FUTURE PROOFING THE TEXAS GRID WITH DISTRIBUTED ENERGY RESOURCES

Prepared by Converge Strategies, LLC, and Synapse Energy Economics for Texas Advanced Energy Business Alliance

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TEXAS ADVANCED ENERGY BUSINESS ALLIANCE

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ABOUT TEXAS ADVANCED ENERGY BUSINESS ALLIANCE

Texas Advanced Energy Business Alliance includes local and national advanced energy companies seeking to make Texas's energy system more secure, clean, reliable, and affordable. "Advanced energy" encompasses a broad range of products and services that constitute the best available technologies for meeting energy needs today and tomorrow. Among these are energy efficiency, demand response, energy storage, natural gas electric generation, solar, wind, hydro, nuclear, electric vehicles, biofuels, and smart grid. TAEBA's mission is to raise awareness among policymakers and the general public about the opportunity offered by all forms of advanced energy for cost savings, electric system reliability and resiliency, and economic growth in the state of Texas. Visit us at www.texasadvancedenergy.org.

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Converge Strategies, LLC (CSL) is a consulting company focused on the intersection of clean energy, resilience, and national security. CSL works with civilian and military partners to develop new approaches to energy resilience policy and planning in the face of rapidly evolving threats, vulnerable infrastructure, and determined adversaries. To learn more about CSL, visit www.convergestrategies.com.

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EXECUTIVE SUMMARY

In 2021, Winter Storm Uri rendered the Texas power grid incapable of meeting even the most basic energy needs of over 70% of the state. This devastating event was not an anomaly, but a sign of times to come. Increasingly unpredictable weather patterns and problematic management of conventional electric generating resources now pose serious threats to the well-being of Texans across the state.

Notably, increased demand, uncertain forecasting, and infrastructure limitations played critical roles in this and other similar disasters. Texas's rapid population growth has made it impossible to forecast grid preparedness beyond 2-3 years. This is particularly problematic given that large new generation projects, which have typically been relied upon when reliability concerns arise, can take 6 years to become operational. To meet the reliability challenges ahead, Texas must take a more holistic approach that considers small, distribution-connected resources and flexible demand—options that can be pursued quickly and cost-effectively to enhance grid resilience.

Distributed Energy Resources (DERs) are smaller, more flexible technologies or systems installed on the distribution system or behind a customer meter, including energy efficiency measures, distributed generation such as solar, battery storage, demand response, and electric vehicles and their charging equipment. DERs offer a cleaner and more affordable alternative to large-scale buildout of power plants and associated transmission, but realization of these benefits will require the removal of the market and regulatory barriers that prevent their optimal deployment in Texas. This report serves to illustrate the benefits of DERs for Texas residents, and to identify steps to facilitate their widespread deployment.

Energy resilience can be understood as the capacity of a system to avoid and/or lessen the consequences of widespread blackouts, and to bounce back from such events in the least harmful manner. The first two sections of the report identify risks to the Texas power grid and present a framework for characterizing the potential resilience contributions of DERs. DERs help protect communities by supplying power to facilities and institutions that support public health and safety during power outages, and support electric power system resilience by providing critical grid services at the times they are needed most.

The third section of the report provides five use cases that highlight DER technologies and business models that are currently being deployed in Texas or elsewhere, and the contribution they can make to a more resilient energy system.

- **Energy Efficiency for Passive Survivability**: Energy efficient buildings both reduce the risks associated with blackouts and empower residents to shelter in place during adverse weather events. Energy efficiency measures contribute to passive survivability, or a building's ability to maintain life-support functions in the event of an emergency. Texas has more untapped cost-effective energy efficiency than any other state, yet it ranks behind 35 other states in terms of its energy efficiency spending. Efficiency measures can be scaled, for example, by increasing annual energy efficiency targets to accelerate deployment.
- **Solar and Storage for Resilient Homes**: Solar photovoltaic systems with battery storage and bidirectional EV charging can independently sustain critical loads at an average home for a day or longer. These services and technologies can be scaled with incentive programs or federal funds from the Infrastructure Investment and Jobs Act and expansion of market participation options.
- **Microgrids for Critical Facilities**: Microgrids are local power systems that can serve the loads they are connected to independently of the power grid. During outages, microgrids (which can incorporate a variety of DER technologies) can disconnect from the grid and keep critical institutions like police and fire stations, emergency shelters, medical facilities, food distribution centers, and water and wastewater treatment plants up and running. Projects utilizing microgrids can be scaled, for example, by removing barriers preventing the full market participation of DERs that support critical facilities.
- **Electric Vehicles to Stabilize the Grid**: Electric vehicles (EVs) rely on battery packs to store the electricity to power their motors, but could also coordinate charging times by, for example, absorbing electricity during high periods of wind or solar production. Crucially, vehicle-to-grid (V2G) configurations allow EVs to send power back to the grid during periods of scarcity. Widespread usage of EVs as supporters of grid resilience can be accomplished through the expansion of existing state grant and incentive programs.
- **Demand Response Delivering Resilience**: Demand response (DR) offers incentives that drive consumers to reduce, shift, and control their electricity usage in times of need, helping to avoid blackouts or involuntary load curtailment. DR can be expanded by reducing barriers to customer enrollment and allowing participation by third-party aggregators.

The final section provides a set of actionable market-based policies designed to employ DERs for greater resilience in Texas. The proposed policies can be found below and are described in more detail in Section Four.

- Increasing energy efficiency targets and prioritizing electricity savings that will help during emergency events;
- Ensuring that DERs are fully compensated by utilities and wholesale markets for all the services they provide to the grid;

- Prioritizing DERs and demand response at critical facilities to ensure these facilities can ride through emergency events and continue to provide community services;
- Providing funding and pricing and rate structures to promote electric vehicle adoption; and
- Allowing aggregations of DERs (known as Virtual Power Plants, or VPPs) to participate in the wholesale markets overseen by ERCOT.

By pursuing these policy recommendations, legislators, regulators, market operators, and other policymakers can ensure that all Texas customers benefit from the potential role that DERs can play in improving grid resilience to ensure that future weather events to not cause devastating grid failures.

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1. INTRODUCTION

Advanced and distributed energy technologies, such as smart thermostats and electric vehicles, are booming in Texas and across the country, while risks to the power grid continue to grow more severe. There is a rapidly expanding opportunity to put distributed energy resources to work to improve resilience in the face of extreme weather and other disasters. This white paper reviews strategies for Texas to use its home-grown fleet of distributed energy resources to future-proof its grid in light of shifting consumer trends, technology innovation, and grid risks.

This report is organized into four sections:

- SECTION 1 discusses risks to the Texas power grid using the example of Winter Storm Uri.
- SECTION 2 presents a framework for characterizing the resilience contributions of DER.
- SECTION 3 summarizes use cases of how distributed energy technologies are being deployed to secure communities and the grid in Texas and around the country.
- SECTION 4 suggests policies to scale up distributed energy for resilience in Texas.

1.1. Risks Factors for the Texas Power Grid

1.1.1. WINTER STORM URI AND SUBSEQUENT SUMMER HEAT WAVES REVEAL VULNERABILITIES OF TEXAS GRID

The blackout during Winter Storm Uri in February 2021 was the largest sustained power outage in the U.S. since the Northeast blackout of 2003. Texans went without power and running water for more days than during winter power outages in 1989 and 2011. Approximately 70 % of Texans lost power, with the average disruption lasting 42 hours, and close to 50 % lost running water.[1] Over 250 people died from low temperatures and carbon monoxide poisoning,[2] and economic damage estimates range from $80 to $130 billion.

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[1] Fiscal Notes Special Edition: Winter Storm Uri, Office of the Texas Comptroller. (October 2021).

[2] February 2021 Winter Storm-Related Deaths – Texas, Texas Department of State Health Services. (December 31, 2021).

Winter Storm Uri was not a novel event; in fact, it was the fourth such very cold weather outage experienced in Texas since 1989. As with each of the wide-scale cold weather outages that preceded it, the initial damage of Winter Storm Uri resulted primarily from a combination of inaccurate demand forecasting and insufficient generation capacity—not due to insufficient total capacity in the system, but rather to the inability of that capacity to meet fluctuating demand where and when it was needed.[3] However, the consequences of Winter Storm Uri were much more severe than those of preceding events, extending months beyond the initial recovery period and revealing new vulnerabilities in the Texas energy system.

When an early heat wave slammed Texas in April of 2021, the Electric Reliability Council of Texas (ERCOT) discovered that the region's reserve capacity was far lower than predicted and the grid came dangerously close to more rolling outages. A post-event analysis of the April 2021 event revealed that, due to lingering infrastructure damage from Winter Storm Uri, power and gas infrastructure owners had taken more of their assets offline for spring maintenance and repair than forecasted by ERCOT, resulting in an inaccurate estimation of the system's operating reserve capacity.

A similar outcome occurred during a heat wave in May 2022, with ERCOT's persistent "conservative operation" of the grid requiring thermal plants to continue running in the event of a need for additional reserves, reducing their ability to perform necessary maintenance during what have historically been considered shoulder months. During the May 2022 heat wave, with over 12,000 megawatt (MW) of thermal units offline for either scheduled or unplanned maintenance, ERCOT required at least one plant to delay its repairs and stay online. A day later, the plant shut down anyway due to equipment failure, joining five other plants that tripped offline and decreased system capacity by 3,000 MW. The loss of capacity forced ERCOT to request that Texans turn their thermostats up to 78 degrees to avoid a blackout. Early post-event reporting indicates that the shrinking windows available to thermal operators for planned maintenance may have contributed to some unplanned outages.[4]

The April 2021 and May 2022 events demonstrate that, beyond extreme weather events themselves, shortening "shoulder" seasons between summer and winter are contributing to

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[3] The Timeline and Events of the February 2021 Texas Electric Grid Blackouts, The University of Texas at Austin Energy Institute. (July 2021).

[4] Texas' grid operator told a power plant to delay repairs ahead of a May heat wave. It was among six that crashed, The Texas Tribune (2022).

system instability and delayed recovery. Against the backdrop of changing seasonal conditions, Texas also faces several energy trends that increase the risk of outages during weather events.

1.1.2. ENERGY TRENDS IN TEXAS ARE CREATING RISK

Population Growth and Increasing Loads

Texas has the fastest growing population of any state and currently has the highest energy usage in the nation, consuming 10% of total U.S. electricity.[5] Annual consumption per home in Texas is 26% higher than the national average.[6] The state's consumption is projected to increase by approximately 100,000 GWh over the next decade, from 392,667 GWh in 2021 to 502,356 GWh in 2031. While Texas also produces more electricity than any other state, most of the state's generation capacity is concentrated in utility-scale plants far from the generated power's end use, which creates a high dependence on transmission integrity. With population growth occurring largely in cities and suburbs, the "energy distance" between customers and the resources supplying them is expected to grow.

Fluctuating Residential Demand

The residential sector currently accounts for the largest share of Texas's electricity consumption,[7] due in part to a boom in home construction and electrification; over 62 % of new home heating in TX has been electric since 2010,[8] and residential demand now drives both the summer and winter power system peaks. Although residential demand accounts for only 25-30% of total electricity demand during normal weather and operating conditions, residential and small commercial loads represent 48-50% of demand during extreme hot or cold weather, significantly outpacing commercial and industrial demand.[9] These event-driven load profiles can lead to tight reserve margins that, in turn, contribute to outages.

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5 Powering the Future: Texas Power Sector Pivoting to Resilience, HARC Climate Risk and Alliance.

6 Review of Wholesale Electricity Markets, Public Utility Commission of Texas (2021).

7 Texas: Profile Analysis, U.S. Energy Information Administration (2019).

8 The Texas Power Crisis, New Home Construction, and Electric Heating, Energy Institute at Haas. (February 22, 2021).

9 Reliability Analysis and Resource Adequacy: Best Practices & Recommendations, Silverstein, A., filed with Public Utility Commission of Texas. (November 22, 2021).

Forecast Uncertainty

Rapid load growth and the increasing share of residential demand fluctuations creates challenges for short-term and long-term load forecasting that are not adequately addressed by traditional resource and system planning models. Load forecast uncertainty worsens as the forward period increases,[10] making it very difficult to predict how prepared the grid is to meet customer demand more than 2-3 years in the future. Exacerbating this issue is the time it takes to plan large generation resources and high voltage transmission infrastructure. Texas is often able to site, construct, and bring new assets into service in six years or less which outpaces any other North American Independent System Operator (ISO), but even that turn-around time extends beyond the window of accurate long-term load forecasting. As a result, the forecast uncertainty is likely to create added risk during the periods of time when changes in customer demand occur before infrastructure is in place to adequately support it.

Transmission Dependencies

The isolation of the ERCOT system from neighboring ISOs prevents accessing substantial quantities of additional capacity through regional interchange. Instead, Texas must rely on in-state transmission to ensure energy delivery across the state. Investing in more, geographically diverse transmission corridors is critical for system resilience, and is the traditional solution for chronically stressed power systems. However, this approach comes with a continued dependence on large, static generation assets and carries the potential for single points of failure on long-lead assets. A broader integration of DERs will allow for more flexibility, a decreased dependence on transmission, and a shorter distance between generation capacity and customer load.

Energy Inefficiency and Demand Response

Winter Storm Uri also revealed that the Texas population increase is incompatible with an unchanged energy infrastructure investment strategy that favors bulk capacity over distributed generation solutions. Indeed, the event highlighted the need to develop flexible energy resources close to critical loads, and to increase measures to reduce load more effectively. Energy efficiency measures in particular could have a strong impact on the stability of the Texas grid, given that overall average electricity consumption per home in Texas is 26% higher than the national average, and energy efficiency targets of utilities in Texas remain far below those of other states (0.4% and 1.2% of annual kWh sales, respectively). During Winter Storm

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[10] Study Process and Methodology Manual: Estimating Economically Optimum and Market Equilibrium Reserve Margins (EORM and MERM), ERCOT. (December, 2017)

Uri, the inefficiency of Texas residential building stock both inflated system demand and failed to offer some Texans sufficient "hours of safety," or the capacity to maintain a livable environment without power or heating, to survive the storm.[11]

This issue is exacerbated by the comparatively low rate of Demand Response (DR) participation in ERCOT. The current trend shows Texas below the national average for demand response as a percentage of peak load reduction.[12] This is an indicator that while DR can provide spot benefits during tight operating conditions, it is not utilized to the fullest extent when the system is under significant stress. The ERCOT request for Texans to curtail their energy usage during the May 2022 heat wave provides an example of uncompensated demand response that cannot be predicted or integrated into planning operations.

