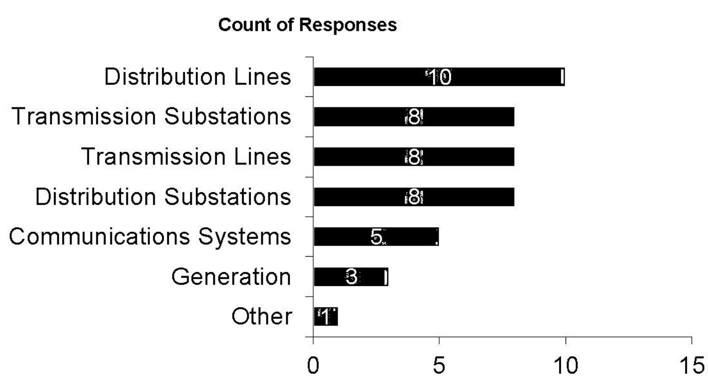
Q. HOW DOES CENTERPOINT HOUSTON'S RESLIENCY PLAN COMPARE TO THE TYPES OF RESILIENCY INVESTMENTS BEING MADE BY THE PEER GROUP?

A. Survey results presented in Figure ELS-2 and Figure ELS-3 confirm CenterPoint's resiliency measures are similar to measures being implemented by the peer utility group. In particular, many utilities are making investments in hardening measures such as pole replacements and flood mitigation measures at substations. Notably, Figure ELS-3 confirms transmission and distribution line upgrades are the most cited programs by survey participants, each of which are among the highest programmatic investment included in CenterPoint Houston's Resiliency Plan.

FIGURE ELS-3



Q. WHAT RECOMMENDATIONS WERE PROVIDED TO CENTERPOINT HOUSTON FOR CONSIDERATION IN THE DEVELOPMENT OF ITS RESILIENCY PLAN BASED ON THE PEER ELECTRIC UTILITY BENCHMARKING?

A. Based on the survey results, Guidehouse recommended that CenterPoint Houston consider resiliency measures in future plans that address wildfire risk such as fire protection and enhanced vegetation management.

Q. DID CENTERPOINT HOUSTON MAKE MODIFICATIONS TO ITS RESILIENCY PLAN BASED ON THE FINDINGS AND RECOMMENDATIONS PROVIDED BY GUIDEHOUSE FROM THE PEER ELECTRIC UTILITY BENCHMARKING?

A. CenterPoint Houston used the Guidehouse analysis to make adjustments to its plan as stated in Mr. Tutunjian's testimony. As noted in my prior responses, CenterPoint Houston added targeted critical circuit vegetation management, a microgrid pilot program, and wildfire mitigation resiliency measures (including targeted vegetation management) after Guidehouse completed its initial review.

VII. SUMMARY OF FINDINGS AND RECOMMENDATIONS

Q. HOW DID GUIDEHOUSE DETERMINE ITS FINDINGS AND RECOMMENDATIONS ON CENTERPOINT HOUSTON'S RESILIENCY PLAN?

A. The findings and recommendations offered in my testimony are based on the results of Guidehouse's independent analysis of resiliency risk for CenterPoint Houston's service area and potential benefits associated with CenterPoint Houston's proposed operations and physical security resiliency measures. Guidehouse's analysis included a risk assessment that forecasts an increase in extreme weather events occurring in CenterPoint Houston's service area over time. Using the results of the risk assessment and identification of benefits, costs, and industry best practice, Guidehouse conducted qualitative and quantitative analyses of CenterPoint Houston's proposed resiliency plan investments. This included benchmarking industry best practices in resiliency planning for electric systems outlined in Section VI of my testimony.

Further detail on Guidehouse's independent analysis and review is provided in Exhibit ELS-2, *Guidehouse's Independent Analysis and Review of CenterPoint Energy Houston Electric's Resiliency Plan*. This report supports my testimony and was prepared with assistance from Guidehouse staff and an outside consulting firm to conduct the peer utility benchmarking study.[33]

Q. PLEASE SUMMARIZE THE OVERALL FINDINGS FROM GUIDEHOUSE'S INDEPENDENT ANALYSIS AND REVIEW OF CENTERPOINT HOUSTON'S RESILIENCY PLAN.

---

[33] First Quartile Consulting provided peer utility benchmarking data.

A. First, Guidehouse finds that CenterPoint Houston's Resiliency Plan appropriately prioritizes operations and physical security resiliency measures that help mitigate resiliency events with the highest amount of risk in CenterPoint Houston's service area. With regards to my testimony, Guidehouse's risk assessment confirms that the frequency and magnitude of extreme weather events is likely to increase over time. These include increased flood risk at substations in areas prone to flooding, and transmission and distribution lines that were built according to standards that existed at the time they were constructed, but are now susceptible to failure due to an increase in frequency and severity of microburst and tornados. Examples of CenterPoint Houston's consideration of the findings of this risk assessment include:

- Several of CenterPoint Houston's resiliency measures target asset replacements to upgrade in locations most susceptible to outages during resiliency events. For example, CenterPoint Houston's Resiliency Plan targets circuits with a high percentage of poles that do not meet its current design standard, making them more susceptible to outages during high wind events.
- CenterPoint Houston's Resiliency Plan targets elevation of critical substation equipment to align with flood profiles outlined in Guidehouse's risk assessment.
- Transmission pole and tower replacements will be designed by CenterPoint Houston to withstand high impact tornados and microbursts.
- CenterPoint Houston is applying grid modernization resiliency measures that emphasize automation as an efficient and cost-effective measure to improve electric transmission and distribution system performance during resiliency events.

Similarly, the BCA analysis performed by Guidehouse indicates that each resiliency measure described above in my testimony is either cost effective (i.e., benefit-cost ratio, or BCA ratio, greater than 1) or provides additional qualitative benefits that support inclusion in CenterPoint Houston's Resiliency Plan. Further, the peer utility benchmarking survey described in Section VI of my testimony indicates that proposed operations and physical security resiliency measures included in CenterPoint Houston's Resiliency Plan are consistent with those deployed at other utilities.

In summation, I conclude that CenterPoint Houston's Resiliency Plan is:

- appropriate for addressing the risks it faces;
- aligned with industry best practice (i.e., Good Utility Practice); and
- beneficial to customers and communities served by CenterPoint Houston.

Q. PLEASE SUMMARIZE THE RECOMMENDATIONS GUIDEHOUSE PROVIDED FOR CENTERPOINT HOUSTON'S CONSIDERATION

A. Guidehouse offered the following recommendations to CenterPoint Houston to further enhance its current and future resiliency plans, including implementation of its current plan:

1. Further assess societal impacts by quantifying such benefits (e.g., positive economic impacts) either collectively or individually, for proposed resiliency measures.
2. Assess the applicability of resiliency measures adopted by other utilities as identified through the peer utility benchmarking survey results, but not included in CenterPoint Houston's Resiliency Plan. For example, targeted vegetation management and fire avoidance measures are commonly included in peer utility

resiliency plans. (*note: after further consideration, CenterPoint Houston included targeted critical circuit vegetation management and wildfire mitigation measures in its Resiliency Plan*).

3. Over the long-term (beyond the 3-year investment horizon), review alternative, non-build resiliency measures such as local generation and storage technologies, in lieu of traditional investments. (*note: CenterPoint Houston added a microgrid pilot program to its Resiliency Plan after Guidehouse's initial review*).
4. Resiliency measure-specific recommendations include:
   - **Digital Substation** – Examine in greater detail additional potential benefits associated with the Digital Substation resiliency measure, considering increased value associated with enhanced communications, automation, visualization and operational considerations;
   - **Substation Physical Security Fencing** – Consider more robust security fencing such as concrete walls for the Substation Fence measure in lieu of wire mesh;
   - **Substation Flood Control** – Refine Substation Flood Control elevation levels using flood inundation results;
   - **Distribution Resiliency – Circuit Rebuilds** – Prioritize Distribution Resiliency –Circuit Rebuild upgrades using more targeted hurricane and wind studies;
   - **Advanced Aerial Imagery Platform / Digital Twin** – Identify additional applications and benefits associated with the Advanced Aerial Imagery

Platform / Digital Twin resiliency measure beyond those listed in our report; and

- **IGSD Installation Measure** – Analyze the benefits of transitioning to fully automated IGSD schemes for new (and potentially existing) schemes.

Q. PLEASE SUMMARIZE HOW CENTERPOINT HOUSTON MADE MODIFICATIONS TO ITS RESILIENCY PLAN BASED ON THE FINDINGS AND RECOMMENDATIONS PROVIDED BY GUIDEHOUSE REGARDING ITS RESILIENCY MEASURES.

A. CenterPoint Houston used the Guidehouse analysis to make adjustments to its plan as stated in Mr. Tutunjian's testimony. For example, as noted in CenterPoint Houston's Resiliency Plan, CenterPoint Houston collaborated with Guidehouse to identify alternatives and metrics included in their Resiliency Plan. Further, CenterPoint Houston added targeted critical circuit vegetation management and wildfire mitigation resiliency measures (including targeted vegetation management for wildfire risk areas) after Guidehouse's initial review. This was informed in part by wildfire risk analysis included in Guidehouse's report. It is also my understanding that recommendations offered in the Guidehouse report applicable to implementation and future resiliency plans will be considered as CenterPoint Houston works to implement and later refine its Resiliency Plan.

VIII. CONCLUSION

Q. PLEASE SUMMARIZE YOUR DIRECT TESTIMONY.

A. Guidehouse's independent assessment of CenterPoint Houston's Resiliency Plan and my testimony finds that its proposed resiliency measure investments are expected to provide substantive benefits to its customers and the Houston region. Accordingly, I recommend the Commission approve CenterPoint Houston's Resiliency Plan and the resiliency measures it proposes over the 3-year investment period spanning 2025 through 2027. My recommendation is supported by the level of rigor Guidehouse applied to evaluate and confirm the benefits associated with CenterPoint's Resiliency Plan. As noted in my findings, Guidehouse's risk assessment confirms that the frequency and magnitude of extreme weather events is likely to increase over time. The resiliency measures CenterPoint Houston proposed to mitigate resiliency events affirmatively address the increased exposure and vulnerability of its transmission and distribution system to such events.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes.

STATE OF NEW YORK §
§
COUNTY OF ESSEX §

AFFIDAVIT OF EUGENE L. SHLATZ

Before me, the undersigned authority, on this day personally appeared Eugene L. Shlatz, who being by me first duly sworn, on oath, deposed and said the following:

1. "My name is Eugene L. Shlatz. I am of sound mind and capable of making this affidavit. The facts stated herein are true and correct based on my personal knowledge. I am currently a consultant for Guidehouse Inc.

2. The foregoing direct testimony and the attached exhibits have been prepared by me or under my direct supervision and are true and correct to the best of my knowledge."

Further affiant sayeth not.

Eugene L. Shlatz

Subscribed and sworn to before me on this 18th day of March 2024.

Notary Public in and for the State of New York

SUSAN E THOMPSON
Notary Public - State of New York
NO. 01TH6444391
Qualified in Essex County
My Commission Expires Nov 28, 2026

Guidehouse
Outwit Complexity

Eugene L. Shlatz

Director (Contract Worker)

eshlatz@guidehouse.com
Tampa, FL
Direct: 802.233.1890

Professional Summary

Gene has over 35 years of management consulting and supervisory experience in energy delivery, electric power generation and distributed energy systems. He has directed numerous engagements on electric system reliability, smart and renewable technologies, microgrids, asset management, electric pricing, due diligence and system adequacy. His clients have included US, Canadian, European and South American electric utilities, electricity consumers, law firms and government agencies. Gene is an expert on electric power delivery systems; and has testified before FERC, state regulatory commissions and U.S. Congress on transmission open access, DG integration, retail rates, regulatory compliance, and capital planning. He has published numerous articles and industry presentations on smart grid, distributed resources, electric reliability, asset management, energy efficiency, and electric pricing.

Professional Experience

Directs project teams and manages consulting engagements for electric utility, government and energy supply clients. Responsible for energy delivery and power production engagements in the following areas:

- **Regulatory/Legal –** capital planning, transmission and distribution program support, renewables integration and pricing, expert witness for state and federal agencies, and civil litigation
- **Operations & Planning –** transmission and distribution performance evaluation; reliability, target setting, remediation analysis, and service quality standards
- **Emerging Technologies –** renewable technology and smart grid integration, energy efficiency and technical/economic assessment of distributed resources
- **Asset Management –** implementation strategy, project prioritization, performance measurement, utilization and cost optimization, electric delivery system planning

Representative Client List and Engagements

Distributed Energy Resources & Advanced Technologies

- **Alberta Utilities Commission.** Lead investigator to evaluate impacts and costs to integrate solar PV and electric vehicles on Distribution Facility Owner distribution systems to year 2050. Conducted analytical studies of mitigation options to address performance violations.
- **American Electric Power.** Program lead to assess DER integration strategies and cost for a multi-state solar PV and electric vehicle forecast. Developed analytical approach to predict system impacts and mitigation options to address distribution system performance violations.
- **Aspen/California Energy Commission**. Conducted several independent reviews of advanced energy systems and applications for applicants seeking EPIC project funding. Technologies evaluated include integrated storage and renewables, advanced simulation software and Microgrids.

Guidehouse
Outwit Complexity

Eugene L. Shlatz

Director (Contract Worker)

- **NYSERDA**. Evaluated impacts of small-scale energy storage on radial and network distribution systems to assess the applicability of standby rates adjustments for New York electric utilities.
- **California Utility (Confidential)**. In response to recent fires in California, evaluated wildfire prevention mitigation strategies to reduce the hazard potential for electric transmission and distribution lines and equipment.
- **Dubai Electric and Water Authority.** Project lead for distribution automation, transmission automation, asset management, and renewables integration smart technology assessment. Conducted technical and economic studies of smart technology options and developed roadmap for implementation of recommended strategies.
- **California Energy Commission/Southern California Edison**. Project manager of DER integration studies for a major utility planning region. Predicted hosting capacity limits and options to increase DER capacity and value via advanced communications and control technologies. Assessed the capability of energy storage to increase capacity limits.
- **U.S. Department of Energy/Dominion Virginia Power.** Project manager of Solar Integration Study to identify renewable capacity impacts and integration requirements in the state of Virginia. Determined distribution hosting capacity limits and impacts of increasing amounts of solar on DVP's generation, transmission and distribution system.
- **Los Angeles Department of Water & Power.** Technical lead of a DER integration study to determine integration requirements and hosting capacity limits, and approaches to target DER and storage based on locational needs and benefits. Assessed communication and control strategies, organization structure, tariffs and rates, and strategies to achieve renewable portfolio targets.
- **Orange & Rockland Utilities.** Project manager of a DG Interconnection benchmarking analysis. Conducting studies to predict hosting capacity limits on O&R's T&D system and mitigation options in support of NY's Renewable Energy Vision initiative.
- **Pacific Gas & Electric Company.** Project manager of a Transmission and Distribution PV Impact Study. It included engineering analyses designed to facilitate the integration of DGPV into the grid. Developed PV values based on analysis across multiple scenarios and attributable to DGPV.
- **Major Southeastern U.S. Utility (Confidential).** Project manager of a Solar Integration Study to assess the technical and economic impact of increasing amounts of solar on the utilities' generation, transmission and distribution system.
- **California Energy Commission/Southern California Edison.** Project manager of a study evaluating DG impacts and integration requirements for up to 12,000 MW of DG in California by 2020. Developed a technical evaluation and costing framework applicable to all CA utilities.
- **U.S. Navy.** Evaluated on-site microgrid options for a major military shipyard, including technical assessment of renewable generation, control strategies, electric system performance and system upgrades required to operate in stand-alone and parallel modes of operation.
- **U.S. Department of Energy (DOE).** Provided technical and program management support for DOE's Smart Grid Investment Grant (SGIG) program. Responsible for impact evaluation of smart grid technologies, including program benefits and implementation strategies.

Guidehouse
Outwit Complexity

Eugene L. Shlatz

Director (Contract Worker)

- **PowerStream (Ontario).** Provided project management and evaluation services for an on-site microgrid comprised of a mix of wind, solar, storage and gas-fired technologies. Developing control and dispatch strategies and methods for assessing MG performance and benefits.
- **NV Energy.** Project manager of DG and large PV integration studies for southern and northern Nevada. Identified technical/capacity limits of renewable energy sources on NV Energy's T&D system. Responsible for technical and economic evaluation of power system impacts and integration costs, including intermittency. Testified before Nevada Commission to support findings.
- **Toronto Hydro.** Project manager of comprehensive evaluation of distributed energy resources versus traditional T&D alternatives for a major urban center. Included a technical assessment of DG systems impacts, technology integration and forecast of cost-effective alternatives.
- **Southern California Edison Company.** Technical support a 3-year integrated grid pilot designed to demonstrate modern grid infrastructure functionality and advance customers' ability to interconnect renewable energy sources, proactively manage customer demand, and improve the safety and reliability of the grid in a cost-effective manner.

Reliability, Benchmarking and Electric System Planning

- **Jersey Central Power & Light.** Principle investigator of a commission-mandated Operations Review of JCP&L's distribution system. The review included an assessment of reliability, storm response, preventative maintenance and budgeting processes. Navigant's report and recommendations were unanimously approved and accepted by the New Jersey Board of Public Utilities.
- **Exelon/Commonwealth Edison.** Lead consultant of an engineering and operational assessment of Exelon's system design, construction and maintenance practices. Our study was filed before the ICC in response to claims of system inadequacy for major storms. Provided expert witness testimony that confirmed ComEd's T&D practices were consistent with or exceeded industry standards
- **Government of Puerto Rico (Public Private Partnership).** Program oversight lead for long-term disaster recovery efforts for the Puerto Rico Electric Power Authority (PREPA) generation, transmission and distribution systems. Responsible for developing Grid Modernization plans to restore the electric grid to current standards, consistent with FEMA and BBA funding requirements.
- **Toronto Hydro (THESL).** Prepared an independent technical assessment of a proposed relocation of a major segment urban transmission and distribution system as evidence before a tribunal in the City of Toronto. Analyzed relocation options and impact on power system reliability and performance.
- **New York Power Authority/ Puerto Rico Electric Power Authority**. Lead investigator and subject matter expert of a study to assess damage caused by major hurricanes in 2017 and to provide recommendations to bring the power generation and delivery system to current design standards.
- **Hawaiian Electric Company**. Project manager of a technical analysis to assess the impact of capital and O&M improvement programs on electric system reliability performance during storms and major events. Demonstrated a correlation of program improvements and system resiliency during storms.
- **BC Hydro.** Lead investigator to benchmark and assess vegetation management practices and applications across the province of British Columbia. Provided recommendations on enhancing processes and VM methods to improve efficiency and cost.

Guidehouse
Outwit Complexity

Eugene L. Shlatz

Director (Contract Worker)

- **Saskatoon Light & Power.** Project manager of a 20-year capital development plan designed to meet reliability and performance objectives at lowest cost. Our assessment included a review and analysis of T&D engineering, maintenance and operations; and recommendations for improvement.
- **Sulphur Springs Valley Electric Cooperative (SSVEC).** Project manager of an independent Feasibility Study of delivery alternatives, including T&D, distributed generation, energy efficiency, energy storage and renewables. Successfully testified as an expert witness before AZ commission.
- **Austin Energy.** Performed a benchmarking and gap analysis of AE's engineering and operations. Prepared recommendations to enhance reliability and operations efficiency.
- **Saskatoon Light & Power.** Project manager of a 20-year capital development plan designed to meet reliability and performance objectives at lowest cost. Our assessment included a review and analysis of T&D engineering, maintenance and operations; including recommendations for improvement.
- **Toronto Hydro Electric System, Limited (THESL).** Performed a long-range planning study for THESL's radial and network downtown distribution system. Evaluated capital expansion versus CDM needed to serve downtown Toronto for 20 years.
- **Sulphur Springs Valley Electric Cooperative (SSVEC)**. Project manager of an independent Feasibility Study of delivery alternatives, including T&D, distributed generation, energy efficiency, energy storage and renewables. Successfully testified as an expert witness before AZ commission.
- **Austin Energy.** Performed a benchmarking and gap analysis of engineering and operations performance for AE's energy delivery organization.
- **Ameren Services.** Conducted a review and predictive assessment of distribution reliability. A methodology was developed to apply fact-based methods to allocate reliability expenditures.
- **American Electric Power.** Conducted a review and predictive assessment of distribution reliability. Applied fact-based methods to prioritize investment decisions and to quantify risk.
- **Potomac Electric Power Company (PHI).** Conducted an investigation and benchmarking analysis of PEPCO's T&D system, including transmission and distribution infrastructure. Prepared recommendations to enhance performance and reduce outage risk.
- **National Grid.** Conducted a system review and predictive assessment of distribution reliability. A strategic methodology was developed to predict system outage performance based on system attributes, equipment performance and historical reliability.
- **Potomac Electric Power Company (PHI).** Project manager of a benchmarking analysis of PEPCO's T&D system, including transmission and distribution infrastructure. Prepared recommendations to enhance performance and reduce outage risk.
- **Dominion – Virginia Power**. Project manager and lead investigator of a comprehensive technical review and risk assessment of secondary networks. Reviewed and analyzed engineering standards, planning criteria, operations and maintenance, and construction methods.

Guidehouse
Outwit *Complexity*

Eugene L. Shlatz

Director (Contract Worker)

Regulatory and Legal

- **Expert Witness - Civil Litigation (Various Jurisdictions).** Expert witness in personal injury cases involving electric utility assets. Conducted technical investigations, reviewed and submitted discovery, and declarations to support evidentiary hearings and agreements.

- **Duke Energy (Florida), Public Service of New Mexico & El Paso Electric.** Conducted studies to determine ancillary service requirements costs. Provided expert testimony ancillary service schedules to support OATT fillings before the U.S. Federal Energy Regulatory Commission.

- **Hydro Ottawa (Ontario).** Conducted an independent review of Hydro Ottawa's asset management and Distribution System Plan to support a rate request filing before the Ontario Energy Board (OEB). Provided recommendations to ensure compliance with OEB filing requirements for capital investments.

- **NorthWestern Energy (FERC).** Expert witness supporting ancillary services schedules and pricing for a filling before the U.S. Federal Energy Regulatory Commission.

- **NorthWestern Energy (Montana/FERC).** Expert witness for NEM Solar Integration and NERC Reliability Performance studies to comply with Montana Public Service Commission and U.S. Federal Energy Regulatory Commission requirements. Conducted technical and economic studies of solar impacts on NorthWestern's service territory and submitted expert testimony to support findings on ancillary services before the MPSC.

- **International Business Machines (IBM).** Conducted a reliability assessment of issues related to the City of Boulder, Colorado's application to the Colorado Public Utility Commission (PUC) to form a municipal electric utility. Conducted independent technical review of separation of electric assets and appeared as an expert witness before the CPSC on behalf of IBM.

- **Green Mountain Power (GMP).** Prepared independent testimony and appeared as an expert witness in a rate filing before the Vermont Public Service Commission (VPSC). Testimony supported capital investments for generation, transmission, distribution, IT/OT and physical assets.

- **NV Energy (Sierra Pacific Power Company).** Conducted a T&D avoided cost study to support an SPPC's rate filing and to determine Excess Energy Charges for net metering customers. Submitted expert testimony before the Nevada Commission on T&D marginal costs and application to NEM solar.

- **Toronto Hydro Electric System, Limited (THESL).** Prepared business case studies for major capital programs in rate filings before the Ontario Energy Board (OEB). Testified as an independent expert witness before the OEB on Distribution System Plans and renewable energy programs in Custom Incentive Rate (CIR) and Incremental Capital Module (ICM) filings.

- **Exelon (Philadelphia Electric Company).** Developed T&D avoided cost study to support PECO energy efficiency programs. Participated in a statewide stakeholder process to approve T&D avoided costs, which included the statewide EE program evaluator, the electric utility and related parties.

- **Puerto Rico Electric Power Authority (PREPA).** Conducted a T&D avoided cost analysis and prepared expert testimony to support PREPA's rate filing and avoided costs applied to net metering.

Eugene L. Shlatz

Director (Contract Worker)

- **Public Utility Authority (Israel).** Conducted a technical and economic review of the Israeli Electric Corporation and Palestinian Electric Authority electric generation and power delivery system on behalf of the PUA. Assessed the adequacy of electric infrastructure, power costs and investment programs.
- **Vermont Department of Public Service (VDPS).** Conducted a geo-targeted analysis of energy efficiency programs designed to defer T&D investments. Worked with electric utility stakeholders to identify cost-effective deferral opportunities and to assess processes designed to target EE programs.
- **Canadian Utility (Confidential) –** Confidential study to assess the value and strategic benefits of the acquisition of electric utility energy delivery assets. Included a technical and economic assessment of key regulatory and acquisition risk factors to support a recommendation.
- **Progress Energy.** Project manager of a best practices and compliance review of fixed asset charging practices. Reviewed methods, systems and practices used to record fixed assets for Florida and the Carolinas to support proposed changes filed with state commissions and the SEC.
- **Citizens Utilities/Vermont Electric Cooperative.** Supported numerous Certificate of Public Good (CPG) applications before the Vermont Public Service Board (VPSB). Expert witness for technical, environmental, and costing studies.
- **Vermont Department of Public Service (VDPS).** Conducted research and prepared sections of the Twenty-Year Electric Plan, including the impact of the independent system operator (ISO) and regional transmission organization (RTO) initiatives on Vermont's transmission providers.
- **Potomac Electric Power Company (PHI).** Project manager of a benchmarking study of storm hardening measures. Assessed the impact of hardening options on reliability and performance. Also assessed service quality (SQI) measures and performance-based rate (PBR) mechanisms.
- **Citizens Utilities (Vermont Electric Division).** Project manager for a T&D Audit mandated by the Vermont Public Service Board. Reviewed T&D plant accounting systems and processes, and provided recommendations for improvement.
- **Massachusetts Department of Telecommunications and Energy (MDTE).** Project manager of a stray voltage assessment of jurisdictional utilities. Identified causes of stray voltage and provided recommendations to mitigate future events, including action and improvement plans

Asset Management

- **Horizon Utilities Corporation.** Developed strategies and provided ongoing support for HU's asset management initiative. Conducted a gap analysis and implementation of asset management strategies and evaluation methods. Included an evaluation of infrastructure upgrades, operational and reliability improvement and implementation strategies using AM-based approaches.
- **First Energy**. Lead consultant of a project team that implemented asset management processes and capital prioritization models for 6 operating companies in three jurisdictions. Responsible for model development and applications, technical review and overall quality assurance.

Guidehouse
Outwit *Complexity*

Eugene L. Shlatz

Director (Contract Worker)

- **Seattle City Light**. Conducted a benchmarking and gap analysis of the power supply and energy delivery business units. It included a business case analysis to support implementation of asset management methods and new AM organization.
- **Pepco/Conectiv (PHI)**. Responsible for an asset management and prioritization assessment of capital improvement and O&M programs for three states and the District of Columbia. It included developing asset prioritization methods for transmission, distribution and IT programs.
- **Entergy**. Responsible for an asset management and prioritization assessment of Entergy's capital improvement programs for six jurisdictional utilities in 5 states. It included developing asset-specific prioritization methods for transmission and distribution programs.
- **PacifiCorp**. Responsible for an asset management and prioritization assessment of PacifiCorp's capital improvement programs for six jurisdictional utilities in 6 states. It included developing asset-specific prioritization methods for transmission and distribution and IT programs.

Work History

- Navigant Consulting, Director
- Stone & Webster Management Consultants, Executive Consultant
- Green Mountain Power Corp, Assistant Vice President, Energy Planning
- Ernst & Whinney, Supervisor
- Gilbert/Commonwealth, Senior Consulting Engineer
- Westinghouse Electric Corporation, Systems Analysis Engineer
- Boston Edison Company, Student Engineer, Cooperative Education Prog.

Certifications, Memberships, and Awards

- Professional Engineer - State of Vermont
- Institute of Electrical and Electronic Engineers, Section Chairman (Past)

Education

- M.S. Electric Power Engineering, Rensselaer Polytechnic Institute
- B.S. Electric Power Engineering, Rensselaer Polytechnic Institute

Articles, Publications and Course Instruction

- Grid Reliability and Resiliency Initiatives for the Island of Puerto Rico," Midwest Energy Solutions Conference, Chicago, February 2019.
- "Microgrid Development – Making it Work: ," Instructor: PowerGen Competitive Power College, Orlando, December 2016.
- "DG Proliferation Trends, Challenges and Solutions Addressing Interconnection Planning, Operations, Benefits & Cost Allocation," Instructor: DistribuTECH University, San Diego, Feb. 2015.

Guidehouse
Outwit Complexity

Eugene L. Shlatz

Director (Contract Worker)

» “Smart Grid and Distributed Energy Storage,” Total Energy USA, Houston Texas, November 2012.

» “Distributed Generation: Grid Impacts and Interconnection Strategies,” Rocky Mountain Electric League, 2012 Spring Management, Engineering and Operations Conference, Omaha Nebraska.

» “Energy Storage Opportunities for Integration of Large-Scale Renewable Generation,” Electricity Storage Association (ESA) Annual Conference, Washington DC, May 2012.

» “Grid Integration of Renewable, Intermittent Resources,” 2011 PowerGen International Conference, December 2011, Las Vegas, NV, with Vladimir Chadliev.

» “Reducing T&D Investments Through Energy Efficiency” IEPEC, August 2011, with K. Parlin & W. Poor.

