Massachusetts Grid Modernization Program Year 2022 Evaluation Report: Advanced Distribution Automation (ADA)

Massachusetts Electric Distribution Companies

Submitted by:

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Reference No.: 219514
June 30, 2023

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Executive Summary

As a part of the Grid Modernization Plan (GMP), the Massachusetts Electric Distribution Companies (EDCs) are investing to enable Advanced Distribution Automation (ADA) on selected circuits across their distribution networks. These investments enable greater automation and are intended to enhance reliability, facilitate integration of DERs, and provide other grid and customer benefits.

This evaluation focuses on the progress and effectiveness of the Massachusetts Department of Public Utilities (DPU) preauthorized ADA investments for each EDC toward meeting the DPU's grid modernization objectives for Program Year (PY) 2022.

Evaluation Process

The DPU requires a formal evaluation process, including an evaluation plan and evaluation studies, for the EDCs' preauthorized grid modernization plan investments. Guidehouse is completing the evaluation to establish a uniform statewide approach and to facilitate coordination and comparability. The evaluation is to measure and assess progress toward achieving the DPU's grid modernization objectives. The evaluation uses the DPU-established Infrastructure Metrics and Performance Metrics along with a set of Case Studies to understand if the GMP investments are meeting the DPU's objectives.

The original Evaluation Plan developed by Guidehouse[1] was submitted to the DPU by the EDCs in a petition for approval on May 1, 2019. Modifications to this original Evaluation Plan were required to enable evaluation of PY 2022. These modifications included 1) an extension of the evaluation window from the four year term spanning 2018 – 2021[2] (hereon referred to as Term 1) to incorporate the new four year term spanning 2022 – 2025 (hereon referred to as Term 2), and 2) revisions required to reflect the new Term 2 investment activity. Modifications to the original Evaluation Plan were submitted to the EDCs for approval on March 1, 2023. The modified Evaluation Plan has been used to develop the analysis and evaluation provided below in this document.

Table 1 illustrates the key Infrastructure Metrics, Performance Metrics, and Case Studies (shown as Other metrics in the table) relevant for the ADA evaluation by EDC.

Table 1. ADA Evaluation Metrics

Metric Type	ADA Evaluation Metrics	ES	NG
IM-4	Number of Devices or Other Technologies Deployed	✓	✓
IM-5	Cost for Deployment	✓	✓

[1] Guidehouse had previously filed as "Navigant Consulting" and did so during the initial evaluation plan filing.

[2] On May 10, 2018, the Massachusetts DPU issued its Order regarding the individual GMPs filed by the three Massachusetts EDCs. In the Order, the DPU preauthorized grid-facing investments over 3 years (2018-2020) for each EDC and adopted a 3-year (2018-2020) regulatory review construct for preauthorization of grid modernization investments. On May 12, 2020, the DPU issued an Order extending the 3-year grid modernization plan investment term to a 4-year term, which introduced a 2021 program year. In addition, on July 1, 2020, Eversource filed a request for an extension of the budget authorization associated with grid modernization investments. The 2018-2021 GMP term results provided for Eversource reflect these changes.

Metric Type	ADA Evaluation Metrics	ES	NG
IM-6	Deviation between Actual and Planned Deployment for the Plan Year	✓	✓
IM-7	Projected Deployment for the Remainder of the GMP Term	✓	✓
PM-10	Numbers of Customers that Benefit from GMP-Funded Distribution Automation Devices	✓	✓
PM-11	Grid Modernization Investments' Effect on Outage Durations	✓	✓
PM-12	Grid Modernization Investments' Effect on Outage Frequency	✓	✓
PM-ES-2	Eversource Customer Outage Metric	✓	
PM-NG-1	National Grid Specific Metric: Impact of ADA Investments on Customer Minutes of Interruption (CMI) for Main-Line Interruptions		✓
Other	Case Studies	✓	✓

IM = Infrastructure Metric, PM = Performance Metric, ES = Eversource, NG = National Grid, UTL = Unitil

* The EDCs are responsible for these metric calculations and the calculations are not addressed in this evaluation

** Metrics apply to ADA

Source: Stamp Approved Performance Metrics, July 25, 2019

Data Management

Guidehouse worked with the EDCs to collect data to complete the ADA evaluation for the assessment of Infrastructure Metrics, Performance Metrics and Case Studies. A consistent methodology was used across Investment Areas and EDCs for evaluating and illustrating EDC progress toward the GMP metrics.

Table 2 summarizes data sources used throughout the ADA evaluation for PY 2022. Section 3.1.1, Section 4.1.1 and Section 5 detail each of the data sources used for the assessment of Infrastructure Metrics, Performance Metrics and Case Studies, respectively.

Table 2. ADA Data Sources

Data Source	Description
2021 Grid Modernization Plan Term Report[3,4,5]	Planned device deployment and cost information from each EDC's appendix to the *2021 GMP Term Report* (filed April 1, 2022). Data was used as the reference to track progress against the GMP targets and are referred to as the GMP Plan in summary tables and figures throughout the report.

[3] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Plan Annual Report 2020. Submitted to Massachusetts DPU on April 1, 2021 as part of DPU 21-30.

[4] NSTAR Electric Company d/b/a Eversource Energy, Grid Modernization Plan Annual Report 2020. Submitted to Massachusetts DPU on April 1, 2021 as part of DPU 21-30. Note that Eversource Energy filed an updated Appendix 1 filing in December of 2021; however that update did not affect any of the data or results in the evaluation.

[5] Fitchburg Gas and Electric Light Company d/b/a Unitil, Grid Modernization Plan Annual Report 2020. Submitted to Massachusetts DPU on April 1, 2021 as part of DPU 21-30.

Data Source	Description
2022 Grid Modernization Plan Annual Report[6,7,8]	All PM-related data are from these 2022 GMP Annual Report Appendices. In addition, data collected as part of EDC Data Template (below) was compared to the data submitted by the EDCs to the DPU in the 2021 Grid Modernization Plan Term Reports and associated Appendix 1 filings. The evaluation team confirmed the consistency of the data from the various sources and reconciled any differences
EDC Device Deployment Data Template	Captures planned and actual device deployment and spend data. Actual device deployment and cumulative spend information were provided by work order ID and specified at the feeder- or substation-level as appropriate. Device deployment information and estimated spend for 2022 were provided as well.
Eversource's 2021 DPU-Filed Plan[9]	Eversource's GMP extension request was approved by the DPU on February 4, 2021. It includes budgets for PY 2021 deployment at the Investment Area level. This data source is included in the EDC Plan for Eversource planned spend at the Investment Area level.
2022-2025 Grid Modernization Plan Track 1 Order[10]	The GMP Track 1 Order was filed by the DPU on October 7, 2022. It includes budgets for PY 2022-PY 2025 deployment at the Investment Area level. This data source is included in the EDC Plan for each EDC's planned spend at the Investment Area level.
EDC DOER Response Appendix[11]	Planned device deployment and cost information from each EDC's Appendix 1 filing was provided in response to DOER requests for information. Data was used as the reference to track progress against the GMP targets and are referred to as the GMP Plan in summary tables and figures throughout the report.

Source: Guidehouse analysis

Findings and Recommendations

At the request of Eversource, for this PY 2022 evaluation, Guidehouse provided analysis of Eversource's Term 1 spend and deployment. Eversource's 2022 ADA deployment finalized 2021's planned carryover, which concluded Term 1 deployment and spending. Table 3 summarizes the Term 1 Infrastructure Metrics results for Eversource's ADA Investment Area through PY 2022.

[6] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Annual Report for Calendar Year 2022. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.
[7] NSTAR Electric Company d/b/a Eversource Energy, Grid Modernization Annual Report for Calendar Year 2022. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.
[8] Fitchburg Gas and Electric Light Company d/b/a Unitil, 2022 Grid Modernization Plan Annual Report. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.
[9] Grid Modernization Program Extension and Funding Report. Submitted to Massachusetts DPU on July 1, 2020 as part of DPU 15-122.
[10] Massachusetts DPU 21-80/DPU 21-81/DPU 21-82 Order on Previously Deployed Technologies issued October 7, 2022.
[11] Plan data is sourced from EDC responses to the first set of information requests issued by the Department of Energy Resources (DOER). These responses were filed on October 4th, December 2nd, and October 5th, 2021, for Eversource, National Grid, and Unitil under DPU dockets 21-80, 21-81, and 21-82.

Table 3. Eversource Term 1 ADA Infrastructure Metrics Summary

Infrastructure Metrics			Eversource
GMP Plan Total, PY 2018-2022*		# Devices Planned	586
		Spend, $M	$60.91
IM-4	Number of devices or other technologies deployed PY 2018-2022*	# Devices Deployed***	586
		% Devices Deployed	100%
IM-5	Cost for Deployment PY 2018-2022*	Total Spend, $M	$60.45
		% Spend	99%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	100%
		% On Track (Spend)	0%
IM-7	Projected Deployment for the Remainder of the GMP Term (i.e., Term 1) **	# Devices Remaining	0
		Spend Remaining, $M	$0.00

*The metric names have been slightly changed here to clarify the time span used in analysis.

**This metric has been interpreted here (i.e., within the context of the 2022 Program Year Evaluation) as the units and spending that the EDC plans to complete their most recent 4-year Term 1 plans. Additional Grid Modernization units and dollars incurred in 2022 are attributed to Term 2, as appropriate, and all units and dollars spent during 2023 through 2025 will be considered as part of Term 2 GMPs.

***Note that "Deployed" here refers to commissioned devices. For full definitions of deployment stages, see Docket 20-46 Response to Information Request DPU-AR-4-11, September 3, 2020.

Source: Guidehouse analysis of 2021 GMP Term Reports and 2022 EDC Data

Table 4 summarizes the Term 2 Infrastructure Metrics results for National Grid's ADA Investment Area through PY 2022. Note that all National Grid deployment and spending in 2022 is included in Term 2 results (recall that Eversource is not continuing its ADA investment as part of Term 2 GMP.)

Table 4. National Grid Term 2 ADA Infrastructure Metrics Summary

Infrastructure Metrics			National Grid**
GMP Plan Total, PY 2022-2025		# Devices Planned	410
		Spend, $M	$37.67
EDC Data Total, PY 2022-2025		# Devices Planned	765
		Spend, $M	$37.68
IM-4	Number of devices or other technologies deployed thru. PY 2022	# Devices Deployed*	24
		% Devices Deployed	6%
IM-5	Cost for Deployment thru. PY 2022	Total Spend, $M	$4.74
		% Spend	13%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	30%
		% On Track (Spend)	68%
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	741
		Spend Remaining, $M	$32.94

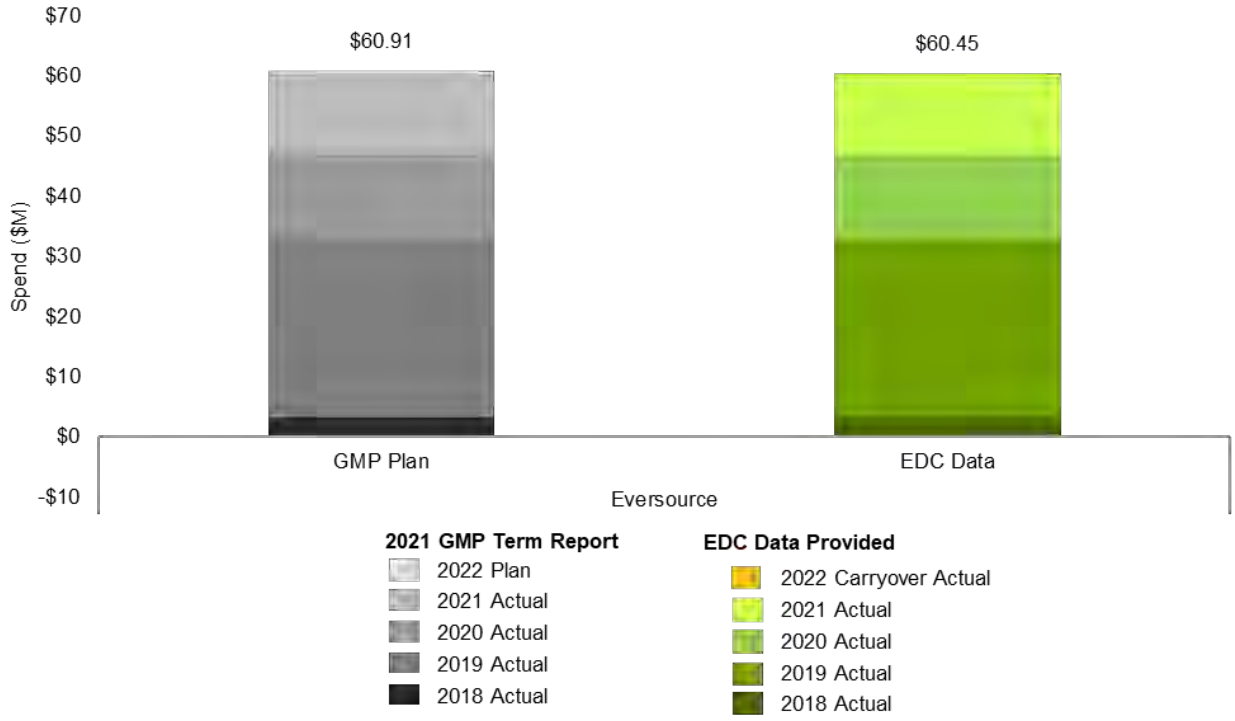
*"Deployed" here refers to commissioned devices. For full definitions of deployment stages, see Docket 20-46 Response to Information Request DPU-AR-4-11, September 3, 2020.

** To more closely align spend projections with DPU pre-authorized budgets, National Grid operations and maintenance (O&M) spend is included in actual and planned spend presented here. O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Figure 1 compares the Term 1 GMP Plans and EDC Data totals and year-over-year spending for Eversource.

Figure 1. Eversource ADA Term 1 Spend Comparison (2018-2022, $M)

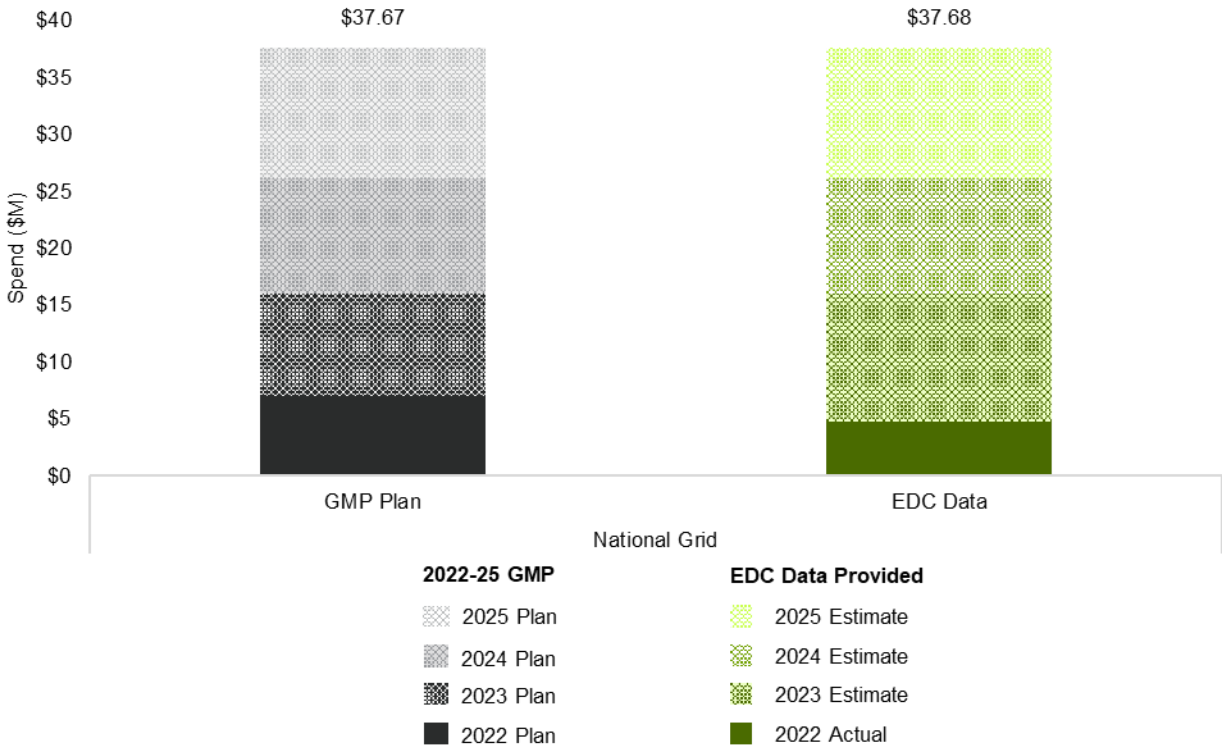


Note: Includes the Eversource planned spend on activity from 2021 that was transferred to 2022, set forth in Eversource's 2021 GMP Term Report, filed on April 1, 2022.

Source: Guidehouse analysis of 2021 GMP Term Report, "GMP Extension and Funding Report," and 2022 EDC Data

Figure 2 compares the Term 2 GMP Plans and EDC Data totals and year-over-year spending with current plan estimate for National Grid.

Figure 2. National Grid ADA Term 2 Spend Comparison (2022-2025, $M)



Note: To more closely align spend projections with DPU pre-authorized budgets, National Grid operations and maintenance (O&M) spend is included in actual and planned spend presented here. O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

Source: Guidehouse analysis of DPU Order (October 7, 2022) and 2022 EDC Data

Table 5 summarizes key findings related Guidehouse's ADA deployment evaluation for each EDC.