1.1.3. THE OPPORTUNITY FOR DISTRIBUTED ENERGY RESOURCES

As the April 2021 and May 2022 heat waves demonstrated, unplanned outages of large thermal generators due to weather, maintenance, and primary fuel availability can result in sudden disruptions to energy supply, which decreases overall system resilience. An exacerbating factor is that today's models of operating reserves for generation capacity fail to account for unpredictable loads and capacity availability not just during, but also following extreme weather events. This imbalance in resource planning should not be taken as a demand signal for more large-scale generation assets; rather, it is a clear indication of the need for more resource diversity in order to avoid common mode failures in the future, which are driven by the forced outage rates inherent in traditional capacity resources.

The fact that the current process of reserve planning in Texas relies almost entirely on a model of addressing perceived reserve shortfalls with planned grid-scale capacity is due in part to a failure in market signaling. ERCOT market signals do not accurately capture the value of resilience benefits that some resources provide, or the fact that, for example, smaller generation projects are completed at a 35% higher rate than their larger counterparts, reaching their MWs at a 53% higher rate.[13] As a result, the market places a continued emphasis on large

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[11] Are We Ready for Another Uri?, RMI. (February, 2022)

[12] Demand Response in the US Wholesale Markets: Recent Trends, New Models, and Forecasts, Heldman, U. in Variable Generation Flexible Demand, pp. 211-257. (2021).

[13] PJM Interconnection Queue Status & Statistics Update, PJM (May 2021)

thermal generation to address reserve margins, despite the fact that increasing bulk thermal power generation far from its end-use leads to transmission congestion and availability issues. Instead, more economic and operational priority should be placed on the completion rate, and benefits of, generation with capacity of less than 20 MW as a solution for potential resource shortfalls.

Distributed energy resources (DERs, described in the next section) offer a targeted set of solutions for the grid vulnerabilities that Winter Storm Uri exposed. DERs can be relatively rapidly deployed to alleviate congestion on transmission lines by reducing load and moving generation closer to the customers. DERs can also be integrated into the distribution system as visible and dispatchable resources that can support grid balancing. DERs can be deployed to provide emergency back-up power to critical facilities and communities—and can play a dual role of reducing load or producing power in response to grid emergencies. DERs can accomplish these objectives while simultaneously making energy more affordable for Texas businesses and residents. Between expanding DER markets and enduring risks to the grid, Texans today face a historic moment of opportunity to invest in energy resilience.

1.2. What Are DERs?

Distributed energy resources, or DERs, are energy resources that are smaller, modular, and more flexible than traditional power plants.[14,15] DERs include technologies such as energy efficiency measures; small-scale and behind-the-meter solar energy and energy storage; smart appliances; electric cars, pick-up trucks and buses; microgrids; and back-up power systems. Customers are choosing these resources to meet their own energy and transportation needs, and DERs can also decrease demand at the system level by injecting power into the local grid or by reducing demand at a specific building or load.[16]

Wood Mackenzie estimates that total DER capacity in the U.S. will reach 387 gigawatts (GW) by

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[14] Distributed Energy Resources 101, TAEBA.

[15] DERs are defined by the Federal Energy Regulatory Commission (FERC) as "any resource located on the distribution system, any subsystem thereof, or behind a customer meter." *See* Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators Final Rule, FERC. (September 17, 2020)

[16] Resource Adequacy Challenges in Texas: Unleashing Demand-Side Resources in the ERCOT Competitive Market, Silverstein, A., EDF. (May, 2020).

2025, with investment exceeding $110 billion between 2020 and 2025.[17] The nature of DER investment is also changing as the market grows. In 2015, two-thirds of DER investment was in load management systems for non-residential buildings and loads. By 2025, analysts estimate that more than 90% of the investment will be in solar, EV infrastructure, batteries, and grid-interactive water heaters.[18]

Texas is already seeing rapid expansion in advanced energy and DER investment. By 2021, Texas had become a national leader in the deployment of DERs such as solar photovoltaics (PV), residential battery storage, and microgrids, and industry analysts project that rapid market growth will continue (Section 3). The pace and scale of anticipated DER growth will require deliberate strategies to ensure that resilience is integrated into system planning, energy market structures, and grid operations. There is a large and rapidly expanding opportunity to put DERs in Texas directly to work supporting grid resilience for the benefit of residents and communities.

1.3. DER Benefits for Texas

With the right policies and market signals in place, DERs can benefit the customers installing and using them while also benefiting all Texans by reducing energy costs, creating jobs, and supporting economic development.[19] DERs can mitigate energy price spikes, and can lower costs to individual consumers by increasing electricity market competition.[20] DERs can also reduce power system costs by deferring or decreasing the need for transmission and distribution infrastructure to address peak load. These cost savings could be substantial; Texas utilities spent $40.6 billion on T&D infrastructure capital investment in the past 10 years and deferring those investments by incorporating DERs could reduce total T&D infrastructure costs by 8.5% annually and save $5.5 billion over ten years.[21]

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[17] 5 Major Trends Driving the $110B US Distributed Energy Resources Market Through 2025, St. John, J. Wood Mackenzie. (June 22, 2020)

[18] The next five years we will see massive distributed energy resource growth, Kellison, B. Wood Mackenzie. (June 23, 2020).

[19] What Advanced Energy Does for Texas, TAEBA. (2019).

[20] A recent study concluded that adding 1,000 MW of DER into the supply stack would reduce electricity costs for Texas consumers by $3.02 billion over 10 years *See* The Value of Integrating Distributed Energy Resources in Texas. TAEBA. (2019).

[21] The Value of Integrating Distributed Energy Resources in Texas. TAEBA. (2019).

Besides lowering energy prices, DERs can promote economic growth and increased employment, particularly through the creation of local jobs. Texas already has more than 254,000 jobs within the advanced energy industry, spread across the state.[22, 23]

DERs offer energy customers more freedom of choice in their energy usage.[24] Local generation and energy storage systems can allow individuals and communities to export power during periods of grid congestion or price spikes, which serves to stabilize the grid while providing financial benefits to the DER owners. These resources also directly support energy resilience in a variety of ways that benefit Texas residents, critical facilities, and the grid as a whole.

Few of the above benefits can be realized unless market and regulatory obstacles are removed and rules changed to facilitate DER development, deployment and use for the mutual benefit of customers, society, and the grid.

2. DERS FOR ENERGY RESILIENCE: AN OVERVIEW

Energy resilience refers to the ability to mitigate the impact of large-scale power outages and recover from them in a manner that minimizes economic and human harm. DERs can make important contributions to energy resilience, at scales ranging from individual loads to regional transmission networks:

1. DERs can generate electricity or manage demand in close geographic proximity to customer load, which reduces dependence on the transmission and distribution infrastructure that may be disrupted during a major event.
2. DERs can keep households, critical facilities, and specific segments of the grid running during grid instability events or outages.

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[22] Advanced Energy Employs 254,300 in Texas, TAEBA. (2020).

[23] Economic Impact of Stimulus Investment in Advanced Energy: An Economic Assessment of Applying Stimulus to Advanced Energy Technologies, Products, and Services in the United States, Advanced Energy Economy. (2021).

[24] Rate design for a DER future: Designing rates to better integrate and value distributed energy resources. Utility Dive, Girouard, C. (February 12, 2018).

3. Grid operators may draw on DERs as a resource for local restoration efforts, making sure that power can be brought back online in as orderly a manner as possible.
4. Unlike standard emergency generators, DERs can generate revenue and/or create savings during everyday operations. The ability of DERs to make money during "blue sky" conditions makes them a cost-effective solution for back-up power and opens the door to innovative private sector business models (see Section 3).

This section presents a framework for characterizing the resilience contributions of DER by technology type, by the community lifelines supported, and by the scale of infrastructure served. The framework is used to organize the use case summaries in Section 3.

2.1. DER Technologies for Resilience

The use cases (Section 3.2-3.6) highlight a range of different DER solutions across the following technology categories.

	Energy efficiency (Section 3.2)
	Distributed Solar (Section 3.3)
	Battery and Thermal Storage (Section 3.3)
	Microgrids (Section 3.4)
	Electric vehicles (Section 3.5)
	Smart Devices, e.g., Smart Thermostats (Section 3.6)
	Demand response (Section 3.6)

2.2. Community Lifelines

The use cases are categorized according to the community lifelines that they support, rather than focusing on specific types of infrastructure. An important step in resilience planning is to define the capabilities and functions that need to be sustained. What needs to stay up and running and why? Critical infrastructure is not inherently "critical" on its own—it is critical to the extent it provides services that support public health and safety, economic security, and national security.

The federal government identifies community lifelines as a primary focus of national emergency planning[25] and defines them as "the most fundamental services in the community that, when stabilized, enable all other aspects of society to function."[26] In Texas, state government, counties, and utilities have different approaches for defining critical facilities (see Section 2.3.2). Community lifelines provide a useful shared language for describing and targeting DER deployment as part of whole community emergency preparedness.

The table below summarizes the seven primary lifeline categories.[27] DERs support resilience within each of these lifelines by enabling emergency power for critical loads and supporting utility service delivery. The use case summaries in this report focus primarily on the energy lifeline and on the food, water, and shelter lifeline, all of which were particularly impacted during Winter Storm Uri, but the principles explored through the use case summaries are applicable to the other lifeline categories.

[25] National Response Framework, 4th edition. U.S. Department of Homeland Security. (2019).

[26] Community Lifelines, U.S. Federal Emergency Management Agency. (2020).

[27] Texas uses the national lifeline categories in its own planning documents that relate to federal disaster funding. *See*, for example, State of Texas CDBG Mitigation (CDBG-MIT) Action Plan: Building Stronger for a Resilient Future, Texas General Land Office. (November 2019).

	1. Food, Water, Shelter, Agriculture
	2. Power Grid, Fuel
	3. Law Enforcement/Security, Fire Service, Search and Rescue, Government Service, Community Safety
	4. Medical Care, Public Health, Patient Movement, Medical Supply Chain, Fatality Management
	5. Infrastructure, Responder Communications, Alerts Warnings and Messages, Finance, 911 and Dispatch
	6. Highway/Roadway/Motor Vehicle, Mass Transit, Railway, Aviation, Maritime
	7. Facilities, HAZMAT, Pollutants, Contaminants

2.3. Infrastructure Scales

DERs can provide resilience to individual homes or to the entire grid. The use cases focus on three distinct resilience objectives:

1. Enabling household and neighborhood resilience
2. Protecting critical community facilities
3. Supporting grid resilience

Although DERs may technically be able to support all three of these objectives simultaneously, each use case focuses intentionally on a single objective.

2.3.1. ENABLING HOUSEHOLD AND NEIGHBORHOOD RESILIENCE

DERs can reduce people's vulnerability to harm from natural disasters and electricity loss by improving the quality and comfort of shelter and reducing the harm resulting from loss of power. In order to shelter in their homes, residents need to maintain safe indoor temperatures, refrigerate food and medicine, and support life-critical home medical equipment. Energy efficiency is the single most effective way to make homes and appliances provide better services and comfort when the power system fails, with distributed generation and storage a close second. As of April 2022, 193,000 Texans are dependent on electricity-powered medical devices;[28] batteries are essential to support such devices over a potential multi-day outage. Many rural Texas families rely on electricity to power their water wells, and to provide water for their livestock.[29]

Disasters may necessitate large-scale evacuations, depending on factors such as the type, scale, timing, and duration of impact. But evacuations are disruptive, costly, and dangerous. During Hurricane Rita in 2005, for example, 80% of the deaths during the storm occurred as a result of heat stroke during evacuation rather than from the impacts of the storm itself.[30] Given these risks, emergency management agencies prioritize shelter-in-place strategies over evacuation whenever feasible.[31] If people are able to stay in their homes, it not only relieves pressure on the roads and traffic, but also on emergency shelters.

During Winter Storm Uri, Texas shelters reported challenges caring for the people they received for the duration required. Some shelters ran out of plugs available for medical

[28] U.S. Department of Health and Human Services, HHS emPOWER Map: Medicare Electricity-Dependent Populations by Geography

[29] Real-World Incident After-Action Report/Improvement Plan Winter Storm 2021, Gillespie County, City of Fredericksburg, (2021).

[30] Deaths Related to Hurricane Rita and Mass Evacuation, Anthony, Z., Bela, P. Chest Journal. (October 24th, 2006).

[31] Planning Considerations: Evacuation and Shelter-in-Place Guidance for State, Local, Tribal, and Territorial Partners, U.S. Department of Homeland Security. (July 2019).

equipment, for example, while others had to relocate when their supplies ran out and/or back-up systems failed.[32, 33]

2.3.2. PROTECTING CRITICAL COMMUNITY FACILITIES

In parallel with supporting shelter-in-place strategies, there is a significant opportunity for DERs to help keep the facilities that support public safety, emergency response, and medical care up and running during power outages. Some critical facilities in Texas, such as hospitals[34] and water and wastewater facilities[35] are required to install emergency power to support critical loads. Many critical facilities, however, do not have back-up power systems, as highlighted in after action reports from Winter Storm Uri[36,37] and in local hazard mitigation plans.[38]

Many different types of public and private facilities can be considered critical, such as police and fire stations, emergency shelters, medical facilities, food distribution centers, and water and wastewater treatment plants. Texas laws and emergency management policies broadly define critical infrastructure (Text Box 1), but Texas does not have an official definition for critical facilities at the community level. Each community defines critical facilities differently in documents such as local mitigation strategies.[39] As of 2021, Texas utilities are also required to report critical facilities to the PUCT, although utility facility designations may vary from those

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[32] 2021 Winter Storm Uri After Action Review Findings Report, City of Austin & Travis County Office of Homeland Security and Emergency Management, (2021)

[33] Real-World Incident After-Action Report/Improvement Plan Winter Storm 2021, Gillespie County, City of Fredericksburg, (2021).

[34] 25 Tex. Admin. Code § 131.141 (2010); the federal government also requires hospitals to have back-up power consistent with NFPA 99. *See* Medicare and Medicaid Programs; Emergency Preparedness Requirements for Medicare and Medicaid Participating Providers and Suppliers (CMS-3178-F), Federal Register, (September 16, 2016) and NFPA 99: Health Care Facilities Code, National Fire Protection Association, (2021)

[35] 30 Tex. Admin. Code §217.36 (2015) and Rules and Regulations for Public Water Systems, Texas Commission on Environmental Quality (December, 2019).

