



November 9, 2022

ComEd Resilience Metrics

Grid Analytics Team

Outline

1. Executive Summary
2. Resilience Metrics
3. Results and Benefits of Resilience Metric Tracking
4. Conclusion

Executive Summary

According to Presidential Policy Directive 21: Critical Infrastructure Security and Resilience, resilience is defined as “the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.

Resilience improvements represent major strategic objectives of any critical infrastructure sector, including electric power. Prerequisites for success include a well-thought-out strategic vision, well-executed action plans, an effective mechanism for allocating capital and prioritizing investment options under financial constraints. Storm events are one of the major causes of substantial disruption to electric utility infrastructure, which affects the continuity of power supply.

It is important to develop metrics that can capture the utility’s performance during each of these events. At ComEd, performance during a storm can be measured by percentage of customers restored within 12 hours of losing power and performance during a gray sky day can be measured by percentage of gray sky days with fewer than 12,000 customer interruptions.

Approach

- The baseline threshold for storm categories were derived by analyzing historical storm data
- Criteria for Gray Sky Day was derived by identifying exponential increase in outages based on weather conditions
- Historical performance on each gray sky day was evaluated and the target of 12,000 customer interruption was selected based on the median of the data set

Goal

- Storm Resiliency - Focuses on speed of recovery during first 12 hours from customers losing power. Helps determine areas to accelerate restoration of large disruptive events
- Gray Sky Day Resiliency - Focuses on robustness and the ability to withstand most weather events

Benefits

- Storm Resiliency - Provides insights and guidance on performance of storm restoration efforts
- Gray Sky Day Resiliency - Provides insights and guidance on performance of customers impacted due to inclement weather

Storm Resiliency Definition

- Calculation:
 - 1) For each storm in a calendar year, calculate the ratio of customers without power for more than 12 hours and total customer interruptions (CI) including customers automatically restored (ACI) through smart switch operations (DA devices), community energy storage, and microgrids (does not include substation reclosing events) – measured in %

$$\text{Storm Event: } x = \frac{\sum \text{Customers Without Power for More Than 12 Hours}}{\text{Sustained CI+ACI Due to Distribution Automation}}$$

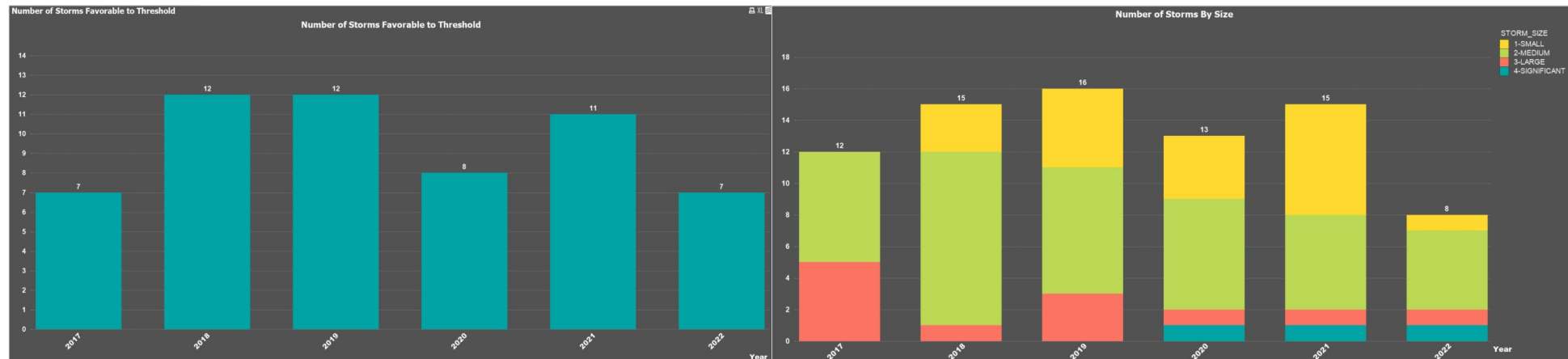
- 2) Based on number of interruptions (storm outages), categorize each storm event significant, large, medium, or small
 - 3) Determine if X is greater than or equal to the threshold value (Y) for the category.
 - 4) If $X < Y$, storm met expectations. If $X \geq Y$, storm did not meet expectations
- Storm event size
 - Since all storms are not equal, to compare and gauge improvement, storms will be categorized into four categories
 - Significant Storms: Defined as greater than 1500 storm outages
 - Large Storms: Defined as between 701 and 1500 storm outages
 - Medium Storms: Defined as between 251 and 700 storm outages
 - Small Storms: Defined as less than or equal to 250 storm outages
 - For each storm size, the average percentage of customers without power for 12+ hours was calculated annually between 2009 and 2018
 - These annual averages were used to determine the baseline threshold values for each storm size
 - Significant = 24.1%
 - Large = 9.0%
 - Medium = 2.8%
 - Small = 0.8%

Storm Resiliency Definition Cont.

