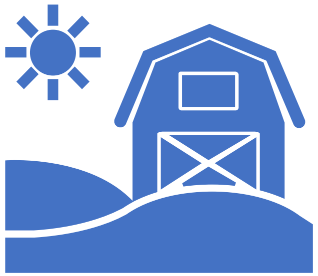
Rural Resilience and Adaptation Sub-Committee

VT Climate Council



Report on Work Program Task 3

July 2, 2021

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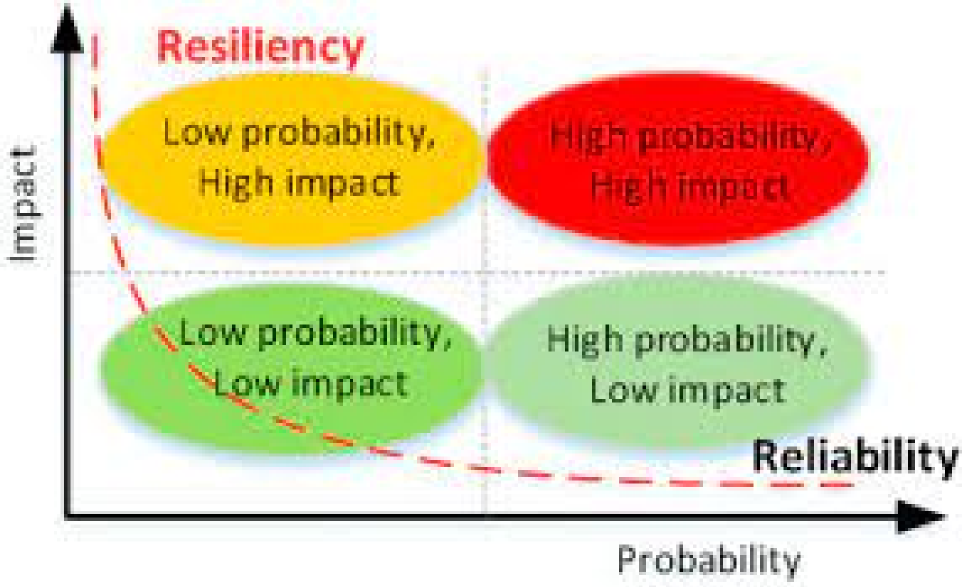
Work Program Tasks

3. Develop recommendations for fortifying electrical and communications infrastructure and implementation of storage-supported local electrical systems.

Background

Joe Eto's Structured Approach to Resilience Planning

Metrics for Resilience in Theory and Practice (Joe Eto, LBNL, 2018)

