4.5.5 Resilience

The interconnection process evaluates distributed generation, and now storage, for reliability impacts on a project-by-project basis; to get a Certificate of Public Good, each project must demonstrate it will not adversely impact system stability and reliability. Reliability, as a concept, is a core tenet of Vermont energy policy (30 V.S.A. § 202a*)*:

> *It is the general policy of the State of Vermont:*
>
> *(1) To assure, to the greatest extent practicable, that Vermont can meet its energy service needs in a manner that is adequate, reliable, secure, and sustainable; that assures affordability and encourages the State's economic vitality, the efficient use of energy resources, and cost-effective demand-side management; and that is environmentally sound.*

Distribution grid reliability is governed by specific requirements and standards.[95] Distribution utilities are also required to file Service Quality and Reliability Plans with the PUC and PSD, reporting on reliability performance metrics such as the frequency and duration of outages, along with a list of the utility's worst-performing circuits and plans to improve their reliability.[96]

Reliability is also a core tenet of the concept of "energy assurance," as articulated in Vermont's Energy Assurance Plan (itself part of the state's Emergency Operations Plan). It defines energy assurance as:

> *"The ability to obtain, on an acceptably reliable basis, in an economically viable manner, without significant impacts due to Energy Supply Disruption Event(s), or the potential for such events, sufficient supplies of the energy inputs necessary to satisfy Residential, Commercial, Governmental, and non-governmental requirements for Transportation, Heating (space and process heat), and Electrical Generation."*[97]

In other words, reliability is a strictly defined term subject to specific standards, metrics, reporting, enforcement, and penalties. It is, foundationally, about avoiding "loss of load" (or power outages), both in number and duration, during day-to-day operations, with metrics focusing on reliability performance over a specified period of time. NERC defines a reliable bulk power system as "one that is able to meet the electricity needs of end-use customers even when unexpected equipment failures or other factors reduce the amount of available electricity."[98] The concept includes both *resource adequacy* — i.e., sufficient supply — and *security*, or the ability to withstand sudden unexpected disturbances, either natural or man-made.

Resilience (or resiliency), on the other hand, is more of a term of art, subject to a variety of proposed definitions, with an evolving landscape of potential metrics but without specific regulatory "teeth."

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[95] See https://www.ferc.gov/sites/default/files/2020-04/reliability-primer_1.pdf, https://www.ferc.gov/industries-data/electric/industry-activities/nerc-standards, and https://www.npcc.org/program-areas/standards-and-criteria/regional-standards.

[96] https://puc.vermont.gov/sites/psbnew/files/doc_library/4900-electricity-outage-reporting_0.pdf

[97] https://publicservice.vermont.gov/sites/dps/files/documents/VT%20Energy%20Assurance%20Plan%20August%202013.pdf

[98] https://www.nerc.com/AboutNERC/Documents/NERC FAQs AUG13.pdf

Nevertheless, it is increasingly heralded, including by stakeholders in Vermont, as an objective of the modern grid and an attribute of various DERs.

FERC has proposed the following definition of resilience, which has been adopted by NERC: "The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[99] Unlike reliability, resilience is usually thought of in terms of a specific, low-probability, high-impact event. But without imposition of a measurement or valuation framework, it is not particularly meaningful to describe a grid as resilient, or to describe a resource as providing grid resilience.

The *Modern Distribution Grid* report describes reliability as an *objective* of the modern grid, while resilience is an *attribute*:

- ***Resilience events*** *cause larger geographic impact on distribution and/or bulk power system with long-duration outage — typically greater than 24 hours and classified as "Major Events" according to IEEE 1366.*
- ***Distribution-level resilience events*** *occur when there are similar infrastructure failures as ones that happen in reliability events (e.g., wires down, poles broken, transformer failure, fuses blown) but at a greater scale that requires significant complexity to address.*
- ***Reliability events*** *have a local impact with short duration outage — generally less than 24 hours and not classified as "Major Events" according to IEEE 1366.*

Exhibit 4-14. Reliablity-Resilience Event Continuum

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[99] https://elibrary.ferc.gov/eLibrary/#, Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing
Additional Procedures, 162 FERC ¶ 61,012, para. 14, FERC Dkt. No. AD18-7-000 (Jan. 8, 2018). Pp. 12-13. Accessed 12/5/20.
[100] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 30

The authors state: "Resilience planning involves assessing the potential distribution system impacts from major resilience events, while reliability planning focuses on maintaining or improving a distribution system's performance in relation to minor outages as measured by the IEEE 1366 reliability metrics (e.g., CAIDI, SAIDI)." They highlight a three-pronged planning approach, developed by the Electric Power Research Institute:

> • ***Prevention:*** *Preventing damage in the distribution system requires changes in design standards, construction guidelines, maintenance routines, and inspection procedures using innovative technologies.*
>
> • ***Survivability:*** *The ability to maintain some basic level of electrical service using resilient technologies to critical consumers or communities in the event of a complete loss of electrical service from the distribution system.*
>
> • ***Recovery****: Rapid damage assessment, flexible grid designs, prompt crew deployment to damaged assets, and readily available replacement components.*

"Fundamental to resilience planning is determining a risk strategy integrated with the approach above," they note in conclusion. "This involves determining the risk associated with threat impacts, determining the appropriate risk tolerance and related strategic approach for accepting certain level of risks, mitigating the impact of certain risks, and enabling the avoidance of other risks. These strategies for various risks inform the development of various grid, customer, and third-party solutions.[101]