- Metric:
 - Metric that measures the speed of recovery during a storm event
 - This metric accounts for:
 - Storm size
 - Sustained customer interruptions
 - Avoided customer interruptions
 - To assess the current storm response process and determine solutions that can improve performance
- How we are doing:
 - YTD September, there was one storm resulting in ~40k customer interruptions and it did not achieve the storm resiliency threshold
 - Communicated to operations and storm is being reviewed

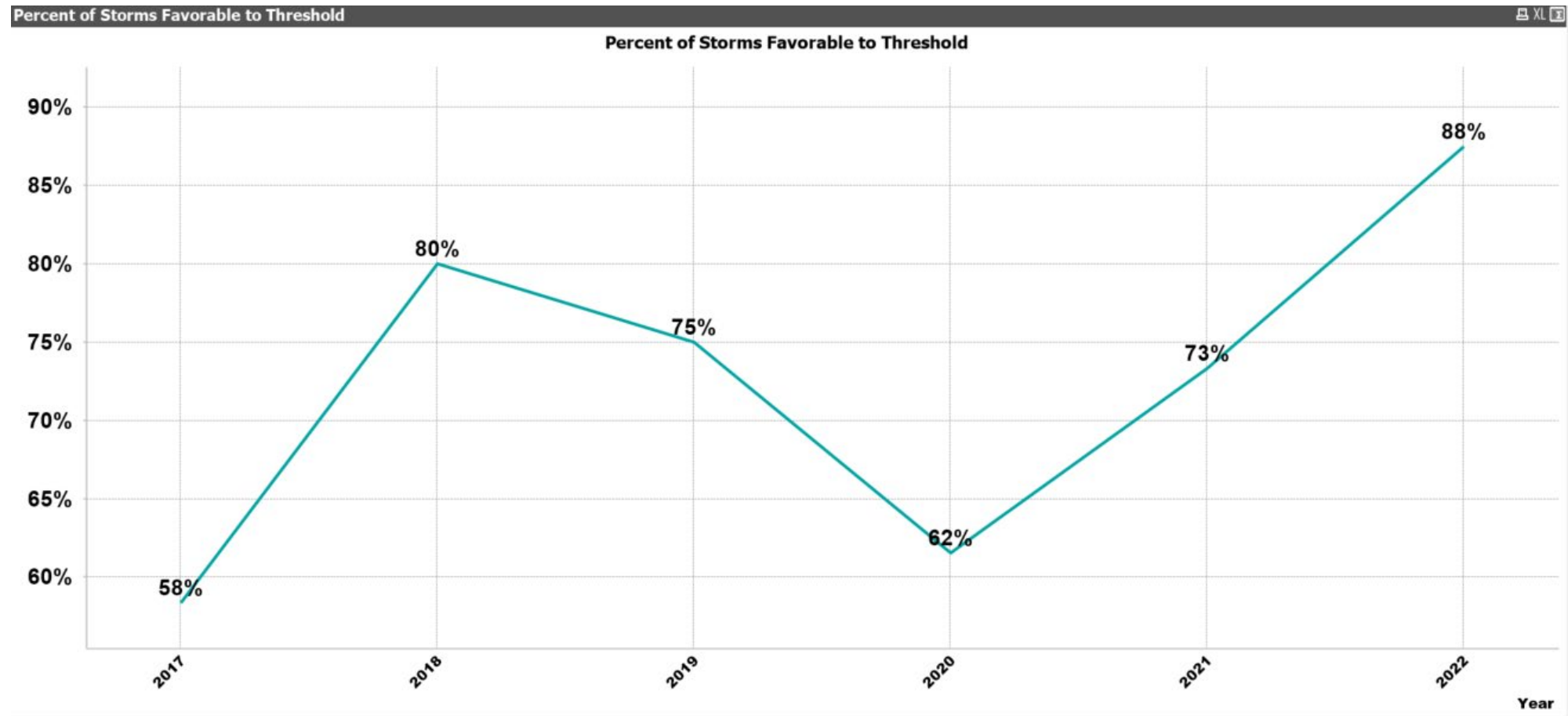
Start Storm Date Time	End Storm Date Time	Last Restore	ICC Report	Sustained Outage Count	Sustained Cust Inter	SAIFI	MED Cust. Int.	Cust Int Hrs	CAIDI(Min)	Max Otg(HR)*	DA ACI	Restored >12Hrs (w/ ACI)	Storm Size
8/3/2022 13:04	8/3/2022 19:10	8/4/2022 19:46	NO	224	37,747	0.009	0	67,371	107	28.0	15781	1.1%	SMALL

✓ Comparison to historical



Storm Resiliency Definition Cont.