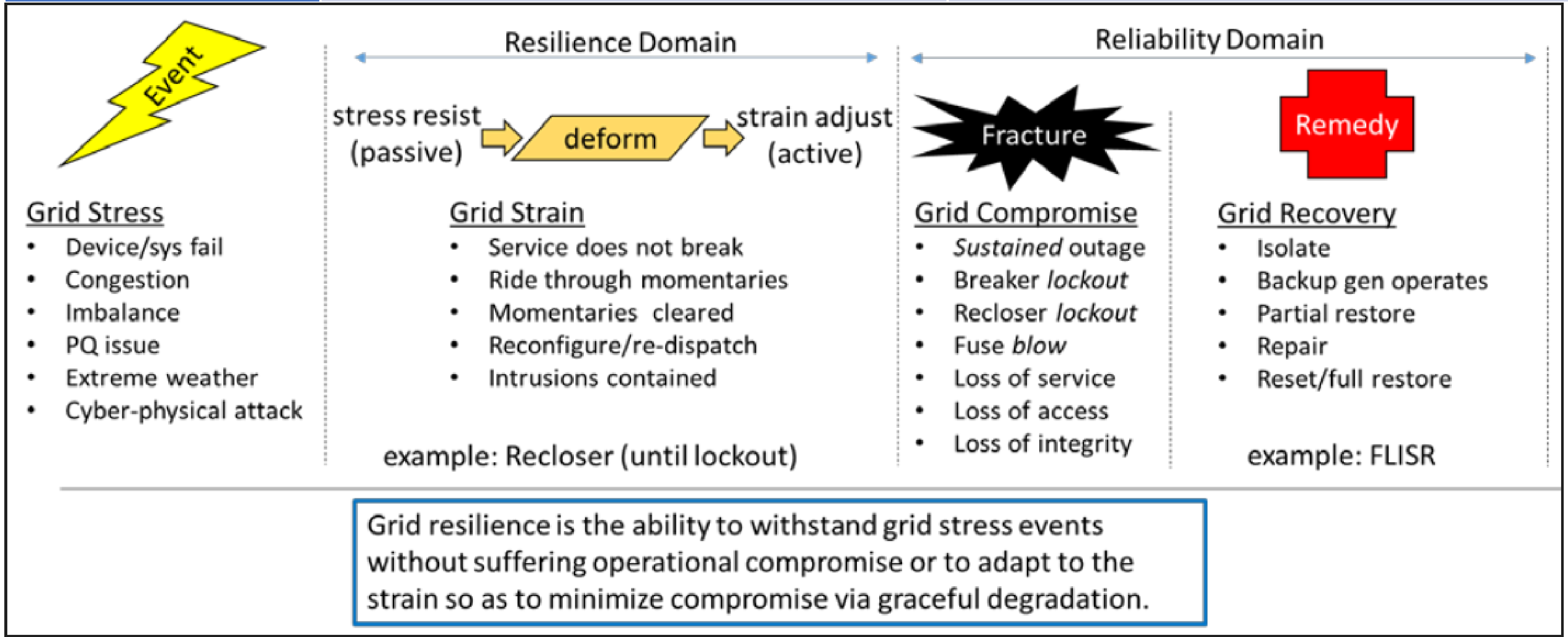


- What resilience **threat(s)** is the focus?
- What **aspect(s)** of the threat(s) is of concern?
  - *Can we measure the extent to which these concerns are or will be addressed? How will we know if we have made things better or if they are getting worse (in the absence of an actual threat)*
- What is our **design standard** for addressing these concerns?
- What are the pros and cons of available **alternatives** for meeting these standards?
  - *What is the lowest cost option?*
  - *What, if any, additional benefits might they provide? What are these worth?*
  - *Are there options for recourse?*

Reliability vs. Resilience

	Reliability	Resilience
Common features/ characteristics	Routine, not unexpected, normally localized, shorter duration interruptions of electric service Larger events will make it into the local headlines	Infrequent, often unexpected, widespread/long duration power interruptions, generally with significant corollary impacts Always front page news, nationally

Metrics for Resilience in Theory and Practice (Joe Eto, LBNL, 2018)



https://gridarchitecture.pnnl.gov/media/advanced/Electric_Grid_Resilience_and_Reliability.pdf

Potential 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)

https://eta-publications.lbl.gov/sites/default/files/5_eto_reliability_and_resilience_based_planning_4.pdf

Potential goals and methodology

The **goal** of fortifying communications infrastructure in the context of the Climate Action Plan is to ensure consumers are able to **access communications within X hours/days of a loss of communications service** in the event of a climate resilience threat with.

The **goal** of fortifying electrical infrastructure in the context of the Climate Action Plan is to ensure consumers are able to **access electric service within X hours/days of a loss of electric service** in the event of a climate resilience threat.

		Time scales			
Location scales		Minutes	4-23 Hours	1-2 Days	3 days+
	Building				
	Circuit				
	Substation				
	Town				
	Load zone				
	State				

Potential methodology (cont.)