[36] City of Waco Texas Severe Winter Storms DR-4586-TX After Action Review, Waco/McLennan County Office of Emergency Management. (2021).

[37] City of Bellaire 2021 February Winter Storms After Action Report / Improvement Plan, City of Bellaire. (2021).

[38] *See*, for example, Harris County Multi-Hazard Mitigation Action Plan Volume 2: Planning Partner Annexes, Harris County Office of Homeland Security and Emergency Management, TetraTech. (2021).

[39] County Hazard Mitigation Status, Texas Division of Emergency Management, (November 1, 2021)

identified by local government.[40] For the purposes of this report, critical facilities are defined as those required to provide community lifeline services.

TEXT BOX 1. CRITICAL FACILITIES IN TEXAS

Texas broadly defines critical infrastructure in its homeland security law[41] and critical facilities in its state Hazard Mitigation Plan.[42] Texas law also sets out criteria for determining whether state agencies are critical facilities.[43,44] These criteria were established as part of legislation following Hurricane Ike in 2008 that requires critical state agencies to assess the feasibility of combined heat-and-power systems that can support emergency operations for at least 14 days.[45] Critical facility designations such as the one below are useful guideposts as Texas communities attempt to deploy DERs to support their own critical facilities.

Critical state governmental facilities are defined as those that are expected to: be continuously occupied; maintain operations for at least 6,000 hours each year; have a peak electricity demand exceeding 500 kilowatts; and serve a critical public health or public safety function during a natural disaster or other emergency situation that may result in a widespread power outage, including a (i) command and control center; (ii) shelter; (iii) prison or jail; (iv) police or fire station; (v) communications or data center; (vi) water or wastewater facility; (vii) hazardous waste storage facility; (viii) biological research facility; (ix) hospital; (x) food preparation or food storage facility.

2.3.3. SUPPORTING GRID RESILIENCE

As discussed in Section 1.3, DERs can support transmission and distribution system resilience by providing electricity, demand flexibility, and other grid services when needed most. Aggregated, coordinated, and compensated DERs can deliver large-scale grid benefits. There are multiple electricity markets and programs in Texas that are designed to support reliable and resilient grid operations, and in which DERs currently participate; however, most of these programs target larger DERs rather than residential and small customer participation, and they recruit limited DER participation relative to the large amount of actual and potential energy efficiency, distributed generation, storage,

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[40] 2 Tex. Util. Code § 38.076 (2021). As of April, 2022, the rulemaking for this requirement under Project No. 51888 remains in the scoping phase. *See* Rulemaking Calendar, Public Utility Commission of Texas, (April 2022).

demand response and other DERs currently available in ERCOT. Some of these programs are managed by ERCOT, whereas others are managed by the utilities (investor-owned, cooperative, and municipal), or by retail electric providers (REPs). The statistics from these programs are drawn from ERCOT's Demand Response webpage, unless otherwise noted.[41] Program examples include:

- ERCOT Emergency Response Service (ERS). ERS compensates loads for turning off in the event of a grid emergency to reduce demand on the system. In 2013, the PUCT allowed small generators—and aggregations of generators—to also participate in the ERS. The total program cost cap for all participating loads and generators is $50 million per year, and the maximum procurement price is $80 per MW per hour.[42] To date, ERS has been deployed when an Energy Emergency Alert is declared to avoid involuntary outages. While this program is helpful, the relatively small scale of ~1,000MW (1.4% of peak demand)[43] is constrained by the program cost cap and does not allow it to address major outages. For example, during Winter Storm Uri, the majority of the ERS fleet was deployed and exhausted within the first 12 hours.
- ERCOT ancillary services markets. The ancillary services markets, such as the Responsive Reserve Services (RRS), are open to loads that can be turned off or on in order to support grid frequency. ERCOT procures RRS resources to ensure that sufficient capacity is available to regulate grid frequency in case power plants trip offline. The total amount of load that can participate in the RRS is limited to 60% of the total responsive reserve requirement. The remaining 40% must be supplied by power generating resources.[44]
- Investor-owned transmission and distribution utility load management programs. Under load management programs, electricity customers agree to reduce their peak demand for a duration requested by the utilities in exchange for payment. In 2021, AEP, CenterPoint, Oncor, and TNMP offered load management programs that saw 325 MW of combined participation during the summer months of 2021. Oncor also established a Winter

[41] Demand Response, ERCOT.

[42] Emergency Response Service Procurement Methodology, ERCOT. (December 17, 2021)

[43] 2021 Annual Report of Demand Response in the ERCOT Region, ERCOT. (2021).

[44] Item 18: 2022 ERCOT Methodologies for Determining Minimum Ancillary Service Requirements, ERCOT. (December, 2021).

Emergency Load Management program in 2021 with a 50 MW demand reduction goal and a budget of $2 million.[45]

- Retail electric providers (REPs), municipal utilities, and cooperative utilities also offer their own demand response programs that focus on addressing high demand and high wholesale prices. These programs vary in terms of their specific structures and participation rates.[46] Some REPs and utilities also use DERs to manage and shape their electric portfolios, including for price hedging, to limit purchases from the wholesale market.

DERs can contribute in other important ways to grid resilience beyond the markets listed above. In some cases, market rules constrain DER participation. In other cases, markets do not exist in Texas to directly compensate DER for the services provided.

3. USE CASES OF DERS FOR ENERGY RESILIENCE

Private sector innovation is creating entirely new pathways for energy resilience across the country. This section contains five use cases of DER technologies and business models that are currently being, or could be, deployed to support a more resilient energy system in Texas. The use cases focus on a diversity of resilience opportunities that could be effectively scaled in Texas and are not intended as an exhaustive catalog.

3.1. Use case Structure

The use cases use a standard structure to review:

- Scope. The use cases focus on different technologies, scales, and community lifelines, using the icons introduced in Section 2 as a legend.
- Technology Overview. A high-level description of the technology and/or the business model and how it contributes to resilience.

[45] Winter Emergency Load Management Market Transformation Program (WELMMTP) 2021/22 Program Manual, Oncor. (December 2021).

[46] 2021 Annual Report of Demand Response in the ERCOT Region, ERCOT. (2021).

- Market Overview. A general overview of the market for the technology to give a sense of the scale and momentum of the opportunity.
- Resilience in Action. A deeper look at how the technologies can be used to support energy resilience in Texas. When specific Texas examples are unavailable, the use cases feature examples from other states that could be adapted.
- Who is Setting the Pace? Examples of jurisdictions that are playing a leadership role in deploying DERs for energy resilience. The examples are drawn from jurisdictions with a variety of policy environments and electricity market structures.
- Pathways to Scale. Examples of policy and program innovations that would enable DER to more fully support energy resilience in Texas. These examples are explored in greater detail in the policy roadmap contained in Section 4.

3.2. Energy Efficiency for Passive Survivability

Energy efficient homes and buildings reduce the risk and harmful consequences of outages and can help residents to shelter in place.

TECHNOLOGY OVERVIEW

Energy efficiency measures—such as air sealing, wall insulation, ceiling insulation, energy efficient windows, and efficient roofing—support passive survivability, which the Houston Advanced Research Center (HARC) defines as "a building's ability to maintain life-support functions in the event of an emergency situation or natural disasters such as a hurricane, high wind, or flood event."[47] In particular, residents in homes with insulation and a sound building envelope can maintain a tolerable indoor temperature during adverse weather conditions and are able to shelter in place for longer periods of time. Energy efficient households also have lower grid-facing demand and therefore may lower system peak demand, and lower post-disaster restoration requirements.[48] Energy efficiency can also enhance social and economic resilience by reducing energy cost burden borne by low-income households.[49]

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[47] Texas Residential Passive Survivability, HARC, State Energy Conservation Office.

[48] Texas utility energy efficiency programs also include load management and demand response. Load management is discussed in Section 3.6.

[49] Enhancing Community Resilience through Energy Efficiency, ACEEE. (October, 2015).

MARKET OVERVIEW

Texas has more untapped cost-effective energy efficiency than any other state, estimated to equal more than 12% of 2025 sales.[50] Texas regulations require the state's investor-owned transmission and distribution utilities to meet energy efficiency goals, set at 30% of annual demand growth and at least 0.4% of peak load.[51] To accomplish these goals, the utilities fund and administer incentive programs for energy savings, which they then contract with energy efficiency service providers to implement. In 2020, the IOUs invested close to $129 million, which produced 502 MW of demand reductions and close to 700 GWh of energy savings.[52] For context, peak demand within ERCOT was 74,380 MW in 2020, and energy use was 382,000 GWh.[53]

RESILIENCE IN ACTION

A recent study found that energy efficiency can directly contribute to passive survivability in Texas during power outages.[54] The study found that increasing wall insulation, for example, can improve survivability during a three-day outage by more than 24%, whereas improving roof absorptivity can increase survivability by more than 27%. The study focused on older buildings, since they perform worse than newer buildings in terms of passive survivability during power outages[55], and because they are more likely to be occupied by people that are more vulnerable to extreme temperatures and have fewer resources to cope.[56]

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[50] State Level Electric Energy Efficiency Potential Estimates, Electric Power Research Institute. (May 2017).

[51] Chapter 25: Substantive Rules Applicable to Electric Service Providers, Public Utility Commission of Texas (2022).

[52] Energy Efficiency Accomplishments of Texas Investor-Owned Utilities, Electric Utility Marketing Managers of Texas (2021).

[53] 2020 State of the Grid Report, ERCOT.

[54] The study uses the Discomfort Index as a metric for passive survivability. *See* Synergies and Trade-offs between Energy Efficiency and Resiliency to Extreme Heat: A Case Study, Baniassadi, A., Sailor, D.J., Building and Environment, 132, pp. 263-272. (2018).

[55] Adapting Existing Energy Planning, Simulation, and Operational Models for Resilience Analysis, NREL. (February, 2020).

[56] Geographic Dimensions of Heat-related Mortality in Seven U.S. cities, Hondula, D.M., Davis, R. E., Saha, M.V., Wegner, C.R., & Vezey, L.M., Environmental Research 138, pp. 439-452. (April 2015)

Energy efficiency can also increase passive survivability during extreme cold. During Winter Storm Uri, parts of Texas experienced multiple days of temperatures below freezing. A study following Superstorm Sandy in New York analyzed the ability of energy efficiency to sustain indoor temperatures during blackouts. The study found that at temperatures below freezing, the temperature inside a standard single-family home would fall to 35 degrees after three days without power. If the same home were equipped with insulation, efficient windows, air sealing, and other high performance measures, the inside temperature would only fall to 60 degrees after a three-day outage.[57] Some housing in New York has since been built to maintain temperature during multi-day outages.[58] In Maine, 160,000 utility customers lost power for multiple days in freezing conditions during an ice storm.[59] Homes built to passive house standards - with sealed and insulated building envelopes, triple-pane windows, and thick walls - recorded indoor temperatures of 58 degrees after four and half days without power and with outdoor temperatures at 5 below zero.[60]

Texas energy efficiency programs could be targeted to improve passive survivability and thermal safety. There were approximately 11.8 million housing units in Texas as of 2021, according to the U.S. Census Bureau, of which 79% are single family homes.[61, 62] An estimated 50% of single-family homes in Texas have inadequate attic insulation,[63] which equates to a market opportunity of 4.8 million homes for this efficiency measure alone. Texas's energy efficiency budgets are limited, however, compared to the overall opportunity in utility service territories. Oncor,[64] which serves areas of East, West, and North-Central Texas, has the largest energy efficiency budget of the IOUs, with $44 million in projected spend in 2022. Oncor residential energy efficiency

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[57] Baby It's Cold Inside, Urban Green Council. (2014).

[58] The Passive House in New York, Gregor, Al. The New York Times. (March 27, 2015); HANAC Corona Senior Residence Certified as Passive House, Stewart, K. Association for Energy Affordability. (December 15, 2020).

[59] Ice Storm Could Cost Maine Energy Customers, Hench, D., Portland Press Herald. (December 30, 2013)

[60] Resilience in the Face of Disaster: Energy Efficiency's Role, Hotchkiss, E. (January, 2018)

[61] QuickFacts: Texas, U.S. Census Bureau. (2021).

[62] Energy Efficiency And Demand Response: Tools To Address Texas's Reliability Challenges, ACEEE, (October 13, 2021)

[63] Energy Efficiency And Demand Response: Tools To Address Texas's Reliability Challenges, ACEEE, (October 13, 2021)

[64] Oncor Electric Delivery Company LLC 2022 Energy Efficiency Plan and Report. Public Utility Commission of Texas, (April 1, 2022).

programs[65] represent 42% of its projected efficiency spend, and 18% of the projected energy savings in 2022. Even if all of Oncor's residential programs budgets were devoted to insulation, the 2022 budget would support only an estimated 5,000-10,000 home retrofits each year.[66] For context, Oncor has 3.25 million residential customers. The other utilities have smaller budgets than Oncor, but their residential programs are similarly small relative to the size of Texas' energy efficiency market opportunity and need.

WHO IS SETTING THE PACE?

Texas ranks behind 35 other states in terms of its energy efficiency spending. Texas spends the equivalent of 0.5% of statewide electricity revenues on energy efficiency, whereas Oklahoma, Arkansas, and Wyoming spend more than twice that amount. Vermont leads the country by spending the equivalent of 7.6% of electricity revenues each year.[67] This low spending translates to low savings rates; as noted above, Texas boasts more untapped cost-effective energy efficiency savings than any other state.

Although the leading efficiency programs emphasize residential insulation and weatherization, passive survivability is not the primary goal of most programs. There are a growing number of building standards, however, that specifically focus on energy efficiency for resilience. The U.S. Green Building Council, for example, has introduced pilot credits for passive survivability and back-up power as part of its LEED standards.[68] Cities are also including passive survivability in their design guidelines for capital projects. Washington, DC, for example, has specific design guidance for power outages that includes energy efficiency to "keep occupants safe during extended power outages.[69]" New York City's design guidelines emphasize efficiency to ensure thermal safety for building occupants.[70] Although the guidelines are for municipal projects, DC notes that "the guidelines can also be used as a resource for private development."

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[65] Take a Load off Texas - Residential, Oncor, (2021).

[66] Depending on the cost for insulation and the share of the cost covered by incentives. Assuming $3,500 per home cost for attic insulation and duct sealing with 100% of the cost paid by the utility program, the three residential programs would result in ~5,400 retrofits. Assumptions on insulation and duct sealing costs based on Energy Efficiency and Demand Response: Tools to Address Texas's Reliability Challenges, ACEEE, (October, 2021).

