GRID MODERNIZATION LAB CONSORTIUM (GMLC)

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION: EQUITY CONSIDERATIONS IN DEFINING AND ADDRESSING ENERGY SECURITY AND RESILIENCY

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Introduction and Summary

This document reviews current research and resources regarding equity considerations in definitions of energy security and resilience (or resiliency). Together with the accompanying spreadsheet tool, it is intended to inform the UTC's understanding of the topics when reviewing Washington Clean Energy Implementation Plans, tariff filings, and general rate cases, and when preparing testimony.

Energy security may be generally defined as *the concept of ensuring consistent, reliable access to energy without disruptions, whether those disruptions stem from extreme weather events that impact the grid, attacks on energy supplies or grid infrastructure, or inability to pay for needed energy supplies at an affordable price.* Adverse impacts of household-level and grid-level energy insecurity disproportionately harm vulnerable communities, such as low-income households, renters, the elderly, or medically vulnerable people. Steps taken to address energy security at either the household or the grid level should take particular care to ensure that these communities' needs are met, and that solutions do not impose additional harms or burdens.

Resilience may be generally defined as *the ability for the electric grid, ecosystems, or households to withstand, recover from, and reduce or minimize the harmful impacts of disruptive events, including extreme weather events or other climate impacts.* As noted above, these disruptive events impose disproportionate harms on vulnerable communities, who are also less likely to have the resources available to either proactively prepare for or recover from disruptions and disasters. Steps taken to improve grid resilience should take particular care to ensure that adequate resources are available to these communities.

Both energy security and resilience are complex topics with many definitions and multiple aspects. They are also deeply interrelated. This document offers more in-depth reviews of definitions of energy security and resilience from both grid perspectives and community or household perspectives, with an emphasis on their roles in energy and social equity. The accompanying spreadsheet tool contains a more granular review of individual resources' definitions of energy security and resilience.

Energy Security

Energy security generally refers to the concept of ensuring consistent, reliable access to energy without disruptions, whether those disruptions stem from extreme weather events that impact the grid, attacks (including physical and cyberattacks) on energy supplies or grid infrastructure, or inability to pay for needed energy supplies at an affordable price.

Definitions of energy security may be grouped into three loose categories based on those considerations: first, **grid or fuel security**, which is concerned with ensuring the consistent delivery of energy to consumers even in the face of climate events or other disruptions; and second, **household energy insecurity**, referring to a given household or community's ability or inability to secure and utilize reliable energy supply at affordable prices. and. A third category, **climate or environmental security**, emphasizes the benefits of climate change mitigation, pollution reduction, and ecosystem sustainability for both national security and household welfare, and should be considered a key element of energy security.

The Washington State Department of Commerce offers one definition of energy security that addresses these various angles: *"Energy Security can mean the uninterrupted availability of energy sources at affordable prices. The uninterrupted availability of our energy resources can be threatened by both manmade and natural disasters which is why one element of energy security is focused on physical and cybersecurity. Energy insecurity, therefore, is the interrupted availability of energy or the inability to afford energy.* (Washington State Department of Commerce).*"* A third dimension of energy security addressed in more recent literature and policy considers climate and environmental impacts as core elements of energy security, recognizing the interdependence of climate impacts and energy systems.

Household energy insecurity is more frequently discussed in literature and addressed in policy as an explicit equity or environmental justice issue. However, grid-level energy security also must contend with considerations related to social equity and distribution of impacts across communities.

Equity dimensions that should be considered in each of these approaches to energy security are summarized in Table 1 and discussed below. Generally, utilities, regulators, and other stakeholders can ensure that energy security is achieved equitably by considering ways that already marginalized or vulnerable populations are disproportionately impacted by energy insecurity, as well as ways in which any steps to address energy security direct benefits to those populations and do not inadvertently cause additional harm.

