5.2.5.2 Alternatives Considered

Alternatives to the substation fire protection barriers are not applicable, as there are no viable alternative options for protecting equipment from catastrophic transformer failures.

5.2.5.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston plans to track and report to the PUCT annually the total number of substation transformer failures detailing whether or not the fire prevention barrier prevented damage to adjacent transformers and other substation equipment. CenterPoint Houston will also estimate outages avoided and damage averted for each future transformer failure where fire prevention barriers are installed.

5.2.5.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Substation Transformer Fire Protection Barriers resiliency measure on a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described at the beginning of Section 5.1 , with resiliency measure-specific inputs and assumptions described below.

1. **Quantitative Benefits** – Key assumptions include the probability of a transformer failure and the likelihood the failure will cause adjacent transformers or nearby equipment to fail. For most substations, high temperatures coupled with high through-fault currents place critical equipment at risk of failure. The probability over the next 10 years that a catastrophic failure is likely to occur at one of the 12 substations is 0.2%, with 75% of such events causing damage to adjacent equipment. The average amount of load at risk at substations where fire protection barrier installations are proposed is 75 MW with restoration times averaging 18 hours.

   Benefits include reduced load loss, shorter restoration times, and the high cost of avoided repairs and crew labor required to restore service. From these assumptions, Guidehouse derived a composite BCA of 3.7 for the 21 substations targeted for fire protection barriers. The Substation Fire Protection Barriers resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 0.5 million and 0.2 annually by 2027.

2. **Qualitative Benefits** – The potential for nearby equipment to fail when a power transformer fails catastrophically is high, resulting in lengthy outages to customers served by the substation. Substations serving critical loads, area industries, and businesses could experience disruption in day-to-day operations and economic harm if such an event occurred. Further, a major fire at a substation would likely draw negative media attention, with associated reduced confidence in the electric utility from its customers and general public. Below in Figure 5-3 are photographs of a fire that occurred at CenterPoint Houston's Kluge Substation in 2016

Figure 5-3: 2016 Substation Fire

Source: CenterPoint Houston.

5.2.5.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that substation hardening/flood control is one of the most common categories of resiliency initiatives identified by peer utilities. Additionally, Figure 5-10 indicates that eight out of the ten utilities surveyed prioritize transmission and distribution substations for resiliency initiative investment. Further, Figure 5-11 indicates that decreasing 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.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that some electric utilities in the jurisdictions examined focus on substation and grid hardening in their resiliency plans. For example:

- DTE's Distribution Grid Plan includes upgrades to transformers and substation equipment in the various infrastructure resilience and hardening efforts proposed.
- Virginia identifies grid hardening resiliency investments as in-scope.

Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Substation Transformer Fire Protection Barriers resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The proposed solution effectively avoids major equipment damage due to transformer failures.

- Installation of firewalls at critical substations is a responsible action to undertake given the potential consequences of a catastrophic failure.
- The proposed measure is consistent with practices deployed at other utilities based on Guidehouse experience and peer utility benchmarking survey results described in Section 5.3.
- Installation of firewalls at critical substations also avoids potentially undesirable attention and loss of confidence in CenterPoint Houston from its customers and the general public for failures that result in major substation fires.

5.2.6 Distribution Pole Replacement/Bracing Program

5.2.6.1 Resiliency Measure Description

CenterPoint Houston's Pole Replacement/Bracing Program resiliency measure is designed to replace poles that have been identified during scheduled inspections as not meeting CenterPoint Houston's minimum remaining strength criteria.[102] Poles are either replaced or braced to meet CenterPoint Houston's current extreme wind and ice loading design standard.[103] Although existing poles meet the design standard in effect at the time they were built, they may not meet changes in the design standard due to increased extreme weather severity and frequency. The estimated percentage of poles replaced or braced is 58% and 42%, respectively, with 69% on lateral line sections and 31% on main line feeders. The pole type, class, and height of replacement poles are based on several conditions specified in CenterPoint Houston's Distribution Pole Replacement Guidelines shown in Figure 5-4. To improve pole resiliency strength in high wind conditions and to expand the life of new poles, CenterPoint Houston has introduced composite (fiberglass) and metal (ductile iron) poles, in addition to traditional wood poles. However, the optimal pole selection will be determined based on a site-specific evaluation by engineering and operational personnel.

[102] The Pole Replacement/Bracing program is adjunct to the Distribution Circuit Rebuild program. The primary distinction is that pole replacements for circuit rebuilds includes replacement of poles on circuits that meet minimum strength requirements but are not compliant with CenterPoint's current heavy loading design standard.

[103] To meet the current design standard for each region, other equipment such as crossarms, insulators and brackets located on these poles may need to be replaced or upgraded. Lines with small conductor (e.g., #4 or #6 wire) may be replaced with high rated conductor.

Figure 5-4: Circuit Rebuild Installation Guidelines

	Wood	Fiberglass	Ductile Iron
Circuit North of US59/HWY 90 (110 MPH)	CL 2	X	X
Circuit South of US59/HWY 90 (132 MPH)	CL 2	X	X
Lateral Poles (110 & 132 MPH)	CL 4	X	X
Secondary Poles (110 & 132 MPH)	CL 6	X	X
IGSD			X
Regulator Rack (Exterior Poles)			X
Transformer Banks (>250's)			X
Double Circuit Poles		X	X
Junction Poles		X	X
Substation Getaway (within 1st Section)		X	X
Capacitor Banks		X	X
Pole Top Switches		X	
Three Phase Terminal Poles		X	

Source: CenterPoint Houston.

CenterPoint Houston's proposed Resiliency Plan quantities and investments for pole replacements is presented below.

- Number of feeders targeted: **5,000 pole installations/bracings** per year (**15,000** total)[104]
- Total project cost: **$99.3 million** over the 3-year Plan

As of January 2024, CenterPoint Houston has replaced/braced 6,732 poles over the past 5 years at a total cost of $122.9 million.

5.2.6.2 Alternatives Considered

The only alternative to replacing/bracing poles that have deteriorated to below CenterPoint Houston's minimum strength criteria is to reactively replace poles after they have failed. This option was rejected as non-viable because of the lower reliability and increased restoration costs.

5.2.6.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually the total number of replacement poles that fail during major storms versus the total number of legacy poles that fail that do not meet its current design standard.

[104] 5,000 poles will be targeted to be analyzed annually to determine whether bracing is sufficient to meet the wind loading requirements (based on location) or if an upgraded pole is the preferred method.

5.2.6.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Pole Replacement/Bracing 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** – Key assumptions include estimates of the average number of sustained, storm-related interruptions avoided on distribution main lines and laterals where poles will be replaced/braced;[105] the average number of customers or load at risk, and the estimated time to restore service. The failure rate of existing poles where rebuilds are proposed is adjusted for wind speeds and event frequency forecasts described in Section 4.2.1, which shows a 2% probability of exceeding 70 mph inland, and 5% probability of exceeding 70 mph in coastal counties in 2030. Of these failures, 25% are assumed to result in interruption of customer load.[106] From these values, approximately 0.5% of inland poles are expected to fail and about 1% of coastal poles in coastal areas are expected to fail. These forecasts are similar to information included in a Florida Power and Light filing which showed measured rate of failure for non-hardened poles during Hurricane Irma to be 0.2%[107] The estimated average load at risk is 15 MW with an average restoration time of 6 hours. Other benefits include reduced costs for truck rolls and crew labor to restore service absent the presence of replacement poles. The Pole Replacement/Bracing resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 41.3 million and 20.8 million annually by 2027. From these assumptions, Guidehouse derived a composite BCA of 6.2.
2. **Qualitative Benefits** – The potential that poles meeting the heavy loading standard will avoid failure and related customer interruptions during major storms and other extreme weather events is significant, particularly during high wind events. For systemwide storms that cause a large number of outages due to pole failures, the number of customers that may experience lengthy interruptions can be high. The ability of stronger poles to materially reduce the impact of extended outages, when coupled with other resiliency measures, collectively reduces the economic impact and disruption of critical load during major storms and other extreme weather events.

5.2.6.5 Benchmarking

Peer Utility Benchmarking

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

[106] Percentage assumes 25% of poles will be oriented perpendicular to prevailing winds or otherwise protected by structures or tree lines.

[107] Florida Power & Light Company. (2022 April). *2023-2032 Storm Hardening Plan, DOCUMENT NO. 02358-2022* [FP&L Storm Hardening Plan]. 02358-2022.pdf (floridapsc.com)

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 include investments related to pole replacements. Additionally, Figure 5-10 indicates that all ten of the utilities surveyed prioritize distribution lines for resiliency initiative investment focus. Further, Figure 5-12 shows that seven of the utilities aim to address aging infrastructure through their resiliency measures, while all ten direct their focus toward 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 or generally consider pole replacement/hardening resiliency investments to be within scope. For example:

- Florida includes pole inspections and replacements as part of their resiliency efforts.
- Hawaii includes upgrading wind criteria and structures as part of their hardening process.
- Connecticut includes system hardening such as stronger wood poles and steel poles.

5.2.6.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Pole Replacement/Bracing resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- It cost-effectively hardens distribution circuits.
- The replacement/bracing of poles to meet CenterPoint Houston's extreme wind and ice design standard will result in fewer failures and sustained interruptions during high wind events.
- CenterPoint Houston's pole replacement criteria ensures the appropriate pole type (wood, fiberglass, or ductile iron) is selected based on locational exposure to storm events and application.
- Based on prior Guidehouse experience and peer utility benchmarking survey results, the installation of more robust poles is consistent with resiliency practices deployed at other utilities.

5.2.7 Distribution Resiliency – Circuit Rebuilds

5.2.7.1 Resiliency Measure Description

CenterPoint Houston's Distribution Resiliency – Circuit Rebuilds resiliency measure is responsive to increased frequency and severity of extreme weather events. It is designed to replace and improve pole strength by meeting current NESC design standards on circuits where a substantial number of poles were installed under the prior standard at the time of construction but do not meet CenterPoint Houston's current and higher extreme wind and ice design standard.[108] This resiliency measure includes utilization of non-wood engineered structures, hardening substation getaways, and removal/replacement of equipment.

The circuits that CenterPoint Houston targets for resiliency rebuild through the installation of more robust poles and associated equipment are those most susceptible to failure during major storms and other extreme weather events that do not meet current engineering design standards. CenterPoint Houston's Distribution Resiliency – Circuit Rebuilds resiliency measure is one of the primary initiatives included in its Resiliency Plan in terms of level of investment. Replacement poles will meet CenterPoint Houston's current extreme wind and ice design standard.[109] The pole type, class, and height of replacement poles is based on several conditions specified in CenterPoint Houston's Distribution Circuit Rebuild Guidelines shown above in Figure 5-4.[110] The circuits chosen for upgrade will be prioritized according to those that serve critical facilities (e.g., hospitals, water treatment plants, police stations); support mobile generation; or serve underserved communities. Circuit selection and pole placement location will be further enhanced with the full implementation of Digital Twin technology presented in Section 5.2.14.

CenterPoint Houston's proposed Resiliency Plan quantities and investments for circuit rebuilds is presented below.

- Number of feeders targeted: **300 to 350 miles** per year for an average of **38 circuits** per year
- Total project cost: **$312.8 million** over the 3-year Plan

As of January 2024, CenterPoint Houston has upgraded over 33 circuits over the past 2 years at a cost of over $84.1 million.

[108] CenterPoint Houston has adopted the latest version of NESC and is designing its distribution poles to Rule 250C (extreme wind) and 250D (extreme ice with concurrent wind loading), regardless of pole height.

[109] To meet the current NESC design standard, other equipment such as crossarms, insulators, and brackets located on these poles may need to be replaced or upgraded. Lines with small conductor (e.g., #4 or #6 wire) may be replaced with high rated conductor.

[110] The table outlines the minimum recommendation template for field use when a consultant/DDS is not available in order to select pole material for each type of installation.

5.2.7.2 Alternatives Considered

The only viable alternative to replacing circuits that do not meet CenterPoint Houston's current design standard is to replace poles that are in need of immediate or near-term replacement. This option was rejected as more costly than proactive replacement. CenterPoint Houston could reduce outage exposure on circuits via reconfiguration and transfer to newly built adjacent circuits. However, reconfiguration does not reduce the risk of pole failures and therefore, is a non-viable alternative.

5.2.7.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the Commission annually the total number of replacement pole failures during major storms versus the total number of poles that fail and that are below its current design standard.

5.2.7.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Distribution Circuit Rebuild 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** – Key assumptions include estimates of the average number of sustained interruptions avoided on distribution circuits targeted for rebuild,[111] the average number of customers or load at risk, and estimated time to restore service. The failure rate of poles where rebuilds are proposed is 3.5% per year, which was derived based on the wind speed and event frequency forecasts described in Section 4.2.1. The percent of failures resulting from poles encountering these wind speeds is 25%. The estimated average number of customers at risk is 1,093, with an average restoration time of 18 hours. The estimated time to repair damage is up to 15 days during extreme weather conditions. Other benefits include reduced costs for truck rolls and crew labor to restore service. The Distribution Circuit Rebuild resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 137.4 million and 69.4 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 7.0.
2. **Qualitative Benefits** – The potential that poles not meeting CenterPoint Houston's current design standard will fail during major storms and other extreme weather events is significant, particularly during high wind events. For systemwide storms that cause many outages due to pole failures, the number of customers that may experience lengthy interruptions is also high. The ability of stronger poles to materially reduce the impact of extended outages, when coupled with other resiliency measures, collectively

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

reduces the economic impact and disruption of critical load during major storms and other extreme weather events.

5.2.7.5 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 are deploying and seeking to address those related to pole replacements. Additionally, Figure 5-10 indicates that all ten of the utilities surveyed prioritize distribution 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. 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 or generally consider pole replacement/hardening resiliency investments to be within scope. For example:

- Hawaii includes upgrading wind criteria and upgrading structures as part of their hardening process.
- Connecticut includes system hardening such as stronger wood poles and steel poles.

5.2.7.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Distribution Circuit Rebuild program is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The replacement of poles conforms to CenterPoint Houston's current and higher extreme wind and ice loading standard and will result in fewer failures and sustained circuit interruptions during high wind events.
- CenterPoint Houston has targeted circuits with a high percentage of poles that do not meet its current design standard and thus are more susceptible to outages during high winds.
- CenterPoint Houston's pole replacement criteria ensures that the appropriate pole type and size is selected based on locational factors and application.

- Guidehouse's analysis of the Distribution Circuit Rebuild resiliency measure produced a BCA that confirms the project is cost-effective.
- Based on prior Guidehouse experience with other utilities and peer utility benchmarking survey results in Section 5.3, the installation of more robust poles is consistent with practices deployed at other utilities.

5.2.8 Strategic Undergrounding/Freeway Crossings

5.2.8.1 Resiliency Measure Description

CenterPoint Houston's Strategic Undergrounding/Freeway Crossings resiliency measure is designed to replace wood poles and accessory equipment on overhead distribution lines at freeway crossings that are at risk of failure during major storms and other extreme weather events, or which could result in significant outages if damaged.[112] For overhead crossings, replacement poles will be concrete and meet CenterPoint Houston's extreme wind and ice design standard.[113] For underground crossings, terminal poles will be replaced with fiberglass poles. Prioritization of freeway crossing upgrades will consider condition, load at risk, and customer outage exposure. A typical crossing is shown in Figure 5-5.

Figure 5-5: Typical Freeway Crossing

Source: CenterPoint Houston photo of a crossing at I-10 and Dwight St.

CenterPoint Houston's proposed Resiliency Plan investments to convert overhead crossings to underground freeway crossings is presented below.

[112] Most overhead line reinforcements will remain overhead; however, some freeway locations may require underground relocation of overhead line crossings, such as those where the use of concrete poles is not feasible.

[113] The concrete poles will require new insulators, brackets, and other ancillary equipment. For some crossings, the existing conductor may also need to be replaced.

- Number of freeway crossings targeted: **10** per year (**30** total); number of overhead lines and underground cable is **8** and **2 per year**, respectively
- Total resiliency measure cost: **$31.2 million** over the 3-year Plan (**$300,000** for each overhead crossing, **$1 million** for each underground crossing)[114]

As of January 2024, CenterPoint Houston has reinforced 621 freeway crossings over the past 3 years at a cost of approximately $60 million.

5.2.8.2 Alternatives Considered

The only viable alternative to reinforcement via new poles is to relocate lines underground. CenterPoint Houston proposes to relocate crossings underground where concrete poles and overhead lines are not feasible or where there are multiple crossings at one location. It may be possible to terminate the line at the dead-end poles adjacent to the highway with one of the terminations connected to an alternative feeder. However, there would need to be a nearby alternate distribution circuit source to make this a cost-effective option, making opportunities to reconfigure freeway crossings limited. That said, this alternative should be considered where feasible.

5.2.8.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually the total number of upgraded freeway line crossings that fail during major storms.

5.2.8.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Strategic Undergrounding/Freeway Crossings 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** – Key assumptions include estimates of the average number of sustained, storm-related interruptions avoided on crossings where poles will be replaced, the average number of customers or load at risk, and estimated time to restore service. The failure rate of circuits where rebuilds are proposed is 2% inland and 5% in coastal areas for a wind speed threshold of 70 mph as described in Section 4.2.1. The estimated average load at risk is 8 MW for 12 kV crossings and 19 MW for 35 kV, with an average restoration time of 4.5 hours. Other benefits include reduced costs for truck rolls and crew labor to restore service absent the presence of replacement poles. The Strategic Undergrounding/Freeway Crossings resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 4.4 million and 2.2 million annually by 2027. Using these assumptions, Guidehouse derived a BCA of 3.8.

[114] The exact number of overhead versus underground freeway crossing replacements will be determined based on site specific engineering and operational analysis. Accordingly, program costs may vary from current estimates.

2. **Qualitative Benefits** – The potential that poles meeting the heavy loading standard will avoid failure and associated customer interruptions during major storms and other extreme weather events is significant, particularly during high wind events. For systemwide storms that cause a large number of customer outages on crossings due to pole failures, the number of customers that may experience lengthy interruptions can be high due to increased restoration times for coordinated repairs with traffic management personnel. Further, access to freeways is needed by emergency vehicles during major storm and other extreme weather events. When a wire is down across a highway, emergency response personnel (e.g., police, fire, national guard) do not have access to respond to make life saving rescues. The ability of stronger poles to materially reduce the impact of extended outages, when coupled with other resiliency measures, collectively reduces the economic impact and disruption of critical load during major storms and other extreme weather events. Line failures on major freeways are also highly visible, with attendant media attention and traveler inconvenience.

5.2.8.5 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 are deploying and seeking to address pole replacements. Additionally, 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. Further, seven of the utilities that responded selected decreasing impact of major events as a primary goal of their resiliency program.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that pole replacement/hardening programs are commonly included electric utility resiliency investments for the jurisdictions examined. Eleven of the 15 jurisdictions summarized in Table 4 of Appendix A either proposed investments or generally consider pole replacement/hardening resiliency 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 includes upgrading structures and using enhanced construction materials.

5.2.8.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Strategic Undergrounding/Freeway Crossings resiliency measure is reasonable and beneficial for inclusion in its Resiliency Plan for the following reasons:

- It cost-effectively enhances distribution resiliency and minimizes traffic and interruption of consumer travel and commerce as confirmed by the BCA value calculated by Guidehouse.
- The replacement of poles that conform to CenterPoint Houston's current design standard will result in fewer failures and sustained interruptions during high wind events and storms.
- CenterPoint Houston's Strategic Undergrounding/Freeway Crossings criteria ensures the appropriate pole type and size is selected based on locational factors and application; or when overhead lines are not suitable, will relocate lines underground below the highway.
- The installation of more robust poles is consistent with practices deployed at other utilities to improve resiliency based on prior Guidehouse experience and peer utility benchmarking survey results.

Grid Modernization

5.2.9 TripSaver®

5.2.9.1 Resiliency Measure Description

CenterPoint Houston's TripSaver® resiliency measure is designed to reduce the duration or number of sustained interruptions on distribution circuit lateral line sections for transient outage events, such as those that occur during momentary tree contact. TripSaver® replaces existing fused cutouts located along the first tap from the main line distribution circuit. For single or repeated momentary faults, the TripSaver® opens and recloses in an effort to clear the momentary fault. For sustained faults, the TripSaver® will open and lock out the lateral branch portion of the circuit. Distribution feeders targeted for TripSaver® installations include locations most susceptible to lateral line section outages, locations with a relatively high number of customers or load at risk, and locations providing service to critical customers or facilities (e.g., hospitals or facilities providing emergency services during storms).

The impact of TripSaver® on outage reduction estimates was informed by the results of the wind analysis presented in Section 4.2.1. Installation of TripSaver® is subject to certain conditions, including maximum line-to-ground fault currents below 6,000 amps, sufficient load current to energize the device, and the absence of large, distributed generation facilities (e.g., greater than 1 MW), among other requirements. Figure 5-6 shows a TripSaver® offered by an electric utility equipment supplier.

Figure 5-6: TripSaver®

Source: S&C Electric.

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

- Number of feeders targeted: **2,500 TripSaver® installations** per year (**7,500** total)
- Total project cost: **$58.9 million** over the 3-year Plan
- The annual maintenance expense for the TripSaver® measure is **$10,000** (**$30,000** over 3 years)

As of January 2024, CenterPoint Houston has installed over 2626 TripSaver® devices with 1271 in progress. The cost of the completed TripSaver® installations over the past 2 years is approximately $12.8 million.

5.2.9.2 Alternatives Considered

Two mitigation alternatives were evaluated as options to TripSaver® devices, including less sophisticated fault isolation schemes and the installation of new feeders to reduce outage exposure.

1. **Reclosing Circuit Breakers** – In lieu of TripSaver® devices, CenterPoint Houston could install single-phase or multi-phase reclosing circuit breakers on lateral taps in locations where the reclosers could better coordinate with upstream breakers. However, reclosers essentially provide the same functionality as TripSaver® devices for most faults, but at higher cost, and therefore were eliminated from consideration as a preferred alternative.[115]
2. **Reconfigure or Construct New Feeders or Substations** – Constructing new distribution feeders for the purpose of reducing outage exposure on laterals via

[115] CenterPoint has installed numerous reclosers on main line circuit sections throughout its service territory where coordination with upstream devices or remote access via SCADA is required.

reconfiguration and permanent load transfer could be a viable alternative on circuits where new load justifies the addition of new feeders. However, this solution is typically far less cost-effective than TripSaver® as it is costly to construct new circuits or substations. Further, this would result in increased outage exposure on the newly built distribution lines and substations.

5.2.9.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report annually on systemwide performance of TripSaver® operations during major storms. The number of successfully avoided interruptions will be estimated based on counter readings made during periodic inspections. Reports will also include metrics for both storm and normal weather operations.

5.2.9.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed TripSaver® resiliency measure on 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** – Key assumptions include estimates of the average number of sustained outages avoided on laterals targeted for TripSaver® installations during major and normal weather events, the average number of customers or average load at risk, and the estimated time to replace fuses on main line taps. The average number of sustained outages avoided per lateral is 0.40 during normal conditions and 0.43. during storms, which includes upward adjustments using results of the wind analysis presented in Section 4.2.1. The amount of load at risk on laterals targeted for TripSaver® installation is 400 kW with an average restoration time during major weather events estimated at 6 hours and 4 hours during normal weather. Restoration intervals were derived based on the amounts of load at risk, lateral location (i.e., distance from work location), and hours for repair, where applicable. Other benefits include reduced cost for truck rolls and crew labor to restore service absent the presence of TripSaver®. The TripSaver® resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 240.3 million and 122.2 million annually by 2027. On a systemwide basis, the BCA TripSaver® is 61.3.
2. **Qualitative Benefits** – TripSaver® devices help avoid blown fuses and related customer interruptions during major storms and other extreme weather events, particularly during high wind conditions. Because many lateral line sections will have lower restoration priority compared to main line outages, outage duration for customers located on lateral line sections is typically longer. For systemwide storms that impact many circuits, TripSaver® can significantly mitigate the number of customers who would sustain extended interruptions due to fuse operations for transient faults. The ability of TripSaver® devices to materially reduce the impact of outages during major storms and extreme weather events, coupled with other resiliency measures, collectively reduces the

economic impact of major storms and extreme weather events within CenterPoint Houston's service territory. It also ensures faster restoration of critical loads at relatively low cost.