[67] State Energy Efficiency Scorecard: 2021 Progress Report, ACEEE. (February, 2022).

[68] Passive Survivability and Back-up Power During Disruptions, U.S. Green Building Council. (2022).

[69] Resilient Design Guidelines, Climate Ready DC.

[70] Climate Resiliency Design Guidelines, New York City Mayor's Office of Resiliency. (September, 2020).

PATHWAYS TO SCALE

- Raise the utility efficiency targets. Increase the annual energy efficiency target and budgets to accelerate deployment. (Section 4.1.1)
- Focus on winter peak. Establish a complementary focus on winter peak demand given the lessons of Winter Storm Uri. (Section 4.1.2)
  Target critical community facilities and critical customers. Expand or create programs to focus energy efficiency efforts on passive survivability for specific types of vulnerable customers and/or on critical facilities that support community lifelines. (4.2.1)

3.3. Solar and Energy Storage for Resilient Homes

Solar and storage systems help Texans stay in their homes during power outages.

TECHNOLOGY OVERVIEW

Solar photovoltaic (PV) and battery energy systems can be configured to provide electricity for households when the electricity grid goes down. Solar PV and energy storage systems can sustain an average home for a day - or longer, depending on how the system is configured and whether it is paired with other resources like home generators or electric vehicles.

MARKET OVERVIEW

The solar PV market is booming nationally, with 121 GW of cumulative solar PV installed across the country as of the end of 2021. Texas installed the largest amount of solar PV capacity of any state in 2021 and is second only to California in terms of total capacity, with 13.8 GW installed.[71] Distributed systems smaller than 1 MW accounted for more than 1.3 GW of the cumulative capacity installed statewide.[72] Residential PV in particular has expanded exponentially in Texas, at an average growth rate of more than 50% each year since 2010. In 2021, the total MW of installed residential PV capacity increased by 70%, from 270 MW in 2020 to 460 MW.[73]

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[71] State Solar Spotlight (Texas), Solar Energy Industries Association, (March 10, 2022)

[72] Data compiled by the Texas Solar Power Association, based on ERCOT data.

[73] Residential PV Analysis and Profile Assignment/Validation Considerations, ERCOT. (March, 2022).

The U.S. energy storage market set a record in 2021, with 3.4 GW of energy storage capacity installed nationally. The residential energy storage sector set a record with 123 MW installed. Texas was the third largest residential market for energy storage behind California and Puerto Rico, with many buyers motivated by the power outages from Winter Storm Uri.[74] Nationally, residential energy storage is projected to grow to 2 GW annually by 2026, and Texas is projected to continue to be the third largest market.

RESILIENCE IN ACTION

There are a growing number of companies that offer standardized residential solar and energy storage systems for Texas homes. Customers can enter into a long-term contract where the company owns and operates the system over time, or customers can purchase the systems themselves.

The length of time that solar or solar plus battery systems can operate independent of the grid will depend on the size of the system, the system inverter type and settings, and the size of the loads supported. A system designed to support an entire house may only provide emergency power for a few hours, whereas a system designed to support only certain critical household loads may be able to operate for more than a day without needing to recharge. In order to support only specific critical loads, residential customers can set up a dedicated electrical subpanel that connects their priority loads directly to the solar and energy storage system - or they can manually turn systems off (e.g., by unplugging them or flipping switches in the fuse box) when a power outage hits.[75] Solar PV systems must also be equipped with an inverter capable of operating independently of the grid in "islanded" mode.[76]

One of the solar and energy storage companies operating in Texas is Sunrun,[77] which offers its Brightbox product. Sunrun has installed solar and energy storage at critical facilities, such as at fire stations in Puerto Rico after Hurricane Maria,[78] but their primary focus is on residential systems. The Brightbox offering combines solar PV panels with battery storage provided by

[74] U.S. Energy Storage Monitor, Wood Mackenzie, (March 10, 2022).

[75] How to Pick a Solar Panel and Battery Backup System, Heffernan, T., Wirecutter. (April 28, 2022).

[76] The IEEE 1547 standard specifies requirements for DERs that intentionally island. *See* Highlights of IEEE Standard 1547-2018, NREL, PJM Technical Workshop on DER Integration. (July 30-31, 2019).

[77] Sunrun Ranked As Leading Residential Solar-Plus-Storage Vendor, Clean Technica, (October 19, 2018).

[78] Sunrun, Empowered by Light Bring Electricity to Fire Stations in Puerto Rico, PV Magazine, (November 20, 2017).

either a Tesla Powerwall system or LG Chem batteries. The Tesla Powerwall stores 13.5 kilowatt-hours of electricity, and the LG Chem battery holds 9.8 kWh, which can sustain key home loads for 8 to 12 hours. With moderate sunshine, the solar PV panels can then replenish the battery storage the next day. During Winter Storm Uri, some system owners reported that they were able to ride through the power outage and provide shelter for their neighbors when other houses around them lost power.[79, 80]

Solar and energy storage powers a home in Fulshear, TX, during Winter Storm Uri. Source: Sunrun

Sunrun also recently launched an offering featuring the all-electric Ford F-150 Lightning light-duty pick-up truck, paired with residential solar PV for resilience.[81] The Lightning comes equipped with a 98 kWh or 131 kWh battery, which can be used to supply power to homes for multiple days during outages as part of the Ford Intelligent Backup Power system.[82] The system includes a bidirectional charging station, an inverter, and a transfer switch.[83] F-150 all-electric trucks are not yet widely available as of the publication of this report, but the use of all-electric pick-ups for resilience builds on the use of hybrid electric trucks observed during Winter Storm Uri. Some Texans with Ford F-150 hybrid electric vehicles, for example, used the vehicles'

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[79] How I Kept My Home Powered Through Recent Blackouts, Sunrun, (March 10, 2021).

[80] Keeping your home powered with a home solar battery, Sunrun, (April 28, 2021)

[81] F-150 Lightning: Intelligent Backup Power | Sunrun | Ford, Sunrun, (February 2, 2022).

[82] PG&E, Ford to explore electric pickup truck as backup generator for home, TechCrunch, (March 10, 2022).

[83] Ford F-150 Lightning Home Integration System To Cost $3,895, InsideEVs, (April 20, 2022).

onboard generators to power essential home equipment for multiple days,[84] and Ford Motor Co. asked its dealers in Texas to loan out trucks with generators to supply power during the outage.[85]

WHO IS SETTING THE PACE?

Residential solar and energy storage systems are being purchased by individual homeowners nationwide and represent a growing potential resilience resource. There are multiple ongoing efforts to use solar and storage to provide resilience to entire neighborhoods, and to use aggregations of residential solar and storage projects to support the grid. In Texas, for example, PearlX is aggregating resilient solar and storage at a Houston apartment building with solar and storage installed at Rice University housing to participate in utility demand response programs.[86,87]

- Several states and utilities have introduced programs that provide residents who install battery storage for back-up power with compensation for participating in demand response programs. Green Mountain Power, an investor-owned utility in Vermont, launched its Bring Your Own Device program for battery storage systems up to 10 kW in size. Under the program, batteries that can discharge for three hours are paid an upfront incentive of $850 per kW, whereas systems with a four-hour duration receive $950 per kW.[88] Stand-alone batteries or batteries paired with pre-existing solar PV arrays receive an additional $100/kW if they are installed in constrained areas of the distribution grid, as identified on the GMP solar map.[89] As of June, 2021, there were 250 participants enrolled in the BYOD program, of which 44% were located in constrained areas of the grid.[90] A similar program in Hawaii

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[84] Texans Are Using Ford F-150 Hybrids to Power Their Frigid Homes During Winter Storm, Motortrend, (February 18, 2021).

[85] Ford Asks Texas Car Dealers to Loan Out Trucks with Generators amid Power Outages Due to Winter Snowstorm, People, (February 18, 2021).

[86] Texas community virtual power plant to use SolarEdge's Energy Bank battery storage, Colthrope, A., Energy Storage News. (January 14, 2022)

[87] PearlX, Rice University unveil sustainable housing unit in Houston, Wells, L., Houston Agent Magazine. (May 5, 2022)

[88] Bring Your Own Device ("BYOD") Terms and Conditions, Green Mountain Power.

[89] GMP Solar Map 2.0, Green Mountain Power.

[90] Communication with GMP. (June 2022).

focuses specifically on aggregating homes that add battery storage to new or existing PV systems.[91]

- Utilities are also partnering with homebuilders to develop residential neighborhoods that use solar and storage to support resilience. Southern Company supported the development of the 62-home Reynolds Landing development in Birmingham, AL. The homes are equipped with smart and energy efficient technologies, and backed up by an offsite microgrid powered by solar PV, battery storage, and a natural gas generator.[92,93] In Florida, the Public Service Commission approved utility investment in a residential development that provides resilience through solar and storage at each home and a central "community energy plant" microgrid that includes battery storage and natural gas engine.[94] In Colorado, the Basalt Vista development features 27 homes for teachers and other members of the local workforce that each include rooftop solar and battery storage configured for resilience.[95, 96] An explicit goal for each of these projects is to explore the support that resilient neighborhoods can also provide to the grid.
- CPS Energy's Save Tomorrow's Energy Plan (STEP) provides incentives for solar, but not for batteries installed with solar. CPS is currently seeking community input on its offerings through its Rate Advisory Committee (RAC).[97]

PATHWAYS TO SCALE

- Leverage federal funds incentives. The $1 billion Energy Improvement in Rural and Remote Areas Program is one of many in the Infrastructure Investment and Jobs Act that could support DER for energy resilience. (Section 4.2.1)

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[91] Battery Bonus: Cash Incentive to Add Energy Storage to an Existing or New Rooftop Solar System, HECO.

[92] Connected Communities Examples: Spotlight on Reynolds Landing, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, (May 4, 2020).

[93] Welcome to Reynolds Landing: An Alabama Community Spearheading the Grid Edge Transition, Gerdes, J., GTM. (March, 2019).

[94] Petition for approval of direct current microgrid pilot program and for variance from or waiver of Rule 25-6.065, F.A.C., by Tampa Electric Company, Florida Public Service Commission, (June 3, 2021).

[95] Colorado Mountain Homes Prepare To Pilot Autonomous Energy Management, National Renewable Energy Laboratory, (November 1, 2021).

[96] Grid Modernization of Cooperatives and Municipal Utilities via Breakthrough System Monitoring, Control and Optimization, National Renewable Energy Laboratory. (2020).

[97] See cpsenergy.com/rac.

- Market participation. Enable 3rd party solar and energy storage providers to more readily and fully participate as virtual power plants in wholesale markets. (Section 4.4.1)
- Support geographic concentrations of solar and energy storage. Encourage resilient solar and energy storage development in high-priority areas through mechanisms such as shared grid upgrade costs. (Section 4.2.4)
- Offer incentives for distributed solar and storage owners to operate their resources in grid-supporting ways, including discharging batteries to mitigate evening PV ramp-down and charging EVs during afternoon peak PV production and late early morning excess wind generation periods (Section 4.2.3).

3.4. Microgrids for Critical Facilities

Microgrids are supporting hundreds of grocery stores and other critical facilities across Texas.

TECHNOLOGY OVERVIEW

Microgrids are local power systems that can serve the loads they are connected to independently of the power grid. During power outages, microgrids can disconnect from the grid and keep critical facilities and critical infrastructure up and running. Microgrids can vary widely in size from a few loads to entire neighborhoods, and can incorporate a broad range of DERs and control technologies. At present, most microgrids contain either a single generator (diesel- or natural gas-fired) or combinations of solar PV, backup generation and/or batteries.

MARKET OVERVIEW

Gas-fired and combined heat-and-power systems make up a large share of U.S. microgrid capacity, although renewable energy and energy storage systems also play significant roles. The market for microgrids has grown rapidly in the U.S., and there were 4.2 GW of microgrids installed within the U.S. by the end of 2021.[98] Texas ranks second behind New York for total installed microgrid capacity.[99] By 2030, the U.S. total microgrid capacity is projected to reach

[98] U.S. Department of Energy Combined Heat and Power and Microgrid Installation Databases. (2021).
[99] Summary Microgrid Dataset, Current Microgrid Installations by State, U.S. DOE (2021).

32.8 GW.[100] Typical microgrid installations include military bases, industrial facilities, individual facilities such as hospitals, and the occasional community facility complex.

RESILIENCE IN ACTION

Critical facilities across Texas have installed microgrids for resilience purposes, and used them to sustain community services during Winter Storm Uri, Hurricane Harvey, and many shorter-term natural disasters and power outages. Microgrids can be customized and expensive, which is a challenge to deploying them at scale. Houston-based Enchanted Rock has developed a unique business model for streamlining and de-risking microgrid deployment.

Enchanted Rock offers "resiliency-as-a-service" through 10 to 20 year agreements, under which the company installs, owns, and operates microgrids at the customer's site in exchange for a monthly service fee. The microgrids are powered by reciprocating engines fueled with natural gas or renewable gas. During normal operations, the microgrids earn revenue by participating in the wholesale markets (mostly providing ancillary services). The wholesale market revenues allow Enchanted Rock to reduce the total cost of the microgrids to their customers. During power outages, the microgrids disconnect from the grid and serve their host sites in islanded mode. Enchanted Rock centrally monitors and dispatches its fleet of microgrids through the company's microgrid network operations systems.

Enchanted Rock has installed microgrids at over 260 critical facilities across Texas. The total capacity of the Enchanted Rock microgrid fleet is 526 megawatts, with an additional 200 MW under construction. The sites include retail stores, hospitals, nursing homes, water utilities,[101] and chemical facilities. During Winter Storm Uri, the Enchanted Rock microgrids provided back-up power to more than 140 sites. The Enchanted Rock microgrids provided more than 5,000 hours of emergency power during the winter storm, with one microgrid sustaining its host facility for more than four days. The 100+ microgrid locations that were not required to island and provide back-up power during Uri continued operating to inject energy into the ERCOT grid.