Table 1: Elements of Energy Security

Element	Energy security dimension(s)	Source(s)	Notes
Affordability / energy burden	Household	Hernandez, Sovacool & Mukherjee, Luke & Heynen	Both household-level and state/grid-level definitions of energy security include affordability of energy as a key component of energy security.
Reliability	Grid	Sovacool & Mukherjee, Hernandez	Reliability is highly interdependent with resilience and is sometimes defined interchangeably. Reliability refers to general stability, outage reduction, vs. resilience addressed in context of harms, major events.
Resilience	Grid, climate/environmental	Sovacool & Mukherjee, Hernandez	Resilience is often cited as an element of energy security - ability to ensure access to energy supplies in face of natural disasters or geopolitical conflicts is indicator of energy security.
Access	Grid, household	Mara et al, Sovacool & Mukherjee, Simpson	Overall population access to grid/electricity, including distribution of access (along race, income, rural/urban lines).
Environmental benefits / pollution reduction	Climate/environmental	Hernandez, Sovacool & Mukherjee, Mara et al, Luke & Heynen	Reduction of harms from energy emissions/infrastructure considered in context of long-term stability, welfare, and security.
Climate stability / emissions reduction	Climate/environmental	Sovacool & Mukherjee, Nyman, Hernandez, Mara et al, Simpson	Some energy security literature addresses tensions between geopolitical definitions of energy security and contribution of fossil fuels to climate instability, emphasizing importance of renewables/GHG emissions reduction as a core ingredient of energy security in a climate- and resource-constrained world.
Domestic supply of energy / proportion of energy supply from imports	Grid, climate/environmental	Sovacool & Mukherjee, Nyman	Classical element of energy security, used in a national security context. An equity lens may consider the impacts of different energy sources on emissions and pollution, especially disproportionate impacts on marginalized communities.
Diversity of supply	Grid, climate/environmental	Sovacool & Mukherjee, Nyman	Classical element of energy security definitions in national security context. Can include, e.g., proportion of renewable energy in generation mix, including emissions and pollution impacts as described above.
Equitable distribution of harms and benefits	Grid, climate/environmental	Luke & Heynen, Simpson, Hernandez	Considers tradeoffs between pursuing national security via a domestic supply of fossil fuels and the harms from that energy production and/or generation. Under this lens, an appropriate balance prioritizes welfare and health of local areas and communities–especially marginalized populations,–and environmental sustainability alongside fuel security needs.

Equity and household energy security

Energy insecurity at the household level disproportionately impacts vulnerable populations, and is correlated with other burdens and harms. For example, low-income households face high energy burdens and are more likely to be energy insecure than higher-income households. Lower-income households are also less likely to be able to afford investments in energy efficiency that could help reduce their energy costs (Hernández, Energy insecurity: A framework for understanding energy, the built environment, and health among vulnerable populations in the context of climate change, 2013). Renters, generally more likely to be lower-income than homeowners, are also disproportionately impacted by high energy burdens and household energy insecurity, because even tenants who may be able to afford energy-efficient upgrades are unable or not permitted to. This dynamic is especially pronounced in homes where tenants, not landlords, are responsible for utility bills, because the burden of higher energy costs is fully shifted to renters, and landlords do not face a direct financial incentive to reduce energy costs in the home that they own (Hernández, 2013; Luke & Heynen, 2020).

Household energy security among vulnerable populations is also correlated with, and can exacerbate, other affordability concerns, such as housing insecurity (due to inability to afford stable housing); hunger (due to inability to afford food, or forced tradeoffs between affording energy and food); and health (due to forced tradeoffs between affording energy or health care) (Hernández, Energy insecurity: A framework for understanding energy, the built environment, and health among vulnerable populations in the context of climate change, 2013).

Household energy insecurity can also include not only those households who cannot reliably afford their energy bills, but also households that are energy insecure because they lack access to energy or electricity entirely (Sovacool & Mukherjee, 2011; Simpson, 2013; Baker, DeVar, & Prakash, 2019).

Finally, Hernández (2016) notes that impacted households may face energy insecurity burdens at the nexus of affordability, access, and other adverse impacts – which may include, for example, health impacts resulting from exposures to hazards related to inadequate household energy access, from gas leaks to stresses from excessive heat or cold, and summarizes energy insecurity as “the interplay between physical conditions of housing, household energy expenditures and energy-related coping strategies.”

Equity and grid energy security

Literature and analysis of energy security concerns at the grid or state level do not always address equity or consider the distribution of impacts when the security of the grid or energy supply is compromised (Nyman, 2018). **However, grid-level energy security considerations include various equity and distributional questions, including:**

- Considering which populations face disproportionate harms in the face of outages, and who would therefore benefit most from investments to ensure security of energy supply and/or the electric grid. For example, medically vulnerable, disabled, and elderly people are more reliant on consistent electricity access for their health, comfort, and safety (Molinari, Chen, Krishna, & Morris, 2017).
- Considering whether steps taken to improve energy security ensure benefits for all populations, including the most vulnerable.