5.2.9.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several of the electric utilities surveyed include TripSaver® in their resiliency plans. Figure 5-9 shows that four of the nine utilities that responded to the question regarding types of investments are deploying and seeking to address resiliency investments related to TripSaver®. Additionally, Figure 5-10 indicates that all ten of the utilities surveyed prioritize distribution lines for resiliency investment. Further, Figure 5-11 indicates that decreasing 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. Automation/customer resiliency is 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 grid modernization initiatives are generally included in electric utility resiliency planning efforts for several of the jurisdictions examined. For example:

- Outage management system upgrades and grid modernization communication systems are identified as in-scope in New Jersey.
- Virginia includes intelligent grid devices as well as operations and automated control systems as part of their resiliency efforts.

5.2.9.6 Resiliency Measure Assessment and Conclusion

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

- The ability of a TripSaver® to significantly reduce frequency and duration of sustained interruptions during high wind events at low cost is high, resulting in a robust BCA.
- Peer utility benchmarking survey results described in Section 5.3 demonstrate that the installation of a TripSaver® or similar technologies is consistent with practices deployed at other utilities.

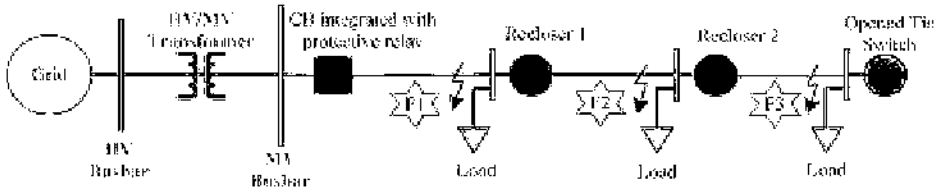
5.2.10 IGSD Installation

5.2.10.1 Resiliency Measure Description

CenterPoint Houston's Intelligent Grid Switching Device ("IGSD") Installation resiliency measure is designed to reduce the number of customers interrupted by faults occurring on main line sections of distribution circuits and reduce restoration time. CenterPoint Houston proposes to install up to 150 IGSD devices per year, either fully automated or remotely operated by distribution system operators, over the 3-year Resiliency Plan. Distribution feeders targeted for IGSD mitigation include locations most susceptible to main line outages[116] with additional consideration of the magnitude of load at risk (e.g., serving greater than 4,000 customers) and service to critical customers or facilities (e.g., hospitals or facilities providing emergency services during storms). A complementary technology resiliency measure includes installing remote equipment required to enable the communications between the IGSD device and the utility's control systems used by distribution controllers. The components allow for communications using the Company's 700MHz radios system, along with the LTE Cellular redundant systems, because any public carrier outages to the LTE Cellular system will also affect the redundancy of the IGSD communications package. The package is designed to include a battery backup.

Candidate feeders for IGSD are those that require minimum line upgrades and sufficient available capacity to accept loads from adjacent feeders or feeders from another substation following an outage on the main line section of the alternate circuit. Further, both the circuit where load will be transferred from and the circuit receiving the load (and vice-versa) should have sufficient load on the non-faulted line sections (e.g., at least 800 customers downstream of the device) and higher than average outage exposure to warrant the installation of IGSD. Successful IGSD load transfer occurs when faults located in line sections between the substation breaker and first line recloser are isolated and the un-faulted line section is transferred to the receiving feeder via closure of the tie transfer recloser.[117] Figure 5-7 illustrates a typical IGSD tie transfer scheme.

Figure 5-7: IGSD Configuration and Tie Transfer Scheme



[116] For example, feeders with main line interruption rates 300% above the average of all other circuits.

[117] Some schemes may utilize motor-operated, gang-connected, three-phase switches with remote access via SCADA communications.

Source: Le, D.P., Bui, D.M., Ngo, C.C., & Le, A.M.T. (2018 November 29). FLISR Approach for Smart Distribution Networks Using E-Terra Software—A Case Study. *Energies Journal, 11(12):3333.* https://doi.org/10.3390/en11123333 [118]

CenterPoint Houston's proposed Resiliency Plan quantities and investments appear below.

- Number of feeders targeted: **150 devices** and about **50 IGSD schemes** per year (**450** and **150** total number of devices, respectively, over 3 years)[119]
- Total project cost: **$48.7 million** for IGSD devices and **$5.1 million** for Telecom support
- The expense to inspect and maintain the new equipment over three years is **$820,000**.

As of January 2024, CenterPoint Houston has completed 1,378 IGSD installations over the past five years, with 9 in progress. The cost of the completed IGSD installations is approximately $35.2 million.

5.2.10.2 Alternatives Considered

Two mitigation alternatives were evaluated as options to IGSD tie transfer schemes. These include less sophisticated fault isolation schemes and the installation of new feeders to reduce outage exposure.

1. **Fault Isolation Devices** – In lieu of IGSD transfer schemes, CenterPoint Houston evaluated the benefits of installing line reclosers and switches on distribution line section absent tie transfer switches and SCADA communications. These less sophisticated options offer increased reliability by reducing the number of customers interrupted during main line or three-phase faults on major lateral line section, however, it typically requires longer restoration times for faults that occur between the substation breaker and first main line recloser, particularly during major storms and other extreme weather events. CenterPoint Houston has installed numerous reclosers that limit the number of customers interrupted for faults occurring downstream of these reclosers with successful outcomes. CenterPoint Houston now seeks to provide enhanced protection through automation and load transfer schemes at modest incremental cost and has targeted many circuits for IGSD in support of its three-year Resiliency Plan.
2. **Reconfigure or Construct New Feeders or Substations** – Constructing new distribution feeders for the purpose of reducing outage exposure on existing circuits through reconfiguration and permanent load transfer is a viable alternative on some circuits, but typically is less cost-effective than installation of IGSD. The former requires costly construction of new circuits or substations and results in increased outage exposure on the newly built distribution lines and substations. The reconfiguration of existing circuits and construction of new circuits or substation is a viable alternative when new circuits are needed to serve incremental load. CenterPoint Houston will

[118] IGSD schemes commonly are referred to Fault detection, Location, Isolation and Service Restoration or FLISR.

[119] Each IGSD transfer schemes is assumed to require 3 switching devices, one at the midpoint of each feeder, and one at the open tie point between each feeder.

construct new circuits during the next three years but does not propose to include these investments in its Resiliency Plan.

5.2.10.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will prepare annual reports via a post storm tracking system, the number of successful load transfers achieved by IGSD's during major storms. This information will be derived from breaker operations and the number of customers per line segment identified as avoided interruptions by new IGSD's.

5.2.10.4 Benefits Analysis

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

1. **Quantitative Benefits** – Key assumptions include estimates of the average number of sustained interruptions avoided on main line circuits targeted for IGSD installations under both major storm events and normal weather events, along with the number of customers or load at risk and estimated time to restore service for outage occurring on main line circuit sections. The average number of interruptions per main line feeders is 1.16 annually, which includes an upward adjustment of 10% using results of the wind analysis presented in Section 4.2. The amount of load at risk averages between 4 MW for 12kV circuits and 8 MW for 34.5kV circuits per line section. Average restoration times are 2 hours, 42 minutes for normal weather events and 10 hours, 51 minutes during major storms and other extreme weather events. Average restoration costs vary depending on distance from work location and hours for repair, with savings of $5,000 during normal weather events and $10,000 in savings for extreme weather events for each IGSD scheme. Annual maintenance expense for the IGSD devices is estimated at $2,500 per scheme. The IGSD resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 58.1 million and 27.7 million annually by 2027. On a systemwide basis, Guidehouse derived a BCA of 15.7.[120]
2. **Qualitative Benefits** – The potential to avoid lengthy customer interruptions via IGSD, either via manual or fully automated switching, underscores the value of the measure. For systemwide storms that impact many circuits, the number of customers that may experience sustained interruptions during major storms and other extreme weather events (which could be avoided through IGSD schemes) can be high. The ability of IGSD schemes to materially reduce the impact of outages during major storms and other extreme weather events, coupled with other resiliency measures, collectively reduce the economic impact of major storms and other extreme weather events within CenterPoint

[120] BCA ratio derived based on the total cost of IGSD installations and operational technology/communications enhancements.

Houston's service territory. It should also result in faster restoration of critical loads at relatively low cost.

5.2.10.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several of the electric utilities surveyed include general smart grid upgrades in their resiliency plans. Figure 5-9 shows that seven of the nine utilities that responded include resiliency investments related to smart grid upgrades. Additionally, Figure 5-10 indicates that all ten of the utilities surveyed prioritize distribution lines for resiliency investment. Further, Figure 5-11 indicates that decreasing 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. Automation/customer resiliency 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 grid modernization is generally included in electric utility resiliency planning efforts for several of the jurisdictions examined. For example:

- Outage management system upgrades and grid modernization communication systems are identified as in-scope in New Jersey.
- Virginia includes intelligent grid devices as well as operations and automated control systems as part of their resiliency efforts.

5.2.10.6 Resiliency Measure Assessment and Conclusion

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

- The IGSD resiliency measure should significantly reduce the number of sustained customer interruptions and restoration times during major storms and other extreme weather events at relatively low cost, resulting in a favorable BCA.
- The installation of IGSD schemes is consistent with practices deployed at other utilities based on peer utility benchmarking survey results presented later in this report.
- CenterPoint Houston's proposed investment in low cost automation also underscores its commitment to apply automation technology to enhance the resiliency of its power delivery system.

5.2.11 Texas Medical Center Substation

5.2.11.1 Resiliency Measure Description

CenterPoint Houston's Texas Medical Center Substation resiliency measure is designed to improve and enhance resiliency, redundancy, and reliability for the Texas Medical Center Substation and surrounding greater Houston area. This new substation will ultimately contain 5 transformers to supply current and future loads as well as reduce loads served by other nearby substations. CenterPoint Houston intends to leverage this new substation to reduce loading for two other substations while supplying backup power to 22 large customers with a total of 70 MW of load that CenterPoint Houston expects to growth at 2% annually. These customers are located within the Medical Center area and a loss of service to these key customers would have a significant societal impact to health and safety. This substation initially prioritizes service to these customers but can be expanded to serve more load in the future by utilizing up to 5 transformers in the proposed expansion plan. The new substation will provide greater resiliency in the Medical Center area and move load within two substations to better balance load in the greater Houston area. The three-year cost for this resiliency measure and investment amounts are presented below.

- Purchase of land was completed at the end of 2022
- Smaller plot of land due to significantly populated area
- Close proximity to underground and transmission circuits as well as in the center of the current and future Medical Center Substation footprint
- Improved resiliency for customers within the largest medical complex in the world and is widely considered to be at the forefront of life science advancement. This will allow for more research and innovation through consistent power being served, even in high impact low frequency events. Medical Center highlights include:
    - World's largest Children's Hospital (Texas Childrens Hospital)
    - World's largest Cancer Hospital (MD Anderson Cancer Hospital)
    - 10 million patients visit Texas Medical Center ("TMC") each year
    - 180,000+ annual surgeries performed in TMC
    - 750,000 ER visits per year in TMC
    - 50 million developed square ft within TMC campus
    - TMC is 8th largest business district within the US
    - 25,000 babies delivered annually in TMC
    - 13,600+ total heart surgeries performed in TMC
    - $3 Billion in construction projects underway

CenterPoint Houston's proposed Resiliency Plan investments for the Texas Medical Center Substation is: **$102 million** over the 3-year Plan,[121] and a total cost of **$214.6** million that includes spending that will occur outside of the 3-year Plan, and operation and maintenance expense of **$150,000** total over three years. As of January 2024, CenterPoint Houston has purchased the land at a cost of approximately $65 million and design of the substation has begun with construction anticipated to begin in June 2024. Construction is expected to be completed by the end of 2026. Once complete, the large customers within the TMC will gain improved resiliency during extreme weather conditions. This substation will also mitigate unplanned substation outages through alternate feeds to customers in the Medical Center area through major underground ("MUG") facilities.

5.2.11.2 Alternatives Considered

CenterPoint Houston evaluated the alternatives to the construction of a new substation, including an assessment of the capability of existing substations, planned growth, resiliency, and reliability within the Medical Center and greater Houston area. Two alternatives were considered:

1. **Continued Use of Existing Substations** – The two existing substations that serve Medical Center load have been expanded to the extent possible and are fully utilized, with limited ability to serve new load. There are also switching constraints for circuit paths from area substations. Due to these constraints, this option was deemed less viable than construction of a new substation.
2. **Construction of Substations in Other Areas** – The alternative of building a substation in a different area was investigated extensively with 15 other potential locations identified. Potential locations were narrowed down to 8. It was determined that the other 7 alternative locations were either not viable or would be more costly overall for building the substation.

5.2.11.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually on the on the performance of the circuits as they are placed into service (in a similar fashion to the method of reporting for other circuits).

5.2.11.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Medical Center Substation project 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.

[121] Total cost, which includes spending outside the 3-year Resiliency Plan, is $158 million. Program BCA is derived based on the total project cost of $158 million.

1. **Quantitative Benefits** – The addition of the substation should materially improve resiliency within the Medical Center and greater Houston area by adding additional circuits to 22 of the largest and most prestigious hospital facilities in the world, resulting in groundbreaking discoveries in medicine benefiting countless people worldwide. The reduction in duration of outages and sustained outage frequency from the addition of this substation and circuits is significant, effectively almost completely eliminating such risk for these customers by providing two sources of power within/near their vault and allowing CenterPoint Houston to reconfigure its underground distribution system in the event of an extreme weather event that compromises one (or even two) of the substations. The estimated average load at risk generally varies by resiliency measure and is dependent on the review but is estimated to be approximately 70 MW with a minimum restoration time of 72 hours during an extreme weather event. The failure rate of existing supply is once every 10 years. The estimated time to repair damage is 5 or more days during extreme weather conditions.

   Other benefits to this resiliency measure include reduced costs for truck rolls and crew labor to restore service absent the presence of damage. The Texas Medical Center Substation project is expected to initially reduce cumulative CMI over the 3-year Resiliency Plan by approximately 4.9 million, but as the substation load grows, this number will increase. Importantly, this is for a critical hospital complex of facilities that cannot withstand an extended outage. From these assumptions, Guidehouse derived a BCA of 0.7.

2. **Qualitative Benefits** – The potential to improve the resiliency within the Medical Center area is significant, particularly for extreme weather events. This area has been prone to flooding in the past (e.g., during Tropical Storm Allison) and serves arguably the largest and most prestigious medical center in the world. This project also provides the benefit of reducing overall loading for two other substations which will improve load balancing, redundancy, and enhancing withstand capabilities during extreme weather conditions. This upgrade will improve resiliency for this critical area and provide capabilities for meeting growing demand for electricity, especially within the congested areas served by all three substations. When leveraged with other resiliency measures, this substation addition materially reduces the economic impact and disruption of critical loads during extreme weather events. The societal impact of outages within the Medical Center area could have severe consequences, ranging from the loss of critical medical infrastructure (i.e., hospitals and medical research facilities), law enforcement challenges, and public safety, among other impacts.

5.2.11.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several electric utilities have included investments similar to CenterPoint Houston's Medical Center Substation resiliency measure in their resiliency plans. For example, Figure 5-11 shows the utility's primary

goal of their resiliency measure, and the most selected category was to decrease impact of major events which is a primary objective of CenterPoint Houston's proposed Texas Medical Center Substation measure. Additionally, Figure 5-14 shows the top categories for most frequent occurrences of different types of resiliency investments, including undergrounding enhancements, substation hardening, and customer resiliency which are all key aspects of the Medical Center Substation resiliency measure.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that 11 out of 15 utilities cited undergrounding circuits and other investments similar to the Medical Center Substation measure in their respective resiliency plans. For example:

- National Grid's Climate Change Resiliency Plan includes investments in distribution system undergrounding as well as general distribution and transmission substation specification design upgrades.
- Hawaiian Electric evaluates their project options using a resilience solution portfolio matrix that weighs societal benefit against resilience solution scope (i.e., point vs. community solutions).

Additionally, two common metrics jurisdictions have used to determine whether a measure qualifies for resiliency investment is the indirect/societal impact and reduced customer outage time. The Medical Center Substation upgrade would deliver vast benefits to the entire Houston region as a critical facility, and these metrics commonly used by other utilities support its inclusion in the resiliency plan.

5.2.11.6 Resiliency Measure Assessment

Guidehouse concludes that CenterPoint Houston's Texas Medical Center Substation project meets the PUCT's proposed resiliency requirements for the following reasons:

- The addition of the substation will enhance the grid by improving the loading characteristics of the Texas Medical Center Substation and greater Houston areas and enhancing the resiliency of the grid during extreme weather events. The addition of a new substation for critical load is consistent with the trending of the utility industry and leverages best practices deployed at other utilities based on prior Guidehouse experience.
- CenterPoint Houston will leverage the design of the substation to provide for greater withstand capabilities during extreme weather events.
- It will provide additional capacity for customers within this area as the electric grid expands due to EV adoption, building electrification, and other types of electrification.

- Guidehouse's analysis of CenterPoint Houston's Texas Medical Center Substation project produced a BCA value less than 1.0, but criticality of load served combined with the ability to serve future load justifies the project.
- The potential for widespread outages and resulting societal consequences of line failures underscores the criticality of maintaining a reliable secondary network in downtown Houston.

Flood Control

5.2.12 Substation Flood Control

5.2.12.1 Resiliency Measure Description

CenterPoint Houston's flood control resiliency measure is designed to protect at-risk substations vulnerable to flooding along shorelines that previously have or are expected to encounter high water conditions that can damage or cause critical equipment to fail or mis-operate. Substations most susceptible to flooding are either located along the Gulf Coast shoreline or are adjacent to rivers and streams as presented in Section 4.2.2 . Several CenterPoint Houston substations have experienced high water conditions in prior storms, some of which have caused equipment to fail, resulting in extended outages and costly repairs. For example, Hurricane Harvey caused severe flooding throughout CenterPoint Houston's service territory with 17 substations experiencing significant inundation, including 8 substations taken out of service as a precautionary measure. To address this risk, CenterPoint Houston proposes to raise vulnerable substation equipment such as protective relays, switchgear, and remote terminal units (i.e., SCADA communications) to at least 2 feet above the design flood based on 500-year flood likelihood within floodplains.

A complementary technology resiliency measure will raise and/or replace the substation site telecommunication huts to the same level as the correlating control house to increase the resilience of the devices transmitting substation data to systems and individuals that monitor the substation in real-time. Without this information, CenterPoint Houston would not have operational visibility into the substation, thus hindering its ability to make operational decisions during a resiliency event.

As discussed in Section 4.2.2, the projected impact of flooding and extent of CenterPoint Houston's service area included in the 100-year, 200-year, and 500-year floodplain is expected to increase over time, as evidenced by historical increases in flood depth and flooded fraction. This results in more substations at risk of flooding in the future. For example, our analysis shows that in Galveston 97% of substations are at risk of flooding for a hypothetical 500-year flood in 2025. Under CenterPoint Houston's resiliency measure, equipment sensitive to flooding will be elevated 2 feet or higher above the design flood elevation levels via permanent structures. Substations targeted for flood control mitigation in CenterPoint Houston's service area include locations most susceptible to flooding with additional consideration of the

magnitude of load at risk and service to critical customers or facilities (e.g., hospitals or facilities providing emergency services during storms).

CenterPoint Houston's proposed Resiliency Plan investments for this resiliency measure is presented below.

- Number of substations targeted: **3** per year (**9** total)
- Total project cost: **$27 million** with an additional **$3.6 million** in OT support.

As of January 2024, CenterPoint Houston has completed 15 substations over the past five years with 1 in progress 1 deferred. The cost of the completed substation flood control measures is $60.4 million.

5.2.12.2 Alternatives Considered

Four mitigation alternatives were evaluated to address substation flooding exposure, including the proposed elevation of sensitive equipment using permanent structures as described in the section above.

1. **Flood Level Monitoring and Reactive Repair** – This alternative requires the continuous monitoring of flood levels and flood related outages on equipment at each substation, with reactive repairs following flooding or high water events.
2. **Proactive Switching** - Pre-emptive switching and load transfers are made at substations that are expected to be impacted by flooding or high water events.

5.2.12.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston plans to track and report annually on future flood conditions at each of the substations where equipment is elevated, including water elevation and equipment at risk for each flooding event. The term "flooding event" is defined as any flooding occurrence negatively impacting equipment within substations. CenterPoint Houston will estimate outages avoided and damage averted for each future major flooding event to measure resiliency measure effectiveness.

5.2.12.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed flood control mitigation resiliency measure on a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described at the beginning of Section 5.1 , with measure specific inputs and assumptions described below.

1. **Quantitative Benefits** – Key assumptions include the likelihood that future flooding events will inundate sensitive equipment to levels that will cause equipment to fail or mis-operate. For most substations, water levels 2 feet above ground level places critical

equipment at risk.[122] As described earlier, the probability over the next 10 years that these conditions are likely to occur at the 10 substations proposed for mitigation averages 3.3%. Of these events, 20% are expected to cause damage to substation equipment. The amount of load at risk that could be mitigated by CenterPoint Houston's flood control mitigation resiliency measure is 75 MW (average of load served from 12.47kV and 34.5kV substations), with an average restoration time of 36 hours.[123] Other benefits of this resiliency measure include avoided cost of repairs and crew time required to restore service, estimated at $500,000 per flooding event. The Substation Flood Control resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 14.2 million and 6.7 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 7.5.

2. **Qualitative Benefits** – The potential for multiple substations to fail during a major flood with attendant lengthy outages would have widespread economic and societal consequences. Substations serving critical loads and resulting impact on industries and businesses served by these substations would be consequential. As described in Section 4.2.2, the frequency of major flood events in CenterPoint Houston's service area has increased over time and is expected to continue to increase.

5.2.12.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several electric utilities include substation flood control investments in their resiliency plans. For example, Figure 5-9 shows that four of the nine utilities that responded to the survey noted making investments to raise substations. Additionally, more than half of responding utilities indicated that the primary goal of their resiliency program is to mitigate the impact of major events with six of the utilities identifying floods as the primary hazard addressed through their resiliency programs. Substation hardening/flood control 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 flood control programs are commonly included in electric utility resiliency investments in the states examined. For example:

- Hawaiian Electric identifies flood mitigation and re-location of equipment outside of flood prone areas as part of their resiliency efforts.

[122] Federal Emergency Management Agency ("FEMA") and American Society of Civil Engineers ("ASCE") standards.

[123] Restoration intervals vary depending on the amount of load at risk, number of feeder ties (and transfer capability), time required to install mobile substations, and hours for repair, where applicable.

- In 2022, the New Jersey Board of Public Utilities approved PSE&G's proposed investment to in electric substation flood mitigation as part of their Strong Energy Program.

Further, the jurisdictional benchmarking report shows that several jurisdictions plan their resiliency efforts to mitigate 100-year floodplain levels using location-based flood probabilities combined with asset elevation data, similar to the approach being taken by CenterPoint Houston for its Resiliency Plan.