One of Enchanted Rock's largest customers is H-E-B, a Texas-headquartered grocery chain. During Winter Storm Uri, 75% of Texas residents reported difficulty procuring food and

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[100] 'The Renewable Energy Economic Benefits of Microgrids, Guidehouse, Civil Society Institute (November, 2021)

[101] Texas water utility selects Enchanted Rock to provide microgrid, Microgrid Knowledge, (April 6, 2022).

groceries as a result of supply chain issues, transportation disruptions, and loss of power at grocery stores.[102] H-E-B's stores across the state were able to stay up and running and provide food, gasoline, and prescription drugs. The microgrids allowed H-E-B to continue to support community lifelines while also saving money. Grocery stores can have $300,000-$900,000 in perishable items in their stores,[103] and H-E-B estimates that it saved approximately $500,000 per store during the storm by preventing food spoilage and maintaining operations and sales.[104]

Since retail stores are often centrally located within communities or along major transportation arteries, they can also support emergency response efforts above and beyond their core business. During Hurricane Harvey in 2017, for example, national guard units and first responders used Buc-ee's convenience stores equipped with Enchanted Rock microgrids as a headquarters for their operations.[105]

WHO IS SETTING THE PACE?

States, cities, and utilities across the country have developed microgrid programs for communities and for critical facilities.[106,107] Many of these programs have been created in response to natural disasters and have been limited in scope. The U.S. Department of Defense (DoD) is a leader in the sustained development of energy resilience policies and projects for critical facilities. U.S. military installations are almost entirely dependent on the commercial power grid. Each year, domestic installations experience hundreds of power outages that last longer than eight hours, many at bases with missions that cannot tolerate even momentary power outages. Projects such as the solar and energy storage microgrid at Fort Hood[108] help

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[102] Winter Storm of 2021, University of Houston, Hobby School of Public Affairs.

[103] How to tackle power outages in the food, beverage industry, Refrigerated and Frozen Foods, (June 29, 2018).

[104] HEB, known for coming to the rescue with water and hot meals, added electricity to that list, The Dallas Morning News, (March 19, 2021).

[105] Buc-ee's Ltd., Enchanted Rock.

[106] Private, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids, National Association of State Energy Officials, National Association of Regulatory Utility Commissioners, (January 2021).

[107] Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs, National Association of State Energy Officials, National Association of Regulatory Utility Commissioners, (February 2022).

[108] Microgrid at Fort Hood Army Base in Texas successfully islands from Utility Grid, EnergyTech, (November 22, 2021).

military installations achieve their requirement to stay up and running for 1-2 weeks without grid electricity. In 2022, the U.S. Army set a target to install a microgrid at all of its bases by 2035.[109]

PATHWAYS TO SCALE

- Enable DERs to more fully participate more fully in the ERCOT market. Updated rules could allow DERs that support critical facilities to more readily compete in the energy and ancillary services markets. (Section 4.4.1)
- Create back-up power requirements for critical facilities. Require back-up power be installed at critical facilities and allow different types of DERs to meet the back-up power mandates. Create dedicated incentives and grants for critical infrastructure resilience. (Section 4.2.2)
- Compensate resilient DERs for the value they create for the distribution grid. Establish new mechanisms for utilities and/or customers to receive payments for the grid services they provide in both ERCOT and non-ERCOT areas (Section 4.2.3).

3.5. Electric Vehicles to Stabilize the Grid

Fleets of electric cars and buses are being coordinated to support grid resilience by shifting electricity demand.

TECHNOLOGY OVERVIEW

Electric vehicles (EVs) such as electric cars and buses rely on battery packs to store the electricity required to power their motors. Vehicle charging times can be coordinated with the needs of the grid. EV charging can be shifted to absorb periods of high wind or solar energy production or shifted away from periods of high demand to reduce strain on the grid. Electric vehicles can also send power back to the grid under vehicle-to-grid (V2G) configurations during peak demand or periods of scarcity. As discussed in Section 3.3, next-generation electric vehicles will also be able to provide resilience directly to homes and critical facilities.

[109] United States Army Climate Strategy, Department of the Army, Office of the Assistant Secretary of the Army for Installations, Energy and Environment, (February 2022).

MARKET OVERVIEW

In the U.S., approximately 2.5 million light-duty EVs have been sold since 2010, with close to 200,000 sold just in the first quarter of 2022.[110] EV adoption is accelerating due to new lower-cost battery technologies, expanding charging infrastructure, rising policy support, and increased consumer interest.[111]

In Texas, there are 128,000 EVs as of May 2022.[112] ERCOT's *2020 Long-Term System Assessment* presents a scenario under which there will be 500,000 electric cars and pick-up trucks on the road by 2025, and 4.5 million by 2035 under current trends.[113] The market for electric buses is small but is rapidly expanding due to new technologies and business models. ERCOT's *System Assessment* also considers a scenario under which 77% of the miles traveled by buses and heavy-duty trucks are powered by electricity in 2035, alongside 7.3 million light duty EVs. A recent study found that If all school buses in Texas were electrified, they could provide 660 megawatts of storage capacity, and supply electricity sufficient to power 122,000 homes for a day.[114] All major school bus manufacturers now make electric models, and there are companies that offer to own and operate electric bus fleets at an annual price that is either cost-neutral or offers cost savings relative to what the school district currently pays to operate their traditional fleet (see below). Electric buses also have larger batteries than cars and can provide a greater amount of power not only to the grid - but also to schools, which may serve as emergency shelters. As of December 2021, 354 school districts in 36 states had committed to purchasing 1,800 electric school buses.[115] In Texas, electric school buses have been deployed by the Everman Independent School District (ISD). Texas cities such as Austin, Bryan-College Station, Houston, Lubbock, and Port Arthur have also purchased electric buses for their public transit fleets.[116]

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[110] Light Duty Electric Drive Vehicles Monthly Sales Updates, Argonne National Laboratory. Light duty vehicles weigh less than 10,000 ponds and are used to transport passengers and cargo. They include cars, vans, SUVs, and pickup trucks.

[111] Electric Vehicle Outlook 2021, BloombergNEF, Bloomberg Finance LP, (2021).

[112] Texas Electric Vehicle (EV) Registration Tool, Dallas-Fort Worth CLean Cities. (May 24, 2022).

[113] 2020 Long-Term System Assessment for the ERCOT Region, ERCOT. (2020).

[114] Electric Buses and the Grid: Unlocking the power of school transportation to build resilience and a clean energy future, Environment Texas Research and Policy Center. (March 17, 2022).

[115] The State of Electric School Bus Adoption in the US, World Resources Institute, (February 2022).

[116] *See*, for example, Electric Fleet, CapMetro, and Port Arthur Transit gets six new electric buses, new charging depot under construction, Gibson, R., 12 News (202).

RESILIENCE IN ACTION

There are multiple ongoing efforts in Texas and other states to use electric vehicles to support the grid by shifting their charging schedules. Austin Energy's EV360℠ Plug-In Electric Vehicle Charging Subscription is a time-of-use pilot program for up to 100 participants to encourage off-peak EV charging through a separate residential meter attached to an in-home electric vehicle charger. Any energy consumption that occurs during on-peak periods is multiplied by Power Supply Charges.[117] CPS Energy, the municipal utility that serves San Antonio, offers incentives for EV customers to sign up for their demand response programs: *Flex*EV Smart Rewards and *Flex*EV Off-Peak Rewards. Under the Smart Rewards program, CPS Energy will provide a utility bill credit for EV customers allowing the utility to make remote adjustments to their charging schedule between high demand hours (2:00 - 9:00 PM during the week). The Off-Peak Rewards program allows customers to set their own charging schedules to avoid peak hours.[118]

Private aggregators are also using EVs to participate in ERCOT's markets. In 2021, for example, Leap announced a partnership with OptiWatt to aggregate a fleet of electric vehicles to participate in the Emergency Response Service market.[119] Leap organizes and connects "virtual power plants" of aggregated DERs to electricity markets, demand response programs, and other sources of revenue. OptiWatt provides software to manage and schedule EV charging. OptiWatt's fleet in Texas consists of 2,500 vehicles.

Electric bus aggregations also provide a promising avenue for aggregated grid services. Buses have consistent daily routes that make energy management planning predictable, and buses are also used less during summer when the grid experiences high loads.[120] Although the cost of purchasing an electric bus is currently higher than buying a diesel bus, fuel and maintenance costs are lower, making buses a competitive option on a lifecycle basis in Texas.[121]

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[117] FY 2022 Electric Tariff Pilot Programs, Austin Energy, (2022).

[118] Electric Vehicles - Charging Solutions. CPS Energy.

[119] Leap Announces Its Expansion in Texas Energy Market and New Partnership With Optiwatt, businesswire.com. (November 17, 2021).

[120] The Path to a Vehicle-to-Grid Future, Davar, Z., SEPA. (February 6, 2020).

[121] Accelerating Electric School Bus Adoption for Grid Reliability and Community Resilience, Advanced Energy Economy. (April 20, 2022).

Companies such as Highland Electric are now offering bus "subscriptions" to school districts under which the company designs, purchases, builds, and maintains the electric bus fleet at no upfront cost to the customer. Highland Electric is the largest provider of turnkey electrification services in the U.S. and currently manages the country's largest single electric school bus deployment in Montgomery County, MD.[122] Highland Electric has partnered with state and local stakeholders in Texas to analyze near-term potential for aggregated fleet deployment. According to the analysis, there are several large districts in Texas that could each procure up to 400 electric school buses over the next four years, equating to more than 90 megawatt-hours of battery capacity, which is enough to power 5,000 homes for one day. This type of project would be capable of providing 24 megawatts of instantaneous power to the grid.

Delivery vehicles also represent an opportunity for vehicle-to-grid DER leverage, because the vehicles charge over the same period, in the same location every day and thus can be used for managed charging and discharging services. E-commerce and delivery giant Amazon has committed to develop an all-electric delivery vehicle fleet as part of its decarbonization strategy.[123] UPS has announced plans to buy at least 10,000 all-electric delivery vans[124] and FedEx plans to electrify its entire fleet of delivery vehicles (at least 200,000 units) by 2040.[125] Given the size of the Texas population and economy many of these electric vehicles will serve within Texas and could be used for energy resilience and grid support, in addition to their primary transportation purpose.

WHO IS SETTING THE PACE?

Programs that manage vehicle charging can provide critical support to the distribution grid and transmission system, especially as transportation continues to electrify. The next frontier for aggregated electric vehicles is V2G programs that allow EVs to proactively feed electricity from their batteries back into the grid.[126] As electric vehicle penetration continues in the future, it is

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[122] Proterra to deliver over 320 V2G-equipped school buses to Montgomery County, Maryland, Charged EVs, (March 5, 2021).

[123] Amazon's first electric delivery vans are now making deliveries — see how they were designed, Meisenzahl, M., Business Insider (February 3, 2021)

[124] UPS Jumps Into The Future With Plan To Buy 10,000 Electric Vans And A Waymo Self-Driving Delivery Pilot, Ohnsman, A., Forbes. (January 29, 2020).

[125] FedEx Plans To Electrify Its Entire Fleet Of Delivery Vehicles By 2040, Foote, B. Ford Authority. (March 4, 2021).

[126] Accelerating Electric School Bus Adoption for Grid Reliability and Community Resilience, Advanced Energy Economy. (April 20, 2022).

critically important that vehicles are integrated into the power grid in an intelligent way. According to McKinsey, when the local electric vehicle penetration hits 25%, the peak power demand may increase by 30%.[127] As a result, integrating vehicles into the grid in a manner that does not create supply-demand imbalances is critical. Integrating vehicles into the grid with bi-directional capabilities through V2G as well as smart charging are important ways to ensure the grid is balanced and adequately supplied. A recent study, for example V2G requires compatible vehicles, bi-directional chargers, and charge management software to control the timing and rate of battery discharge. V2G programs require close coordination with electric utilities to ensure technical feasibility and communication between the vehicle, charger, grid and software platform. In Texas, Austin Energy and Pecan Street launched the first V2G pilot project in the state in 2019, which uses a Nissan Leaf to supply power during periods of peak demand. Examples of V2G programs from elsewhere in the country include:

- A fleet of electric vehicles based in Delaware was the first V2G aggregation to successfully participate in the PJM ancillary services market in 2013.[128] [129]
- Highland Electric piloted the first successful example of a V2G school bus in a distribution grid demand response program, in partnership with Beverly Public Schools in Massachusetts. The EV bus participated in the National Grid ConnectedSolutions demand response program, and delivered 3 MWh of energy to the grid, or enough to power 100 homes for a day.[130]
- Nuvve, a company specializing in V2G, is working with SDG&E in California to interconnect bi-directional electric buses in three school districts for participation in California's summer Emergency Load Reduction Program.[131] This program builds on traditional demand response structures by adding a mechanism for utilities to compensate behind-the-meter resources that export energy when CAISO issues a grid alert. The V2G buses will be paid for export at $2/kWh for 30-60 hours of response every year. In addition to its work with school buses, Nuvve and its subsidiary, Levo Mobility, LLC, also use Nuvve's proprietary

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[127] The Potential Impact of Electric Vehicles on Global Energy Systems, McKinsey, (July 2018).

[128] Electric Vehicles Start Selling Power into PJM Grid, Tweed, K. GTM. (May 2, 2013).

[129] Your electric vehicle could become a mini power plant, Grist, (June 21, 2021).

[130] Massachusetts Electric School Bus Helps Power Electricity Grid In Breakthrough For Vehicle-to-Grid Technology, Proterra, (October 13, 2021).

[131] Vehicle-to-Grid Pilot: Leveraging Big Batteries on Electric School Buses to Support the Grid, SDG&E NewsCenter. (April 21, 2021)

V2G technology and $750 million of committed capital to electrify delivery, ride hailing and ride sharing, and municipal fleets on an "as-a-service" basis.[132]

PATHWAYS TO SCALE

- Update existing Texas grant and incentive programs, such as Diesel Retrofit Program, Governmental Alternative Fuel Fleet Grant Program, and Light Duty Motor Vehicle Incentive Program, to provide more funding for EVs for mobile resilience and to allow private ownership of bus fleets and charging infrastructure. (Section 4.3.1).
- Identify opportunities to integrate EVs into local hazard mitigation strategies as a way to address unmet back-up power needs. (Section 4.3.2).
- Provide incentives for customers to better coordinate EV loads and charging times with grid resources (Section 4.3.3).

3.6. Demand Response Delivering Resilience

Consumers choosing smart thermostats and building energy management systems are actively strengthening grid resilience and optimization.

TECHNOLOGY OVERVIEW

As the grid continues to modernize, electricity consumers are increasingly incentivized to take advantage of demand response technologies and programs to manage their electricity use in ways that respond to grid needs. Demand response (DR) is an opportunity for electricity consumers to reduce, shift, and control their electricity usage in all seasons and times in response to time-based pricing or other forms of financial incentives.