- Considering whether steps taken to improve energy security, such as any increase in domestic fossil fuel production, may have adverse and disproportionate impacts on vulnerable populations.

Reduction of climate and environmental impacts as energy security

A growing body of literature on energy security includes reducing climate and environmental impacts as a core security dimension. The impacts of climate change contribute to extreme weather events and geopolitical destabilization, and these impacts are exacerbated by fossil fuel production and use.

Energy production and generation impose more immediate impacts on their surrounding environment as well: air and water pollution impacts from fossil fuel production and use, and water management and streamflow impacts from both thermoelectric and hydroelectric power generation, can also negatively impact the welfare, stability, and therefore overall security of a population, with disproportionate harms borne by already vulnerable populations (Simpson, 2013; Luke & Heynen, 2020). Therefore, encouraging or mandating utilities to reduce climate impacts—by, for example, transitioning away from fossil fuels and toward non-emitting sources of energy—can contribute to energy security (Sovacool & Mukherjee, 2011; Mara, Nate, Stavytskyy, & Kharlamova, 2022). A joint consideration of equity, climate impacts, and pollution as elements of energy security may include:

- Evaluating which communities are primarily harmed by extreme weather and other climate impacts and ensuring that adequate adaptation, mitigation, and resilience investments are directed toward those areas. The communities most heavily impacted by extreme weather tend to be socioeconomically marginalized, including low-income communities and people of color (Luke & Heynen, 2020; Chakraborty, Collins, & Grineski, 2019).
- Evaluating the distribution of harmful public health impacts of pollution from local or regional fossil fuel and hydroelectric energy production, which also disproportionately falls on marginalized communities, especially low-income communities and people of color (Simpson, 2013; Luke & Heynen, 2020). This information may help inform decisions about infrastructure siting or plant retirements.

Resilience

Energy security is a relatively more well-established concept with working knowledge across the electric power industry, as outlined above. Resilience, however, is a newer and evolving concept in the electric power sector. Just as with energy security, it is important to differentiate *grid resilience* from *community resilience* or *household resilience,* with the latter two being more closely linked to question of equity than the first. In some cases, resilience can also refer to *ecosystem* or *ecological resilience*, a definition that encompasses much broader, non-energy concepts, and refers to the management of ecosystems in order to ensure that adequate resources can sustain biodiversity and human needs over the long term, even in the face of extreme events (Baker, DeVar, & Prakash, 2019; Climate Justice Alliance, 2018).

Resilience or resiliency is event-dependent (or event-type dependent), as well as dependent upon the communities, households, and individuals involved. Events vary by geographic location, which will require different resilience solutions. For example, solutions that serve people in the event of wildfires will not necessarily serve them in the event of a major earthquake, and may pose entirely different risks than those posed by a cyberattack. The built environment exists to serve the needs of people and societies (Dillard, Helgeson, & Cauffman, 2018). As such, **while resilience is a question of how well infrastructure performs during and after a disruptive event, resilience planning should first and foremost focus on ensuring that the needs of the impacted community are met..**

Defining Grid Resilience

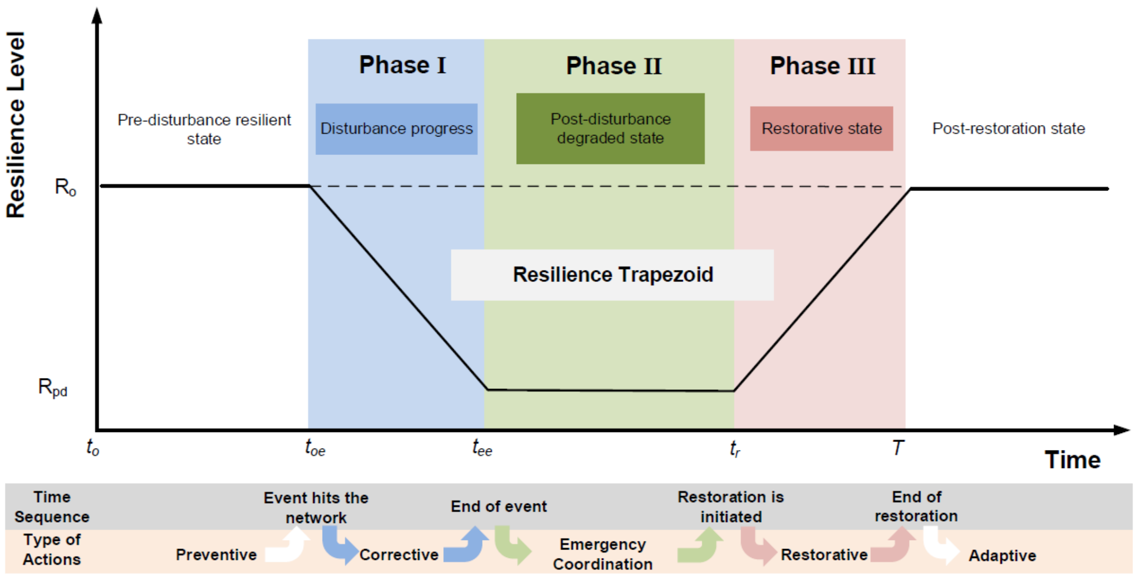
Resilience is a broad concept with several different definitions in working use. Following are three commonly used definitions of resilience or resiliency (words used interchangeably here) as it relates to the US electric power industry:

