Due to climate change, New York communities will experience hazards and conditions they have not encountered before. *Photo from iStock, 1130140918.*

Resilience Insights from New York State Stakeholders

A diverse set of New York State stakeholders—representing state agencies, authorities, utilities, and regulators—were interviewed on their perceptions of energy resilience. This summary synthesizes the 34 interviews to examine the degree of shared understanding around resilience, to identify opportunities to address common challenges, and to align stakeholder interests to better serve New York State's services, systems, and people.

Energy resilience has become a national priority as Americans experience more power outages attributed to climate change, extreme weather, and cyber events. Energy system owners and operators recognize that they must prepare differently for outages today than in the past. The call for transformational change is matched by an unprecedented amount of federal funding and private sector investment. Decision makers at every level face the unique challenges and opportunities of effectively and equitably executing this transition to more resilient systems.

The New York State Energy Research and Development Authority (NYSERDA) recently added resilience to its mission statement. As part of an effort to better understand and integrate resilience into NYSERDA initiatives and investments, the authority engaged the National Renewable Energy Laboratory (NREL) to develop a framework to measure and value resilience benefits.

For 15 years, NREL has worked with communities to develop resilience plans that have a quantifiable impact on social welfare through health, safety, and economic measures. Figure 1 shows NREL's framework for quantifying, valuing, and monetizing the system-wide impact of resilience investments (Anderson, Hotchkiss, and Murphy 2022). NREL researchers also developed a comprehensive resilience assessment methodology to help prevent power disruptions, to quickly restore electricity if an outage occurs, and to mitigate outage damage (Anderson et al. 2019). Research related to measuring, valuing, and justifying resilience investments are ongoing areas of exploration.

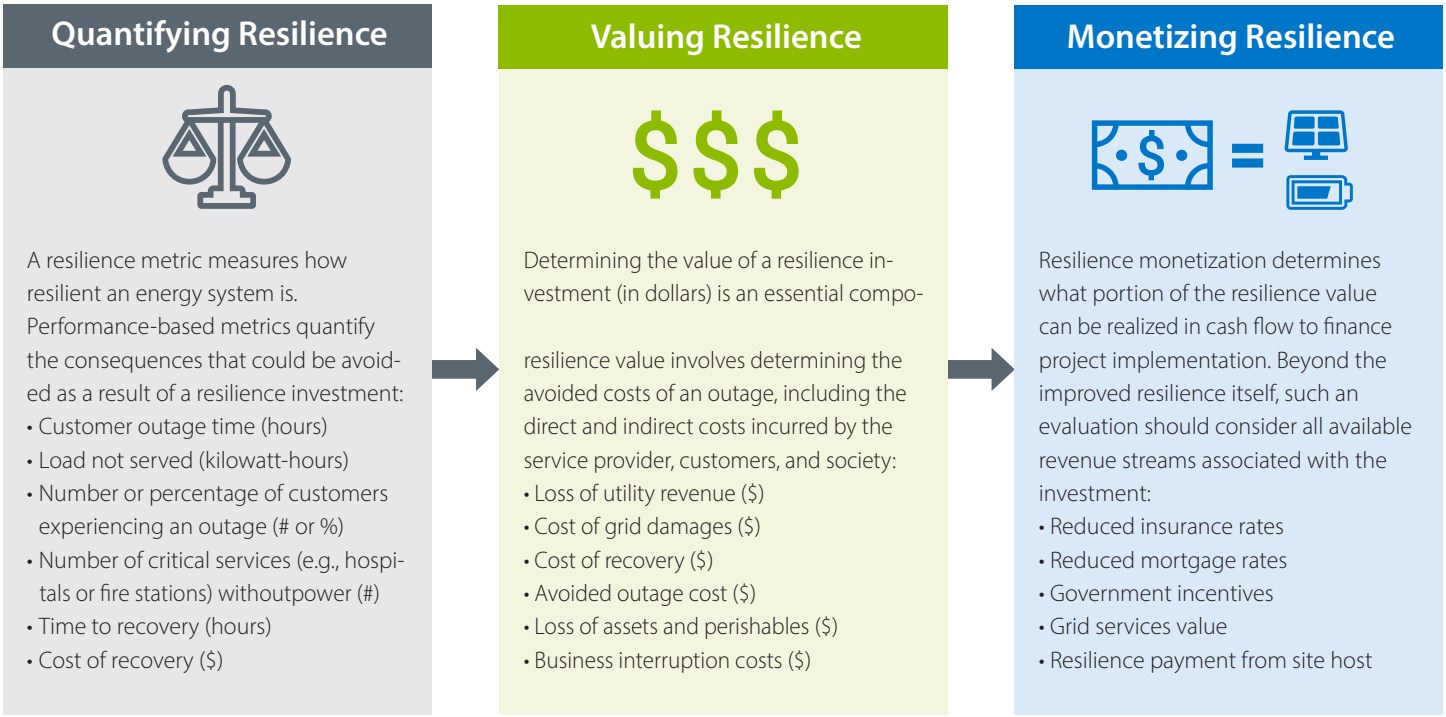

Figure 1. Evaluating resilience investments requires quantifying, valuing, and monetizing its impact on system resilience. *Anderson, Hotchkiss, and Murphy 2022*.