A leading example is the use of smart thermostats in residences and building energy management systems in commercial, and industrial spaces to manage internal energy use and participate in utility- or grid operator-offered DR programs. Smart thermostats track for consumers how much energy they use every day, show how they can use less, and can respond

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[132] Stonepeak Partners LP and Evolve Transition Infrastructure LP (NYSE: SNMP) have partnered with Nuvve to finance fleet electrification. See Nuvve and Stonepeak Finalize 'Levo' Joint Venture Providing up to $750 Million in Funding to Electrify Fleets, School Transportation News. (August 4, 2021)

to signals from local utilities, energy services and demand response aggregators, or the grid operator to adjust the temperature and reduce energy demand. Additional demand response measures include building energy management systems, grid-connected appliances, stand-alone devices or systems with automated controls, and transactive or smart devices that respond to real-time price or grid operational signals. DR measures can create significant energy cost savings for the customer and the grid and alleviate stress on the electricity grid to avoid brownouts or blackouts.

MARKET OVERVIEW

In the U.S, the smart thermostat market reached $937 million in 2020 and is projected to grow to $3.3 billion by 2028.[133] The adoption of smart thermostats is driven in large part by the cost savings provided to consumers when they are able to optimize their heating and cooling systems.

In Texas, over 8.5 million homes have central heating and/or cooling systems, making smart thermostat use an option for most consumers. To date, only around one million of those homes have installed smart thermostats. For those that have, fewer than 10% are participating in a demand response program.[134] Thus, there remains a large opportunity for consumers across Texas to provide demand response by reducing or modifying their own electricity use - or by participating as part of a DR aggregation.

RESILIENCE IN ACTION

Smart thermostats are working across Texas electricity markets and programs to support reliable and resilient grid operations. Texas municipal utilities, cooperative utilities, and investor-owned utilities each use smart thermostat programs to manage winter and summer peak loads and reduce consumers' exposure to high prices in the real-time market. Examples include:

- Guadalupe Valley Electric Cooperative (GVEC) offers its Peak-Time Payback Program,135 which provides customers with a Google Nest or Ecobee thermostat with an $85 bill credit

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[133] U.S. Smart Thermostat Market to Reach USD 3280.3 million by 2028 at a CAGR of 17.1%:, Fortune Business Insights, (March 1, 2022).

[134] See August 16, 2021 "Comments of Advanced Energy Management Alliance" in Project No. 52373, at p. 6.

[135] Peak-Time Payback Program, Guadalupe Valley Electric Cooperative.

for signing up, and a $30 payment for staying enrolled from June through September each year. GVEC advertises the program as a way to reduce strain on the power grid and stabilize the wholesale prices that are passed through to members.

- CenterPoint Energy offers a $50 coupon for the purchase of a smart thermostat and has enrolled approximately 21,000 customers in their residential load management program. The program requires the residential customer to enroll and agree to let the program sponsor turn off or adjust the energy usage via their smart thermostat device. Program sponsors can be retail electric providers, alarm service providers, load management aggregators, energy consultants, and other entities. Under this program, there have been two test load management events. During the summer's peak period test events that resulted in a total demand reduction of 24 MW, or more than 1.25 kW of summer load reduction per household.136,137
- CPS Energy is engaging customers through its Save for Tomorrow Energy Plan (STEP) program. CPS Energy will give consumers $85 to enroll in the Rush Hour Rewards program and another $30 if enrollment continues throughout the summer and winter seasons. CPS Energy now has over 150,000 smart thermostat devices in customers' homes and businesses that are able to earn a rebate and annual retention incentives for enrolling their smart thermostats.138 Two notable CPS "Energy Savings Events" when thermostats were dispatched include:

    1. Summer 2020: The 19-day event, 2.5-hour average duration event saw a 231 MW reduction at the CPS Energy peak.[139]
    2. Winter Storm Uri 2021: The first-ever winter curtailment took place from 14 February to 19 February 2021. 93% of thermostats enrolled were dispatched. The curtailment ran continuously for over 100 hours. This compares with 60 hours of curtailment in the typical four-month summer DR season.

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[136] September 16th, DR Work Session Response Programs, Public Utility Commission of Texas Work Session, (September 16, 2021)

[137] Evaluation, Measurement & Verification of CPS Energy's FY 2020 DSM Programs, Frontier Energy. (June 24, 2020).

[138] Overview of CPS's Demand Response Programs, Public Utility Commission of Texas Work Session, (September 16, 2021).

[139] Overview of CPS's Demand Response Programs, Public Utility Commission of Texas Work Session, (September 16, 2021).

Retail electricity providers (REPs) and other market participants are using smart thermostats for demand response in Texas as a price hedging tool. When wholesale electricity prices are high, a smart thermostat aggregation can be dispatched to reduce the amount of electricity that must be purchased by REPs from the market. Resideo Technologies[140] and Leap, for example, have partnered with Texas REPs to deploy aggregated smart thermostats for hedging. The two companies have also analyzed the risk management advantages of using DERs as hedges in Texas, compared with conventional financial hedging mechanisms.[141] Their simulations suggest that using aggregations for wholesale market hedging would translate to households in Texas saving approximately $140 per year, if REPs were able to more broadly implement wholesale-price-sensitive residential demand response programs.[142]

WHO IS SETTING THE PACE?

In Arizona, Arizona Public Service Company (APS) has a network of over 52,000 smart thermostats participating in the nationally recognized Cool Rewards program that provides incentives in the form of bill credits and exclusive discounts to conserve electricity.[143] The program is now recognized as one of the five largest Bring Your Own Thermostat (BYOT) programs in the country and is considered one of the largest utility-managed thermostat virtual power plants. APS works directly with Google to provide their customers access to promotional pricing for Google Nest smart thermostat models, at no cost except shipping and taxes. Throughout the summer of 2021, Cool Rewards raised participating consumers' thermostats just a few degrees to conserve energy, resulting in nearly 80 MW of demand reduction. As with other similar programs, a key component of the Cool Rewards program is to pre-enroll the smart thermostats in the demand response program before sending them out to customers.

Google's Rush Hour Rewards solution is currently utilized in Texas by Austin Energy, CenterPoint Energy, CPS Energy, and Guadalupe Valley Electric Cooperative.

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[140] Resideo manufactures and distributes smart home products and software, including temperature and lighting controls, security systems, and water and air monitoring. *See* https://www.resideo.com/us/en/

[141] Demand Response as a Real-Time, Physical Hedge for Retail Electricity Providers: The Electric Reliability Council of Texas Market Case Study, Blohm, A., Crawford, J., Gabriel, S., Energies, (February 3, 2021).

[142] Demand Response as a Real-Time, Physical Hedge for Retail Electricity Providers: The Electric Reliability Council of Texas Market Case Study, Blohm, A., Crawford, J., Gabriel, S., Energies, (February 3, 2021).

[143] APS Virtual Power Plant Benefits Customers, Smart Grid & Environment, businesswire, (November 8, 2021).

PATHWAYS TO SCALE

- Prioritize demand-side solutions and bridge the gap between market potential and market participation. (Section 4.4.1).
- Adopt pre-enrollment in the DR program as an opt-out, rather than an opt-in, as a condition of receiving the discounted thermostats. (Section 4.1.2)
- Expand the participation of third-party aggregators - not just REPs - in the ERCOT market.[144] (Section 4.4.1).

4. RESILIENCE POLICY ROADMAP

This section provides a focused set of immediately actionable market-based policies to improve resilience using distributed energy resources in Texas. Building on the use cases in Section 3, the policies focus on:

1. Energy efficiency and demand response
2. Distributed generation
3. Electric vehicles
4. DER aggregation, which is cross-cutting

Several specific recommendations accompany each policy category. To the extent possible, these recommendations focus on altering and enhancing existing policies and programs to be proactive rather than responsive and align with resilience priorities and goals. The recommendations seek to leverage the buying power of those who are willing to invest in resilience on their own, which also supports a more equitable distribution of resilience investment to a broader group set of individuals, communities, and facilities. The recommendations also focus on prioritizing and targeting resilience investments because fully redundant systems would be impractical and cost prohibitive. For example, approaches can focus on geographic areas where the grid is constrained and where populations are at higher risk from extended grid outages. The table below summarizes the policy categories contained in this section, as well as the associated recommendations and potential timing.

[144] Work Session, Public Utility Commission of Texas, (September 16, 2021).

It is important to note that this section focuses on DERs for resilience, but the portfolio of actions required to support resilience extends beyond these recommendations. This includes:

- Defining critical customers and facilities and doing so consistently across state agencies and regulators;
- Strengthening building codes through new legislation and regulation;[145]
- Reaching more residents (including low- and middle-income residents) with resilient DER solutions, by focusing on affordable housing and multi-family buildings and aligning payment streams with the stream of savings, such that customers bear no upfront cost and receive net savings from the outset; and [146,147]
- Pairing non-energy related capital improvements with resilient DER solutions, such as aligning roof replacements with the installation of solar PV and battery systems;
- Addressing transmission congestion that prevents generation from reaching the customers that need it and supporting transmission buildout to enable deployment of cost-effective large-scale advanced energy.

In conclusion, leadership at all levels is needed in order for the state to achieve its resilience goals. The roles of each key actor are summarized at a high level below, with more detail in the table and sections describing each recommendation to follow.

- Regarding energy efficiency and demand response,
    - The PUCT can update existing policies and practices to better reflect resilience priorities, with the Energy Efficiency Resource Standard (EERS) being the top priority.
    - Retail electricity providers or other third-party demand response providers can focus incentives on energy efficiency technologies that help achieve the updated EERS and better align with state priorities and resilience goals.
- Regarding distributed generation,
    - The Texas legislature can: (1) define critical customers and facilities consistently across the state, (2) direct retail electricity providers or other third-party providers to expand or create new competitive services to target resilience at

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[145] Insurance Institute for Business and Home Safety, Texas Coastal Building Codes Survey.

[146] Entergy New Orleans Pilots Residential Rooftop Solar Program, Entergy, (February 20, 2019).

[147] Illinois Solar for All.

these critical facilities and customers, and (3) and create back-up power requirements for certain classes of critical facilities, in line with state definitions.
    - The PUCT can: (1) direct utilities to enhance the revenue streams for resilient DERs to align with the value they create for the distribution grid and/or the ERCOT market and (2) direct utilities to address barriers to investment by supporting geographic concentrations of smaller, resilient DERs by sharing grid upgrade costs between utilities and customers and enabling the sharing of grid upgrade costs across customers.
- Regarding electric vehicles,
    - Communities can use state incentive and grant funding to purchase electric vehicles that can provide backup power to critical community facilities.
    - The PUCT can (1) direct utilities to work with communities to advance vehicle-to-grid capabilities and electric vehicle use by homes and critical community facilities and (2) direct ERCOT to adopt products and pricing mechanisms that compensate retail electricity and other third party providers for mitigating the impacts of electric vehicles on summer and winter peaks.
- Regarding aggregation of resilient DERs, ERCOT can (1) enable resilient DERs of all scales to participate more fully in markets and (2) offer greater flexibility for smaller scale DERs to participate through aggregation.

Policies	Recommendations
Energy Efficiency and Demand Response to Reduce Peak Loads and Enable Residents to Shelter Locally	The PUCT can update the Energy Efficiency Resource Standard (EERS) to better align with resilience goals and outcomes.
	To better align with EERS updates, retail electricity providers or other third-party demand response providers can focus incentives on energy efficiency technologies that get more kW reduction.
Distributed Generation to Increase Customer Independence and Enable Grid Benefits from Export	The Texas legislature can direct retail electricity providers or other third-party demand response providers to expand or create new competitive services to target resilience at critical facilities and customers.
	The Texas legislature can create back-up power requirements for certain classes of critical facilities.
	The PUCT can direct utilities to compensate DERs for the value they create for the distribution grid and/or the ERCOT market.
	The PUCT can direct utilities to support geographic concentrations of smaller, resilient DERs with shared grid upgrade costs.
Electric Vehicles as Energy Storage for Residences and Critical Community Facilities	Communities can use state incentive and grant funding to purchase electric vehicles that can provide backup power to critical community facilities.
	The PUCT can direct utilities to work with communities to advance vehicle-to-grid capabilities and EV use by homes and critical community facilities.
	The PUCT can direct ERCOT to adopt ancillary service products and electricity pricing mechanisms that compensate retail electricity and other third party providers for mitigating the impacts of EVs on summer and winter peaks.
Aggregation of Distributed Energy Resources to Reduce Resilient Grid Costs	ERCOT can enable resilient DERs to participate more fully in the wholesale energy and ancillary services markets.
	ERCOT can allow for data validation flexibility.

4.1. Energy Efficiency and Demand Response to Reduce Peak Loads and Enable Residents to Shelter Locally

4.1.1. THE PUCT CAN UPDATE THE ENERGY EFFICIENCY RESOURCE STANDARD (EERS) TO BETTER ALIGN WITH RESILIENCE GOALS AND OUTCOMES.

For many years, Texas has significantly underinvested in EE and DR which help to create a more resilient grid. Texas' current Energy Efficiency Resource Standard (EERS) policy requires each utility to achieve savings of 30 % of its sales growth and at least 0.4 % of its summer weather-adjusted peak demand for its combined residential and commercial customers in the previous program year. Additionally, savings for programs directed to hard-to-reach customers need to represent at least 5 % of each utility's total demand reduction goal. The energy efficiency cost recovery factor (EECRF) caps energy efficiency and demand response efforts at $0.001263 per kWh for residential customers and $0.000790 per kWh for commercial customers (increased or decreased by a rate equal to the most recently available calendar year's percentage change in the South urban CPI, as determined by the Federal Bureau of Labor Statistics). Also, most programs, with the exception of the targeted low-income program, must be cost-effective using the utility cost test.[148]

The efficiency targets have not been adjusted since 2011 and are woefully unambitious and outdated.[149] The PUCT can increase the energy and peak demand goals to reflect the current contributions of energy efficiency and demand response, and potential future contributions to resilience, while also reducing energy costs for all Texans. In practice, the Texas IOUs have exceeded their EERS program summer peak demand reduction goals each year from 2003 through the present. In 2020 (the most recent year reported), Texas IOUs delivered approximately 500 MW of peak demand reduction, far exceeding the goal of 200MW. These savings came at a lifetime cost of

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[148] PUCT Project No. 48692. Rulemaking Proceeding to Amend 16 TAC §25.181 AND 16 TAC §25.183, and Adopt New 16 TAC §25.182, Relating to Energy Efficiency Cost Recovery Factor, Public Utility Commission of Texas, (March 15, 2019).