- ✓ Comparison to historical
 - YTD September, performance is 88% which is an improvement compared to prior years for the same time



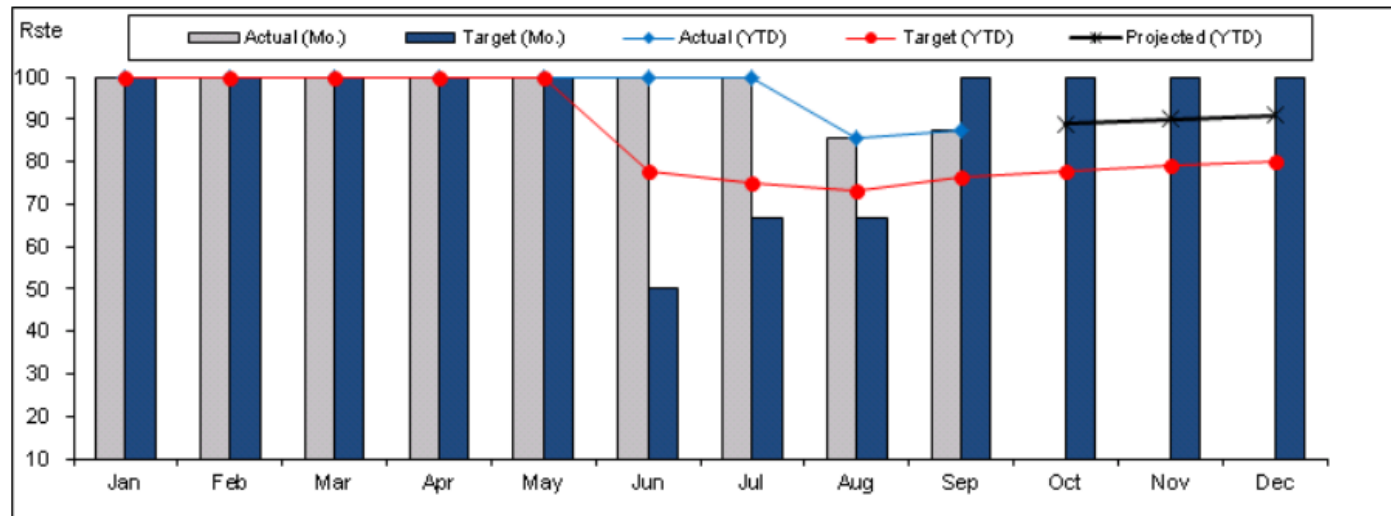
Storm Resiliency Definition Cont.

- Key Performance Indicator (KPI) Tier 3 Metric - 2022

ComEd Operations Operational Excellence Storm Resiliency

Reporting Period: September 2022

Good ↑

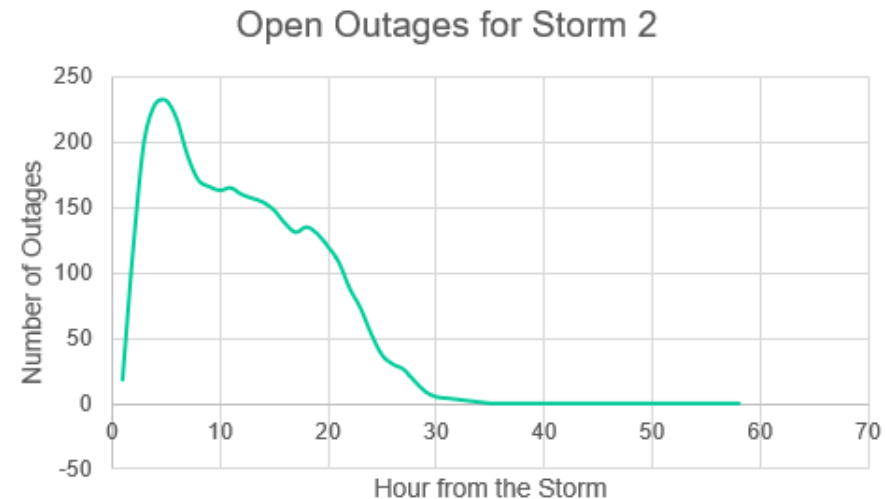
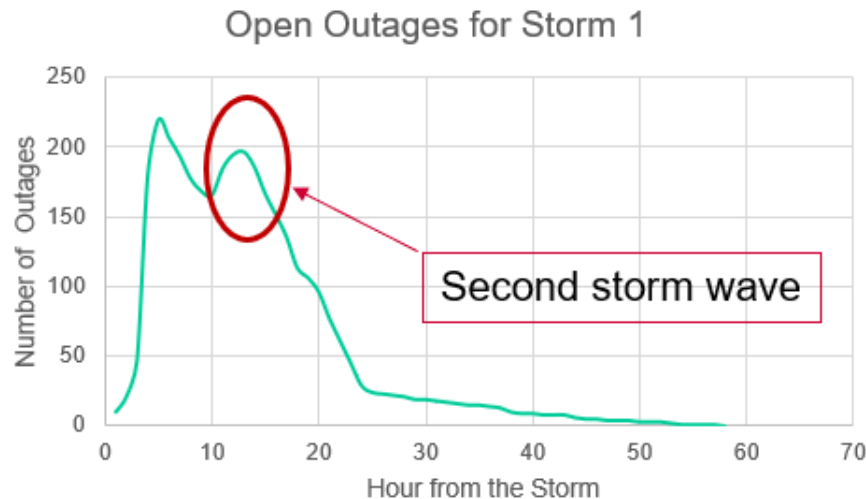