5.2.12.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Substation Flood Control resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The proposed solution provides significant value to CenterPoint Houston customers and the general public. The likelihood of severe flooding is high at each of the substations where elevating sensitive equipment is proposed, resulting in a robust BCA.
- The proposed measure is consistent with practices deployed at other utilities based on peer utility benchmarking survey results presented later in this report.[124]
- Implementation of flood control measures at substations helps avoid the significant negative economic and societal impacts associated with widespread, lengthy outages.

5.2.13 Control Center Facility Upgrades

5.2.13.1 Resiliency Measure Description

CenterPoint Houston's Control Center ("Addicks Operations Center" or "AOC") Facility Upgrade resiliency measure is designed to protect the backup control center from damage caused by major floods or storm surges. The Control center facility is located within the Harris County floodplain and is susceptible to flooding for 500-year or greater events. The AOC is also located downstream of an earthen dam. If the dam were to breach, the Control center facility would be inundated with water.[125] The AOC is a critical facility as it provides essential backup to CenterPoint Houston's primary operations control center. It can also function as CenterPoint Houston's primary distribution operations center for the entire CenterPoint Houston footprint when needed. Flooding would result in the loss of critical data and functionality of monitoring devices and control systems. Damage would be extensive as servers, control stations, and other facility equipment would be damaged beyond repair. Most important, a loss of the Control

[124] An example of a utility that has installed comparable flood mitigation is FirstEnergy's Jersey Central Power & Light operating company, which recently reported on its efforts to enhance flood protection for substations as described here: FirstEnergy. (2023 February). *High and Dry: JCP&L Substation Investments Keeping Electricity Flowing During Storms* [FirstEnergy Substation Flood Control]. https://www.firstenergycorp.com/newsroom/featured_stories/jcpl-substation-investments-keeping-electricity-flowing-during-storm.html

[125] During Hurricane Harvey, emergency management officials raised concerns about a breach due to detection of seepage at the dam.

center facility would jeopardize CenterPoint Houston's ability to maintain continuous contingency support of critical operating systems. To mitigate exposure to flood damage, CenterPoint Houston proposes to construct a concrete wall around the facility.

The cost to build the flood wall is **$7 million**. Construction would be completed by 2027.

5.2.13.2 Alternatives Considered

The only viable alternative to constructing a flood wall around the perimeter of the Control center facility is to construct a new backup control center outside of the Harris County floodplain. While viable, the cost of a new control center would far exceed the cost of a concrete wall.

5.2.13.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston plans to track and report on future flood events in the vicinity of AOC including water elevation and equipment at risk for each event.

5.2.13.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Control center facility Upgrade resiliency measure on a quantitative and qualitative basis. The quantitative analysis adheres to the BCA methodology described at the beginning of Section 5.1 , with resiliency measure-specific inputs and assumptions described below.

1. **Quantitative Benefits** – Key assumptions include the likelihood that absent perimeter fencing future flooding events will inundate sensitive equipment to levels that will cause systems or equipment to fail. The amount of load at risk of an extended outage avoided by CenterPoint Houston's Control center facility Upgrade resiliency measure is 5,000 MW, with restoration times extended by 1 day.[126] Other benefits of this project include avoided load loss, shorter restoration times, avoidance of the cost to repair systems and equipment at the Control center facility, avoided repairs and crew time required to restore service, and recovery of lost data from servers. The cost to repair a damaged AOC is estimated at $20 million. The Control center facility Upgrade is expected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 6.1 million and 2.5 million annually by 2027. From these assumptions, Guidehouse's analysis of CenterPoint Houston's Control center facility Upgrade derived a BCA of 12.5.
2. **Qualitative Benefits** – The potential for extended outages due to a loss of the primary and backup control centers could have widespread economic and societal impacts to CenterPoint Houston's customers, critical loads, and industries and businesses. As described in Section 4.2.2, the frequency of major flood events in CenterPoint Houston's service area has increased and is expected to continue to rise over time.

[126] Restoration intervals will vary depending on the amount of load at risk and extent of damage at the back up control center.

5.2.13.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several electric utilities have included investments similar to CenterPoint Houston's Control Center Facility Upgrades resiliency measure in their resiliency plans. For example, in Figure 5-9, which captures the types of investments included in a utility's resiliency plans, four out of the nine surveyed utilities cited data center facilities upgrades and five cited monitoring of assets. Furthermore, CenterPoint Houston's investment in control center facility upgrades targets mitigation of exposure to flood damage, and in Figure 5-12, seven out of the ten respondents stated that floods were the main hazard addressed through their resiliency programs.

Jurisdictional Benchmarking

Similar to the findings for substation flood control, the jurisdictional benchmarking report provided as Appendix A to this report shows that several flood control programs are commonly included in electric utility resiliency investments in the states examined. For example, Hawaiian Electric identifies hardening and upgrading structures, enhanced construction methods, and re-location of equipment outside of flood prone areas as part of their resiliency efforts. Furthermore, the jurisdictional benchmarking report shows that several jurisdictions plan their resiliency efforts to mitigate 100-year floodplain levels using location-based flood probabilities combined with asset elevation data, similar to how CenterPoint Houston's Control Center Facility Upgrade resiliency measure is being prioritized due to its susceptibility to flooding for 500-year or greater events.

5.2.13.6 Resiliency Measure Assessment

Guidehouse concludes that CenterPoint Houston's Control center facility Upgrade resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The AOC has a critical role in service restoration during storms. While the likelihood of a simultaneous malfunction of the primary and backup control centers is low, the consequences would be severe. The loss of visualization and control of the transmission and distribution system would hinder operations staff, likely resulting in extended outages.
- The low cost of preventing such an event through the proposed upgrade resulted in a favorable BCA value.
- The proposed measure is also consistent with practices deployed at other utilities based on Guidehouse experience and familiarity with control center backup facilities.

- Implementation of the Control Center Facility Upgrades resiliency measure avoids the significant negative economic and societal impacts associated with extended outages if the AOC were to become inoperable due to flooding simultaneous with malfunction of CenterPoint Houston's primary operations control center.

Information Technology for Operations

5.2.14 Advanced Aerial Imagery Platform / Digital Twin

5.2.14.1 Resiliency Measure Description

CenterPoint Houston's Advanced Aerial Imagery Platform / Digital Twin resiliency measure is designed to improve and enhance the visibility of the overall transmission, substation, and distribution systems managed by CenterPoint Houston by digitizing a replication of the physical equipment installed. This will allow for overlay of imagery to determine vegetation management risk and analyze potential improvements to equipment to improve performance during extreme weather event conditions. Improvements made would be based on good engineering design standards prior to incurring the expense of installing equipment upgrades. This allows for a more streamlined approach, including a reduction in engineering design time, improvements in installation expediency and placement of equipment, increased resiliency, and customer benefits.

Over time, CenterPoint Houston proposes to leverage this software in tandem with other software to "rank" projects based on their value add to customers. Utilizing this software will help reduce costs over time by focusing on improvements with the greatest resiliency benefits. CenterPoint Houston will leverage the digital model to review and determine optimal placement of projects, maximizing potential benefits for future resiliency efforts as well as identifying other resiliency measures or projects that could offer higher benefits. This software is also capable of "learning" and leveraging prior analyses to improve future projects. It can also be used to review different scenarios and model performance of these improvements in different extreme weather event scenarios, as well as leveraging the imagery to determine encroachments from vegetation (or other sources) and identify broken/leaning equipment to address.

CenterPoint Houston intends to initially prioritize this software to determine how existing projects are performing from a resiliency basis and use this to determine if/how these projects could provide improved resiliency (e.g., better location, greater number per circuit, and potential weather risks are a few examples of how this will be leveraged). The estimated three-year cost for this resiliency measure and investment amounts is presented below.

- Back-casting analysis targeted for the entire system is targeted to be completed by the end of 2024. Leveraging the software to produce a detailed analysis on a per device/circuit is estimated to reduce the amount of study time for manual processes (from days to hours)

- Forecasting analysis for existing initiatives targeted for the entire system is targeted to begin in 2024 and continue with making enhancements/modifications to plans through the completion of 2027. This will allow for more granular circuit-level analysis.

Total estimated project cost: **$9.0 million** over the 3-year Plan with an additional **$0.9 million** in IT support providing centralized data products to digital technologies and analytics applications to enable real-time decision making. Doing so involves developing a reusable data foundation to support grid resiliency. This foundation will use cloud native technologies to improve agility, resiliency, performance, and ease of use. This data foundation will be leveraged for data analysis, machine learning and AI, and digital technologies. As of January 2024, CenterPoint Houston has shared data with the software vendor in a test environment (after starting the overall vendor selection process in September 2023) and is now working to transition to the production environment. Once the transition to the production environment is complete, CenterPoint Houston will begin analyzing circuits for its initial back cast analysis. The three-year operation and maintenance expense is **$60,000**.

5.2.14.2 Alternatives Considered

CenterPoint Houston evaluated it proposed improved Advanced Aerial Imagery Platform / Digital Twin resiliency measure in comparison to its existing methodology and was able to identify significant improvements through this new software, including reduced analysis time and a progression of improvements in design and project location achieved by AI "learning." CenterPoint Houston reviewed and analyzed the qualifications of many different vendors and was able to determine the best solution to meet its needs. One alternative considered is described below.

1. **Build Internal Software Applications** – Building in-house software applications to perform similar functions would likely take much more time to complete, estimated at approximately 24-36 months to complete. This was rejected by CenterPoint Houston because it seeks a more immediate solution than this option provides.

5.2.14.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually the improvements observed with vegetation management and circuit design improvements observed with the other resiliency plan program reporting for major storm events.

5.2.14.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Advanced Aerial Imagery Platform / Digital Twin 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** – Key assumptions include estimates of the average number of sustained interruptions avoided on circuits targeted for improvements during storms, the

average number of customers or load at risk, and estimated time to restore service. The reduction in failure rate where analysis is performed is approximated at 10% for an estimated 100 distribution projects (based on other utility results). The estimated average load at risk generally varies by resiliency measure and is dependent on the review but is estimated to be a minimum of 15 MW (and likely much greater) with a minimum restoration time of 4-8 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 damage; it also provides design efficiency benefits and better selection for locating new equipment. The annual maintenance expense for software support is $20,000. The Advanced Aerial Imagery Platform / Digital Twin resiliency measure is expected to reduce cumulative CMIs by 0.8 million over the 3-year Plan and 0.3 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 3.4.

2. **Qualitative Benefits** – The potential to improve engineering designs with greater visibility into the grid is significant, particularly for extreme weather events. When leveraged with all other resiliency measures, this advanced aerial imagery platform coupled with the software analysis materially reduces the cost of engineering design, enhance vegetation management and improve IGSD schemes, assist in targeting transmission tower/pole and distribution pole resiliency, and flooding event mitigation, among other potential applications.

5.2.14.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several electric utilities include investments in tools similar to CenterPoint Houston's Advanced Aerial Imagery Platform / Digital Twin resiliency measure. Additionally, Figure 5-9 shows that five of the nine utilities surveyed identified cloud-based data handling improvements and monitoring of assets as types of resiliency investments included in their plans, which are both key facets of CenterPoint Houston's proposed measure. Furthermore, CenterPoint Houston's Advanced Aerial Imagery Platform / Digital Twin will have the capability to identify improvements for the prevention of most, if not all, of the listed natural hazards shown in Figure 5-12.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that some of the key applications of the Advanced Aerial Imagery Platform / Digital Twin resiliency measure are commonly included in electric utility resiliency investments in the states examined. For example, 7 out of the 15 jurisdictions analyzed include vegetation management investments, 11 include pole replacement, and eight include substation flood control. Further, the jurisdictional benchmarking report shows that several jurisdictions include criteria for additional investments and upkeep, which supports the approach being taken by CenterPoint Houston by including Digital Twin in its resiliency plan.

5.2.14.6 Resiliency Measure Assessment

Guidehouse concludes that CenterPoint Houston's Advanced Imagery Platform/Digital Twin resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The addition of the imagery platform and Digital Twin will enhance the functionality of CenterPoint Houston's transmission and distribution system by analyzing and mitigating the risks of line failures, enhancing the resiliency of the grid during extreme weather events.
- CenterPoint Houston will leverage the proposed software to improve the design of its transmission, substation, and distribution systems while providing for greater withstand capabilities during extreme weather events. It will also act to provide guidance for optimal location of equipment for mitigation of outages and greater customer benefit.
- Guidehouse's analysis of CenterPoint Houston's Advanced Aerial Imagery Platform / Digital Twin resiliency measure produced a BCA that confirms the resiliency measure is cost-effective.
- The use of advanced aerial imagery as an input to a Digital Twin system is consistent with trends in utility industry best practices deployed at other utilities based on prior Guidehouse experience.
- The resiliency measure contributes to CenterPoint Houston's overarching objective of increasing the resiliency of the electric grid.

5.2.15 Advanced Distribution Technology

5.2.15.1 Resiliency Measure Description

CenterPoint Houston's Advanced Distribution Technology resiliency measure aims to create a more resilient and reliable system by modernizing the functionality of the electric grid and improving quality of service and operational efficiency through deployment of next generation electric meters. Use cases and resiliency benefits enabled by installation of next generation meters includes premise-level under-frequency load shedding ("UFLS"), local load management, advanced fault detection, and improved service restoration capability. Over time, CenterPoint Houston proposes to leverage the capabilities of Advanced Distribution Technology along with other tools to help increase resiliency in the face of extreme weather-related outage events by improving fault location detection accuracy, managing cold load pick-up and phase imbalances, enabling premise-level UFLS which will reduce outage duration for customers during load shed by expanding load shed capability, potentially reducing the amount of mobile generation for load shed scenarios, and allowing local load management and monitoring which will help accommodate distributed generation and EVs and reduce the risk of transformer failures.

The Advanced Distribution Technology resiliency measure will focus on both deployment of the next generation electric meters and associated hardware infrastructure as well as development of software and Distributed Intelligent Applications ("DI Apps"). The primary technologies the resiliency measure will employ include: (1) next generation of advanced meters ("AMS"); (2) Pole Mounted Router ("PMR") firmware upgrades; (3) deployment of mesh network or similar network solutions; (4) DI App Licensing; and (5) Headend Software compatible with next generation meters.

As of January 2024, CenterPoint Houston has completed software and hardware testing for the resiliency measure including Itron UtilityIQ ("UIQ") Head Test Environment Build and Itron PMR Dual Field Area Network Mesh Firmware Testing. Next steps include additional technology system deployment and phased deployment of meters.

Total cost of the project over the three years from 2025 through 2027 is estimated to be **$225.8 Million,** plus **$15** million for operation and maintenance expense. This project is expected to carry over through completion in the 2029 timeframe.

5.2.15.2 Alternatives Considered

CenterPoint Houston evaluated two alternatives to its proposed Advanced Distribution Technology resiliency measure:

1. **Installation of remote-controlled switches** – One alternative to using meters for UFLS is to install additional remote-controlled switches to disconnect load during load shed. This would require installing several switches on a circuit and upgrading communication infrastructure to accommodate the increased demand. This approach would also require evaluation of circuit configuration and additional manual switching, if needed, to ensure that services to critical loads such as hospitals are not inadvertently disconnected.
2. **Installation of telemetry devices/sensors** – CenterPoint Houston could install additional sensors or remote telemetry devices to improve detection of faults, determine load imbalances, and enable accurate transformer loading measurements. However, this is cost prohibitive due to the number of additional devices needed and the telecommunication infrastructure that would need to be built to accommodate the devices.

Both alternatives require installation of numerous additional devices and infrastructure. As CenterPoint Houston's existing meters are nearing useful life and since the next generation meters can provide the same capabilities that the alternative options provide, it is financially, technologically, and operationally more advantageous to pursue the Advanced Distribution Technology resiliency measure.

5.2.15.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT annually the total number of transformer failures reported by downstream meters on Advanced Distribution Technology and downstream meters supporting ERCOT directed load shed outage events.

5.2.15.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Advanced Distribution Technology 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** – Key assumptions include estimates of the average number of sustained interruptions avoided on distribution circuits and transformers where Advanced Distribution Technology is deployed during major storm events, the average number of customers or load at risk, and estimated time to restore service. The average failure rate of distribution transformers for CenterPoint Houston system during storms is 1,978 per year. The reduction in failure rate where an overcurrent condition becomes detectable from Advanced Distribution Technology is 33%. The estimated average load at risk is estimated to be a minimum of 15MW with an average restoration time of 8 hours. Other benefits include reduced costs for truck rolls and crew labor to restore service. The Advanced Distribution Technology resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 61.1 million and 40.6 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 4.8.
2. **Qualitative Benefits** – Next generation meters installed through this resiliency measure will support DI Apps focused on improving grid reliability and resiliency. Presently, meters provide data in 15-minute intervals and not all meters connected to a transformer provide data synchronously. The Advanced Distribution Technology resiliency measure will provide CenterPoint Houston access to synchronized customer load data which will allow it to respond more quickly to outage events, reduce risk of failures, and expand load shed capabilities to reduce emergency outage times. With the development of premise-level UFLS capability, CenterPoint Houston will have access to more load to meet NERC and ERCOT UFLS requirements by redesignating distribution loads currently unavailable for emergency load shedding because they are connected to relay-exempt distribution circuits serving critical load such as hospitals. With more distribution loads available for manual load shed in response to generation shortages or other bulk power system disruptions, CenterPoint Houston can rotate emergency outages more efficiently to reduce overall customer outage duration.

5.2.15.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, shows the types of resiliency investments being made by peer utilities. For example, Figure 5-9 presents the responses from nine utilities for the types of investments included in their resiliency plan and seven indicate they are making resiliency investments in smart grid upgrades. This is similar to CenterPoint Houston's Advanced Distribution Technology resiliency measure as once successfully deployed it will modernize and enhance the functionality of the electric grid.

Jurisdictional Benchmarking

In the jurisdictional benchmarking report provided as Appendix A to this report there are several grid modernization efforts and metering upgrades included in resiliency plans for the states examined. For example, Dominion Energy's Phase 3 Electric Grid Transformation Projects were recently approved by the Virginia regulator which includes investments in advanced metering infrastructure.

5.2.15.6 Resiliency Measure Assessment

Guidehouse concludes that CenterPoint Houston's Advanced Distribution Technology resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The replacement of existing meters with next generation electric meters will expand automation capabilities by allowing incorporation of DI Apps and improved transformer loading measurements through the availability of time-synchronized data.
- CenterPoint Houston's plan to deploy the Advanced Distribution Technology resiliency measure is consistent with practices deployed at other utilities based on prior Guidehouse experience.
- The potential for widespread outages and resulting societal consequences of transformer failures and load shed events underscores the criticality of maintaining a robust, modern, and versatile metering system.

5.2.16 Digital Substation

5.2.16.1 Resiliency Measure Description

CenterPoint Houston's Digital Substation resiliency measure is in the early stages of design and development. In support of this resiliency measure, CenterPoint Houston is evaluating the benefits of adopting increased digitization and automation in accordance with the International Electrotechnical Committee's ("IEC") 61850 communications protocol. The 61850 standard promotes use of digital equipment, adoption of cybersecurity measures, and large amounts of data capture to enhance reliability and real-time monitoring of critical substation equipment. Key features of CenterPoint Houston's Digital Substation resiliency measure include the substitution of copper wiring with less costly fiber optics for easier conversion to digital communications, enhanced situational awareness for better and faster operational decisions, adoption of compact

digital protective relays allowing for a more compact substation control facility, standardized configurations for increased speed of installation, centralized communications/data collection busses (i.e., via merging units), and proactive detection of equipment abnormalities and incipient failure with an overall smaller substation design footprint. These features will help drive down O&M costs, collectively enhance reliability and resiliency, and lower the cost of constructing new substations over time.[127]

The estimated three-year cost for this resiliency measure and investment amounts is presented below.

- Number of substations targeted: **4 to 5** per year (**12 to 15** over three years)
- Total project cost: **$25 million** for substation equipment[128]
- The lower cost to inspect and maintain the new structures will result in a reduction of **$600,000** in expense total over three years.

As of January 2024, CenterPoint Houston has initiated elements of the IEC 61850 protocol and digitization at 3 substations with 4 in progress. Resiliency Measure cost for completed projects is $8 million.

5.2.16.2 Alternatives Considered

The only viable alternative to substation digitization and adoption of the IEC 61850 communications protocol is to continue with conventional substation design and analog copper-based communication systems for the Company's substation control houses. However, this is contrary to CenterPoint Houston's Digital Substation resiliency measure objective to introduce automation and technology advances to increase reliability and resiliency and reduce costs.

5.2.16.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will provide to the PUCT an annual report on the progress of transition to digital technology, including key features and benefits associated with digitization and automation.

5.2.16.4 Benefits Analysis

Benefits associated with CenterPoint Houston's proposed Digital Substation resiliency measure are generally described above. However, because the resiliency measure is in the initial stages of development, quantification of benefits is premature.

1. **Quantitative Benefits** – Although CenterPoint Houston has not collected or estimated benefits related to the installation of substation components, it proposes to do so as described in the metrics reporting section above. In lieu of such information, benefits

[127] Operational efficiency and safety is enhanced via the adoption of Generic Object-Oriented Substation Event ("GOOSE") rapid data collection and transmittal used for automated transfer of substation switchgear busses and related applications.

[128] Program BCA is based on $25 million for substation equipment and excludes incremental OT investments.

used by Guidehouse to calculate a BCA value are the additional time for technicians to drive to substations to obtain event data following faults, reduced outage restoration time resulting from fault locating features of new relays, and reduced relay failures. The BCA includes annual savings in operation and maintenance expense of $200,000 for the Digital Substations resiliency measure. The Digital Substation resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 1.3 million and 0.8 million annually by 2027. Using these assumptions, Guidehouse derived a BCA of 1.9.

2. **Qualitative Benefits** – CenterPoint Houston's Digital Substation resiliency measure intends to modernize CenterPoint Houston's electric delivery system through technology adoption and automation. Specific applications and features of this resiliency measure are highlighted above. The resiliency measure should achieve resiliency benefits by improving system performance during major storms and other extreme weather events through the use of real-time monitoring and visualization. Over the long-term, a more compact design with fewer equipment components should lower the cost of new substations, particularly in urban areas with space constraints. It also provides greater flexibility to site new substations due to the smaller amount of space needed to build a substation using digital equipment.

5.2.16.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several electric utilities have included investments similar to CenterPoint Houston's Digital Substation measure in their resiliency plans. For example, Figure 5-9 shows that five of the nine utilities surveyed include digital substation OT systems in their resiliency pans and seven of the nine utilities include smart grid upgrades that aim to deliver similar benefits to that of CenterPoint Houston's proposed Digital Substation resiliency measure. Furthermore, Figure 5-11 shows that the primary goal for most of the surveyed utility resiliency planning efforts is to decrease the impact of major events. This aligns with the purpose and benefits of Digital Substation, which should improve system performance during major storms and reduce customer minutes interrupted.

Jurisdictional Benchmarking

The jurisdictional benchmarking report did not identify specific examples of this type of resiliency measure, however, based on our industry knowledge we expect that many other utilities are making similar types of investments.

5.2.16.6 Resiliency Measure Assessment and Conclusion

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

- The introduction of grid modernization initiatives such as those associated with digitization and automation is consistent with leading utility practices based on Guidehouse's experience advising clients in North America and worldwide.[129]
- As implementation proceeds, CenterPoint Houston's Digital Substation resiliency measure should enhance reliability and resiliency of CenterPoint Houston's system while lowering the cost of constructing new substations over the long-term.