» “Value of Distributed Generation and Smart Grid Applications,” DistribuTECH, San Diego, Feb. 2011.

» “Prioritization Methods for Smart Grid Investments,” EEI Perspectives, April-May, 2010.

» “Evaluation of Targeted Demand-Side Management at ConEd (CECONY),” ACEEE Energy Efficiency Conference, September, 2009, with Craig McDonald.

» “DER Operational & Grid Benefits” Electric Light & Power, February, 2009.

» “Benefits of Smart Grid Integration with Distributed Energy Storage Systems,” Infocast Power Storage Conference, July, 2008.

» “The Rise of Distributed Energy Resources,” Public Utilities Fortnightly, Feb, 2007, with S. Tobias.

» “Risk Planning & Project Prioritization: Bringing Energy Delivery to the Next Level in Asset Management,” InfoCast T&D Asset Management Conference, St. Louis, MI, May 2004.

» “Valuation Methods: Estimating the Value of Avoiding the Risks Associated with T&D Reliability Failures,” EEI Spring 2004 T&D Conference, Charlotte, NC, April 2004.

» “Reliability Tradeoffs,” EEI Perspectives, January-February, 2004, with Daniel O’Neill.

» “What’s the Outlook for Distributed Generation Interconnection Standards?” 2003 PowerGen International Conference, Las Vegas, Nevada, December 2003.

» “Federal Interconnection Standards: Putting DG in a Box,” Public Utilities Fortnightly, April 2003, with Stan Blazewicz.

» “An Innovative Approach to Fact-Based Distribution Reliability Cost Optimization,” Distribution 2000, Brisbane, Australia, November 1999, with Cheryl Warren.

» “System Reliability: Competitive Issues,” Rethinking Electric Reliability Conf., Chicago Il, Sept 1997.

» “Reliability: Competition & Keeping the Lights On,” EUCI, Denver, Colorado, October 1998.

» “System Reliability in a Restructured Environment,” Electric System Reliability in a Competitive Environment Workshop, Denver, Colorado, October 1997.

» “Privatization Efforts in South America” EUCI Workshop, Denver, Colorado, January 1997.

» “Open Access Pricing Issues,” Transmission Pricing Conference, Vail, Colorado, Sept. 1996.

Guidehouse
Outwit Complexity

Eugene L. Shlatz

Director (Contract Worker)

Testimony and Appearances as an Expert Witness

Case Description	Company	Year	Docket	Jurisdiction
Rate Cases, Resource Planning, Open Access and Regulatory Investigations				
Request for Increase in Retail Rates	Kentucky Power	2023	2023-00159	Kentucky
Wholesale Rate Filing (OATT)	NorthWestern	2019	ER-1756-000	FERC
Retail Rate Filing (Net Metering)	NorthWestern	2018	D2018.2.12	Montana
Request for Increase in Retail Rates	GMP	2017	17-3112	Vermont
Transfer of Electric Assets (Municipalization)	IBM	2017	15A-0589E	Colorado
Marginal Cost Study (NEM & Rate Filing)	NV Energy	2016	16-06006	Nevada
Custom Incentive Rate Filing	Toronto Hydro	2016	EB -2014-0116	Ontario
Incremental Capital Module (Rate Filing)	Toronto Hydro	2014	EB-2012-0064	Ontario
Summer/Winter 2011 Storm Review	Exelon/ComEd	2013	11-0588	Illinois
Distributed Generation Integration	NV Energy	2012	10-04008	Nevada
Distributed Utility Planning	CUC	2011	6290	Vermont
Power Purchase Contracts – IURC Complaint	Jay REMC	2003	9704-CP-069	Indiana
Section 205 Filing – Wholesale Rates	NISource	1998	ER96-35-000	FERC
Open Access Transmission Tariff Filing	NISource	1997	ER96-399-000	FERC
Request for Increase in Wholesale Rates	NISource	1996	ER92-330-000	FERC
Request for Increase in Retail Rates	GMP	1996	5532	Vermont
Least-Cost Planning Integrated Resource Plan	GMP	1991	5270	Vermont
Request for Increase in Retail Rates	GMP	1991	5428	Vermont
Request for Increase in Retail Rates	GMP	1990	5370	Vermont
Request for Increase in Retail Rates	GMP	1989	5282	Vermont
Request for Increase in Retail Rates	GMP	1988	5125	Vermont
Certificates of Public Good				
Transmission Line Construction Authorization	SSVEC	2010	E-01575A	Arizona
Northern Loop Transmission Upgrades	Velco/CUC	2004	6792	Vermont
Substation Reconstruction – Richford	CUC	2003	6682	Vermont
Island Pond to Bloomfield Line	CUC	2001	6044	Vermont
HK Webster Substation	CUC	1999	6045	Vermont
Burton Hill Substation	CUC	1999	6046	Vermont
Border to Richford 120/46kV Line	CUC	1998	5331A	Vermont
New Transmission Lines and Substation	IBM	1991	5549	Vermont
New Substation – Northern Vermont	GMP	1990	5459	Vermont
Gas Turbine Interconnection Facilities	IBM	1989	5347	Vermont
Dover Substation Expansion	GMP	1987	5226	Vermont
Industry Restructuring & Asset Transactions				
Purchase of Electric Assets	VEC	2004	6853	Vermont
Certificate of Consent, Sale of Distribution Assets	CUC	2004	6850	Vermont
Certificate of Consent, Sale of Transmission Assets	Velco/CUC	2004	6825	Vermont
Prudency Review and Audit Support	CUC	2003	5841/5859	Vermont
Competitive Opportunities Filing	ConEdison	1997	96-E-0897	New York

Guidehouse

Exhibit ELS-2: Guidehouse Independent Analysis and Review of CenterPoint Energy Houston Electric, LLC's Resiliency Plan

Final Report

Submitted by:
Guidehouse Inc. on behalf of CenterPoint Energy Houston Electric, LLC

April 2024

Table of Contents

List of Figures

List of Tables

Disclaimers

This deliverable (the "Report") was prepared for CenterPoint Energy Houston Electric, LLC ("CenterPoint Houston"), on terms specifically limiting the liability of Guidehouse Inc. ("Guidehouse"), for use in connection with a filing by CenterPoint Houston at the Public Utility Commission of Texas ("PUCT" or "Commission") seeking approval of CenterPoint Houston's transmission and distribution system resiliency plan pursuant to 16 Tex. Admin. Code § 25.62 (the "Resiliency Plan Proceeding"). Other than for use in the Resiliency Plan Proceeding as provided by applicable laws and rules, the Report is not to be distributed without Guidehouse's prior written consent and subject to execution of a third-party access agreement. Guidehouse's conclusions are the results of the exercise of its reasonable professional judgment and are based, in part, upon facts provided to Guidehouse by CenterPoint Houston, which Guidehouse has accepted with CenterPoint Houston's permission as true and accurate without independent verification or inquiry.

Use of the Report is limited solely to the Resiliency Plan Proceeding. Other than as permitted by the laws and rules applicable to the Resiliency Plan Proceeding, the Report may not be distributed to any third party without Guidehouse's express prior written consent. Guidehouse has used reasonable care and exercised its reasonable professional judgement in preparing the Report but does not make any representations or warranties of any kind to any third party with respect to the Report. Guidehouse accepts no liability of any kind whatsoever for any claims, liabilities and damages, if any, alleged by third parties as a result of decisions made, or not made, or actions taken, or not taken, based on this Report.

1. Executive Summary

CenterPoint Houston seeks approval from the Public Utility Commission of Texas ("PUCT" or "Commission") for approximately $2 billion in transmission and distribution ("T&D") investments over the 3-year period of 2025 through 2027, as described in its Resiliency Plan. Guidehouse Inc. ("Guidehouse") prepared this report on behalf of CenterPoint Energy Houston Electric, LLC ("CenterPoint Houston") to inform the development and refinement of CenterPoint Houston's Resiliency Plan (see Exhibit BAT-2). It summarizes Guidehouse's independent analysis of resiliency risks CenterPoint Houston faces and independent review and analysis, including benefit-cost analysis ("BCA"), of resiliency measures included in CenterPoint Houston's Resiliency Plan.

1.1 Risk Assessment

1.1.1 Natural Disaster Threats

Guidehouse's risk assessment indicates that the frequency and magnitude of extreme weather events such as high winds (e.g., hurricanes), floods, extreme heat, and wildfires is likely to increase over time in CenterPoint Houston's service territory as summarized below:

- **High Wind Risk** – Guidehouse analysis shows maximum wind speeds increasing from 2020 to 2050 for nearly all counties served by CenterPoint Houston for 100-year, 200-year, and 500-year events. By 2030, almost all counties will begin experiencing maximum wind speeds exceeding 87 mph for a 500-year event with coastal counties experiencing wind speeds exceeding 99 mph.
- **Flood Risk** – Flood risk varies significantly by location and elevation. Guidehouse's analysis shows that the mean flood depths as well as flooded fractions (i.e., percentage of buildings flooded) are projected to increase from 2020 to 2050 for nearly all counties served by CenterPoint Houston. Galveston and Matagorda counties are projected to experience the highest average flood depth due to their proximity to the coast and lower elevation. Nearly all buildings in Galveston counties are projected to flood if a 200-year or 500-year flood were to occur in 2030. Over 30% of buildings are expected to flood in Harris and Fort Bend counties should a 200-year or 500-year flood event occur in 2030.
- **Extreme Heat Risk** – CenterPoint Houston's territory will also experience rising temperatures throughout this decade. The number of days exceeding 38°C (100°F) is projected to increase for all counties, but the increase for Harris County is particularly prominent, with a rise in expected days exceeding 100°F increasing from about 20-25 today to over 50 in 2030. In addition to average temperature increases, heat wave events are also expected to rise in duration, with an average increase of 11 days between 2020 and 2030, with Colorado County projected to see an increase of 16 days.

- **Wildfire Risk** – Although wildfire risk is currently low in CenterPoint Houston's service territory, it is projected to rise significantly by 2050 to relatively high levels in summer months in most counties in CenterPoint Houston's service territory.

1.1.2 Physical Security and Cybersecurity Threats

Guidehouse's physical security and cybersecurity risk assessment indicates that the frequency and magnitude of physical attacks and cyber-attacks is likely to increase over time, suggesting the need for continued resiliency investments in these areas.

- **Physical Security Risk** – Physical security threats and vulnerabilities for cyber systems represent major concerns from an operational perspective, particularly for enabling technologies such as information technology ("IT") / operational technology ("OT") systems that are critical for efficient and effective operations of the CenterPoint Houston electric system. CenterPoint Houston technology infrastructure systems and facilities are exposed to increasing physical security risks from domestic terrorists, violent extremists, cartels, and foreign adversaries.
- **Cybersecurity Risk** – Cyber-attacks across all critical infrastructure sectors have increased over the past five years with notable examples including the 2021 Colonial pipeline attack, numerous operating system vulnerability exploitations, and the rise of malware and ransomware attacks targeting electric system supply chains and other vulnerabilities. IT/OT cyber systems and technology infrastructure that support the CenterPoint Houston electric system are exposed to constant and increasing risk of failure to operate as designed, compromise, or misuse by foreign and domestic adversaries.

1.2 Analysis and Review of Operations and Physical Security Resiliency Measures

With regards to the operations and physical security resiliency measures included in CenterPoint Houston's Resiliency Plan, Guidehouse performed an independent analysis and review of each measure using both quantitative and qualitative methods. Guidehouse's evaluation of these measures was also informed by the future risk profiles for wind and flooding resiliency events developed as part of Guidehouse's risk assessment.

Guidehouse finds that the operations and physical security resiliency measures included in CenterPoint Houston's Resiliency Plan are appropriate for inclusion in CenterPoint Houston's Resiliency Plan and generally follow best practices for resiliency planning for the following reasons:

- Focuses primarily on asset replacement or upgrades targeted to locations most susceptible to outages during resiliency events as well as other measures with general resiliency benefits.

- Targets circuits with a high percentage of poles that met design standards at the time they were constructed, but do not meet its current design standards and thus are more susceptible to failure resulting in outages during high winds.
- Targets elevating critical substation equipment to align with flood profiles outlined in the Guidehouse risk assessment.
- Targets transmission pole and tower replacements vulnerable to high impact tornadoes and microbursts.
- Includes grid modernization resiliency measures that emphasize automation as an efficient and cost-effective approach to improve T&D performance during resiliency events.
- Results from Guidehouse's BCA indicate that, overall, the benefits of these measures significantly outweigh the costs and, in most cases, the benefits outweigh costs over the life of the individual measure. Further, in many cases there is additional qualitative value that supports inclusion of the measure in CenterPoint Houston's Resiliency Plan. These findings indicate that CenterPoint Houston's Resiliency Plan will provide positive value to the customers and communities it serves. Table 1-1 presents the results of Guidehouse's analysis and includes the three-year capital costs, and operations and maintenance ("O&M") expenses, BCA ratios, and customer minutes of interruption ("CMI") saved for each resiliency measure, grouped by resiliency category.

Table 1-1: Resiliency Measure Costs and Benefits

Resiliency Measure	3-Year Capital Cost ($MM)	3-Year O&M Expense ($MM)	BCA Ratio	3-Yr CMI 2025-2027 (million)	Annual CMI 2027 (million)
System Hardening					
Transmission System Hardening	$376.0	$0.75	6.0	206.0	87.6
S90 Tower Replacements	$103.8	$0.00	4.9	41.7	16.4
69kV - 138kV Conversion Projects	$268.4	$0.00	1.9	46.8	20.0
Coastal Resiliency Upgrades	$259.0	$0.75	1.4	21.9	21.9
Substation Transformer Fire Protection Barriers	$2.4	$0.00	3.7	0.5	0.2
Distribution Pole Replacement/Bracing	$99.3	$0.00	6.2	41.3	20.8
Distribution Resiliency – Circuit Rebuilds	$312.8	$0.00	7.0	137.4	69.4
Strategic Undergrounding/Freeway Crossings	$31.2	$0.00	3.8	4.4	2.2
System Hardening Subtotal	**$1,452.9**	**$1.50**	**4.5***	**500.0**	**238.5**
Grid Modernization					
TripSaver®	$58.9	$0.03	61.3	240.3	122.2
Intelligent Grid Switching Device ("IGSD") Installation	$53.8	$0.82	15.7	58.1	27.7
Texas Medical Center Substation	$102.0	$0.15	0.7	4.9	4.9
Grid Modernization Subtotal	**$214.7**	**$1.00**	**21.1***	**303.4**	**154.8**
Flood Control					

Resiliency Measure	3-Year Capital Cost ($MM)	3-Year O&M Expense ($MM)	BCA Ratio	3-Yr CMI 2025-2027 (million)	Annual CMI 2027 (million)
Substation Flood Control	$30.6	$0.00	7.5	14.2	6.7
Control Center Facility Upgrades	$7.0	$0.00	12.5	6.1	2.5
Flood Control Subtotal	**$37.6**	**$0.00**	**8.4***	**20.3**	**9.2**
Information Technology for Operations					
Advanced Aerial Imagery Platform / Digital Twin	$9.9	$0.06	3.4	0.8	0.3
Advanced Distribution Technology	$225.8	$15.00	4.8	61.1	40.6
Digital Substation	$25.0	$(0.60)	1.9	1.3	0.8
IT for Operations Subtotal	**$260.7**	**$14.46**	**4.5***	**63.2**	**41.7**
System Security					
Substation Physical Security Fencing	$15.0	$0.00	15.6	14.7	7.3
Substation Security Upgrades	$19.5	$0.09	19.9	25.1	12.5
System Security Subtotal	**$34.5**	**$0.09**	**18.0***	**39.7**	**19.8**
Vegetation Management					
Targeted Critical Circuit Vegetation Management	$0.0	$25.00	1.8	13.9	4.2
Vegetation Management Subtotal	**$0.0**	**$25.00**	**1.8**	**13.9**	**4.2**
Total	**$2,000.4**	**$42.05**	**6.6***	**940**	**468**

*Average BCA weighted by resiliency measure cost.
Source: Guidehouse BCA of CenterPoint Houston's proposed resiliency measures.

As shown in the table above, CenterPoint Houston's proposed resiliency measures are expected to provide significant savings as measured by CMI. Over the 3-year Plan, cumulative CMI savings is expected to be 940 million. By 2027, annual CMI savings is expected to be 468 million. Guidehouse further notes that several resiliency programs are complementary, such that additional benefits are realized when resiliency measures are combined. For example, pole replacements that are proposed on distribution circuits where IGSD schemes or TripSavers® are proposed will yield greater benefits than on a standalone basis.

To summarize, Guidehouse's risk and BCA analysis confirms that each resiliency measure is either cost-effective based on the calculated BCA ratio or otherwise provides qualitative benefits that support their inclusion in CenterPoint Houston's Resiliency Plan. Further, Guidehouse's benchmark survey of peer utility resiliency planning practices indicates that CenterPoint Houston's proposed resiliency measures are generally consistent with those deployed at peer utilities.

Guidehouse offered the following recommendations to CenterPoint Houston to further enhance its Resiliency Plan.

1. For Plan implementation, conduct an asset level analysis of each measure to determine the preferred or optimal location of individual projects for each year over the three-year Resiliency Plan.

2. Further assess societal impacts by quantifying such benefits (e.g., positive economic impacts), either collectively or individually for proposed resiliency measures.
3. Apply Digital Twin technology and applications to prospectively refine the Resiliency Plan and target the highest value assets, including selection of individual projects within each proposed resiliency measure.
4. Assess the applicability of resiliency measures adopted by other utilities, as identified through the peer utility benchmarking survey results, but not included in CenterPoint Houston's Resiliency Plan. For example, wildfire avoidance measures are included in peer utility plans in areas susceptible to fire hazards. (*note: after completion of the initial Guidehouse review, CenterPoint Houston included additional wildfire mitigation measures in its Resiliency Plan*)
5. Over the long-term (i.e., beyond the three-year investment horizon of its current Plan), review alternative, non-build resiliency measures, such as local generation and storage technologies, in lieu of traditional investments. (*note: after completion of the initial Guidehouse review, CenterPoint Houston added a microgrid pilot project to its Resiliency Plan*).
6. Resiliency measure-specific recommendations include:
   a. **Digital Substation** – Examine in greater detail additional potential benefits associated with the Digital Substation resiliency measure, considering increased value associated with enhanced communications, automation, visualization, and operational consideration.
   b. **Substation Physical Security Fencing** – Consider more robust security fencing such as concrete walls for the Substation Physical Security Fencing resiliency measure in lieu of wire mesh.
   c. **Substation Flood Control** – Refine proposed Substation Flood Control elevation levels using flood inundation results.
   d. **Distribution Resiliency – Circuit Rebuilds** – Prioritize Distribution Resiliency – Circuit Rebuild upgrades using more targeted hurricane and wind studies.
   e. **Advanced Aerial Imagery Platform / Digital Twin** – Identify additional applications and benefits associated with the Advanced Aerial Imagery Platform / Digital Twin resiliency measure beyond those listed in our report.
   f. **IGSD Installation Resiliency Measure** – Analyze the benefits of transitioning to fully automated IGSD schemes for new (and potentially existing) schemes.

1.3 Analysis and Review of Technology Resiliency Measures

With regards to the technology resiliency measures included in CenterPoint Houston's Resiliency Plan, Guidehouse performed an independent analysis and review of each measure using a qualitative assessment approach. Guidehouse reviewed the five CenterPoint Houston technology resiliency measures and identified the effectiveness and benefits of each measure in a qualitative comparative analysis process that compared relevant functions and security practices in each resiliency measure with industry best practices described in the National Institute of Technology Cybersecurity Framework ("NIST CSF").

The technology resiliency measures included in CenterPoint Houston's Resiliency Plan target centralized management of assets and data, communication and control for critical electrical systems and the personnel responsible for those systems, detection and response to cybersecurity threats, information protection, data security, access control, and continuous monitoring for security. By targeting these areas, CenterPoint Houston should bolster its resilience against cybersecurity threats and meet its objective to enhance electric grid resilience in an increasingly digital landscape. Further, many of these resiliency measures are fundamental to CenterPoint Houston's ability to effectively manage and quickly recover from extreme weather events by enabling communication, control, and visibility during such events.

Guidehouse finds that CenterPoint Houston's Resiliency Plan appropriately prioritizes technology resiliency measures that help mitigate cybersecurity risk. CenterPoint Houston is deploying measures that can be classified as enabling technologies per the Institute of Electrical and Electronics Engineers ("IEEE") by aiming to optimize operations, improve reliability, and ultimately ensure uninterrupted service delivery. Further, findings from a peer utility benchmarking survey indicates that proposed technology resiliency measures included in CenterPoint Houston's Resiliency Plan are consistent with those deployed at other utilities and are: 1) appropriate for addressing the physical security and cybersecurity risks each measure faces; 2) aligned with industry best practices; and 3) beneficial to customers and communities served by CenterPoint Houston. Based on these findings, as well as Guidehouse's analysis of the correlation between CenterPoint Houston's proposed resiliency measures and the NIST CSF framework, Guidehouse finds that CenterPoint Houston's technology resiliency measures are reasonable for inclusion in CenterPoint Houston's Resiliency Plan.

Guidehouse offered the following recommendations related to CenterPoint Houston's proposed technology resiliency measures to further enhance its current and future resiliency plans:

1. **Networking, Vulnerability, and Security – Data Management –** Investigate if downstream applications support encryption for data-in-transit, as applications that do not support encryption for data-in-transit may be affected in relation to uptime, availability, and general resilience. For vulnerability, review patterns in deployment, such as applications, components, or any other system component that has repeatable settings and configurations so that CenterPoint Houston is aligned to industry general and cybersecurity best practices. For network, analyze network component and system

best practices so that CenterPoint Houston's network environment is further logically secured to ensure network zones are locked down and isolated.

2. **Data Center Refresh –** When considering any type of data migration, ensure that all on premises options such as application, workflow, and process optimizations are investigated to determine if they can be migrated, as migrating data to any new environment will affect uptime, application reliability, and support overall resilience. This is due to the eccentricities of any new environment, regardless of cloud or another on premise environment.
3. **Voice and Mobile Data Refresh – Field Devices –** Leverage multiple sources of asset (field device) information in accordance with visual checks to ensure all legacy technology is properly tracked and decommissioned. Assets with end-of-life software that are still attached to the system and unaccounted for can either affect uptime/ resilience of the overall system if there is a malfunction, as well as become an attack vector for an external threat.
4. **Backhaul Microwave Communication – Device Migration –** Develop a settings checklist, or asset configuration guide, so they can be easily replicated and installed on all new field devices, removing the opportunity for incorrect settings being applied. This could potentially impact communication and responses in a weather-driven or other event that could impact the electric distribution and transmission systems.
5. **IT/OT Cybersecurity Monitoring –** During implementation and deployment of Splunk and Nozomi, notify all users of the deployment, including detail on expectations to limit false flags while ensuring suspicious events and alerts and unexpected interactions are addressed. For the Splunk Integration, tune ingested information to minimize false alarms and unnecessary resource usage. Lastly, for the Nozomi Integration, refine vulnerability scanning so that only relevant suspicious or anomalous code is present in reports and Nozomi's finding and vulnerability dashboards.
6. **Metrics for All Technology Resiliency Measures** – Identify and establish metrics to determine risks, especially around loss, misuse, or compromise of systems and equipment. This will assist with ensuring CenterPoint Houston is aware of events and trends so that it can take appropriate actions to increase resilience.

2. Introduction and Background

Guidehouse prepared this report on behalf of CenterPoint Houston to inform the development and refinement of CenterPoint's Resiliency Plan. This report summarizes Guidehouse's independent analysis of resiliency risks CenterPoint Houston faces and independent review and analysis, including BCA, of resiliency measures and projects considered for CenterPoint Houston's Resiliency Plan. This report is organized as follows:

1. **Section 2 (Introduction and Background)** – Introduces Guidehouse's understanding of resiliency risks CenterPoint Houston must manage for its electric service area and policy context for how Texas and other state jurisdictions are addressing resiliency of the electric system as an emerging topic of interest and emphasis in the electric utility industry.
2. **Section 3 (Purpose of Guidehouse Analysis and Review)** – Provides overview of Guidehouse's qualification as an independent expert on resiliency planning for electric systems as well as the objectives and approach taken to perform Guidehouse's independent analysis and review of CenterPoint Houston's Resiliency Plan.
3. **Section 4 (Resiliency Risk Analysis)** – Presents results and findings from Guidehouse's independent assessment of resiliency risks facing CenterPoint Houston's electric service area attributed to: 1) natural disaster threats and other weather-driven events and, 2) physical and cybersecurity threats and vulnerabilities. This includes evaluation of historical weather-driven resiliency events, discussion of human threats, and forecasting of weather-driven risk based on historical data and climate trends.
4. **Section 5 (CenterPoint Houston Resiliency Plan Review)** – Presents results and findings from Guidehouse's independent review of CenterPoint Houston's Resiliency Plan, including benchmarking against best practices in resiliency planning among peer utilities. It includes an analysis of potential benefits of proposed measures included in the Plan, and conclusions provided to CenterPoint Houston based on this review.
5. **Section 6 (Summary of Findings and Recommendations)** – Summarizes the findings, conclusions, and recommendations from Guidehouse's independent analysis and review of CenterPoint Houston's Resiliency Plan.

The resiliency measures and projects considered for CenterPoint Houston's Resiliency Plan and contained in this report include the following:

System Hardening: PURA § 38.078(b)(1), 16 TAC § 25.62(c)(1)(A)

- Transmission System Hardening
- S90 Tower Replacements
- 69-138kV Conversion Projects
- Coastal Resiliency Upgrades

- Substation Transformer Fire Protection Barriers
- Distribution Pole Replacements/Bracing
- Distribution Resiliency – Circuit Rebuilds
- Strategic Undergrounding/Freeway Crossings

Grid Modernization: PURA § 38.078(b)(2), 16 TAC § 25.62(c)(1)(B)

- TripSaver®
- IGSD Installation
- Texas Medical Center Substation

Flood Control: PURA § 38.078(b)(5), 16 TAC § 25.62(c)(1)(E)

- Substation Flood Control
- Control Center Facility Upgrades

Information Technology for Operations: PURA § 38.078(b)(6), 16 TAC § 25.62(c)(1)(F)

- Advanced Distribution Technology
- Advanced Aerial Imagery Platform / Digital Twin
- Digital Substation

System Security: PURA § 38.078(b)(8), 16 TAC § 25.62(c)(1)(H)

- Substation Physical Security Fencing
- Substation Security Upgrades

Cybersecurity / Information Technology / Operational Technology: PURA § 38.078(b)(6-8), 16 TAC § 25.62(c)(1)(F-H)

- IT – Data Center Refresh
- OT – Voice and Mobile Data Radio System Refresh
- OT – Backhaul Microwave Communication
- Cyber – Cybersecurity Monitoring
- Cyber – Network Security & Vulnerability Management

Vegetation Management: PURA § 38.078(b)(9), 16 TAC § 25.62(c)(1)(I)

Wildfire Mitigation: PURA § 38.078(b)(10), 16 TAC § 25.62(c)(1)(J)

Microgrid Pilot Project

2.1 Resiliency Risk in Texas

Resiliency refers to the ability to prevent, withstand, mitigate, respond to, and quickly recover from disruptive events. When applied to the electric sector, resiliency typically refers to the ability of the electric system to achieve one or more of these objectives when a major weather-driven event (e.g., hurricanes, flooding, wildfires) impacts the area, or other potential disruption occurs (e.g., targeted attacks on a utility's critical physical infrastructure or cyber systems).[1]

Resiliency risk to electric utilities in Texas is demonstrated by the historical evidence and trends described in Section 4.2 and introduced below. The information included in this subsection of the report focuses on the unique characteristics of Texas and CenterPoint Houston's service area with regards to weather-driven resiliency events, with further analysis presented in Section 4 . Section 4 also describes physical and cybersecurity risk for Texas and CenterPoint Houston's service area.

2.1.1 Topographic and Climatological Conditions

Texas is particularly susceptible to weather-driven resiliency events due to its large size and range of topographic and climatological conditions. In fact, the National Aeronautics and Space Administration ("NASA") states that Texas is ranked first in the U.S. in variety and frequency of natural disasters.[2] The Texas Division of Emergency Management's ("TDEM") 2023 Texas State Hazard Mitigation Plan identifies 16 weather-related hazards applicable to Texas.[3] The most notable hazards that pose significant risk to operation of the electric grid are hurricanes, floods, severe coastal flooding, severe wind, severe winter weather, and extreme heat.

Figure 2-1 shows the historical impact of weather-driven hazards in Texas for the period of 2000 to 2021, amounting to over $50 billion in total recorded property and crop damage. TDEM estimates anticipated losses over the next five-year planning cycle (2022-2026) to be over $13 billion.