Potential climate resilience **threats:**

- Acute shocks
  - Flooding (F)
  - Ice storms (I)
  - Heavy wet snow (S)
  - Extreme wind, Gradient Wind (W)
- Chronic stressors
  - Prolonged cold snaps (C)
  - Prolonged heat waves (H)

Potential climate resilience **solutions:**

- Vegetation management (v)(maintenance vs widening, widening being resilience)
- Strategic location of utility infrastructure (e.g., line relocation, undergrounding, elevating resources) (i)
- Storm-hardening construction: larger class poles, covered wire, spacer cable, self-supporting cable (c)
- Self-healing systems (h)
- Storage (s)
- Microgrids (m)

Potential methodology (cont.)

Identify potential solutions that:

A. Best mitigate "worst" locational impacts (# of buildings/accounts, towns affected)
B. Best mitigate "worst" time scale impacts (days-weeks)
C. Best mitigate worst locational impacts x time scale impacts
D. Best match largest # of location x time scale x threat intersections
E. Best mitigate most likely/frequent/impactful threats (requires threat weighting)
F. Best support interdependent systems and/or independence from such systems (requires identification – communications infrastructure is one)

Prioritize potential solutions that:

A. Screen for benefits ≥ costs
   - This includes consideration of the lifespan of the mitigation measure
B. Screen for least-cost, best-fit
C. Screen for equity or other ancillary objectives
   - Social burden metric: food burden, water burden, home heating, burden, security, medical - based on facilities in home or surrounding community that have power (work on this being done at U. of Buffalo). SafeGraph tool cross-referenced with utility OMS, CAIDI, SAIFI for major event days – map facilities to how they provide for human needs.

Important questions!

1. How much do we want to buy down the "long end of the tail" (low probability, high-impact risks)?
2. What is the design standard? Should it be based on impact (MWh not served, etc.) or consequence (i.e., what keeps you up at night)?
3. Who pays? Costs to ratepayers can impact rates to the detriment of other important climate investments such as electrification of heating and transportation (in other words, don't want to "tax the good" of electricity). However, reliability/resilience of electricity will become increasingly important as Vermonters come to rely more on it for heating & transportation....

Draft Recommendations

Recommendation #1

Identify climate resilience threats/aspect of threats applicable to Vermont electric and communications infrastructure

Recommendation #2

Refine municipal electric/communications vulnerability index methodology and develop tool for broad use by stakeholders to identify priority areas for investment

-This includes prioritization of locations where communications are served by solely by digital voice service (fiber, coax cable, Voip), which require electrical power at the home, that also lack cell coverage/copper-wire landlines, to the extent that this information can be identified (in other words, where communications are entirely dependent on electricity)

Recommendation #3

Integrate energy/communications resilience considerations into emergency management and land use planning frameworks

Recommendation #4

Establish framework for valuing resilience investments and metrics for measuring impacts (e.g., ICE and POET calculators)

Recommendation #5

Deploy foundational technology statewide to enable and optimize storage and other grid management technologies (e.g., GridLogic, Virtual Peaker, Distributed Energy Resource Management System)

Recommendation #6

Update interconnection standards to:

-Enable full smart inverter functionality and distributed energy resource interoperability to maximize use cases (including islanding) and minimize risks of cascading trips of generators offline.

-Maximize storage contribution and use cases while maintaining system stability and reliability.

Recommendation #7

Review state and local permitting and inspection processes and standards to encourage greater deployment of distributed energy resources that enhance resilience

Recommendation #8

Identify low-cost/effort “upgrades” to normal utility reliability investments that would also support resiliency goals

Recommendation #9

Identify modifications to policies and programs that would enhance resilience, while also seeking to align benefits/beneficiaries with costs/cost causers

Recommendation #10

Seek stimulus (ARPA), federal infrastructure bill, and other non-ratepayer funding for costs of resilience upgrades that exceed benefits, such as:

-Resiliency Zones: batteries installed at or near critical facilities, potentially paired with solar (and/or small wind) and with a microgrid /islanding where possible, to allow them to continue to operate in the event of extended disruptions to electric service.