The Department assisted the Rural Resilience & Adaptation Subcommittee of the Climate Council in developing Climate Action Plan recommendations related to energy infrastructure resilience. The strategies and actions included in the initial adopted plan encompass the domains of prevention, survivability, and recovery, with numerous specific actions under each of the following strategies:

A. Create a policy, planning, and organizational foundation to support effective investments in infrastructure resilience.
B. Public, private, and nonprofit entities should be prepared to respond and recover quickly to disruptions caused by severe weather and other climate change threats.
C. Increase the resilience of critical infrastructure to severe weather and other climate change threats by reducing vulnerabilities of specific facilities.
D. Increase the resilience of critical infrastructure to severe weather and other climate change threats by improving system efficiency, reliability, and redundancies.[102]

Several key questions remain. Who is the responsible entity for each action? How will the necessary action be funded? And how will we know when resiliency has been increased, especially when the threat landscape (in this case, climate-change-induced baseline as well as severe weather) keeps getting worse?

Along with understanding how climate change will impact weather and infrastructure in Vermont, it will be necessary to develop metrics to measure the impact of investments, especially if ratepayer dollars are

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[101] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 30

[102] https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf, pp. 148-152

proposed to be used. Lawrence Berkeley National Laboratory's Joe Eto has proposed the following as potential metrics for measuring the impacts of resilience investments:

Exhibit 4-15. Grid Modernization Lab Consortium Resilience Metrics

GMLC Resilience Metrics	Data Requirements
Cumulative customer-hours of outages	customer interruption duration (hours)
Cumulative customer energy demand not served	total kVA of load interrupted
Avg (or %) customers experiencing an outage during a specified time period	total kVA of load served
Cumulative critical customer-hours of outages	critical customer interruption duration
Critical customer energy demand not served	total kVA of load interrupted for critical customers
Avg (or %) of critical loads that experience an outage	total kVA of load severed to critical customers
Time to recovery	
Cost of recovery	
Loss of utility revenue	outage cost for utility ($)
Cost of grid damages (e.g., repair or replace lines, transformers)	total cost of equipment repair
Avoided outage cost	total kVA of interrupted load avoided
	$ / kVA
Critical services without power	number of critical services without power
	total number of critical services
Critical services without power after backup fails	total number of critical services with backup power
	duration of backup power for critical services
Loss of assets and perishables	
Business interruption costs	avg business losses per day (other than utility)
Impact on GMP or GRP	
Key production facilities w/o power	total number of key production facilities w/o power (how is this different from total kVA interrupted for critical customers?)
Key military facilities w/o power	total number of military facilities w/o power (same comment as above)

[103]

For example, one of the infrastructure resilience actions included in the Climate Action Plan is:

> *Identify mission critical facilities in collaboration with local and regional planners, utilities, and transportation providers to identify actions, procedures, or investments to mitigate the impact of extreme weather events to services provided by these facilities. Examples of mission-critical facilities include designated emergency shelters, first responder facilities, hospitals and other medical facilities, key infrastructure such as water/wastewater pumping and treatment and sewer, key communications infrastructure such as fiber nodes, government offices, fuel suppliers, transportation hubs, supermarkets and other facilities municipalities identify as critical to serving communities during extreme weather events.*

An investment proposed to enhance resilience at such a facility could be tied to a metric such as "time to recovery," "critical services without power," or "loss of assets and perishables." Projects to serve mission-critical facilities could look like backup power at a single facility, or perhaps a microgrid serving a number of facilities that are both physically close and on the same "part" of the grid (such as GMP's forthcoming microgrid in Panton, and similar projects being evaluated under its "Resiliency Zones" initiative).[104]

A microgrid serving a community facility or facilities falls somewhere in between the spectrum of "resilience for one" (residential storage) and "resilience for all" (increased tree trimming,

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[103] https://eta-publications.lbl.gov/sites/default/files/5_-_eto_reliability_and_resilience_based_planning_4.pdf. In this table, "GMP" refers to Gross Municipal Product and "GRP" refers to Gross Regional Product.
[104] https://greenmountainpower.com/gmp-announces-pioneering-microgrid-in-panton-vt/

undergrounding lines, etc.), and matters from the perspective of assigning costs (or attributing benefits). Utilities are required to provide every customer with reliable electric supply, and "upstream" investments (vegetation management, moving cross-country lines to roadsides, even strategic undergrounding) will likely benefit more customers for every dollar invested, making these types of investments potentially the most equitable.

Meanwhile, there are instances where customers may make individual investments, with or without utility involvement, to enhance their individual reliability (or, potentially, resiliency). One example is customer-sited generators, or batteries, such as those deployed under Green Mountain Power's Powerwall and Bring Your Own Device tariffs.[105] In those programs, customers pay for the enhanced personal grid reliability that the battery storage offers, while all the utility's customers both pay for and gain benefit from the other values provided by the storage in the aggregate, such as reducing peak-related charges. A microgrid benefits a specific group of customers (campus, community, etc.), but can also provide system-wide values to all customers, akin to the fleet of residential batteries, which may help offset a large portion of its own costs.

Exhibit 4-16. Resilience Solutions Map

[106]

4.5.6 Communications

Of course, realization of the modern grid will succeed or fail in large part based on the availability and attributes of communications infrastructure. Ubiquitous communications networks that reach the grid edge, with sufficient speeds, information-carrying capabilities, and both physical and cyber security

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[105] https://greenmountainpower.com/rebates-programs/home-energy-storage/
[106] https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf, p. 38