System Security

5.2.17 Substation Physical Security Fencing

5.2.17.1 Resiliency Measure Description

CenterPoint Houston proposes to replace chain link fences with more resilient and less permeable wire mesh fences at critical substations to thwart unauthorized access and equipment damage from vandals (stealing copper wire) or terrorists. Substations targeted for enhanced fencing will be chosen based on network vulnerability, load criticality, and location (e.g., those located in remote or hidden areas). Substation security in locations targeted for enhanced fencing will typically be supplemented with mobile cameras to monitor and detect intrusions.

The estimated three-year cost for this resiliency measure and investment amounts is presented below.

- Number of substations targeted: **5** per year (**15** total)
- Total project cost: **$15 million**

As of January 2024, CenterPoint Houston has installed wire mesh fencing at 15 substations with no installations in progress. The average cost of the completed substation fence enhancements is approximately $715,000.

5.2.17.2 Alternatives Considered

The only potentially viable alternative is to add security personnel to continuously monitor substations. This option will substantially increase costs and deemed not feasible due to the large number of substations that would need to be monitored (i.e., over 300).

5.2.17.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT the attempted or successful substation break-ins as these events occur (may want to only report on break-ins where there is loss of load). These reports will describe the nature of intrusion, damage to equipment, load loss, and

[129] For example, Guidehouse personnel assigned to assess CenterPoint's Resiliency Plan provided detailed grid modernization recommendations, including adoption of the IEC 61850 communications protocol, to the Dubai Electric & Water Authority ("DEWA").

law enforcement follow up actions. Additionally, an annual report of intrusions avoided by enhanced fencing will be provided to the PUCT.

5.2.17.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Substation Physical Security Fencing resiliency measure on 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** – Key assumptions include estimates on the number of attempted intrusions, and, for these, the percentage that will lead to equipment damage and interruption of load. The analysis accounts for the potential for multiple, concurrent intrusions by terrorist organizations. The amount of load risk is adjusted upward to account for load loss at multiple substations. The probability that over the next 10 years unauthorized access might occur at each of the 15 substations where wire mesh fencing is proposed, is 2% (i.e., once every 50 years). The amount of load at risk is estimated at 729MW,[130] which includes concurrent equipment outages resulting from terrorist or vandal actions (e.g., gunshots or release of explosive devices). Restoration interval to restore the grid is estimated at 24 hours based on concurrent interruptions at several substations. Other benefits include avoided cost of repairs and crew time required to restore service absent the presence of enhanced fencing. The Substation Physical Security Fencing resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 14.7 million and 7.3 million annually by 2027. Guidehouse's analysis resulted in a composite BCA of 15.6 for the 15 substations.
2. **Qualitative Benefits** – The likelihood of terrorist activity is low compared to incident rates or outages associated with other resiliency measures. However, the consequences of such actions can be significant, causing lengthy outages and major load interruption across CenterPoint Houston's service territory. Such an event could result in widespread economic and societal harm. Critical loads, industries, and businesses served by impacted substations could experience severe inconvenience and economic harm. Further, terrorist activity on the grid would bring forth adverse media attention and heightened community awareness and concern.

5.2.17.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, shows that several electric utilities include substation security upgrades in their plans. For example, Figure 5-9 shows that five of the nine survey respondents include substation physical security upgrades in their resiliency investment plans. Four utilities also noted threat intelligence and management investments, which are often undertaken to ensure the safety of substations. Additionally, Figure

[130] Tier 1 NERC first level load at risk.

5-12 shows that six of the ten utilities identified physical attacks as a hazard addressed through their resiliency programs.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that substation physical security investments have been identified in resiliency programs in both New York and Virginia. Additionally, Hawaiian Electric's Resiliency Working Group considered several human threat magnitude thresholds in their threat scenarios, with examples such as physical substation attacks from rifles or explosives. These metrics and repair times follow a similar methodology that CenterPoint Houston has adopted in evaluating their Substation Security Upgrades resiliency measure.

5.2.17.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Substation Physical Security Fencing resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The resiliency measure should result in a reduction in damage to substation equipment and avoidance of widespread concern that terrorist actions would bring to the region.
- While the likelihood of unauthorized substation access and major damage is low, the modest cost of resilient fencing supports the proposed investment. Despite the low probability of a major event, the resiliency measure produces a favorable BCA.
- Wire mesh fencing proposed at existing substations meets CenterPoint Houston's current design standard for new substations.
- Implementation of security measures avoids potential highly undesirable economic and societal impacts associated with widespread, lengthy outages.

5.2.18 Substation Security Upgrades

5.2.18.1 Resiliency Measure Description

CenterPoint Houston proposes to upgrade existing security monitoring systems at critical transmission substations to detect unauthorized access from individuals committing vandalism or terroristic activities. Substation security includes unauthorized entry detection systems, video surveillance cameras, and associated communications that link to CenterPoint Houston's control center. These systems will enable operating center staff to rapidly notify law enforcement of an effort at or active intrusion to reduce potential equipment damage and customer outages caused by vandals or individuals with terroristic intentions.[131] Substations targeted for security will be chosen based on network vulnerability, load criticality, and location

[131] Substation security upgrades may be performed in conjunction with substation fencing upgrades described in Section 4.1.18.

(e.g., those located in remote or hidden areas). Enhanced security in some substations will include upgraded perimeter fencing as described in Section 5.2.17.

The estimated three-year cost for this resiliency measure and investment amounts is presented below.

- Number of substations targeted: **12** per year (**36** total)
- Total project cost: **$19.5 million**
- Total operation and maintenance expense: **$90,000**

As of January 2024, CenterPoint Houston has installed security systems at a total of 41 substations with 12 in progress. The average cost of the completed substation security upgrades is $18,450,000.

5.2.18.2 Alternatives Considered

The only potentially viable alternative is to add security personnel to continuously monitor substations. This option will substantially increase costs and deemed not feasible due to the large number of substations that would need to be monitored (i.e., over 300).

5.2.18.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will track and report to the PUCT the attempted or successful substation break-ins as these events occur **(may want to only report on break-ins where there is loss of load).** These reports will describe the nature of intrusion, damage to equipment, load loss, and law enforcement follow up actions. Additionally, an annual report of intrusions avoided by enhanced fencing will be provided to the PUCT.

5.2.18.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's Substation Security Upgrades resiliency measure on 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** – Key assumptions include estimates on the number of attempted intrusions and, for these, the percentage that will lead to equipment damage and interruption of load. The analysis accounts for the potential for multiple, concurrent intrusions by individuals acting in coordination or in conjunction with or in support of terrorist organization with the amount of load risk being adjusted upward to account for load loss at multiple substations. The probability over the next 10 years that unauthorized access will cause damage with load loss at each of the 36 substations proposed for security systems is 2% (i.e., once every 50 years). The amount of load at risk is estimated at 729 MVW which includes potential concurrent outages resulting from terrorist actions. Restoration time is estimated at 24 hours, which includes concurrent

repairs on several substations for those involving terrorist action. Other benefits include the avoided cost of repairs and crew time required to restore service absent the presence of security. The Substation Security Upgrades resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 25.1 million and 12.5 million annually by 2027. From these assumptions, Guidehouse derived a BCA of 19.9.

2. **Qualitative Benefits** – The likelihood of vandal or terrorist activity is low compared to incident rates or customer outages associated with other resiliency measures.[132] However, the consequences of such actions can be significant, with lengthy outages and major customer load interruption across CenterPoint Houston's service territory. Such an event could result in widespread socio-economic impact, have national security implications, and create societal harm. If only single substations were impacted, those serving critical loads, industries, and businesses would be severely impacted. If several substations fed by the transmission network were to fail, it would result in even greater inconvenience and economic harm. Further, terrorist or vandal activity on the would invariably bring forth adverse media attention, public safety concern, and heightened political and community concern. It should be expected that local, state, and federal law enforcement agencies would be engaged given the severity of terrorist activity or vandalism on critical grid infrastructure.

5.2.18.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates that several electric utilities include substation security upgrades in their plans. For example, Figure 5-9 shows that five of nine respondents include substation physical security upgrades in their resiliency investment plans. Four utilities also noted threat intelligence and management investments, which are often undertaken to ensure the safety of substations. Additionally, in Figure 5-12, six of the ten utilities indicated physical attacks as a hazard addressed through their resiliency programs.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that substation physical security investments have been identified in resiliency programs in both New York and Virginia. Additionally, Hawaiian Electric's Resiliency Working Group considered several human threat magnitude thresholds in their threat scenarios, with examples such as physical substation attacks from rifles or explosives. These metrics and repair times follow a similar methodology that CenterPoint Houston has adopted in evaluating their Substation Security Upgrades resiliency measure.

[132] The Department of Energy ("DOE") tracks and issues reports on critical infrastructure attacks. In 2023, there were 90 instances of reported attacks, including substation attacks that attracted nationwide media attention.

5.2.18.6 Resiliency Measure Assessment and Conclusion

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

- The resiliency measure should reduce potential damage to substation equipment, possible public safety implications, and widespread concern that terrorist actions or major vandalism would bring to the region, state, and nation.
- While the likelihood of unauthorized substation access and major damage is low, the cost of resilient fencing supports the proposed investments. Despite the low probability of a major event, the project also produces a favorable BCA.
- The installation of security measures at existing transmission substations meets CenterPoint Houston's current practice for new substations.
- Implementation of security measures avoids highly undesirable potential national security, economic, and societal impacts associated with widespread, lengthy outages.

5.2.19 Targeted Critical Circuit Vegetation Management

5.2.19.1 Resiliency Measure Description

CenterPoint Houston's Targeted Critical Circuit Vegetation Management ("VM") resiliency measure is designed to reduce critical load customer outages during resiliency events, as measured by SAIDI performance for critical load circuits during resiliency events (i.e., Major Events as defined by the PUCT), as measured by SAIDI performance for critical load circuits during resiliency events. Currently, CenterPoint Houston's proactive VM budget for the 2024 Plan is $34 million. CenterPoint Houston proposes to increase annual spending by $8.3 million for each year of its 3-year Resiliency Plan, targeting circuits with critical load customers with the objective to reduce major event VM SAIDI for critical load circuits below its five-year historical average of 52.5 minutes (Table 5-2) by 33 percent.

Reductions in SAIDI for critical load circuits will be achieved by targeting danger or hazard trees for removal, along with off cycle trimming on distribution main line segments clearances that have become compromised by fast growth tree species. CenterPoint Houston proposes to perform targeted VM on 833 miles of main and lateral line sections annually on distribution circuits serving critical loads and that have greater exposure to tree-related interruptions. Unlike the prior 18 resiliency measures that are capitalized, all incremental spending on targeted VM is expensed.

Table 5-2: Five-Year VM SAIDI for Major Events (Minutes)

Year	VM SAIDI Major Events
2019	13.3
2020	42.2
2021	107.1
2022	0.0
2023	99.7
Average	**52.5**

Source: CenterPoint Houston

Over the past five years, CenterPoint Houston has expended **$141.5** million on proactive VM with an average annual spend of approximately **$28.3** million. All expenditures are expensed to a maintenance account.

5.2.19.2 Alternatives Considered

The only viable option to targeted VM is to perform reactive tree trimming on distribution main and lateral line sections serving critical loads where tree-caused outages have already occurred and where the potential for additional tree-related outages is high. CenterPoint Houston did not pursue this alternative as it would not likely lead to a measurable reduction in SAIDI because trees would not be proactively trimmed or removed prior to outages.

5.2.19.3 Resiliency Measure Metrics and Effectiveness

CenterPoint Houston will report to the PUCT annually an estimate of the reduction in SAIDI for resiliency events achieved through targeted VM on circuits serving critical load customers.

5.2.19.4 Benefits Analysis

The primary benefit of CenterPoint Houston's Critical Circuit VM resiliency measure is the reduction in CMI as measured by SAIDI for critical load circuits during resiliency events. Unlike other measures that focus on capital investments, targeted VM is expensed with most benefits achieved during the year targeted VM is performed. Further, the actual reduction in SAIDI for this resiliency measure will be determined following the completion of the work for each year of the Resiliency Plan. The preliminary analysis assumes CenterPoint Houston will meet its targeted annual SAIDI reduction of 17.5 minutes by 2027 to meet the five-year average VM SAIDI target of 357 minutes. The Targeted Critical Circuit VM resiliency measure is projected to reduce cumulative CMIs over the 3-year Resiliency Plan by approximately 13.9 million and 4.2 million annually by 2027. For the 3-year Targeted Critical Circuit VM measure Guidehouse derived a BCA ratio of 1.8.

5.2.19.5 Benchmarking

Peer Utility Benchmarking

The peer utility benchmarking survey, discussed in Section 5.3, indicates vegetation management programs are a common component of electric utility resiliency plans. For example, Figure 5-14 lists the most frequent occurrences of different types of resiliency investments and vegetation management was within the top eight categories, with three utilities listing it as a common program.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that many of the jurisdictions examined include vegetation management programs as part of their resiliency planning efforts. For example:

- Hawaiian Electric identified enhanced vegetation management as one of the three top priorities items in-scope of their investments, particularly in critical grid areas susceptible to damage from wind and falling debris.
- In Massachusetts, Eversource launched a vegetation resiliency pilot program.
- In Louisiana, Entergy's 10-Year Resiliency Plan, designed to improve overall system resilience from 2024 to 2033, includes vegetation management as a critical priority.

5.2.19.6 Resiliency Measure Assessment and Conclusion

Guidehouse concludes that CenterPoint Houston's Targeted Critical Circuit Vegetation Management resiliency measure is reasonable and beneficial for inclusion in CenterPoint Houston's Resiliency Plan for the following reasons:

- The proposed resiliency measure is expected to provide significant value to CenterPoint Houston customers and the general public. The likelihood of lowering SAIDI is high on distribution main and lateral line sections where targeted tree trimming or removal is proposed.
- The proposed measure is consistent with practices deployed at other utilities based on peer utility benchmarking survey results presented later in this report.
- Implementation of proactive vegetation management helps avoid the significant negative economic and societal impacts associated with widespread, lengthy outages during high wind events. Targeting additional VM spend on critical load circuits recognizes the additional value that avoided outages for critical load customers (e.g., hospitals and police, fire, and EMS stations) has for the communities they serve.

5.2.20 Wildfire Mitigation

Guidehouse conducted an overall qualitative assessment of CenterPoint Houston's proposed wildfire mitigation resiliency measures, which were added to CenterPoint Houston's Resiliency Plan after Guidehouse completed its initial review. Guidehouse did not complete a quantitative

assessment of benefits because further analysis would be needed to estimate current level of risk in terms of probability of occurrence and the potential reduction in this probability for each measure or collection of measures. Guidehouse has typically seen wildfire mitigation measures be justified and evaluated against alternatives through an analysis of relative risk reduction with the objective of minimizing the risk of wildfire ignition attributed to electric utility equipment. Guidehouse recommended to CenterPoint Houston that they consider such analysis to help prioritize which wildfire mitigation measures should be deployed in different locations. Guidehouse also performed a wildfire risk analysis, included as Section 4.2.5 of this report, to inform CenterPoint Houston's decision on whether to include wildfire mitigation in its Resiliency Plan.

Guidehouse's assessment finds that all of CenterPoint Houston's proposed wildfire mitigation resiliency measures are reasonable for inclusion in its Resiliency Plan as they are generally consistent with the types of wildfire mitigation resiliency measures included in other electric utility wildfire mitigation plans. We validated this by reviewing three wildfire mitigation plans in different jurisdictions (PG&E in California[133], NV Energy in Nevada[134], and Xcel Energy in Colorado[135]) and found that all three utilities include almost all of these measures in their plans. Guidehouse identified additional wildfire mitigation resiliency measures that are commonly included in the wildfire mitigation plans of other electric utilities with relatively high wildfire risk (e.g., California electric utilities) for CenterPoint Houston to consider, but recognizes that not all measures are applicable to CenterPoint Houston's system and fire risk profile. It is Guidehouse's understanding that CenterPoint Houston will be evaluating potential additional wildfire mitigation measures for inclusion in subsequent resiliency plans.

Given the findings of our risk analysis and our overall assessment of the proposed resiliency measures, we agree that the wildfire mitigation measures being proposed should be included in CenterPoint Houston's Resiliency Plan.

5.2.21 Microgrid Pilot Project

Guidehouse conducted an overall qualitative assessment of CenterPoint Houston's proposed microgrid pilot project resiliency measure. Guidehouse did not complete a quantitative assessment because CenterPoint Houston is proposing this measure as a demonstration project to gain learnings and determine costs, benefits, and implementation challenges for such projects before considering greater investment. Findings from the pilot could help inform future BCA to determine if such investments are cost-effective for more broad application as part of

[133] Pacific Gas and Electric Company (PG&E), 2023-2025 Wildfire Mitigation Plan. **https://www.pge.com/assets/pge/docs/outages-and-safety/outage-preparedness-and-support/2023-wildfire-mitigation-plan.pdf**.

[134] NV Energy, Natural Disaster Protection Plan. **https://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2020_THRU_PRESENT/2020-2/529.pdf#xd_co_f=YmM2NGYyYjQtM2QyNS00MDhlLWI4MmYtY2U1MDFjOTc0ZTFh~**.

[135] Xcel Energy Public Service Company of Colorado, 2020 Wildfire Mitigation Plan. **https://www.xcelenergywildfiremitigation.com/wp-content/uploads/2021/05/PSCo_2020-Wildfire-Mitigation-Plan_Rev-1-.pdf**

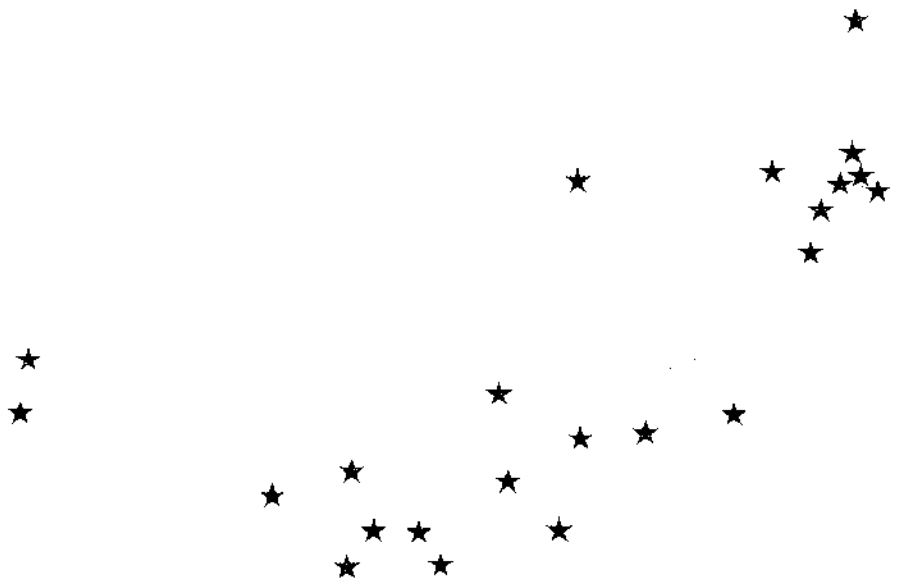
CenterPoint Houston's future resiliency plans. Guidehouse agrees that a microgrid pilot project is a reasonable first step to take to determine if microgrids are a worthwhile investment to achieve resiliency benefits. Microgrid projects are commonly included in electric utility resiliency planning efforts, often initially in the form of pilot projects, as evidenced in the jurisdictional benchmarking discussed later in this report.

5.3 Benchmarking Study

5.3.1 Resiliency Survey Approach

Guidehouse included a peer utility resiliency benchmarking study as part of this report. First Quartile, a pre-eminent provider of benchmarking and consulting services to utilities, conducted a peer utility resiliency survey on behalf of Guidehouse The resiliency survey was issued to 21 North American electric utilities located in the Southern, Northeastern, and Southwestern U.S., and one is East Canadian. Most of the utilities that received the survey are part of First Quartile's benchmark community participants. In addition, the survey was issued to utilities operating in geographies and coastal areas such as those served by CenterPoint Houston's Houston Electric. From the 21 utilities, 10 responded to the survey. Figure 5-8 shows the location of each of the utilities that responded to the survey, including CenterPoint Houston. In two instances the map includes subsidiaries for the responding utility; therefore, the map shows more than ten utilities.

Figure 5-8: Map of Resiliency Survey Participant Utilities



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

5.3.2 Resiliency Investment Types

The resiliency survey included questions designed to identify the types of resiliency investments U.S. electric utilities are deploying and the types of system issues they are seeking to address through these investments. Figure 5-9 presents the responses from nine utilities for the types of investments included in their resiliency plans, indicating that CenterPoint Houston's proposed Resiliency Plan investments are well aligned with industry practice.

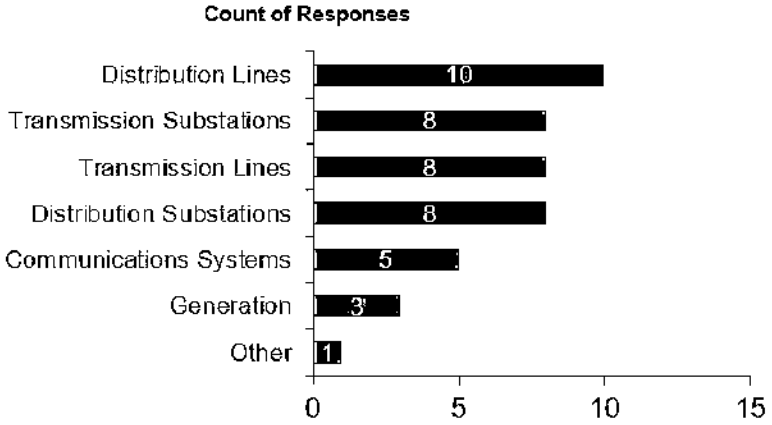
Figure 5-9: Resiliency Survey Investment Types

Type of Investments	Utility Companies								
	102	103	106	107	108	109	114	122	123
Changes to emergency response plans		✓		✓			✓	✓	
Governance risk and compliance tracking		✓				✓	✓		
Threat intelligence and management	✓	✓					✓	✓	
Line/Circuit rebuilds	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pole replacements	✓	✓	✓	✓	✓	✓	✓	✓	✓
Undergrounding of key lines or portions (e.g. freeway crossings)	✓	✓	✓		✓	✓		✓	✓
Conversion projects – e.g. from 69kV to 138kV	✓	✓				✓		✓	
Raising substations	✓	✓	✓		✓				
Reconductoring projects	✓	✓		✓	✓		✓		
Smart grid upgrades	✓	✓	✓	✓		✓	✓	✓	
Data Center Facilities upgrades	✓	✓					✓	✓	
Data storage and handling	✓	✓				✓	✓	✓	
Smart grid data modifications	✓	✓					✓	✓	
Operational data resiliency	✓	✓				✓	✓	✓	
Cyber Security	✓	✓	✓				✓	✓	✓
Monitoring of assets	✓	✓				✓	✓	✓	
Cloud based data handling improvements	✓	✓					✓	✓	
Application security							✓	✓	
Telecommunication infrastructure	✓	✓					✓	✓	
Microwave communications	✓	✓					✓	✓	
Voice and mobile data enhancements	✓	✓					✓	✓	
Use of monitoring cameras, communications	✓	✓	✓				✓	✓	
Substation fencing	✓	✓	✓				✓	✓	
Substation security upgrades	✓	✓	✓				✓	✓	
Network security	✓	✓					✓	✓	
Trip savers	✓	✓		✓		✓			
Digital substation OT systems	✓	✓				✓	✓	✓	
Substation automation	✓	✓	✓			✓	✓	✓	

Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

The resiliency survey also highlights the types of system components where utilities place the highest investment focus for resiliency initiatives. Figure 5-10 indicates the highest priority resiliency measures are distribution lines, followed by transmission lines, and transmission and distribution substations. Five of the ten utilities prioritize communication systems. These findings are in alignment with the CenterPoint Houston's proposed resiliency measures for T&D assets and communication systems described in Section 5.2.