[1] These definitions are similar to how resiliency measures and resiliency events are defined in the Public Utility Commission of Texas' (PUCT) rule on Transmission and Distribution System Resiliency Plans. PUCT Order Adopting New 16 TAC §25.62. T&D System Resiliency Plans. Project No. 55250. (pp. 72-75). https://interchange.puc.texas.gov/Documents/55250_43_1360196.PDF

[2] National Aeronautics and Space Administration [NASA]. (2017). *Natural and Manmade Hazards in the State of Texas* [NASR Report]. https://nisar.jpl.nasa.gov/documents/7/NISAR_Applications_Hazards_Texas.pdf

[3] TDEM. (2023). *2023 Texas State Hazard Mitigation Plan* [THMAP report]. https://txdem.sharepoint.com/:b:/s/TDEMWebsiteFiles/EYpeKiYJdYtCtdoSyqlYGDQBJ_2RMO0QEOjlVSjC9c2fzA?e=wZwXcQ

Figure 2-1: Texas Historical Event Summary (2000-2021)

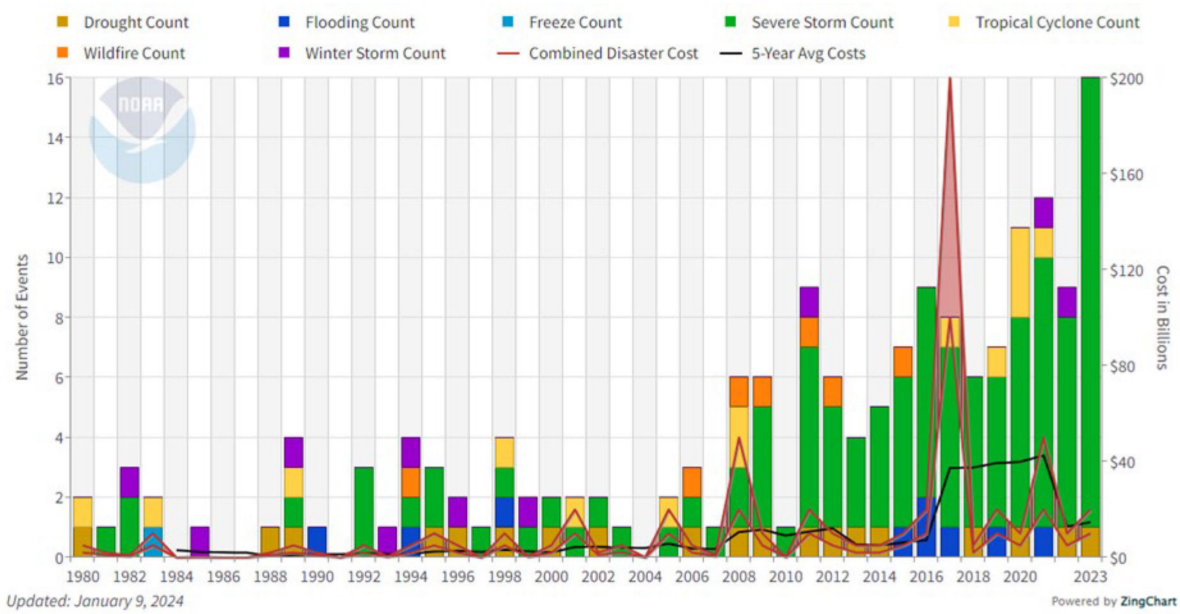
Hazard	Property & Crop Damages	Average Annual Events	Annualized Losses	Estimated Losses 2022–2026
Drought	$11,850,529,029	557	$538,660,410	$3,128,021,583
Hurricane	$11,320,920,805	1	$514,587,309	$2,988,228,166
Hailstorm	$11,262,699,441	1,294	$511,940,884	$2,972,860,275
Flood	$7,691,855,852	514	$349,629,811	$2,030,313,672
Tornado	$2,775,172,354	136	$126,144,198	$732,524,178
Severe Coastal Flooding	$2,451,511,967	9	$111,432,362	$647,091,984
Severe Wind	$1,478,222,789	962	$67,191,945	$390,186,192
Severe Winter Weather	$1,349,395,052	341	$61,336,139	$356,181,303
Wildfire	$1,090,393,150	55	$49,563,325	$287,816,122
Lightning	$85,796,186	35	$3,899,827	$22,646,444
Extreme Heat	$992,701	91	$45,123	$262,031
Total anticipated losses over the next five-year planning cycle				$13,556,131,950

Source: TDEM. (2023) [THMAP report, p.3.] Reference Materials (texas.gov)

Going back further in time and considering *frequency* of major disaster events, the National Oceanic and Atmospheric Administration National Centers for Environmental Information ("NOAA-NCEI") identifies 170 confirmed weather or climate-related events in Texas for the period 1980-2023 where losses exceeded $1 Billion per event. In total, the estimated losses for these events were nearly $400 Billion. These events included 19 droughts, 9 floods, 1 freeze, 110 severe storms, 14 tropical cyclones, 7 wildfires, and 10 winter storms. The 110 severe storm events combined with the 14 tropical cyclone events represented 73% of the total events with combined damages nearing the overall total damage cost. NCEI also noted the average annual frequency of such events has increased from 3.9 events per year over the 43-year period to a recent annual average of 11.0 events per year for the past five years.[4] This trend is evidenced in Figure 2-2 developed by NOAA-NCEI. These numbers represent significant threats to the Texas electric sector with increasing likelihoods and frequency of individual events with significant impact.

[4] NOAA-NCEI. (2024 January). *Billion-dollar weather and climate disasters: Texas Summary* [NOAA-NCEI Technical Report]. https://www.ncei.noaa.gov/access/billions/state-summary/TX#:~:text=From%201980%E2%80%932023%2C%20there%20were,and%2010%20winter%20storm%20events

Figure 2-2: Texas Billion Dollar Disaster Events 1980-2023 (CPI Adjusted)



Source: NOAA-NCEI Technical Report. (2024 January). NCEI Chart

Many of these natural hazards are expected to increase in severity over the rest of this decade. Increasingly sophisticated climate and weather models, digital elevation models, and land cover data allows Guidehouse to quantify this increase at a granular level such as on the county basis presented later in Section 4 .

2.1.2 Risks Specific to CenterPoint Energy Houston Electric Service Area

CenterPoint Houston's electric service area in Texas is particularly susceptible to heavy rain and flooding as well as severe storms, including hurricanes, tropical storms, depressions, tornadoes, other severe wind events, and winter storm events. In TDEM Region 4[5], which covers most of CenterPoint Houston's service area, many of these hazards have recorded property and crop damages for the period of 2000-2021 as shown in Figure 2-3.

[5] TDEM region map located here shows that all counties served by CenterPoint are in TDEM Region 4: TDEM. (n.d.). *Regions*. https://tdem.texas.gov/regions.

Figure 2-3: TDEM Region 4 Hazard Ranking by Total Damages (2000-2021)

Region 4 Hazard Rankings by Total Damages

Hazard	Hazard Ranking	Total Damages
Hurricane	1	$4,084,033,024
Flood	2	$1,546,670,341
Severe Coastal Flood	3	$413,978,834
Drought	4	$171,229,891
Severe Wind	5	$79,397,008
Hailstorm	6	$65,439,927
Tornado	7	$61,350,962
Severe Winter Weather	8	$45,338,067
Lightning	9	$4,612,221
Extreme Heat	10	$0
Wildfire	11	$0
Grand Total		**$6,472,050,275**

Source: TDEM. (2023). [THMAP report, p.6]. Reference Materials (texas.gov)

CenterPoint Houston's service area is diverse in terms of geography and climate risk. Common lines of demarcation used by CenterPoint Houston to address the unique risks across its system is Highway 59/69 and Highway 90, which provide a general separation between inland and coastal counties. These lines of demarcation, which run through CenterPoint Houston's service area, are a general way to think geographically about the unique weather-driven risks in different parts of CenterPoint Houston's system. As the data in Section 4.2 will show, historical as well as projected wind speed and flood levels are generally higher for coastal regions compared to inland regions. Guidehouse considered these distinctions in its analysis.

2.2 Policy Background

2.2.1 Electric System Resiliency Planning Precedent in Other Jurisdictions

Over the past several decades, increased frequency and severity of extreme weather events has led to greater attention by electric T&D utilities and their regulatory bodies on the need to build a more resilient electric system. Many electric utilities are making operational changes to improve the resiliency of their systems during and after extreme weather events, including increasing investment in resiliency-focused measures and projects. Further, the rising risk of physical security and cybersecurity threats has brought these emergent risks into the fold for electric utility resiliency planning and regulation.

Regarding electric sector resilience, the federal government has pursued a number of initiatives and executive orders, including the U.S. Department of Energy ("DOE") Partnership for Energy Sector Climate Resilience and State and Local Energy Assurance Planning initiatives as well as the Federal Energy Regulatory Commission ("FERC") and DOE joint effort to incentivize electric utility resiliency planning.[6] The DOE has produced numerous resources related to resiliency planning for the electric sector, further demonstrating the increased emphasis on this topic at the national level.[7] Further, electric sector resiliency is a primary component of the Bipartisan Infrastructure Law that passed in late 2021, with $11 billion in grants available for states, tribes, and utilities to enhance resilience of electric infrastructure against disruptive events such as extreme weather and cyber-attacks.[8] While the Electric Reliability Council of Texas ("ERCOT") power region located solely in Texas is outside of FERC's jurisdiction, these examples provide useful context on how the broader U.S. is considering the importance of resiliency planning.

State governments are also taking action on electric utility resiliency. While each state in the U.S. faces unique climate conditions and associated resiliency risk, the trend of increased attention on extreme weather events and cybersecurity is seen across many different parts of the U.S. Examples of such efforts are identified in Table 2-1. Appendix A to this report (Resiliency Planning Regulatory Jurisdiction Benchmarking) provides additional detail on electric utility resiliency planning in other jurisdictions, including the following findings:

1. Electric resiliency planning is observed in many jurisdictions, either driven by policy and regulation or through proactive requests made by investor-owned utilities with their regulator.
2. CenterPoint Houston's proposed Resiliency Plan seems similar in-scope to what is observed in other jurisdictions.
3. Magnitude threshold can have different meanings depending on utility and location
4. Metrics are commonly used to identify the need for resiliency grid investments and to measure their effectiveness.
5. Benefit-cost analysis is a commonly used measure to determine effectiveness.
6. Reporting requirements commonly accompany utility resiliency investments.

[6] MJ Bradley & Associates Issue Brief. (2020 February). *Key Considerations for Electric Sector Climate Resiliency Policy and Investments.* [MJB&A Issue Brief]. (p. 3). mjba_keyconsiderationsforclimateresiliencepolicyandinvestment.pdf (erm.com)

[7] U.S. DOE, Energy Resilience in the Public Sector. https://www.energy.gov/scep/slsc/energy-resilience-public-sector.

[8] U.S. DOE, DOE Fact Sheet: The Bipartisan Infrastructure Deal Will Deliver for American Workers, Families and User in the Clean Energy Future. https://www.energy.gov/articles/doe-fact-sheet-bipartisan-infrastructure-deal-will-deliver-american-workers-families-and-0

7. Equity and environmental justice are considerations that some utilities are beginning to account for in resiliency planning.
8. Protection against cybersecurity threats is an emerging area for utility resiliency planning.

Table 2-1: Examples of Electric Utility Resiliency Planning Across the U.S.

State/ Territory	Utility	Description	Relevant Legislation	Relevant Regulatory Dockets
California	All investor-owned utilities ("IOUs") and SCE	Various regulatory proceedings in California address resiliency including climate adaptation and vulnerability assessments (with focus on disadvantage communities), equity resilience maps[9], physical risk assessment, and mitigation plans for distribution assets, a distributed energy resources ("DER") framework that focuses on resilience value, funding for grid safety, and resilience, wildfire mitigation plans, and interconnection processes, tariffs, and partnerships to support resilience projects like microgrids.[10] More recently, the state legislature established the Strategic Reliability Reserve Fund to help improve electric grid reliability and resiliency given climate change and increase in extreme weather events.[11]	Senate Bill (SB) 699 (2014) SB 901 (2018) SB 1339 (2018)	Rulemaking on Physical Security of Electrical Corporations Pursuant to Senate Bill 699 (Docket R.15-06-009) Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning and Evaluation of Integrated DERs (Docket R. 14-10-003) Rulemaking to consider strategies and guidance for climate change adaption R.18-04-019 Application of SCE for approval of its Grid Safety and Resiliency Program (Docket A.18-09- 002) Rulemaking to Implement Electric Utility Wildfire Mitigation Plans Pursuant to Senate Bill 901 (Docket R.18-10-007) Rulemaking Regarding Microgrids Pursuant to Senate Bill 1339 and Resiliency Strategies (Docket R. 19-09- 009)
California	SDG&E	SDG&E has developed a flexible adaptation pathways framework with adjustable metrics to enable the utility to flexibly adjust the plan as new information is gathered.[12]	SB 379 (2015) SB 246 (2015)	CPUC Rulemaking 13-11-006

[9] U.S. Department of Energy Grid Modernization Laboratory Consortium. (2022 September). *Considerations for Resilience Guidelines for Clean Energy Plans For the Oregon Public Utility Commission and Oregon Electricity Stakeholders.* [Resilience Guidelines for Oregon]. (pp. 17-18, 24-25). Considerations for Resilience Guidelines for Clean Energy Plans (pnnl.gov)

[10] Pacific Northwest National Laboratories, Bosque Advisors, and Sandia National Laboratories. (2023 September). *Resilient Electric Grid: Defining Measuring, and Integrating Resilience into Electricity Sector Policy and Planning.* [PNNL report on Resilient Electric Grid]. (p. 14). Resilient Electric Grid (pnnl.gov)

[11] London Economics. (2023). (pp. 33-34). *Resilience in the electricity distribution sector and related policy questions.* [London Economics Resilience Report]. Project Documents | Distribution Sector Resilience, Responsiveness & Cost Efficiency | Engage with Us (oeb.ca)

[12] MJB&A Issue Brief. (p. 16).

639

State/ Territory	Utility	Description	Relevant Legislation	Relevant Regulatory Dockets
Connecticut	All IOUs	Regulatory proceedings in Connecticut have led to development of a framework for advancing equitable grid modernization and enhanced resilience through distribution system planning as well as targets and metrics to improve effectiveness of utility resilience programs.[13]	SB 7 (2018)	Investigation into Distribution System Planning of the Electric Distribution Companies (Docket 17-12-03) Resilience and Reliability Standards and Programs (Docket 17-12-03RE08)
Florida	All IOUs	Florida has a long history of leading in resiliency planning, beginning in 1992 when the utility regulator develop its first storm cost risk mitigation plan for IOUs.[14] In 2017, the regulator conducted a review of electric utility preparedness and restoration activities to identify opportunities to improve resilience.[15] More recently, in 2019, legislation was adopted that requires utilities to submit an electric transmission and distribution storm protection plan on an annual basis looking outward 10 years.[16]	SB 796 (2019)	Review of Florida's Electric Utility Hurricane Preparedness and Restoration Actions (Docket 2017-0215-EU)
Hawaii	All IOUs	Several regulatory proceedings in Hawaii have considered resilience including: 1) grid modernization planning with a focus on resilience value of DERs, 2) a microgrid services tariff to increase resilience and reliability, and 3) an integrated grid planning effort informed by stakeholder engagement on resilience priorities.[17]	House Bill (HB) 2110 (2018)	HECO's Grid Modernization Strategy (Docket 2017-0226) Investigation into Establishment of a Microgrid Services Tariff Pursuant to House Bill 2110 (Docket 2018-01633) Investigation into Integrated Grid Planning (Docket 2018-0165)

[13] PNNL report on Resilient Electric Grid. (p. 14).

[14] MJB&A Issue Brief. (pp. 8-10).

[15] PNNL report on Resilient Electric Grid. (p. 14).

[16] MJB&A Issue Brief. (pp. 8-10).

[17] PNNL report on Resilient Electric Grid. (p. 14).

State/ Territory	Utility	Description	Relevant Legislation	Relevant Regulatory Dockets
Illinois	Commonwealth Edison and Ameren Illinois	Several regulatory proceedings have considered resilience including a microgrid proceeding that identified resilience benefits and development of resilience metrics as part of a broader set of performance metrics. Additionally, the utility has worked collaboratively with the City of Chicago since 2018 to identify opportunities for increased energy resilience. This included the co-development of the city's first resiliency plan to include several goals related to building a more resilient energy system.[18] The Multi-Year Integrated Grid Plan (MYIGP) highlights a set of operating investments designed to meet customer expectations, achieve performance metrics, and support the objectives outlined in Section 16-105.17(d). The investments are driven by four priority areas for the Company's future electric grid vision: Safety and Reliability, Resiliency, Clean Energy Transition, and Customer Experience[19]	Section 16-108.18(e) of the Public Utilities Act (220 ILCS 5/16-105.17) Sec. 16-105.17. MYIGP	Commonwealth Edison Company Petition Concerning the Implementation of a Demonstration Distribution Microgrid (Docket 17-0331) Commonwealth Edison Company Petition for the Establishment of Performance Metrics (Docket 22-0067) Order Requiring Commonwealth Edison to file an Initial Multi-Year Integrated Grid Plan (22-0486) Order Requiring Ameren Illinois Company to file an Initial Multi-Year Integrated Grid Plan (22-0487)
Massachusetts	Eversource	At the urging of the utility regulator, Eversource has pursued a number of climate mitigation and resilience strategies including investments in advanced technologies, a vegetation management resiliency pilot, a tree resilience program, and development of a Climate Adaptation Plan.[20]	N/A	Preparation and Response of National Grid to the October 29, 2017 Wind Storm (Docket 18-02)
Michigan	DTE	Michigan Public Service Commission approved a rate increase for DTE Energy customers supporting its roadmap to improve reliability and resiliency. DTE's 2023 Distribution Grid Plan included investments aimed at improving reliability and resiliency, accelerating response to customer outages, and increasing grid capacity.[21]	N/A	Michigan Commission's motion for DTE Electric to develop and submit draft five-year investment and maintenance distribution plans (Case U-20147)

[18] MJB&A Issue Brief. (pp. 23-24).

[19] Ameren Illinois Multi-Year Integrated Grid Plan. (2023 January). (p. 9). https://www.icc.illinois.gov/docket/P2022-0487/documents/332988/files/580139.pdf

[20] MJB&A Issue Brief. (pp. 6-8).

[21] Michigan PSC Case No: U-20147. (2023 September). [DTE 2023 Distribution Grid Plan]. (p. 13). *DTE 2023 Distribution Grid Plan.* 0688y00000A4YUXAA3 (site.com)

State/ Territory	Utility	Description	Relevant Legislation	Relevant Regulatory Dockets
New Jersey	PSE&G	Regulator approved funding for hardening/modernizing electric and gas infrastructure to enhance resilience in response to Superstorm Sandy.[22]	Infrastructure Investment Program NJAC 14:3 2A (2018)	Petition of PSE&G for Approval of the Second Energy Strong New Jersey Program (Docket EO18060629) Value of DERs (Case 15-E-0751)
New York	Con Edison	Following Superstorm Sandy, regulator approved funding for storm hardening and resilience driven by a Storm Hardening and Resiliency Collaborative. DER valuation as part of the Reforming the Energy Vision initiative also considers resilience benefits.[23] More recently, the utility regulator ordered the utility to develop a Climate Change Vulnerability Study which included a Conceptual Resilience Management Framework for monitoring "signposts" that will inform the development of flexible solutions and further prioritization of assets and options to increase systemwide resilience.[24] As part of these efforts, Con Edison developed an analytical framework to evaluate resiliency investments including a risk assessment and prioritization model and cost-benefit analysis model.[25]	Subdivision 29 to Public Service Law 66 (2022)	Rates, Charges, Rules and Regulations of Con Edison for Electric Service (Case 13-E0030) Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision (Case 14-M-0101) Proceeding on Motion of the Commission Concerning Electric Utility Climate Studies and Plans (Case 22-E-0222)
Puerto Rico	Puerto Rico Electric Power Authority	Regulatory proceedings that consider resilience include: 1) utility's integrated resource plan which considers resilience through DER investments and, 2) regulation on microgrid development.[26] In 2019, the Puerto Rico Grid Modernization Plan proposed investments in the following to promote resiliency: transmission and substations, distribution, generation and infrastructure, technology, and microgrids[27]	N/A	Puerto Rico Electric Power Authority Integrated Resource Plan (Docket CEPRAP-2018-0001) Regulation om Microgrid Development (Regulation 9028)

[22] PNNL report on Resilient Electric Grid. (p. 14).

[23] PNNL report on Resilient Electric Grid. (pp. 14-15).

[24] MJB&A Issue Brief. (pp. 8-10).

[25] London Economics Resilience Report. (pp. 21-26).

[26] PNNL report on Resilient Electric Grid. (p. 15).

[27] Autoridad de Energia Electricia and Central Office for Recovery, Reconstruction and Resiliency. The Grid Modernization of Puerto Rico. (p. 9). Grid Modernization for Puerto Rico (pr.gov)

State/ Territory	Utility	Description	Relevant Legislation	Relevant Regulatory Dockets
South Carolina	All IOUs	To address lessons learned from Winter Storm Uri in 2021, regulator now requires utilities to assess extreme cold weather threats, impacts, vulnerabilities, and resilience solutions.[28]	N/A	Regarding Measures to Be Taken to Mitigate Impact of Threats to Safe and Reliable Utility Service (Docket 2021-66-A)
Various Gulf Coast States	Entergy	Utility developed a "Building a Resilient Energy Gulf Coast Plan" that includes a cost-benefit analysis framework that incentivizes forward-looking resiliency planning.[29]	N/A	N/A
Virginia	Dominion Energy	Utility developed a grid modernization plan that includes resiliency measures such as intelligent grid devices, operations and automated control systems, and grid hardening.[30]	SB 966 (2018)	Petition of Dominion Energy Virginia for Approval of a Plan for Electric Distribution Grid Transformation Projects (Case PUR2018-00100)

[28] PNNL report on Resilient Electric Grid. (p. 13).

[29] MJB&A Issue Brief. (p. 12).

[30] PNNL report on Resilient Electric Grid. (p. 15).

2.2.2 Statutory Authority in Texas for Resiliency Planning (HB 2555)

CenterPoint Houston's Resiliency Plan is responsive to state legislation passed in 2023 that recognizes the benefit to customers (i.e., reduced restoration times and costs) and the need for electric utilities to enhance the resiliency of their systems given the state's recent experience with extreme weather events such as Winter Storm Uri in 2021 as well as numerous high impact hurricanes and subsequent flooding events such as Hurricane Harvey in 2017. This legislation, referred to as House Bill ("HB") 2555, was passed by the Texas Legislature in May 2023, adding Section 38.078 to the Public Utility Regulatory Act ("PURA") titled "Transmission and Distribution System Resiliency Plan and Cost Recovery."

2.2.3 PUCT Regulatory Requirements for Resiliency Plans (Rule 25.62)

To implement the legislation, the Texas Legislature required the PUCT to adopt a rule allowing electric utilities to file a plan with the PUCT to enhance the resiliency of their T&D systems and seek cost recovery treatment. The PUCT rule establishes the requirements and procedures for an electric utility to submit a system Resiliency Plan to enhance the resiliency of its T&D system.[31] As defined in the rule, a Resiliency Plan is comprised of one or more measures designed to prevent, withstand, mitigate, or more promptly recover from the risks posed to the utility's system by resiliency events.

Proposed resiliency measures in the PUCT rule must fit into one or more of the following categories:

1. hardening electric T&D facilities;
2. modernizing electric T&D facilities;
3. undergrounding certain electric distribution lines;
4. lightning mitigation measures;
5. flood mitigation measures;
6. information technology (IT);
7. cybersecurity measures;
8. physical security measures;
9. vegetation management; or
10. wildfire mitigation and response.

Further, the plan must include the following:

- Definition of the type of resiliency events and resiliency-related risks (including magnitude threshold) that each measure included in the Plan is designed to address.

[31] PUCT Order Adopting New 16 TAC §25.62. T&D System Resiliency Plans. Project No. 55250. https://interchange.puc.texas.gov/Documents/55250_43_1360196.PDF

- Description of how T&D systems are susceptible to the defined resiliency events included in the Plan.
- Historical evidence of the utility's experience with and forecast risk of the identified events.
- Explanation of how proposed measures are distinct from similar measures already adopted and, if appropriate, explain how the related items work in conjunction with one another.
- Explanation of how the utility prioritized certain events, geographic areas, systems, or facilities for the proposed measures.
- Discussion of alternatives considered and why the selected measures were proposed over those alternatives.
- Identification of any measures that may require a transmission system outage to implement.
- Evidence of effectiveness of each proposed measure in preventing, withstanding, mitigating, or more promptly recovering from the defined resiliency events.
- Identification of benefits of the proposed resiliency measures such as reduced system restoration costs, reduction in frequency or duration of outages for customers, and any improvement in the overall service reliability for customers.
- Identification of whether any measure requires coordination with federal, state, or local government programs and funding opportunities.
- Proposed metrics or criteria for evaluating effectiveness of measures (tying evidence of effectiveness to these metrics/criteria). For an evaluation metric or criteria that is not quantitative, the Resiliency Plan must explain why quantitative evaluation is not possible.
- Presentation of a three-year "systematic approach" that the utility will use to carry out the plan.
- Cost estimates of capital deployment and implementation.
- An executive summary or comprehensive chart explaining the plan objectives, resiliency events or related risks the plan is designed to address, the proposed resiliency measures, proposed metrics, costs and benefits, and how the overall plan is in the public interest.

3. Purpose of Guidehouse Analysis and Review

3.1 Guidehouse Qualifications as Independent Expert

Guidehouse regularly consults for electric investor-owned, municipal, and cooperative utilities in addition to state and federal agencies. This includes several engagements that specifically addressed resiliency planning, such as:

- **Duke Energy Florida** – Guidehouse conducted a detailed analysis of storm hardening investment to support two successive Storm Protection Plans for approval by the Florida Public Service Commission.
- **New Jersey Board of Public Utilities** ("NJBPU") – Guidehouse was engaged by the NJBPU to conduct an independent investigation of Jersey Central Power & Light's emergency storm procedures, restoration practices, and resiliency measures to address customer interruptions caused by Superstorm Sandy.
- **AEP Kentucky Power** – Guidehouse recently assessed Kentucky Power's storm reliability performance and proposed measures to enhance distribution system resiliency. Our assessment included an electric utility benchmark survey similar to the benchmarking of resiliency measures discussed in this report.
- **Commonwealth Edison** – Guidehouse conducted an independent assessment of Commonwealth Edison's maintenance and operational practices in response to an investigation by the Illinois Commerce Commission ("ICC") to address customer interruptions during major storms.

As a matter of practice, Guidehouse is committed to maintaining an independent and unbiased approach to its engagements. Specific to our analysis and review of CenterPoint Houston's Resiliency Plan, we took the following steps to maintain independence:

- Our review includes a critical assessment of CenterPoint Houston's proposed resiliency measures to those adopted by other utilities that have successfully implemented resiliency programs. Recommendations are provided to further improve CenterPoint Houston's proposed resiliency measures;
- Quantifying benefits via a rigorous fact-based approach, using data collected from CenterPoint Houston from prior storms and applying forecast risk to determine the value each measure is expected to provide in terms of mitigating the impacts of extreme weather events on CenterPoint Houston's power delivery system;
- Conducting a forecast of weather variability and hazards using independent sources, absent direct input or advice from CenterPoint Houston on the methods applied;
- Comparing CenterPoint Houston's resiliency measures to those of leading utility practices obtained from an independent survey of electric utility resiliency programs conducted by a reputable firm with expertise in benchmarking; and

- Proposing metrics reporting and effectiveness measures that CenterPoint Houston and the Public Utility Commission of Texas (Commission) can rely on to determine if CenterPoint Houston's proposed investments are delivering value to its customers over time.

3.2 Purpose and Objectives

3.2.1 Summary of CenterPoint Houston's Objectives

CenterPoint Houston's Resiliency Plan is intended to enable the company to take necessary actions to help prevent, withstand, mitigate, and quickly recover from disruptive events, such as extreme weather, and physical and cybersecurity attacks. A robust, targeted, and well-executed Resiliency Plan has the potential to positively improve the customer experience over time by reducing frequency and length of outages, among other potential benefits. It also improves the economic vitality of the communities served by the utility by reducing economic impacts that can result from prolonged outages caused by a resiliency event. This can be demonstrated through performance measures such as quicker restoration time, improved customer communications, and reduced outage impacts on customers and communities. A primary objective of the Resiliency Plan is to enhance the capabilities and strength of the electric system so that it is resilient and continues to serve electric loads during resiliency events.

3.2.2 Summary of Guidehouse's Objectives

The purpose of Guidehouse's independent analysis and review of CenterPoint Houston's Resiliency Plan is to present evidence of the potential need and value of resiliency-focused measures and projects for CenterPoint Houston's service area. Guidehouse objectives included:

1. Advise CenterPoint Houston on best practices in electric utility resiliency planning based on Guidehouse industry expertise and experience working with utilities in other jurisdictions on resiliency planning efforts.
2. Provide independent analysis of weather-driven and human threat risks faced by CenterPoint Houston, including a forward-looking forecast of weather-driven risk considering climate trends, that could be used as evidence of the potential need for investments that address specific resiliency events.
3. Provide independent review and analysis of CenterPoint Houston's Resiliency Plan, including all resiliency measures under initial consideration by CenterPoint Houston, to help inform CenterPoint Houston's selection and prioritization of resiliency measures to pursue.

3.3 Approach

Guidehouse worked closely with CenterPoint Houston's team developing its Resiliency Plan to apply a framework for evaluating resiliency measures and projects under consideration. This included gathering and organizing data and information that would then be used to perform the

BCA of CenterPoint Houston's resiliency measures and projects to the extent feasible. In addition, including where derivation of BCA was not feasible or produced low values, Guidehouse considered qualitative factors such as industry best practice informed by a review of resiliency planning efforts in other jurisdictions and peer utility benchmarking.