Storm Resiliency (YTD)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual %	100	100	100	100	100	100	100	86	88			
Target %	100	100	100	100	100	78	75	73	76	78	79	80
Projected %										89	90	91
Number of Storms Fav. To Threshold	0	0	1	2	2	3	5	6	7			
# of Storms	0	0	1	2	2	3	5	7	8			

Storm Resiliency Cont.

- Storm 1 and Storm 2 have a similar outage range, as seen in the Table. However, Storm 1 occurred at 8 PM and had a second storm wave, while Storm 2 occurred at 1 PM. Distribution automation restored 26,511 customers for Storm 1 storm whereas it restored 30,872 for Storm 2

#	Start Storm Date Time	End Storm Date Time	Sustained Outage Count	Sustained Customer Interruption	CAIDI (Min)	Max Outage (HR)	DA ACI	Restored >12Hrs (w/ ACI)
Storm 1	6/20/2021 20:18	6/21/2021 17:34	540	54,131	331	93.1	26,511	8.00%
Storm 2	9/7/2021 13:02	9/8/2021 6:13	420	40,946	231	39.4	30,372	3.70%



Gray Sky Day Definition

- **Gray Sky Days (GSD) Definition:** Includes any calendar day that meets any one of the following weather criteria:
 - $\geq 80^{\circ}\text{F}$ average temperature across the system
 - $\leq 0^{\circ}\text{F}$ average temperature across the system
 - $\geq 25\text{MPH}$ average sustained wind speeds across the system
 - $\geq 25\text{MPH}$ average one-hour wind gust across the system
 - $\geq 0.75"$ average rain across the system
 - $\geq 3,000$ lightning strokes across the system
- Uses ICC definition of a customer Interruption i.e. applying ICC exclusions such as customer related, planned outages, fire/police requests, alternative retail electric supplier (RES) or utilities outages
- GSD Intensity measures extremity of qualifying weather conditions
- Three color codes (yellow, orange, red) account for average daily temperature, wind speed, rainfall, and lightning strokes
- These color codes can be used to evaluate reliability performance on a given GSD



Yellow

- **Average temperature** between 80 and 85 degrees
- **Average temperature** between 0 and -5 degrees
- **Average sustained wind speed** between 25 and 30 MPH
- **Average of one-hour wind gust** between 25 MPH and 30 MPH
- **Average rainfall** between 0.75" and 1"
- **Lightning stroke count** between 3,000 and 6,000



Orange

- **Average temperature** between 85 and 90 degrees
- **Average temperature** between -5 and -10 degrees
- **Average sustained wind speed** between 30 and 35 MPH
- **Average of one-hour wind gust** between 30 MPH and 35 MPH
- **Average rainfall** between 1" and 1.25"
- **Lightning stroke count** between 6,000 and 10,000



Red

- **Average temperature** greater than 90 degrees
- **Average temperature** less than -10 degrees
- **Average sustained wind speed** ≥ 35 MPH
- **Average of one-hour wind gust** ≥ 30 MPH
- **Average rainfall** greater than 1.25"
- **Lightning stroke count** greater than 10,000

Gray Sky Day Resiliency Cont.

- Metric:
 - Measures the sturdiness or robustness of the system and ability to withstand events
 - This metric accounts for:
 - Weather conditions (Independent of storm definition)
 - Sustained customer interruptions
 - To assess the robustness of the system based on various weather conditions and determine solutions that can improve performance
 - The historical performance between 2014 and 2018 on each Gray Sky Day was evaluated and the target of 12,000 customer interruption was selected based on the median of the data set

- Calculation:

1) Metric is measured in percentage of GSDs that do not exceed the target value. The target value is set at 12,000 customer interruptions.

$$\text{\# of Gray Sky Days} < 12000 \text{ CI} / \text{Total \# of Gray Sky Days} = \% \text{ of Success}$$

- How we are doing:

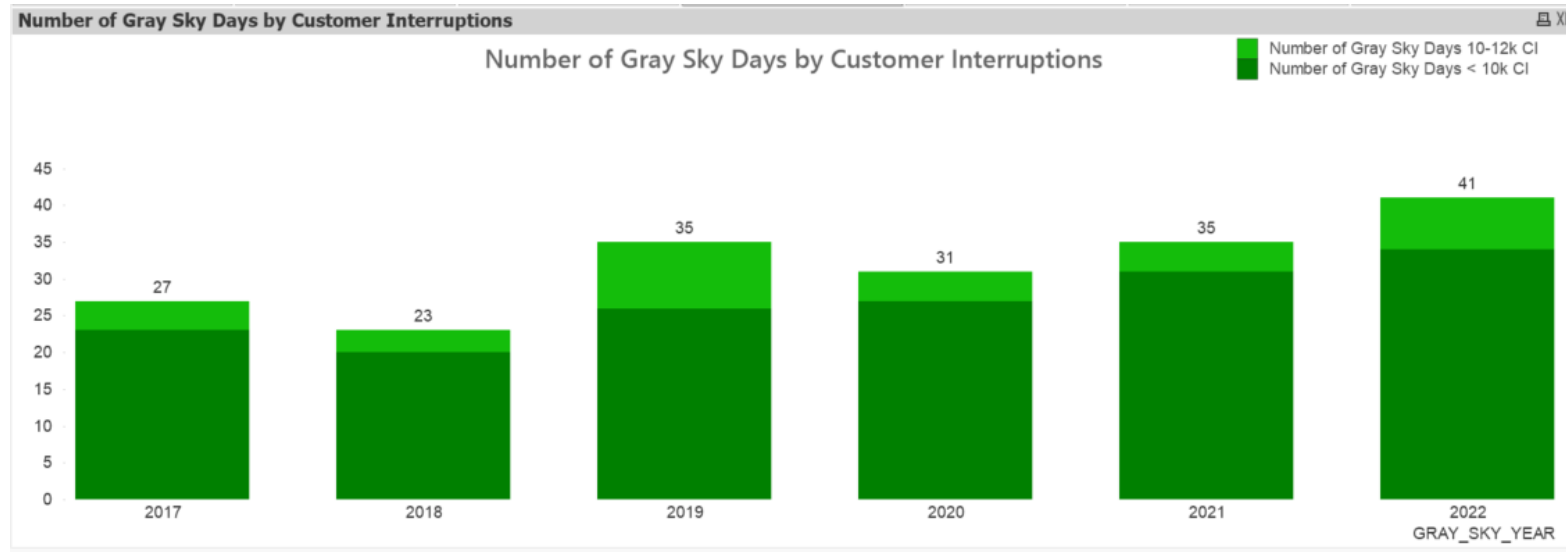
- YTD through September, 70% or 41 out of 58 Gray Sky days had less than 12k customer Interruptions compared to 2021 which had 69% or 35 out of 51 Gray Sky Days had less than 12k customers Interruptions.

– YTD target of 76%

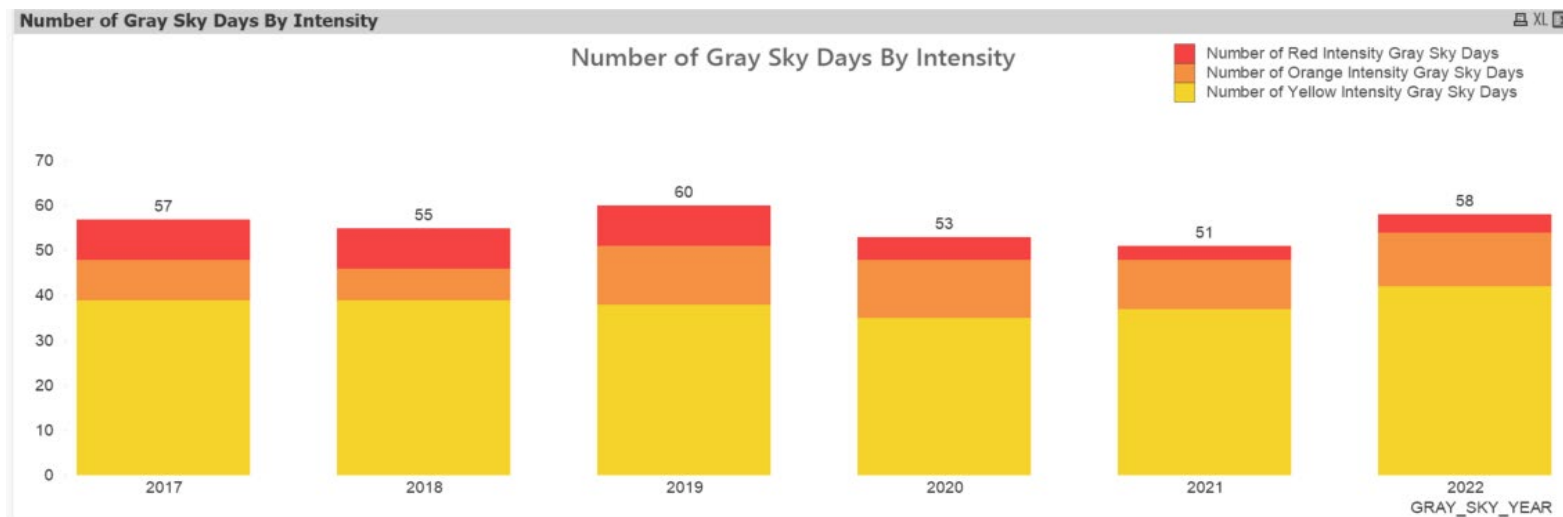


Gray Sky Day Resiliency Cont.