[149] Summary of Enactments 82nd Legislature, Texas Legislative Council, (2011).

12/kW-yr., which is significantly less than the cost of new entry for a combustion turbine.[150,151,152] Based on a peak demand of approximately 75,000MW, Texas IOUs achieved a 0.7 % reduction in peak demand.[153] That same year, Austin Energy provided roughly 60 MW of peak demand reductions. With a peak demand of approximately 2,800MW, Austin Energy is achieving peak demand reductions of an estimated 2 %.[154,155] This comparison suggests that at least a doubling of the summer peak demand reduction goal for the Texas IOUs is a reasonable and very achievable target. The experience of other U.S. utilities indicates that a much higher peak and energy savings are cost-effective and feasible in Texas as well. Texas should immediately double the pearl demand reduction goal and simultaneously commission a study to determine the costs and benefits of going higher. The last energy efficiency potential study was completed in 2008, before smart thermostats and LEDs were broadly available.

The PUCT should increase the utilities' program savings requirements and budgets to deliver greater levels of energy and peak demand savings and resilience benefits from energy efficiency and demand response to all Texans. The PUCT should revise the utility EE programs to prioritize measures that deliver both summer and winter savings; examples include high-efficiency space and water heat pumps, building shell air sealing and insulation, energy audits and behavioral efficiency programs, and smart thermostats. The PUCT should also update the IOU performance incentives to ensure that they appropriately motivate the IOUs to achieve the energy and peak demand goals. Winter-specific activities could build on programs such as the Oncor Winter Commercial Load Management Program.[156]

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150 Electric Utility Marketing Managers of Texas (EUMMOT). Energy Efficiency Accomplishments of Texas Investor-Owned Utilities Calendar Year 2020, Frontier Energy, (2020).

151 Overview of Investor Owned Utilities' (IOU) energy efficiency portfolios, focusing on demand response offerings, Work Session, Public Utility Commission of Texas, (September 16, 2021).

152 The 2018 PJM CONE study, used in the Estimation of the Market Equilibrium and Economically Optimal Reserve Margins for the ERCOT Region for 2024, found a CONE of $93.5/kW-yr for new CT units.

153 2020 Summer Reliability Assessment, North American Electric Reliability Corporation, (June 2020).

154 Overall Demand and Energy Savings Goals for Austin Energy Recommendation: The Low-Income Consumer Task Force reaffirms the goal, City of Austin, Texas.

155 Austin Energy System Peak Demand, City of Austin, Texas, (April 14, 2021).

156 Winter Emergency Load Management, Oncor, (December 6, 2021).

Both ERCOT operating reliability costs and natural gas prices have increased significantly since the PUCT adopted the official EECRS avoided costs for 2022. This makes the value of saved energy significantly higher, so the PUCT should consider increasing the official avoided cost figures used to determine EE measure cost-effectiveness.

Lastly, the PUCT can define critical community customers and critical residential customers in a way that is consistent with definitions used in other planning proceedings, establish a goal for these types of customers (much like the goal that was established for hard-to-reach customers), and identify one or more programs where these types of customers are eligible for services and the services provided meet the passive survivability and resilience needs of these customers. Texas utilities offer multiple types of energy efficiency programs to residential customers. Standard offer programs, for example, provide standard incentives for common energy efficiency measures for multi-family, single-family, and mobile homes. Market transformation programs are targeted to overcome specific market hurdles or introduce new technologies.[157][158]

For example, the Residential and Small Commercial Solutions Pilot MTP provides $/kW incentives as well as technical assistance, education on financing energy efficiency projects, and communications services. In addition to capturing kW reductions, the implementer helps residential and small commercial contractors improve their ability to identify, evaluate, and sell efficiency improvements to home and small business owners and assist consumers in evaluating energy efficiency proposals from vendors. The program could be expanded to incorporate resilience measures, financing, and customer support on resilience and passive survivability for critical residential customers, based on geographic location, income, age and/or disability, among other potential eligibility requirements.

Similarly, the Texas Schools Conserving Resources (SCORE) and CitySmart MTPs can be expanded to help improve resilience of critical community facilities including schools and other municipal government buildings.[159]

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[157] The details for each utility can be found on their websites and in each utility's annual Energy Efficiency Plan and Report to the PUCT. *See* Electric Utility Energy Efficiency Plan and Report Filings, Public Utility Commission of Texas, (2022).

[158] Chapter 25: Substantive Rules Applicable To Electric Service Providers. Public Utility Commission of Texas (2022).

[159] Electric Utility Marketing Managers of Texas (EUMMOT). Energy Efficiency Accomplishments of Texas Investor-Owned Utilities Calendar Year 2020, Frontier Energy, (2020).

4.1.2. TO BETTER ALIGN WITH EERS UPDATES, RETAIL ELECTRICITY PROVIDERS OR OTHER THIRD-PARTY DEMAND RESPONSE PROVIDERS CAN FOCUS INCENTIVES ON ENERGY EFFICIENCY TECHNOLOGIES THAT GET MORE KW REDUCTION.

This recommendation includes technologies with demand response capabilities for which participation can be secured at the time of the energy efficiency measure installation. Energy efficiency measures that reduce summer and winter peak demand include weatherization, installation of efficient cold-climate space heating/cooling systems, battery storage, electric vehicles, and water heating systems. Weatherization reduces demand in all hours, including summer and winter peak hours. Replacement of electric resistance heating with a heat pump can reduce space heating demand in winter peak hours and replace older air conditioning units. Replacement of central and packaged air conditioning units with more efficient options can also reduce space cooling demand in summer peak hours. Replacement of electric-resistance water heaters with heat pump water heaters can reduce water heating demand during summer and winter peaks. Battery storage and electric vehicles with vehicle-to-grid capabilities can provide stored energy to homes and critical community facilities during summer and winter peaks, offsetting the need for power from the grid.

Energy efficiency measures with demand response capabilities include smart thermostats, central air conditioners, energy management systems, battery storage, electric vehicles, rooftop solar inverters, electric resistance water heaters, and air-to-water heat pumps (AWHPs).[160] Energy efficiency and demand response providers can focus their offerings on these measures that reduce summer and winter demand and/or have demand response capabilities. These providers can also offer higher incentives for these measures to align with their grid resilience value.[161] Incentive offerings can also be tiered to provide additional support for customers and communities that bear higher risk of experiencing a grid outage and/or are more vulnerable to the consequences of grid outages.

While peak savings from demand response grew roughly 11 % from 2017 to 2018, the number of customers enrolled in demand response programs dropped 20 %.[162] Texas will realize the benefits of energy efficiency measures with demand response capabilities if these capabilities are activated and in use from the time the measure is installed. Some technologies, such as smart thermostats, can be

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[160] Heat Pump Water Heaters Can be Demand Response Assets, Greentech Media, (June 25, 2019).

[161] The Hidden Battery: Opportunities in Electric Water Heating, The Brattle Group, (January 2016).

[162] Demand Response and Advanced Metering, Federal Energy Regulatory Commission, (2021).

pre-enrolled in demand response programs and should be.[163] Existing technologies should be improved to allow for pre-enrollment in demand response programs. All new technologies should be developed with this pre-enrollment capability enabled at the outset. Providers can then focus their efforts entirely on training customers on how to participate in these programs. For any existing technologies that cannot be pre-enrolled in demand response programs, providers can proactively help customers enroll and participate in these programs.

4.2. Distributed Generation to Increase Grid Independence and Enable Grid Benefits from Export

4.2.1. THE PUCT CAN DIRECT RETAIL ELECTRICITY PROVIDERS OR OTHER THIRD-PARTY DEMAND RESPONSE PROVIDERS TO EXPAND OR CREATE NEW COMPETITIVE SERVICES TO TARGET RESILIENCE AT CRITICAL FACILITIES AND CUSTOMER CLASSES.

Similar to the recommendation for energy efficiency in the previous section, Texas can utilize its existing definitions of critical facilities and customers to target energy investment, particularly within the commercial and residential customer groups. These could include, for example, the definitions discussed in Text Box 1, the lists of critical facilities that will be reported to the PUCT by the utilities, or refer to specific definitions within Texas law, such as "critical care residential customers," or utility customers that are "dependent upon an electric-powered medical device to sustain life." Incentives could be provided, for example, through an expansion of existing utility programs or from federal funds for energy resilience, such as those contained in the Infrastructure Investment and Jobs Act (IIJA), which includes the $335 million Energy Storage Pilot Grant Program and the $1 billion Energy Improvement in Rural and Remote Areas Program. DERs, including energy storage and microgrids, can provide "system adaptive capacity" and are therefore eligible for funding under the Section 40101(d) Grid Resilience Formula Grants to States and Indian Tribes.[164] Texas will receive $30 million under 40101(d).[165]

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[163] SECC Webinar - Demand Response: What Have We Learned and What's to Come?, Uplight, (February 2, 2021).

[164] System adaptive capacity is defined as "the ability of the electrical grid to continue to supply electricity where needed during disruptive events." *See* Frequently Asked Questions: Grid Resilience Formula Grants to States and Indian Tribes IIJA Section 40101(d), NETL. (May, 2022)

[165] DOE's Draft Allocation of Funds under the IIJA Section 40101(D): Formula Grants to States and Indian Tribes for Preventing Outages and Enhancing the Resilience of the Electric Grid, DOE. (2022)

Municipal utilities in the state, such as Austin Energy and CPS Energy, have offerings that can be adopted in other service territories. CPS' Save Tomorrow's Energy Plan (STEP), a portfolio of 17 different residential and commercial customer offerings encompassing energy efficiency, demand response, and solar, saved 926 MW of capacity (exceeding the target of replacing a power plant) from 2009 to 2020.[166]

It is important to note that provider offerings should address resilience. For example, providers can specify that new solar PV systems must use a 1547 inverter as it has islanding capabilities and settings and can operate independently during grid outage. Providers can also consider offerings to replace existing solar PV system inverters with new 1547 units. Also, islandable distributed generation can be paired with battery storage but both need to be allowed to disconnect from the grid without penalty in order to provide resilience.[167]

4.2.2. THE TEXAS LEGISLATURE CAN CREATE BACK-UP POWER REQUIREMENTS FOR CERTAIN CLASSES OF CRITICAL FACILITIES.

Texas law currently requires critical facilities such as hospitals and wastewater treatment plants to have back-up power for their critical loads. The Texas legislature can consider requiring back-up power at additional facilities that provide critical lifelines. In Florida, for example, the state required all nursing homes to install back-up power with 48-72 hours of fuel supply following heat-related deaths after Hurricane Irma.[168,169] Florida also requires gas stations to have the equipment necessary to accept mobile back-up power.[170]

Texas should also allow more resilient technologies than diesel generators to support back-up power requirements.[171] Texas code requires water utilities to develop emergency preparedness plans that

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[166] The Brattle Group. Assessment and Benchmarking of CPS Energy's STEP Program, (February 14, 2022).

[167] Sandia National Laboratories. 2021. Regulatory Mechanisms to Enable Investments in Electric Utility Resilience. Case study on Green Mountain Power's battery storage offerings. Page 29.

[168] Study shows heat-related deaths rose in Florida nursing homes after Hurricane Irma, WUSF, (December 15, 2021).

[169] Fla. Admin. Code. R. 59A-4.1265

[170] § 526.143, Fla. Stat. (2012).

[171] 'Like a bomb went off': Residents pick up the pieces after wildfire consumes West Texas town, The Dallas Morning News, (March 19, 2022).

would ensure minimum water pressure levels during extended power outages. Instead of focusing only on diesel generators, water utilities can meet the planning requirement through a range of different strategies and technology solutions, including "the use of onsite electrical generation or distributed generation facilities" or "any other alternative determined by the commission to be acceptable.[172]" Not all Texas regulations are as flexible, however. In 2021, the Texas Legislature allowed utilities to recover the costs of procuring and operating temporary "facilities that provide temporary emergency electric energy" to support grid restoration following widespread power outages.[173] The law specifies, however, that those facilities cannot include energy storage, and that they cannot sell energy or ancillary services. In California, utilities have deployed temporary generators to supply power to customers at over 60 specific substations during wildfire safety-related power shutoffs since 2020.[174] California regulators have outlined an approach for transitioning from temporary diesel generators to clean energy generators starting in 2022.[175]

In addition to requiring back-up power at critical facilities and allowing more technologies to supply emergency power, the Texas Legislature could also re-consider the creation of a critical infrastructure resiliency fund. In the 2021-2022 legislative session, House Bill (H.B.) 2275 proposed a fund to support resilience measures such as grid hardening, energy storage, energy efficiency, and demand response.[176] H.B. 2275 passed the Texas House by over 100 votes but was not passed by the Texas Senate. The Legislature could build on H.B. 2275 in future legislative sessions.

4.2.3. THE PUCT CAN DIRECT UTILITIES TO COMPENSATE DERS FOR THE VALUE THEY CREATE FOR THE DISTRIBUTION GRID AND/OR THE ERCOT MARKET.

DERs can provide direct support to the distribution grid in a way that is not currently compensated in existing markets and programs. These grid services can include, for example,

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172 2 Tex. Water Code §13.1394 (2021)

173 H.B. 2483 of 2021 created 2 Tex. Util. Code §39.918 (2021)

174 *See*, for example, Microgrids in California, Tesfai, L. NARUC Regulators' Financial Toolbox: Resilience Technologies Webinar (August 25, 2021) and

175 Decision Adopting Rates, Tariffs, and Rules Facilitating the Commercialization of Microgrids Pursuant to Senate Bill 1339 and Resiliency Strategies, Decision 21-01-018, CPUC. (January, 2021).

176 H.B. 2275, 87th Leg., R.S. (2021)

local feeder reliability improvements, local distribution capacity relief, and voltage support, all of which can help defer or avoid traditional distribution system investment. Several states are currently exploring specific tariffs for compensating microgrids and other non-wires investments.[177] In Arkansas and Louisiana,[178] Entergy has proposed the Power Through program in which the utility would partially recover the cost of investing in customer-sited microgrids from ratepayers, based on the value of the grid services provided. The Arkansas Public Service Commission approved the Power Through proposal in May 2021.[179] Non-ERCOT utilities can earn a rate of return when they deploy DERs for the benefit of customers and the grid. ERCOT utilities can adopt a resilience tariff that credits customers for providing services in support of grid resilience.