Detail on the methodological approach used by Guidehouse to perform its resiliency risk analysis is provided at the beginning of Section 4. Details on the methodological approach used by Guidehouse to perform its review and analysis of CenterPoint Houston's planned resiliency measures and projects is provided in Section 5.1.

4. Resiliency Risk Analysis

4.1 Analytical Approach: Assessment of Natural Disaster Threat Risks

4.1.1 Methodology

CenterPoint Houston's service territory in Texas includes areas in the following counties: Austin, Brazoria, Chambers, Colorado, Fort Bend, Galveston, Harris, Liberty, Matagorda, Waller, and Wharton. These counties, and broadly speaking the southeast region of Texas, are at risk for several extreme weather events, including hurricanes, flooding, tornadoes, extreme heat, and extreme cold. Guidehouse used data and other information on extreme weather events found in the NOAA storm database[32] to select the following 10 events for analysis, 9 of which from the 2013-2023 period. Hurricane Ike was more than 10 years ago but was included given the significant damage it caused to the electrical grid.

1. Hurricane Ike: September 2008
2. Thunderstorm and Wind: February 2013
3. Hurricane Harvey: August 2017
4. Tornadoes and Flash Flood: January 2019
5. Tornadoes: April 2019
6. Tropical Storm Imelda: September 2019
7. Winter Storm Uri: February 2021
8. Hurricane Nicholas: September 2021
9. Tornadoes: March 2022
10. Tornadoes: January 2023

Guidehouse also used historical weather data during these events from a selection of weather stations in CenterPoint Houston's territory.[33] Weather stations were selected based on the availability of data during the selected events. Guidehouse projected flood, wind speed, and extreme temperature risks in CenterPoint Houston's territory for 2025 and 2030 using Jupiter Intelligence's ClimateScore Global Indices model, described in further detail below.

[32] National Centers for Environmental Information. (2019). *Storm Events Database | National Centers for Environmental Information.* [NCEI Database] www.ncdc.noaa.gov/stormevents/.

[33] National Oceanic Atmospheric Administration, US Department of Commerce. (n.d.). *State Propagation.* [State Propagation] www.weather.gov/nwr/states_dyn?state=TX

4.1.2 Assumptions

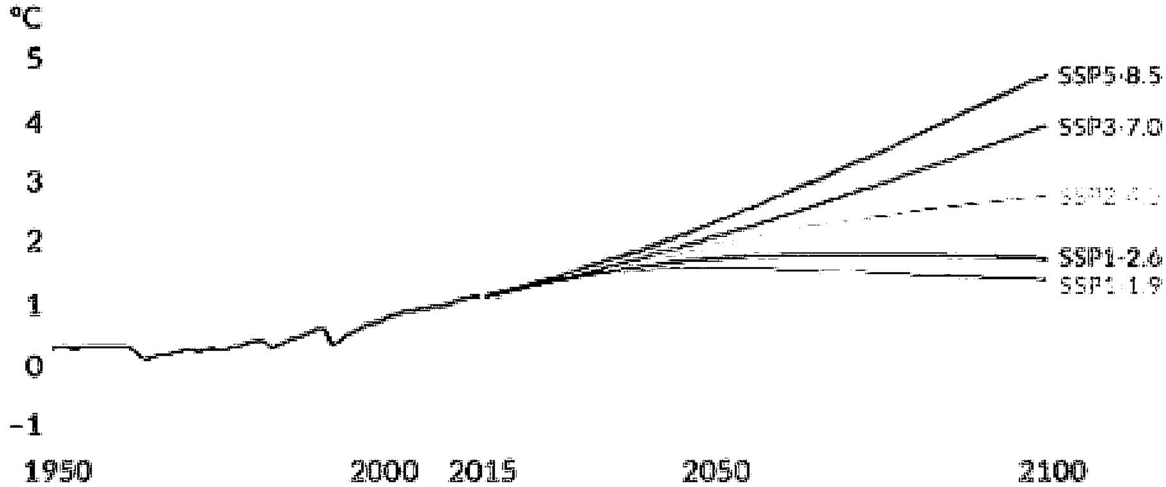
A key assumption for the historical assessment of risk presented in this report is that historical data from weather stations is representative of the conditions experienced by CenterPoint Houston's electric T&D assets in those counties. While this is broadly true for illustrating differences between larger geographies such as counties, there could be significant variations within a county that individual weather stations are not capturing. Therefore, the analysis provided in this report should be viewed as an indicator of potential risk for a broader geographic area and not an assessment of risk for specific electric T&D assets in CenterPoint Houston's service territory.

A key assumption for forecasting risk is the uncertain impact of global climate change on CenterPoint Houston's service territory. Guidehouse is using three distinct Intergovernmental Panel on Climate Change ("IPCC") scenarios[34] of the future impact of climate change as shown in Figure 4-1 and Table 4-1. The scenarios represent the impact of a certain amount of greenhouse gas emissions in a defined timeframe. They are defined in terms of social metrics or the total accumulated excess heat. Social metrics include demographics, economic growth, and the energy mix used and are summarized as shared socio-economic pathways ("SSPs").

Each SSP is closely tied to a representative concentration pathway ("RCP") that has a specific excess heat flux (Watts/square meter). A higher number for RCP represents higher accumulated heat and extent of climate change. Among the scenarios shown in Figure 4-1 RCP 8.5 presents the greatest amount of change to natural hazards and RCP 2.6 presents the smallest amount of change. However, given the relatively near-term 10-year timeframe of our analysis, the differences between the scenarios are not as large as they would be under a 20-year or 30-year timeframe.

[34] IPCC. (2003). *AR6 Synthesis Report: Climate Change 2023.* [IPCC Report]. www.ipcc.ch/report/ar6/syr/

Figure 4-1: Global Surface Temperature Change Increase Relative to the Period 1850-1900 by IPCC Scenarios



Source: IPCC. (2021). *Summary for Policymakers.* (p.22). Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

Table 4-1: Description of the Three IPCC Scenarios Used

IPCC CMIP6 Scenario	2100 Temperature Rise (°C)	Emissions Trend	Description
SSP1-2.6 (RCP 2.6)	1.8	Strong decline	Significant reduction in fossil fuels
SSP2-4.5 (RCP 4.5)	2.7	Slow decline	Middle of the Road
SSP5-8.5 (RCP 8.5)	4.4	Rising	Fossil fuel led Development

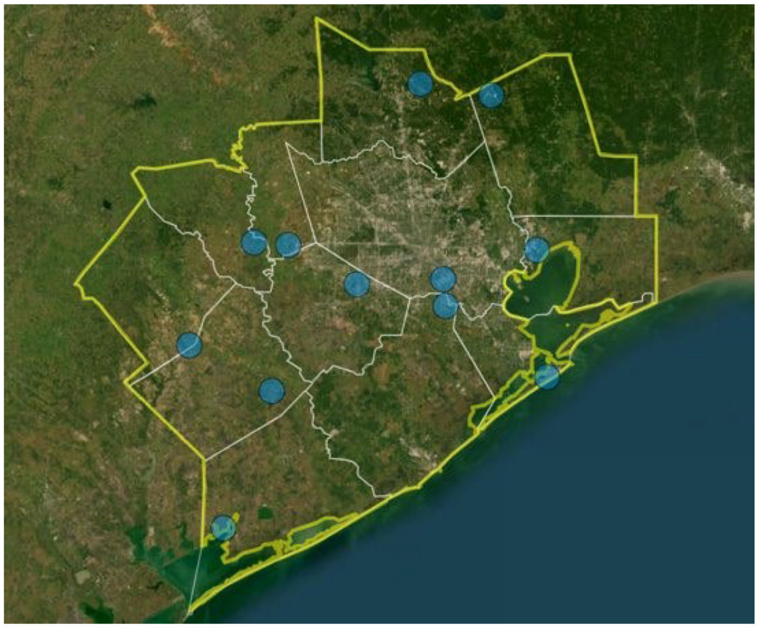
Source: IPCC. (2023). Sixth Assessment Report — IPCC.

Even with the limits imposed by these assumptions, the historical and projected future data presented later in this section of the report provide evidence of the significant risks posed by these natural hazards and the expected increase in their intensity over time. Natural hazards such as flood depths and wind speeds were projected for several return periods which are events of varying probabilities and intensity. For example, a 10-year return period would indicate a 10% probability, and a 100-year return period would indicate a 1% probability.

4.1.3 Overview of Data and Modeling Tools Used

For historical event data, Guidehouse used data reported by 12 weather stations in CenterPoint Houston's territory identified as blue dots in Figure 4-2. Data was isolated to a period of two days before and after the selected events. Core Weather, a Guidehouse proprietary aggregation tool, was used for this purpose.

Figure 4-2: Weather Stations in CenterPoint Houston's Territory



Source: Guidehouse analysis, with inputs from Core Weather.

In addition to the weather station data, storm reports from NOAA were used for Hurricane Ike[35], Hurricane Harvey[36], Tropical Storm Imelda[37], and Hurricane Nicholas[38]. These storm reports provide key data on flood inundation and precipitation for southeast Texas and surrounding regions during these historical events.

For future projections, Guidehouse used Jupiter Intelligence's ClimateScore Global Indices model. This model uses 100 equidistant points for each county to calculate county averages of metrics for wind, flood, and extreme temperatures. ClimateScore combines the output of downscaled general circulation models ("GCMs") with a digital elevation model ("DEM") and land cover data.

A review of the historical extreme weather events in CenterPoint Houston's service area considered for this analysis indicates that CenterPoint Houston's T&D assets are subject to:

1) Wind damage driven by hurricanes, tornadoes, and microbursts;
2) Flood damage driven by coastal storm surges during a hurricane and flash floods during extreme precipitation events;

[35] National Oceanic and Atmospheric Administration. (2009 January). *Tropical Cyclone Report Hurricane Ike.* [Hurricane Ike Report]. Tropical Cyclone Report (noaa.gov)

[36] National Oceanic and Atmospheric Administration. (2018 May). *NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT HURRICANE HARVEY*. [Hurricane Harvey Report]. Hurricane Harvey (noaa.gov)

[37] National Oceanic and Atmospheric Administration. (2020 February). *NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT TROPICAL STORM IMELDA.* [Tropical Storm Imelda Report]. Tropical Storm Imelda (noaa.gov)

[38] National Oceanic and Atmospheric Administration. (2021 September). *NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT HURRICANE NICHOLAS*. [Hurricane Nicholas Report]. Hurricane Nicholas (noaa.gov)

3) Extreme cold during winter storms; and
4) Chronic and rising high temperature events.

Several critical CenterPoint Houston assets such as T&D poles, transformers, switches, and breakers are at acute as well as chronic risks from such events as discussed in the context of specific CenterPoint Houston resiliency measures included in its Resiliency Plan in Section 5 .

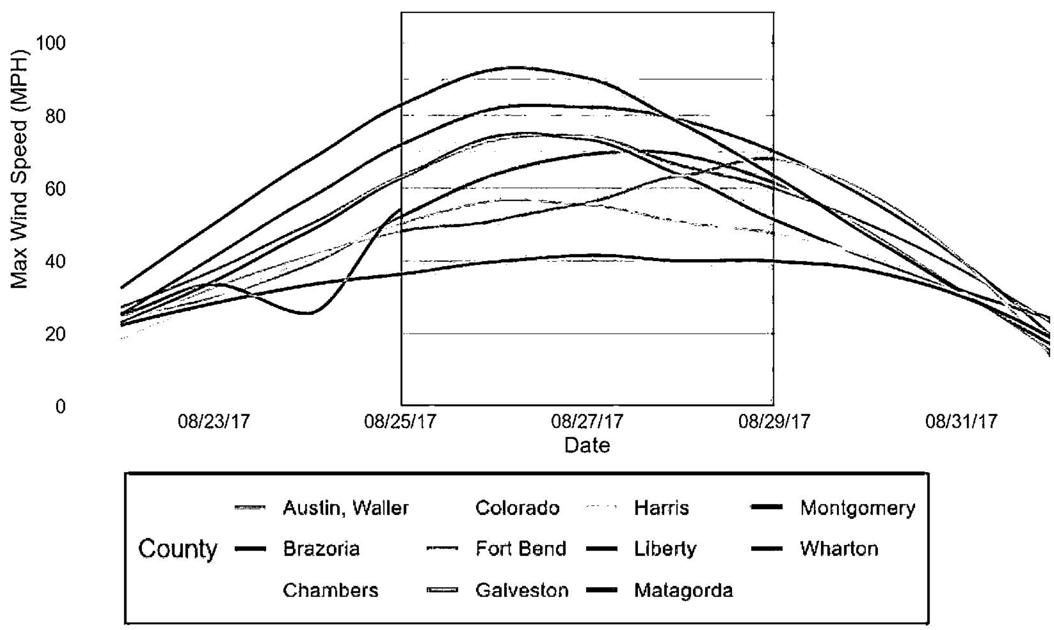
4.2 Assessment of Natural Disaster Threats

4.2.1 Hurricane Risk Profile

4.2.1.1 Historical Hazard Assessment

During Hurricane Harvey, a Category 4 hurricane, maximum hourly wind speeds exceeding 90 mph were observed for Matagorda County and exceeding 80 mph for Galveston County (see Figure 4-3).

Figure 4-3: Wind Speeds During Hurricane Harvey



Gray shaded area highlights peak wind period during the event.
Source: Guidehouse analysis, with inputs from NOAA Weather Stations and NCEI.

As shown in Figure 4-4, 7 counties, some as far inland as Austin and Waller counties, classify Hurricane Harvey wind speeds in their top 5% of extended windiest periods. NOAA estimated total damage from Hurricane Harvey at $125 billion. Texas Department of Insurance estimated a total of 391,000 residential and commercial claims related to Hurricane Harvey across all of Texas.[39]

[39] Texas Department of Insurance. (2018 September). *Hurricane Harvey Data Call.* harvey-dc-04252019.pdf (texas.gov)

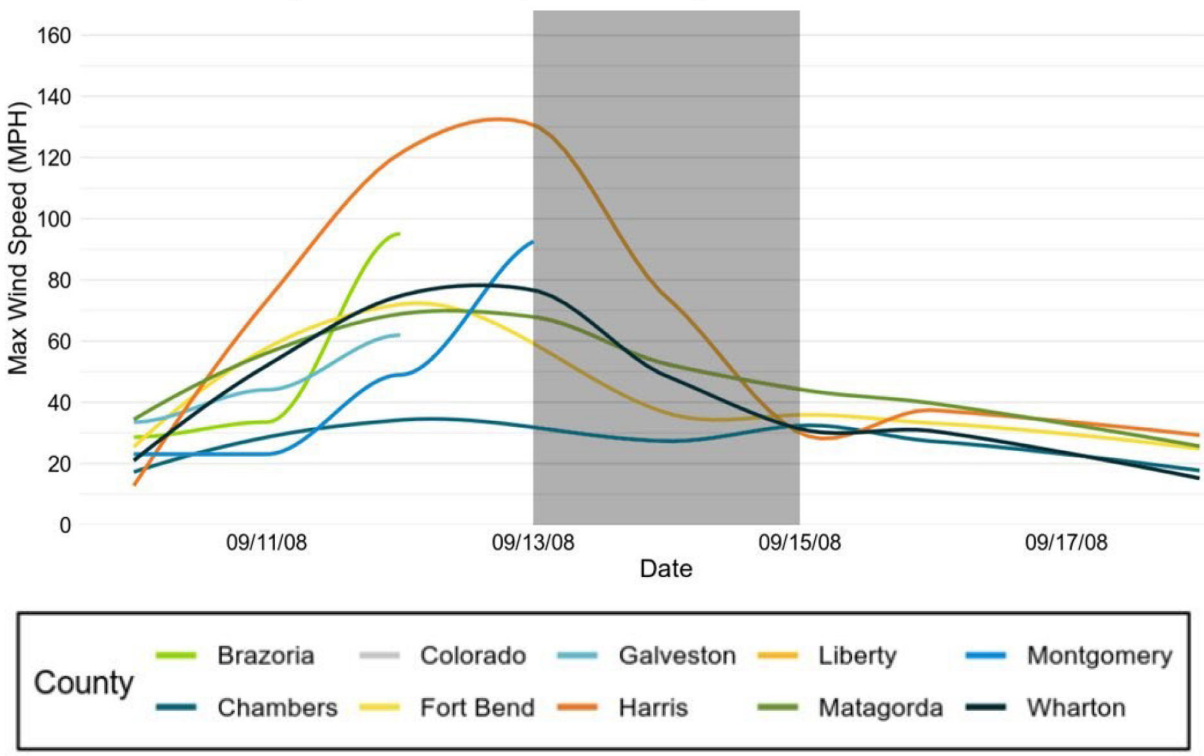
Figure 4-4: Top 5% of Storms by Counties

County	Exceedance Model			
	Exceedance #	Duration	Intensity Average	Intensity Max
Austin & Waller	2	4	66.4	74.5
Brazoria	4	5	67.0	92.6
Chambers	2	3	56.7	69.6
Galveston	1	3	82.4	90.1
Harris	2	3	66.9	74.5
Matagorda	2	5	85.0	110.5

Source: Guidehouse analysis, with inputs from NOAA Weather Stations and NCEI.

Hurricane Ike, another powerful and destructive Category 4 hurricane, measured 900 miles wide, engulfing Galveston and other coastal areas with widespread damage and destruction estimated at $29.5 billion.[40] During Hurricane Ike, Harris coastal weather station captured wind measurements exceeding 130 mph (see Figure 4-5). However, the highest wind speed experienced during Hurricane Ike may be understated because Ike's center made landfall near Galveston, but the coastal counties of Brazoria and Galveston lack data as their respective weather stations were shut off due to the extreme storm conditions.

Figure 4-5: Wind Speeds During Hurricane Ike

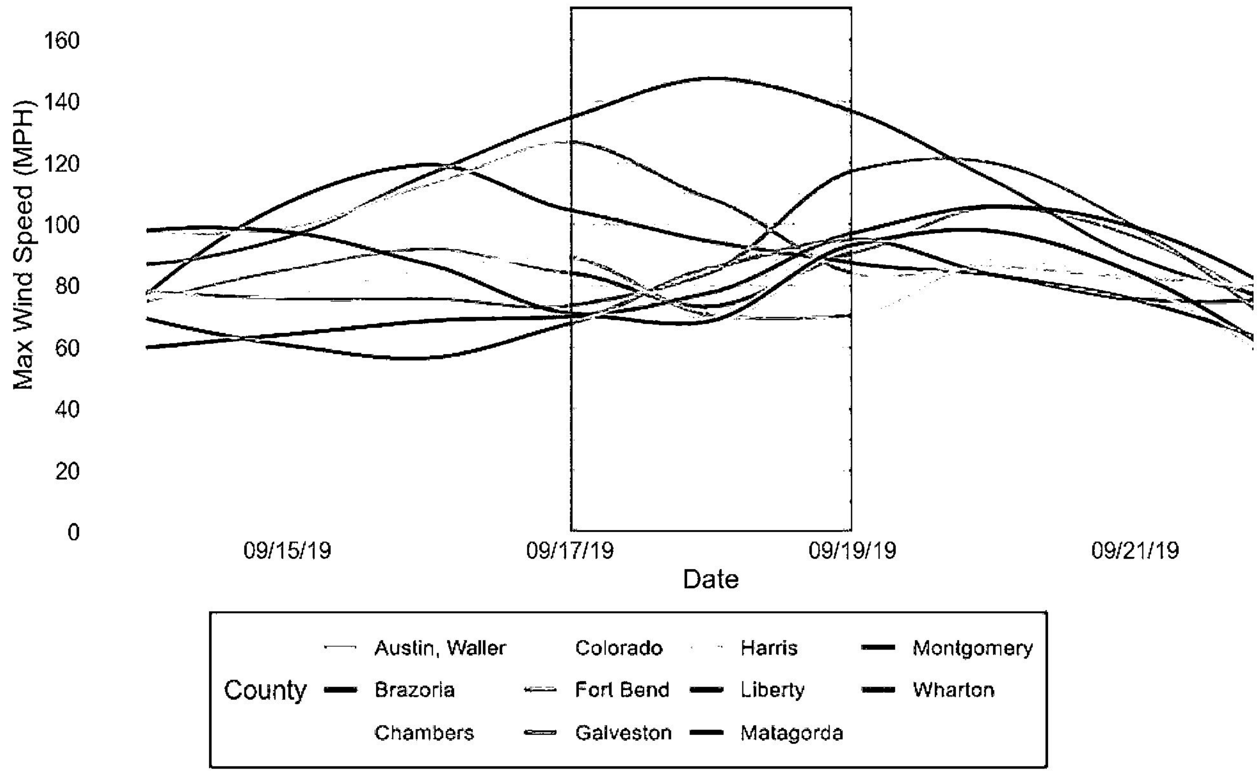


[40] Texas Digital Library. (2011). *Hurricane Ike Impact Report*. [Hurricane Ike Impact Report]. Microsoft Word - Hurricane Ike Impact Report (tdl.org) Texas A&M University Report

Gray shaded area highlights peak wind period during the event.
Source: Guidehouse analysis, with inputs from NOAA Weather Stations and NCEI.

Tropical storm Imelda was a relatively short-lived event that moved inland over Texas just after it developed. The storm and its remnants meandered inland for a couple of days after landfall and produced historic rainfall totals and devastating flooding over portions of southeastern Texas. NOAA estimated total damage at $5 billion.[41] Even in this relatively short-lived storm, maximum wind speeds measured in Harris County exceeded 150 mph (see Figure 4-6).

Figure 4-6: Wind Speeds During Hurricane Imelda



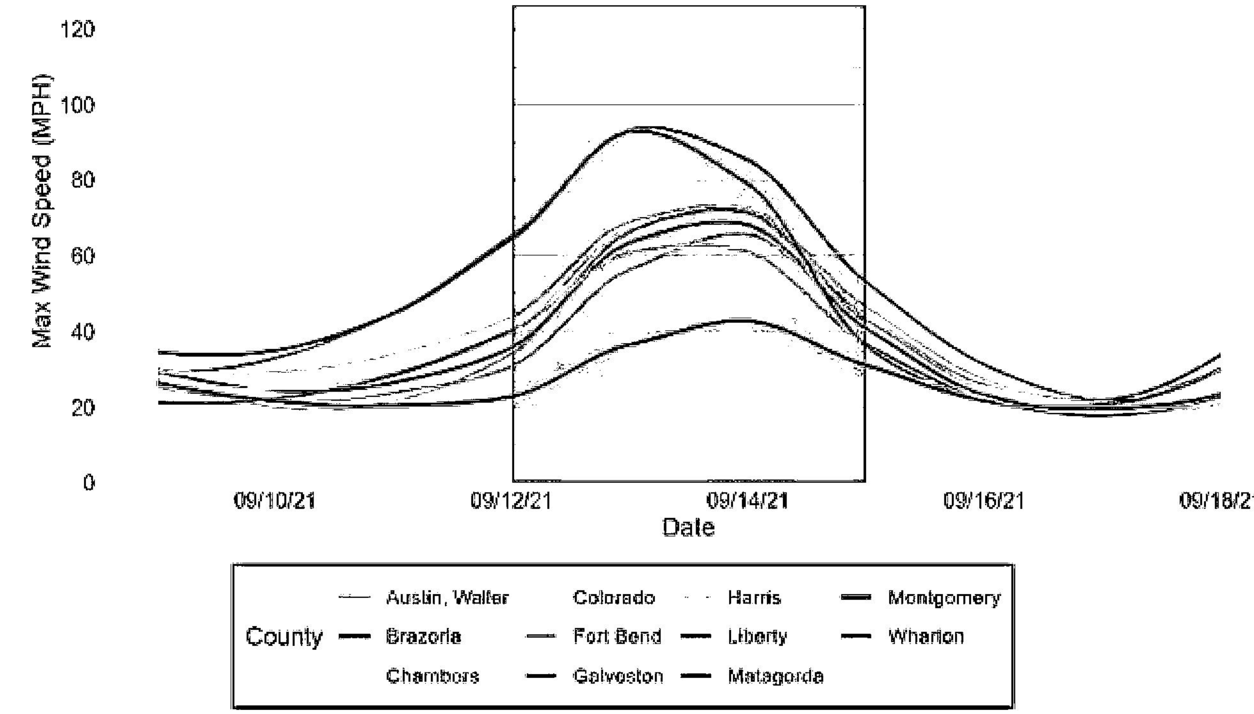
Gray shaded area highlights peak wind period during the event.
Source: Guidehouse analysis, with inputs from NOAA Weather Stations and NCEI.

Hurricane Nicholas made landfall in Matagorda County as a Category 1 hurricane in September 2021. Wind Results for Hurricane Nicolas show that coastal stations Matagorda and Galveston experienced wind speeds over 95 mph, the highest observed. All counties in CenterPoint Houston's service area experienced high wind speeds during this event (see Figure 4-7). This hurricane resulted in power losses for about half a million people.[42]

[41] Tropical Storm Imelda Report. (p.6).

[42] Fort Bend Star (2021 September) *Hurricane Nicholas Leaves Widespread Power Outages in Wake.* [Hurricane Nicholas in Fort Bend]. Hurricane Nicholas leaves widespread power outages in wake | County News | fortbendstar.com

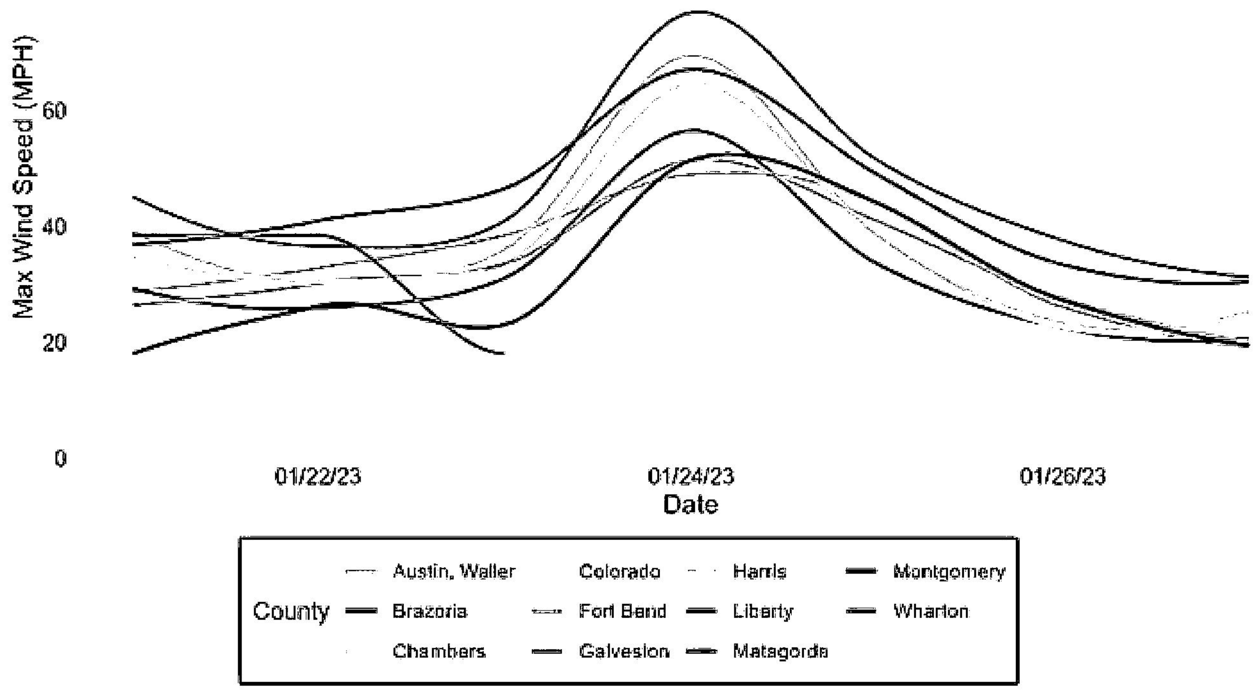
Figure 4-7: Wind Speeds During Hurricane Nicholas



Gray shaded area highlights peak wind period during the event.
Source: Guidehouse analysis, with inputs from NOAA Weather Stations and NCEI.

The 3 tornado events analyzed occurred in January 2022, March 2022, and January 2023. The maximum wind speed observed during the tornado events was lower than for hurricanes. The most severe of these 3 events occurred in January 2022 when the coastal counties of Galveston and Matagorda experienced 60-75 mph wind (Figure 4-8).