Background: Understanding Resilience

> Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.

In 2014, NREL developed this definition for resilience based on stakeholder input from more than 200 individuals from local, state, and federal government entities (Hotchkiss and Dane 2019). In 2022, stakeholders in New York State were asked to react to this definition and to reflect on whether and how it resonates with their work. These discussions revealed general alignment, with no strong views in agreement or disagreement. Instead, many stakeholders noted that it resembles definitions and practices used in their respective organizations. In the following analysis, the NREL research team draws connections between the various interviews to identify where defining resilience would serve New York State stakeholders or help answer pressing questions.

Establishing a definition of resilience helps distinguish it from similar concepts, such as reliability.

"Reliability is the ability to maintain power delivery to customers in the face of routine uncertainty in operating conditions, as in cases of flu tuating load and generation, fuel availability, and outage of assets under normal operating conditions. Reliability events typically result in shorter outage durations (seconds to hours) and smaller areas of impact (facilities, campuses, or neighborhoods).

Resilience focuses on preparing for, absorbing, adapting to, and recovering from low-probability, high-consequence disruptive events. Resilience events typically result in longer outage durations (days to months) and larger geographic areas of impact (states, regions, or islands). As a result, they could lead to cascading impacts in other critical infrastructures and parts of the economy"

– Anderson, Hotchkiss, and Murphy 2022

REFLECTIVE: using past experience to inform future decisions

RESOURCEFUL: recognize alternative ways to use resources

ROBUST: well-conceived, constructed and managed systems

REDUNDANT: spare capacity purposely created to accommodate disruption

FLEXIBLE: willingness and ability to adopt alternative strategies in response to changing circumstances

INTEGRATED: bringing together a range of distinct systems and institutions

INCLUSIVE: prioritizing broad consultation to create shared ownership in decision-making

Figure 2. The U.S. Department of Energy national laboratories have developed different typologies of resilience metrics. One typology defines various attributes of resilience, such as these examples.. *Image by Taylor Henry, NREL.*

Themes from Stakeholder Interviews

Several themes related to resilience emerged during the interviews. These represent priorities and values for NYSERDA to consider as it advances its resilience initiatives.

Resilience is Broader than Reliability

Utilities track power system reliability using the System Average Interruption Duration Index (SAIDI), which is the measure of the total time an average customer experiences long-term power interruptions each year, and the System Average Interruption Frequency Index (SAIFI), which measures the frequency of the interruptions (EIA 2020). There is an ease to tracking reliability using these standardized metrics, said one utility stakeholder, who expressed a desire for resilience metrics with a similar simplicity. In distinguishing between the two, one participant explained that they now see reliability as one piece of larger resilient operations.

Implementing a shared definition of resilience and its attributes will allow system operators to track their system's performance and measure the value of resilience investments. Understanding whether an investment results in the intended benefit (e.g., withstanding shocks or rapidly recovering from an outage) is key.

Resilience Has a Strong Local Dimension

When discussing different climate-related consequences, several interviewees acknowledged that many resilience capacities must be focused locally. Interviewees also underscored the importance of community participation to prepare for, respond to, and recover from disruptions. There was agreement that resilience solutions are effective when they reflect a given population's lived experiences and cultures and when community input shapes the vision of success.

Stakeholders from one agency described the need for place-based resilience and adaptation planning in the following terms: "When we define local resilience, it is going to be resilience of what, to what, for whom, in what place, and at what scale. Who participates, who pays, and who benefits?" Knowledge of the local infrastructure, the availability and quality of information, the social and economic networks, and the environmental resources and risks, among other factors, must complement national best practices.

Resilience Must Focus on Equity

Living in a healthy, just, and equitable community is a reliable predictor of people's physical and emotional well-being. Disparities in the health outcomes of different social groups can be attributed to race and income as well as environmental conditions, such as poor air quality and water and soil contaminants. Under the Climate Leadership and Community Protection Act, New York State requires that disadvantaged communities receive at least 35% of investments in clean energy and energy-efficiency programs to ensure that all New Yorkers reap the benefits of this nation-leading law (New York State 2022).

Health and climate disparities are evident during major hardships when under-resourced communities struggle to

Participating Organizations

NYSERDA and NREL are indebted to the New York State stakeholders who volunteered their time for the interviews and shared their expertise. All comments in this summary came from members of one of the following organizations, though they are intentionally not attributed.