4.2.4. THE PUCT CAN DIRECT UTILITIES TO SUPPORT GEOGRAPHIC CONCENTRATIONS OF SMALLER, RESILIENT DERS WITH SHARED GRID UPGRADE COSTS.

Texas IOUs charge residential customers who trigger the need for grid upgrades 100 % of the cost, similar to the model used for larger commercial customers.[180] As these upgrades offer benefits to other residential customers and the grid as a whole, these grid upgrade costs can be shared between utilities and groups of customers. For example, utilities should pay for transfer trip protection on a feeder as it enables DERs all along the feeder. There are several models currently under consideration in various states for how to share grid upgrade costs for smaller DER projects, including reimbursement, group interconnection, and socialization.[181,182]

The reimbursement model requires first-movers to pay the full costs of the grid upgrade upfront. However, these individuals are eligible to receive partial reimbursement from other community members that interconnect on shared equipment through their utility up to a certain point. The major downside to this approach is that it still requires the initial participant in a geographic area to bear

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[177] Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs, National Association of State Energy Officials, National Association of Regulatory Utility Commissioners, (February 2022).

[178] Louisiana Docket U-36105, Louisiana Public Service Commission

[179] Order No. 7, Docket No. 20-049-U, Arkansas Public Service Commission (May, 2021)

[180] Distributed Generation, Public Utility Commission of Texas.

[181] Interstate Renewable Energy Council, (September 13, 2017).

[182] Maine Public Utilities Commission, Docket 2022-00071, Interconnection Standards, Practices, and Procedures to Support Access to Solar Energy and Battery Storage for Maine Homes and Businesses, Interstate Renewable Energy Council, (February 2022).

the burden of the entire upfront cost of the upgrade, which remains inherently inequitable and may limit participation if it is not feasible for that customer to pay the full upfront cost at that time.

The group interconnection model functions similarly to the way residents subscribe to a community solar offering. Residents can subscribe to an interconnection project at a specified scale (e.g., 500kW). Once subscriptions reach the scale of the project, a group interconnection study can be conducted and costs allocated equitably to each subscriber in the project. Utilities can proactively reach out to customers in priority communities and neighborhoods to ensure that each project captures all interested customers and include those that share grid services (e.g., who share circuit, transformer, and feeder equipment). This approach also allows neighbors to discuss the project with one another and for utilities to partner with community groups to engage with residents who live in close proximity to one another. The major downside to this approach is that one or more subscribers in the group interconnection study can drop out. When this occurs, the study may need to be repeated and costs reallocated among the remaining applicants which could increase costs and delay the project. A solution to this issue involves developing a wait list if project subscriptions exceed scale. So long as the residents on the waitlist are from the same neighborhood and share grid equipment, subscribers who drop out could be replaced with new subscribers without the need to repeat the group interconnection study as costs would not change.

Another option is a socialization approach, where the PUCT could consider allocating the grid upgrade costs for smaller DERs to all customers, under the rationale that the upgrade will become part of the utility's infrastructure that is funded by and shared across all customers. The socialization approach also assumes equitable DER implementation - that all customers will eventually install one or more DERs.[183]

The reimbursement model is a reactive approach whereas the group interconnection and partial assignment models are proactive approaches. Shifting from a reactive to a proactive approach can better align distributed energy resources with grid resilience needs. Also, grid upgrade costs for low-income customers, especially affordable housing and multifamily buildings that serve renters, should be shared with all customers. The PUCT recently opened Project No. 51603, Review of Distributed Energy Resources, which provides an opportunity to make these updates.[184]

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[183] DER Interconnection Cost Allocation Proposal: Docket No. 19-55, Strategen Consulting for the Massachusetts Attorney General's Office, (February 28, 2020).

[184] To enhance reliability, Texas regulators will consider standardizing distribution system interconnections, Utility Dive, (April 4, 2022).

4.3. Electric Vehicles as Energy Storage for Residences and Critical Community Facilities

4.3.1. COMMUNITIES CAN USE STATE INCENTIVE AND GRANT FUNDING TO PURCHASE ELECTRIC VEHICLES THAT CAN PROVIDE BACKUP POWER TO CRITICAL COMMUNITY FACILITIES.

The Texas Commission on Environmental Quality administers the Governmental Alternative Fuel Fleet Grant Program which supports the purchase or lease of new, all-electric vehicles by municipalities with more than 15 vehicles. Grant amounts vary from $15,000 to $70,000 depending on vehicle class and up to 10 % of awarded grant funds may support purchase, lease, or installation of electric vehicle chargers.[185] Municipal governments should leverage this grant program to increase their EV fleets and charging infrastructure that can serve critical community facilities. Also, the state should include smart charging equipment in this grant program, transition the Diesel Retrofit Program to focus more on electric vehicles, and increase the available incentives in the Light Duty Motor Vehicle Incentive Program.

Battery energy storage systems (BESS) are widely recognized for their ability to enhance energy resilience by extending the run-time of backup generators and enabling renewable generators to produce power through outages. Many BESS solutions are stationary, interconnected with permanent infrastructure, and designed to serve localized loads. As a supplement or alternative to stationary BESS, mobile energy storage systems (mobile ESS) can be physically dispatched to prioritized locations based upon evolving emergency response needs and serve more facilities. Mobile ESS becomes more useful during less predictable resilience events due to the geographical flexibility this form of battery storage can offer.

There are two types of mobile ESS: self-mobile and towable mobile. Self-mobile ESS are electric vehicles. These vehicles range from light duty vehicles to transit buses (with an anticipated future inclusion of heavy-duty trucks as all-electric options become available). Towable mobile ESS are larger, containerized solutions that need to be transported to a location to be deployed. Municipalities should focus on self-mobile ESS as these types of vehicles are eligible for the grants and more readily used on typical days as well as during resilience events, increasing the return on investment.

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[185] Electricity Laws and Incentives in Texas, Alternative Fuels Data Center.

Mobile ESS can also serve more critical facilities. Fire and police stations are typically considered critical facilities by communities and their utilities, prioritized for service restoration, and have backup generators to ensure service continuity. Community centers and schools may provide important services to a municipality during a resilience event but may not be classified as critical by their utilities. Mobile ESS could be used to provide additional support to stationary BESS and backup generators at fire and police stations and provide support to community centers that may lack sufficient stationary BESS and backup generators during a resilience event.

For example, while school buses are used to transport school children on normal days, a fleet of electric school buses could provide power to a community center during a resilience event so long as the community center had bi-directional electric vehicle charging infrastructure. These centers can support critical community lifelines such as cooling, heating, water and food, medication, phone and computer charging, and internet connectivity. In addition to the use of heavy-duty vehicles for construction and maintenance activities on normal days, a fleet of electric public works vehicles could support first responders at a fire or police station or in the field during a resilience event.

4.3.2. THE PUCT CAN DIRECT UTILITIES TO WORK WITH COMMUNITIES TO ADVANCE VEHICLE-TO-GRID CAPABILITIES AND EV USE BY HOMES AND CRITICAL COMMUNITY FACILITIES.

As described in Section 3.2, vehicles such as the all-electric Ford F-150 Lightning will create new resilience opportunities for both homes and critical facilities. Integrating EVs into emergency management and hazard mitigation strategies, however, will require planning, training, and experience. EVs can support community lifelines, but communities need to coordinate with their utilities and across their emergency management departments to ensure the required protocols, infrastructure, and controls are put in place. Utilities need to develop interconnection specifications that address metering, islanding, and controls to enable the EVs and other forms of backup generation to function in both typical day and resilience event modes. A DOE Vehicle-to-Everything initiative was announced in April 2022 to ensure coordination of technical standards, protocols, and other requirements needed across agencies and actors. The PUCT should follow this initiative closely and adopt consistent standards.[186]

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[186] Department of Energy, Department of Energy Announces First of Its Kind Collaboration to Accelerate "Vehicle-to-Everything" Technologies, (April 20, 2022).

Local emergency management agencies can be consulted as to which of their unmet back-up generator needs could potentially be served by mobile storage or other means. In Florida, for example, the counties in the Tampa Bay region identified a backlog of more than $25 million in back-up power generation in their local hazard mitigation strategies as potential candidates for battery back-up.[187]

Communities also need to update emergency management and hazard mitigation plans to include future mobile ESS. These plans should contain a description of how mobile ESS will be used during a future resilience event. Mobile ESS can augment existing backup generation, act as the primary source of backup generation, support first responders in the field, or aid in evacuation. Communities also need to develop additional training on mobile ESS operations and incorporate mobile ESS into practice drills for municipal government leaders, staff, and first responders.[188] Early planning and practice drills will be needed to ensure that mobile ESS are pre-positioned, correctly connected at the host site, fully charged, and operational by the time the resilience event occurs.

4.3.3. THE PUCT CAN DIRECT ERCOT TO ADOPT ANCILLARY SERVICE PRODUCTS AND ELECTRICITY PRICING MECHANISMS THAT COMPENSATE RETAIL ELECTRICITY AND OTHER THIRD-PARTY PROVIDERS FOR MITIGATING THE IMPACTS OF EVS ON SUMMER AND WINTER PEAKS.

Charging fleets of larger electric vehicles at critical community facilities will require more, faster chargers which will increase electricity demand. An EV-only time-of-use (TOU) pricing rate can incentivize fleet operators to charge mobile ESS off-peak, such as during afternoon peak PV production and late early morning excess wind generation period. Lowering electricity demand during peak hours can lower the costs to operate municipal buildings and reduce the likelihood of outages. Also, this pricing structure reinforces good planning for resilience events. Off-peak pre-charging of electric vehicle fleets in advance of severe weather will result in lower costs and improve grid reliability in the days and hours leading up to a resilience event.

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[187] Clear Sky Tampa Bay - Tampa Bay Regional Policy Landscape Analysis, Tampa Bay Regional Planning Council, (October 2021).

[188] Mobile Energy Storage Systems Study, Synapse Energy Economics, (February 1, 2020).

Utilities can work with residential and municipal government customers to charge off-peak and reduce or eliminate demand charges associated with EV charging.[189] As discussed in Section 3.4, several municipal utilities in Texas have established programs for residential charging. Utilities can extend these residential programs to municipal government customers with fleets of EVs.

4.4. Aggregation of Distributed Energy Resources to Reduce Resilient Grid Costs

4.4.1. ERCOT CAN ENABLE RESILIENT DERS TO PARTICIPATE MORE FULLY IN THE WHOLESALE ENERGY AND ANCILLARY SERVICES MARKETS.

As discussed in Section 2, DER technologies that support critical facilities, such as microgrids and solar and energy storage, can also participate in other markets in order to earn revenue and/or generate savings for project owners. Current ERCOT rules allow distributed generators to register as Distribution Generation Resources (DGR) and then earn compensation in the energy and ancillary services markets.[190] However, these rules do not allow generators to register as DGR if they are on a part of the distribution grid that could be curtailed during a load shedding event.[191] This requirement is a barrier to smaller-scale generators that could be both providing back-up power and participating in the ERCOT markets.

Also, unregistered distributed generation (mostly rooftop solar smaller than 1MW) do not currently receive compensation in ERCOT.[192] ERCOT needs to focus payments on smaller DERs with resilience capabilities such as rooftop solar PV combined with energy storage (either stationary or mobile).[193] Retail electricity providers as well as third party providers should be able to bid to participate and receive these payments on behalf of their customers.

Even after these barriers are removed, proactive dispatch of aggregated resilient DERs (instead of use solely as a curtailment resource) is necessary to improve grid resilience. ERCOT can allow

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[189] Electric Vehicles - EV Charging Solutions, CPS Energy.

[190] Distributed Generation (DG) and Demand Response (DR) in ERCOT, ERCOT.

[191] NPRR1016 Issue, ERCOT.

[192] Distributed Generation (DG) and Demand Response (DR) in ERCOT, ERCOT.

[193] Putting Distributed Energy Resources to Work in Wholesale Electricity Markets report, Advanced Energy Economy, (September 2019).

resilient DERs to export energy to the grid before it reaches emergency status, including Emergency Response Service (ERS) and non-ERS exports.

4.4.2 ERCOT CAN ALLOW FOR DATA VALIDATION FLEXIBILITY.

ERCOT currently requires telemetry for each site with resilient DERs. However, this can be cost prohibitive for residences with smaller DER installations. For aggregations of smaller installations, telemetry could be required on the aggregate level, or third parties could provide metering to reduce cost. Also, ERCOT can allow aggregators and retail electricity providers to view the ERCOT Smart Meter Texas Portal, so these entities can see the data ERCOT is seeing closer to real-time. And, ERCOT and the PUCT can adopt widely used international measurement and verification standards for determining DER contributions to and impacts on the grid for both operations prediction and compensation purposes. Other RTOs and ISOs are working on refining measurement and verification practices for smaller scale DERs in response to and coordination with FERC Order 2222, which allows communication at the level of the aggregation, not the individual DER.[194,195] ERCOT should review practices in other RTOs and ISOs to identify and implement best practices. ERCOT can also conduct its own metering study to inform an approach that works for the region.

CONCLUSION

The impact of Winter Storm Uri on the Texas electricity system—and the dire human and economic consequences of that impact—brought into stark relief the vulnerabilities of the state's electric grid and the importance of increasing grid resilience to safeguard the health and wellbeing of all Texans and the Texas economy. If policymakers in Texas seek to minimize the risk and severity of grid disturbances by looking only to the types of large-scale infrastructure solutions that have worked in the past, they will fail to arrive at the least-cost, most reliable solution. Optimizing electricity system operation in the 21st century will require managing flexible electricity demand, not just supply; making the best use of DERs that many customers are already installing to provide grid services that can avoid or minimize outages; and ensuring that communities and critical facilities are equipped with DERs to maintain electricity and minimize the human and economic impact of grid events.

[194] NYISO Meter Data Study Final Report, New York Independent System Operator Inc., (December 8, 2017).

[195] FERC Order 2222 Filing Framework, Midcontinent Independent System Operator Inc., (August 2, 2021).

The use cases and policy solutions outlined in this report provide a roadmap to ensure that DERs are being deployed faster and in more places to increase resilience, and to ensure that those DERs already being deployed by customers are providing maximum resiliency benefits. By following this roadmap, policymakers can ensure that no tools are left untouched in their efforts to shore up the Texas grid in light of the significant vulnerabilities that it is now acknowledged to face.