- Number of Gray Sky Days <12,000 Customer Interruptions



✓ Number of Gray Sky Days



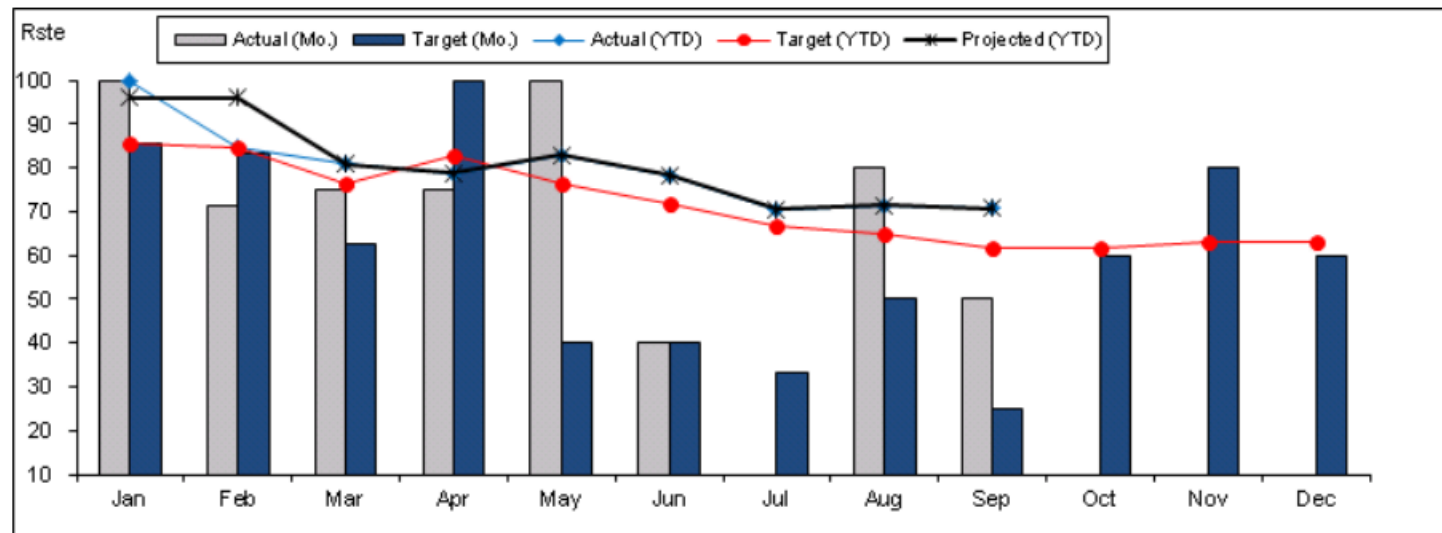
Gray Sky Day Resiliency Cont.

- Key Performance Indicator (KPI) Tier 3 Metric - 2022

ComEd Operations Operational Excellence Gray Sky Resiliency

Reporting Period: September 2022

Good



Gray Sky Day Resiliency (YTD)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual %	100	85	81	79	83	78	71	71	71			
Target %	86	85	76	83	76	72	67	65	62	62	63	63
Projected %										70	71	70
# of Gray Sky Days Fav. To Target	6	11	17	26	34	36	36	40	41			
Total Number of Gray Sky Days	6	13	21	33	41	46	51	56	58			

Gray Sky Days Outage Calendar

- Gray Sky Day indicator added to Outage Statistics Calendar

Cause	System	West Op Region	North Op Region	South Op Region	Chicago Op Region
All Causes	301	127	81	34	59
	222 2559	316 1692	197 2559	62 1439	147 1963
	8,722 28.4%	5,802 46.7%	1,754 20.8%	20 0.9%	1,146 15.2%
	30,734 1,033	12,420 1,033	8,440 1,025	2,322 666	7,552 844

An Exelon Company

Outage Statistics Calendar

Questions or comments: [\[Email Icon\]](#)

AREA TYPE: Oper. Region System Organizations: All Month: Mar Year: 2022 Go Reset Save CAIDI Scorecard

Outage Definition: ICC Definition (>1 Minute) Storm Filter: ?