Figure 4-8: Wind Speeds During January 2022 Tornadoes



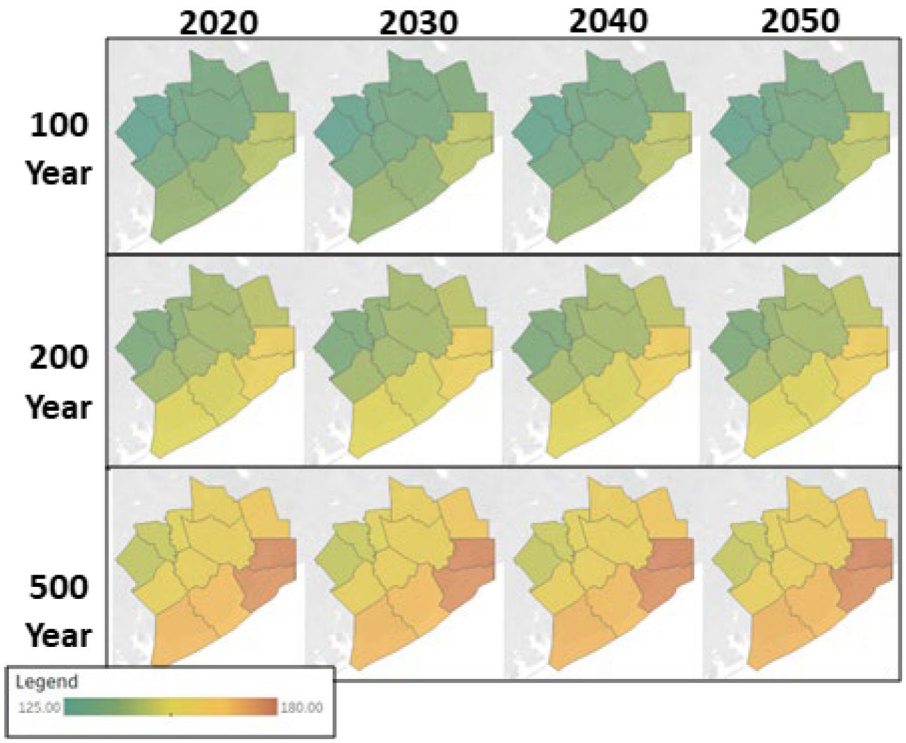
No event window (gray band) as the event occurred on the single day of January 24th.
Source: Guidehouse analysis, with inputs from NOAA Weather Stations and NCEI.

4.2.1.2 Future Forecast Risk Profile

Guidehouse's forecast of high winds focused on hurricanes given that historical evidence indicates higher wind speeds experienced during those events relative to tornadoes. While the science for forecasting future hurricane events remains uncertain with respect to frequency of events, it is possible to forecast intensity of wind events.[43] Our analysis using the RCP4.5 scenario shows maximum wind speeds increasing from 2020 to 2050 for nearly all the counties served by CenterPoint Houston for 100-year, 200-year, and 500-year events (see Figure 4-9). By 2030, almost all counties begin experiencing maximum wind speeds exceeding 87 mph for a 500-year event with coastal counties experiencing wind speeds exceeding 99 mph. By 2050, nearly all counties in CenterPoint Houston's territory will experience wind speeds exceeding 93 mph with coastal counties approaching 112 mph for a 500-year event.

[43] Emanul, K., (2017 March 1). *Will Global Warming Make Hurricane Forecasting More Difficult?* Bulletin of American Meteorological Society. https://doi.org/10.1175/BAMS-D-16-0134.1

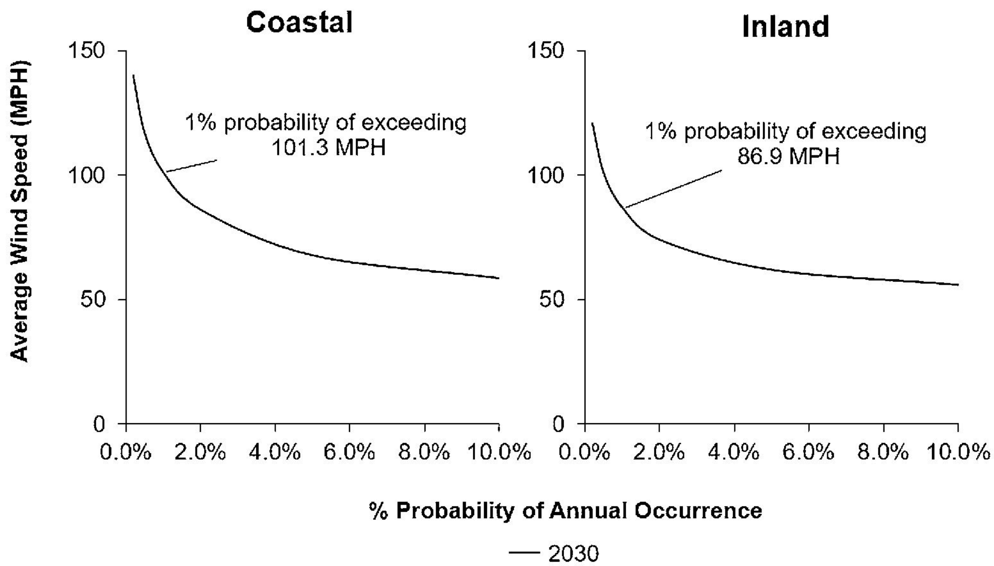
Figure 4-9: Maximum Annual Wind Speeds ("KPH") 2020-2050



Color changes may be too subtle to notice visually. Refer to absolute numbers in the descriptive text.
Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

Guidehouse used the projected wind speed for return periods between 10-year and 500-year events to calculate probabilities of exceeding different wind speeds as shown in Figure 4-10. Wind thresholds of 70 mph are considered critical for existing non-hardened poles based on our previous experience and have a probability of exceedance of 4.5% in coastal counties and 2.7% in inland counties by 2030 under the RCP 4.5 climate scenario. If we use the RCP 8.5 scenario for 2030, these probabilities of exceedance are about the same- at 4.3% for coastal counties and 2.6% for inland counties. Given that this is a 2030 timeframe, this lack of difference is not surprising. Climate scenarios start differing from each other only in a 20-30 year timeframe.

Figure 4-10: Probability of Annual Occurrence- Wind Speeds in 2030



Coastal Counties: Brazoria County, Chambers County, Galveston County, Harris County, Liberty County, Matagorda County

Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

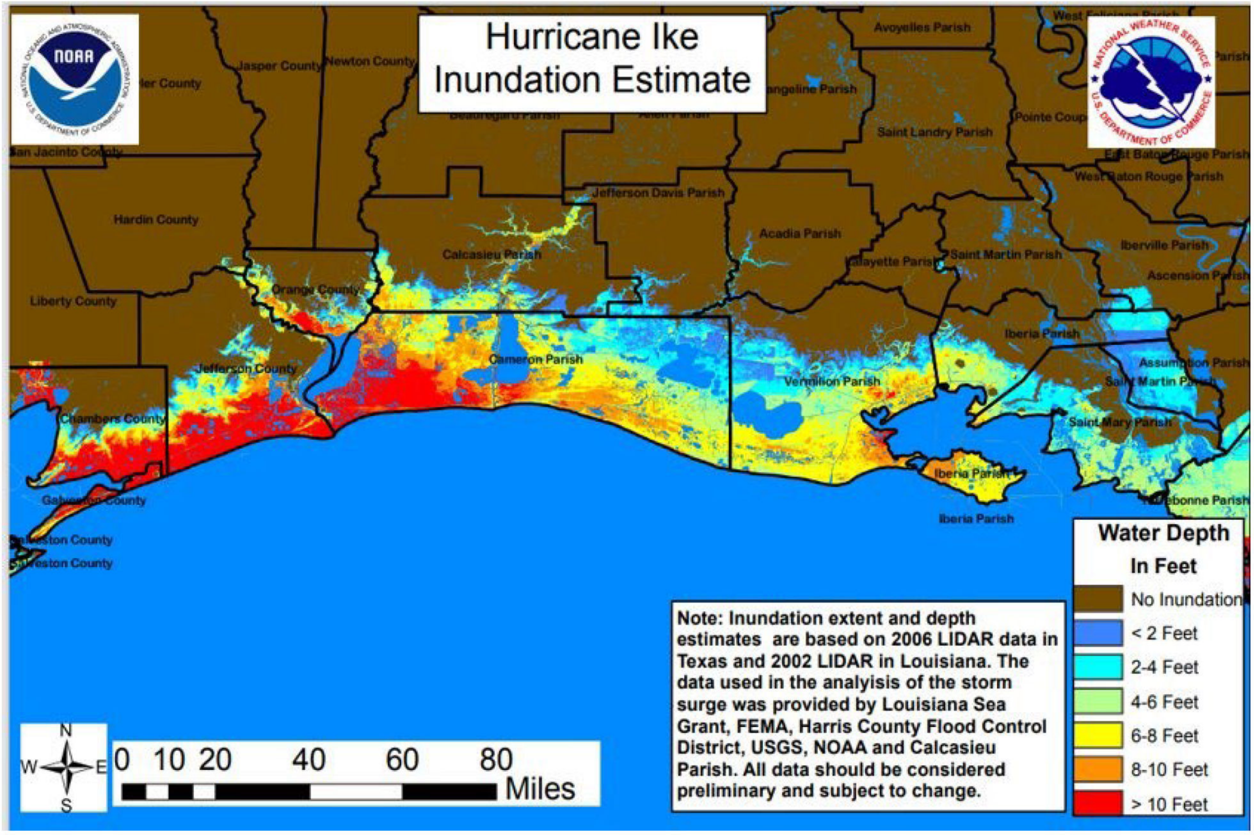
4.2.2 Flooding Risk Profile

CenterPoint Houston's service area is subject to several different types of flood risks, including extreme precipitation-driven flash floods and riverine floods, and coastal storm surge-driven floods. The frequency and intensity of flood events in CenterPoint Houston's service area has been rising similar to other parts of the U.S. For example, parts of the Houston metro region have experienced three 500-year floods in just the last 20 years.

4.2.2.1 Historical Evidence

Of the 10 historic events analyzed, Hurricanes Ike, Harvey, Imelda, and Nicholas resulted in significant flooding. During Hurricane Ike, Galveston, Chambers, and Jefferson counties were exposed to the highest level of coastal flooding, resulting in a significant number of electric T&D assets being at risk of exposure to inundation of over 10 feet of water (see Figure 4-11).

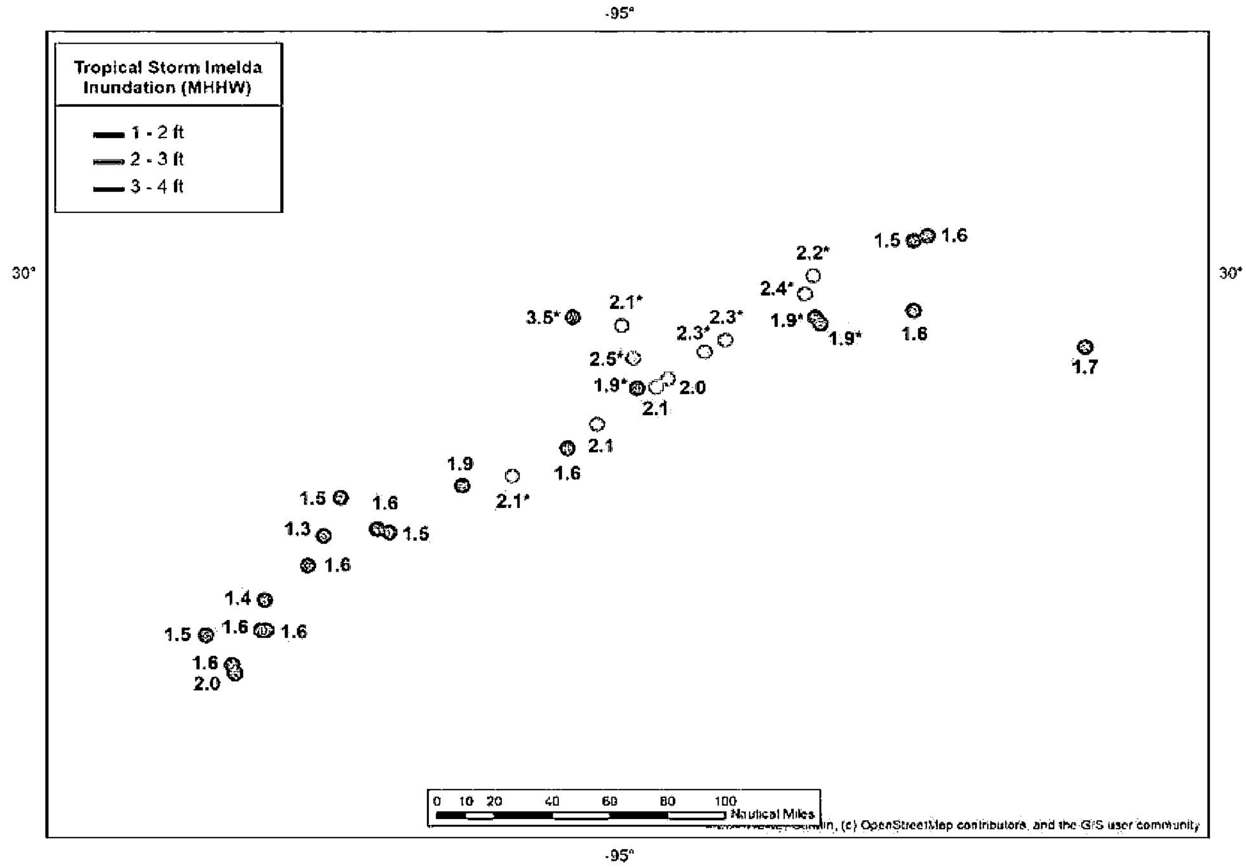
Figure 4-11: Hurricane Ike Inundation Estimates from NOAA



Source: NOAA. (2008). Hurricane Ike Inundation Estimate.

During Hurricane Imelda, high levels of rainfall and minor storm surges resulted in floods along the coastal and inland counties of southeastern Texas. Within CenterPoint Houston's service area, Matagorda County experienced the highest levels of rainfall (44.29 inches); however, Jefferson County experienced the greatest amount of flood damage at around 3 to 4 feet of inundation (see Figure 4-12).

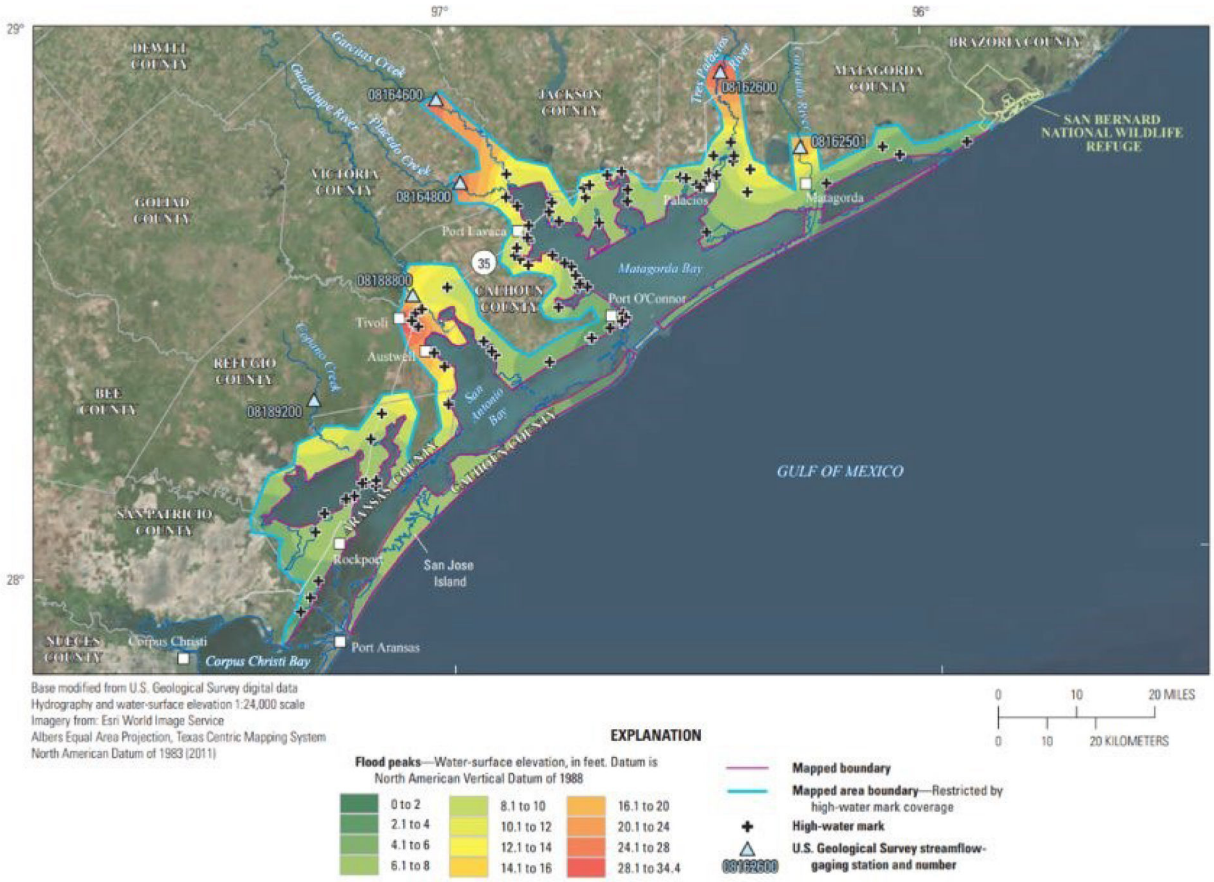
Figure 4-12: Hurricane Imelda Inundation Estimates from NOAA



Source: NOAA. (2020 February 7). *National Hurricane Center Tropical Cyclone Report.* (p.25). Tropical Storm Imelda - National Hurricane Center.

During Hurricane Harvey, high levels of rainfall and coastal storm surges caused floods along the coastal and inland counties of southeastern Texas, resulting in inundations of 6 to 30 feet (see Figure 4-13). Within CenterPoint Houston's service area, 17 substations flooded, causing 8 substation outages that collectively resulted in loss of service for 1,081,288 customers.

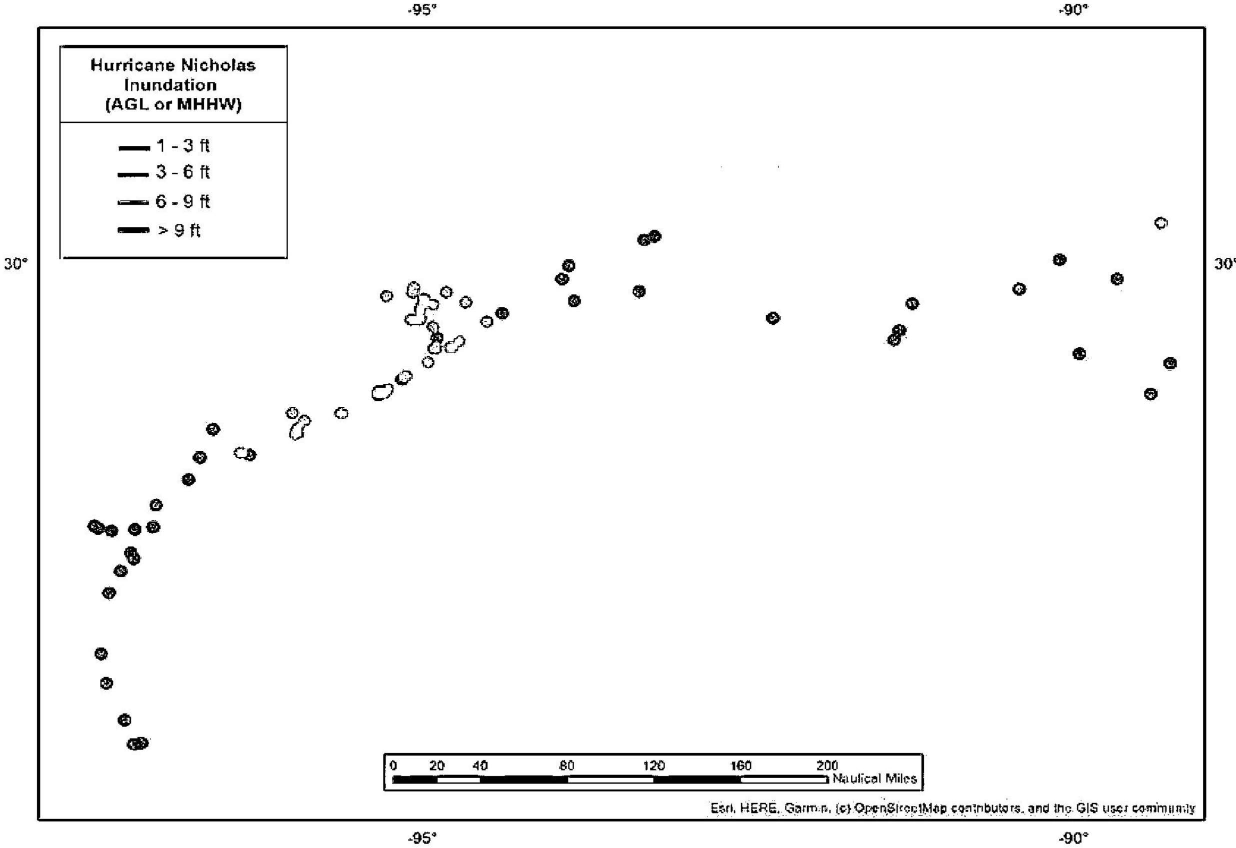
Figure 4-13: Hurricane Harvey Inundation Estimates from USGS



Source: USGS. (2018). *Characterization of Peak Streamflows and Flood Inundation of Selected Areas in Southeastern Texas and Southwestern Louisiana from the August and September 2017 Flood Resulting from Hurricane Harvey.* (p.41). Scientific Investigations Report 2018–5070.

During Hurricane Nicholas, high tides in combination with storm surges resulted in flood levels of up to 9 feet. The counties of Brazoria, Galveston, and Harris were hit hardest by the floods (see Figure 4-14).

Figure 4-14: Hurricane Nicholas Inundation Estimates from NOAA



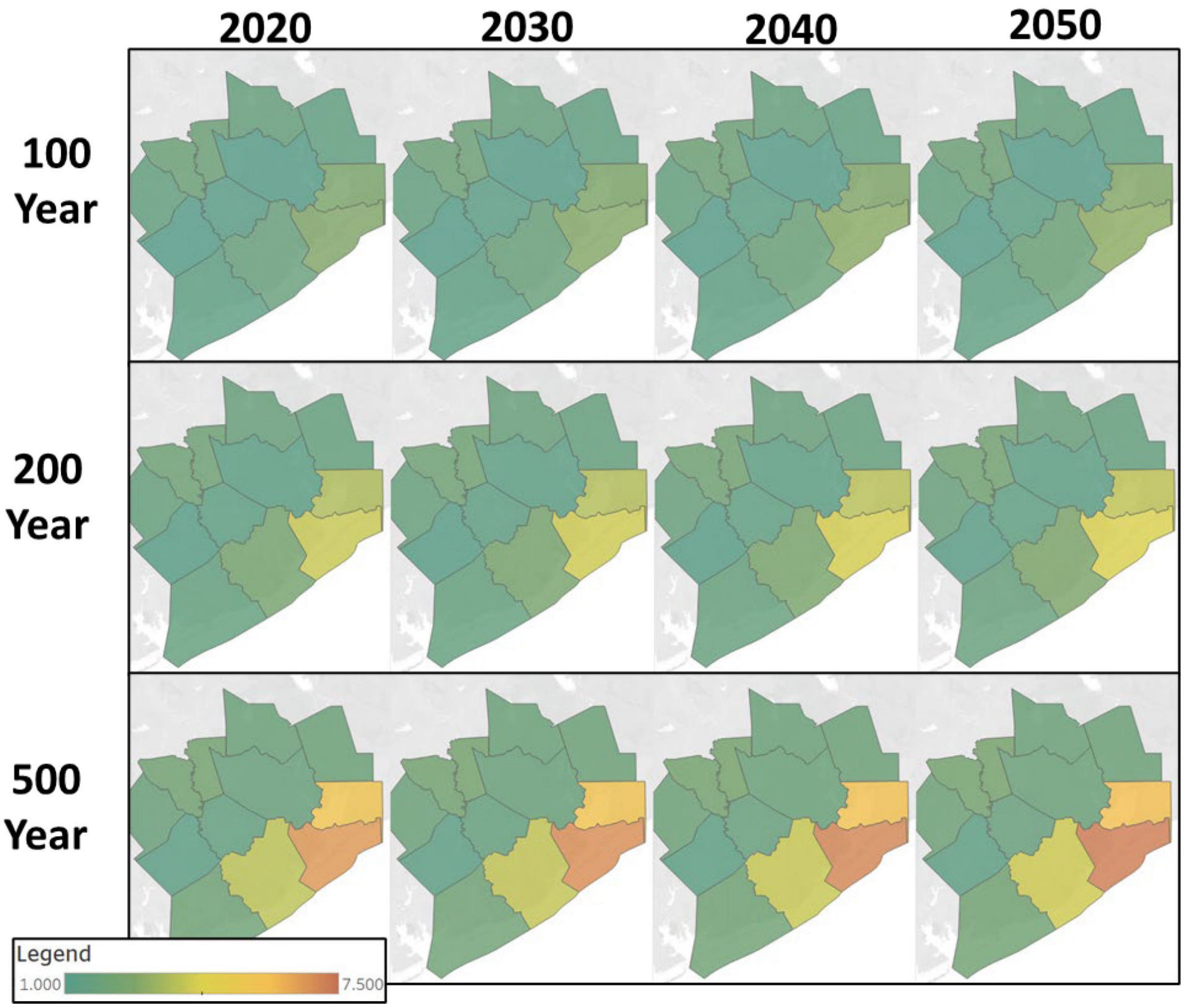
Source: NOAA. (2022 March 28). *NATIONAL HURRICANE CENTER TROPICAL CYCLONE REPORT.* (p.44). Hurricane Nicholas.

4.2.2.2 Future Forecast Risk Profile

Flood risk varies significantly by location and elevation.[44] County averages and locational (i.e., resolution under 3280.84 ft) projections reveal different, but complementary information. Our analysis shows that the mean flood depths as well as flooded fractions (i.e., percentage of buildings flooded) at the county level are projected to increase from 2020 to 2050 for nearly all the counties for 100-year, 200-year, and 500-year events (see Figure 4-15 and Figure 4-16). Galveston and Matagorda counties are projected to experience the highest average flood depth due to their proximity to the coast and lower elevation. Nearly all buildings in Galveston counties are projected to flood if a 200-year or 500-year flood were to occur in 2030. Over 30% of buildings are expected to flood in Harris and Fort Bend counties should a 200-year or 500-year flood event occur in 2030.

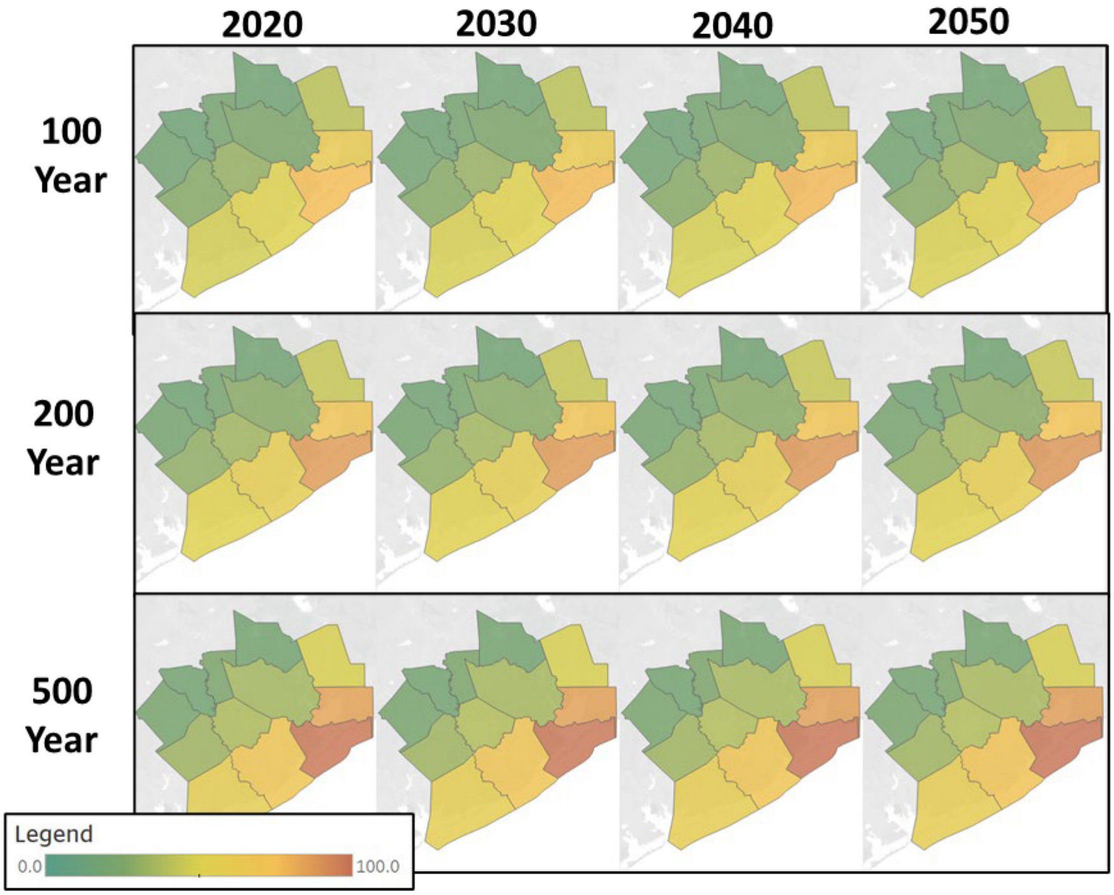
[44] Water Resources Research (2020 September). *Implications of Using Global Digital Elevation Models for Flood Risk Analysis in Cities* [DEM Flood Risk Analysis]. https://doi.org/10.1029/2020WR028241

Figure 4-15: Forecast Flood Depth 2020-2050 (meters)



Color changes may be too subtle to notice visually. Refer to absolute numbers in the descriptive text.
Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

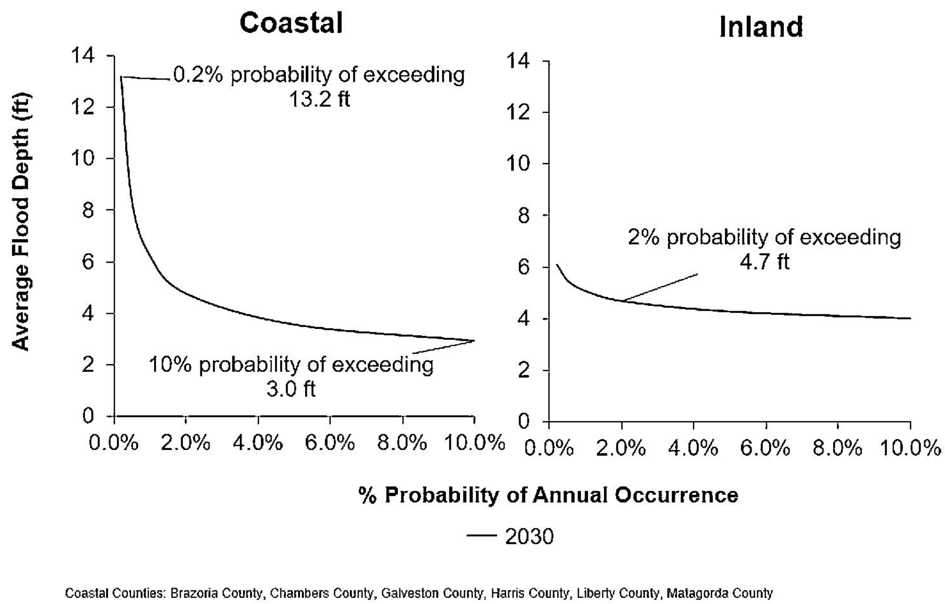
Figure 4-16: Forecast Flooded Fraction 2020-2050



Color changes may be too subtle to notice visually. Refer to absolute numbers in the descriptive text.
Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

Guidehouse used the projected flood depths for return periods between 10-year and 500-year events to calculate probabilities of exceeding different flood depths as shown in Figure 4-17. Flood depths of 4 feet are deemed critical for failure of substation components such as switches and breakers and have a probability of exceedance of 3.6% in coastal counties and 1.2% in inland counties by 2030 using the RCP4.5 scenario. If we use the RCP 8.5 scenario for 2030, these probabilities of exceedance are 3.8% for coastal counties and 11.2% for inland counties. Given that this is a 2030 timeframe, this relative lack of difference especially for coastal counties is not surprising. Climate scenarios start differing from each other only in a 20–30-year timeframe.