Table 5. Summary of Infrastructure Metrics Findings for ADA Investment Area

EDC	Summary of Findings
Eversource	Eversource's ADA circuit selection criteria included reducing customer zone sizes, targeting poor reliability areas, and minimizing cost. In PY 2021, Eversource met underground oil switch replacement target. It also met 91% of overhead recloser deployment target. Eversource pivoted to a different area work center for resources mid-year to attempt to meet the overhead recloser target but fell slightly under target. In hindsight, Eversource suggests it could have pivoted earlier or employed a contracting strategy. The remaining 9 reclosers were commissioned in PY 2022. The underground auto-restoration loop scheme was discontinued. This was first-of-a-kind technology for Eversource. Eversource SCADA-commissioned 18 devices but encountered software and communication challenges in getting the devices to operate as a loop scheme. After performing engineering and troubleshooting in 2020 and 2021, Eversource discontinued the investment. Lessons learned include the need to fully understand the communications requirements (latency, bandwidth, capacity) of a new technology. Alternative approaches will be explored as part of the ADMS investment. Eversource managed its spending closely to original pre-authorized budget. This meant continually re-evaluating the portfolio of investments and re-adjusting. As a result, Eversource's Term 1 ADA spending from 2018-2022 ($60.45 million) came close to DPU pre-authorized budget of $58 million. Eversource has deployed distribution automation on portions of its system for several years. The ADA investment has been some of the newest distribution automation, but overall Eversource has a higher level of saturation for this type of technology than, say, National Grid. In some cases, Eversource installed ADA devices on circuits that already had pre-existing ADA devices on other locations on the circuit. Eversource ADA investments have focused, among other benefits, on reducing zone size to 500 customers.

EDC	Summary of Findings
National Grid	National Grid saturation of ADA devices is low from a system-wide perspective, as it is still in early stages of its ADA. As such, National Grid has an opportunity to improve reliability as saturation increases. National Grid targeted feeders with poor reliability performance for ADA investments. National Grid is addressing long-lead times for equipment, resource constraints, and streamlining the installation process. This will enable National Grid to come closer to achieving its projected deployment schedule. National Grid pivoted from using internal crew into a combination of internal and contractors. To improve efficiency, all devices are pre-programmed prior to installation. Much of National Grid's progress in 2022 was comprised deploying OH DA w/o Ties and Feeder Monitors. The majority of 2022 spend ($4.5M) was on OH DA w/o Ties ($2.4M) and Feeder Monitors ($1.6M). National Grid had eight additional FLISR schemes placed into service. There were 17 successful FLISR operations. This reduced each event by restoring approximately 40% of customers from the initial outage customer count. National Grid installed some of its ADA devices at strategic tie points between circuits. Tie reclosers are expected to have enhanced reliability and redundancy benefits for customers. However, reconductoring and pole upgrades are sometimes needed to ensure that load can be shifted safely between circuits, adding to the project costs. National Grid plans to operate GMP ADA devices using a public cellular network to keep projects moving forward. National Grid is evaluating a 700MHz private radio communications network and if found to be acceptable they propose to use a combination of a public cellular and private communications for GMP ADA devices. National Grid is in early stages of its effort to deploy the ADA investment and has limited ADA on its system. As such the saturation of ADA devices is low on a system-wide perspective. This should provide an opportunity to improve reliability as saturation increases and National Grid continues to leverage this investment.

Source: Guidehouse analysis of 2021 GMP Term Reports and EDC Data

Table 6 and Table 7 summarize the Performance Metric Results for each EDC's ADA Investment Area in PY 2022. Table 6 shows the results for the Performance Metric that analyzes the Effect on Outage Duration (CKAIDI) and Table 7 shows the results for the Effect on Outage Frequency (CKAIFI). In both tables, the baseline and PY 2022 results are summarized for both system-wide circuits and ADA circuits.

Table 6. ADA Performance Metrics Summary: CKAIDI

Eversource ADA	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIDI Statistics								
Total Circuits	2,284	2,284	289	289	2,284	2,284	289	289
Total Circuits with Non-zero Customers	1,443	1,443	260	260	1,443	1,443	260	260
% Zero CKAIDI	19%	19%	2%	2%	27%	33%	4%	10%
Average CKAIDI	128	103	149	131	177	74	190	72
Simple Avg. CKAIDI	97	78	145	127	147	62	175	77
Change from Baseline (Baseline - Plan Year)					-49	29	-41	58
% Change from Baseline					-38%	28%	-28%	45%
Std. Dev.	146	115	149	135	358	101	382	88

National Grid ADA	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIDI Statistics								
Total Circuits	1,141	1,141	61	61	1,141	1,141	70	70
Total Circuits with Non-zero Customers	816	816	36	36	816	816	36	36
% Zero CKAIDI	2%	3%	0%	0%	16%	17%	3%	3%
Average CKAIDI	226	112	336	127	140	100	134	89
Simple Avg. CKAIDI	206	107	332	129	131	95	137	94
Change from Baseline (Baseline - Plan Year)					86	12	202	38
% Change from Baseline					38%	11%	60%	30%
Std. Dev.	264	86	318	80	165	109	155	67

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse analysis of 2022 GMP Annual Reports Appendix 1

Table 7. ADA Performance Metrics Summary: CKAIFI

Eversource ADA	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIFI Statistics								
Total Circuits	2,284	2,284	289	289	2,284	2,284	289	289
Total Circuits with Non-zero Customers	1,443	1,443	260	260	1,443	1,443	260	260
% Zero CKAIFI	19%	19%	2%	2%	27%	33%	4%	10%
Average CKAIFI	0.98	0.92	1.15	1.11	1.22	0.91	1.32	0.99
Simple Avg. CKAIFI	0.68	0.64	1.05	1.01	0.92	0.63	1.25	0.87
Change from Baseline (Baseline - Plan Year)					-0.24	0.01	-0.17	0.12
% Change from Baseline					-25%	1%	-15%	11%
Std. Dev.	0.76	0.70	0.77	0.73	1.28	0.99	1.33	1.03
National Grid ADA	**2015-2017 Avg. CKAIFI (Baseline)**				**2022 CKAIFI (Program Year)**			
	System-wide		**ADA Circuits**		**System-wide**		**ADA Circuits**	
	w/ EMEs	**w/o EMEs**	**w/ EMEs**	**w/o EMEs**	**w/ EMEs**	**w/o EMEs**	**w/ EMEs**	**w/o EMEs**
CKAIFI Statistics								
Total Circuits	1,141	1,141	61	61	1,141	1,141	61	61
Total Circuits with Non-zero Customers	816	816	36	36	816	816	36	36
% Zero CKAIFI	2%	3%	0%	0%	16%	17%	3%	3%
Average CKAIFI	1.02	0.92	1.21	1.11	1.04	0.91	1.03	0.85
Simple Avg. CKAIFI	0.88	0.79	1.17	1.08	0.87	0.77	1.10	0.87
Change from Baseline (Baseline - Plan Year)					-0.02	0.01	0.17	0.26
% Change from Baseline					-2%	1%	14%	23%
Std. Dev.	0.65	0.60	0.68	0.64	1.03	0.89	0.95	0.69

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse analysis of 2022 GMP Annual Reports Appendix 1

Table 8 presents the results for the ADA-specific Performance Metrics: Numbers of Customers that Benefit from GMP Funded Distribution Automation Devices, Average Zone Size (Eversource-specific metric), and Average Main-Line Customer Minutes of Interruption (National Grid-specific metric).

Table 8. ADA Performance Metrics Summary: ADA-Specific Metrics

	Eversource	National Grid
Total Number of Customers Benefiting from DA Devices	254,626	113,311
Average Change in Zone Size: ADA Circuits	231	N/A
Average Change in Main-Line Customer Minutes of Interruption	N/A	57,647

Source: Guidehouse analysis of 2022 GMP Annual Reports Appendix 1

Table 9 summarizes key findings related to Guidehouse's ADA Performance Metrics evaluation for each EDC.

Table 9. Summary of Performance Metrics Findings for ADA Investment Area

PM	Eversource	National Grid
PM-12: Grid Modernization investments' effect on outage durations	Outage duration for ADA circuits in PY 2022 improved by 58 minutes from baseline on non-EME days. *	Outage duration for ADA circuits in PY 2022 improved by 38 minutes from baseline on non-EME days. ADA circuits performed better in PY 2022 than system-wide circuits on average. *
PM-13: Grid Modernization investments' effect on outage frequency	Outage frequency for ADA circuits in PY 2022 was 11% better than baseline on non-EME days, but 15% worse for EME days. System-wide circuits performed better than ADA circuits on average in PY 2022. *	Outage frequency for ADA circuits in PY 2022 was 23% better than baseline for non-EME days, and 14% better for EME days. ADA circuits performed better than system-wide circuits on average in PY 2022. *
PM-11: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Almost 254,626 (14%) Eversource customers benefitted from ADA devices.	Over 113,000 (8%) National Grid customers benefitted from ADA devices.
PM-ES2: Protective Zone: Average Zone Size per Circuit	The average zone size on circuits with ADA devices decreased by 231 customers in PY 2022 from 2018.	N/A – Eversource specific metric
PM-NG1: Main Line Customer Minutes of Interruption Saved	N/A – Nat. Grid specific metric	Main-line CMI for circuits with ADA decreased (improved) 35% in PY 2022 from baseline. *
Case studies	Case studies showed that ADA investments have been yielding reliability improvements for customers.	Case studies showed that ADA investments have been yielding reliability improvements for customers.

** Note: This metric is not able to readily discern whether change in this metric was due to ADA investment or other factors.*

Source: Guidehouse Analysis

Guidehouse submits the following recommendations for EDC consideration in PY 2022:

1. Both Eversource and National Grid circuits with ADA investment showed lower (improved) outage duration on average relative to the baseline (based on the defined metric) for non-EME days. For EME days, National Grid circuits with ADA investment also showed improved outage duration on average when compared to baseline years; however, for Eversource, this metric was worse than baseline.
    - Recommendation: Continue investment in this technology, but continue to monitor and try to verify the impacts (noting that the defined metric does not paint a complete picture as has been previously observed) on circuits receiving Term 2 investments as well as those that have received Term 1 investment (to understand the longer term impacts of the investments over time).

2. Both Eversource and National Grid circuits with ADA investment showed lower (improved) outage frequency on average relative to the baseline (based on the defined metric) for non-EME days. For EME days, National Grid circuits with ADA investment

also showed improved outage duration on average when compared to baseline years; however, for Eversource, this metric was worse than baseline.

- Recommendation: Continue investment in this technology approach, but continue to monitor and try to verify the impacts (noting that the defined metric does not paint a complete picture as has been previously observed) on circuits receiving Term 2 investments as well as those that have received Term 1 investment (to understand the longer term impacts of the investments over time).

3. Eversource ADA schemes are operating as designed in the majority of cases observed. In these cases, the schemes are able to restore power rapidly and automatically to multiple sections of a circuit. Eversource automated ADA operations typically take just under or just over one minute.
    - Recommendation: Eversource may consider fine-tuning ADA schemes to complete more operations in under (rather than just over) one minute. Outages under one minute are considered momentary and do not count towards SAIFI and SAIDI in Massachusetts. While this change would make minimal difference to customer experience, it would make a difference to Eversource's reliability performance metrics.
    - Recommendation: Eversource should consider ADMS-based FLISR for faster operation and restoration.
    - Recommendation: continue to explore case studies for Term 1 investments to validate operation.

4. Guidehouse observed a few instances where Eversource ADA schemes did not operate as expected, due to devices not operating or miscoordination. Eversource has a follow-up tracking system in place to address the issues observed in these cases.
    - Recommendation: Eversource should continue to monitor and follow up on each instance where ADA schemes did not perform the FLISR operation as designed.

5. National Grid's ADA FLISR schemes are operating as designed and proving effective in rapidly restoring power to customers after fault occurrence. In many cases, a few of which are highlighted in case studies, FLISR schemes have automatically restored power to customers in less than one minute (the Massachusetts threshold for a sustained outage).
    - Recommendation: National Grid should continue to evaluate more locations for ADA FLISR deployment.
    - Recommendation: continue to explore case studies for Term 1 investments to validate operation. Also, consider case studies for Term 2 investments to validate and verify their operation.

6. National Grid's ADA FLISR schemes are sophisticated in their ability to restore two or more sections of a circuit simultaneously, coordinating the operation of multiple (four or more) devices.

7. When designing the ADA FLISR schemes, National Grid has taken measures including reconductoring and circuit upgrades, which allow neighboring circuits to "carry"

additional load during emergencies. Guidehouse observed one case where FLISR did not operate because a load transfer operation would have overloaded the rating of an asset.

- Recommendation: National Grid should evaluate whether further system upgrades may be justified to allow load transfer in emergencies.

8. Guidehouse observed one instance where a National Grid ADA scheme operated as designed, but due to the location of the fault no customers were restored.
    - Recommendation: National Grid should evaluate the potential for further circuit sectionalization to reduce customer zone size.

9. The CKAIDI and CKAIFI reliability related Performance Metrics as defined have deficiencies in measuring the effectiveness of Grid Modernization Investments. These items have been pointed out as recommendations in Evaluation Reports from prior program years, and so the details are not repeated here. The case study approach addresses some of these shortcomings.
    - Recommendation: Continue to track these Performance Metrics, but also continue to perform case studies (for Term 1 and Term 2 investments as appropriate, as mentioned above) and explore other methods of isolating the specific impacts of Grid Modernization investments (e.g., frequency of device operations). [12,13]

[12] The EDCs do have additional reliability metrics that are being tracked: National Grid has the *Mainline Customer Minutes of Interruption Saved* metric (PM-NG1), and Eversource has the *Protective Zone Average Zone Size per Circuit* metric (PM-ES2), which provide additional information about reliability performance. However, neither of these metrics directly isolates and measures the investments' performance impact on customer reliability vis a vis other factors that may impact reliability.

[13] We are aware that the EDCs are actively exploring additional methods to isolate reliability benefits. For reference, National Grid conducted additional analysis to understand how Grid Modernization investments are influencing system reliability and provided findings from this analysis within its 2022 GMP Annual Report filed April 24, 2023 under DPU docket 23-30.

1. Introduction to Massachusetts Grid Modernization

This section provides a brief background to the grid modernization evaluation process along with an overview of the Advanced Distribution Automation (ADA) Investment Area and specific ADA evaluation objectives. These are provided for context when reviewing the subsequent sections that address the specific evaluation process and findings.

1.1. Massachusetts Grid Modernization Plan Background

The following subsections summarize the progression of Massachusetts Grid Modernization Plans (GMPs) filed by the three Massachusetts Electric Distribution Companies (EDCs): Eversource, National Grid, and Unitil.

1.1.1. Grid Modernization Term 1 (2018-2021)

On May 10, 2018, the Massachusetts DPU issued its Order[14] regarding the individual Grid Modernization Plans (GMPs) filed by the three Massachusetts EDCs.[15,16] In the Order, the DPU preauthorized grid-facing investments over 3 years (2018-2020) for each EDC and adopted a 3-year (2018-2020) regulatory review construct for preauthorization of grid modernization investments. On May 12, 2020, the DPU issued an Order[17] extending the 3-year grid modernization plan investment term to a 4-year term, which introduced a 2021 program year.

During the GMP term spanning 2018-2021 (hereon referred to as Term 1) the grid modernization investments were organized into six Investment Areas to facilitate understanding, consistency across EDCs, and analysis.

- Monitoring and Control (M&C)
- Advanced Distribution Automation (ADA)
- Volt/VAR Optimization (VVO)
- Advanced Distribution Management Systems/Advanced Load Flow (ADMS and ALF)
- Communications/IoT (Comms)
- Workforce Management (WFM)

A certain level of spending for each of these GMP Investment Areas was preauthorized by the DPU, with the expectation they would advance the achievement of DPU's grid modernization objectives:

[14] Massachusetts DPU 15-120/DPU 15-121/DPU 15-122 (Grid Modernization) Order issued May 10, 2018 (DPU Order).

[15] On August 19, 2015, National Grid, Unitil, and Eversource each filed a grid modernization plan with the DPU. The DPU docketed these plans as DPU 15-120, DPU 15-121, and DPU 15-122, respectively.

[16] On June16, 2016, Eversource and National Grid each filed updates to their respective grid modernization plans

[17] Massachusetts DPU 15-120; DPU 15-121; DPU 15-122 (Grid Modernization) Order (1) Extending Current Three-Year Grid Modernization Plan Investment Term; and (2) Establishing Revised Filing Date for Subsequent Grid Modernization Plans (issued May 12, 2020).

- Optimize system performance by attaining optimal levels of grid visibility command and control, and self-healing
- Optimize system demand by facilitating consumer price responsiveness
- Interconnect and integrate distributed energy resources (DER)

For Term 1, the Massachusetts DPU's preauthorized budget for grid modernization varied by Investment Area and EDC. Eversource originally had the largest preauthorized budget at $133 million, with ADA and M&C representing the largest share ($44 million and $41 million, respectively). National Grid's preauthorized budget was $82.2 million, with ADMS representing over 50% ($48.4 million). Unitil's preauthorized budget was $4.4 million and VVO makes up 50% ($2.2 million).

On July 1, 2020, Eversource filed a request for an extension of the budget authorization associated with grid modernization investments.[18] The budget extension, approved by the DPU on February 4, 2021,[19] included $14 million for ADA, $16 million for ADMS/ALF, $5 million for Communications, $15 million for M&C, and $5 million for VVO.[20] These values are included in the Eversource total budget by Investment Area in Table 10.