Figure 5-10: Resiliency Survey Investment Per System Components

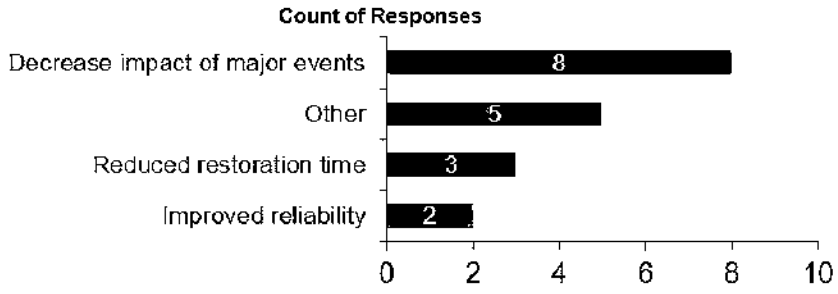


Source: Guidehouse analysis, with inputs from the First Quartile Resiliency Survey.

5.3.3 Resiliency Program Goals

The results of the resiliency survey indicate that CenterPoint Houston's Resiliency Plan goals and priorities align with those of similarly situated electric utilities in North America. CenterPoint Houston's proposed resiliency measures and projects are consistent with the survey group in terms of the types of priorities, natural hazards addressed, system impacts mitigated, and plans to measure effectiveness of individual resiliency initiatives. Figure 5-11 highlights what peer group electric utilities selected as the primary goal of their resiliency programs. The four categories of resiliency program primary goals include: decrease impact of major events, reduced restoration time, improved reliability, and a combination of factors shown as "Other." The "Other" category includes responses such as: address high impact and low frequency events; decrease restoration cost; support asset management and distribution planning goals; and avoid outages through a stronger and more resilient electric system. Most utilities indicated that the primary goal of their resiliency program is to mitigate the impact of major events. This finding generally aligns with the goals and objectives of CenterPoint Houston's Resiliency Plan, as described in the program reviews in Section 5.2.

Figure 5-11: Primary Goal of Resiliency Program

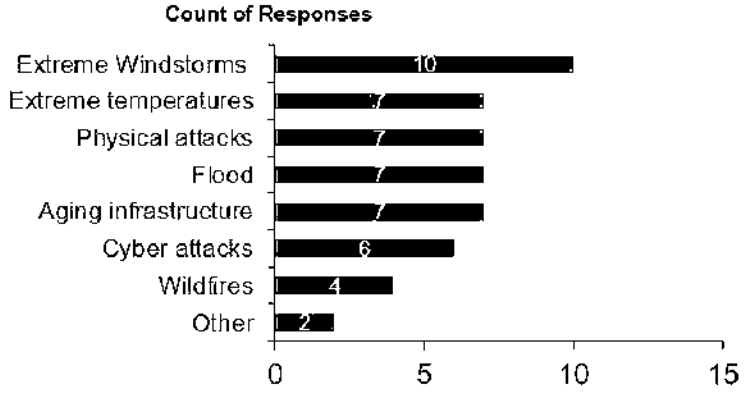


Source: Guidehouse analysis, with inputs from the First Quartile Resiliency Survey.

Figure 5-12 shows how utility resiliency survey respondents responded to questions about what hazards are being addressed through their resiliency programs. The survey results also align with CenterPoint Houston's Resiliency Plan as evident in the list of resiliency measures listed in this report. CenterPoint Houston's Resiliency Plan includes measures to address extreme weather events such as circuit rebuild and pole replacement projects, which help mitigate T&D asset damages due to extreme wind speeds while also addressing aging infrastructure.

Other measures included in CenterPoint Houston's Resiliency Plan, such as the Substation Flood Control resiliency measure and investments to address physical and cybersecurity risks, are also consistent with addressing the types of hazards other electric utilities are planning for. Although wildfires are a natural hazard concern for some electric utilities, this is historically considered a relatively low risk in CenterPoint Houston's service territory. This historic risk is changing especially in summer months as shown in the Natural Hazards Quantification section. The "Other" category in this figure includes additional considerations identified by survey respondents, such as: minor flood concerns in transmission and substations but not in distribution; flooding in coastal areas; and avoided system overloads in substation transformers, substation switchgear and along distribution circuits.

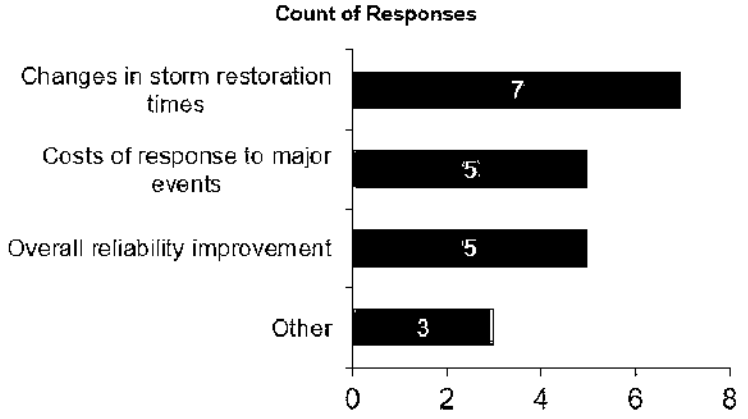
Figure 5-12: Hazards Addressed Through Resiliency Program



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

Figure 5-13 reveals how utility resiliency survey respondents measure the effectiveness of individual resiliency initiatives. Most of the responding utilities measure effectiveness of their resiliency initiatives by monitoring changes in storm restoration times, and many utilities consider costs of response to major events and overall reliability improvement. The "Other" category included the following additional responses: measuring differences in number of outages on hardened circuits versus past performance and compared to other circuits; tracking length of outages and better recovery from significant rare events; and avoidance of disruption to the T&D system due to those events. CenterPoint Houston plans to track and report to the PUCT the overall effectiveness of the resiliency measures described in Section 5.2 in alignment with benchmark measures (Figure 5-13).

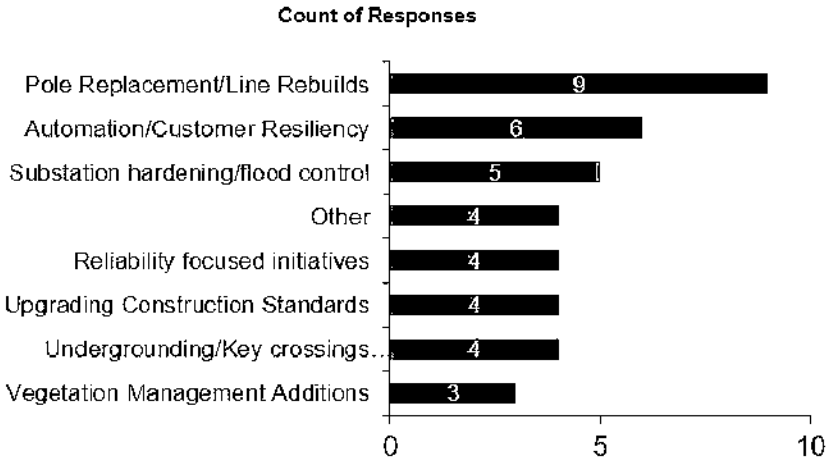
Figure 5-13: Measuring the Effectiveness of Individual Resiliency Initiatives



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

The resiliency survey also helped identify the most frequent occurrences of different types of resiliency investments with the top eight categories presented in Figure 5-14. The three most common resiliency investments are: pole replacements and line rebuilds; automation and customer resiliency; and substation hardening and flood control. The "Other" category included the following responses: wildfire mitigation, reliability projects budgeted but not yet executed, and capacity projects addressing preparations for data centers. CenterPoint Houston's Resiliency Plan includes resiliency measures that fall under the three most common investments seen in this benchmarking group.

Figure 5-14: Top Categories of Resiliency Initiatives



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

5.4 Review of Technology Resiliency Measures in CenterPoint Houston's Plan

5.4.1 Voice and Mobile Data Radio System Refresh

5.4.1.1 Resiliency Measure Description

CenterPoint Houston's Voice and Mobile Data Radio System Refresh resiliency measure will apply a phased approach by service area and upgrade its current communication system to achieve increased resilience in day-to-day operations, facilitate improved 911 dispatching, and enhance field work coordination with the command center. CenterPoint Houston currently has a disparate communication system that includes cell phones and multiple manufacturers and models of radios including handhelds and truck radios. The radios are the primary method used for communication within the organization for field work, however, CenterPoint Houston has had recent issues with obtaining replacement parts for radio equipment that has become outdated. These measures will consist of an upgrade of outdated equipment that has been in service for 13+ years and considered end-of-life or no longer has replacement parts readily available. This upgrade will improve CenterPoint Houston's ability to maintain or restore communication during extreme weather events if failure of radio equipment occurs. Additionally, the resiliency measure involves connecting all CenterPoint Houston field personnel with radios to the upgraded communication system for more universal coverage.

The estimated 3-year cost for this measure is $15.6 million.

5.4.1.2 Alternatives Considered

CenterPoint Houston considered a private LTE communication system but determined it could not be adopted in time to meet short-term and mid-term communication needs. It has been determined there are no viable alternatives, leaving refresh as the only option. Utilization of a Project 25 ("P25") or Digital Mobile Radio ("DMR") system in Land Mobile Radio ("LMR") is possible, but the need from the LMR is still the same, which is portability, and mobile radio coverage and connectivity through a dispatch console system. It was determined this would be the most feasible approach.

5.4.1.3 Resiliency Measure Effectiveness

Guidehouse used a qualitative comparative analysis approach to evaluate this measure. A quantitative analysis was not conducted due to data limitations and lack of metrics to benchmark against. Rather, Guidehouse evaluated the benefits and features associated with this proposed resiliency measure on a qualitative basis with measure-specific inputs and assumptions.

CenterPoint Houston plans to use the following performance metrics for tracking the effectiveness of the Voice and Mobile Data Radio System Refresh resiliency measure:

- Dispatch speed,
- Field tests completed,
- Remoteness of communications, Decrease in maintenance time,
- Annual number of End-of-life equipment replacements to:
    - Maintain continuity,
    - Avoid truck rolls, and
    - Integrate GPS tracking and text messaging.

This analysis compared CenterPoint Houston's resiliency measure with the NIST CSF Categories, to identify levels of correlation between the five CSF Functions and the proposed system in terms of developing resilient systems. Guidehouse's analysis determined whether the resiliency measure had high, medium, or low correlations to the individual subcategories of the CSF.

The subcategories selected for reporting from the medium correlations were selected based on Guidehouse's professional judgment and conclusion that the resiliency measure had a partial or indirect correlation, along with Guidehouse's professional judgment that the measure was sufficiently implementing the intent of the subcategory from a resiliency perspective. The system features that were mapping to low correlation were considered to be relatively ineffective in improving resiliency, although depending on the context of the proposed resiliency measure, they may still have value in pursuing from reliability or policy perspectives. For a detailed explanation of the methodology used, refer to Section 5.1.3.

Table 5-3 lists Functions and associated categories with high and/or medium correlations to the resiliency measure:

Table 5-3: Voice and Mobile Data Radio Refresh Analysis Results

Function	Categories
Identify	• Risk Assessment ("RA") • Risk Management Strategy ("RM")
Protect	• Access Control ("AC") • Data Security ("DS") • Information Protect Processes and Procedures ("IP") • Protective Technology ("PT")
Respond	• Communications ("CO")
Recover	• Communications ("CO")
Please note: Guidehouse did not include the "Detect" function as part of these analysis results as it did not have high or medium correlations.	

5.4.1.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Voice and Mobile Data Radio Refresh resiliency measure and the Guidehouse analysis indicates that the measure will provide a high level of effectiveness. Based on the results of its analysis, Guidehouse determined that the Voice and Mobile Data Radio Refresh resiliency measure offers resiliency benefits. All determinations below are based on CenterPoint Houston information on measure descriptions, interviews, and responses to data requests for additional measure details.

The analysis identified the following categories and results where the category and associated subcategory(ies) have a high correlation to the resiliency measure:

Risk Assessment ("ID.RA") *The organization understands the cybersecurity risk to organizational operations (including mission, functions, image, or reputation), organizational assets, and individuals.*	
Analysis Results Description:	Identifying risks, including vulnerabilities, potential impacts, and threats, supports resiliency by being one of the first steps for risk management as a core element for mitigation of impact to power operations. CenterPoint Houston plans to upgrade its communication system to address a key identified vulnerability that some equipment will no longer be supported. Without the upgrade, field personnel may have to perform their duties without communication devices, impacting power operation responses, especially during extreme weather events.

Risk Management Strategy ("ID.RM") *The organization's priorities, constraints, risk tolerances, and assumptions are established and used to support operational risk decisions.*	
Analysis Results Description:	Risk management strategies support resilience by ensuring risk tolerances are understood so mitigation efforts can be established and implemented. CenterPoint Houston identified a risk of failure to radio components that are end-of-life, which would disable communication or reduce communication coverage size, causing a failure in communication in some locations. This would, in turn, negatively impact system restoration efforts. Therefore, this resiliency measure will help address and mitigate potential risk to system operations and restoration.

Access Control ("PR.AC") *Access to physical and logical assets and associated facilities is limited to authorized users, processes, or devices, and is managed consistent with the assessed risk of unauthorized access to authorized activities and transactions.*	
Analysis Results Description:	Limiting access to devices for individuals who need access, supports resilience by ensuring Only those that require access to a device can attain it, and dissuades those that do not, from manipulating it. CenterPoint Houston has leased sites that are more susceptible to physical security issues, especially where a telecommunications shelter is involved. The resiliency measure upgrades would potentially remove the need for those leased sites and introduce vendors and capabilities for better coverage.

Data Security ("PR.DS") *Information and records (data) are managed consistent with the organization's risk strategy to protect the confidentiality, integrity, and availability of information.*	
Analysis Results Description:	Hardware integrity verification and availability are important from a risk strategy perspective to ensure communications are available, authentic, complete, and tamperproof. CenterPoint Houston plans to strengthen integrity verification and availability, including adequate communication capacity, based on information provided from each vendor in the Request for Proposal process. CenterPoint Houston requires potential vendors for this refresh to be able to maintain coverage, at a minimum, and, if possible, reduce base station sites to reduce the physical footprint for the mobility coverage area.

Information Protection Processes and Procedures ("PR.IP") *Security policies (that address purpose, scope, roles, responsibilities, management commitment, and coordination among organizational entities), processes, and procedures are maintained and used to manage protection of information systems and assets.*	
Analysis Results Description:	Establishing agreements as necessary and baselining details for equipment assist with resilience of the power system by ensuring the devices are being used on the appropriate frequencies and any agreements with third parties are in place so there are agreed upon terms of usage and support. CenterPoint Houston plans to implement improved capabilities for managing the baseline configurations when resetting radios that have been changed (e.g., system crash). This resiliency measure includes this additional functionality while also potentially re-signing co-channeling agreements with third parties to address frequency usage.

Protective Technology ("PR.PT") *Technical security solutions are managed to ensure the security and resilience of systems and assets, consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	Protected communication networks and mechanisms in place such as failsafe, load balancing, etc., are needed to ensure the communication system is available in both normal and adverse situations, which supports the resilience of power system operations. CenterPoint Houston plans to perform periodic checks of equipment and grounding testing to ensure the devices are functioning correctly as part of this resiliency measure. Additionally, there will be improved communication load balancing and backup systems used in instances of device/equipment failures.

Communications ("RS.CO") *Response activities are coordinated with internal and external stakeholders, (e.g., external support from law enforcement agencies).*	
Analysis Results Description:	Incident response activities are key in supporting system and operations resiliency. CenterPoint Houston plans to continue to use the radio system for communications specific to incident investigations and field coordination for responding to impacts from extreme weather events. Radio is also the method used to report incidents.

Communications ("RC.CO") *Restoration activities are coordinated with internal and external parties (e.g., coordinating centers, Internet Service Providers, owners of attacking systems, victims, other CSIRTs, and vendors).*	
Analysis Results Description:	Communication of recovery activities and third-party agreements are necessary to provide time sensitive recovery response for system recovery and restoration. CenterPoint Houston plans to continue to use the radio system for communication and coordination activities specific to recovery and system restoration activities and will have third-party agreements in place for equipment warranties, maintenance, and support.

5.4.1.5 Resiliency Measure Assessment

Guidehouse concludes there is a high level of correlation to system and business resilience and system restoration with CenterPoint Houston's Voice and Mobile Data Radio System Refresh resiliency measure. This was based on the high level of correlation the measure has in relation to the NIST CSF functions. Particular areas in which this resiliency measure supports a strong and resilient electric transmission and distribution system include:

- Risk Management with regards to updating equipment that no longer has replacement parts available.

During emergencies or natural events, traditional communication methods such as landlines or cellular networks can be less reliable than radio communications. Benefits that will be realized with this measure are listed below:

- Consistent communication for CenterPoint Houston personnel extending to field personnel. By having access to radio communications there will be greater communication coverage, ensuring quicker responses to outages or other impacts to system operations
- Ability to have redundancy and backup power sources to minimize impacts to communications during emergencies

It is determined that the Voice and Mobile Data Refresh resiliency measure is necessary for CenterPoint to achieve the objective of strengthening the resiliency of its electric transmission and distribution system, via dependable and universally used communication methods.

5.4.1.6 Benchmarking

Peer Utility Benchmarking

In the ever-evolving landscape of utility communication systems, the utilization and efficacy of radio communications infrastructure stands as a time-tested method used by utilities. This traditional approach has long served as a reliable means of facilitating real-time communication and coordination among utility personnel. However, there are different types of voice and mobile data systems available to utilities, including Private Long-Term Evolution ("PLTE") networks and commercial networks. PLTE networks run specifically for the benefit of an organization, and only authorized users of that organization have access to the PLTE network. Relying on commercial telecommunication providers can be problematic during large-scale grid outages, as evidenced by proactive measures taken by Pacific Gas and Electric Company ("PG&E") during the wildfires in California in October 2019, which resulted in telecommunications towers going offline due to insufficient backup power. Consequently, some utilities are considering the benefits of implementing a PLTE network to mitigate reliance on commercial providers and enhance their ability to manage recovery efforts independently during extreme weather events or system outages[136]. This example illustrates clear benefits from the use of PLTE within utilities from a resilience perspective.

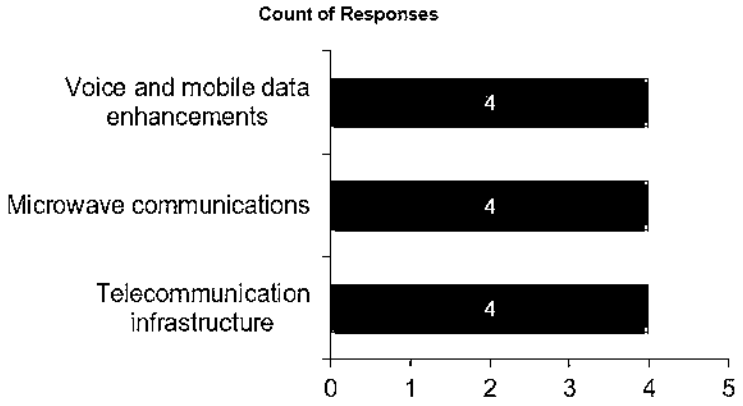
Overall, while a PLTE network can represent a promising advancement in radio communications technology, CenterPoint Houston has determined that the investment required for deployment and infrastructure development for PLTE is substantial and would take up to 10 years to implement. This long implementation timeline does not align with the company's immediate operational need, leading CenterPoint Houston to opt to prioritize other voice and mobile data initiatives that offer more immediate benefits and align more closely with their budgetary considerations while ensuring grid resiliency.

[136] Khalid, S., Hotovec, S. and Clancy, J. (2023), Utilities' Need for Advanced Telecommunications. Climate and Energy, 39: 1-10. **https://doi.org/10.1002/gas.22323**

CenterPoint Houston's aim in refreshing their voice and mobile data systems for day-to-day communications, to facilitate improved 911 dispatching, enhance field work coordination with the command center, and upgrade retired equipment aligns with the fundamental investments that have been made by its industry peers.

Through a separate benchmarking exercise, discussed in Section 5.3, nine utilities provided survey responses regarding communications technology investments they have made. As shown in Figure 5-15, voice and mobile data enhancements are technology resiliency investments that at least four of the nine responding utilities have adopted. This data is essential for understanding the investments that other utilities have made as it pertains to communication technology and offers valuable insight into what aspects of these investments tie back into the offerings of that will be used at CenterPoint Houston related to the Voice and Mobile Data Radio System Refresh resiliency measure.

Figure 5-15: Communication Technology Benchmarks with Utility Partners



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

As shown in Figure 5-9 under the row that reads, "Voice and Mobile Data Enhancements," we see that over 50% of CenterPoint Houston's peer utilities have made similar investments, which tells us that other utilities are also looking toward this type of investment to bolster reliability within their organizations. Guidehouse concludes that given their time and budgetary considerations, CenterPoint Houston's investments in their near-term voice and mobile data enhancements will provide more immediate benefits from a resiliency perspective. A well-functioning telecommunications network plays a pivotal role in reliable grid operations, and the absence of reliable systems can impact the ability of CenterPoint Houston personnel to swiftly respond to operational needs.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows telecommunications upgrades are being made in electric utility resiliency investments in several of the states examined. For example, Dominion Energy Virginia ("Dominion") petitioned the

Virginia State Corporation Commission ("VA Commission") for Approval of a Plan for Electric Distribution Grid Transformation Projects that included telecommunications and physical security enhancements.[137] In 2023, the VA Commission went on to approve this and other enhancements designed to improve the safety and security of Dominion's electric distribution system.[138] The approval by the VA Commission, inclusive of telecommunications enhancements, exemplifies the proactive approach that is being taken in other jurisdictions toward enhancing the resiliency of the grid.

5.4.2 Data Center Refresh

5.4.2.1 Resiliency Measure Description

CenterPoint Houston's Data Center Refresh resiliency measure addresses the following aspects to support resiliency of its transmission and distribution systems:

- Updating existing processes from manual connection and router adjustment between centers to an automatic turnover system to increase the resilience of cloud-based data centers.
- Improving application recovery and introducing a comprehensive tool for recovery plan management.
- Transitioning to newer Intel-based server hardware, specifically Gen 11, increasing availability and reducing failure susceptibility.
- A comprehensive redesign of the complex Storage Area Network ("SAN") Fabric Storage network across the fiber network. The current setup involves various vendors and isolated storage pockets and unnecessary fabrics. The resiliency measure will eliminate isolated storage packets, enhancing the system's efficiency.
- Developing a single storage platform that will allow for multi-protocol usage as well as cloud native capabilities of replication, tiering, and archiving.

The infrastructure will be implemented to support replacement technology to perform transmission and distribution operations functions and will include key performance indicators ("KPIs") and additional metrics to monitor key attributes to assess measure effectiveness and reliability. The combination of aspects of this resiliency measure, which in most cases begins implementation 2024; including planning, offers a more sustainable infrastructure. The resiliency measure addresses issues and concerns with outdated and end-of-life systems, applications, and equipment, while also streamlining processes. The implementation will last three years, with automated failover being the immediate component, taking one year. All implementation components are aligned with the broader objective of enhancing grid resilience.