Figure 4-17: Probability of Annual Occurrence: Flood Depths in 2030



Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

4.2.3 Extreme Temperature Risk Profile

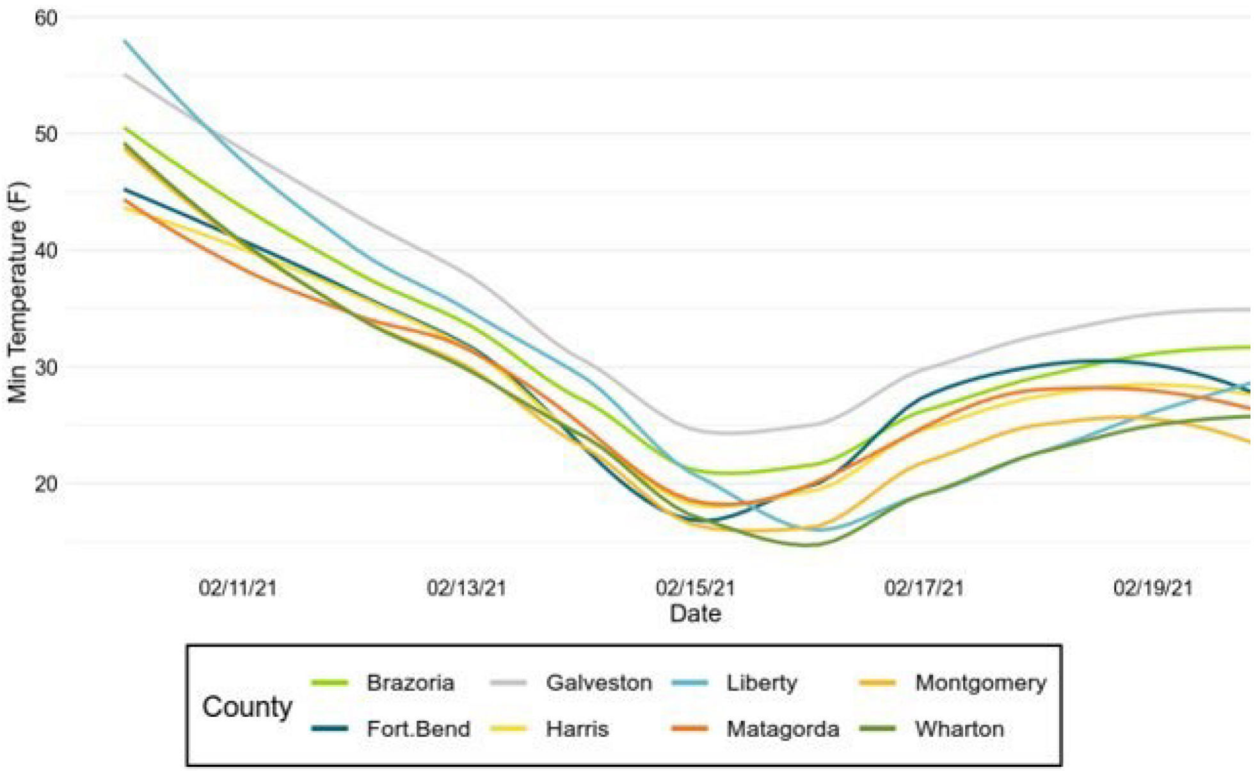
Extreme temperatures can have a significantly negative impact on utility operations. For example, extreme heat will affect transformer performance and can result in significant increase in demand, while extreme cold can also result in significant increase in demand.

4.2.3.1 Historical Evidence and Current Risk Profile

Among the 10 historical weather events analyzed, Winter Storm Uri resulted in the lowest temperatures and days below freezing. NOAA climatological data derived from weather stations shows that temperatures for most counties where the minimum temperature stayed below freezing for multiple days (see Figure 4-18). Meanwhile, the maximum temperature for most counties did not exceed 40°F during the worst of the storm (see Figure 4-19). However, Chambers, Austin, Waller, and Colorado counties did not report weather station data for this event likely due to the storm's disruptions on their operations. The Federal Reserve Bank of Dallas estimated the state's storm-related financial losses associated with Winter Storm Uri to range from $80 billion to $130 billion.[45]

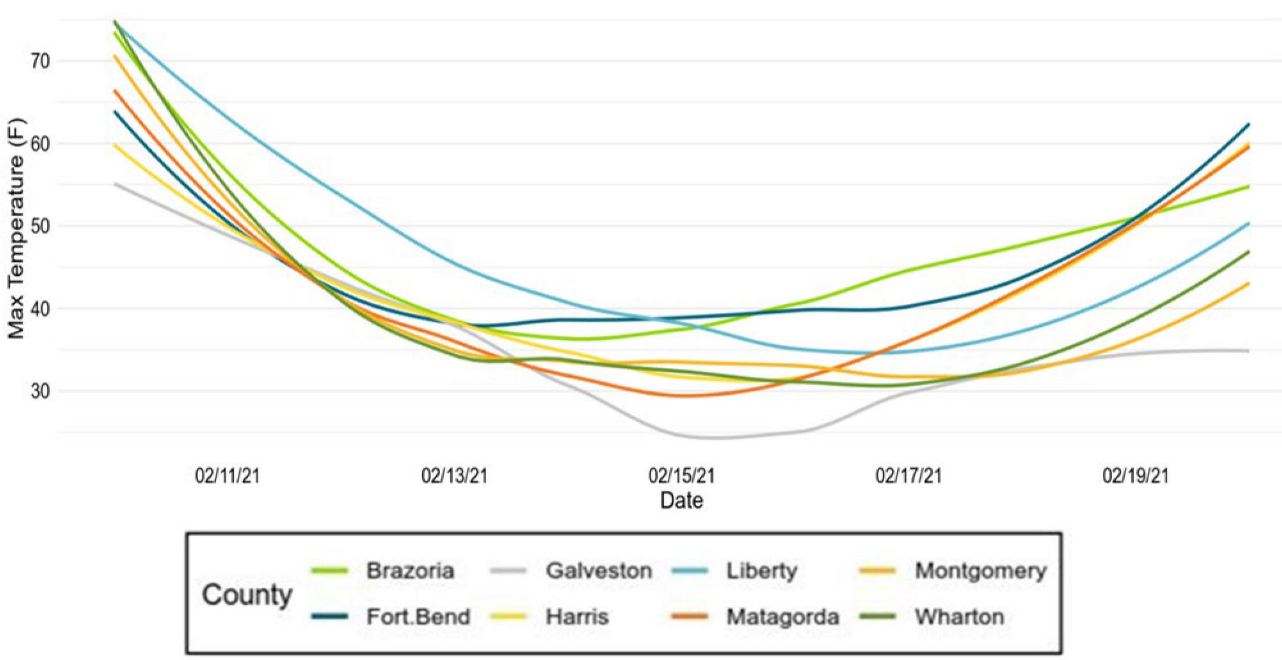
[45] Federal Reserve Bank of Dallas (2021 April). *Cost of Texas' 2021 Deep Freeze Justifies Weatherization.* [Deep Freeze Analysis]. Cost of Texas' 2021 deep freeze justifies weatherization - Dallasfed.org

Figure 4-18: Minimum Temperatures During Winter Storm Uri



Source: Guidehouse analysis, with inputs from National Weather Service NOW Database.

Figure 4-19: Maximum Temperatures During Winter Storm Uri

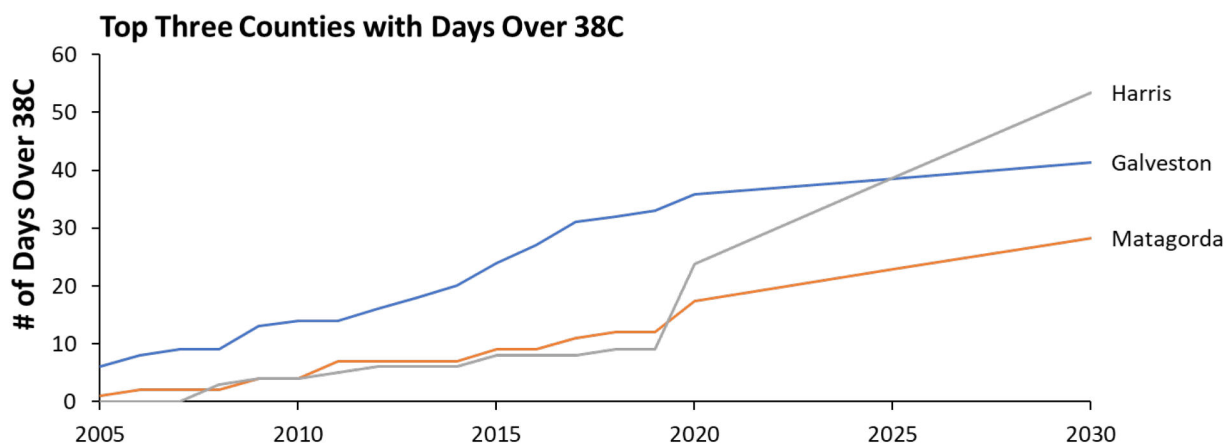


Source: Guidehouse analysis, with inputs from National Weather Service NOW Database.

4.2.3.2 Future Forecast Risk Profile

Rising temperatures and extreme heat are more chronic risks than acute, event-driven risks. Guidehouse has combined historical data and future projections to project change in number of days exceeding 38°C (100°F) from 2005 to 2030 for Harris, Galveston, and Matagorda counties (see Figure 4-20). These results show a projected increase in number of days exceeding 38°C for all counties, but the increase for Harris County is particularly prominent with a rise in expected days from about 20-25 today to over 50 in 2030.

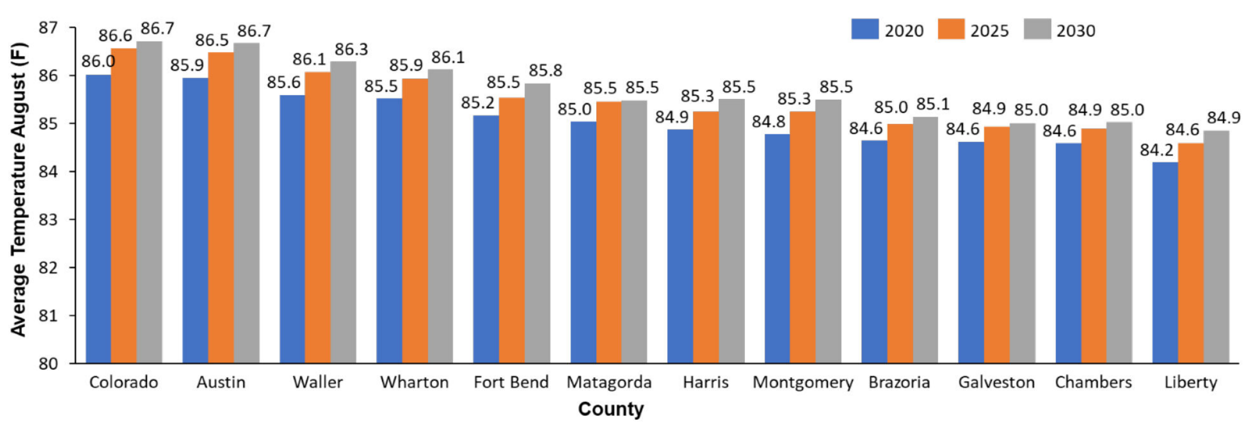
Figure 4-20: Number of Days Exceeding 38°C



Source: Guidehouse analysis, with inputs from National Weather Service data.

Instances of chronic temperature rise are concentrated in summer months. For example, average temperature in August is projected to rise across CenterPoint Houston's service area as seen in Figure 4-21. The mean temperature rise for August average is 1.5°F.

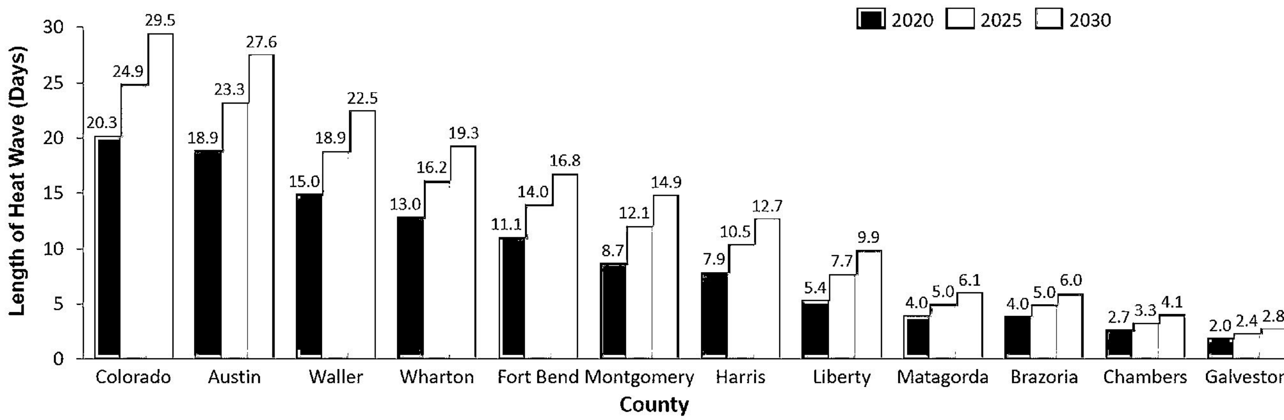
Figure 4-21: Average Temperatures in August 2020-2030 by County



Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

In addition to average temperature increases, heat wave events are also expected to rise in duration with an average increase of 11 days between 2020 and 2030, with Colorado County projected to see an increase of 16 days (see Figure 4-22).

Figure 4-22: Length of Heat Waves 2020-2030 by County



Source: Guidehouse analysis, based on Jupiter Intelligence modeling.

4.2.5 Wildfire Risk Profile

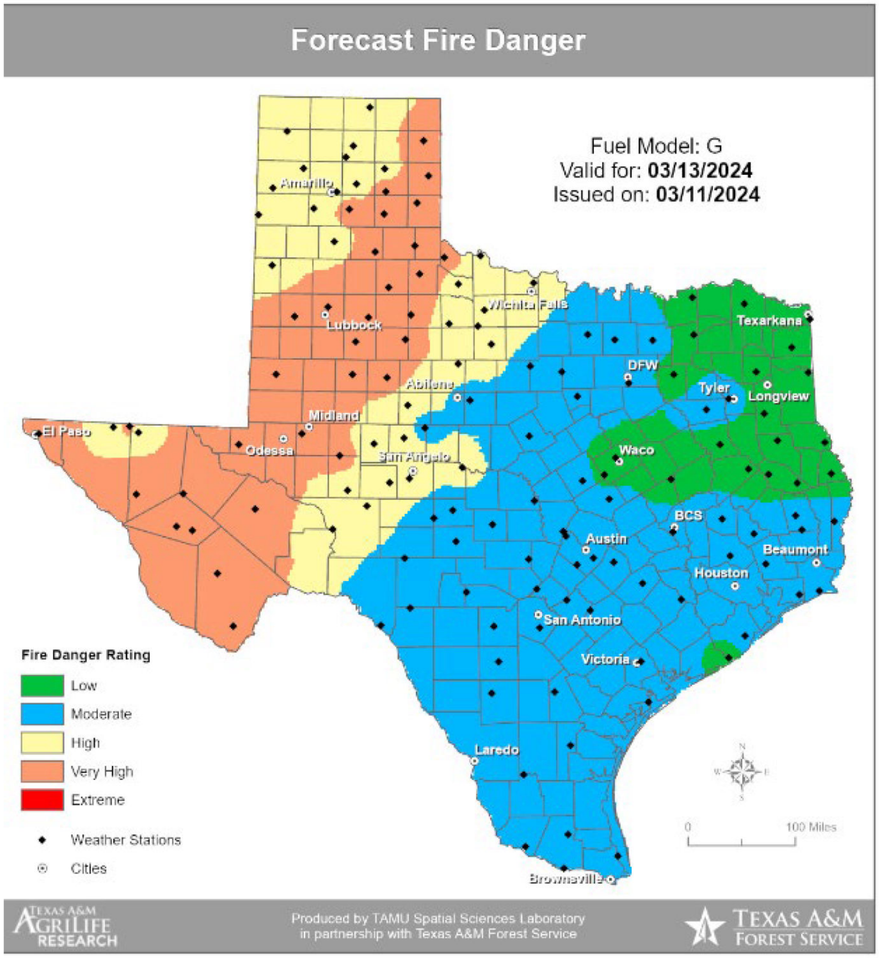
4.2.5.1 Historical Hazard Assessment

Wildfire risk in Texas has historically been low but rising air temperatures and reduced precipitation have led to drier vegetation, which when combined with high wind speeds can significantly increase the speed and spread of wildfires once ignited. Utilities are at a particularly high risk of being the source of ignition given their transmission and distribution systems are primarily located above-ground. As indicated in the media, the Smokehouse Creek Fire that began in February 2024 and continued into March 2024 burned approximately 1 million acres[46] and will be investigated by a special committee of the Texas House of Representatives.[47] CenterPoint Houston currently uses Texas A&M projections to determine the risk of wildfire spreading in its service area (see Figure 4-23). These projections are designed to provide a 2 to 4 day forecast to help structure a wildfire response. The conditions shown in Figure 4-23 for March 13, 2024 are representative of the low to moderate wildfire risk in CenterPoint Houston's territory in Spring months.

[46] Reuters. (2024 February 29). *Xcel Energy shares fall from potential Texas wildfire liability.* Xcel Energy shares fall from potential Texas wildfire liability | Reuters

[47] Driggars, A. (2024 March 12). *Texas House speaker appoints committee to investigate Panhandle wildfires.* Texas House speaker appoints committee to investigate Panhandle fires (statesman.com)

Figure 4-23: Wildfire Risk Map of Texas for March 13, 2024



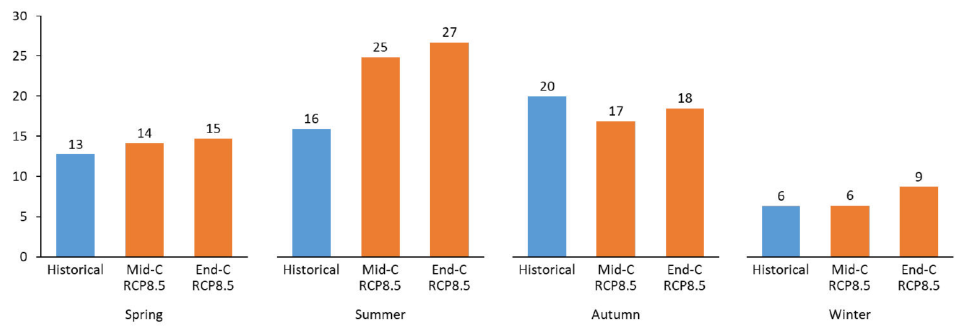
Source: Texas A&M University Forest Service. (n.d.). *FIRE DANGER: OBSERVED & FORECAST FIRE DANGER.* Wildfires and Disasters | OBSERVED & FORECAST FIRE DANGER TFS (tamu.edu).

While the Texas A&M projections are a peer reviewed and robust data source for near-term wildfire response, a complementary data source may be useful to project how this risk will change in future.

4.2.5.2 Future Hazard Assessment

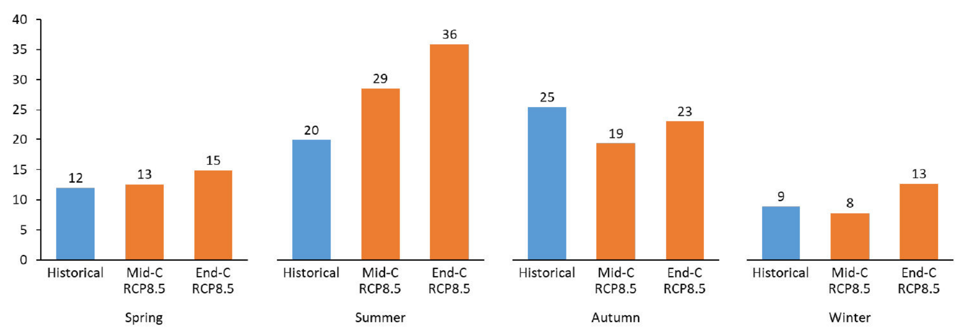
Argonne National Laboratory launched a "Climate Risk and Resilience" tool in 2023 that projects various natural hazards in mid-century and end of the century timeframes on a 12 kilometer ("km") by 12 km resolution. Guidehouse has used the outputs from this tool to develop summary projections for all counties in CenterPoint Houston's territory. Based on these projections, the risk of wildfires is projected to increase over the next few decades. Projected fire weather index ("FWI") for mid-century from the Argonne National Laboratory shows an increase in wildfire risk across CenterPoint Houston's service area in summer months increasing from historical medium to mid-century high. However, the risk remains relatively low for spring, autumn, and winter months. FWI is estimated using projected weather conditions such as dryness of vegetation and wind speed. An FWI value of 25 or above is considered high for Texas. These projections from Argonne National Laboratory were developed using the RCP8.5 climate change scenario with example results shown in Figure 4-24 and Figure 4-25.

Figure 4-24: Fire Weather Index (FWI) for Harris County Fire Weather Index (FWI) for Harris County



Source: Guidehouse analysis, with inputs from Argonne National Laboratory Fire Weather Index data.

Figure 4-25: Fire Weather Index (FWI) for Colorado County: Fire Weather Index (FWI) for Colorado County



Source: Guidehouse analysis, with inputs from Argonne National Laboratory Fire Weather Index data.

4.3 Assessment of Physical and Cybersecurity Threats

CenterPoint Houston stated the IT/OT-Cybersecurity Monitoring Program Resiliency Measure is a comprehensive program that will include deployment of advanced firewalls, passive network sensors and other cyber technologies to over 400 sites (CenterPoint Houston Resiliency Plan, Section VI.5.a). Physical and cybersecurity threats are often considered together when assessing risks to IT and OT cyber systems, in part due to the risk of coordinated physical and cyber attacks (including both cyber systems and the facilities in which they are housed).

4.3.1 Physical Security Risk Profile

The Texas Department of Homeland Security (TDHS) Texas Homeland Security Strategic Plan (THSSP) identifies specific physical security threats to the energy sector, which TDHS cites as a lifeline critical public infrastructure sector.[48] Resiliency is critically important for the electric sector not only for the operation of its own systems, but also for the operation of other critical infrastructure sectors that all rely on a stable electric supply. In the context of physical security risk, TDHS describes Texas cartels that use military and terrorist tactics to accomplish their goals and expand their control of criminal activities in Texas as a key risk. Domestic terrorism has become more prevalent in recent years and poses a credible threat to the electric sector as well. In addition, Texas-based homegrown violent extremists continue to aspire to conduct attacks in Texas, and individuals sympathetic to foreign terrorist organizations continue to provide them material support in the form of recruitment, financial resources, and propaganda. All terrorist actors will continue to utilize digital media to facilitate radicalization/recruitment and communicate, and law enforcement's ability to detect planned criminal activity will be challenged as such actors move to more secure communication platforms.[49]

The THSSP report describes statewide intelligence capabilities to reduce the threats of terrorist attacks and criminal activities. From a utility perspective, the CenterPoint Houston IT/OT systems reviewed in this report are dependent on existing and improved facility-level physical security measures to provide access control protective measures to detect and mitigate the threat of internal or external man-made hazards to its IT/OT systems.

Physical security threats and vulnerabilities for cyber systems represent major concerns from an operational perspective, particularly for enabling technologies such as IT/OT systems that are critical for efficient and effective operations of the CenterPoint Houston electric delivery system.

4.3.1.1 Historical Evidence

The connection of OT environments to IT networks, the interdependencies between IT systems (e.g., SAP) with the reliable operations of the electric system, and the introduction of a wide variety of Internet of Things (IOT) devices associated with smart grid applications all contribute to the need for electric utilities to continually enhance operational automation, control, efficiency, and, most importantly, security. When CenterPoint Houston implements its planned resiliency measures for digital transformation, greater operational resiliency can be achieved, however, that resiliency can quickly disappear if malicious actors exploit existing and new attack vectors (e.g., compromised credentials, zero-day attacks, poor encryption practices, malware, vulnerability exploitation, misconfigured systems, and trust relationships) that may emerge with increased physical and cyber system interconnectivity.

Awareness of the need for physical security for electric facilities has increased since an initial sniper attack on a California substation in 2013, which resulted in regulatory action[50] to identify and protect critical transmission substations and their primary control centers. In a FERC ruling,

[48] Texas Department of Homeland Security [TDHS]. (2021 June). *Texas Homeland Security Strategic Plan: 2021-2025* [THSSP: Technical Report], (p. 21). https://gov.texas.gov/uploads/files/press/HSSP_2021-2025.pdf

[49] TDHS. THSSP. (p. 21).

[50] NERC. (2015 July 14). *CIP-014-2: Physical Security* [Transmission System Reliability Standard]. https://www.nerc.com/pa/Stand/Reliability%20Standards/CIP-014-2.pdf

FERC directed the North American Electric Reliability Corporation ("NERC") to develop a mandatory reliability standard to promote physical security initiatives for critical transmission substations and to study the impacts of physical attacks on other transmission substations across the North American electric grid. More recent attacks in 2022 and 2023 disrupted power in North Carolina, Washington state, and Oregon. At the State level, the California Public Utilities Commission ("CPUC") issued Physical Security Decision (D.19-01-018)[51] and became the first state to adopt rules to protect its electric distribution grid against terrorist attacks. Since then, state legislators in North Carolina, South Carolina, and Arizona have introduced bills to mandate improved physical security at distribution substations that are not covered by the NERC Standards.

4.3.1.2 Current Risk Profile

In its report on reliability risk priorities, NERC states physical and cybersecurity risks are rising, and the nature of the attacks continues to evolve: "there has been an uptick in physical security events, including copper theft and ballistic damage, against the Bulk Power System ("BPS") and specifically at distribution substations. Vulnerabilities to such events are exacerbated by commodity prices, supply chain constraints, environmental activists, and domestic violent extremists."[52]

Current protective measures to mitigate malicious activities at electric infrastructure facilities have necessarily focused on substations that have been identified as particularly critical, using various threat and vulnerability assessments and physical security plans. Coordinated attacks on multiple substations that target expensive electric elements, such as the sniper attack at Metcalf substation in 2013 that focused on transformers and other critical electrical equipment with long replacement lead-times, could have a significant impact on the safety and well-being of U.S. citizens and the economy.[53] CBS News reported a 71% increase in physical attacks on electric grid facilities in 2022 alone.[54] Citing 25 physical attacks on nationwide electric infrastructure, including one in the El Paso area in 2022, the Dallas Morning News examined vulnerabilities associated with Texas substations and concluded a coordinated attack on power infrastructure could cause a cascading failure of the Texas power grid.[55] CenterPoint Houston operates over 300 electric substations and other physical locations, such as control centers, IT data centers, and service centers, containing IT/OT cyber systems, providing a large physical attack surface for malicious actors.