Table 10. Term 1 (2018-2021) Preauthorized Budget, $M

Investment Areas	Eversource	National Grid	Unitil	Total
ADA	$58.00	$13.40	N/A	**$71.40**
ADMS/ALF	$33.00	$48.40	$0.70	**$79.10**
Comms	$23.00	$1.80	$0.84	**$25.60**
M&C	$56.00	$8.00	$0.35	**$64.75**
VVO	$18.00	$10.60	$2.22	**$30.80**
WFM	--	--	$0.30	**$1.00**
2018-2021 Total	**$188.00**	**$82.20**	**$4.41**	**$272.65**

Source: DPU Order, May 10, 2018, and Eversource filing "GMP Extension and Funding Report," July 1, 2020

1.1.2. Grid Modernization Term 2 (2022-2025)

On July 2, 2020, the Massachusetts DPU issued an Order[21] that triggered further investigation into modernization of the electric grid. In the order, the DPU required that the EDCs file a grid modernization plan on or before July 1, 2021. In accordance with this order, the Massachusetts EDCs filed grid modernization plans for a 4-year period spanning 2022-2025 (hereby referred to as Term 2).[22] In these plans, the EDCs outlined continued investment in the areas that received

[18] Grid Modernization Program Extension and Funding Report. Submitted to Massachusetts DPU on July 1, 2020 as part of DPU 15-122

[19] Massachusetts DPU 20-74 Order issued on February 4, 2021.

[20] The DPU allowed flexibility to these budgets to accommodate changing technologies and circumstances. For example, EDCs can shift funds across the different preauthorized investments if a reasonable explanation for these shifts is supplied.

[21] Massachusetts DPU 20-69: Investigation by the Department of Public Utilities on its own Motion into the Modernization of the Electric Grid – Phase Two (issued July 2, 2020).

[22] On July 1, 2021, Eversource, National Grid, and Unitil each filed a grid modernization plan with the DPU for the period spanning 2022-2025. The DPU docketed these plans as DPU 21-80, 21-81, and 21-82, respectively.

investment during Term 1 (referred to as Track 1 Investment Areas), and investment in new Investment Areas (Track 2 Investment Areas). The Track 2 grid modernization investments were organized into the following additional Investment Areas to facilitate understanding, consistency across EDCs, and analysis.

- Interconnection Automation
- Probabilistic Power Flow Modeling
- Distributed Energy Resource Mitigation (DER Mitigation)
- Distributed Energy Resource Management System (DERMS)
- Demonstration Projects

1.1.3. Investment Areas

Table 11 and Table 12 summarize the DPU pre-authorized GMP investments.

Table 11. Overview of Term 2, Track 1 Investment Areas

Investment Areas	Description	Objective
Monitoring and Control (M&C)	Remote monitoring and control of devices in the substation for feeder monitoring or online devices for enhanced visibility outside the substation	Enhancing grid visibility and control capabilities, reliability increase
Advanced Distribution Automation (ADA)	National Grid-only investment for Term 2. ADA allows for isolation of outage events with automated restoration of unaffected circuit segments	Reduces the impact of outages
Volt/VAR Optimization (VVO)	Control of line and substation equipment to optimize voltage, reduce energy consumption, and increase hosting capacity	Optimization of distribution voltage to reduce energy consumption and demand
Advanced Distribution Management Systems	New capabilities in real-time system control with investments in developing accurate system models and enhancing Supervisory control and data acquisition (SCADA) and outage management systems to control devices for system optimization and provide support for distribution automation and VVO with high penetration of DER	Enables high penetration of DER by supporting the ability to control devices for system optimization, ADA, and VVO
Communications/IoT	Fiber middle mile and field area communications systems	Enables the full benefits of grid modernization devices to be realized
Workforce Management (WFM)	Unitil-only investment for Term 2 to improve workforce and asset utilization related to outage management and storm response	Improves the ability to identify damage after storms

Source: Grid Mod RFP – SOW (Final 8-8-18).pdf; Guidehouse

Table 12. Overview of Term 2, Track 2 Investment Areas

Investment Areas	Description	Objective
Interconnection Automation	Eversource plans to integrate, into a single software, both their existing Distributed Generation (DG) tools and customer interconnection portal.	Improve the DG interconnection process with reductions in time & resources for a growing number of applications
Probabilistic Power Flow Modeling	Eversource plans to use a simulation of locational load and generation based on variables such as customer behavior and energy market prices.	Leverage GMP term 1 ALF investments into an automated approach to system modelling.
DER Mitigation	Unitil plans to install ground-fault overvoltage protection as well as upgrade either voltage regulators or load tap changers for three substations with reverse power flow issues	Address reverse power flow issues caused by DER saturation at three specific substations.
DERMS	Software that forms the hub of DER management functions and integrates with other applications such as a Demand Response Management System ("DRMS") and ADMS, to create the DERMS Platform.	Cost-effectively optimize system performance and integrate DERS with more granularity
Demonstration Projects	Two demonstration projects proposed by National Grid to test new tools. Includes Active Resource Integration (ARI) and Local Export Power Control	Facilitates the interconnection of DG in certain areas of the EDC's distribution system that are approaching saturation
Project Management and Third-Party Evaluation	Investment into evaluation and project management. Evaluation includes third party evaluator budget, where the evaluator will conduct studies on appropriate topics related to the deployment of preauthorized investments. Project management includes portfolio management and reporting.	Assess and report on GMP deployment progress and performance of grid modernizing investments.

Source: Massachusetts DPU 21-80/DPU 21-81/DPU 21-82 Order on New Technologies and Advanced Metering Infrastructure Proposals issued November 30, 2022.

The Massachusetts DPU preauthorized budget for Track 1 investments and Track 2 investments on October 7, 2022[23] and November 30, 2022, [24] respectively. The preauthorized budget for grid modernization varies by Investment Area and EDC. National Grid has the largest preauthorized track one budget at $300.8 million, with Communications and VVO representing the largest share ($103 million and $76 million, respectively). Eversource's preauthorized Track 1 budget is $176.6 million, with M&C representing about 50% ($76.3 million). Unitil's preauthorized track one budget is $9.1 million with VVO making up more than 50% ($5.4 million).

[23] Massachusetts DPU 21-80/DPU 21-81/DPU 21-82 Order on Previously Deployed Technologies issued October 7, 2022.

[24] Massachusetts DPU 21-80/DPU 21-81/DPU 21-82 Order on New Technologies and Advanced Metering Infrastructure Proposals issued November 30, 2022.

Table 13. Term 2 (2022-2025) Preauthorized Budget, $M

Investment Areas	Eversource	National Grid	Unitil	Total
ADA	--	$37.70	--	**$37.70**
ADMS*	$21.90	$61.00	$1.50	**$84.40**
Comms**	$38.00	$102.80	$0.82	**$141.62**
M&C	$76.30	$4.10	$1.10	**$81.50**
VVO	$40.40	$76.40	$5.40	**$122.20**
WFM	--	--	$0.25	**$0.25**
IT/OT	--	$18.80	--	**$18.80**
Track 1 Total	***$176.60***	***$300.80***	***$9.07***	***$486.47***
Interconnection Automation	$2.77	--	--	**$2.77**
Probabilistic Power Flow	$2.07	--	--	**$2.07**
DER Mitigation	--	--	$1.04	
DERMS	$16.00	$24.60	$0.16	**$41.80**
Demonstration Projects	--	$6.40	--	**$6.40**
Project Management and Third-Party Evaluation	$8.00	$4.40	$0.30	**$12.70**
Track 2 Total	***$29.00***	***$35.40***	***$1.50***	***$65.90***
2022-2025 Total	**$205.60*****	**$336.20**	**$10.57**	**$552.37**

* Given as $1.66M minus DERMS cost from DPU Order, Oct. 7, 2022, and calculated from DPU Order, Nov. 30, 2022.

** Includes Communications Modernization for Eversource, with added budget taken from DPU Order, Nov. 30,2022.

*** Budget includes $16.3 million in funds remaining from the supplemental budget approved in D.P.U. 20-74 for DMS, substation automation, and VVO investments that Eversource sought to expend in calendar year 2022.

Source: DPU Order on Previously Deployed Technologies, October 7, 2022, and DPU Order on New Technologies, November 30, 2022 under docket 21-80, 21-81, and 21-82.

1.1.4. Evaluation Goals and Objectives

The DPU requires a formal evaluation process (including an evaluation plan and evaluation studies) for the EDCs' preauthorized GMP investments. Guidehouse is completing the evaluation to enable a uniform statewide approach and to facilitate coordination and comparability. The evaluation measures the progress made toward the achievement of DPU's grid modernization objectives. It uses the DPU-established Infrastructure Metrics and Performance Metrics, as well as Case Studies that illustrate the performance of specific technology deployments, to help determine if the investments are meeting the DPU's GMP objectives.

As previously noted, the Massachusetts DPU order on Track 2 technologies was released on November 30, 2022. The EDCs waited for DPU ruling on these technologies prior to commencing with significant investment, and thus were not able to complete deployment of

Track 2 technologies within the remaining 2022 calendar year.[25] Guidehouse has, therefore, not included evaluation findings for Track 2 technologies in this PY 2022 evaluation report, but instead will report GMP Track 2 evaluation findings for PY 2023 through PY 2025 in future program year reports.

1.1.5. Metrics for Evaluation

The DPU-required evaluation involves Infrastructure Metrics and Performance Metrics for each Investment Area. In addition, selected case studies have been added for some Investment Areas (e.g., M&C) as part of the evaluation to help facilitate understanding of how the technology performs in specific instances (e.g., in remediating the effects of a line outage).

1.1.5.1. Infrastructure Metrics

The Infrastructure Metrics assess the deployment of the GMP investments. Table 14 summarizes the Infrastructure Metrics.

Table 14. Infrastructure Metrics Overview

Metric		Description	Applicable IAs	Metric Responsibility*
IM-1	**Grid Connected Distribution Generation Facilities**	Tracks the number and type of distributed generation facilities in service and connected to the distribution system	ADMS/ALF	EDC
IM-2	**System Automation Saturation**	Measures the quantity of customers served by fully or partially automated devices.	M&C, ADA	EDC
IM-3	**Number and Percent of Circuits with Installed Sensors**	Measures the total number of circuits with installed sensors which will provide information useful for proactive planning and intervention.	M&C	EDC
IM-4	**Number of Devices or Other Technologies Deployed**	Measures how the EDC is progressing with its GMP from an equipment or device standpoint.	All IAs	Evaluator
IM-5	**Cost for Deployment**	Measures the associated costs for the number of devices or technologies installed; designed to measure how the EDC is progressing under its GMP.	All IAs	Evaluator
IM-6	**Deviation Between Actual and Planned Deployment for the Plan Year**	Measures how the EDC is progressing relative to its GMP on a year-by-year basis.	All IAs	Evaluator

[25] Within PY 2022, there was limited spend for Track 2 technologies for both Unitil and Eversource. Unitil reported approximately $20k collectively across DER mitigation, workforce management, and Program Management and EM&V, while Eversource reported approximately $6k for DERMS.

Metric		Description	Applicable IAs	Metric Responsibility*
IM-7	**Projected Deployment for the Remainder of the GMP Term**	Compares the revised projected deployment with the original target deployment as the EDC implements its GMP.	All IAs	Evaluator

PM = Performance Metric, IA = Investment Area, ES = Eversource, NG = National Grid, UTL = Unitil

* Column indicates which EDC is responsible for calculating each metric, for statewide metrics, all EDCs are responsible

Source: Guidehouse Review of DPU Order, May 10, 2018[26]

1.1.5.2. Performance Metrics

The Performance Metrics assess the performance of all the GMP investments. Table 15 summarizes the Performance Metrics used for the various Investment Areas. This report discusses Performance Metrics that pertain specifically to the M&C Investment Area.

Table 15. Performance Metrics Overview

Metric		Description	Applicable IAs	Metric Responsibility*
PM-1	**VVO Baseline**	Establishes a baseline impact factor for each VVO-enabled circuit which will be used to quantify the peak load, energy savings, and greenhouse gas (GHG) impact measures.	VVO	All
PM-2	**VVO Energy Savings**	Quantifies the energy savings achieved by VVO using the baseline established for the circuit against the annual circuit load with the intent of optimizing system performance.	VVO	All
PM-3	**VVO Peak Load Impact**	Quantifies the peak demand impact VVO/CVR has on the system with the intent of optimizing system demand.	VVO	All
PM-4	**VVO Distribution Losses without Advanced Metering Functionality (AMF) (Baseline)**	Presents the difference between circuit load measured at the substation via the SCADA system and the metered load measured through advanced metering infrastructure.	VVO	All
PM-5	**VVO Power Factor**	Quantifies the improvement that VVO/CVR is providing toward maintaining circuit power factors near unity.	VVO	All

[26] Massachusetts DPU 15-120/DPU 15-121/DPU 15-122 (Grid Modernization) Order issued May 10, 2018 (DPU Order), pg. 198-201.

Metric		Description	Applicable IAs	Metric Responsibility*
PM-6	**VVO – GHG Emissions**	Quantifies the overall GHG impact VVO/CVR has on the system.	VVO	All
PM-7	**Voltage Complaints**	Quantifies the prevalence of voltage-related complaints before and after deployment of VVO investments to assess customer experience, voltage stability under VVO.	VVO	All
PM-8	**Increase in Substations with DMS Power Flow and Control Capabilities**	Examines the deployment and data cleanup associated with deployment of ADMS, primarily by counting and tracking the number of circuits and substations per year.	ADMS/ ALF	All
PM-9	**Control Functions Implemented by Circuit**	Examines the control functions of DMS power flow and control capabilities, focused on the control capabilities including VVO-CVR and FLISR.	ADMS/ ALF	All
PM-10	**Numbers of Customers that benefit from GMP funded Distribution Automation Devices**	Shows the progress of ADA investments by tracking the number of customers that have benefitted from the installation of ADA devices.	ADA	ES, NG
PM-11	**Grid Modernization investments' effect on outage durations**	Provides insight into how ADA and M&C investments can reduce outage durations (CKAIDI). Compares the experience of customers on GMP M&C-enabled circuits as compared to the previous 3-year average for the same circuit.	M&C, ADA	All
PM-12	**Grid Modernization investments' effect on outage frequency**	Provides insight into how ADA and M&C investments can reduce outage frequencies (CKAIFI). Compares the experience of customers on M&C-enabled circuits as compared to the prior 3-year average for the same circuit.	M&C, ADA	All
PM-ES-1	**Advanced Load Flow – Percent Milestone Completion**	Examines the fully developed ALF capability across Eversource's circuit population.	ADMS/ ALF	ES
PM-ES-2	**Protective Zone: Average Zone Size per Circuit**	Measures Eversource's progress in sectionalizing circuits into protective zones designed to limit outages to customers located within the zone.	ADA	ES

Metric		Description	Applicable IAs	Metric Responsibility*
PM-UTL-1	**Customer Minutes of Outage Saved per Circuit**	Tracks time savings from faster AMI outage notification than customer outage call, leading to faster outage response and reduced customer minutes of interruption.	M&C	UTL
PM-NG-1	**Main Line Customer Minutes of Interruption Saved**	Measures the impact of ADA investments on the customer minutes of interruption (CMI) for main line interruptions. Compares the CMI of GMP ADA-enabled circuits to the previous 3-year average for the same circuit.	ADA	NG

PM = Performance Metric, IA = Investment Area, ES = Eversource, NG = National Grid, UTL = Unitil

* Column indicates which EDC is responsible for calculating each metric, for statewide metrics, all EDCs are responsible

Source: Stamp Approved Performance Metrics, July 25, 2019.[27]

1.1.5.3. Case Studies

The impacts of GMP devices on system reliability metrics can be difficult to discern due to the range of factors that affect these metrics. Storm conditions, vehicle accidents and other factors drive reliability from year to year. This is especially likely if the device has less than several full years of operation to affect the metric.

Guidehouse, in consultation with the EDCs, developed a case study approach to provide more insight into the actual operation of the GMP devices and to illustrate how these investments provide customer reliability and operational benefits. The case studies help to illustrate the benefits provided by GMP devices during outages and other events. This approach investigates outage events on specific circuits where the GMP equipment was used to address the outage. The approach also allows for comparison between what did occur due to the presence of the GMP device and what would have likely happened had the GMP investment not been made.

1.2. ADA Investment Area Overview

Eversource and National Grid are investing in ADA, with only National Grid continuing investment into Term 2. Unitil does not have preauthorized ADA investments in its GMP. ADA investments will enable a greater level of distribution grid automation and are expected to result in improved electric system reliability. As identified in the 2021 Grid Modernization Term Reports, filed by the EDCs on April 1, 2022, and the PY 2022 EDC Data Request, received by the EDCs in early 2022, the ADA investments totaled to $73.94 million from 2018 to 2022:

- $60.45 million by Eversource

[27] Massachusetts Department of Public Utilities, Grid Modernization Plan Performance Metrics. Submitted on July 25, 2019, as part of DPU 12-120,15-121, & 15-122

- $13.49 million by National Grid (includes $9.03 million from Term 1 and $4.46 from Term 2).

Table 16 summarizes the preauthorized budget for the ADA investment area for the first and second GMP terms.

Table 16. GMP Preauthorized Budget for ADA, $M

Period	Eversource	National Grid	Unitil	Total
GMP Term 1 (2018 – 2021)	$60.45	$13.49	N/A	**$73.94**
GMP Term 2 (2022 – 2025)	N/A	$37.70	N/A	**$37.70**

Source: Term 1 preauthorized budgets were populated using DPU Order, May 10, 2018, and Eversource filing "GMP Extension and Funding Report," July 1, 2020. Term 2 preauthorized budgets were populated using DPU Order, October 7, 2022, and DPU Order, November 30, 2022 under docket 21-80, 21-81, and 21-82.

The following subsection discusses EDC-specific approaches to ADA.

1.2.1. EDC Approach to ADA

ADA investments all serve to increase visibility of the distribution grid, add more control and restoration options, reduce the customer zone size for fault isolation, and reduce the impact and extent of outages when they occur.