System Id: All selected (3) Voltage: All selected (9) Job Type(ml)=Mainline: All selected (6) Cause Code: All selected (12) Cause Detail: All selected (60) Material Involved: All selected (89) Material Location: All selected (13) Damage Desc: All selected (4)

March - 2022 This Month

3,218 Outages - 216,043 Customer Interruptions with a CAIDI of 92

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1 104 57 391 4,419 1,162 19 0.4% 32° 58° 42°	2 117 48 538 9,852 3,075 190 1.9% 26° 61° 41°	3 77 58 543 3,313 640 144 4.4% 24° 39° 31°	4 80 81 562 2,873 254 180 6.3% 22° 46° 35°	5 301 222 2,559 30,734 1,033 8,722 28.4% 33° 71° 53°
6 323 125 1,895 20,694 1,522 2,608 12.6% 31° 63° 40°	7 116 86 624 5,296 665 489 9.2% 19° 37° 32°	8 96 62 1,684 4,806 587 23 0.5% 12° 41° 30°	9 86 37 339 9,940 3,827 174 2.0% 22° 44° 33°	10 91 58 1,104 6,080 1,928 219 3.6% 15° 36° 25°	11 83 85 509 2,096 245 94 4.5% 11° 33° 23°	12 23 97 321 543 177 55 10.1% 5° 25° 16°
13 31 61 368 2,289 632 37 1.6% 18° 54° 36°	14 82 110 433 1,999 337 409 21.0% 32° 65° 47°	15 81 57 401 5,058 1,642 72 1.4% 28° 63° 43°	16 106 54 887 8,241 1,242 121 1.5% 29° 71° 51°	17 100 69 513 5,767 662 89 1.6% 39° 73° 53°	18 98 66 950 6,091 1,338 276 4.7% 34° 51° 43°	19 79 56 805 8,405 2,466 111 1.4% 33° 52° 40°
20 55 51 450 6,294 1,149 20 0.3% 27° 65° 45°	21 80 55 1,501 8,981 1,661 746 9.0% 34° 76° 56°	22 104 72 527 6,700 958 379 5.7% 41° 62° 52°	23 160 103 1,129 5,537 642 468 8.5% 37° 61° 50°	24 109 83 1,397 6,063 710 231 3.9% 30° 47° 41°	25 206 80 1,542 12,865 2,132 723 5.9% 32° 51° 40°	26 73 51 868 6,837 1,271 8 0.1% 23° 39° 31°
27 33 61 403 1,792 871 30 1.7% 19° 37° 28°	28 74 108 560 4,578 702 528 11.6% 16° 40° 29°	29 70 68 448 3,991 724 221 5.7% 26° 45° 35°	30 90 43 1,609 5,028 1,436 58 1.2% 38° 63° 51°	31 90 39 512 8,881 2,643 270 4.1% 30° 58° 37°		

Legend:

Calendar Day: Click on the calendar day to view the daily performance by major causes

Indicates DA Fuse Saving Mode (Fast Trip) - hover over to view time span

Outage Statistics:

Outages

CAIDI Max

Premise Affected (CI) Max

Extended CI (>=4Hrs) % of CI

Historic Weather:

°F Min|Max|Avg

Sunny Day

Rainy Day⁽¹⁾

Lightning Day⁽²⁾

Windy Day⁽³⁾

Grey Sky Day⁽⁴⁾

Grey Sky Day⁽⁵⁾

Grey Sky Day⁽⁶⁾

Click on weather icons to view temperature details

⁽¹⁾ Precipitation ≥ 0.1" inches at 3+ airports

⁽²⁾ Lightning Strokes ≥ 500 or at least two airports experiencing thunderstorms

⁽³⁾ Wind Speed ≥ 30(mph) or Wind Gust ≥ 35(mph)

⁽⁴⁾ Avg Temp > -5° or ≤ 0°, Avg Temp ≥ 80° or < 85° or Avg Wind Speed ≤ 25(mph) or < 30(mph) or Avg Wind Gust ≤ 25(mph) or < 30(mph) or Avg Precipitation ≤ 0.75" or < 1" or Lightning Strokes ≥ 3000 or < 6000

⁽⁵⁾ Avg Temp > -10° or ≤ -5°, Avg Temp ≥ 85° or < 90° or Avg W Precipital 6000 or < 72

⁽⁶⁾ Avg T ≥ 35(mph) Precipital Weather

Cause	Sys
All Causes	20
	8
	72
	12,865

Cause	System	West Op Region	North Op Region	South Op Region	Chicago Op Region
All Causes	206	71	29	79	27
	80 1542	132 617	41 587	104 1542	100 477
	723 5.9%	411 21.5%	18 0.4%	271 8.8%	23 1.5%
	12,865 2,132	1,956 205	5,635 2,132	3,086 639	2,188 657