- International Council on Large Electric Systems (CIGRE) definition: *"the ability to limit the extent, severity, and duration of system degradation following an extreme event."*
- IEEE Task Force on Definition and Quantification of Resilience definition: *"the ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capacity to anticipate, absorb, adapt to, and/or rapidly recover from such an event."*
- US President's National Infrastructure Advisory Council definition (which informs FERC definition): *"the ability to reduce the magnitude and/or duration of disruptive events; the effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."*

In large part, these and many other definitions specify that resilience relates to *extreme* or *disruptive events*, often referred to as High Impact-Low Frequency (HILF) events, referring to extreme circumstances that cause power to be unavailable to a large number of customers for substantial periods of time. Characteristic of these definitions of resilience are that they consider actions before, during, and after the event, rather than just in the recovery phase.

Importantly, resilience is not reactive, but anticipates (Philips et all, 2022) events for which there is little predictive data because they are so infrequent. Adaptation, in post-recovery phase, may mean aligning to a "new normal" rather than returning identically to a pre-event state. Sometimes these stages of resilience are referred to as "the five r's": recon, resist, respond, recover, restore (Cicilio et al, 2021). Resilience is often represented in a "resilience trapezoid" like this one:

Figure 1: Grid Resilience Trapezoid



(figure from Moreno et al 2020)

It is generally concluded that clearer definitions of resilience and consistent metrics are still needed. Additionally, it is important to differentiate grid resilience from individual and community resilience, which may have more implications in the equity space.

Finally, ensuring that equity is central to addressing grid resilience begins with the planning process, and requires that community voices be present at the planning table. Effectively ensuring both grid and community resilience requires interested participants to take active roles in the process of planning for how to prepare for and respond to disruptive events. Some of these participants have already been traditionally included in these processes, such as policymakers, regulators, and utilities. However, the communities who are directly impacted by these disruptive events are critical but overlooked stakeholders in resilience planning. As regulators and utilities increase their emphasis on equity, it will also be tantamount to build partnerships with community stakeholders, especially in vulnerable named communities, to build skills that enable their effective participation in decision-making processes that directly impact how resilience is addressed for that community.

Defining community resilience

Although there is some cohesion around the definition of grid resilience, there is not yet a consensus definition of community resilience, which is a concept understood and applied differently, largely because each community is uniquely different and therefore will define, prioritize, and plan for resilience in different ways. However, there are several core elements that are present across many existing definitions, summarized in Patel et al, 2017. **The nine core elements of community resilience identified by Patel et. al. are:**

1. **Local knowledge** (community understands its existing vulnerabilities)
    a. Factual knowledge base
    b. Training & education

    c. Collective efficacy and empowerment (agency as a local community)
2. **Community networks & relationships/social networks/community linkages**
3. **Communication**
    a. Risk communication before and after event
    b. Crisis communication during
4. **Health** (physical & mental)
    a. Pre-existing health
    b. Delivery of health services during & after event
5. **Governance/leadership**
    a. Infrastructure & services
    b. Public involvement & support
6. **Resources** ("natural, physical, human, financial, and social resources")
7. **Economic investment**
    a. Distribution of financial resources, economic programming, and post-event economic development
8. **Preparedness/planning/risk mitigation**
9. **Mental outlook** (adaptability, willingness and ability to change after a disaster while accepting things will be different)

Mayer et al (2019) find three trends in the literature on community disaster resilience: 1) that the definitions and metrics for measuring community resilience continue to evolve and are improving, 2) that *social capital* is central to community resilience, and 3) many programs are aimed at advancing of communities' adaptive capacities rather than merely on hardening infrastructure.