Within Term 1 Eversource's investments included new overhead recloser installations, underground oil switch replacements, and a pilot to develop underground auto-reclosing loops. Some of the reclosers are at tie locations between circuits.

In Term 1, National Grid's ADA investments included new installations of overhead reclosers and upgrades to existing reclosers with SCADA. Some of these reclosers are at tie locations between circuits. In 2020, National Grid added feeder monitors to its ADA investments for enhanced fault location.

Moving into Term 2, National Grid elected to continue its ADA program as a deployment of ADA/FLISR (Fault Location, Isolation, and Service Restoration). The initial installation of preselected schemes was based on "emergent reliability trends." These initial installations were used for the continued evaluation prior to additional schemes being installed.

Table 17 summarizes these GMP ADA devices and technologies. Sections 3 (Infrastructure Metrics), 4 (Performance Metrics), and 5 (Case Studies) below discuss specifics related to each EDCs' goals and objectives in the ADA Investment Area, while Section 2 below explains the evaluation process.

Table 17. Devices and Technologies Deployed Under ADA Investment

EDC	Device/ Investment Type	Description	Term
Eversource	New Overhead Recloser Locations	New SCADA-enabled overhead recloser installations at new locations to increase auto-sectionalizing capability and reduce customer zone size.	1
	New Recloser Locations with Ties	New SCADA-enabled overhead recloser installations at new locations with ties to adjacent feeders, to add power supply redundancy and increase switching options.	1
	Underground Oil Switch Replacement	New SCADA-enabled switches that replace century-old oil-filled underground switches in Boston and Cambridge, to reduce manual operation and increase auto-sectionalizing capability.	1
	4 kV Auto-Reclosing Loops	This investment was previously called 4 kV Vacuum Fault Interrupters (VFI) Retrofit Program. Eversource commissioned 18 devices but could not expand this investment to loop several circuits with multiple tie points.	1
National Grid	New Overhead Recloser Locations	SCADA-enabled overhead recloser installations at new locations to increase auto-sectionalizing capability and reduce customer zone size.	1 2
	New Overhead Recloser Locations with Ties	New SCADA-enabled overhead recloser installations at new locations with ties to adjacent feeders, to add power supply redundancy and increase switching options.	1 2
	Feeder Monitors	Installation of interval power monitoring devices on feeders to aid in fault location where National Grid does not have distribution information.	1 2

Source: Guidehouse

1.3. ADA Evaluation Objectives

This evaluation focuses on the progress and effectiveness of the DPU preauthorized ADA investments for each EDC toward meeting the DPU's grid modernization objectives. Table 18 illustrates the key Infrastructure Metrics and Performance Metrics relevant for the ADA evaluation.

Table 18. ADA Evaluation Metrics

Metric Type	ADA Evaluation Metrics	ES	NG
IM	System Automation Saturation*	✓	✓
IM	Number of Devices or Other Technologies Deployed*	✓	✓
IM	Cost for Deployment	✓	✓
IM	Deviation between Actual and Planned Deployment for the Plan Year	✓	✓
IM	Projected Deployment for the Remainder of the GMP Term	✓	✓
PM	Numbers of Customers that Benefit from GMP-Funded Distribution Automation Devices	✓	✓
PM	Grid Modernization Investments' Effect on Outage Durations	✓	✓
PM	Grid Modernization Investments' Effect on Outage Frequency	✓	✓

Metric Type	ADA Evaluation Metrics	ES	NG
PM	Protective Zone: Average Zone Size per Circuit	✓	
PM	Main Line Customer Minutes of Interruption Saved		✓
Other	Case Studies**	✓	✓

IM = Infrastructure Metric, PM = Performance Metric, ES = Eversource, NG = National Grid, UTL = Unitil

* Denotes that generating the metric is EDC responsibility

** In addition to the IMs and PMs listed, Case Studies were added to the evaluation to help explain the operation and value of the selected ADA investments.

Source: Guidehouse Stage 3 Evaluation Plan submitted March 1, 2023

The EDCs provided the data supporting the Infrastructure Metrics and Performance Metrics as well as for case studies to the evaluation team. The Infrastructure Metrics analysis measures whether the investments are taking place on the projected schedule and budget. The Performance Metrics analyses provide insight into the reliability impacts due to grid modernization investments. The Case Studies facilitate understanding of the reliability improvement mechanisms and performance at select feeder locations.

Table 19 summarizes the ADA evaluation objectives and associated research questions. The scope of the ADA evaluation includes tracking the ADA infrastructure deployment against the plan and evaluating the impact on system reliability.

Table 19. ADA Evaluation Objectives and Associated Research Questions

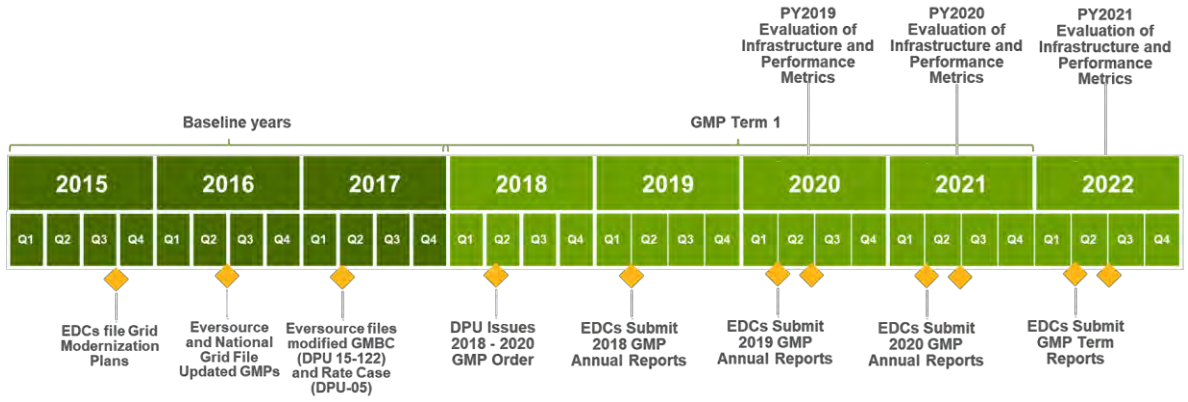
Associated Research Questions
1. Are the EDCs progressing in deployment of their ADA investments according to their GMPs?
2. What factors, if any, are affecting the deployment schedule of ADA equipment?
3. What is the cost of deploying various types of ADA equipment?
4. What is the effect of ADA investments on key reliability metrics, such as SAIDI and SAIFI?
5. Is the FLISR automation for the overhead and underground equipment operating as designed?

Source: Guidehouse Stage 3 Evaluation Plan submitted to EDCs on March 1, 2023

2. ADA Evaluation Process

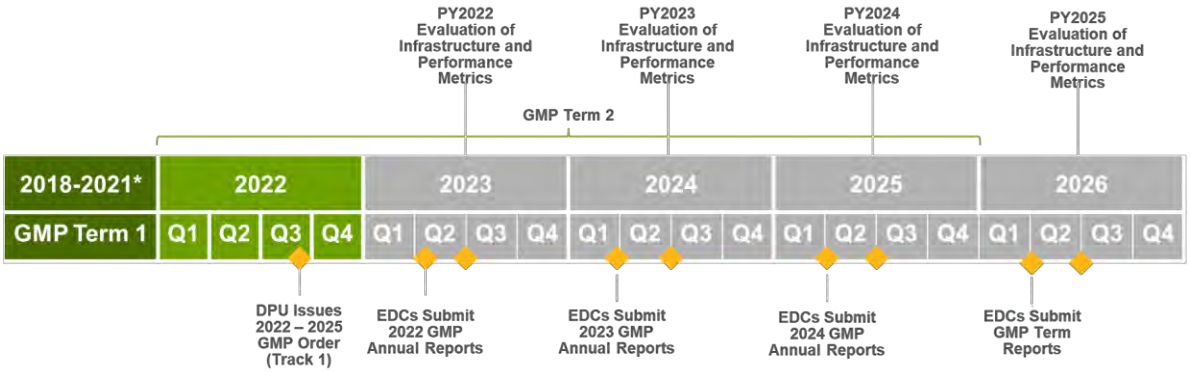
This section presents a high-level overview of Guidehouse's methodologies for the evaluation of Infrastructure and Performance Metrics, as well as Case Studies. Figure 3 highlights the Term 1 filing background and timeline of the GMP order and evaluation process, and Figure 4 indicates the expected timeline for Term 2.

Figure 3. ADA Evaluation Timeline Term 1



Source: Guidehouse review of the DPU orders and GMP process

Figure 4. ADA Evaluation Timeline Term 2



Source: Guidehouse review of the DPU orders and GMP process

As a note, spend and deployment was conducted in PY 2022 to account for any spend and deployment from Term 1 (2018-2021 plan) as well as new spend to be included in Term 2 (2022 – 2025). Term 1 spend and deployment will be denoted separately within the analysis for Eversource, as Eversource provided data to support a comparison of Term 1 and Term 2 planned versus actual activity.

2.1. Infrastructure Metrics Analysis

Guidehouse annually assesses the progress of each EDC toward deploying ADA devices and technologies. Table 20 and Table 21 highlight the Infrastructure Metrics that were evaluated.

Table 20. Term 1 Infrastructure Metrics Overview – Eversource Only

Infrastructure Metrics			Calculation
IM-4	Number of devices or other technologies deployed thru. PY 2022	# Devices Deployed	$\sum_{PY=2018}^{2021}(Devices\ Commissioned)_{PY} + Devices\ Commissioned_{CY2022(T1)}$
		% Devices Deployed	$\frac{\sum_{PY=2018}^{2021}(Devices\ Commissioned)_{PY} + Devices\ Commissioned_{CY202}}{\sum_{PY=2018}^{2021}(Devices\ Commissioned)_{PY} + (Planned\ Devices)_{CY2022(T}}$
IM-5	Cost through PY 2022	Total Spend, $M	$\sum_{PY=2018}^{2021}(Actual\ Spend)_{PY} + Actual\ Spend_{CY2022(T1)}$
		% Spend	$\frac{\sum_{PY=2018}^{2021}(Actual\ Spend)_{PY} + Actual\ Spend_{CY2022(T1)}}{\sum_{PY=2018}^{2021}(Actual\ Spend)_{PY} + Planned\ Spend_{CY2022(T1)}}$
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	$\frac{(Devices\ Commissioned)_{CY2022(T1)}}{(Planned\ Devices)_{CY2022(T1)}}$
		% On Track (Spend)	$\frac{(Actual\ Spend)_{CY2022(T1)}}{(Planned\ Spend)_{CY2022(T1)}}$
IM-7	Projected Deployment for the remainder of the GMP Term (i.e., Term 1)*	# Devices Remaining	N/A*
		Spend Remaining, $M	N/A*

Note: This table pertains to Infrastructure Metrics for Eversource only. Planned devices and spend are based on the 2021 GMP Term Report filing (filed on April 1, 2022 under DPU docket 21-80). All CY2022 spend and deployment data given above, to be calculated, includes only units/dollars dedicated to work intended for Term 1, and excludes any deployment and spend apportioned for Term 2.

* This metric has been interpreted here (i.e., within the context of the 2022 Program Year Evaluation) as the units and spending that the EDC plans to complete their most recent 4-year Term 1 plans. Additional Grid Modernization units and dollars incurred in 2022 are attributed to Term 2, as appropriate, and all units and dollars spent during 2023 through 2025 will be considered as part of Term 2 GMPs.

Source: Guidehouse

Table 21. Term 2 Infrastructure Metrics Overview – All EDCs

Infrastructure Metrics			Calculation
IM-4	Number of devices or other technologies deployed thru. PY 2022	# Devices Deployed	$(Devices\ Commissioned)_{PY2022}$
		% Devices Deployed	$\frac{(Devices\ Comissioned)_{PY2022}}{(Devices\ Comissioned)_{PY2022} + \sum_{PY=2023}^{2025}(Planned\ Devices)_{PY}}$
IM-5	Cost through PY 2022	Total Spend, $M	$(Actual\ Spend)_{PY2022}$
		% Spend	$\frac{(Actual\ Spend)_{PY2022}}{\sum_{PY=2022}^{2025}(Planned\ Spend)_{PY}}$

Infrastructure Metrics			Calculation
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	$\frac{(Devices\ Commissioned)_{PY2022}}{(Planned\ Devices)_{PY2022}}$
		% On Track (Spend)	$\frac{(Actual\ Spend)_{PY2022}}{(Planned\ Spend)_{PY2022}}$
IM-7	Projected Deployment for the remainder of the GMP Term	# Devices Remaining	$\sum_{PY=2022}^{2025}(Planned\ Devices)_{PY} - (Devices\ Comissioned)_{PY2022}$
		Spend Remaining, $M	$\sum_{PY=2022}^{2025}(Planned\ Spend)_{PY} - (Actual\ Spend)_{PY2022}$

Note: CY2022 spend and deployment data given above includes only units/dollars within Term 2 plans, and excludes any deployment and spend apportioned for Term 1 (carryover).

Source: Guidehouse

Section 3.2 provides the results from the evaluation of Infrastructure Metrics. To evaluate Infrastructure Metrics, Guidehouse:

- Reviewed the data provided by the EDCs to their progress through PY 2022 (see Section 3.1.2, "Data QA/QC Process")
- Interviewed representatives from each EDC to understand the status of the ADA investments, including:
  - Updates to their planned ADA investments
  - Reasons for deviation between actual and planned deployment and spend

2.2. Performance Metrics Analysis

Performance Metrics were evaluated for each EDC, focusing on the reliability metrics (CKAIDI and CKAIFI) at the circuit level. Table 22 describes the Performance Metrics used in the PY 2022 evaluation.

Table 22. ADA Performance Metrics Overview

Performance Metrics		EDC	Description
PM-11	Number of Customers that Benefit from GMP-Funded Distribution Automation Devices	All	Provides insight into how many customers have benefitted from the installation of ADA devices. Compares the automated zone size on GMP ADA-enabled circuits as compared to the previous 3-year average for the same circuit.
PM-12	Grid Modernization Investments' Effect on Outage Durations	All	Provides insight into how ADA devices reduce the duration of outages (CKAIDI). Compares the experience of customers on GMP ADA-enabled circuits as compared to the previous 3-year average for the same circuit.

Performance Metrics		EDC	Description
PM-13	Grid Modernization Investments' Effect on Outage Frequency	All	Provides insight into how ADA investments can reduce outage frequency (CKAIFI). Compares the experience of customers on GMP ADA-enabled circuits as compared to the previous 3-year average for the same circuit.
PM-ES2	Protective Zone: Average Zone Size per Circuit	ES	Measures Eversource's progress in sectionalizing circuits into protective zones designed to limit outages to customers located within the zone.
PM-NG1	Main Line Customer Minutes of Interruption Saved	NG	Measures the impact of ADA investments on the CMI for main line interruptions. Compares the CMI of GMP ADA-enabled circuits to the previous 3-year average for the same circuit.

Source: Stamp Approved Performance Metrics, July 25, 2019.

2.3. Case Study Analysis

The evaluation team developed a case study approach to provide more insight into the actual operation of the GMP devices and to illustrate how these investments provide customer reliability and operational benefits. The impacts of GMP devices on system reliability metrics can be difficult to discern due to the range of factors that affect these metrics. Storm conditions, vehicle accidents and other factors drive reliability from year to year. The case studies illustrate the benefits provided by GMP devices during outage events. This approach investigates outage events on specific circuits where the GMP equipment operated to address the outage. It also allows for comparison between what did occur due to the presence of the GMP device and what would have likely happened had the GMP investment not been made.

For the ADA evaluation, Guidehouse conducted seven Case Studies: four for Eversource and three for National Grid. Section 5 details the analysis and the results.

3. ADA Infrastructure Metrics

Assessment of the Infrastructure Metrics includes Infrastructure Metric data collection and QA/QC, assessment of ADA deployment progress for each EDC, and conclusions drawn from the analysis.

3.1. Data Management

Guidehouse worked with the EDCs to collect data to complete the M&C evaluation and the assessment of Infrastructure Metrics. The following subsections highlight data sources and the data QA/QC processes followed to complete the evaluation and calculate the Infrastructure Metrics.

3.1.1. Data Sources

Guidehouse used a consistent methodology (across Investment Areas and EDCs) for evaluating the data and illustrating EDC progress indicated by the GMP metrics. The following subsections summarize data sources.

3.1.1.1. Term 1 Planned Deployment and Spend for PY 2022

To assess progress against planned carryover deployment and spend for Eversource, Guidehouse used the planned device deployment and cost information from each its *2021 GMP Term Report*[28,29,30], which were filed on April 1, 2022. These filings served as the sources for planning data in this report and are referred collectively as the *GMP Term 1 Plan* each EDC in summary tables and figures throughout this report.

Table 23 lists the sources for the planned and actual quantities reviewed, and it specifies the color/shade used to represent these quantities in graphics throughout the rest of the report.

Table 23. GMP Term 1 Deployment Categories Used for the EDC Plan

Representative Color	Data	Description
	2022 Plan	Planned unit deployment and spend in 2022
	2021 Actual	Actual reported unit deployment and spend in 2021
	2020 Actual	Actual reported unit deployment and spend in 2020
	2019 Actual	Actual reported unit deployment and spend in 2019
	2018 Actual	Actual reported unit deployment and spend in 2018

[28] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Plan Annual Report 2020. Submitted to Massachusetts DPU on April 1, 2021 as part of DPU 21-30.
[29] NSTAR Electric Company d/b/a Eversource Energy, Grid Modernization Plan Annual Report 2020. Submitted to Massachusetts DPU on April 1, 2021 as part of DPU 21-30. Note that Eversource Energy filed an updated Appendix 1 filing in December of 2021; however that update did not affect any of the data or results in the evaluation.
[30] Fitchburg Gas and Electric Light Company d/b/a Unitil, Grid Modernization Plan Annual Report 2020. Submitted to Massachusetts DPU on April 1, 2021 as part of DPU 21-30.