[137] Dominion Petition to Virginia State Corporation Commission for Approval of a Plan for Electric Distribution Grid Transformation Projects. (2019 January). [Dominion Petition for Approval of Electric Distribution Grid Transformation Projects]. (p. 1).

[138] SCC Approves Dominion Grid-Transformation Plan. (2023 September) [SCC Press Release]. https://scc.virginia.gov/newsreleases/release/SCC-Approves-DEV-Grid-Transformation-Plan-(1)

CenterPoint Houston plans to shift from an on-premises data center model to a hybrid model which is aimed at enhancing grid resiliency through improved response and recovery capabilities, ultimately minimizing risks related to service interruptions. A data center is a physical facility utilized by organizations to house critical applications and data through a network of computing and storage resources, facilitating the delivery of shared applications and data. Key components include routers, switches, firewalls, storage systems, servers, and applications delivery controllers.[139]

5.4.2.2 Alternatives Considered

CenterPoint Houston considered various alternatives from three vendors- Dell, HP, and IBM- to address the introduction of new Cisco switches. They aimed to enable automatic failover to replace the current equipment lacking this capability and to ensure uninterrupted operations.

The determining factors were compatibility for hybrid cloud and the skill set within the personnel. CenterPoint Houston is looking to transition their IBM-HP equipment into Intel-based systems to increase system agility. CenterPoint Houston is looking into a modern system that can become hybridized with the cloud or be able to transition into full cloud. Alternatives will depend on the vendors and the products that are being offered.

CenterPoint Houston will migrate many of their legacy applications into a cloud environment leveraging cloud solutions to improve the ability to recover them. Some of the software cannot simply be moved to the cloud and will need alternative options for recovery as they decide what could be moved to the cloud. The alternatives are to keep systems on premises and leverage replication or move to a hybrid environment and solution.

5.4.2.3 Resiliency Measure Effectiveness

Guidehouse evaluated the benefits and features associated with CenterPoint Houston's proposed Data Center Refresh resiliency measure on a qualitative basis with measure-specific inputs and assumptions. This analysis compared CenterPoint Houston's resiliency measure with the NIST CSF Categories, to determine the levels of correlation between the five CSF Functions (Identify, Detect, Protect, Respond, and Recover) and the proposed system in terms of developing resilient systems. Guidehouse performed the analysis and identified whether the resiliency measure had high, medium, or low correlations to the individual subcategories of the CSF. For the purpose of this report, Guidehouse is only reporting on features, applications, or business processes with a high or, in some instances, medium correlation to subcategories of the NIST CSF.

CenterPoint Houston also plans to use the following performance metrics for tracking the effectiveness of the Data Center Refresh resiliency measure in moving from an on-premises model to a cloud-based model:

[139] Cisco (2024)

- Number of replaced systems,
- Number of manual processes replaced by automation,
- Decreased storage footprint (on premises) vs. Increased resource management/storage efficiency improvements (cloud-based system),
- Decreased data compression rates, and
- Decreased application recovery time

The subcategories selected for reporting from the medium correlations were selected based on Guidehouse's professional judgment and conclusion that the resiliency measure had a partial or indirect correlation, along with Guidehouse's professional judgment that the measure was sufficiently implementing the intent of the subcategory from a resiliency perspective. The system features that were mapping to low correlation were considered to be relatively ineffective in improving resiliency, although depending on the context of the proposed measure, they may still have value in pursuing from reliability or policy perspectives. For a detailed explanation of the methodology used, refer to Section 5.1.3.

Table 5-5 lists CSF Functions and associated categories with high and/or medium correlations to the resiliency measure:

Table 5-4: Data Center Refresh Analysis Results

Function	Categories
Identify	• Asset Management ("AM") • Business Environment ("BE") • Governance ("GV") • Risk Assessment ("RA")
Protect	• Access Control ("AC") • Data Security ("DS") • Information Protection Processes and Procedures ("IP") • Protective Technology ("PT")
Recover	• Improvements ("IM")
Please note: Guidehouse did not include the "Respond" and "Detect" functions as part of these analysis results as they did not have high or medium correlations.	

5.4.2.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed resiliency measure and determined that the measure will provide a high level of effectiveness. Based on the results of its analysis, Guidehouse determined that the measure offers resiliency benefits. All determinations below are based on CenterPoint Houston information on measure descriptions, interviews, and responses to data requests for additional resiliency measure details.

The analysis identified the following categories and results where the category and associated subcategory(ies) have a high correlation to the resiliency measure:

Asset Management ("ID.AM") *The data, personnel, devices, systems, and facilities that enable the organization to achieve business purposes are identified and managed consistent with their relative importance to organizational objectives and the organization's risk strategy.*	
Analysis Results Description:	Asset management is a vital part of resiliency. Addressing supply chain and warehousing operations, strategies will be devised to identify and implement upgrades that will phase out aging and end-of-life equipment. CenterPoint Houston will inventory the associated data center hardware and software to successfully implement the resiliency measure. CenterPoint Houston plans to move existing on premises services to cloud-based applications through a SaaS deployment or directly into a cloud space such as Azure for clients and personnel. It plans to continue on premises as needed until they can transition to a hybrid platform, then possibly a fully cloud model. Additionally, data flows will be improved through the implementation of new Cisco switches aimed at automatic failure prevention. CenterPoint Houston plans to transition from their aging and end-of-life IBM-HP hardware to a more modern Intel-based server hardware that can add security features and provide for a hybrid (on premises and cloud) environment showing their prioritization for critical systems. The service life of these assets typically spans six years, though in some cases, it extends to seven years.

Business Environment ("ID.BE") *The organization's mission, objectives, stakeholders, and activities are understood and prioritized; this information is used to inform cybersecurity roles, responsibilities, and risk management decisions.*	
Analysis Results Description:	CenterPoint Houston highlights the comprehensive understanding and prioritization of its critical system and their dependencies and critical functions by improving their failover, recovery, and redundancy capabilities for some of their software services through this resiliency measure. Specifically, the Cisco upgrade aspect of this resiliency measure emphasizes the importance of enhancing the availability of their data centers and transitioning to an automatic failover solution from the primary to their backup center. CenterPoint Houston's focus on increasing resilience includes improving software application availability by migrating to the cloud or a hybrid platform where a full cloud solution is not possible.

Governance ("ID.GV") *The policies, procedures, and processes to manage and monitor the organization's regulatory, legal, risk, environmental, and operational requirements are understood and inform the management of cybersecurity risk.*	
Analysis Results Description:	CenterPoint Houston will leverage third-party services as part of the design, procurement, integration, and implementation of its resiliency measure. It is important that partners understand their roles and responsibilities from a cybersecurity perspective. CenterPoint Houston highlighted cybersecurity roles and responsibilities for both internal personnel and external partners. They also provided assurance of defined and controlled access processes during implementation, including formal request and approval procedures. CenterPoint Houston has an access provisioning system that would be leveraged and a physical escorting process that would ensure only those approved, will have electronic or physical access to the systems included in this resiliency measure.

Risk Assessment ("ID.RA") *The organization understands the cybersecurity risk to organizational operations (including mission, functions, image, or reputation), organizational assets, and individuals.*	
Analysis Results Description:	CenterPoint Houston demonstrates an understanding of cybersecurity risks pertaining to its operational functions and asset protection. Threats are identified, documented, and prioritized for risk response using the vulnerability assessment tool prior to introducing new hardware into production. CenterPoint Houston also identified manual failover mechanisms between data centers as a risk due to reduced recovery capacity and increased downtime. CenterPoint Houston is prioritizing setting up an automated method for failing over between data centers, demonstrating a proactive approach to mitigating risks.

Access Control ("PR.AC") *Access to physical and logical assets and associated facilities is limited to authorized users, processes, or devices, and is managed consistent with the assessed risk of unauthorized access to authorized activities and transactions.*	
Analysis Results Description:	CenterPoint Houston employs robust access control measures to manage both physical and logical asset access, ensuring that only authorized users, processes, or devices are granted entry, aligning with assessed risks of unauthorized access. Remote access is limited to company storage personnel and relevant management teams, with some least privilege principles applied, to ensure individuals have the least number of privileges necessary to perform their tasks. Third-party access follows a formal account creation and approval process, with regular recertification and manual removal capabilities. Network segmentation is implemented across the enterprise and is continually considered for enhancement. Overall, CenterPoint Houston maintains effective access management practices, prioritizing security and risk mitigation.

Data Security ("PR.DS") *Information and records (data) are managed consistent with the organization's risk strategy to protect the confidentiality, integrity, and availability of information.*	
Analysis Results Description:	CenterPoint Houston's information management and security strategy aligns with its risk strategy, emphasizing the protection of data confidentiality, integrity, and availability. CenterPoint Houston implements Self Encrypting Drives ("SEDs") in resiliency measure aspects like the SAN Fabric to safeguard data-at-rest, complemented by a software layer for monitoring traffic within the SAP environment. CenterPoint Houston's in-transit data is mostly internal traffic that leverages network segmentation to ensure traffic is seen by the appropriate parties. A subset of their system employs encryption tools such as PGP with a global key manager. Additionally, they encrypt the traffic from the firewalls to the logs servers that aggregate network logs. CenterPoint Houston includes proper disposal procedures like shredding drives prior to disposal to sanitize the data. Furthermore, they are increasing system availability by upgrading to an automated failover architecture for data centers, transitioning software into a cloud or hybrid solution as well as increasing storage capacity with the SAN fabric upgrade. CenterPoint Houston utilizes a test environment for testing new equipment and making vendor updates when applicable before deployment into production.

Information Protection Processes and Procedures ("PR.IP") *Security policies (that address purpose, scope, roles, responsibilities, management commitment, and coordination among organizational entities), processes, and procedures are maintained and used to manage protection of information systems and assets.*	
Analysis Results Description:	CenterPoint Houston establishes baseline configuration for its information technology and industrial control systems, incorporating security principles and concepts like least functionality. Least functionality ensures only essential capabilities and prohibits or restricts the use of non-essential functions; though it lacks ongoing maintenance and historical tracking within programs. CenterPoint Houston leverages data lifecycle techniques, such as change management, backup and retention procedures, and data destruction techniques. For change management processes, baselines are established before implementation begins, but will be adjusted as needed during the upgrade. Backups are made at the application and file level and are included in the disaster recovery process. For retention, copies of application/ file information are triplicated and follow CenterPoint Houston's data retention policy. CenterPoint Houston plans to enhance data protection by shredding drives upon equipment and hardware decommissioning, collapsing storage SAN fabrics, and integrating virtual SAN fabrics into other devices within the SAN fabric program to lessen the attack radius of external threats.

Protective Technology ("PR.PT") *Technical security solutions are managed to ensure the security and resilience of systems and assets, consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	CenterPoint Houston prioritizes the protection of its communications and control networks by implementing a range of security measures, including electronic and physical access controls such as authentication, encryption, and other security features. Network security and cybersecurity teams at CenterPoint Houston are responsible for managing the protection of network devices involved in these programs, ensuring robust safeguards are in place. Additionally, the primary objective of the Cisco upgrade is to improve failover capabilities, particularly for the automatic failover program, demonstrating CenterPoint Houston's dedication to maintain network resilience and continuity in the face of potential disruptions. CenterPoint Houston also leverages the use of authentication mechanisms for physical and logical access, as well as encryption for data management.

Improvements ("RC.IM") *Recovery planning and processes are improved by incorporating lessons learned into future activities.*	
Analysis Results Description:	CenterPoint Houston is intending to improve its ability to recover its applications in Business Continuity and Disaster Recovery ("BCDR") situations through this resiliency measure. CenterPoint Houston intends to move to a cloud solution where it is possible for many of its applications. On premises replication and recovery is currently in place with next steps to move toward development of a Hybrid Cloud (Cloud and OnPremises) BCDR strategy, with eventual intentions of full cloud migration. The data center automated failover program will also improve the recovery strategy in a case where one of CenterPoint Houston's data centers becomes unavailable. The current manual processes involve identifying the issue and manually contacting someone to perform the necessary steps, estimated to take around three hours. The automated recovery will further improve system availability, further making their system more resilient.

5.4.2.5 Resiliency Measure Assessment

Guidehouse concludes there is a high level of correlation to system and business resilience and system restoration with CenterPoint Houston's Data Center Refresh resiliency measure. This was based on the high level of correlation the measure has in relation to the NIST CSF functions. Particular areas in which this resiliency measure supports a strong and resilient electric transmission and distribution system include:

- Business Environment
- Governance
- Access Control

- Data Security
- Protective Technology
- Improvements

Upgrading the outdated equipment and implementing solutions that improve system availability through enhanced recovery solutions was the intent of many aspects of this resiliency measure. Ensuring that CenterPoint Houston maintains a resilient business environment that provides critical services needed for normal operations as well as during system duress or recovery states.

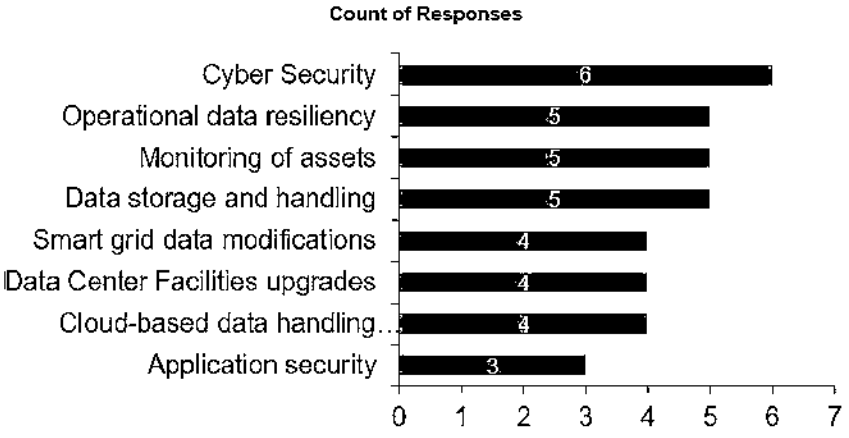
Through access control and data security, CenterPoint Houston will continue to protect their system as they move forward with upgrading to the latest technology. Moving to a on premises solution for replication, then a hybrid system, with goals to fully implement in the cloud environment leveraging cloud solutions will provide CenterPoint Houston with the ability to recover quickly from a natural disaster or a cybersecurity event using the latest methods of recovery that these solutions provide.

5.4.2.6 Benchmarking

Peer Utility Benchmarking

Through a separate peer utility benchmarking exercise, discussed in Section 5.3, nine utilities provided survey responses regarding information technology investments they have made. As shown in Figure 5-16, four of the nine other utilities that were surveyed indicated they have also made investments in their data center facilities and have migrated toward cloud-based data handling. Additionally, five of the nine utilities stated that they have invested in data storage and handling.

Figure 5-16: Information Technology Benchmarks with Utility Partners



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

What we are seeing here is a growing trend within the industry toward modernization and adaptation of cloud technologies. This alignment indicates a strategic shift toward more agile, scalable, and cost-effective data management solutions.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that data center upgrades are being made in electric utility resiliency investments in several of the states examined. For example, Green Mountain Power has a goal for keeping their data centers reliable and efficient. Green Mountain Power's investment requirements include projects for failover systems, providing enhanced levels of redundancy and resiliency to key operational systems that could more easily succumb to extreme weather-related impacts in their current configuration.[140] Through this jurisdictional perspective, it's clear that utilities are making strides toward enhancing protections within their data centers, viewing these investments as key grid resiliency initiatives.

5.4.3 Backhaul Microwave Communication

5.4.3.1 Resiliency Measure Description

CenterPoint Houston's Backhaul Microwave Communication resiliency measure will replace end-of-life microwave equipment used for large data transfer with standardized units, the goal of which is to facilitate improved maintenance, repair, and replacement procedures, and includes the communication for dispatching crews for blue sky and weather events. This initiative aims to streamline operations by minimizing the need for personnel to carry multiple pieces of technology and maintain multiple system platforms. Upgrading and modernizing with standardized field devices will allow CenterPoint Houston to move into technologies and implementations such as field transparency, metrification of field data, mitigation of concurrency misalignments, and dashboarding at a level that was not possible previously. Converging to a single centralized system will also provide CenterPoint Houston with the possibility of new automation and availability options that were not previously available. Backhaul support will further extend to CenterPoint Houston's transmission and distribution operations and service centers as a primary or secondary method of data communication between facilities. Additionally, the microwave system will support the transfer of information from substations to CenterPoint Houston personnel. The microwave system is a backup system for monitoring and controlling field devices where there is fiber optic control and as a primary system at sites that are not fiber compatible.

The estimated 3-year cost for this resiliency measure is $12.1 million.

[140] GMP Power Climate Plan. (p. 7).

5.4.3.2 Alternatives Considered

CenterPoint Houston considered multiple communication alternatives when evaluating this resiliency measure. The primary alternative would be the use of fiber optics at all facilities and assets. While a desirable alternative, CenterPoint Houston determined this is not feasible due to cost and difficulty of creating fiber optics connections to remote locations and assets. CenterPoint Houston, however, does have fiber to many of its locations and, in those locations, it is the primary communication method used. For facilities that are not fiber compatible, CenterPoint Houston currently has in place older microwave communication equipment. For these facilities, CenterPoint Houston considered simply maintaining the existing equipment. CenterPoint Houston determined that it needs to acquire updated equipment due to the lack of support, end-of-life equipment inherits; reducing the need to maintain multiple equipment platforms, and utilizing features that currently cannot be used due to technological incompatibilities between the different platforms.

After considering these alternatives, CenterPoint Houston concluded that purchasing a modern backhaul microware system for communication needs at its locations and assets was the most resilient and efficient communication option for the organization. The use of such modern equipment would eliminate the end-of-life issues related to CenterPoint Houston's existing equipment that are not fiber compatible.

5.4.3.3 Resiliency Measure Effectiveness

Guidehouse reviewed CenterPoint Houston's Backhaul Microwave resiliency measures using a qualitative comparative analysis. A quantitative analysis was not conducted due to data limitations and lack of metrics to benchmark against.

CenterPoint Houston also plans to use the following performance metrics for tracking the effectiveness of the Backhaul Microwave Communications resiliency measure:

- Amount of end-of-life equipment replaced by modern vendor-supported systems,
- Decrease in maintenance time, and
- Increased collection of data points.

Guidehouse evaluated the benefits and features associated with CenterPoint Houston's proposed Backhaul Microwave resiliency measure on a qualitative basis with measure-specific inputs and assumptions. This analysis compared CenterPoint Houston's resiliency measure with the NIST CSF Categories, to identify levels of correlation between the five CSF Functions (Identify, Detect, Protect, Respond, and Recover), and the proposed system in terms of developing resilient systems. Guidehouse determined whether the resiliency measure had high, medium, or low correlations to the individual subcategories of the CSF. For the purpose of this report, Guidehouse is only reporting on features, applications, or business processes with a high or, in some instances, medium correlation to subcategories of the NIST CSF.

The subcategories selected for reporting from the medium correlations were selected based on Guidehouse's professional judgment and conclusion that the resiliency measure had a partial or indirect correlation, along with Guidehouse's professional judgment that the measure was sufficiently implementing the intent of the subcategory from a resiliency perspective. The system features that were mapping to low correlation were considered to be relatively ineffective at improving resiliency, although depending on the context of the proposed program, they may still have value in pursuing from reliability or policy perspectives. For a detailed explanation of the methodology used, refer to Section 5.1.3.

Table 5-4 lists Functions and associated categories with high and/or medium correlations to the resiliency measure:

Table 5-5: Backhaul Microwave Communication Analysis Results

Function	Categories
Identify	• Asset Management ("AM") • Business Environment ("BE") • Risk Assessment ("RA") • Supply Chain Risk Management ("SC")
Protect	• Access Control ("AC") • Data Security ("DS") • Information Protection Processes and Procedures ("IP") • Maintenance ("MA") • Protective Technology ("PT")
Detect	• Security Continuous Monitoring ("CM")

5.4.3.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Network Security and Vulnerability Management resiliency measure Guidehouse's analysis indicates that the measure will provide a high level of effectiveness for detecting of threats to the system. Based on the results of its analysis, Guidehouse determined that the measure offers resiliency benefits. All determinations below are based on CenterPoint Houston information on resiliency measure descriptions, interviews, and responses to data requests for additional measure details.

The analysis identified the following categories and results where the category and associated subcategory(ies) have a high and medium correlation to the resiliency measure:

Asset Management ("ID.AM") *The data, personnel, devices, systems, and facilities that enable the organization to achieve business purposes are identified and managed consistent with their relative importance to organizational objectives and the organization's risk strategy.*	
Analysis Results Description:	Asset management is a vital part of resiliency. Identifying the hardware for upgrades or expansion helps manage, protect, and ensure system availability. CenterPoint Houston will inventory the associated microwave hardware to successfully implement the resiliency measure. CenterPoint Houston will replace end-of-life equipment to create a standard microwave system. This will require identifying all end-of-life equipment and new replacement equipment. Leading to a better repair and maintenance program, thereby improving resiliency. Replacing end-of-life radios with new equipment offers several key benefits to CenterPoint Houston. Enhancing reliability by providing improved performance and reducing the frequency of equipment failures, while minimizing disruptions to CenterPoint Houston, is the penultimate goal of the resiliency measure. Investing in new radio equipment will strengthen CenterPoint Houston's communication infrastructure while enhancing resiliency.

Business Environment ("ID.BE") *The organization's mission, objectives, stakeholders, and activities are understood and prioritized; this information is used to inform cybersecurity roles, responsibilities, and risk management decisions.*	
Analysis Results Description:	Understanding the dependencies that need to be prioritized to ensure CenterPoint Houston meets its objectives is a critical part of resiliency. The Backhaul Microwave Communication resiliency measure will improve communication for multiple platforms that depend on it as a primary or secondary method for data communication. The microwave system is used for: data communication into the SCADA system, assisting with supporting meters for industrial business, improving security by providing video feeds from some substation locations, and improving system health by sending traveling wave data, data from digital fault recorders, and monitoring capacitor banks in the field. As part of the microwave refresh, CenterPoint Houston will be deploying a microwave management system that focuses on the health of the microwave system and allows for maintaining consistency on the latest firmware released by the vendor, adding additional support for delivering critical services.

Risk Assessment ("ID.RA") *The organization understands the cybersecurity risk to organizational operations (including mission, functions, image, or reputation), organizational assets, and individuals.*	
Analysis Results Description:	Identifying the risks to the system is critical to resilience because it improves CenterPoint Houston's situational awareness of weaknesses that could be exploited. The Backhaul Microwave Communication resiliency measure will include various risk assessment activities that will help CenterPoint Houston understand where additional controls need to be put in place. Prior to deploying and implementing the new equipment into production, CenterPoint Houston will perform an evaluation of the vendor and the product. The evaluation is scoped to be a technical assessment of vulnerabilities within the product, which would be performed in the test environment. This assessment will verify whether there are any components that are communicating outside of the desired parameters and will also include a vulnerability assessment to determine if there are any potential weaknesses that could impact their performance. Additionally, the evaluation plays a crucial role in enhancing resilience by identifying potential vulnerabilities, that could turn into risks, that could impact CenterPoint Houston. Leveraging evaluation findings enables proactive measures to mitigate risk, enhancing robust systems, and ensuring continuity of operations. Overall, integrating evaluation processes into resilient strategies will empower CenterPoint Houston.