- ConEdison
- National Grid
- New York Independent System Operator
- New York State Department of Environmental Conservation
- New York State Department of Financial Services
- New York State Department of Public Service
- New York State Department of State
- New York State Office of General Services.

withstand, respond to, and rapidly recover from disruptions. Stakeholders noted that communities that are already overburdened by persistent inequitable distributions of pollution also face increased consequences from climate change, including, for example, New York State's increased inland flooding, heat waves, and coastal storms.

Generally, stakeholders agreed that policymakers need inclusive and specific resilience strategies that resonate with frontline communities, which requires long-term commitment and active listening to understand community concerns. One interviewee pointed to the Buffalo Sewer Authority's Green Infrastructure Stewardship Program as a success story. The community identified stormwater management as a key concern for addressing climate change resilience, reducing pollution, protecting the water supply, and improving the quality of life in neighborhoods experiencing sewer flooding. The program includes green infrastructure deployment to manage runoff, along with workforce development to prepare Buffalo's young adults to enter a fast-growing environmental sector.

Resilience is Critical for a Healthy Economy

A storm and power outage in one location can quickly disrupt the regional supply chain, resulting in significant losses. Climate change can also generate economy-wide risks through disruption to business models, cascading failures from extreme disasters, and increased litigation. Several interviewees noted the importance of considering the ability to anticipate, to prepare for, and to adapt to "changing conditions" in reference to the consequences of climate change as well as the expected changes coming from New York State's clean energy transition. Deep decarbonization will significantly affect specific sectors and the economy as a whole.

A solar photovoltaic array in New York City provides redundant power for city residents. *Photo from Aeon Solar, NREL 18523*

Community Resilience

Many stakeholders stressed the importance of fostering resilience at the local level. The research literature refers to "community resilience," which is facilitated by four essential assets: (1) an information-sharing environment, (2) engaged governance, (3) community leadership, and (4) problem-solving ability (Slingerland et al. 2022).

The Financial Value of Resilience Must be Measured

Several stakeholders expressed interest in financial valuation strategies, such as the value of lost services and good due to lost supply of power. To use metrics in practice, however, organizations need to quantify the baseline resilience of existing systems and then track impacts from resilience investments against this baseline. Several interviewees raised challenges around measuring the costs and benefits of resilience, including nonfinancial benefits, such as social and health advantages, and misalignment between who pays and who benefits from resilience investments. To quantify the benefits of resilience investments, one stakeholder suggested measuring lost tax revenue and state domestic product attributed to power disruptions. Another was interested in measuring the aggregated cost of repairing a vulnerable system over decades of maintenance compared to an upfront investment in storm hardening.

Resilience Measures Must be Informed by Context

Resilience was largely a context-specific phenomena for the stakeholders interviewed. This was illustrated with examples of geographic variation and disproportionate financial resources. Context can also refer to customers' differing expectations for grid reliability and restoration times. A region with newer physical assets in its energy system might prioritize resilience investments less than a region with aging infrastructure that is due for improvement. The context-specific nature of resilience can pose a challenge to establishing more standardized practices; however, several stakeholders observed that resilience is not an outcome but an iterative process because context and conditions will always be changing. Individual emergencies and communities are unique, but inclusive planning and proactive measures can harden the grid and help anticipate and respond to any number of threats.

Resilience Requires Physical Measures

Energy resilience requires investments to make assets more robust, which can include hardening or upgrading components and lines. It also requires siting assets in locations that will not be prone to disruptions from hazards or threats,

such as floodplains. As the energy sector modernizes, there will be more opportunities to integrate distributed renewable energy resources or battery energy storage systems that can help communities withstand shocks and more rapidly recover. Meanwhile, smart controls and grid edge devices could create potential cybersecurity vulnerabilities if asset owners and operators do not prepare for known security concerns and anticipate emerging threats. Incorporating resilience by design into New York State's communities, systems, and infrastructure will reap benefits for decades to come.

Opportunities for New York State

The research team identified potential opportunities to incorporate resilience planning and to address challenges raised in the stakeholder interviews.

Increase Understanding of Changing Conditions

Resilience planning means not only addressing the threats and hazards of today but also anticipating future needs. Additionally, understanding what stakeholders are becoming resilient to, and for whom, is key to addressing challenges. Adaptive capacity is strongly connected to resilience and needs to be incorporated into resilience strategies. One energy sector representative explained that historical trends can no longer inform preparedness because new hazards are arising that have not been encountered before. In this way, resilience must not only reflect lessons learned from the past but also, importantly, anticipate what is coming.