Source: Plan and actual data is sourced from the EDCs' 2021 GMP Term Report Appendix 1 filed April 1, 2022 under DPU dockets 22-40, 22-41, and 22-42.

3.1.1.2. Term 2 Planned Deployment and Spend for PY 2022

Guidehouse used the planned device deployment and cost information from each EDCs' filed responses to the first set of information requests issued by the Department of Energy Resources (DOER).[31] These responses were filed on October 4th, October 5th, and December 2nd, 2021, for Eversource, Unitil, and National Grid respectively. These filings served as the sources for planning data in this report and are referred collectively as the *DOER Responses* for each EDC in summary tables and figures throughout this report.

Table 24 lists the different sources for the planned and actual quantities reviewed, and it specifies the color/shade used to represent these quantities in graphics throughout the rest of the report.

Table 24. GMP Term 2 Deployment Categories Used for the EDC Plan

Representative Color	Data	Description
	2025 Plan	Projected 2025 unit deployment and spend
	2024 Plan	Projected 2024 unit deployment and spend
	2023 Plan	Projected 2023 unit deployment and spend
	2022 Plan	Projected 2022 unit deployment and spend

Source: Plan data is sourced from EDC responses to the first set of information requests issued by the Department of Energy Resources, filed October 5, 2021 under DPU docket 21-80, 21-81, and 21-82.

3.1.1.3. PY 2022 Actual Deployment and Spend, Planned Deployment and Spend for the Remainder of Term 2

Guidehouse collected device deployment data using standardized data collection templates (e.g., the All Device Deployment workbook file) for all EDCs in January through March 2023. The data collected provides an update of planned and actual deployment, in dollars and device units, through the end of PY 2022. Data from these sources are referred to as EDC Data in summary tables and figures throughout the report.

The EDC device deployment data (collected in the All Device Deployment workbook) captured planned and actual device deployment and spend data. Actual device deployment and cumulative spend information were provided by work order ID and specified at the feeder- or substation-level, as appropriate.

The evaluation team also collected the current implementation stage of the work order (commissioned, construction, or design), the commissioned date (if applicable), and all cumulative costs associated with the work order.

[31] Plan data is sourced from EDC responses to the first set of information requests issued by the Department of Energy Resources (DOER). These responses were filed on October 4th, December 2nd, and October 5th, 2021, for Eversource, National Grid, and Unitil under DPU dockets 21-80, 21-81, and 21-82.

Table 25 summarizes the date of file version receipt used for the evaluation. The collected data was compared to the data submitted by the EDCs to the DPU in the 2022 Grid Modernization Plan Annual Reports and associated Appendix 1 filings. [32,33,34] The evaluation team confirmed the consistency of the data from the various sources and reconciled any differences.

Table 25. EDC Data Received for Analysis

EDC	File Version
Eversource	Received 3/20/2023
National Grid	Received 3/29/2023
Unitil	Received 3/30/2023

Source: Guidehouse

Table 26 and Table 27 summarize the categories used for the revised planned and actual deployment and spend and specifies the color and pattern used in bar graphs to represent each in the remainder of the report.

[32] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Annual Report for Calendar Year 2022. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.
[33] NSTAR Electric Company d/b/a Eversource Energy, Grid Modernization Annual Report for Calendar Year 2022. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.
[34] Fitchburg Gas and Electric Light Company d/b/a Unitil, 2022 Grid Modernization Plan Annual Report. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.

Table 26. Term 1 EDC Device Deployment and Spending Data Legend – Eversource Only

Representative Color	Data	Description
Device Deployment Data		
	2022 Design/Engineering	Detailed design and engineering is in progress, but the device is not yet in construction (from All Device Deployment workbook)
	2022 Construction	Field construction is in progress, but the device is not yet in-service (from All Device Deployment workbook)
	2022 In-Service	Device is installed and "used and useful" but not yet commissioned to enable all Grid Modernization functionalities (from All Device Deployment workbook)
	2022 Commissioned	Device is fully operational with all Grid Mod functionalities, and thus is considered "deployed" in PY 2022 (from All Device Deployment workbook)
	2021 Actual	Actual 2021 deployment (units) (provided in 2022 Appendix 1 filings)
	2020 Actual	Actual 2020 deployment (units) (provided in 2021 Appendix 1 filings)
	2019 Actual	Actual 2019 deployment (units) (provided in 2020 Appendix 1 filings)
	2018 Actual	Actual 2018 deployment (units) (provided in 2019 Appendix 1 filings)
Spend Data		
	2022 Actual	Actual 2022 spend (provided in All Device Deployment workbook)
	2021 Actual	Actual 2021 spend ($) (provided in 2022 Appendix 1 filings)
	2020 Actual	Actual 2020 spend ($) (provided in 2021 Appendix 1 filings)
	2019 Actual	Actual 2019 spend ($) (provided in 2020 Appendix 1 filings)
	2018 Actual	Actual 2018 spend ($) (provided in 2019 Appendix 1 filings)

Note: This legend for deployment and spend data summaries are provided for Eversource only, as National Grid and Unitil tracked all spending and all deployment for all of 2022, independent of Term status (i.e., whether the work was carried over from PY 2021 of Term 1).

Source: Guidehouse

Table 27. Term 2 EDC Device Deployment and Spending Data Legend

Representative Color	Data	Description
Device Deployment Data (from All Device Deployment workbook)		
	2025 Plan	Planned 2025 Deployment
	2024 Plan	Planned 2024 Deployment
	2023 Plan	Planned 2023 Deployment
	2022 Commissioned	Device is fully operational with all Grid Mod functionalities, and thus is considered "deployed" in PY 2021
	2022 In-Service	Device is installed and "used and useful" but not yet commissioned to enable all Grid Modernization functionalities
	2022 Construction	Field construction is in progress but the device is not yet in-service
	2022 Design / Engineering	Detailed design and engineering is in progress but the device is not yet in construction
Spend Data (from All Device Deployment workbook)		
	2025 Estimate	Planned 2025 spend
	2024 Estimate	Planned 2024 spend
	2023 Estimate	Planned 2023 spend
	2022 Actual	Actual 2022 spend

Source: Guidehouse

3.1.2. Data QA/QC Process

To enable accuracy, Guidehouse conducted a high-level QA/QC of all device deployment data received. This review involved following up with the EDCs for explanations regarding the following:

- Potential errors in how the forms were filled out (e.g., circuit information provided in the wrong field)
- Missing or incomplete information
- Large variation in the unit cost of commissioned devices
- Variance between the aggregated year-end total information and work order-level data
- Variance between the actual unit costs and planned unit costs

3.2. Deployment Progress and Findings

Guidehouse presents findings from the Infrastructure Metrics analysis for the ADA investment area in the following subsections.

3.2.1. Statewide Comparison

This section discusses the scope of ADA investments relative to the number of feeders and customers within the EDCs in Massachusetts, and it summarizes the deployment progress and findings across all three EDCs.

3.2.1.1. Impact on Massachusetts

Across the three EDCs in Massachusetts, ADA investments have impacted about 23% of total EDC customers and 12% of feeders. Table 28 summarizes the number of feeders and customers covered by GMP ADA investments spanning 2018 through 2022.

Table 28. Number of Massachusetts Feeders and Customers Covered by ADA Investment

ADA Impact	Eversource		National Grid		Total	
	Feeders	Customers	Feeders	Customers	Feeders	Customers
Systemwide Total	2,284	1,352,952	1,141	1,346,266	3,411	2,699,218
2018-2022 Commissioned	225	254,626	47	113,311	417	367,937
% System Total	10%	19%	4%	8%	8%	14%

Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1, filed April 24, 2023

3.2.1.2. GMP Term 1 Infrastructure Metrics Results

At the request of Eversource, Guidehouse provided analysis of Eversource's Term 1 spend and deployment. Table 29 summarizes the Infrastructure Metrics results for Eversource's ADA Investment Area through PY 2022. Subsequent sections explain both EDCs' progress and plans in greater detail.

Table 29. Eversource Term 1 ADA Infrastructure Metrics Summary

Infrastructure Metrics			Eversource
GMP Plan Total, PY 2018-2022*		# Devices Planned	586
		Spend, $M	$60.91
IM-4	Number of devices or other technologies deployed PY 2018-2022*	# Devices Deployed***	586
		% Devices Deployed	100%
IM-5	Cost for Deployment PY 2018-2022*	Total Spend, $M	$60.45
		% Spend	99%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	100%
		% On Track (Spend)	0%
IM-7	Projected Deployment for the Remainder of the GMP Term (i.e., Term 1) **	# Devices Remaining	0
		Spend Remaining, $M	$0.00

*The metric names have been slightly changed here to clarify the time span used in analysis.

** This metric has been interpreted here (i.e. within the context of the 2022 Program Year Evaluation) as the units and spending that the EDC plans to complete their most recent 4-year Term 1 plans. Additional Grid Modernization

units and dollars incurred in 2022 are attributed to Term 2, as appropriate, and all units and dollars spent during 2023 through 2025 will be considered as part of Term 2 GMPs.

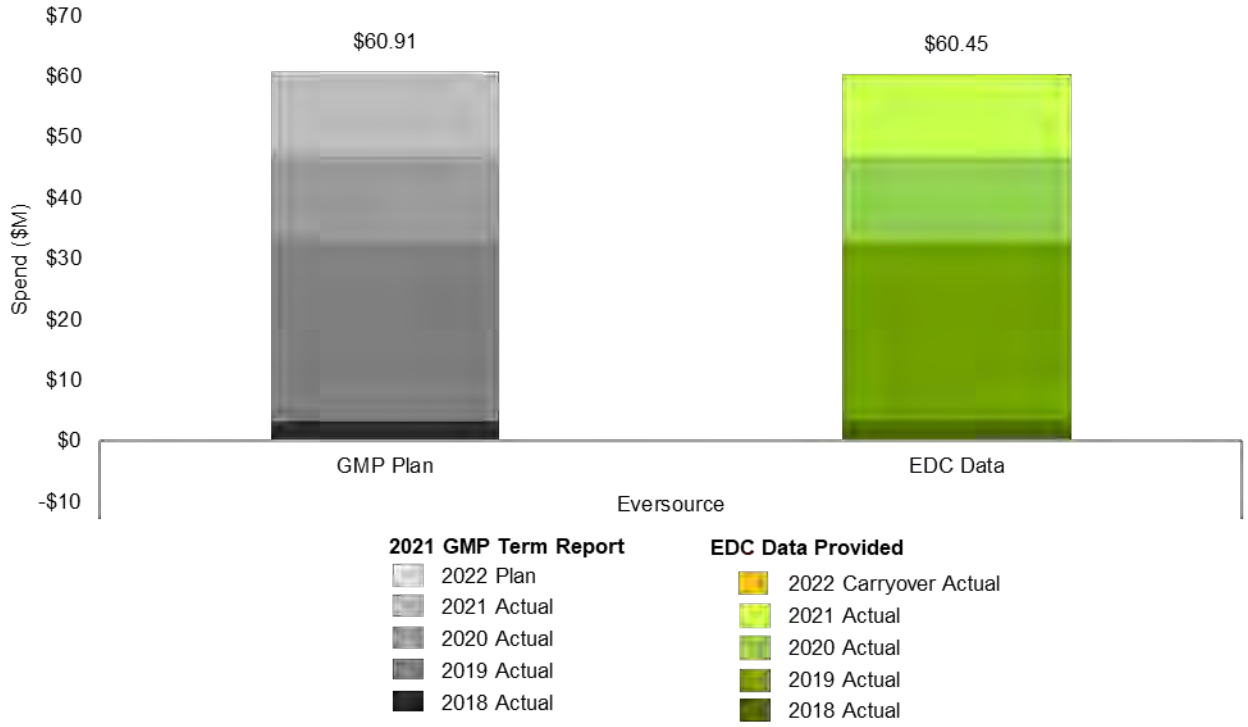
***Note that "Deployed" here refers to commissioned devices. For full definitions of deployment stages, see Docket 20-46 Response to Information Request DPU-AR-4-11, September 3, 2020.

Source: Guidehouse analysis of 2021 GMP Term Report and 2022 EDC Data

Based on reported data, Eversource finalized progress in ADA device deployment in 2022. It met deployment target for overhead reclosers without ties, deploying nine in total. With this, it met 100% of overhead recloser deployment target. Eversource ultimately cancelled Term 1's AR loop project, transferring $1.46 million of capital spend to expense/O&M.

Figure 5 highlights planned versus actual spend in ADA for Eversource. The sections that follow include detailed differences between planned and actual spend.

Figure 5. Eversource Term 1 ADA Spend Comparison (2018-2022, $M)



Note: Includes the Eversource planned spend on activity from 2021 that was transferred to 2022, set forth in Eversource's 2021 GMP Term Report, filed on April 1, 2022.

Source: Guidehouse analysis of 2021 GMP Term Reports, GMP Extension and Funding Report, and 2022 EDC Data

In addition to the capital costs in Figure 5, Eversource incurred approximately $45k in O&M costs toward the ADA investment area in PY 2022; however, given that approximately $62k was retracted from the 4kV Oil Switch replacement's O&M expenditure, Eversource's net O&M expenditure in PY 2022 was approximately $17k.

3.2.1.3. GMP Term 2 Infrastructure Metrics Results

Table 30 includes the Infrastructure Metrics results through PY 2022 for National Grid, as Eversource has no plans to continue the ADA investment as part of GMP. Results for National Grid compare all actual PY 2022 spend and deployment, independent of Term status, to

planned PY 2022 spend and deployment outlined in their respective 2022-2025 GMPs.[35] The following National Grid-specific subsections provide further detail.

Table 30. National Grid Term 2 2022 Infrastructure Metrics for ADA

Infrastructure Metrics			National Grid**
GMP Plan Total, PY 2022-2025		# Devices Planned	410
		Spend, $M	$37.67
EDC Data Total, PY 2022-2025		# Devices Planned	765
		Spend, $M	$37.68
IM-4	Number of devices or other technologies deployed thru. PY 2022	# Devices Deployed*	24
		% Devices Deployed	6%
IM-5	Cost for Deployment thru. PY 2022	Total Spend, $M	$4.74
		% Spend	13%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	30%
		% On Track (Spend)	73%
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	741
		Spend Remaining, $M	$31.34

*Note that "Deployed" here refers to commissioned devices. For full definitions of deployment stages, see Docket 20-46 Response to Information Request DPU-AR-4-11, September 3, 2020.

** To more closely align spend projections with DPU pre-authorized budgets, National Grid operations and maintenance (O&M) spend is included in actual and planned spend presented here. O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

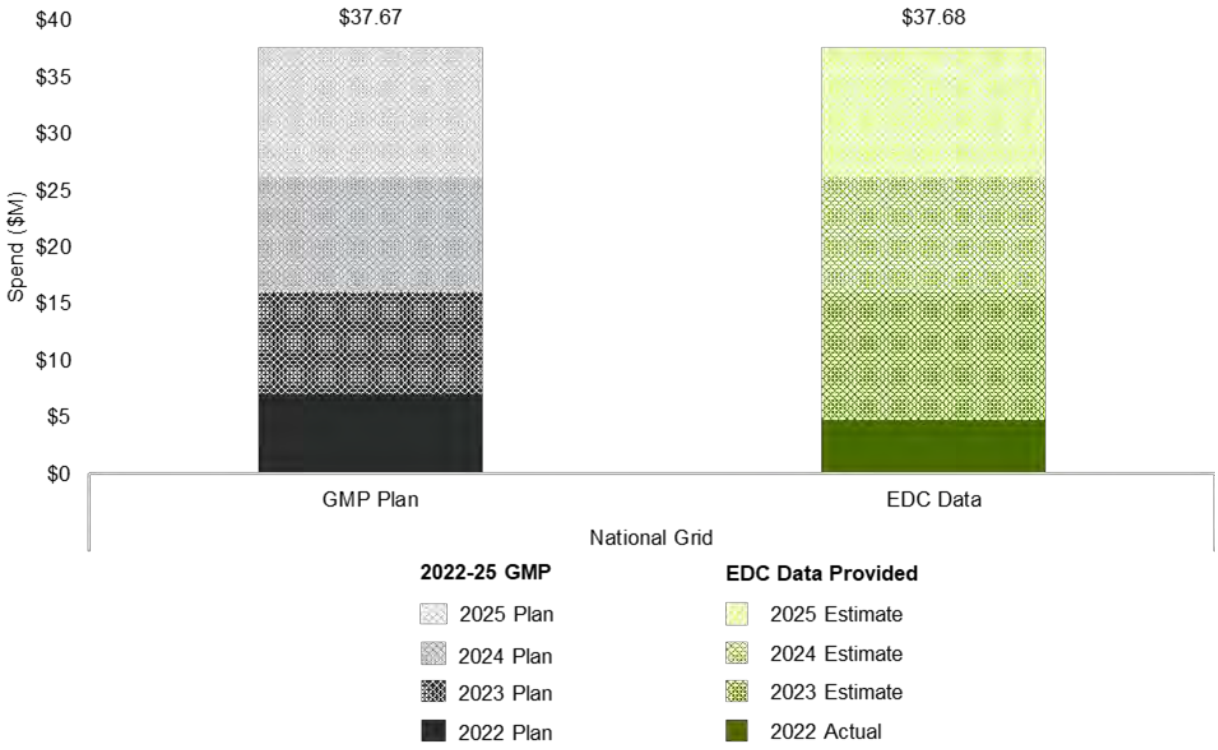
Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

PY 2022's ADA Infrastructure Metrics findings show National Grid put in service eight additional FLISR schemes in PY 2022 (52 devices) which resulted in 17 successful FLISR operations. Spend and deployment were below plans, with barriers to deployment being resource constraints in design/engineering and in deployment crews. National Grid is addressing long-lead times for equipment and resource constraints as well as streamlining this installation process to enable National Grid to come closer to achieving its projected deployment schedule. More detail is provided in Section 3.2.3.