Supply Chain Risk Management ("ID.SC") *The organization's priorities, constraints, risk tolerances, and assumptions are established and used to support risk decisions associated with managing supply chain risk. The organization has established and implemented the processes to identify, assess and manage supply chain risks.*	
Analysis Results Description:	Identifying whether a vendor provides high quality products and is reputable is an important part of resiliency. As part of the Backhaul Microwave Communication resiliency measure, CenterPoint Houston plans to assess the vendor prior to procuring its product or services. During interviews, CenterPoint Houston stated that they would not only evaluate or assess the product prior to bringing it to production but also assess the vendor. This is a vital step to supply chain quality and security and adds an additional layer of resiliency to their overall system as the microwave technology plays an important role in data communication.

Access Control ("PR.AC") *Access to physical and logical assets and associated facilities is limited to authorized users, processes, or devices, and is managed consistent with the assessed risk of unauthorized access to authorized activities and transactions.*	
Analysis Results Description:	Controlling access to any system is an important part of protecting the system from bad actors, reducing system downtime and therefore improving resiliency. As part of the Backhaul Microwave resiliency measure, CenterPoint Houston intends to continue to physically protect the equipment necessary for functionality. All new equipment will be placed inside physical barriers with additional controls such as a substation fence, cyber keys, login access requirements, and individual key assignments that only allow privileged users access to the equipment. Additionally, the system upgrades will improve remote access management as it will include a universal platform that will standardize the microwave system and introduce advanced capabilities such as remote control, monitoring, and troubleshooting. Older equipment that will be removed does not have these capabilities. These improved access controls will not only protect the system, but also increase system capabilities to further improve resiliency.

Data Security ("PR.DS") *Information and records (data) are managed consistent with the organization's risk strategy to protect the confidentiality, integrity, and availability of information.*	
Analysis Results Description:	Securing the data that will flow through the microwave system and ensuring that it is available are important aspects of resiliency. As part of this resiliency measure, CenterPoint Houston plans to add a layer of protection while data is in-transit improving the redundancy channels with the equipment upgrades. The new microwave system will have the ability to encrypt data-in-transit via the IPsec protocol for encryption. By reducing the incompatible microwave technology that currently exists and replacing the older equipment, CenterPoint Houston will have the ability to leverage more current technologies. Additionally, the new equipment will replace end-of-life equipment and provide for a more resilient communication pathway ensuring the availability of data transfers. CenterPoint Houston will also be testing the equipment in their test environment to ensure the systems are as secure as possible prior to introducing them to production.

Information Protection Processes and Procedures ("PR.IP") *Security policies (that address purpose, scope, roles, responsibilities, management commitment, and coordination among organizational entities), processes, and procedures are maintained and used to manage protection of information systems and assets.*	
Analysis Results Description:	Security policies such as baseline configuration maintenance are rigorously upheld at CenterPoint Houston. Efforts are underway to establish and maintain baseline configurations as part of the ongoing maturity process for the backhaul microwave system. CenterPoint Houston's efforts to enhance protection processes are under consideration, with plans to incorporate Internet Protocol Security ("IPsec") encryption into new equipment. IPsec encryption for backhaul microwave networks requires system compatibility to encrypt data packets and transmit them securely over the wireless access points. While the full implementation of encryption capabilities is contingent upon further evaluation, a significant portion of vendor-selected systems is expected to support IPsec tunnel encryption. The potential utilization of microwave encryption with the new system presents an opportunity for further resiliency, with plans to standardize and improve microwave encryption capabilities in the future by strengthening bulk encryption measures.

Maintenance ("PR.MA") *Maintenance and repairs of industrial control and information system components are performed consistent with policies and procedures.*	
Analysis Results Description:	The maintenance and repair function best with established policies and procedures that can be leveraged by CenterPoint Houston to improve system availability further enhancing resiliency. During interviews, CenterPoint Houston stated it executes the maintenance and repair processes whenever issues arise. There is a predetermined program specifically dedicated to managing maintenance and repairs for radio links. An approval process is in place for maintenance and repair tasks.

Protective Technology ("PR.PT") *Technical security solutions are managed to ensure the security and resilience of systems and assets, consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	CenterPoint Houston has implemented capabilities that provide the extent of condition and validation, contributing to the overall health and effectiveness of the system that is leveraging the microwave system to transmit this type of data to the ADMS. It is important to address resiliency risk associated with older microwave radios, which tend to fail more frequently and possess fewer capabilities. Implementing redundant systems for all substations mitigates the risk of communication loss or prolonged outages in case of failure, especially for older systems with limited capabilities. The integration of recloser devices with remote operation capabilities will impact CenterPoint Houston's ADMS. This integration has the potential to necessitate an increase in system capacity, a factor that flows beyond the current scope of operations. It is imperative to consider the relationship between backhaul microwave system and remote operations. The remote operation functionality predominantly serves purposes relating to the remote control within the intelligent grid switching device. The backhaul microwave system plays a crucial role in facilitating remote operations by providing the necessary communication infrastructure for transmitting control signals between the intelligent grid switching device and the ADMS. Any enhancement or modifications to the backhaul microwave system directly impacts the ability to perform remote operations effectively. Enhancing redundancy is one of the key objectives of this resiliency measure, aligning with the extensive goal of improving system reliability and resilience.

Security Continuous Monitoring ("DE.CM") *The information system and assets are monitored to identify cybersecurity events and verify the effectiveness of protective measures.*	
Analysis Results Description:	CenterPoint Houston's information system and assets undergo continuous monitoring to detect cybersecurity events and validate the efficiency of protective measures. CenterPoint Houston's scrutiny extends to the physical environment, where security cameras are integrated with the backhaul microwave system, playing a crucial role in detecting potential cybersecurity threats. Having access to the video feeds allows CenterPoint Houston personnel to respond to a potential threat. The Backhaul Microwave Communication resiliency measure will enhance video feeds by improving communication throughput and provide a redundant communication line that assist with ensuring critical security video feeds are available for surveillance.

5.4.3.5 Resiliency Measure Assessment

Guidehouse concludes that CenterPoint Houston's Backhaul Microwave Communication resiliency measure provides resiliency benefits. Primarily, the measure is aimed at reducing

communication loss and control for critical electrical systems. In addition, the goal of the backhaul microwave installation is to have a secondary method of communication available under system duress caused by extreme weather or cybersecurity events, helping reduce risk of losing critical data and controls from remote locations as a primary form of communication. Redundancy is one of the primary methods for ensuring a resilient electric delivery service. System recovery will also improve as the redundancy that the microwave system provides would allow for business continuity and a clear view of communications link failures.

5.4.3.6 Benchmarking

Peer Utility Benchmarking

Efficient and reliable communication infrastructure is essential for the seamless operation of critical systems and operations across utilities. Communication devises are enabling technologies that allow CenterPoint Houston to have a real-time view of its entire system and make faster and more informed decisions. Guidehouse recognizes that as organizations continue to evolve, ensuring robust communication networks becomes paramount to support the diverse needs of utility operations.

CenterPoint Houston has wired and wireless communication technology deployed on their network; CenterPoint Houston has fiber optic networks at many of its locations and, in those locations, it is the primary communication method used. For facilities that are not fiber compatible, CenterPoint Houston has microwave communication equipment in place.

Through a separate benchmarking exercise, discussed in Section 5.3, nine utilities provided survey responses regarding communications technology investments they have made. As shown in Figure 5-15, microwave communications and telecommunication infrastructure are technology resiliency investments that at least four of the nine responding utilities have adopted. This data is essential for understanding the investments that other utilities have made as it pertains to communication technology and offers valuable insight into what aspects of these investments tie back into the offerings of that will be used at CenterPoint Houston related to the Backhaul Microwave Communications resiliency measure.

From the comparative analysis shown in Figure 5-9, we see that from the row indicating microwave communication investments, there are over 50% peer utilities that have also deployed and are investing in this technology. The fact that over 50% of peer utilities are also investing in these systems indicates that these utilities recognize the benefits of microwave communication for their operations, and its ability to meet evolving demands, enhance operations efficiency, and its positive impact on grid resiliency.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that system upgrades are commonly included in resiliency planning efforts in the states examined, similar to

CenterPoint's Backhaul Microwave Communications. For example, Green Mountain Power is making a concerted effort to invest in measures that ensure reliable and resilient grid operations. The utility stated that programs will be concentrated in three key areas, including enhancements to their communications technology.[141] This highlights the ongoing upgrades in communications technology being made by electric utilities, with a clear focus on making strategic investments that will contribute to increased grid resiliency.

5.4.4 Network Security and Vulnerability Management

5.4.4.1 Resiliency Measure Design

CenterPoint Houston's Network Security and Vulnerability Management resiliency measure is focused on proactive procedures to enhance its cybersecurity posture and align with industry standards and best practice. Through systemic threat detection and vulnerability scanning processes, CenterPoint Houston identifies and addresses potential weaknesses across endpoint and system environments. CenterPoint Houston's ongoing evaluation of cybersecurity risk includes comprehensive penetration testing to assess the resilience of its infrastructure, ensuring that it stays ahead of emerging threats. Additionally, replacing the end-of-life network security equipment allows CenterPoint Houston to have the latest in service and manufacturer supported equipment.

Application Security: This project will develop and operationalize tools and processes to ensure all application development is completed securely with control of the point of origin/subcomponents of every in-house developed software product. The implementation process consists of assessing the current development environment; understanding gaps in current processes; working with development teams and leadership to evaluate products in the market that facilitate a consistent, measurable, auditable development process that includes software vulnerability scanning during the development process; implementing the chosen cybersecurity application development tool; and implementing process changes to ensure Company objectives are met.

Vulnerability management is a continuous cybersecurity process that includes identifying, evaluating, mitigating, and reporting software and network vulnerabilities. Identifying, monitoring, and responding to both urgent and complex issues are essential components of vulnerability management and cybersecurity. In another measure, CenterPoint Houston will be upgrading to a Governance, Reliability, and Compliance ("GRC") tool to automate its processes and replace its manual processes of using spreadsheets, which will reduce potential data input errors. CenterPoint Houston also plans to deploy a vulnerability assessment tool to support the vulnerability management process.

Additionally, as part of this measure, CenterPoint Houston also plans to refresh the hardware for over 200 appliances, firewalls, and hardware for critical software such as Palo Alto, QRadar and

[141] GMP Power Climate Plan. (p. 7).

Cyber Ark which is currently being used for firewall protection (Palo Alto), threat detection (QRadar) and as a password vault (Cyber Vault) for housing important privileged access management information. Through these hardware refreshes, CenterPoint Houston aims to bolster its resilience against cyber threats, aligning with the broader objective of enhancing grid resilience in an increasingly digital landscape.

5.4.4.2 Alternatives Considered

CenterPoint Houston is in the process of determining the solutions and tools that will continue to be implemented to address vulnerability management and GRC procedures. CenterPoint Houston currently uses Rapid7. CenterPoint Houston is doing its due diligence to consider other vendors and solutions as potential options for replacement.

5.4.4.3 Resiliency Measure Effectiveness

Guidehouse evaluated the benefits and features associated with CenterPoint Houston's proposed Network Security and Vulnerability Management resiliency measure on a qualitative basis with measure-specific inputs and assumptions. This analysis compared CenterPoint Houston's resiliency measure with the NIST CSF Categories, to identify levels of correlation between the five CSF Functions (Identify, Detect, Protect, Respond, and Recover), and the proposed system in terms of developing resilient systems. Guidehouse performed the analysis by identifying whether the resiliency measure had high, medium, or low correlations to the individual subcategories of the CSF. For the purpose of this report, Guidehouse is only reporting on features, applications, or business processes with a high or, in some instances, medium correlation to subcategories of the NIST CSF.

CenterPoint Houston also plans to use the following performance metrics for tracking the effectiveness of the Network security & Vulnerability Management resiliency measure:

- Number of applications in scope having gone through their Secure Software Development Lifecycle ("SSDLC") process,
- Amount of peer reviews, code reviews, code scans,
- Number of application security vulnerabilities detected/remediated,
- Number of network segments ingested on a daily basis,
- Number of suspicious / malicious alerts
- Number of packets stopped at firewalls
- Number of packets inspected, and
- Net number of rules moved from layer 4 to layer 7

The subcategories selected for reporting from the medium correlations were selected based on Guidehouse's professional judgment that the resiliency measure had a partial or indirect correlation, along with Guidehouse's professional judgment that the resiliency measure was

sufficiently implementing the intent of the subcategory from a resiliency perspective. The system features that were mapping to low correlation were considered to be relatively ineffective in improving resiliency, although depending on the context of the proposed resiliency measure, it may still have value in pursuing from reliability or policy perspectives. For a detailed explanation of the methodology used, refer to Section 5.1.3.

Table 5-6 lists the CSF Functions and associated categories with high and/or medium correlations to the measure:

Table 5-6: Network Security and Vulnerability Management Analysis Results

Function	Category
Identify	• Asset Management ("AM") • Business Environment ("BE") • Governance ("GV") • Risk Assessment ("RA") • Supply Chain Risk Management ("SC")
Detect	• Anomalies and Events ("AE") • Security Continuous Monitoring ("CM") • Detection Processes ("DP")
Protect	• Access Control ("AC") • Awareness and Training ("AT") • Data Security ("DS") • Information Protection Processes and Procedures ("IP") • Protective Technology ("PT")
Please note: Guidehouse did not include the "Respond" and "Recover" functions as part of these analysis results as they did not have high or medium correlations.	

5.4.4.4 Benefits Analysis

Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed Network Security and Vulnerability Management resiliency measure. Guidehouse's analysis indicates that the resiliency measure will provide a high level of effectiveness for detection of threats to the system. Based on the results of its analysis, Guidehouse determined that the resiliency measure offers resiliency benefits. All determinations below are based on CenterPoint Houston's information on measure descriptions, interviews, and responses to data requests for additional measure details.

The analysis identified the following categories and results where the category and associated subcategory(ies) have a high and medium correlation to the resiliency measure:

Asset Management ("ID.AM") *The data, personnel, devices, systems, and facilities that enable the organization to achieve business purposes are identified and managed consistent with their relative importance to organizational objectives and the organization's risk strategy.*	
Analysis Results Description:	CenterPoint Houston is upgrading and refreshing technology that needs to be updated. This resiliency measure helps ensure CenterPoint Houston has network and security tools that meet industry standard to achieve resiliency of the services it provides. CenterPoint Houston listed the hardware and software it will upgrade and refresh with a priority in criticality and business need. Network devices that are coming to end-of-life is being prioritized, as part of this resiliency measure. Having the latest network security hardware available will ensure the network is being updated by the manufacturer and has the latest security features installed to ensure a robust and resilient network.

Business Environment ("ID.BE") *The organization's mission, objectives, stakeholders, and activities are understood and prioritized; this information is used to inform cybersecurity roles, responsibilities, and risk management decisions.*	
Analysis Results Description:	Establishing critical functions assists with ensuring resiliency on the services being provided. CenterPoint Houston plans to improve resilience by upgrading the ability to failover or switch from its primary and/or backup control center. It is important that CenterPoint Houston implement the network refresh to assist with ensuring successful failover. Additionally, CenterPoint Houston will include a GRC tool that will assist with ensuring a strong process flow is in place for critical steps toward security and resiliency activities. Dependencies for critical functions must be established to improve overall resilience.

Governance ("ID.GV") *The policies, procedures, and processes to manage and monitor the organization's regulatory, legal, risk, environmental, and operational requirements are understood and inform the management of cybersecurity risk.*	
Analysis Results Description:	Implementing an automated solution will improve managing NIST CSF alignment and compliance efforts. CenterPoint Houston plans to implement a GRC tool that will assist with the transition from a manual process to an automated solution. This provides a simpler method for approval and compliance efforts by including a taxonomy for risk indicators, catalog control, and stakeholder notification. CenterPoint Houston also intends to mature the GRC process by implementing a risk tolerance program using residual risk data. This will also improve upper management's view on actions that need to be approved to move forward with risks. CenterPoint Houston intends to mitigate or remediate, further improving the system resilience. The GRC tool will also improve the prioritization of remediation efforts with a sign off process, further improving its resiliency posture.

Risk Assessment ("ID.RA") *The organization understands the cybersecurity risk to organizational operations (including mission, functions, image, or reputation), organizational assets, and individuals.*	
Analysis Results Description:	Implementing a tool that will scan for vulnerabilities will improve the view of potential weaknesses or gaps in a system, further reducing risk of impact to the system. CenterPoint Houston plans to use a Vulnerability Assessment tool Rapid7, to scan individual machines and assess potential security risks. The refresh will ensure CenterPoint Houston has the latest version and threat intelligence libraries for assessing against any potential security gaps. Having awareness of these gaps allows CenterPoint Houston to mitigate them.

Supply Chain Risk Management ("ID.SC") *The organization's priorities, constraints, risk tolerances, and assumptions are established and used to support risk decisions associated with managing supply chain risk. The organization has established and implemented the processes to identify, assess and manage supply chain risks.*	
Analysis Results Description:	Utilizing support services, including third parties, to help implement the latest technology for refreshing network equipment can ensure equipment is functioning as expected. CenterPoint Houston has a resident Palo Alto representative to assist with the implementation of its network security refresh for Palo Alto network devices. Additionally, it has a team of engineers to assist around the clock for any issues with implementation and ongoing maintenance or issues. Having these third-party service providers supporting through implementation greatly improves CenterPoint Houston's ability to ensure its network is fully functioning and resilient.

Anomalies and Events ("DE.AE") *Anomalous activity is detected, and the potential impact of events is understood.*	
Analysis Results Description:	The capability to detect anomalous activity and vulnerabilities is critical to identifying and mitigating weaknesses to improve cybersecurity resiliency. CenterPoint Houston plans to implement security measures that detect potential security gaps in its network and associated systems. CenterPoint Houston stated that it has architecture diagrams that allow it to be aware of the data flows of communication in its network. This is good initial step to detecting anomalous activity.

Security Continuous Monitoring ("DE.CM") *The information system and assets are monitored to identify cybersecurity events and verify the effectiveness of protective measures.*	
Analysis Results Description:	As part of its ongoing system security program, CenterPoint Houston uses monitoring features from the hardware and software it will be refreshing to including monitoring of the system's network, users, and vulnerabilities. CenterPoint Houston plans to implement malicious communication detection as part of the network equipment that will be refreshed to monitor the network for unwanted communication. CenterPoint Houston will also monitor for gaps or vulnerabilities within the system using a refreshed vulnerability scanner, Rapid 7.

Detection Processes ("DE.DP") *Detection processes and procedures are maintained and tested to ensure awareness of anomalous events.*	
Analysis Results Description:	Detecting system anomalies helps ensure awareness of cybersecurity events and prepare for quick remediation or mitigation actions. CenterPoint Houston plans to refresh the systems that assist with threat detections in its network and on its system endpoints. CenterPoint Houston plans to improve its detection efficiency by replacing its QRadar system with a cloud-based software that will assist with streamlining and alerting. CenterPoint Houston will continue to use network security features such as sandboxing and threat signature technologies with the network refresh it will be implementing.

Access Control ("PR.AC") *Access to physical and logical assets and associated facilities is limited to authorized users, processes, or devices, and is managed consistent with the assessed risk of unauthorized access to authorized activities and transactions.*	
Analysis Results Description:	Managing and controlling who can access critical systems is vital for a more secure and resilient system. CenterPoint Houston has access control for remote users and protects its systems by limiting the users that can access its system remotely. CenterPoint Houston is including an update on hardware for the Cyber Ark which is used as a vault for passwords and also plans to limit remote access to the system to only a privileged team that requires request, approval, and provisioning of access. This includes the vulnerability servers and network security appliances that are part of the resiliency measure. CenterPoint Houston has physical protections in place to further prevent unauthorized access, further improving its resiliency posture.

Awareness and Training ("PR.AT") *The organization's personnel and partners are provided cybersecurity awareness education and are trained to perform their cybersecurity-related duties and responsibilities consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	Cybersecurity awareness and training assists personnel with understanding their key role to quickly identify, prioritize, approve, and execute solutions to address cybersecurity issues. CenterPoint Houston plans to include awareness and training for the GRC tool to all user levels. This will include understanding the policies and procedures related to this tool and ensuring that all critical personnel understand their roles and responsibilities.

Data Security ("PR.DS") *Information and records (data) are managed consistent with the organization's risk strategy to protect the confidentiality, integrity, and availability of information.*	
Analysis Results Description:	Protecting an organization's data is key to maintaining integrity of data and confidentiality. CenterPoint Houston plans to implement several data protection controls to ensure the new hardware and software being implemented is secure. CenterPoint Houston will implement encryption and secure communication protocols such as Hypertext Transfer Protocol Secure ("HTTPS"). For some hardware, CenterPoint Houston will forward network log information to a log aggregator. This information will be sent using encryption methods. For data that resides within the hardware itself, CenterPoint Houston plans to physically destroy hard drives via shredding, rather than send them back to the manufacturer to prevent retrieval of critical data.

Information Protection Processes and Procedures ("PR.IP") *Security policies (that address purpose, scope, roles, responsibilities, management commitment, and coordination among organizational entities), processes, and procedures are maintained and used to manage protection of information systems and assets.*	
Analysis Results Description:	Information protection techniques are necessary to maintain confidentiality and secure critical information. CenterPoint Houston is including information protection techniques such as hard drive shredding in this resiliency measure. CenterPoint Houston plans to mature its information protection methodologies to further increase resiliency by creating business case documentation of existing vulnerabilities identified by its vulnerability assessment tool. CenterPoint Houston currently scans its network environment with endpoint and system security scanning tools to mitigate potential environmental vulnerabilities. It also performs web inspection and penetration testing.

Protective Technology ("PR.PT") *Technical security solutions are managed to ensure the security and resilience of systems and assets, consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	Protecting assets using security solutions that ensure networks are protected and are available can ensure a functional and resilient communication infrastructure. CenterPoint Houston plans to upgrade its network equipment with the latest firewalls, routers, and switches to protect its communication and control networks. CenterPoint Houston will include system redundancy to ensure high availability on the network and will have multiple scanners for its vulnerability assessment scanning tool. CenterPoint Houston also plans for the GRC tool to be on premises for redundancy purposes. Lastly, some of the software is being transitioned into the cloud, allowing for increased availability capacity to enable a more resilient system.

5.4.4.5 Resiliency Measure Assessment

Guidehouse concludes that there is a high level of correlation between resiliency and CenterPoint Houston's Network Security and Vulnerability Management resiliency measure. This was based on the high level of correlation the measure has in relation to the NIST CSF functions.

The areas in which these measures support a strong and resilient electric transmission and distribution system include:

- Risk Assessment
- Access Control
- Information Protection Processes and Procedures
- Protective Technology

- Security Continuous Monitoring

Through continuous monitoring and proactive risk controls, CenterPoint Houston will be fortifying its defenses to protect against potential cyber threats, thereby minimizing the risk of cyber-related disruptions to critical grid operations. Guidehouse concludes that CenterPoint Houston's Network Security and Vulnerability Management resiliency measure supports grid resiliency by ensuring the stability and integrity of its infrastructure.

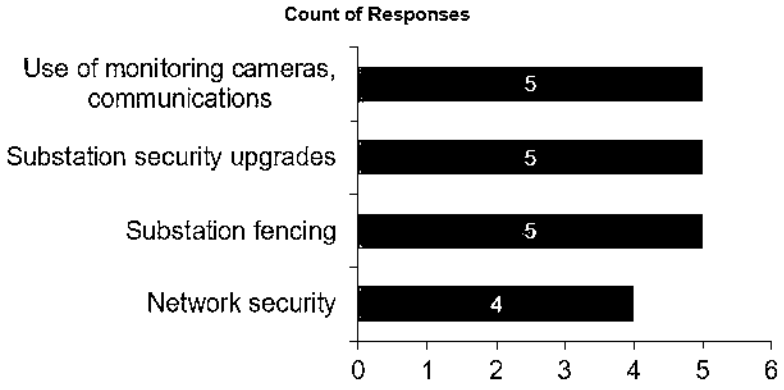
5.4.4.6 Benchmarking

Peer Utility Benchmarking

As stated above, vulnerability management is an ongoing cybersecurity process that includes identifying, evaluating, mitigating, and reporting software and network vulnerabilities. As utilities increasingly rely on digital infrastructure to drive productivity and innovation, and the rising risk exposure to cyber-intrusion and other network vulnerabilities utilities face, the need to safeguard sensitive utility and customer data, mitigate cybersecurity risks, and ensure the integrity of network assets has never been greater. Peer utility benchmarking provides an indication of types of investments made by other entities within the realm of network security and vulnerability management resiliency measures.