---

[51] California Public Utility Commission. (2019 January 22). *Physical Security of Electric Infrastructure (R.15-06-009).* https://www.cpuc.ca.gov/about-cpuc/divisions/safety-policy-division/risk-assessment-and-safety-analytics/physical-security-of-electric-infrastructure

[52] NERC. (2023 August 17). (p. 36).

[53] Smith, R. (2014 March 12). *U.S. Risks National Blackout from Small-Scale Attack.* https://www.wsj.com/articles/SB10001424052702304020104579433670284061220

[54] Sganga, N. (2023 February 22). *Physical attacks on Power Grids rose by 71% last year, compared to 2021.* https://www.cbsnews.com/news/physical-attacks-on-power-grid-rose-by-71-last-year-compared-to-2021/

[55] Williams, M. (2023 February 9). *Plots, attacks against power grids are increasing nationwide. How vulnerable is Texas?* https://www.dallasnews.com/news/2023/02/09/plots-attacks-against-power-grids-are-increasing-nationwide-how-vulnerable-is-texas/

From an IT/OT cyber system perspective, the risks of physical attacks are somewhat less, but still significant, due to the impact of physical intrusions and ballistic attacks on critical electric facilities. Most cyber systems associated with electric grid and business operations rely on hardened facilities, such as secure buildings or locked enclosures, to prevent physical damage to critical cyber systems, such as protective relays, SCADA systems, and telecommunications systems. The NERC 2023 report cites and promotes the 2023 National Cybersecurity Strategy[56] report "Secure by Design" concept to implement security controls during the design, installation, and construction phases to mitigate the risks of weaker security controls by new entrants to the grid and current participants during the DER interconnection stage. Implementing the "Secure by Design" approach is also applicable to CenterPoint Houston's proposed technology resiliency measures.

4.3.1.3 Future Forecast Risk Profile

The NERC report on reliability risk priorities indicates physical and cybersecurity risks are rising, while the nature of the attacks continues to evolve.[57] As an example, ballistic attacks on electric facilities using drones as a delivery vehicle is an emerging threat. Combining the trends cited above, including the increasing rate of domestic terrorism in Texas and physical security risks in CenterPoint Houston's electric service area, Guidehouse expects physical and cybersecurity attacks to increase in number and severity over the next five years.

4.3.2 Cybersecurity Risk Profile

The TDHS THSSP report describes cyber threats as follows: "Cyberattacks and intrusions can be used by criminals, terrorists, insiders, and hostile foreign nations to disrupt delivery of essential services, mask other attacks, or shake citizens' confidence in the government. Cyberattacks are relatively easy to execute and challenging to disrupt and investigate, as demonstrated in the August 2019 ransomware attack that impacted 23 local government entities in Texas, and the frequency of attacks and intrusions has increased significantly during the past five years. As the cyber threat continues to grow and evolve, a particular concern is the potentially severe consequence of an effective cyberattack against critical infrastructure facilities and systems. Cyber threats could also result in the denial or disruption of essential services, including [electric] utilities."[58]

4.3.2.1 Current Risk Profile

Cyberattacks across all critical infrastructure sectors have increased over the past five years with notable examples including the 2021 Colonial pipeline attack, numerous operating system vulnerability exploitations, and the rise of malware and ransomware attacks targeting supply chains and other vulnerabilities by foreign and domestic threat vectors.

---

[56] The White House. (2023 March). *National Cybersecurity Strategy* (pp. 1-35). https://www.whitehouse.gov/wp-content/uploads/2023/03/National-Cybersecurity-Strategy-2023.pdf

[57] NERC. (2023 August 17). (p. 32).

[58] TDHS. (p. 23).

4.3.2.2 Future Forecast Risk Profile

As noted above, CenterPoint Houston operates over 400 electric substations and other physical locations. There are approximately 375 IT/OT cyber systems at these locations, which provides a significant digital attack surface for malicious actors. The NERC report on reliability risk priorities identifies physical and cybersecurity risks as rising, while the nature of the attacks continues to evolve beyond current protective measures and controls.[59] Additional factors leading to an increased future cybersecurity risk profile for CenterPoint Houston and other electric utilities include the following:[60]

- The emergence of Artificial Intelligence (AI) and machine learning tools deployed by cyber adversaries is likely to increase the number and types of attacks, as well as the probability of attack success.
- An increasing trend to virtualize and host critical cyber systems in Cloud environments may create additional cyber risk during use, transmission, and storage of data.
- Supply chain risks derived from compromise of critical cyber system components during the development and procurement cycles.
- Increasing deployment of DERs and DER aggregators, which are largely unregulated, presents increased cybersecurity risk to the electric grid because their control systems could become compromised and used as an attack vector into electric systems.[61]
- Increasing lack of a robust cyber workforce requires organizations in the electric sector and other critical infrastructure sectors to rely heavily on automated tools to develop robust cybersecurity defenses.
- Increasing remote work by utility workers also increases the risk of compromise of critical cyber systems, which can be mitigated by hardening telecommunications platforms to protect data-in-transit.

Considering these trends as well as previously discussed physical security trends of increasing rate of domestic terrorism in Texas and continued attacks by foreign adversaries, Guidehouse expects cybersecurity risks to increase in CenterPoint Houston's service area absent additional cybersecurity investments. In particular, the risk of coordinated attacks combining physical and cyber intrusions across multiple facilities is expected to increase.

[59] NERC. (2023 August 17). (p. 32).

[60] NERC. (2023 August 17). (p. 37).

[61] NERC. (2022 December). *Cyber Security for Distributed Energy Resources and DER Aggregators.* https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_Cybersecurity_for%20DERs_and_DER_Aggregators.pdf

5. CenterPoint Houston Resiliency Plan Review

5.1 Analytical Approach: Resiliency Measure Reviews and Benefit-Cost Analysis

5.1.1 Overview

Guidehouse performed an assessment of CenterPoint Houston's proposed electric T&D resiliency measures and projects for its Resiliency Plan covering years 2025 through 2027 to help inform CenterPoint Houston's refinement of the Plan and provide evidence of the potential value of the proposed resiliency measures. Although some of the measures may continue for up to 10 to 15 years, CenterPoint Houston's Resiliency Plan and Guidehouse's evaluation focuses on costs and outage reduction measures over the 3-year Plan. Guidehouse analyzed each of CenterPoint Houston's proposed Resiliency Plan measures and projects using the following consistent outline:

- **Project Description** – Provides pertinent details on objectives and rationale supporting the measure. Describes how the measure achieves CenterPoint Houston's Resiliency Plan objectives, including mitigating the risk of resiliency events. Presents the quantity of proposed measures and projects and areas targeted, along with amounts spent as of January 2024 and proposed over the 3-year Resiliency Plan.
- **Alternatives Considered** – Describes alternatives CenterPoint Houston considered in lieu of the proposed resiliency measure. Explains why alternatives were determined to be less effective than the proposed resiliency measure(s).
- **Resiliency Measure Metrics and Effectiveness** – Presents metrics and measures CenterPoint Houston proposes to report to the PUCT annually for each resiliency measure. Describes how the reported values will be derived and relevant data associated with each measure.
- **Benefits Analysis** – Outlines resiliency measure benefits, both quantitative and qualitative. Documents values and assumptions applied to quantify benefits, including BCA ratios when calculated. Qualitative benefits are those associated with societal factors such as regional impacts, economic considerations, public safety, inconvenience, and impact on critical facilities. A BC ratio of 1.0 or above indicates when benefits accrued over the life of the asset exceed costs while values below 1.0 are when costs exceed lifetime benefits. For the latter, qualitative benefits are relied upon to support Resiliency Plan measures.
- **Resiliency Measure Assessment and Conclusions** – For each resiliency measure, Guidehouse summarizes its findings based on the preceding sections and provides conclusions as to whether/how the measure achieves Resiliency Plan objectives.

Guidehouse's evaluation of CenterPoint Houston's resiliency measures are evaluated at the individual level. However, specific projects within each measure will be evaluated and selected for implementation based on an asset level evaluation. Guidehouse recommends CenterPoint Houston conduct an asset level analysis of each program to determine the preferred or optimal location of individual projects over the three-year Resiliency Plan. Further, Guidehouse recommends CenterPoint Houston refine the programmatic analysis used to develop the current Resiliency Plan to include an asset level analysis to select projects for inclusion in future Resiliency Plan filings to the PUCT. For example, the more detailed asset level analysis could identify specific substations for Flood Control or Security Upgrades, and specific distribution feeders and transmission lines for the Distribution Circuit Rebuild or Transmission System Hardening measures.

5.1.2 Methodology Used for Review of Operations Resiliency Measures

Guidehouse critically reviewed each of CenterPoint Houston's proposed resiliency measures to determine whether the measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan. A key objective of our assessment was to determine the effectiveness of each measure at mitigating the impact of major storms and extreme weather events on CenterPoint Houston's transmission and distribution system. Guidehouse analyzed each measure in accordance with good utility practice and quantified the extent to which each measure reduces outage exposure and duration of interruption of electric service. An important element of our assessment of mitigation effectiveness was consideration of future forecast risk attributed to major storms and other extreme weather events as described in Section 4 . For example, the projected increase in flood inundation levels in various parts of CenterPoint Houston's service area by 2030 was a factor that Guidehouse incorporated into its analysis of the potential benefits of flood mitigation measures. A similar approach was applied for measures impacted by high wind events.

To derive resiliency measure benefits, Guidehouse collected relevant data from CenterPoint Houston to analyze assets at risk of failure during major storms and extreme weather events. This included identifying the likelihood of equipment failure and extent to which inoperable systems will negatively impact reliability. We first conducted interviews with CenterPoint Houston subject matter experts to obtain details on resiliency measure selection and historical data used to assess effectiveness. Guidehouse then derived benefit-cost ratios using a BCA approach for each resiliency measure (i.e., CenterPoint Houston program or project). The BCA approach is a lifecycle analysis of resiliency measure costs and benefits.[62] BCA provides a consistent measure to determine if the estimated benefits (translated into monetary value) outweigh the estimated costs, suggesting the program or project is worthwhile to pursue. We also compared CenterPoint Houston's proposed measures with industry practices based on a peer utility benchmarking study described in Section 5.3 .

[62] The BCA includes benefits quantified during normal weather events to provide realistic values for each program, which otherwise would appear to be low if calculated solely for major storms and extreme weather events.

5.1.2.1 Assumptions

Conducting BCA necessarily requires assumptions to be made, including both general and resiliency measure specific. Flood inundation, temperature, and wind speed forecasts for 2030 described in Section 4.2 are also incorporated into the quantitative analysis. General assumptions that typically are applied for the purpose of determining BCA values include:

- Resiliency measure costs for which CenterPoint Houston seeks PUCT approval are those projected for years 2025 through 2027; BCA calculations include amounts spent in prior years for individual resiliency program measures initiated prior to 2025.[63]
- Resiliency measure benefits are quantified for the first 10 years; terminal value analysis is applied to derive resiliency measure benefits over the remaining asset lives.
- Resiliency measure benefits are grouped for all asset locations within scope for the measure, except where the measure mitigates impacts at a specific location (e.g., Coastal Islands Resiliency program or pole replacements north and south of U.S. 59/69).
- Quantified resiliency measure benefits include avoided outages, decreased outage duration, reduced operation and maintenance expense, material and equipment savings, reduced crew labor and truck rolls, and avoided collateral damage due to asset failure.[64]
- Qualitative resiliency measure benefits include customer satisfaction, regional economic impacts, environmental benefits, media attention, public safety, and avoidance of terrorist threats.
- BCA ratios are derived based on the net present value (NPV) of costs and benefits over the life of the measure.
- Value of Lost Load (VOLL) is $25,000/MWh for all resiliency measures.[65]
- Average customer load is 6 kW.
- Load growth is 2% annually unless otherwise specified for individual resiliency measures.
- Weighted average cost of capital (WACC) is 6.51%.
- Annual inflation is 2%.

Societal, environmental, and other non-utility impacts are addressed qualitatively. Specific assumptions for each resiliency measure are documented in the applicable resiliency measure review sections below.

[63] For example, the Coastal Islands Resiliency program.

[64] Other benefits not directly attributable to resiliency such as deferred capacity needed for load growth are not quantified, and rather are presented as a qualitative benefit

[65] $25,000/MWh was adopted by the PUCT as an interim VOLL on February 1, 2024. See memo dated January 25, 2024: *PUCT Staff recommendations for interim VOLL.* https://interchange.puc.texas.gov/Documents/55837_9_1361634.PDF

5.1.2.2 Overview of Data and Modeling Tools Used

The primary tool Guidehouse used to derive BCA values is its proprietary benefit-cost model. The model applies the assumptions and methods described above, together with storm and other extreme weather event forecasts from Section 4.2 to derive risk factors for each program measure. Risk factors evaluated in the benefit-cost model include:

- **Circuit and Equipment Failure Rates** – The decrease in failure rates achieved by program measures during major storms and extreme weather events. Includes the reduction in failure rates achieved by replacing or upgrading at-risk circuits, equipment, and facilities on T&D circuits and substations.
- **Outage Duration** – The decrease in outage duration achieved by program resiliency measures during storms and extreme weather events.
- **Collateral Damage** – The avoidance of the additional cost incurred caused by equipment failure on nearby devices; for example, catastrophic substation transformer failures that cause adjacent transformers to fail.
- **Restoration Cost** – The savings in crew labor, truck rolls, and trouble order processing achieved by program resiliency measures.
- **O&M**– The decrease (or increase for new equipment installed) in O&M resulting from the resiliency measure.
- **VOLL** – As defined in Section 5.1.2.1.
- **Economic Assumptions** – As defined in Section 5.1.2.1.

The application of the assumptions outlined above to derive BCAs for each CenterPoint Houston resiliency measure is presented in Section 5.2.

5.1.3 Methodology Used for Review of Technology Resiliency Measures

Guidehouse critically reviewed each of CenterPoint Houston's proposed resiliency measures to determine whether the measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan. A key objective of our assessment was to determine each resiliency measures' effectiveness from a resiliency perspective by applying the NIST framework. Additionally, Guidehouse applied the Presidential Policy Directive 21 (PPD-21) definition of resilience, which defines resilience as, "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions [and] the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."[66] This definition is commonly used within the cybersecurity field as evidenced by its use in the 2021 Cybersecurity and Infrastructure Security Agency: Infrastructure Security Division ("CISA-ISD")

[66] The White House. (2013 February 12*). Presidential Policy Directive – Critical Infrastructure Security and Resilience* [PPD-21]. (p. 12). https://www.cisa.gov/sites/default/files/2023-01/ppd-21-critical-infrastructure-and-resilience-508_0.pdf

report on Lessons Learned from the Regional Resiliency Assessment Program.[67] The NIST built on this through further expansion of this definition, stating that resilience is, "[t]he ability to anticipate, withstand, recover from, and adapt to adverse conditions, stresses, attacks, or compromises on systems that use or are enabled by cyber resources. Cyber resiliency is intended to enable mission or business objectives that depend on cyber resources to be achieved in a contested cyber environment."[68] This extension captures cyber resilience from the business process cyber system perspective.

5.1.3.1 NIST Framework Methodology

Due to uncertainty and the evolving nature of cyber threats, the International Energy Agency (IEA) recommended the use of a common framework to provide consistency in assessing risks associated with disparate systems within their operating environments. IEA recommended five potential frameworks,[69] including the Department of Homeland Security Cybersecurity Capability Maturity Model (C2M2, which evaluates the maturity of an organization's cybersecurity capabilities), the NIST CSF (described in detail below), the NISTIR 7628 Guidelines (which focus on smart grid characteristics, risks, and vulnerabilities), ISO/IEC TR 27019 (which is applicable to utility process control systems), and ISO 22301 (which relates to business continuity management). In addition, the ERCOT uses industry best practices, including the NIST CSF, to shape security policies, develop cybersecurity programs, identify cyber threats, and mitigate the impacts of cyber intrusions.[70]

The CSF is a set of best practices and recommended controls commonly used in the electric utility industry at the international, federal, and state levels to guide cybersecurity and resiliency activities and the assessment and mitigation of cybersecurity risks as part of an organization's overall risk management process. Based on professional judgment, fitness for the resiliency assessment at hand, and a current trend within the NERC and the FERC to align NERC Critical Infrastructure Protection (CIP) Reliability Standards in the North American electrical grid with the CSF,[71] Guidehouse developed and applied a comparative analysis of CSF best practices with analyses and reviews of applicable functions and security solutions included in the Technology Resiliency Measures included in CenterPoint Houston's Resiliency Plan.

[67] Cybersecurity & Infrastructure Security Agency: Infrastructure Security Division [CISA-ISD]. (2021 June). *Methodology for Assessing Regional Infrastructure Resilience: Lessons Learned from the Regional Resiliency Assessment Program* [CISA-ISD Technical Report]. (p. 8). https://www.cisa.gov/sites/default/files/publications/DIS_DHS_Methodology_Report_ISD%20EAD%20Signed_with%20alt-text_0.pdf

[68] NIST Glossary: *Definition of Cyber Resiliency.* https://csrc.nist.gov/glossary/term/cyber_resiliency

[69] International Energy Agency [IEA]. (2021). *Enhancing Cyber Resilience in Electricity Systems* [see *Table 4. Overview of regularly referred to instruments for cybersecurity in the electricity sector*] (pp. 30-32). https://iea.blob.core.windows.net/assets/0ddf8935-be23-4d5f-b798-3aad1f32432f/Enhancing_Cyber_Resilience_in_Electricity_Systems.pdf

[70] ERCOT. (2023 March). *Protecting ERCOT's Electric System from Cyber Attacks.* https://www.ercot.com/files/docs/2019/09/17/Cybersecurity_One_Pager_FINAL.pdf

[71] Marron, J., Copstein, A, & Bogle, D. (2021 September 29). *Benefits of an Updated Mapping between the NIST CSF and the NERC Critical Infrastructure Protection Standards* [NIST CSWP 21 White Paper]. https://doi.org/10.6028/NIST.CSWP.21

The NIST CSF[72] consists of three primary components:

1. Framework Core
2. Implementation Tiers
3. Framework Profiles

The Framework Core (the "Core") is a set of cybersecurity activities, outcomes, and informative references that are common across sectors and critical infrastructure. Elements of the Core provide detailed guidance for developing individual organizational Profiles. Through use of Framework Profiles, the Framework helps an organization align and prioritize its cybersecurity activities with its business/mission requirements, risk tolerances, and resources. The Implementation Tiers provide a mechanism for organizations to view and understand the characteristics of their approach to managing cybersecurity risk, which will help in prioritizing and achieving cybersecurity objectives, including resiliency objectives.

While reviewing CenterPoint Houston's Resiliency Plan measures for IT and OT cyber systems, Guidehouse applied a qualitative comparative analysis[73] between the NIST CSF Core functions, categories, and sub-categories and the features described by CenterPoint Houston in documentation and interviews or inferred by professional judgment for each of the technology resiliency measures included in CenterPoint Houston's Resiliency Plan. Correlations at the NIST CSF function level were identified and applied to develop qualitative benefit analyses.

For some business-oriented IT cyber systems, Guidehouse also applied a qualitative comparative analysis between the NIST CSF functions and features described by CenterPoint Houston in documentation and interviews or inferred by professional judgment for each of the technology resiliency measures included in CenterPoint Houston's Resiliency Plan. In addition to correlations at the NIST CSF Function level, the Guidehouse analysis included a review of redundancy, which aligns with the NERC description of "risk reduction benefits associated with added redundancy, diversity, and minimization of very high risk assets."[74] The CISA-ISD report also described redundancy as a component of the mitigation building block for resilience that resists or absorbs negative impact, reduces the severity or consequence of an event, and supports the reliability of infrastructure systems.[75]

5.1.3.2 Assumptions

Physical and cybersecurity benefits are difficult to measure with a traditional return on investment (ROI) calculation as the benefits of security projects are generally realized in avoided costs and other avoided negative impacts. As examples of potential avoided costs and

---

[72] NIST. (2018 April 16). *Framework for Improving Critical Infrastructure Cybersecurity* [v1.1], https://nvlpubs.nist.gov/nistpubs/CSWP/NIST.CSWP.04162018.pdf

[73] CISA-ISD. (*Comparative Analysis* section, p. 71)

[74] NERC. (2023 August 17). *2023 ERO Reliability Risk Priorities Report*. (p. 33). https://www.nerc.com/comm/RISC/Related%20Files%20DL/RISC_ERO_Priorities_Report_2023_Board_Approved_Aug_17_2023.pdf

[75] CISA-ISD. (*Part 1*, p. 8)

negative impacts, Security Made Simple identifies major cost components related to cyberattacks, including falling stock prices, loss of customers, cyber insurance costs, lawsuits, compliance penalties and sanctions, and business interruption costs.[76] Each of these cost factors may or may not be included in the cost of data breaches statistics described below, depending on the rigor of the underlying data collection instrument.

The IEA reports utilities in the critical gas and electricity infrastructure sectors were subjected to an average of 504 weekly cyberattacks per organization in 2020, which increased to 736 weekly cyberattacks in 2021 and 1,101 cyberattacks in 2022.[77] While most of these attacks were likely unsuccessful, utilities may not have the capability to detect, deter, defend, and recover from successful attempts. This upward trend coupled with recent FBI reports[78] on increasing cyber intrusion activity by nation-state actors on critical public infrastructure indicates CenterPoint Houston Energy's risk of a successful cyberattack is likely to increase substantially over the next five years.

In addition, Statista reports the average cost of data breaches in the U.S. increased steadily from $5.4 million dollars in 2013 to $9.48 million dollars in 2023.[79] This upward trend indicates a strong probability the annual average cost of a single data breach will continue to increase over the next five-year period. IBM reported similar annual averages for overall 2023 data breach costs in the U.S.[80] IBM further identified a 23% increase in the average cost of a data breach between 2022 and 2023.[81] In addition, IBM reported the cost of a data breach escalates substantially with longer detection times and increased system downtime.[82]

Combating these deleterious impacts requires a comprehensive approach to physical and cybersecurity efforts. In a 2021 study, Claroty reported, "organizations have internalized the lessons learned from high-profile cyberattacks and are prioritizing cybersecurity by increasing investments and implementing new or updated processes and controls."[83] This finding aligns with the current CenterPoint Houston approach to implement diverse physical and cybersecurity resiliency measures. While rejecting a comprehensive approach to cyber resiliency is always an option, Claroty stated, "[t]he cost for critical infrastructure organizations of doing nothing is not

[76] Security Made Simple. (2021 August 25). *What does a cyberattack do to a company's value?* https://securitymadesimple.org/cybersecurity-blog/what-does-a-cyberattack-do-to-a-companys-value/

[77] Casanovas, M., & Ngheim, A. (2023 August 1), *Cybersecurity – is the power system lagging behind?,* [International Energy Agency Technical Report - *Table: Average number of weekly cyberattacks per organisation in selected industries, 2020-2022*] https://www.iea.org/commentaries/cybersecurity-is-the-power-system-lagging-behind

[78] FBI.gov. (2024 January 31). *China's Hackers Have Entire Nation in Their Crosshairs, FBI Director Warns.* https://www.fbi.gov/news/stories/china-s-hackers-have-entire-nation-in-their-crosshairs-fbi-director-warns [See also FBI.gov. (n.d.). *The China Threat.* https://www.fbi.gov/investigate/counterintelligence/the-china-threat]

[79] Statista. (2024 January). *Average cost of a data breach in the United States from 2006 to 2023.* https://www.statista.com/statistics/273575/us-average-cost-incurred-by-a-data-breach/#:~:text=As%20of%202023%2C%20the%20average,dollars%20in%20the%20previous%20year.

[80] IBM. (2023). *Cost of a Data Breach Report* [IBM Technical Report, Figure 3, pp. 11-12]. https://www.ibm.com/reports/data-breach

[81] IBM. (Figure 4, p. 13)

[82] IBM. (p. 7).

[83] Claroty. (2021). *The Global State of Industrial Cybersecurity 2021: Resilience amid Disruption* [White Paper, p. 6]. https://claroty.com/resources/reports/the-global-state-of-industrial-cybersecurity

tolerable. The longer an organization goes without the right cyber physical systems security capabilities in place, the more likely they are to experience a major breach."[84] Guidehouse concurs with this statement; the more CenterPoint Houston integrates physical and cyber systems into its overall operational model, the more critical a robust defense-in-depth cybersecurity strategy becomes to develop a strong and resilient network.

IEA identifies the difficulties of identifying clear monetary benefits for developing cyber resiliency, "It remains questionable whether an outcome-based approach can be fully relied upon as a reasonable strategy for the resilience of critical infrastructure. The situation differs from that in grid development, where an investment can be motivated by system modeling analysis showing reduced operational costs or higher reliability, and where the actual impact on grid losses or interruption durations can be measured. A cyber resilience investment can hardly ever be weighed against a monetisable [sic] benefit or proven to be effective in retrospect by demonstrating prevented attacks. It is exactly because simply setting targets is not a realistic option that cybersecurity policies for the electricity sector are a complex issue for policy makers."[85]

Accordingly, Guidehouse considered "avoided cost" as a benefit of each of the resiliency measures analyzed below without itemizing specific costs. The more salient analysis regards the resilience impact of each of the measures because a benefit of each of them is avoided cost by detecting, deterring, or mitigating successful attacks. While Guidehouse reviewed the physical and cybersecurity resiliency measures included in CenterPoint Houston's Resiliency Plan individually, it should be noted that the benefit of these measures is cumulative toward ensuring a strong and diverse cybersecurity posture that identifies, detects, deters, and defends against physical or cyber-attacks and ensures a resilient operational posture that can respond to and recover from any successful attacks. This means that, in general, the benefits of these measures can increase exponentially as more measures are adopted (i.e., the whole is greater than the sum of its parts).

5.2 Review of Operations and Physical Security Resiliency Measures in CenterPoint Houston's Resiliency Plan

The following sections present Guidehouse's assessment of CenterPoint Houston's proposed Resiliency Plan measures related to operations and physical security. Each resiliency measure reviewed includes a description, proposed metrics to define effectiveness, alternatives considered, quantitative and qualitative benefits, and summary assessment and conclusions. The benefits analysis section for each proposed CenterPoint Houston resiliency measure describes the approach and assumptions Guidehouse used to derive project valuation using the

[84] Claroty. (2022 December 20). *How Cyber-Physical Security Maximizes ROI* [Technical Blog]. https://claroty.com/blog/how-cyber-physical-system-security-maximizes-roi

[85] International Energy Agency [IEA]. (2020 October). *Power Systems in Transition: Challenges and opportunities ahead for electricity security* (IEA Technical Report, *Cyber Resilience - Policy and regulatory approaches* section, p. 45)..

following two measures: benefit-cost ratio (referred to as BCA below) and CMI reduced. Results are summarized in Table 5-1 using a VOLL of $25,000/MWh.[86]

Table 5-1: Resiliency Measure Costs and Benefits

Resiliency Program	3-Year Capital Cost ($MM)	3-Year O&M Expense ($MM)	BCA Ratio	3-Yr CMI 2025-2027 (million)	Annual CMI 2027 (million)
System Hardening					
Transmission System Hardening	$376.0	$0.75	6.0	206.0	87.6
S90 Tower Replacements	$103.8	$0.00	4.9	41.7	16.4
69kV-138kV Conversion Projects	$268.4	$0.00	1.9	46.8	20.0
Coastal Resiliency Upgrades	$259.0	$0.75	1.4	21.9	21.9
Substation Transformer Fire Protection Barriers	$2.4	$0.00	3.7	0.5	0.2
Distribution Pole Replacement/Bracing	$99.3	$0.00	6.2	41.3	20.8
Distribution Resiliency – Circuit Rebuilds	$312.8	$0.00	7.0	137.4	69.4
Strategic Undergrounding/Freeway Crossings	$31.2	$0.00	3.8	4.4	2.2
System Hardening Subtotal	**$1,452.9**	**$1.50**	**4.5***	**500.0**	**238.5**
Grid Modernization					
TripSaver®	$58.9	$0.03	61.3	240.3	122.2
IGSD Installation	$53.8	$0.82	15.7	58.1	27.7
Texas Medical Center Substation	$102.0	$0.15	0.7	4.9	4.9
Grid Modernization Subtotal	**$214.7**	**$1.00**	**21.1***	**303.4**	**154.8**
Flood Control					
Substation Flood Mitigation	$30.6	$0.00	7.5	14.2	6.7
Control Center Facility Upgrades	$7.0	$0.00	12.5	6.1	2.5
Flood Control Subtotal	**$37.6**	**$0.00**	**8.4***	**20.3**	**9.2**
Information Technology for Operations					
Advanced Aerial Imagery Platform / Digital Twin	$9.9	$0.06	3.4	0.8	0.3
Advanced Distribution Technology	$225.8	$15.00	4.8	61.1	40.6
Digital Substation	$25.0	$(0.60)	1.9	1.3	0.8
IT for Operations Subtotal	**$260.7**	**$14.46**	**4.5***	**63.2**	**41.7**
System Security					
Substation Physical Security Fencing	$15.0	$0.00	15.6	14.7	7.3
Substation Security Upgrades	$19.5	$0.09	19.9	25.1	12.5
Group Subtotal	**$34.5**	**$0.09**	**18.0***	**39.7**	**19.8**
Vegetation Management					
Targeted Critical Circuit Vegetation Management	$0.0	$25.00	1.8	13.9	4.2
Group Subtotal	**$0.0**	**$25.00**	**1.8**	**13.9**	**4.2**

[86] $25,000/MWh was adopted by the PUCT as an interim VOLL on February 1, 2024. See memo dated January 25, 2024: *PUCT Staff recommendations for interim VOLL.* https://interchange.puc.texas.gov/Documents/55837_9_1361634.PDF

Resiliency Program	3-Year Capital Cost ($MM)	3-Year O&M Expense ($MM)	BCA Ratio	3-Yr CMI 2025-2027 (million)	Annual CMI 2027 (million)
Total	**$2,000.4**	**$42.05**	**6. 6***	**940**	**468**

*Average BCA weighted by resiliency measure cost
Source: Guidehouse BCA of CenterPoint Houston's proposed resiliency measures

Table 5-1 presents the estimated total CMIs reduced for each of CenterPoint Houston's resiliency measures for the years 2025 through 2027 and the annual CMI each resiliency measure is projected to achieve by 2027.[87] Over the 3-year Plan, cumulative CMI savings is estimated to be 940 million. By 2027, annual CMI savings is estimated to be 468 million.