Figure 6 highlights planned versus actual spend on ADA for National Grid. Further details on the differences between planned and actual spend are provided in National Grid's results subsections.

[35] On July 1, 2021, Eversource, National Grid, and Unitil each filed a grid modernization plan with the DPU for the period spanning 2022-2025. The DPU docketed these plans as DPU 21-80, 21-81, and 21-82, respectively.

Figure 6. National Grid Term 2 ADA Spend Comparison (2022–2025, $M)



Note: To more closely align spend projections with DPU pre-authorized budgets, National Grid operations and maintenance (O&M) spend is included in actual and planned spend presented here. O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

3.2.2. Eversource

This section discusses Eversource's ADA investment progress through PY 2022 alongside Term 1 deployment.

3.2.2.1. Overview of GMP Deployment Plan

Eversource's objective is to increase distribution grid visibility and control and provide additional automated switching to restore electric service. Its investments focus on the following:

- Replacing legacy underground 4kV oil switches with modern, automated switches
- Adding automated overhead reclosers at new locations along a feeder and at tie points that were previously manually operated
- Deploying a new technology to automate 4 kV underground circuits

These investments should help reduce the impact of outages by decreasing the number of customers in each zone between sectionalizing automated devices and tying circuits for added redundancy in power supply.

For its ADA program, Eversource prioritized circuits with customer zone sizes of >500 customers in Eversource West and >1,000 customers in Eversource East. (A zone is the number of customers on a feeder between two sectionalizing switches.) In prioritizing circuits, Eversource also took reliability scores into consideration. In the case of outages during major events (e.g., storms), these distribution automation investments will reduce the duration and extent of outage events and will benefit customers. From a system planning perspective, having real-time information increases the flexibility to shift load based on prevailing conditions with the potential to defer capital upgrades. As part of Eversource's longer term planning, the new ADA devices will be incorporated into the ADMS platform when it is available.

Table 31. Eversource GMP ADA Technologies

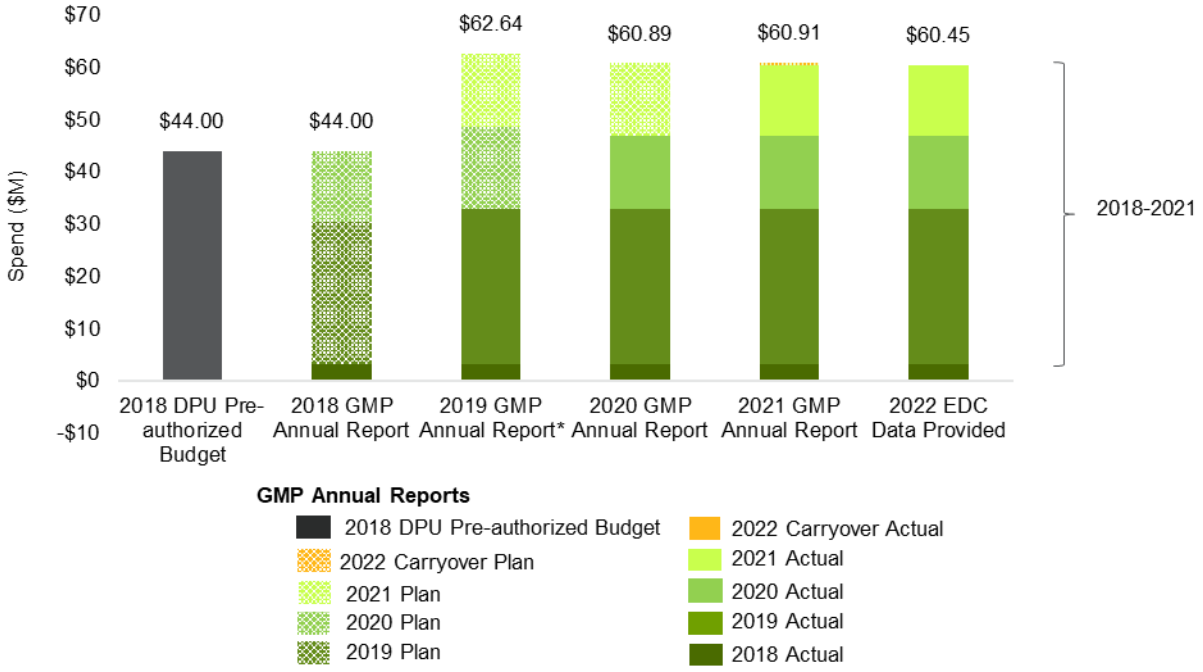
Overhead ADA	Underground ADA
(1) New Recloser Locations	**(3) 4kV Oil Switch Replacement**
New SCADA-enabled overhead recloser installations at new locations to increase auto-sectionalizing capability and reduce customer zone size.	New SCADA-enabled switches that replace obsolete, oil-filled underground switches in Boston and Cambridge, to reduce manual operation and increase auto-sectionalizing capability.
(2) New Recloser Locations with Ties	**(4) 4 kV Auto-Reclosing Loops**
New SCADA-enabled overhead recloser installations at locations with ties to adjacent feeders, to add power supply redundancy and increase switching options.	The original project involved retrofitting the 4 kV underground VFI switches to modern, SCADA-enabled switches. After GMP approval in 2018, Eversource enhanced the project to include a new technology to automate the restoration of underground switches. The deployment was a first-of-a-kind project for Eversource. After attempting to overcome the communication challenges in automating the first loop scheme, Eversource discontinued the project.

Source: Guidehouse analysis of GMP Annual Reports and EDC Data

3.2.2.2. Term 1 ADA Deployment Plan Progression

Figure 7 shows the progression of Eversource's ADA deployment plans from DPU-preauthorization in 2018 through PY 2022. Eversource largely met its 2018-2021 ADA plan in 2021. Eversource's 2022 ADA deployment finalized 2021's pre-commissioned devices.

Figure 7. Eversource Term 1 ADA Planned vs. Actual Spend Progression, (2018-2022, $M)



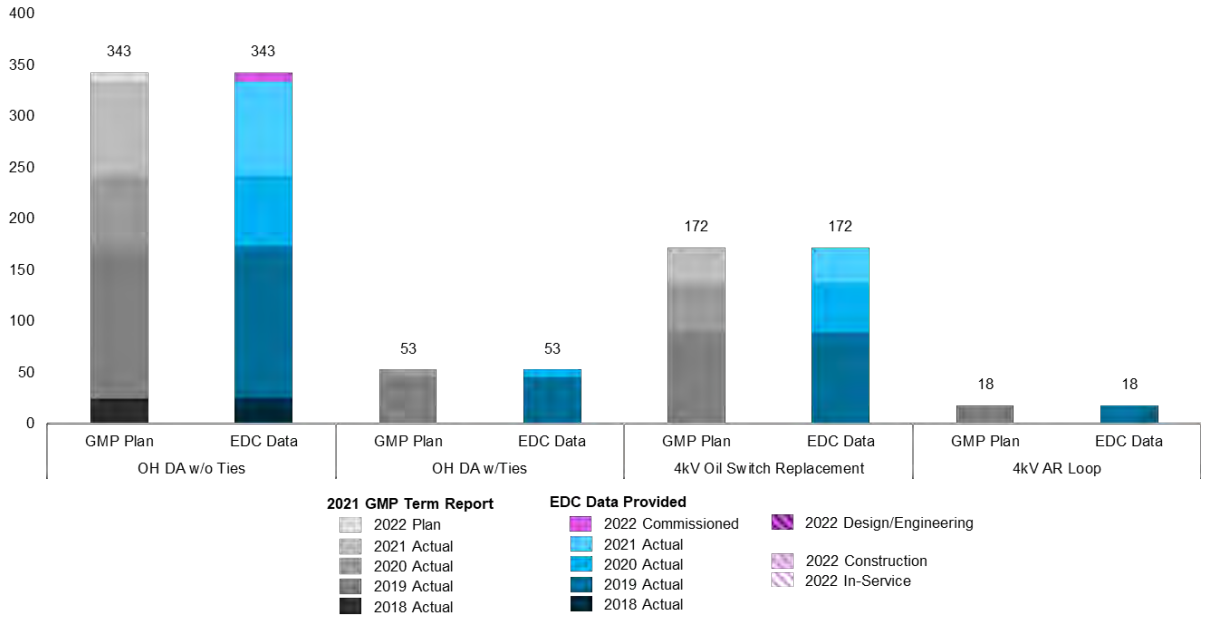
*Note that Eversource received pre-authorization from the Department for another $14 million in spending for its ADA investment area in late 2020.

Source: Guidehouse analysis of DPU Order (May 10, 2018), 2018-2020 GMP Annual Reports, Eversource GMP Extension and Funding Report filed on July 1, 2020, *2021 GMP Term Reports and 2022 EDC Data*

3.2.2.3. Term 1 ADA Device Type Progress through PY 2022

In 2022, Eversource met its target overhead recloser w/o ties deployment, commissioning 9 devices as planned. Figure 8 and Table 32 show the progress and details of each device type for the 2018-2022 period.

Figure 8. Eversource Term 1 ADA Planned vs. Actual Deployment (2018-2022, Unit Count)



Source: Guidehouse analysis of 2021 GMP Term Reports and 2022 EDC Data

Table 32. Eversource Term 1 ADA Deployment Progress (2018-2022)

	OH DA w/o Ties	OH DA w/Ties	4kV Oil Switch Replacement	4kV AR Loop
2018-2022 Total	**343**	**53**	**172**	**18**
Engineering/Design during PY 2022*	0	0	0	0
Construction during PY 2022*	0	0	0	0
In-Service during PY 2022*	0	0	0	0
Commissioned in PY 2022	9	0	0	0
Commissioned in PY 2021	91	0	35	0
Commissioned in PY 2020	70	8	48	1
Commissioned in PY 2019	148	45	89	17
Commissioned in PY 2018	25	0	0	0

*Deployment of these devices began during PY 2022 but was not completed during the program year. Units and dollars spent to deploy remaining units during 2023 through 2025 will be considered as part of Term 2 GMPs.

Source: Guidehouse analysis of 2021 GMP Term Report and 2022 EDC Data

Eversource discontinued its 4kV auto-reclosing loop investment, with spend ($1.46 million) ultimately being transferred to expense/O&M in PY 2022. Earlier in 2019, Eversource had placed 18 4kV devices in service with the intention to automate them into an automatic loop scheme. These substation and related field devices are located in manholes and were installed, in service, and SCADA commissioned. However, communication challenges prevented the devices from operating together in an automated loop scheme configuration. Eversource paused construction on the second loop scheme while it worked to resolve the technical challenge with the first scheme. In 2020, Eversource conducted engineering and research to

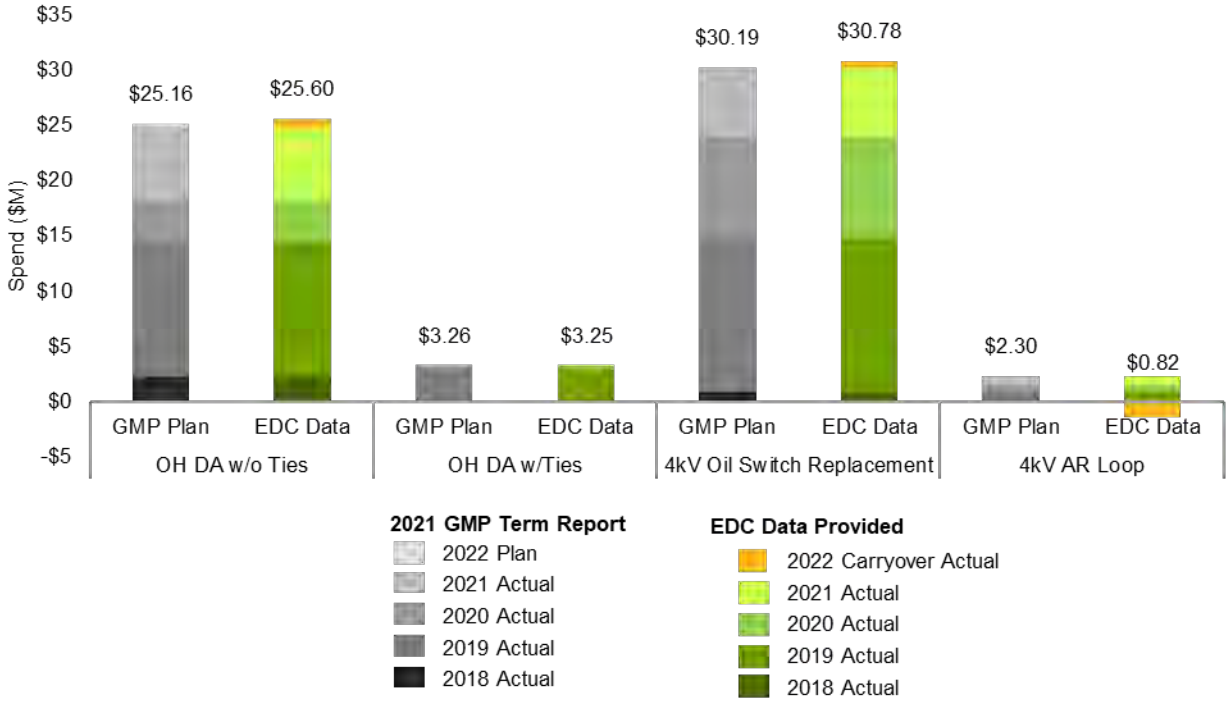
resolve the issue, but was unsuccessful. While the 18 devices are fully operational in SCADA, they are no longer undergoing loop scheme automation. The second scheme (comprising 16 devices) is no longer planned.

Eversource ADA spending is tracking closely (99%) to plan (as filed in Eversource 2021 Term Report). Actual spending from 2018-2022 ($60.45 million) also came close to DPU pre-authorized budget of $58 million. For PY 2022, actual spending was 197% of plan and device deployment was 100% of plan.

- Spend for OH DA w/o Ties exceeded planned PY 2022 spend by approximately $440,000 (200% of budget), as costs per deployed unit wound up well above forecast costs.
- Eversource incurred approximately $590k in costs associated with the closeout and reconciliation of work orders for 4kV Oil Switch Replacement. During this closeout process, Eversource determined some charges should be reallocated, resulting in a debit to the GMF. This debit was not recorded during PY 2022 and it will be reflected in PY 2023.
- $1.48M in spend previously reported for Eversource's 4kV AR was transferred due to cancellation of the AR loop project, bringing the Term 1 cost of deployment for this equipment to 36% of its planned total.

Figure 9 shows Eversource's planned versus actual spend over the 2018-2022 Term 1 period, broken out by device type. The EDC Data in Figure 9 is presented in more detail in Table 33.

Figure 9. Eversource Term 1 ADA Spend Plan vs. Actual (2018-2022, $M)



Source: Guidehouse analysis of 2021 GMP Term Reports and 2022 EDC Data

Table 33. Eversource Term 1 ADA Total Spend Comparison (2018-2022, $M)

	OH DA w/o Ties	OH DA w/Ties	4kV Oil Switch Replacement	4kV AR Loop
2018-2022 Total	**$25.60**	**$3.25**	**$30.78**	**$0.82**
PY 2022 Actual	$0.89	$0.00	$0.59	-$1.48
PY 2021 Actual	$6.53	$0.00	$6.19	$0.84
PY 2020 Actual	$3.84	$0.46	$9.19	$0.57
PY 2019 Actual	$12.07	$2.80	$13.88	$0.89
PY 2018 Actual	$2.27	$0.00	$0.93	$0.00

Source: Guidehouse analysis of 2021 GMP Term Reports and 2022 EDC Data

Eversource has integrated incremental GMP deployment with its base capital spending. For example, GMP investments are on a coordinated schedule with base capital activities to achieve cost efficiencies. Nevertheless, Eversource continues to track incremental GMP spending separately from base activities using separate work orders.

The following sub-sections discuss the progress through PY 2022 and actuals for PY 2022 for each device type.

Replacement of Underground 4 kV Oil Switches

This investment is focused on modernizing legacy underground switches in Boston and Cambridge. Installed in 1920-1940, these switches represent some of the oldest assets in Eversource's distribution grid and are not suited to serving the densely populated hubs of Boston and Cambridge. These switches (Figure 10, left panel) cannot be automated or provide remote communication. They require a fault to be traced to one of many manholes, often inaccessible and requiring lengthy repairs. For these reasons, Eversource accelerated this program, replacing 89 switches in 2019 ahead of the planned 67. In 2020, Eversource replaced 48 oil switches, 3 times the plan. In 2021, Eversource replaced 35 oil switches, meeting its plan for the GMP term.

The new GMP devices, called vacuum fault interrupters (VFI), perform better than legacy devices in terms of improving customer reliability and ease of operation (Figure 10, right panel). The new switches are SCADA-enabled and capable of automatically isolating faults and restoring sections of the grid using SCADA control. Once the fault zone is isolated, Eversource crews can quickly access SCADA data to determine the fault location for repairs. The expected result is a reduction in the duration and extent of outages in Boston and Cambridge. Additionally, these devices will integrate with and allow for future automation.

Underground oil switch replacement is complex, in part due to high customer density and inaccessibility of small legacy manholes. Outages must be carefully planned along with the use of backup generators to minimize customer impact. For these reasons, budget was exceeded in PY 2021. Despite these challenges, Guidehouse determined that the Eversource deployment was completed on schedule.