Through a separate benchmarking exercise, discussed in Section 5.3, nine utilities provided survey responses regarding communications technology investments they have made. As shown in Figure 5-17, network security are resiliency investments that at least four of the nine responding utilities have adopted. This data is essential for understanding the investments that other utilities have made as it pertains to security investments and offers valuable insight into what aspects of these investments tie back into the offerings that will be used at CenterPoint Houston related to the network security and vulnerability management resiliency measure.

Figure 5-17: Physical Security Benchmarks with Utility Partners



Source: Guidehouse analysis, based on inputs from the First Quartile Resiliency Survey.

For the benchmarking described in Section 5.3, nine utilities provided survey responses regarding IT investments it has made. As shown in Figure 5-9, we can see from the row titled

cybersecurity that six of the nine surveyed utilities have also invested in their cybersecurity infrastructure for resiliency purposes. This data helps demonstrate the growing recognition within the industry of the importance of protecting critical cyber assets and data from cyber threats. Additionally, the finding that four of the nine utilities have also made investments in their network security infrastructure suggests a concerted effort to fortify defenses against potential vulnerabilities and intrusions.

Overall, these investments highlight a proactive approach among utilities to safeguard against evolving cyber threats, ultimately contributing to the resilience and reliability of critical infrastructure systems.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows network security and vulnerability management upgrades that are being made in electric utility resiliency investments in the states examined. For example, Ameren Illinois recognizes that the expected increase in the number of sensors, potential control points, and reliance on public networks will increase the attack surface for nefarious activities by hackers. Given this, it was determined that there is a need for reliance on monitoring their state and potentially controlling their performance to maintain reliability and resilient grid conditions.[142] Through the jurisdictional perspective, the importance of network security and vulnerability management is made clear as it prevents the occurrence of cyber events by malicious actors and enhances grid resiliency as a result.

5.4.5 IT/OT-Cybersecurity Monitoring

5.4.5.1 Resiliency Measure Description

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 is proposing to build a sustainable cybersecurity resiliency measure that provides enhanced monitoring for greater visibility, analytics, integration of data sources, better protections, and detections for responding to cybersecurity threats. Specifically, the proposed OT tool set will provide visibility into the operational environments that was not previously available. It shows network traffic detection, OT asset visibility, and provides alerts for abnormal or malicious behavior. The resiliency measure allows for 24x7 monitoring of operational assets, based on industry best practices (e.g., NIST SP 800-82r3). The resiliency measure will fill gaps in segmentation, monitoring, and OT asset management.

CenterPoint Houston will use Splunk as their logging system as well as for Key Performance Indicator ("KPI") visibility, Palo Alto for segmentation, and Nozomi for internal network monitoring threat detection and response. This resiliency measure will introduce automation

[142] Ameren Illinois Multi-Year Integrated Grid Plan. (p. 98).

capabilities to learn CenterPoint Houston's operating baseline and tune to identify anomalous activity that could lead to a cybersecurity incident. CenterPoint Houston will include, as part of the measure, a testing center that will assist with onboarding all IT, OT, and physical security system data sources. Training will be provided to Security Operations Center ("SOC") personnel to understand the alerts and take appropriate action against any attempts at intrusion or successful intrusions by attackers.

Resiliency Measure Details:

- Scope includes ~300 transmission and distribution sites, standardizing the security monitoring architecture for all sites.
- This resiliency measure covers CenterPoint Houston's Transmission & Distribution systems.
- Tentative schedule - begin in 2024, continue into 2025, and complete by end of 2025.

5.4.5.2 Alternatives Considered

Other technology platforms were considered and evaluated via an objective process that aligns business requirements, company and product features, and included other important factors such as fiscal and support considerations. The Guidehouse analysis team determined this resiliency measure is directly related to monitoring for cybersecurity breaches and addresses other cybersecurity threats and vulnerabilities, therefore did not evaluate other methods.

5.4.5.3 Resiliency Measure Effectiveness

A cybersecurity threat targets computer networks, systems, and user data. These threats can come in the form of malware, phishing, and other malicious activity. Cybersecurity monitoring plays a crucial role in enhancing organizational resilience by analyzing network traffic patterns to identify, mitigate, and prevent potential cyber threats. This approach allows for early detection, isolation, neutralization, and response to potential threats. Most monitoring will analyze network traffic, allowing organizations to identify and respond to malicious activities. By monitoring network traffic patterns, malicious traffic patterns, and unauthorized access attempts, organizations can quickly isolate and neutralize potential threats.

CenterPoint Houston also plans to use the following performance metrics for tracking the effectiveness of the IT/OT-Cybersecurity resiliency measure:

- Number of alerts,
- Number of systems being monitored (system transparency),
- Incident response time,
- System information ingestion rates,
- Volume of recorded malicious behavior,

- Volume of data inspected,
- Number of Data sources migrated to SOC, and
- Number of SOC rules, use cases, and SOC playbooks developed.

Guidehouse evaluated the benefits and features associated with CenterPoint Houston's proposed OT- Cybersecurity Monitoring resiliency measure on a qualitative basis with measure-specific inputs and assumptions. This analysis compared CenterPoint Houston's resiliency measure with the NIST CSF Categories, to identify levels of correlation between the five CSF Functions (Identify, Detect, Protect, Respond, and Recover), and the proposed system in terms of developing resilient systems. Guidehouse performed the analysis and identified whether the resiliency measure had high, medium, or low correlations to the individual subcategories of the CSF. For the purpose of this report, Guidehouse is only reporting on features, applications, or business processes with a high or, in some instances, medium correlation to subcategories of the NIST CSF.

The subcategories selected for reporting from the medium correlations were selected based on Guidehouse's professional judgment and conclusion that the resiliency measure had a partial or indirect correlation, along with Guidehouse's professional judgment that the measure was sufficiently implementing the intent of the subcategory from a resiliency perspective. The system features that were mapping to low correlation were considered to be relatively ineffective in improving resiliency, although depending on the context of the proposed resiliency measure, they may still have value in pursuing from reliability or policy perspectives. For a detailed explanation of the methodology used, refer to Section 5.1.3.

Below in Table 5-7 is the list of Functions and associated categories with high and/or medium correlations to the resiliency measure:

Table 5-7: IT/OT-Cybersecurity Monitoring Analysis Results

Function	Category
Identify	• Risk Assessment ("RA")
Detect	• Anomalies and Events ("AE") • Security Continuous Monitoring ("CM") • Detection Processes ("DP")
Protect	• Protective Technology ("PT") • Data Security ("DS") • Information Protection Processes and Procedures ("IP")
Respond	• Analysis ("AN")
Please note: Guidehouse did not include the "Recover" function as part of these analysis results as it did not have high or medium correlations.	

5.4.5.4 Benefits Analysis

CenterPoint Houston also 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. Guidehouse evaluated the benefits associated with CenterPoint Houston's proposed IT/OT-Cybersecurity Monitoring resiliency measure. Guidehouse's analysis indicates that the resiliency measure will provide a high level of effectiveness for detection of threats to the system. Based on the results of its analysis, Guidehouse determined that the measure offers resiliency benefits. All determinations below are based on CenterPoint Houston's information on resiliency measure descriptions, interviews, and responses to data requests for additional measure details.

The analysis identified the following categories and results where the category and associated subcategory(ies) have a high correlation to the resiliency measure:

Risk Assessment ("ID.RA") *The organization understands the cybersecurity risk to organizational operations (including mission, functions, image, or reputation), organizational assets, and individuals.*	
Analysis Results Description:	CenterPoint Houston will deploy a cybersecurity monitoring system that will identify vulnerabilities that are possibly present within devices. Once the vulnerabilities have been identified, they will be documented within and aggregated with the logging solutions threat intelligence engine for indications of compromise. This information is then leveraged against security research data sources that provide information on how to respond to potential threats. The monitoring system will inherently document the identified threats for processing. Identifying these threats and vulnerabilities will provide CenterPoint Houston the necessary information to perform assessments that identify business impact likelihoods and determine their risk. The monitoring system will aggregate data to correlate against potential risks, providing cybersecurity subject matter experts ("SMEs") with critical information necessary to make informed decisions on necessary actions to respond to a cybersecurity threat. The monitoring system will use automation to reduce system noise (i.e., false or minor threats) and prioritize alerts for potential threats.

Asset Management ("ID.AM") *The data, personnel, devices, systems, and facilities that enable the organization to achieve business purposes are identified and managed consistent with their relative importance to organizational objectives and the organization's risk strategy.*	
Analysis Results Description:	To ensure successful implementation of CenterPoint Houston's cybersecurity monitoring system, all cyber-related assets and their software/applications will need to be accounted for, and also maintained on an annual basis to ensure accuracy of the inventory, which CenterPoint Houston plans to do. This ensures that all cyber systems and associated software are identified and tracked for monitoring. The data flows from each cyber system will be included as part pf the monitoring program to ensure all system-related information is aggregated for monitoring. All resources that provide vital data into the monitoring system will need to be prioritized and managed based on their criticality to sustaining a resilient power system.

Anomalies and Events ("DE.AE") *Anomalous activity is detected, and the potential impact of events is understood.*	
Analysis Results Description:	An effective cybersecurity monitoring system should have a baseline of network operations and expected data flows to detect anomalies from users and systems. CenterPoint Houston's proposed cybersecurity monitoring system aims to provide better network visibility, analytics, and protections. The system will have machine learning capabilities that allow for a better understanding of the targets and attack methods being used. Machine learning would also constantly update the threshold for incident alerts and escalation. CenterPoint Houston will be deploying Nozomi, which will analyze and catalog attack data and allow for impact evaluation for potential attacks. These two systems paired together will allow CenterPoint Houston to better detect and evaluate the potential impacts of events.

Security Continuous Monitoring ("DE.CM") *The information system and assets are monitored to identify cybersecurity events and verify the effectiveness of protective measures.*	
Analysis Results Description:	Network monitoring is a key element for detecting cybersecurity events. It offers awareness and is a detective control which provides information to support appropriate, necessary, and timely responses to events. CenterPoint Houston's cybersecurity monitoring system will include monitoring activity for malicious code. An effective cybersecurity monitoring system should be capable of monitoring external service provider activity to detect potential cybersecurity threats. CenterPoint Houston's resiliency measure includes monitoring of the network, and better visibility and analytics that will be used for response, including internal and external traffic, personnel, connections, devices, and software. Nozomi will provide common vulnerability and exposure ("CVE") lookups based off the model and firmware of the device in a "passive scan" instead of an "active scan." A passive scan sifts through traffic, whereas an active scan sends test packets through the network.[143]

[143] Tenable Network Security, Inc. (2009 October). *Passive Vulnerability Scanning Introduction* **[TNS Report].** https://www.tenable.com/sites/drupal.dmz.tenablesecurity.com/files/uploads/documents/whitepapers/Passive%20Vulnerability%20Scanning%20Introduction.pdf

Detection Processes ("DE.DP") *Detection processes and procedures are maintained and tested to ensure awareness of anomalous events.*	
Analysis Results Description:	Robust cybersecurity monitoring systems have detection processes and procedures that are maintained and tested to ensure awareness of anomalous events. Roles and responsibilities associated with these processes and procedures should be well defined to ensure accountability. CenterPoint Houston's deployment of the resiliency measure will have detection requirements in place that will allow the system to learn and tune to such detections, thereby only alerting when there is a potential threat. A primary focus of the resiliency measure will include an improvement to the detection process, which has the benefit of increasing system awareness for appropriate, necessary, and timely responses to events. Additionally, an effective cybersecurity monitoring system encompasses security event detection, including communication of the information to System Operation Control ("SOC") personnel via alerts. CenterPoint Houston indicated that SOC personnel will receive alerts through this new system and take action in response to a detected event.

Data Security ("PR.DS") *Information and records (data) are managed consistent with the organization's risk strategy to protect the confidentiality, integrity, and availability of information.*	
Analysis Results Description:	System visibility, availability, and integrity are necessary to provide secure and resilient system. The IT/OT-Cybersecurity Monitoring resiliency measure will assist in availability with use of RAID technology for backing up data stores. System resource planning has been defined and finalized for storage with defined active and non-active timeframes. Maintenance programs have been developed and finalized with plans to be implemented in as part of this resiliency measure. With this resiliency measure, CenterPoint Houston plans to actively monitor data 24x7, not just for alerts but also ensure only authorized users access the information. OT data will be kept on premises with a "defense-in-depth" approach behind multiple firewalls. Splunk and Nozomi support industry standard encryption for data at-rest and in-transit.

Information Protection Processes and Procedures ("PR.IP") *Security policies (that address purpose, scope, roles, responsibilities, management commitment, and coordination among organizational entities), processes, and procedures are maintained and used to manage protection of information systems and assets.*	
Analysis Results Description:	A baseline configuration of all systems being monitored is necessary to identify if a bad actor is manipulating a system, a functionality of CenterPoint Houston's proposed cybersecurity monitoring system. This is an inherent requirement for identifying potential threats. Through interviews and data requests, Guidehouse determined that CenterPoint Houston will be implementing a system development lifecycle process for the resiliency measure. Additionally, a change control process will be monitored through the monitoring system and any changes within the environment must first be approved by compliance personnel as required by NERC CIP reliability standards requirement CIP-010. A focus of this resiliency measure is to provide better protection to the enterprise system, which includes generation facilities, transmission facilities, distribution facilities, and the command center. OT monitoring will be incorporated into the SOC and incident response ("IR") and business continuity ("BC") plans. Nozomi will be used to identify vulnerabilities within the OT environment and provide vendor recommendations, integrated into CenterPoint Houston's current vendor management plan.

Protective Technology ("PR.PT") *Technical security solutions are managed to ensure the security and resilience of systems and assets, consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	Effective cybersecurity monitoring systems include logging systems that document and allow for review of system logs to determine if a cybersecurity response action is warranted. CenterPoint Houston stated that Splunk would be deployed as part of their central logging system. From the interviews conducted by Guidehouse, we have concluded that CenterPoint Houston has implemented firewalls and follows network architecture best practices to protect the CenterPoint Houston environment, which will be vital for the successful implementation of the CenterPoint Houston's cybersecurity monitoring system resiliency measure. Nozomi provides system level broadcasts for detection of removable media to ensure appropriate levels of protections and restrictions are in place. Additionally, CenterPoint Houston will design alert use cases for Nozomi to process.

Awareness and Training ("PR.AT") *The organization's personnel and partners are provided cybersecurity awareness education and are trained to perform their cybersecurity-related duties and responsibilities consistent with related policies, procedures, and agreements.*	
Analysis Results Description:	To ensure the efficient functioning of essential cyber monitoring systems, personnel with a role in the use and execution of the related monitoring systems will need to undergo training. The training should equip the necessary SOC personnel with knowledge to ensure readiness to respond appropriately. CenterPoint Houston has emphasized the necessity of cybersecurity to their architects and SMEs.

Analysis ("RS.AN") *Analysis is conducted to ensure effective response and support recovery activities.*	
Analysis Results Description:	CenterPoint Houston's IT/OT-Cybersecurity Monitoring system will provide greater understanding of cyber incidents using network analysis capabilities and historical monitoring. This will provide improved analysis capability for both proactive and reactive threats. Monitoring occurs on OT environments 24x7, which will provide additional analysis to support response and recovery efforts, and the resiliency measure will provide enhancements to alerting that can provide notifications to guide response type and potentially reduce response time.

5.4.5.5 Resiliency Measure Assessment

Guidehouse can conclude that CenterPoint Houston's IT/OT-Cybersecurity Monitoring resiliency measure has resiliency benefits, including reduction in potential cyber-attacks, and improved detection and response times to cybersecurity threats. Implementation of security measures also avoids potentially high undesirable economic and societal impacts associated with widespread, lengthy outages.
This resiliency measure focuses on receiving cyber threat intelligence and potential risks from information sharing sources by leveraging indicators of compromise that the cyber threat and response software will use to identify a potential cybersecurity threat. This information is internally documented by the cyber threat and response software and compared to the sharing sources to determine if threats exist. It will then alert CenterPoint Houston SOC personnel with the necessary information to respond. The cyber threat and response software will also use machine learning to tune the system to reduce system noise by learning potential threats and prioritizing by risk level.

Guidehouse has determined the measure has several areas that support strong resiliency by providing baselining of the network, detections of anomalous activities, cybersecurity event identification, impact determination, communication, process improvement, and maintaining threat details that would feed into event responses. These capabilities, when combined, collectively provide the support needed to maintain a resilient system and network.

Overall, Guidehouse has found a significant correlation of detective controls for system protection from malicious events, and potential intrusions to support inclusion of CenterPoint

Houston's IT/OT-Cybersecurity Monitoring resiliency measure in their Resiliency Plan. This measure will provide CenterPoint Houston with a cyber monitoring system that will provide real-time insight into network traffic, alert for potential threats, and support quicker responses to attempted intrusions. These controls will reduce cyber risk for CenterPoint Houston by enabling a quicker response to malicious events and attempts at intrusion, enhancing overall organizational resilience.

5.4.5.6 Benchmarking Analysis

Peer Utility Benchmarking

Guidehouse also performed a review of cybersecurity practices of other peer utilities and determined that cybersecurity monitoring is a key element of their cybersecurity systems. Not only is it on the forefront of their programs, but it is also considered in 10-year plans for modernizing the State's electrical system (e.g., Duke Energy, State of South Carolina, and the Power/Forward Carolina plan).

Benchmarking results, shown in Section 5.3, support this conclusion. This data is essential for understanding the investments that other utilities have made as it pertains to cyber monitoring efforts and offers valuable insight into what aspects of these investments tie back into the offerings that CenterPoint Houston is pursuing.

We can see that well over 70% of peer utility respondents have made investments within their respective companies in similar areas as it pertains to cyber monitoring efforts. This insight suggests a standardization or alignment in the industry providing opportunities for shared best practices within the utility sector.

Additionally, some peer utilities responded that they have regulatory obligations to require system monitoring and logging as a minimum, with an additional risk-based approach for establishing and implementing additional controls to ensure the core controls are being implemented and managed as necessary, to protect the bulk electric systems ("BES") and associated BES Cyber Systems.

Lastly, some peer utilities also indicate that some states are supporting cybersecurity resiliency planning as part of state resilience plans, planning reports, or approvals of plans for electric distribution grid transformation projects, all of which include reliability and resiliency measures specific to cybersecurity.

Jurisdictional Benchmarking

The jurisdictional benchmarking report provided as Appendix A to this report shows that cybersecurity monitoring upgrades are being made in electric utility resiliency investments in many of the states examined. For example, Duke Energy North Carolina's multi-year rate plan includes cybersecurity monitoring as a key requirement in resiliency investments to increase

protection against attacks.[144] The jurisdictional benchmarking underscores the significance of cybersecurity monitoring enhancements, as evidenced through this example, where utilities are prioritizing resilient investments to bolster their protections against potential cyber events.

[144] Duke Energy MYRP Application. (p. 72).

6. Summary of Findings and Recommendations

6.1 Resiliency Risk for Natural Disaster Threats

6.1.1 Findings

Guidehouse's risk assessment indicates that the frequency and magnitude of extreme weather events such as high winds events (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. By 2050, nearly all counties in CenterPoint Houston's service territory could experience wind speeds exceeding 93 mph with coastal counties approaching 112 mph for a 500-year event.
- **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 territory, it is slated to rise significantly by 2050 to relatively high levels in summer months in most counties in CenterPoint Houston's territory.

6.1.2 Recommendations for Future Resiliency Measures

While county-level natural disaster quantification is reasonable for a resiliency measure level analysis, more granular spatial quantification could improve CenterPoint Houston's implementation of their Resiliency Plan as this would help them choose the most valuable locations to target for specific resiliency measures.

CenterPoint Houston's current portfolio of resiliency measures will help address high wind and flooding events forecast to 2030. We recommend that CenterPoint Houston also consider including measures that address the impact of rising temperatures on transformer derating in future resiliency plans. Examples of such measures include transformer replacement and capacity expansion through conventional or distributed generation resources.

Although the risk of wildfires in CenterPoint Houston's service territory is currently low, it is projected to rise during the summer months over time. Considering the high impact of this risk on utility operations as well as the general public, we recommend that CenterPoint Houston develop a detailed wildfire mitigation plan that consists of:

- Risk assessment to determine which areas of the service area are at highest risk of a wildfire;
- Operational guidelines such as when and where to conduct power shutoff and restoration;
- Investment planning that considers best practices such as selective undergrounding, covered conductors, grid modernization technologies; and
- Community and first responders outreach programs to keep customers up to date on activities and coordinate wildfire responses.

Covered conductors have been used by peer utilities such as Southern California Edison in granular high risk fire areas (HFRA), as defined by the CPUC, where the utility has right of way.[145] Guidehouse recommends that before undertaking a covered conductor program, CenterPoint Houston should define HFRAs for their service territory, identify circuits at high risk of ignition, and determine the ability to do vegetation clearance around those circuits.

Some investments in CenterPoint Houston's current resiliency plan such as IGSD, TripSaver®, and the microgrid pilot project can also help support wildfire mitigation and enable power shut off and restoration in the event of a wildfire.

Subsequent to the development of Guidehouse recommendations, CenterPoint Houston added wildfire mitigation resiliency measures to its Resiliency Plan. Guidehouse reviewed the wildfire mitigation measures proposed by CenterPoint Houston and found them all reasonable for inclusion in its Resiliency Plan as they align with measures commonly included in wildfire mitigation plans of other electric utilities, including several of the measures identified above. To help inform prioritization of different measures for implementation, Guidehouse recommends that CenterPoint Houston evaluate the relative risk reduction benefits of different measures, a common practice other electric utilities have used to determine which wildfire mitigation measures to deploy for different parts of their system. While some measures can be more costly, they can provide greater risk reduction benefits compared to other measures, as is the

[145] Covered Conductor: A Wildfire Mitigation Solution | T&D World (tdworld.com)

case with selective undergrounding. More costly measures that provide greater risk reduction should be considered at areas with the highest level of risk when other measures may not provide sufficient reduction of wildfire risk.

6.2 Resiliency Risk for Physical Security and Cybersecurity Threats

6.2.1 Findings

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 IT/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** – 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 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.

6.3 Review of Operations and Physical Security Resiliency Measures

6.3.1 Findings

Guidehouse's evaluation of CenterPoint Houston's Resiliency Plan was informed by its analysis of future risk profiles for wind and flooding resiliency events in CenterPoint Houston's service territory as described above. 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 designed to withstand 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. For example, Table 6-1 shows that assuming a VOLL of $25,000/MWh all but one of the resiliency measures has a benefit-cost ratio less than 1. Further, in many cases there is additional qualitative value that supports inclusion of the measure in CenterPoint Houston's Resiliency Plan. 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 TripSaver® are proposed will yield greater benefits than on a standalone basis. These findings indicate that CenterPoint Houston's Resiliency Plan will provide positive value to the customers and communities it serves.

6.3.2 Recommendations

Guidehouse offers 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*)