Another state agency representative noted that "simply going back to the way we were with additional ability to withstand hazards may no longer be tenable." Stakeholders advocating environmental justice were particularly reticent to adopt the term resilience if resilience is largely accepted to mean maintaining the status quo. One of the most difficult areas of resilience is how to assist communities if ultimately no number of investments will secure their sustainability or long-term survival. One participant described "building social adaptive capacity" as a way to face emerging unknowns.

Assist Statewide Coordination and Standards Development

Some stakeholders noted that New York State currently does not have statewide standards or codes addressing resilience, although certain municipalities or agencies might operate with their own guidelines. One interviewee referenced a good example in the Climate Resiliency Design Guidelines from the New York City Mayor's Office, which "provide step-by-step instructions on how to supplement historic climate data with specific, regional, forward-looking climate change data in the design of City facilities" (New York City 2022). The New York City Department of City Planning released valuable interactive tools, including the NYC Flood Hazard Mapper, and resources on zoning for floodplain and coastal resilience. A coordinated approach to statewide standards would help normalize best practices and expectations for all.

Develop Data Assets to Benefit Investment Decisions

Uncertainties around changing conditions and mitigating solutions often contribute to a reluctance to increase resilience investments. For example, certain areas of New York State are experiencing inland flooding and heat waves due to multiple factors that are sometimes not well understood. More data and actionable data analysis would help prepare for natural hazards and anticipate long-term trends. In addition, some stakeholders were concerned that an incomplete understanding of all future risks could lead to resilience investments with negative unintended consequences. One example was a proposed floodwall in New York City that would protection one community from storm surges while possibly redirecting flooding to others nearby. Developing and sharing quality data and success stories related to solutions can inform investments in a more comprehensive and equitable manner.

Metrics and Valuation Strategies

Findings from the interviews indicate that a major challenge for resilience is translating abstract and complex concepts into real-world decisions and activities that can be assessed in a meaningful way. Nearly every participant described tracking grid reliability by the frequency and duration of outages and institutionalizing mitigation indicators; however, participants did not reference any formal resilience metrics in use despite broad appreciation for the task.

National laboratories have been researching resilience metrics, but there is no single metric that applies to the resilience of different energy sector domains. A utility underscored the value of creating a set of known measures of an energy system's effectiveness under different hazard and threat conditions. Resilience solutions, such as installing emergency backup systems and hardening critical system components, can come with increased capital or operating costs. Understanding how to balance investment costs against the values, or benefits, they provide is an important step in prioritizing or incentivizing resilience actions. Valuation strategies and metrics also allow stakeholders to track successes. For example, one electricity provider noted that the company avoided 680,000 outages based on changes they made to the utility system after Hurricane Sandy. With this measurement, the company was able to quantify how resilience investments benefited its customers and assess its ability to withstand extreme storms.

Conclusions

Resilience is a complex and nuanced topic that has only recently started gaining attention in the energy and electric grid sectors. As federal agencies, state offic , and private companies prioritize funding for resilience, it is important that the energy sector's definition of esilience is congruent across New York State and aligns with national efforts. Resilience will inevitably come to play a role in the programs and services of every agency in the state, and decision makers will need to effectively determine when, where, and by how much resilience measures should be taken.

Through the 34 stakeholder interviews, NYSERDA and NREL were able to baseline current perspectives on resilience and identify information gaps and common interests that the statewide resilience mission can address. Participants showed great interest in transforming and building energy and infrastructure systems to withstand, respond to, and rapidly recover from disruptions. Although reliability is well understood across agencies, expanding the view to include the resilience of low-frequency, high-consequence events will require new and accessible tools, data, and evaluation practices. Stakeholders underscored the necessity of community participation in resilience planning and allocating resources to ensure that benefits equitably each disadvantaged communities. Interviewees also related to the "changing conditions" in NREL's definition of esilience because historical precedent will no longer predict future conditions, and recovery will not mean a return to the previous state. The costs of resilience investments are fairly well understood and measured, but the benefits a e less so.

In a forthcoming companion report, NREL lays out a framework for quantifying and valuing resilience, discusses the current state of resilience valuation tools, and provides case studies of resilience projects in New York State that demonstrate measurements of resilience attributes. By implementing the resilience planning process, regional stakeholders can work together to better anticipate and prepare for disruptive events and to improve the capacity to safely, securely, and promptly recover.

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A NYSERDA-NREL Collaboration

In February 2022, NYSERDA initiated a project with NREL to quantify and value the benefits of implementing measu es to strengthen resilience. NYSERDA has recently added resilience to its mission statement and is working to foster resilience investments across the energy grid and built environment. The resilience project with NREL includes several components: a) discussions with internal and external stakeholders toward codifying a common understanding of resilience, and b) a literature review of energy resilience metrics and fundamentals. These two components are the foundation for a third project to develop a framework to measure and value resilience, coupled with illustrative examples.

NREL Transforming ENERGY

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