Figure 10. Old Oil-Filled Switches (Left) and New VFI Switches (Right)

Source: Eversource

4 kV Underground Auto-Reclosing Loops

In its 2018 GMP annual report, Eversource proposed retrofitting its underground 4 kV VFI switches to enable remote control and automation. Eversource modified this program to include a new, leading-edge technology for creating auto-restoration loops. This program was proposed to enable existing field ties on underground circuits in an automated restoration switching scheme. Eversource used a Schweitzer (SEL) distribution automation controller with 4G/5G communications to bring in data from field devices at one 4 kV substation which would communicate information back to the SCADA system. The results of this project would inform future ADA deployments.

Eversource found underground auto-reclosing loops challenging to design and deploy. Eversource installed one scheme in 2019, placing 18 devices in service with SCADA capability. This met the original plan. In 2020, it encountered software and communications challenges in commissioning auto-restoration loop functionality for this scheme. Eversource spent 2020 and 2021 conducting reconfiguration and engineering to resolve the issue, meanwhile placing the second planned scheme on hold. After two years of troubleshooting, Eversource discontinued the auto-reclosing project. Lessons learned include the need to prepare for integration of various manufactures of equipment and the challenges to communications with underground devices inherent in new technology deployments. The 18 devices continue to function in SCADA.

New Overhead Reclosers

Eversource installed pole-top reclosers at new locations along its overhead distribution lines (Figure 11. Adding new recloser locations reduces zone sizes and increases sectionalizing capability with expected reliability benefits for customers within the new zone created.

Eversource exceeded its 2019 target for overhead recloser installations. In 2020 it overcame control and protection coordination issues in the southeast Massachusetts area and again exceeded 2020 deployment targets. In 2021, Eversource commissioned all but 9 of its planned 100 overhead reclosers. Work was started on the remaining 9 in 2021 and was finished in 2022. The carryover was partly due to shared resources with the Provincetown battery project.

Figure 11. Eversource Overhead Recloser

Source: Eversource

New Overhead Reclosers with Feeder Ties

This investment was completed in 2020. This is the same technology as overhead reclosers the previous section describes, except these are installed at strategic locations to tie feeders together. For the GMP, Eversource selected locations where feeders are already in close proximity and where ties can be created without adding new line extensions. This is a cost-effective way of adding redundancy to Eversource's distribution grid.

Eversource planned 38 overhead tie recloser devices in the original 3-year GMP term. It commissioned 45 in 2019, exceeding its 3-year target one year ahead of time. It commissioned an additional eight tie reclosers in 2020 (against plan of zero).

3.2.2.4. Term 1 Infrastructure Metrics Results and Key Findings

Table 34 presents the Term 1 Infrastructure Metrics results through PY 2022 for each investment type related to Eversource's ADA investment area.

Table 34. Term 1 2022 Eversource Infrastructure Metrics for ADA Devices

Infrastructure Metrics			OH DA w/o Ties	OH DA w/Ties	4kV Oil Switch Replacement	4kV AR Loop
GMP Plan Total, PY 2018-2022*		Devices	343	53	172	18
		Spend, $M	$25.16	$3.26	$30.19	$2.30
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed	343	53	172	18
		% Devices Deployed	100%	100%	100%	100%
IM-5	Cost for Deployment thru. PY 2022	Total Spend, $M	$25.60	$3.25	$30.78	$0.82
		% Spend	102%	100%	102%	36%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	100%	N/A	N/A	N/A
		% On Track (Spend)	197%	N/A	N/A	N/A
IM-7	Projected Deployment for the remainder of the GMP Term (i.e., Term 1)**	# Devices Remaining	0	0	0	0
		Spend Remaining, $M	$0.00	$0.00	$0.00	$0.00

*The metric names have been slightly changed here to clarify the time span used in analysis.

** This metric has been interpreted here (i.e., within the context of the 2022 Program Year Evaluation) as the units and spending that the EDC plans to complete their most recent 4-year Term 1 plans. Additional Grid Modernization units and dollars incurred in 2022 are attributed to Term 2, as appropriate, and all units and dollars spent during 2023 through 2025 will be considered as part of Term 2 GMPs.

Source: Guidehouse analysis of 2021 GMP Term Report and 2022 EDC Data

A summary of Guidehouse's evaluation findings for Eversource is below:

- Eversource's ADA circuit selection criteria included reducing customer zone sizes, targeting poor reliability areas, and minimizing cost.
- In PY 2021, Eversource met underground oil switch replacement target. It also met 91% of overhead recloser deployment target. Eversource pivoted to a different area work center for resources mid-year to attempt to meet the overhead recloser target but fell slightly under target. In hindsight, Eversource suggests it could have pivoted earlier or employed a contracting strategy. The remaining 9 reclosers were commissioned in PY 2022.
- The underground auto-restoration loop scheme was discontinued. This was first-of-a-kind technology for Eversource. Eversource SCADA-commissioned 18 devices but

encountered software and communication challenges in getting the devices to operate as a loop scheme. After performing engineering and troubleshooting in 2020 and 2021, Eversource discontinued the investment. Lessons learned include the need to fully understand the communications requirements (latency, bandwidth, capacity) of a new technology. Alternative approaches will be explored as part of the ADMS investment.

- Eversource managed its spending closely to original pre-authorized budget. This meant continually re-evaluating the portfolio of investments and re-adjusting. As a result, Eversource's Term 1 ADA spending from 2018-2022 ($60.45 million) came close to DPU pre-authorized budget of $58 million.
- Eversource has deployed distribution automation on portions of its system for several years. The ADA investment has been some of the newest distribution automation, but overall Eversource has a higher level of saturation for this type of technology than, say, National Grid. In some cases, Eversource installed ADA devices on circuits that already had pre-existing ADA devices on other locations on the circuit. Eversource ADA investments have focused, among other benefits, on reducing zone size to 500 customers.

3.2.3. National Grid

This section discusses National Grid's ADA investment progress through PY 2022 and projected PY 2022 estimates.

3.2.3.1. Overview of GMP Deployment Plan

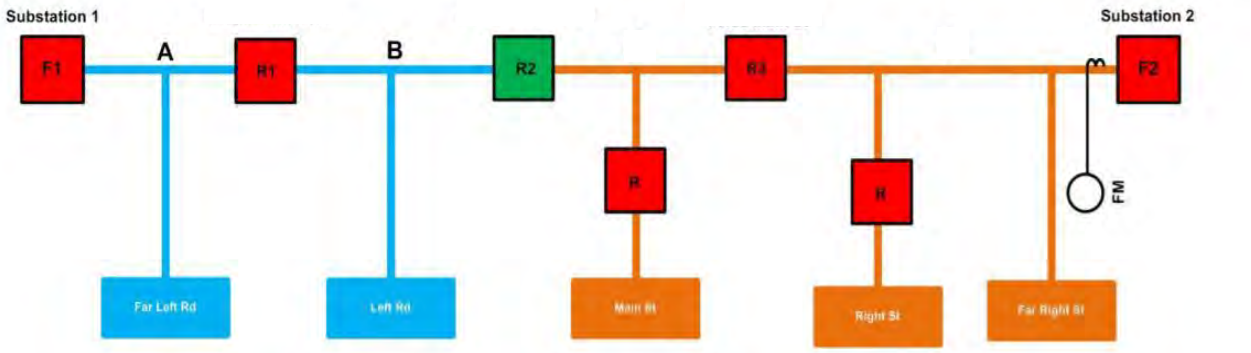
With its ADA investments, National Grid's objective is to improve grid reliability by adding automation and control capabilities at new and existing overhead feeder locations. In 2020, National Grid added Feeder Monitors to its ADA program for more granular fault location capabilities at strategic locations on its distribution feeders.

With the GMP ADA investments, National Grid has been incorporating additional control and automation capability on existing reclosers and installing new recloser at various locations. The ADA program includes replacing manual tie points between adjacent feeders with remote-controlled automated switches.

National Grid's criteria for ADA feeder selection included but was not limited to: feeder metrics, poorly performing or worst-performing feeders, feeder length, and number of customers served. In the GMP timeframe, National Grid did not deploy ADA on circuits with moderate to high DER penetration, which would require detailed load-flow analysis.

Figure 12 illustrates the benefit of reliable ADA investments on National Grid's distribution grid. It depicts National Grid's distribution feeders, substations, and reclosers. If a fault occurs at point A, F1 (substation breaker) will lock out and R1 (a recloser switch) will automatically open. The entire blue zone will experience loss of power supply from substation 1. With ADA, R2 (a recloser switch that ties two feeders together) would sense loss of power and close automatically. This would restore power to customers in zone B, which would then be supplied from substation 2 instead of substation 1. This process isolates the effects of a fault to the smallest possible section of the grid, in this case, Far Left Road.

Figure 12. National Grid's Illustrative ADA Scheme



Source: National Grid

National Grid expects the benefits of ADA to include:

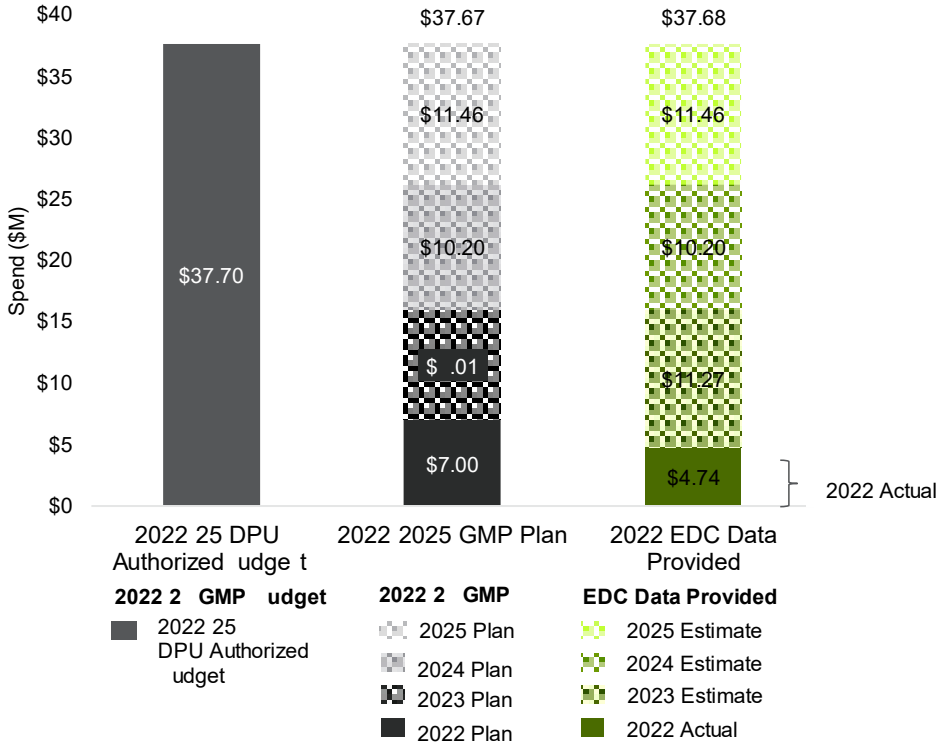
- **Optimizing system performance:** National Grid anticipates a 25% reduction in main-line customer minutes of interruption (CMI) on the individual feeders targeted for the ADA deployment.
- **Optimizing system demand:** The additional operational data collected by the automated switches will support the improved management of the distribution system, assisting in demand optimization.
- **Interconnecting and integrating DER:** The additional operational data collected by the automated switches will support the improved management of the distribution system, assisting in the interconnection of distributed generation and potential integration of distributed resources as a tool to operate the system.

National Grid has integrated lessons learned from the ADA demonstration pilot in its Worcester Smart Energy Solutions Pilot into the Massachusetts GMP ADA program. National Grid learned that the distributed, localized ADA operating model in Worcester was too difficult to operate and maintain. In the Worcester pilot, when the SCADA system (EMS) lost communications to the field device, devices would continue to operate without control room knowledge or interaction. Switches changing position without control knowledge was determined not to be the best approach going forward. After deliberating with several vendors, National Grid adopted a centralized ADA model instead. A centralized ADA model brings field device data back through the communications network, performs centralized decision-making and issues the commands to reclosers.

3.2.3.2. Term 2 ADA Deployment Plan Progression

Figure 13Figure 13 shows the progression of National Grid's GMP Term 2 ADA deployment plans from DPU-preauthorization in 2022 through PY 2022-2025. National Grid has spent $4.46 million through PY 2022 out of the DPU pre-authorized budget of $37.70. Supply chain delays and resource constraints have impacted both PY 2022 deployment and spend.

Figure 13. National Grid Term 2 ADA Planned vs. Actual Spend (2022-2025, $M)



Note: To more closely align spend projections with DPU pre-authorized budgets, National Grid operations and maintenance (O&M) spend is included in actual and planned spend presented here. O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

Source: Guidehouse analysis of DPU Order (October 7, 2022), DOER Responses and *2022 EDC Data*

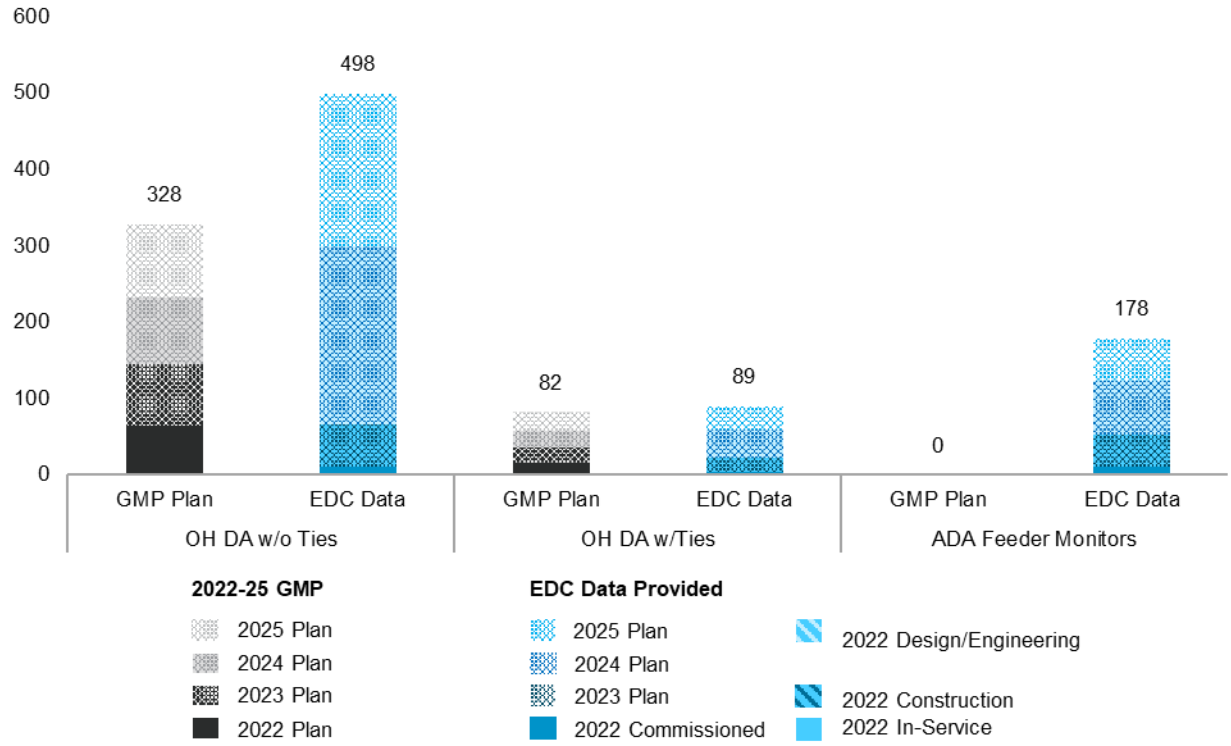
3.2.3.3. Term 2 ADA Device Type Progress through PY 2022

Figure 14 below shows National Grid's planned versus actual device deployment progress for PY 2022, as well as planned investment for PY 2023 through PY 2025. The EDC Data in Figure 14 is also shown in Table 35.

Figure 14 indicates an increase ADA deployment in National Grid's Massachusetts territory in PY 2022. National Grid had commissioned two FLISR schemes in late PY2020. In PY 2021, National Grid picked up momentum and commissioned 14 schemes. In PY 2022, National Grid had eight additional FLISR schemes placed into service. With the devices underway, National Grid is planning to deploy more ADA devices than plan while staying under the DPU pre-authorized budget.

Each National Grid FLISR scheme consists of overhead recloser devices that work together with pre-programmed logic to quickly isolate a fault and restores the non-faulted portion of the circuit. In addition, National Grid installed feeder monitors at strategic points for more granular fault location and enhanced FLISR operation. Training has been completed for the control center workforce in using the FLISR automation functionality.

Figure 14. National Grid Term 2 ADA Planned vs. Actual Device Deployment (2022-2025, Unit Count)



Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Table 35. National Grid Term 2 ADA Deployment Progress (2022-2025)

	OH DA w/o Ties	OH DA w/ Ties	Feeder Monitors (ADA)
2022-2025 Planned Deployment	**498**	**89**	**178**
PY2025 Planned	200	30	55
PY2024 Planned	233	37	70
PY2023 Planned	55	19	42
Commissioned in PY 2022	10	3	11
In-Service during PY 2022*	11	1	3
Construction during PY 2022*	18	10	13
Engineering/Design during PY 2022*	1	0	6

*Deployment of these devices began during PY 2022 but was not completed during the program year. All units and dollars spent to deploy remaining units during 2023 through 2025 will be considered as part of Term 2 GMPs.

