median household income) can help understand

[23] Jeffers, Robert "Bobby," Sandia National Labs. 2021. "A Performance-Based Approach to Equitable Resilience Planning." PowerPoint, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

where to send resources for recovery, including human needs, particularly if coupled with software such as the The Resilience Node Cluster Analysis Tool (ReNCAT). [24] With an increasing focus on equity in utility service, understanding social burden and the impact of resilience investments may be an important contribution.

Regulatory Considerations and Approaches

Resilience and reliability are not the only two metrics that regulators are concerned with when considering the value of utility investments -- cost is also an important consideration. Maintaining a reliable, efficient, and increasingly sustainable grid day-to-day is a primary concern and, especially with large investments, there may be tradeoffs, compromises, and integration of line items that a utility proposes to invest in and items the regulator approves for cost recovery. Synapse Energy Economics outlines four regulatory objectives: reasonable rates, customer equity, the public interest, and continuity of electric service (which encompasses resilience and reliability). Synapse urges that these objectives should be measured and measurable.[25] Benefit-cost analyses are typically used to inform regulatory decision making related to utility investments, but these approaches run into challenges when considering resilience investments due to the many difficulties of quantifying anticipated benefits, as discussed above.

Even on the cost side, there is a point where additional investment will hit a point of diminishing returns. In other words, where investing another $1 in resilience will not realize more than $1 in benefits and investments will reflect the preference for resilience over other system goals. Utilities face several generic constraints when devising resilience investment plans:

- The utility does not have an unlimited amount of money;
- Gold plating is a significant concern for regulators and stakeholders;
- Different threats can occur across a utility system; and
- There is more information available about system impacts after an event than during or before an event.

Regulatory Mechanisms

Furthermore, according to a Sandia National Labs report, "We find that regulatory mechanisms are not currently structured or applied to effectively address resilience, nor do incentives align well with the resilience goals of ratepayers and community representatives. Where regulatory mechanisms are applied to resilience, other goals than resilience have been the primary goal and resilience has not been well integrated."[26] In essence, existing cost-of-service ratemaking incentivizes capital expenditures by utilities; therefore, investments that do not fit this definition but do enhance resilience may not be financially attractive or pursued by the utility. This financial model also minimizes the utility's interest in

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[24] Jeffers, Robert "Bobby," Sandia National Labs. 2021. "A Performance-Based Approach to Equitable Resilience Planning." PowerPoint, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021

[25] Kallay, Jennifer "Jenn," Synapse Energy Economics. 2021. "Regulatory Mechanisms to Enable Investments in Electric Utility Resilience". PowerPoint presentation at 45, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

[26] "Regulatory Mechanisms to Enable Investments in Electric Utility Resilience Designing Resilient Communities: A Consequence-Based Approach for Grid Investment Report Series," Sandia National Laboratories at 6-7 (June 2021). https://www.synapseenergy.com/sites/default/files/Regulatory_Mechanisms_to_Enable%20_Investments_in_Electric_Utility_Resilience_SAND2021-6781_19-007.pdf.

leveraging customer or non-utility investments, such as using distributed energy resources as a resilience service.

To address these issues, a regulator may look to utilize a variety of methods to address resilience and to ensure that ratepayer funding is used cost-effectively by the utility and results in benefits to customers. As discussed in the case studies below, Sandia (and Synapse) reviewed actions in Vermont, California, New Jersey, Hawaii, and Puerto Rico that have started to look at ratemaking alternatives, such as performance-based ratemaking, integrated planning tariffs and programs to leverage private investment, additional business streams for the utility, enhanced cost recovery, and securitization.[27,28]

Case Study: Hawaii Performance-Based Regulation

Hawaii experiences a variety of frequent threats. The Hawaii Public Utility Commission (PUC) outlined resilience improvements as one of the goals for the system, although embedded in a broader goal. The Hawaii PUC adopted a performance-based regulation framework for addressing their goals. Their multi-year program has the following components: integrated grid planning process (IGP); multiyear rate plan (MRP); revenue decoupling; performance metrics and earnings-sharing mechanism; cost recovery mechanism for exceptional investments (Major Project Interim Recovery or MPIR); and microgrid services tariff.