-Strategic upgrades to substations, distribution, and transmission capacity across the Vermont grid needed to enable the state's renewable and electrification goals, after first exploring feasibility of any lower-cost options, e.g. flexible load management, curtailment, and storage.

-Non-wires alternatives to address system resilience to the extent they are lower cost or offer co-benefits. Seek and provide utilities with non-ratepayer funds to help bridge the cost -benefit gaps.

Additional resources

- 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.

- Vermont Energy Assurance Plan (2013)
  - Energy assurance defined 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.*
  - Involves **planning & preparation**, **training & education**, and **response activities**

- Rule 4.900, NERC, and NPCC reliability standards; also *NPCC DER Guidance Document, Distributed Energy Resource (DER) Considerations to Optimize and Enhance System Resilience and Reliability*

- FERC/NERC "resilience" definition: "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." (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.

- 30 V.S.A. 248 (b)(3) system stability & reliability criterion
- PUC docket 20-014, a PUC investigation "into electrical power losses and their impact on telecommunications Resiliency"
- CEP & IRP Guidance
- GMP Climate Plan
- DOE Workshop: Building a Resilient Community Using Distributed Energy Resources

Additional telecom information

From the PSD's 10-Year Telecommunications Plan (section 12.6, page 153):

12.6 Reducing In-Home Telecommunications Vulnerabilities

An often-overlooked public safety vulnerability is consumer telecommunications equipment's reliance on grid-based electrical power. Fiber optic or coaxial cable, and even DSL in some cases, are fundamental in the delivery of broadband and voice-over-internet-protocol services into consumer's homes. However, in the absence of a back-up power source, these technological platforms can cease to function during a power outage at the consumer's location. This vulnerability must be considered in Vermont, where extreme weather events such as winter storms can cause power outages that last hours to days.

For context on this vulnerability, the original public switched telephone network (PSTN) was designed and deployed parallel to the commercial electric power network. The PSTN relied on analog signals transmitted over copper wires and telephone sets at consumer locations. The copper pairs serving each customer could carry sufficient electrical power for operation regardless of the state of the commercial electrical power network. Even in the face of a power outage, as long the PSTN network was uncompromised, telephone service remained intact. While many consumers still subscribe to traditional voice service over copper pairs (i.e., the PSTN), these services increasingly rely on remote terminals that require their own backup power and are thus susceptible to service disruptions during power-outages. This Plan presents three mitigation strategies to reduce the digital connectivity vulnerabilities created by home telecommunications equipment reliant on grid power:

1. Encourage providers to go above and beyond compliance regarding battery backup systems
Per FCC rules, providers such as those supplying voice-over-internet-protocol services must inform their consumers that their systems may not work during electrical power outages and offer battery backup options. In light of the state's goal for universal access to digital services, providers could be encouraged to go beyond compliance with these rules. For example, providers could be encouraged to offer additional or longer-lasting battery backup systems, and/or provide more customer education on the issue.

2. Encourage vulnerable or concerned consumers to adopt alternative communications means or power supplies
Vulnerable or concerned consumers should be encouraged to consider adopting alternative or additional communications means to reduce potential instances of communication disruptions. Depending on availability, these could include mobile wireless services or copper-pair telephone service. While adopting alternative or additional communications tools does not address the vulnerabilities of digital connections on their own, consumer education and empowerment around alternatives could be an effective part of the overall solution.

3. Ensure that electrical power network improvements are targeted at vulnerable areas
Because digital services require commercial power, the most effective solution to this vulnerability is to minimize commercial electrical power outages. While this is a complex task, the path toward minimization should include identifying and working to mitigate outages in especially vulnerable areas: those areas where a concentration of locations have access to digital services (and thus where there is likely to be a high adoption rate for these services) and where there is low availability of mobile wireless service in the event of an outage. Green Mountain Power's initiative to clear ash trees from rights-of-way (because ash trees killed by emerald ash borers could fall on power lines) is a strong example of a program being implemented to proactively forestall potential electrical outages.