Emergency responders, including utility companies, will also require some support and cooperation from communities during extreme events in order to respond quickly and effectively (Elkady, 2022). If communities can provide responders what is needed, hazards can be reduced and services restored more quickly. Reactive responses during and after a disruptive event cannot substitute for proactive planning, and many necessary planning steps cannot be effectively addressed during an emergency. **Some specific steps that can be addressed proactively by utilities and encouraged by regulators include:**

1. Having communities and sub-populations provide accurate and timely information to responders.
2. Convincing communities to follow responder instructions, which requires communication that is accessible to populations' cultural and linguistic needs, and establishing trust and transparency well before emergency strikes.
3. Ensuring that people are prepared with both information and resources before an extreme event, including understanding of the risks imposed by different types of disruptive events and knowing where to seek shelter, supplies, or other support.
4. Having community members play a significant role in their own recovery, since the number of responders is necessarily limited and the motivation of people in their own communities is high. As a corollary to this, organizing and training volunteer responders, instead of having all assistance by members of the public be spontaneous, can support an organized, safe, and efficient response to disruptions.

In other words, proactive communication and preparedness are critically important elements of community resilience. Providing information to customers before events occur (and regularly reinforcing that information) can help communities be resilient. As noted above, all communication must be appropriate for and accessible to the relevant stakeholder groups – i.e., care must be taken to identify whether communication is accessible to people with low literacy or low computer literacy or to non-English speaking populations. Utilities and public agencies may, for example, turn to trusted community "insiders" to communicate key emergency response information. Other considerations relevant to meeting the needs of named communities should always be considered. Additionally, all such proactive emergency response communication must also inform customers of what is expected of them, as well as what they should expect from their electric utility and other authorities.

Useful exercises for utilities and regulators to enable this type of proactive community engagement and planning may include conducting a risk assessment and stakeholder engagement process well ahead of a disruptive event in order to develop management plans and establish lines of communication, as described in the European Resilience Management Guidelines (Gaitanidou, Bellini, & Ferreira, 2018) and by ICF (Bruzgul & Weisenfeld, 2021).

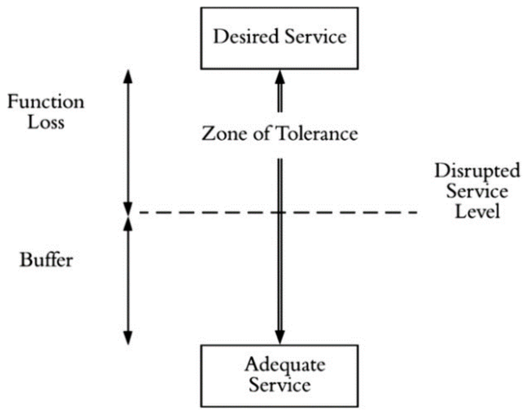
As a final example, one tangible tool for addressing community resilience may be "community resilience hubs," a relatively new concept referring to making investments in shared spaces such as libraries or schools to ensure that they retain electricity, water, and other key resources during a disaster. These "hubs" may then provide a safe haven for people to meet their basic needs and connect with others while, for example, waiting for household power to be restored. Again, the success of a resilience hub will depend on proactive investment in both the physical space and communication with and among community members to spread knowledge of the hub and ensure that its features meet the community's needs (Hussain & Zetkulic, 2021).

Defining individual and household resilience

During and in the aftermath of extreme events, significant risk disparity can exist even between different households within the same community (Esmalian et al 2021). Society is not uniform, and different sub-populations even within named communities have different needs and expectations.

The impacts of an extreme event are a function of a household's or individual's *exposure* and its *vulnerability*. Two houses exposed to the same extreme weather event or wildfire scenario can be impacted very differently because of differing levels of vulnerability. As noted by Esmalian et al (2021), households have their own "zone of tolerance" for disaster situations. This zone is determined by their particular vulnerabilities, needs, and expectations of service. In other words, a given household will have a level of desired service – generally, that everything in the household is functional. A household's zone of tolerance, then, refers to occurrences where there is some – but usually not complete – function loss. Below the zone of tolerance is a level of minimum adequate service for basic survival needs. A wider zone of tolerance is indicative of greater household resilience, as is a lower level of minimum adequate service. An array of factors contribute to these differing levels, and are illustrated by Figure 2 below.