Synapse offered a critique of some areas to monitor and improve in the resilience space, specifically: policies / goals are articulated but at times unclear how they will be prioritized and addressed by the utility; lack of performance metric for resilience; need for scrutinization of spending by regulators; clarification on how the MPIR will encourage resilience; and lack of focus on critical customers.[29]

Case Study: Vermont Tariff Design

Vermont experiences less frequent threats than Hawaii and has a goal to reduce peak demand-related utility costs and/or provide customers with backup power during outages (i.e., resilience is not a focus on this goal). Vermont implemented two energy storage tariffs that can lead to improved customer resilience: Bring Your Own Device (BYOD) tariff with a third-party or customer-owner; and Energy Storage System (ESS) tariff with a utility owner. Synapse offered a critique of some areas to monitor and / or improve for resilience, such as: incentive cap limits customer participation; lack of requirement for generation (storage only); lack of islanding requirement; lack of focus on critical customers; and no performance metric to specifically improve resilience.

Pilot Programs for Resilience Technologies

For the past few years, states have started to examine specific technologies and how those technologies can provide resilience benefits to the local system. Utility pilots may help determine appropriate

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[27] Id. at 20.

[28] Kallay, Jennifer, Synapse Energy Economics. 2021. "Regulatory Mechanisms to Enable Investments in Electric Utility Resilience." PowerPoint on slide 44, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

[29] Kallay, Jennifer, Synapse Energy Economics. 2021. "Regulatory Mechanisms to Enable Investments in Electric Utility Resilience." PowerPoint, NARUC webinar on Regulators' Financial Toolbox: Resilience Technologies, August 25, 2021.

technologies to address the need, the costs, benefits, and value of these investments, and how customers can help participate in these efforts.[30]

States such as California and Illinois have specifically looked at the role of microgrids to enhance local reliability and resilience in the face of events, such as weather risks or areas of a service territory prone to outages.[31] Both states have approved pilots for microgrids to understand the benefits provided, including resilience.[32] Other states have started to look at the resilience benefits of energy storage.[33] Some states have investigated how technologies, such as energy storage and microgrids can provide resilience services and their operational characteristics. From there, the utility and regulator began to identify the value of resilience to the system, community, and customer, as well as understand the conditions under which a program may be utilized.

Case Study: State Microgrid Programs in Connecticut and California

In 2012, the Connecticut legislature passed a law creating a new microgrid grant program to enhance community reliability and resilience after several major storms and hurricanes resulted in wide-spread outrages across Connecticut. To date, Connecticut has issued approximately $36 million in grants to communities to build microgrids housed around critical facilities that can provide electricity to those facilities when an outage occurs. Fuel sources for these microgrids can be fuel cell, renewables, batteries, or fossil fuels. In 2016, additional funding became available for proposals that used energy storage or renewable energy technologies to operate the microgrid. The Connecticut Department of Energy and Environmental Protection, Connecticut Green Bank, and its two investor-owned utilities, Eversource and United Illuminating jointly ran the program. [34]

The California Public Utilities Commission (CPUC) took a three-step approach to developing their microgrid program: (1) understand microgrid technology; (2) understand regulatory treatment options; and (3) catalog lessons learned on supporting resiliency. Their approach to understanding microgrid technology came from (a) their research and development (R&D); (b) formal proceedings and staff working groups; (c) participation with national laboratories and state working groups such as the

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[30] In 2020, Michigan constructed a list of Utility Pilot Best Practices and Future Pilot Areas; available at: https://www.michigan.gov/documents/mpsc_old/MPG_Pilots_Report_Draft073120_698001_7.pdf

[31] *Order Instituting Rulemaking Regarding Microgrids Pursuant to Senate Bill 1339 and Resiliency Strategies*, Decision Adopting Short-Term Actions to Accelerate Microgrid Deployment and Related Resiliency Solutions, D. 20-06-017, California Public Utilities Commission (June 17, 2020). https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M340/K748/340748922.PDF