Appendix B presents resiliency measure specific and subtotals per categories BCAs for VOLLs ranging from $5,000/MWh to $65,000/MWh. Composite BCAs range from a low of 1.4 for a VOLL of $5,000/MWh to 17.2 for a VOLL of $65,000/MWh.

In addition to the resiliency measure-specific metrics described in this section of the report, CenterPoint Houston proposes to track and report to the Commission annual restoration times, restoration cost, and reliability performance during resiliency events as actions of overall effectiveness of resiliency measures included in its Resiliency Plan. The annual reports to the Commission will document changes in the impact of resiliency events to customer reliability, damage to T&D assets and associated restoration cost, which is generally consistent with metrics being used by other utilities based on benchmarking provided in Section 5.3 and Appendix A

System Hardening

5.2.1 Transmission System Hardening

5.2.1.1 Resiliency Measure Description

CenterPoint Houston's Transmission System Hardening resiliency measure is designed to replace wooden poles (single pole and H-Frame) on line segments where a substantial number of poles do not meet CenterPoint Houston's current wind loading design standard for new 138kV structures, along with airflow spoiler additions to mitigate galloping conductors along transmission lines. Although existing poles meet the design standard in effect at the time they were built, CenterPoint Houston has since modified their design standard in response to increased extreme weather severity and frequency. A large percentage of lines targeted for system hardening are rated 138kV.[88] CenterPoint Houston proposes to replace wood poles with concrete poles, metal monopole poles, or lattice towers that include installation of galloping

[87] The annual CMI value for 2027 is typically higher than the 3-year average as the aggregated quantity of measures undertaken increases each year.

[88] Most of CenterPoint Houston's 69kV transmission lines are wood pole construction. The replacement of 69kV poles is addressed in CenterPoint Houston's 69kV-138kV Conversion Projects resiliency measure.

conductor mitigation. The transmission line segments that CenterPoint Houston proposes to harden include line sections most susceptible to failure during major storms and other extreme weather events.

CenterPoint Houston's Transmission System Hardening resiliency measure (along with 69kV and 138kV Conversions and Tower Replacements) is one of its key resiliency measures based on level of investment. Poles replaced will meet CenterPoint Houston's current wind loading standard. Figure 5-1 presents typical 138kV wood pole structures proposed for hardening.

Figure 5-1: Examples of Transmission 138kV Wood Structures

Source: CenterPoint Houston.

CenterPoint Houston's proposed Transmission System Hardening measure replacement quantities and investment amounts appear below.

- Miles of transmission targeted: **5 to 30 miles** per year (approximately **50 miles** total)
- Total project cost: **$376 million** over the 3-year Plan
- The annual expense to inspect and maintain the new structures is **$750,00** total over three years.

Over the past five years, CenterPoint Houston has invested $621.3 million in transmission hardening projects.

5.2.1.2 Alternatives Considered

CenterPoint Houston evaluated three alternatives to the proposed replacement of wood poles.

1. **Stronger Single Wood Poles** – Single, stronger wood poles offer a marginal increase in resiliency. Further, new wooden H-frame is now considered an obsolete design standard by CenterPoint Houston for resiliency.

2. **Overhead to Underground Relocation** – An alternative to replacing poles is to relocate lines underground. This option was rejected as cost prohibitive for almost all existing 138kV transmission lines owned and operated by CenterPoint Houston. The cost of underground transmission is 5 to 10 times more costly than overhead lines.
3. **New Construction or Line Relocation**[89] – CenterPoint Houston could reduce outage exposure on at-risk lines by constructing new lines to operate at the same or higher voltage (along the same or new rights-of-way). These new lines would be built to a higher capacity line rating to meet future load growth. However, these options are far more costly and, therefore, are deemed to be non-viable alternatives.[90]

5.2.1.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually the total number of new poles that fail during major storms versus total existing poles that are below existing wind loading standards that fail.

5.2.1.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Transmission System Hardening resiliency measure on both a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described in Section 5.1, with project-specific inputs and assumptions described below.

1. **Quantitative Benefits** – Key assumptions include estimates of the average number of sustained interruptions avoided on transmission circuits targeted for rebuild during storms,[91] the average number of customers or load at risk, and estimated time to restore service. Failure rate of line sections where new towers are proposed is 0.2% annually and is based on the wind severity and frequency analysis for tornadoes or microbursts described in Section 4.2. The likelihood a severe wind event will cause two 138kV poles to fail (e.g., an N-2 event) is estimated at 10%. The estimated average cost of each pole replacement is $75,000. The estimated average load at risk is 175MW with an average restoration time of 48 hours.[92] The estimated average time to repair damage is 5 days or longer during extreme weather conditions. Other benefits include reduced costs for truck rolls and crew labor to restore service absent the presence of replacement poles. The Transmission System Hardening resiliency measure is projected to reduce total CMI over the 3-year Resiliency Plan by approximately 206 million and 87.6 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 6.0.

---

[89] CenterPoint has and will continue to evaluate the viability of underground relocation of line segments on a case-by-case basis.

[90] CenterPoint's transmission planning organization continually evaluates new or upgraded lines needed to reliably meet future growth, but these typically do not eliminate the need to replace inadequate wood poles. Further, CenterPoint's proposed 69kV-138kV Conversion Projects resiliency initiative, in some instances, meet growth requirements.

[91] Ibid.

[92] Load at risk is based on the contingency events impact on more than one line, as CenterPoint's transmission system is designed to meet first contingency planning criteria without loss of load.

2. **Qualitative Benefits** – The potential for new poles to avoid failure and customer interruptions during major storms is significant, particularly for high wind events. For systemwide storms that cause multiple transmission line outages, the number of customers interruptions absent pole hardening could be high. The ability of stronger poles to materially reduce the threat of extended outages is also high. When coupled with other transmission and distribution resiliency measures, transmission hardening can materially reduce the economic impact and disruption of load during major storms. The societal impact of outages from transmission line failures on a widespread basis could have severe consequences, ranging from the loss of critical infrastructure (e.g., water and sewage treatment), law enforcement challenges, and public safety, among other societal impacts. Some lines proposed for hardening, if unaddressed and interrupted, may contribute to a degradation of reliability and operational integrity of the high voltage transmission grid during major storms.

5.2.1.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that the majority of electric utilities surveyed include pole replacement/hardening investments in their resiliency plans. Figure 5-9 shows that all nine utilities that responded to the question regarding types of investments include pole replacements. Additionally, Figure 5-10 indicates that eight of the ten utilities surveyed prioritize transmission lines for resiliency investment. Further, Figure 5-12 shows that seven of the utilities aim to address aging infrastructure through their resiliency programs, while all ten indicate focus on mitigating extreme windstorm hazards. Pole replacement/line rebuilds was also one of the most common categories of resiliency initiatives identified by peer utilities.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that pole replacement/hardening programs are commonly included in electric utility resiliency investments for the jurisdictions examined. Eleven of the 15 jurisdictions summarized in Table 4 of Appendix A either proposed investments for or otherwise generally consider pole replacement/hardening resiliency investments to be within scope. For example:

- Connecticut includes system hardening such as stronger wood poles and steel poles as part of their resiliency efforts.
- Hawaii identifies hardening and reinforcing critical transmission circuits as in-scope, which includes upgrading structures and using enhanced construction materials.

5.2.1.6 Resiliency Measure Assessment and Conclusions

Guidehouse concludes that CenterPoint Houston's Transmission System Hardening resiliency measure is reasonable and beneficial for inclusion in its Resiliency Plan for the following reasons:

- The replacement of poles and galloping conductor mitigation conforms to CenterPoint Houston's wind loading standard for 138kV transmission, resulting in fewer line failures and interruption of critical load during high wind events.
- CenterPoint Houston has targeted transmission line sections with a high percentage of poles that do not meet its current wind loading design standard and that are susceptible to outages during high winds.
- Guidehouse's analysis of CenterPoint Houston's Transmission System Hardening resiliency measure produced a BCA that confirms the program is cost-effective.
- The installation of more robust poles is consistent with practices deployed at other utilities based on prior experience and benchmark survey results.
- The potential for widespread outages and resulting societal consequences of line failures underscores the criticality of maintaining a reliable transmission network.

5.2.2 S90 Tower Replacements

5.2.2.1 Resiliency Measure Description

CenterPoint Houston's S90 Tower Replacements resiliency measure is designed to replace transmission 90-degree corner lattice towers with concrete or steel poles on circuits vulnerable to high wind events (e.g., tornadoes and microbursts). All towers targeted for replacement are rated 345kV. CenterPoint Houston proposes to replace transmission towers that have deteriorated or are unable to meet CenterPoint Houston's current wind loading standard. CenterPoint Houston's S90 Tower resiliency measure is one of CenterPoint Houston's primary resiliency initiatives based on level of investment. Towers replaced with poles will meet CenterPoint Houston's current National Electric Safety Code ("NESC") wind loading standard and is based on the American Society of Civil Engineers ("ASCE") 7-16 wind map and 100-year Mean Recurrence Interval ("MRI"), Exposure C or D (dependent on the proximity to the Gulf of Mexico). The failure rate of line towers where asset hardening is proposed is 0.2% based on wind speed and probability of tower failure based on the analysis from Section 4.2.

Figure 5-2 displays typical transmission towers before and after replacement. Lattice towers are replaced by stronger steel or concrete monopoles to improve resiliency.

Figure 5-2: Typical Transmission Towers Before and After Replacement

Source: CenterPoint Houston.

The following presents CenterPoint Houston's proposed Resiliency Plan investments for S90 Tower Replacement resiliency measures.

- Number of towers targeted: **27** in 2025 and **3** in 2026 and 2027 (**30** total).
- Total project cost: **$103.8 million** over the 3-year Plan

As of January 2024, CenterPoint Houston has identified 77 towers in need of replacement, of which 34 have been replaced with poles over the past 4 years. The cost of these upgrades is $119 million.

5.2.2.2 Alternatives Considered

CenterPoint Houston evaluated two alternatives to the proposed replacement of S90 towers.

1. **Overhead to Underground Relocation** – One alternative to replacing towers is to relocate overhead lines underground. This option was rejected as cost prohibitive for almost all lines constructed with towers.
2. **New Construction or Line Relocation** – CenterPoint Houston could reduce outage exposure on at-risk lines by constructing new lines to operate at the same or higher voltage (along the same or new rights-of-way). These new lines would be built to a higher capacity line rating to meet future load growth. However, these options are far more costly and, therefore, are deemed to be non-viable alternatives.

5.2.2.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the Commission annually the total number of new structures that fail during major storms versus the total number of towers that fail and that are below its current design standard. CenterPoint Houston will also document transmission line performance as measured by the number of outages on transmission lines that have new towers to those that are pending.

5.2.2.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed S90 Tower Replacements resiliency measure on both a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described in Section 5.1, with project-specific inputs and assumptions described below.

1. **Quantitative Benefits** – Key assumptions include estimates of the average number of sustained interruptions avoided on transmission lines with towers targeted for replacement with poles during storms, the average number of customers or load at risk, and estimated time to restore service. The failure rate of line sections where new towers are proposed is 0.2% annually and is based on the wind severity and frequency analysis for tornadoes from Section 4.2. The likelihood of load loss for a common mode (N-2) failure on a tower line is estimated at 75%. The estimated average load at risk is 729 MW with an average restoration time of 60 hours. The estimated time to repair damage is 5 days during extreme weather conditions. Other benefits include reduced costs for truck rolls and crew labor to restore service absent the presence of replacement towers. The Transmission Tower Replacements resiliency measure is projected to reduce total CMI over the 3-year Resiliency Plan by approximately 41.7 and 16.4 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 4.9.
2. **Qualitative Benefits** – The potential that new towers will avoid failure and customer interruptions during major storms is significant, particularly for high wind events. For systemwide storms that cause multiple transmission line outages due to tower failures, the potential for a large number of customers to experience lengthy interruptions is high. The ability of new towers to materially reduce the threat and impact of extended outages is equally high. When coupled with other T&D resiliency measures, new transmission towers materially reduce the economic impact and disruption of load during major storms. The societal impact of outages from transmission line failures on a widespread basis could have severe consequences, ranging from the loss of critical infrastructure (e.g., water and sewage treatment), law enforcement challenges, and public safety, among other impacts. Some lines proposed for hardening, if left unaddressed, may contribute to a degradation of reliability and operational integrity of the transmission grid during major storms.

5.2.2.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that 8 of the 10 electric utilities surveyed prioritize transmission lines for resiliency investment, as shown in Figure 5-10. Additionally, Figure 5-12 shows that 7 of the utilities aim to address aging infrastructure through their resiliency programs, while all 10 direct their focus toward mitigating extreme windstorm hazards.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that transmission programs are commonly included in electric utility resiliency investments for the jurisdictions examined. 7 of the 15 jurisdictions summarized in Table 4 of Appendix A either proposed investments or otherwise generally consider transmission investments to be within scope. For example:

- Connecticut includes system hardening such as steel poles and fiberglass cross arms as part of their resiliency efforts.
- Hawaii identifies hardening and reinforcing critical transmission circuits as in-scope, which includes upgrading structures and using enhanced construction materials.

5.2.2.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's S90 Tower Replacements resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The replacement of towers with concrete or steel poles that meet CenterPoint Houston's current wind loading standard will cause fewer line failures and interruption of critical load during high wind events.
- For this measure, CenterPoint Houston is targeting transmission line sections with a high percentage of towers that do not meet its current design standard and that are susceptible to outages during high wind events.
- Guidehouse's analysis of the S90 Tower Replacements resiliency measure produced a BCA that confirms it is cost-effective.
- The installation of more robust poles is consistent with practices deployed at other utilities based on prior experience and peer utility benchmarking survey results.
- The potential for widespread outages and resulting societal consequences of line failures underscores the criticality of maintaining a reliable transmission network.

5.2.3 69kV-138 kV Conversion Projects

5.2.3.1 Resiliency Measure Description

CenterPoint Houston's 69kV-138kV Conversion Projects resiliency measure converts 69kV lines on CenterPoint Houston's transmission system to operate at a higher voltage. The project has several purposes: (1) remove aged 69kV transformers and replace deteriorated poles or structures that do not meet CenterPoint Houston's current wind loading design standard; (2)

eliminate the need to maintain 69kV spare equipment; (3) provide additional 138kV paths into downtown Houston to relieve high loading on existing 138kV circuits; and (4) further enhance grid resiliency by increasing lines ratings via voltage conversion. For these conversions, CenterPoint Houston proposes to replace wood poles with concrete or metal monopole poles and replace conductor, insulators, and associated hardware.[93]

Over time, CenterPoint Houston proposes to eliminate or convert its entire 69kV network to operate at 138kV. The transmission line segments that CenterPoint Houston propose to convert as part of its Resiliency Plan include lines most susceptible to failure during major storms and extreme weather events. CenterPoint Houston's 69kV-138kV Conversion Projects resiliency measure is one of CenterPoint Houston's primary resiliency measures based on level of investment. Poles and structures that are replaced and upgraded to operate at 138kV will meet CenterPoint Houston's current wind loading standard from ASCE 7-16 and is based on the 100-year MRI Exposure C or D (dependent on proximity to Gulf of Mexico).

CenterPoint Houston has prioritized 10 projects based on location and weather risk. Conversion measure quantities and investment amounts appear below.

- Mileage of 69kV lines targeted: **108 miles**
- Total project cost: **$268.4 million** over the 3-year Plan

As of January 2024, CenterPoint Houston has upgraded 8 circuits over the past 4 years to 138 kV specifications. The cost of these upgrades was $162 million.

5.2.3.2 Alternatives Considered

CenterPoint Houston evaluated two alternatives to the proposed voltage conversion projects.

1. **Overhead to Underground Relocation** – One alternative to replacing existing wood poles is to relocate 69kV lines underground. This option was rejected as cost prohibitive as well as prolonging CenterPoint Houston's conversion of its 69kV network. Further, the cost of underground transmission is 5 to 10 times more costly than overhead lines.
2. **Line Relocation**[94] – CenterPoint Houston could reduce outage exposure on at-risk 69kV lines by relocating lines along new rights-of-way (ROW) with less exposure to storms.

However, this option was eliminated from consideration due to added cost, desire to retain existing ROWs, and limited opportunities for relocation.

5.2.3.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually the total number of number of outages of 69 kV converted lines to determine effectiveness.

[93] CenterPoint will re-use existing conductor when the condition and rating of the conductor is suitable for 138kV operation.

[94] CenterPoint has and will continue to evaluate the viability of underground relocation online segments on a case-by-case basis.

5.2.3.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed 69kV-138kV Conversion Projects resiliency measure on both a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described in Section 5.1, with resiliency measure-specific inputs and assumptions described below.

1. **Quantitative Benefits**[95] – Key assumptions include estimates of the average number of sustained interruptions avoided on transmission circuits targeted for conversion during storms,[96] the average number of customers or load at risk, and estimated time to restore service. The failure rate of line sections where hardening is proposed is 0.2% based on wind speed and frequency analysis described in Section 4.2.1. The likelihood a severe wind event will cause two 138kV poles to fail (e.g., an N-2 event) is estimated at 10%. The cost of each pole replacement is $75,000. The estimated average load at risk is 75 MW with an average restoration time of 48 hours.[97] Other benefits include reduced costs for truck rolls and crew labor to restore service absent the presence of replacement poles. The 69kV-138kV Conversion resiliency measure is projected to reduce total CMI over the 3-year Resiliency Plan by approximately 46.8 million and 20 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 1.9.
2. **Qualitative Benefits** – The potential for a converted line to avoid failure and customer interruptions during major storms and other extreme weather events is significant, particularly for high wind events. For systemwide storms that cause multiple transmission line outages, the number of customer interruptions would be high. The ability of upgraded lines with stronger poles to reduce the threat of extended outages is equally high. When coupled with other T&D resiliency measures, converted transmission lines materially reduce the economic impact and disruption of critical load during major storms and other extreme weather events. The societal impact of outages from transmission line failures on a widespread basis could have severe consequences, ranging from the loss of critical infrastructure (e.g., water and sewage treatment), law enforcement challenges, and public safety, among other societal impacts.

5.2.3.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several of the electric utilities surveyed include conversion projects in their resiliency plans. Figure 5-9 shows that four of the nine utilities that responded to the question regarding types of investments include conversion projects. Additionally, Figure 5-10 indicates that eight of the ten utilities

[95] Additional benefits include the potential to defer transmission capacity related to load growth, but not included in BCA totals.

[96] Guidehouse assumes for purposes of this study that the number of avoidable transmission pole failures during normal weather is far lower than major storms and other extreme weather events.

[97] Load at risk is based on contingency events that impact more than one line, as CenterPoint's transmission system is designed to meet first contingency planning criteria without loss of load.

surveyed prioritize transmission lines for resiliency initiative investment focus. Further, Figure 5-12 shows that seven of the utilities aim to address aging infrastructure through their resiliency programs, while all ten direct their focus toward mitigating extreme windstorm hazards.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that transmission programs are commonly included in electric utility resiliency investments for the jurisdictions examined. Seven of the 15 jurisdictions summarized in Table 4 either proposed investments or otherwise generally consider transmission investments to be within scope. For example:

- DTE's Distribution Grid Plan specifically includes 4.8kV Hardening in the various infrastructure resilience and hardening efforts proposed.
- Further, Entergy's 10-Year Resiliency Plan proposes approximately 9,600 distribution and transmission projects that will collectively harden more than 269,000 structures over 11,000-line miles.

5.2.3.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's 69kV-138kV Conversion Projects resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The upgrading of 69kV lines to meet CenterPoint Houston's current wind loading standard will result in fewer line failures and interruption of critical load during high wind events.
- CenterPoint Houston has targeted transmission line conversion to better withstand high winds. It will also enhance resiliency via increased line ratings with attendant capability to serve future growth.
- Guidehouse's analysis of the CenterPoint Houston's 69kV-138kV Conversion Projects measure produced a BCA that confirms it is cost-effective; however, the additional benefits associated with increased capacity rating and elimination of a voltage class no longer in use, while not quantified, further supports the measure.
- The conversion of low voltage transmission to operate at higher voltage is consistent with practices deployed at other utilities based on prior Guidehouse experience.
- The potential for widespread outages and resulting societal consequences of line failures underscores the criticality of maintaining a reliable transmission network.

5.2.4 Coastal Resiliency Upgrades

5.2.4.1 Resiliency Measure Description

CenterPoint Houston's Coastal Resiliency Upgrades includes large-scale line upgrades in coastal areas, designed to prevent the loss of electric supply to coastal areas following the loss of critical transmission supply lines and/or significant power quality issues. A loss of transmission lines for a common mode failure of a transmission circuit followed by the loss of a second line due to high winds or corrosion could result in an extended interruption of supply to coastal areas.[98]

CenterPoint Houston proposes to upgrade existing lines to improve resiliency of supply to coastal areas. On overhead lines, poles and towers that are replaced will meet CenterPoint Houston's current wind loading design standard. The second initiative includes the rerouting of a single transmission line and building a new transmission circuit to mitigate power quality concerns. This is also intended to avoid a loss of critical lines that could cause unacceptable low voltages and overloads, resulting in the loss of radial feeds to industrial customers and generators with up to 1,100 MW of load at risk. Analysis from Section 4.2 indicates that the probability of exceeding 140 mph winds in coastal areas in 2030 is 0.2%.

The cost of the project over three years is **$259 million** and a total project cost of **$504.5** million. The annual expense to inspect and maintain the new facilities is **$750,000**.

5.2.4.2 Alternatives Considered

CenterPoint Houston identified two potential alternatives to the proposed coastal transmission upgrades:

1. **Local Generation** – One option is to install generation along coastal areas, either from conventional generating sources such as gas combustion turbines or alternative resources such as energy storage. While viable, there would be considerable challenges for third-party owners to obtain a permit for a thermal generation source. Similarly, the size of an energy storage facility large enough to meet coastal area load under contingency conditions would be costly. Further, each source is subject to failure during major floods and storm surges.
2. **Build New 138kV Transmission Lines** – Another option is to build new 138kV transmission lines however, this option was rejected due to environmental impacts and relatively high costs. For this alternative, CenterPoint Houston reviewed a number of options, each proving to be less cost-effective than the proposed upgrades. Further,

[98] Also referred to as an N-1-1 contingency event. Defined by the North American Electric Reliability Corporation (NERC) as "A sequence of events consisting of the initial loss of a single generator or transmission component (Primary Contingency), followed by system adjustments, followed by another loss of a single generator or transmission component (Secondary Contingency). The forced outage of a double-circuit transmission line in excess of 0.5 miles in length is defined by ERCOT as a Credible Single Contingency.

some options did not solve contingency needs while other options were not cost-effective or did not fully resolve the contingency exposure.

5.2.4.3 Resiliency Measure Metrics and Effectiveness

Once the project is completed and in operation, targeting 2027, CenterPoint Houston will track and report to the PUCT annually the total number of outages and interruption of supply avoided.

5.2.4.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Coastal Resiliency Upgrades measure on both a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described in Section 5.1, with resiliency measure-specific inputs and assumptions described below.

1. **Quantitative Benefits**[99] – Key assumptions include estimates of the frequency of sustained interruptions avoided for common mode tower failures during major storms and other extreme weather events,[100] the average load at risk, and estimated time to restore service. The failure rate of line sections where hardening is proposed is 0.2% based on wind speed and frequency analysis described in Section 4.2.1. The likelihood a severe wind event will cause two structures or lines to fail (e.g., an N-2 event) at both locations is estimated to be 20%. These values consider the potential loss of critical lines during major storms, but exclude power quality events (e.g., low area voltage) due to loss of area generation. The estimated average load at risk is 1350 MVA with an average restoration time of up to 120 hours.[101] Other benefits include reduced costs for crew labor to restore service absent a new line, including the time and cost associated with the installation of mobile generators at a cost of $25 million per event. The Coastal Resiliency Upgrades project is projected to reduce total CMI over the 3-year Resiliency Plan by approximately 21.9 million and 21.9 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 1.4.
2. **Qualitative Benefits** – The ability of reinforced lines to avoid failure and customer interruptions during major storms and severe weather events is significant, particularly during high wind events. Absent these upgrades, if a major storm were to cause tower failure with the loss of two lines, the potential for a loss of electric supply during major storms would be high. The ability of new 138kV transmission lines to reduce the threat of extended outages is equally high. The avoidance of low area voltage or voltage collapse due to a loss of area generation adds to potential consequential impacts. The societal impact of outages affecting coastal area load could have severe consequences, ranging

[99] Additional benefits include the potential to defer transmission capacity related to load growth, but not included in BCA totals.

[100] Guidehouse assumes for purposes of this study that the number of avoidable common mode transmission tower failures during normal weather is far lower than major storms and extreme weather events.

[101] Load at risk is based on the contingency events impact of more than one line section, as CenterPoint's transmission system is designed to meet first contingency planning criteria without loss of load. Restoration of load on the islands based on installation of mobile generation.

from the loss of critical infrastructure (e.g., water and sewage treatment), law enforcement challenges, and public safety, among other societal impacts.

5.2.4.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several of the electric utilities surveyed include transmission improvement projects in their resiliency plans. Figure 5-9 shows that all 9 utilities that responded to the question regarding types of investments include both line/circuit rebuilds and pole replacements. Additionally, Figure 5-10 indicates that 8 of the 10 utilities surveyed prioritize transmission lines for resiliency initiative investment. Further, Figure 5-11 indicates that decreasing the impact of major events and reducing restoration time were the most common primary goals of utility resiliency plans selected by those surveyed, which aligns with CenterPoint Houston's objectives for this resiliency measure. Pole replacement/line rebuilds was also one of the most common categories of resiliency initiatives identified by peer utilities.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that transmission programs are commonly included in electric utility resiliency investments for the jurisdictions examined. 7 of the 15 jurisdictions summarized in Table 4 either proposed investments or otherwise generally consider transmission investments to be within scope. For example:

- Entergy's 10-Year Resiliency Plan proposes approximately 9,600 distribution and transmission projects that will collectively harden more than 269,000 structures over 11,000-line miles.
- Hawaii identifies hardening and reinforcing critical transmission circuits as in-scope, which includes upgrading structures and using enhanced construction materials.

5.2.4.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Coastal Resiliency Upgrades is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- First, the Coastal Resiliency Upgrades resiliency measure mitigates the risk of an extended interruption of electric supply to coastal areas for contingency outages during resiliency events or structure failures during storms.
- The installation of new 138kV transmission lines will avoid the lengthy interruption of critical load during high wind events. It will also enhance resiliency via increased capacity to serve coastal area load growth.

- Guidehouse's analysis of the CenterPoint Houston's Coastal Resiliency Upgrades produced a BCA that confirms the measure is marginally cost-effective, but that we conclude should be approved by the Commission due to the magnitude and disruption associated with a loss of coastal area load.
- CenterPoint Houston's proposal to install new transmission to meet a N-1-1 contingency without load loss is consistent with good utility practice.
- Lastly, the potential for lengthy sustained outages and resulting societal consequences to island residents and businesses underscores the criticality of maintaining reliable electric supply to the islands.

5.2.5 Substation Transformer Fire Protection Barriers

5.2.5.1 Resiliency Measure Description

CenterPoint Houston's Substation Transformer Fire Protection Barriers resiliency measure is designed to protect power transformers and other equipment vulnerable to damage caused by the catastrophic failure of adjacent transformers. Although substation transformer failures are uncommon compared to other distribution equipment failures (e.g., broken poles), the consequences and impact of a catastrophic failure can be severe. An enormous amount of energy is released when a transformer catastrophically fails, with the possibility of extensive damage to nearby equipment from associated fire and debris. The potential for lengthy outages and costly repairs if such an event occurs is high. Extinguishing the fire also presents challenges to fire department personnel.

CenterPoint Houston proposes to install either concrete or metal barriers between substations transformers in locations where the impact of a catastrophic failure is high. As discussed in Section 4.2 , increased variability and higher temperatures over time increases the risk of transformer failures. Substations targeted for substation fire protection barriers include locations where the magnitude of load at risk is high or those that serve critical customers or facilities (e.g., those serving hospitals or facilities providing emergency services).

CenterPoint Houston's proposed Resiliency Plan quantities and investments is presented below:

- Number of substation fire protection barriers targeted: **4** per year (**12** total)
- Total project cost: **$2.4 million** (**$200,000** for each barrier)

As of January 2024, CenterPoint Houston has installed fire protection barriers at 41 substations with 5 more in progress. The collective cost of the completed substation fire protection barriers to date is $10.5 million.