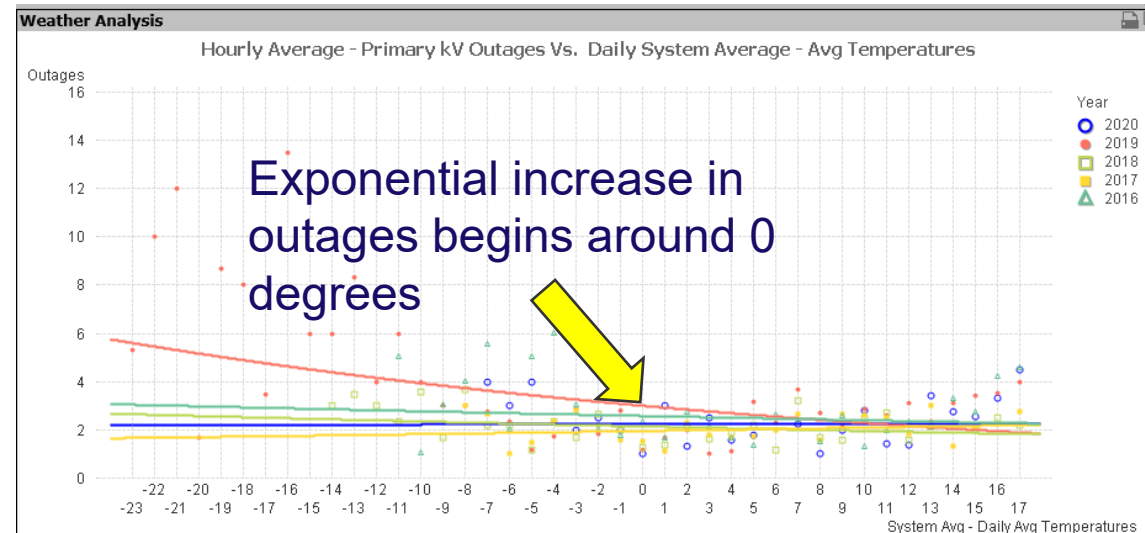
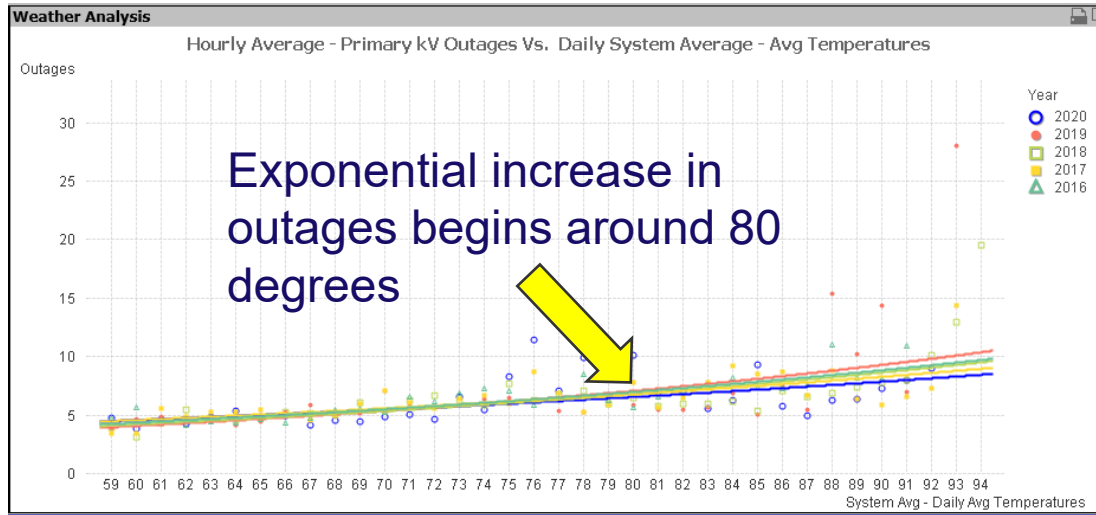
Conclusion

- ComEd's resiliency metrics can be expanded beyond weather conditions. For this reason, ComEd is leading the IEEE Distribution Resiliency Taskforce to develop the 'Distribution Resiliency Guide' by rallying a team of over 60 utilities, universities, National Labs and Industry across the world. The framework requires a set of inputs, models, and outputs to facilitate a systematic, risk-informed, data-driven, resilience-focused decision-making process. The guide is to be completed by end of 2024.
- ComEd has developed Storm and Gray sky day resiliency metrics to track storm performance. ComEd has invested significantly in system infrastructure improvements.
- ComEd analyses the storm performance using these metrics and can focus investments and planning based on the system performance (resilience).
- The ComEd resiliency metrics provides clear picture of storm restoration (speed of recovery) and gray sky day (system robustness) performance.

APPENDIX

Metric 2: Gray Sky Day Resiliency

- Weather Criteria: Temperature



Metric 2: Gray Sky Day Resiliency Cont.

- Weather Criteria: Wind