[32] *Commonwealth Edison Co.*, Order, Illinois Commerce Commission, Docket No. 17-0331 (February 28, 2018). https://www.icc.illinois.gov/docket/P2017-0331/documents/276063/files/482264.pdf

[33] "Planning Considerations for Energy Storage in Resilience Applications," Pacific Northwest National Laboratory (March 2020). https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-29738.pdf; "Advancing Electric System Resilience with Distributed Energy Resources: A Review of State Policies," NARUC (April 2020). https://pubs.naruc.org/pub/ECD7FAA5-155D-0A36-3105-5CE60957C305; Energy Storage Policy Best Practices from New England Ten Lessons from Six States, Clean Energy Group/Clean Energy States Alliance (August 2021). https://cdn.cesa.org/wp-content/uploads/Energy-Storage-Best-Practices-from-New-England.pdf

[34] "Microgrid Grant and Loan Program," Microgrid Grant and Loan Program (Connecticut Department of Energy and Environmental Protection, 2020), https://portal.ct.gov/DEEP/Energy/Microgrid-Grant-and-Loan/Microgrid-Grant-and-Loan-Program.

NARUC-NASEO Microgrid State Working Group.[35] Working with national laboratories and other states has been helpful to the CPUC to share their findings and hear feedback from state and expert peers.

In the R&D space, there is a public purpose customer charge (on customer bills) that feeds into their Electric Program Investment Charge (EPIC) program (as well as other programs such as low-income programs) with the purpose of driving innovation and solutions for the benefit of Californians. In 2015, the CPUC directed their EPIC program administrators – CPUC, California Energy Commission and three investor-owned utilities – to focus part of their funds on microgrid and resiliency programs. To date, approximately forty-seven microgrid programs have been actualized from the EIPC program and lessons learned have been cataloged.

In their formal proceeding, Rulemaking R1909009, initiated in 2019 in response to legislation a year prior, SB1339, directing the CPUC to support the commercialization of microgrids. Stakeholders have been critical to the CPUC grasping the nuance of microgrid technology through comments on staff proposals and utility proposals. The CPUC has issued three decisions. Major decisions include (a) addressing public-safety shut offs through microgrids; and (b) initiating a CPUC staff microgrid and resiliency working group to lead stakeholders in preparing proposals through a variety of lens such as streamlining interconnection processes, microgrid incentive program, the value of resiliency.

The public-safety shut off microgrid program has been successful for supporting substations and temporary generation. For example, in one instance, about sixty-two substations were powered at different points during public-safety shut off periods. Individuals were able to leverage these programs as well as he utility.

The CPUC has leveraged a few regulatory treatment options. In addition to funding from R&D programs, the CPUC is considering how utility owned microgrids located in disadvantaged communities could be rate based. The microgrids would be funded in part (staff time, for example) through their Microgrid Incentive Program, which is an approximately $2 million program.

Additionally, the CPUC has identified a need to create a microgrid-like environment around utility substations. The substations are in the utilities rate base and paired with mobile diesel generation. Regulators treat diesel generators as an expense; the generators are not rate based. This treatment sends a signal that the program is temporary, and customers will not experience an increase since it is not part of rate base. These expenses are booked in a memorandum account which will go through a reasonable review either in a rate case or standalone review. For studying cleaner microgrid solutions at substations, the utilities would be able to include the expense as a balancing account to give them more certainty into those investments and a chance to receive recovery through a rate base.

The CPUC has also identified tariff changes that support customer and third-party ownership. The tariff clarifies how the customer/third-party will leverage the microgrid and costs associated with a microgrid for the third-party/customer. (Regulators should be cautious about leaving stranded assets in a situation where grid defection may cause remaining customers undue burden of costs.) Customers/third-parties may use the microgrid for resiliency, but also for other benefits such as leveraging time of use programs.