Figure 2: Household Resilience Matrix



(figure from Esmalian et al 2021)

Some of these will be similar, though not uniform, within named communities. Previous disaster experience, for instance, influences households' preparedness, adaptation, and risk perception. (It is also important to note that socioeconomically vulnerable populations are often also located in disaster-prone areas, e.g., in floodplains or high fire-risk locations.) If a household has previously faced a similar disaster, they may be less likely to be "blindsided" by it, and vice versa – for example, a Washington household would likely be blindsided by facing a Category 4 hurricane, as would a Louisiana household experiencing an earthquake.

Unsurprisingly, disaster preparedness increases resilience. The reasons for or correlations with preparedness – and lack thereof – fall under the general categories of socioeconomic status, household composition (e.g. age, disability), minority status, and access to stable housing and transportation.

Generally, higher income correlates to higher levels of mitigation and preparedness actions. Education and race relate to risk perception and preparedness, for example. Especially noteworthy is how race and income may impact communication between authorities and individuals or households, where more marginalized communities may experience more mistrust. Homeownership, type of residence, and duration of residency all relate to adjustment and adaptive actions. Physical health of households (e.g. disability, chronic illness) impacts a household's acceptable service threshold, as does age of household members.

Hazard knowledge specifically and formal education in general correlate to increased preparedness in disasters. This could in part be attributed to the higher income often associated with higher level of education. Higher income often provides people with the resources to prepare with substitutions for normal services. This could include everything from stores of prepared food to flashlights to backup generators. When considering service substitution, it is important to identify what need is being met (e.g., light but not refrigeration, or safe food but not safe water).

Social capital is a predictor of household resilience, as noted with community resilience, above. It may be worth it for utilities to invest in community-building activities seemingly unrelated to energy. A single household with a backup generator, for instance, can serve as a *de facto* center of communications, food preparation, and aid to other households within its social network, while those with less social capital are forced to rely on publicly available and potentially less available community centers and emergency services, and will be less likely to have others actively inquiring after and ensuring their wellbeing.

Additionally, the resilience of the crews restoring systems is an important but sometimes overlooked component of system resilience (Schweikert et al, 2021). Lacking food, showers, and a safe place to sleep, crews may become fatigued. Further, since crews are generally members of the communities they serve, they may be impacted by the same extreme event and be needed to care for their own families or property at the same time they are needed to restore service to everyone.

Conclusion

Energy security and resilience are complex, interrelated topics. Both terms can be used to refer to considerations at the household, grid, and even ecosystem level. Both issues relate to questions of ensuring that electricity remains reliable and affordable for all, especially in the face of disruptions, including extreme weather events exacerbated by climate change. Finally, under-resourced and vulnerable communities—those populations referred to as "named communities" in the context of CETA—face disproportionate harms or burdens when energy security and resilience at all levels are not effectively addressed.

Grid-level energy security is a relatively well-defined concept with stable metrics. Grid resilience, however, is a concept still being defined by the industry. The connection between grid assets and equity is perhaps not obvious, but there is certainly a connection. Investment in grid hardening and the order in which service is restored after an outage both impact different communities and households differently. In addition to traditional reliability metrics like System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), policymakers, regulators, and utilities will need new approaches to evaluate incremental and long-term investments in named communities to demonstrate grid and community resilience and address energy equity goals.

When considered at a household or a community scale, both energy security and resilience are more nuanced and more closely, or perhaps more obviously, tied to social equity. These remain hard to define and measure because they are fundamentally about the impact of both routine and extreme events on people, not on machines or infrastructure.

Definitions of energy security from a community and household perspective revolve around access to energy being uninterrupted for either technical or household economic reasons. Household and community resilience are defined in terms of people's ability to get access to the services they need after an interruption, noting that needed services are not necessarily electricity itself, but rather heating, refrigeration, communication, and other end uses that largely rely on the delivery of electricity.

Finally, electric utilities and regulators in Washington should pay particular attention to communication with named communities to effectively and equitably address both resilience and energy security. Although microgrids and energy storage, for example, are effective technological investments in grid and community resilience, keeping energy affordable, prioritizing trust and accessibility when sharing information with community stakeholders, and helping people prepare for times that they may be without power may ultimately improve equity outcomes more than technology alone would.

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