[35] NARUC-NASEO Microgrid State Working Group resources are available at https://www.naseo.org/issues/electricity/microgrids

Resources for More Detailed Information

Application of a Standard Approach to Benefit-Cost Analysis for Electric Grid Resilience Investments Designing Resilient Communities: A Consequence-Based Approach for Grid Investment Report Series, Sandia National Laboratories (May 2021). https://www.synapse-energy.com/sites/default/files/Standard_Approach_to_Benefit-Cost_Analysis_for__Electric_Grid_Resilience_Investments_19-007.pdf

"Electricity Grid Resilience: Climate Change Is Expected to Have Far-reaching Effects and DOE and FERC Should Take Actions," GAO-21-346, U.S. General Accountability Office (March 2021). https://www.gao.gov/assets/gao-21-346.pdf

"Federal Efforts to Enhance Grid Resilience," GAO-17-153, U.S. General Accountability Office (January 2017). https://www.gao.gov/assets/gao-17-153.pdf

FERC—NERC—Regional Entity Staff Report: The February 2021 Cold Weather Outages in Texas and the South Central United States, Federal Energy Regulatory Commission (FERC), North American Electric Reliability Corporation (NERC), and Regional Reliability Entities (November 2021). https://cms.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and.

National Association of Regulatory Utility Commissioners' Center for Partnerships and Innovation Resilience landing page. (Accessed December 2021). https://www.naruc.org/cpi-1/critical-infrastructure-cybersecurity-and-resilience/resilience/

"North American Energy Resilience Model," U.S. Department of Energy, Office of Electricity (July 2019). https://www.energy.gov/sites/prod/files/2019/07/f65/NAERM_Report_public_version_072219_508.pdf

Performance Metrics to Evaluate Utility Resilience Investments Designing Resilient Communities: A Consequence-Based Approach for Grid Investment Report Series, Sandia National Laboratories (May 2021). https://www.synapseenergy.com/sites/default/files/Performance_Metrics_to_Evaluate_Utility_Resilience_Investments_SAND2021-5919_19-007.pdf

"Planning for the Electric System of the future. The Path to a More Resilient Energy Grid," Critical Consumer Issues Forum (July 2020). http://www.cciforum.com/wp-content/uploads/2020/07/CCIF-Resilience-Report-July-2020-Final.pdf

"Planning for the Electric System of the Future - Cciforum.com." Critical Consumer Issues Forum, July 2020. http://www.cciforum.com/wp-content/uploads/2020/07/CCIF-Resilience-Report-July-2020-Final.pdf.

The Quest for Public Purpose Microgrids for Resilience: Considerations for Regulatory Approval Designing Resilient Communities: A Consequence-Based Approach for Grid Investment Report Series, Sandia National Laboratories (July 2021). https://www.synapseenergy.com/sites/default/files/The_Quest_for_Public_Purpose_Microgrids_for_Resilience_SAND%202021_8207_19-007.pdf

Regulatory Mechanisms to Enable Investments in Electric Utility Resilience Designing Resilient Communities: A Consequence-Based Approach for Grid Investment Report Series, Sandia National

Laboratories (June 2021). https://www.synapseenergy.com/sites/default/files/Regulatory_Mechanisms_to_Enable%20_Investments_in_Electric_Utility_Resilience_SAND2021-6781_19-007.pdf

“Reliability Issues Steering Committee Report on Resilience,” NERC (November 8, 2018). https://www.nerc.com/comm/RISC/Related%20Files%20DL/RISC%20Resilience%20Report_Approved_RISC_Committee_November_8_2018_Board_Accepted.pdf

“Resilience Framework, Methods, and Metrics for the Electricity Sector,” Technical Report PES-TR83, IEEE Power & Energy Society Industry Technical Support Leadership Committee Task Force (October 2020). https://resourcecenter.ieee-pes.org/publications/technical-reports/PES_TP_TR83_ITSLC_102920.html

“The Resilience Planning Landscape for Communities and Electric Utilities Designing Resilient Communities: A Consequence-Based Approach for Grid Investment Report Series,” Sandia National Laboratories (April 2021). https://www.synapse-energy.com/sites/default/files/Resilience_Planning_Landscape_for_Communities_%20Electric_Utilities_SAND2021-4171_19-007.pdf