Source: Guidehouse analysis of 2021 GMP Term Report and 2022 EDC Data

National Grid deployed 11 overhead reclosers without ties, and 3 overhead reclosers with ties in PY 2022. Installing reclosers at strategic locations that can tie two feeders together increases the redundancy and reliability benefits of ADA investments. Tie reclosers allow customers to be supplied from alternate sources and allow for load to be shifted between circuits, increasing the number of possible FLISR switching operations. National Grid performed reconductoring or pole

upgrades in some cases to ensure load shifting between feeders is possible without overloading.

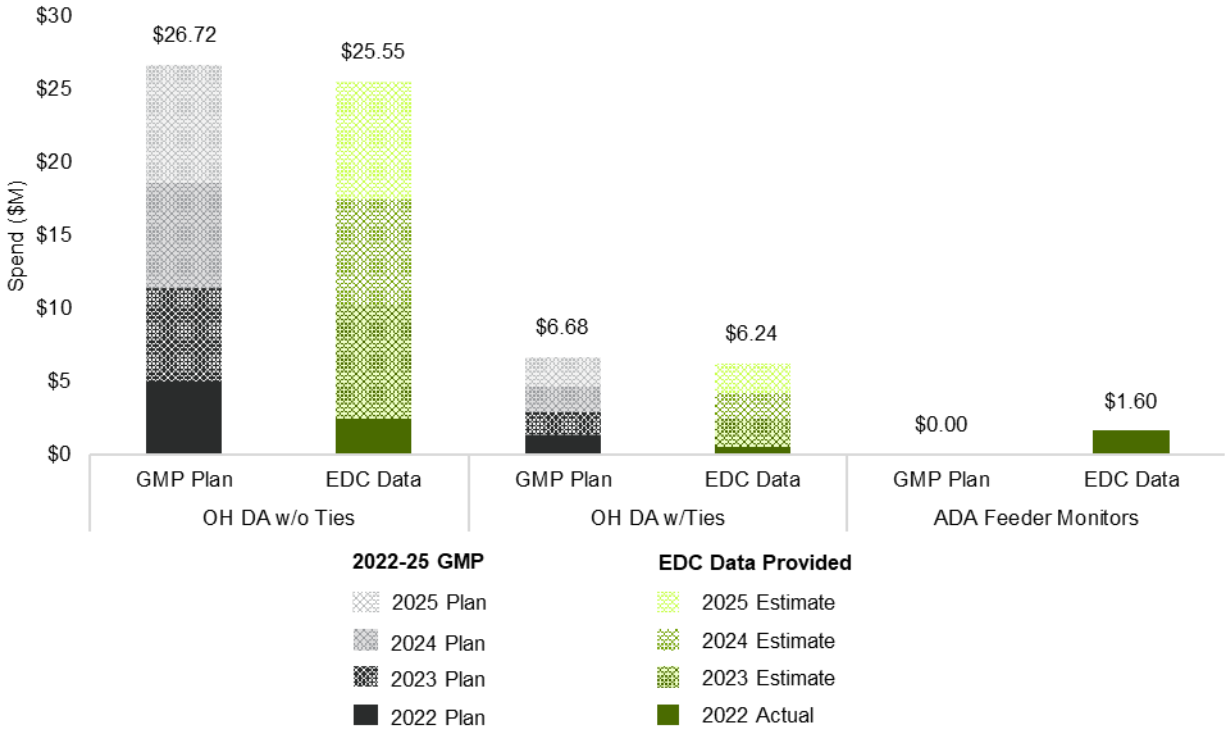
In PY 2022, much of National Grid's progress was comprised deploying OH DA w/o Ties and Feeder Monitors. The majority of 2022 spend ($4.5M) was on OH DA w/o Ties ($2.4M) and Feeder Monitors ($1.6M). Spend was less than initially planned due to an increase in customer work required for FLISR, and long lead times for required equipment. Additional delays can be attributed to National Grid being under-resourced for engineering/design work and field deployment of equipment.

To address delays, National Grid has pivoted from sole use of National Grid staff to supplementation using incremental resources. In addition, National Grid has started to diversify vendors and pre-program devices before installation. Despite impediments to progress, 2022 saw 17 successful operations for National Grid, with increases in the efficacy of deploying investments. However, National Grid's remaining deployment that was targeted for 2022 has been transferred to 2023-2025 plans.

Figure 15 shows National Grid's shows planned versus actual spend for PY 2022, as well as planned investment for PY 2023 through PY 2025. The EDC Data in

Figure 15 is also shown with additional details in Table 36. National Grid's actual spend for overhead reclosers with and without ties was below planned spend. Starting in PY 2022, National Grid is making investments in ADA Feeder Monitors, which had no 2021 GMP plans. No spend is currently planned for ADA Feeder Monitors in 2023 through 2025.

Figure 15. National Grid Term 2 ADA Spend Plan vs. Actual (2022-2025, $M)



Note: O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Table 36. National Grid Term 2 ADA Total Spend Comparison (2022-2025, $M)

	OH DA w/o Ties	OH DA w/Ties	Feeder Monitors (ADA)
2022-2025 Planned Total	**$25.55**	**$6.24**	**$1.60**
PY 2025 Planned	$8.10	$2.02	$0.00
PY 2024 Planned	$7.23	$1.81	$0.00
PY 2023 Planned	$7.82	$1.95	$0.00
PY 2022 Actual	$2.40	$0.46	$1.60

Note: O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Figure 16 illustrates National Grid's pole-top reclosers and controls, which include G&W Viper Overhead Reclosers and SEL control cabinets. It plans to migrate to an ADMS in the coming years, at which point it may use a DMS FLISR application in place of its current NovaTech OrionLX substation automation platform. (See Guidehouse's *2022 ADMS Evaluation Report* for more detail.)

Figure 16. National Grid Pole-top Reclosers and Controls

Source: National Grid

National Grid plans to operate the ADA devices installed in 2022 using a mix of public and private cellular network. National Grid recognized that cellular may not be the preferred technology to operate grid-controlling assets like reclosers, especially during major outage events. Cellular could be hampered by busy signals and will require telecommunication providers to maintain their backup electrical power. During 2021 and 2022, testing of a private 700MHz radio system has been in progress. As their 700Mhz radio system is acceptance tested and rolled out, National Grid proposes to deploy a combination of public cellular and private 700MHz radio network depending on coverage availability. (See Guidehouse's *2022 Communications Evaluation Report* for more detail.)

3.2.3.4. Term 2 Infrastructure Metrics Results and Key Findings

Table 37 presents the Infrastructure Metrics results through PY 2022 for each investment type related to National Grid's ADA investment area.

Table 37. Term 2 2022 National Grid Infrastructure Metrics for ADA Devices

Infrastructure Metrics			OH DA w/o Ties	OH DA w/Ties	Feeder Monitors (ADA)
GMP Plan Total, PY 2022-2025		# Devices Planned	328	82	0
		Spend, $M	$26.72	$6.68	$0.00
EDC Data Total, PY 2022-2025		# Devices Planned	498	89	178
		Spend, $M	$25.55	$6.24	$1.60
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed*	10	3	11
		% Devices Deployed	3%	4%	N/A
IM-5	Cost for Deployment thru PY 2022	Total Spend, $M	$2.40	$0.46	$1.60
		% Spend	9%	7%	0%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	16%	19%	N/A
		% On Track (Spend)	48%	37%	N/A
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	488	86	167
		Spend Remaining, $M	$23.15	$5.79	$0.00

Note: The metric names have been slightly changed here to clarify the time span used in analysis. O&M spend is provided in aggregate for each investment area and is therefore excluded from device-specific summaries of spend.

*Note that "Deployed" here refers to commissioned devices. For full definitions of commissioned and in-service, see Docket 20-46 Response to Information Request DPU-AR-4-11, September 3, 2020.

Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Guidehouse's Infrastructure Metrics evaluation findings for National Grid as follows:

- National Grid targeted feeders with poor reliability performance for ADA investments.
- National Grid is addressing long-lead times for equipment, resource constraints, and streamlining the installation process. This will enable National Grid to come closer to achieving its projected deployment schedule.
- National Grid pivoted from using internal crew into a combination of internal and contractors. To improve efficiency, all devices are pre-programmed prior to installation.
- Much of National Grid's progress in 2022 was comprised deploying OH DA w/o Ties and Feeder Monitors. The majority of 2022 spend ($4.5M) was on OH DA w/o Ties ($2.4M) and Feeder Monitors ($1.6M).
- National Grid had eight additional FLISR schemes placed into service. There were 17 successful FLISR operations. This reduced each event by restoring approximately 40% of customers from the initial outage customer count.
- National Grid installed some of its ADA devices at strategic tie points between circuits. Tie reclosers are expected to have enhanced reliability and redundancy benefits for customers. However, reconductoring and pole upgrades are sometimes needed to ensure that load can be shifted safely between circuits, adding to the project costs.
- National Grid plans to operate GMP ADA devices using a public cellular network to keep projects moving forward. National Grid is evaluating a 700MHz private radio

communications network and if found to be acceptable they propose to use a combination of a public cellular and private communications for GMP ADA devices.

- National Grid is in early stages of its effort to deploy the ADA investment and has limited ADA on its system. As such the saturation of ADA devices is low on a system-wide perspective. This should provide an opportunity to improve reliability as saturation increases and National Grid continues to leverage this investment.

4. ADA Performance Metrics

Guidehouse's assessment of the Performance Metrics (PMs) included Performance Metric (PM) data collection, data Quality Assessment and Quality Control (QA/QC), data analysis for each EDC, and determination of findings and conclusions from the analysis.

4.1. Data Management

This section discusses the data sources used for the PM evaluation and summarizes the QA/QC steps, and selection of circuits used in the PY 2022 analysis.

4.1.1. Data Sources

2022 Grid Modernization Plan Annual Report Appendix 1[36,37,38]**:** On April 24, 2023 each EDC submitted Appendix 1 along with its Annual Report. The Appendix 1 contains feeder-level data for all feeders within each EDC's territory. All PM-related data presented below are from these 2022 GMP Annual Report Appendices. These documents contain baseline and program year data for all circuits for each EDC. Key data from these Appendices that were utilized in this analysis include:

- Customer Counts
- Feeder Level SAIDI (CKAIDI) and SAIFI (CKAIFI) for the Plan Year and Baseline Years
- Number of Customers that Benefit from GMP Investments
- Average Protective Zone Size
- Main Line Customer Minutes of Interruption

Work Order Information: Circuit-level work order data was collected during the infrastructure metrics evaluation to understand the current status (e.g., Construction, Design, In-Service, Commissioned) of GMP investments. This work order data was used to determine when GMP investments were commissioned on each circuit with more granularity than is provided in the Appendix 1 data.

4.1.2. Data QA/QC Process

The evaluation team reviewed the Appendix 1 filings for completeness, accuracy, and alignment with the metrics set forward in the DPU Stamp Approved Metrics. The QA/QC process involved the following:

- Check that the change in CKAIDI/CKAIFI, average zone size, and customer minutes of interruption were properly calculated using the Stamp Approved Metric's definition. Note: DPU Stamp Approved Metric Guidance defines this as " ASELINE – PROGRAM YEAR"

[36] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Annual Report for Calendar Year 2022. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.

[37] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Annual Report for Calendar Year 2022. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.

[38] Fitchburg Gas and Electric Light Company d/b/a Unitil, 2022 Grid Modernization Plan Annual Report. Submitted to Massachusetts DPU on April 24, 2023, as part of DPU 23-30.

- Comparison of circuits with GMP investments in the Appendix 1 filing and the work order data collected during the Infrastructure Metric analysis.

- Comparison of PY 2021 and PY 2022 Appendix 1 filings to ensure baseline reliability data match.

- Comparison of circuit lists between Appendix 1 tabs to understand changes in circuit lists due to decommissioning and reconfigurations that occurred during the baseline and program years.

During this QA/QC process, the evaluation team identified issues in the Eversource Appendix 1 filings that may require adjustments and updates. There were circuits showing customers benefitting from DA devices, but not showing OH DA installed on those circuits. Additionally, there were discrepancies between Eversource's work order data and Appendix 1 device deployment data with regards to which circuits had received ADA investments. Eversource is looking further into the cause of circuits with customers benefitting but no OH DA installed on them and clarifying the discrepancies between work order data and Appendix 1 device deployment.

4.1.3. Circuit Selection

Guidehouse provides CKAIDI and CKAIFI findings for all circuits (systemwide) and for circuits that received ADA investments by the end of 2022.[39] To provide results for the stamp-approved metrics as currently defined, Guidehouse provides findings for CKAIDI and CKAIFI for circuits with ADA devices installed during 2018 through 2021 as well as the whole of 2022.[40]

The evaluation team identified a number of circuits for each EDC that had been reconfigured, split, or decommissioned between the baseline and program year. As a result of these changes, a comparison of CKAIDI/CKAIFI metrics was either not possible or deemed to be potentially misleading and these circuits were excluded from the analysis. Similar measures were taken to ensure that other performance metrics were calculated using a consistent circuit list between the baseline and the program year.[41]

The subsections below detail which circuits were included in the analysis for each EDC.

[39] Equipment installed in the first half of the program year has at least half a year to fully operate and provide measurable reliability benefits to customers on a particular circuit, and using the half-year cutoff for circuit analysis also allows—on average—half the devices deployed in the program year to be included in the analysis. The evaluation team determined that this was a reasonable rule to use for exploring reliability impacts of the installed grid modernization devices, being mindful that many other factors affect these metrics, including weather, car strikes, and animal/bird interference.

[40] PY 2022 reliability metrics provided are inclusive of ADA devices installed through PY 2022 in order to best avoid potential calculation errors arising through misalignment between Appendix 1 filings and more granular work-order data. Guidehouse analyzed performance metrics for ADA circuits for circuits that received ADA investment either in PY 2022 or before.

[41] A comparison of system wide baselines between this report and the PY 2021 PM Evaluation Report shows differences in the baseline circuit list, which is expected given changing customer counts and changes in circuit configurations.

4.1.3.1. Eversource Circuits

Eversource commissioned ADA devices in PY 2018 through PY 2022. Table 38 shows circuits with ADA devices commissioned through PY 2022. A number of circuits were excluded from the analysis due to being newly created, reconfigured, split, or retired since the baseline period, as discussed above. A larger percentage of ADA circuits were not included in the CKAIDI and CKAIFI analysis, as the evaluation team removed circuits that did not serve customers, and also removed circuits that did not have CKAIDI and CKAIFI data in the baseline period or PY 2022. A smaller percentage of ADA circuits were not included in the Average Zone Size analysis due to not having sufficient information to calculate zone size.

Table 38. Eversource Circuits Included in Analysis

Eversource Circuits[42]	System-Wide	ADA Commissioned Through PY 2022
Total Circuit Count	2,284	289
Circuits for CKAIDI/CKAIFI Analysis		
Circuits Included in Analysis	1,443	260
% of Total Circuits Included In Analysis	63%	90%
Circuits for Average Zone Size Analysis		
Circuits Included in Analysis	1,757	281
% of Total Circuits Included In Analysis	77%	97%

Note: Circuits included in CKAIDI/CKAIFI analysis do not include circuits that are networked, spare, reconfigured, split, decommissioned, served zero customers, or circuits that do not have reliability data available during the baseline period or program year.

Source: Guidehouse Analysis of GMP Annual Reports and EDC Data

4.1.3.2. National Grid Circuits

National Grid commissioned ADA devices in PY 2020 through PY 2022. Table 39 shows circuits with ADA devices commissioned through PY 2022. A number of circuits were excluded from the analysis due to being newly created, reconfigured, split, or retired since the baseline period, as discussed above. In addition, the evaluation team removed circuits that did not serve customers, and also removed circuits that did not have data in the baseline period or PY 2022. Ultimately a larger percentage ADA circuits were removed from the analysis as compared to system-wide circuits.

Table 39. National Grid Circuits Included in Analysis

National Grid Circuits[42]	System-Wide	ADA Commissioned Through PY 2022
Total Circuit Count	1,141	61

[42] Total circuit count does not include circuits that are networked, spare, or served zero customers during baseline period or program year. Circuits included in analysis do not include circuits that have been reconfigured, split, or decommissioned between the baseline and program year, or circuits that do not have reliability data available during the baseline period or program year.

National Grid Circuits[42]	System-Wide	ADA Commissioned Through PY 2022
Circuits for CKAIDI/CKAIFI Analysis		
Circuits Included in Analysis	816	36
% of Total Circuits Included In Analysis	72%	59%
Circuits for Mainline Customer Minutes of Interruption Saved		
Circuits Included in Analysis	816	36
% of Total Circuits Included In Analysis	72%	59%

Note: Circuits included in analysis do not include circuits that are networked, spare, reconfigured, split, decommissioned, served zero customers, or circuits that do not have reliability data available during the baseline period or program year.

Source: Guidehouse Analysis of GMP Annual Reports and EDC Data

4.2. ADA Performance Metrics Analysis and Findings

Evaluation of the various performance metrics for each EDC is provided below. A summary of findings is presented first, followed by an overview of the analysis approach to facilitate understanding of the detailed results analysis. The analysis for each relevant metric is then provided, organized by EDC.

Results Summary: Table 40 provides a high-level summary of the results for each performance metric and EDC.

Table 40. Summary of Findings for ADA Investment Area

PM	Eversource	National Grid
PM-12: Grid Modernization investments' effect on outage durations	Outage duration for ADA circuits in PY 2022 improved by 58 minutes from baseline on non-EME days. *	Outage duration for ADA circuits in PY 2022 improved by 38 minutes from baseline on non-EME days. ADA circuits performed better in PY 2022 than system-wide circuits on average. *
PM-13: Grid Modernization investments' effect on outage frequency	Outage frequency for ADA circuits in PY 2022 was 11% better than baseline on non-EME days, but 15% worse for EME days. System-wide circuits performed better than ADA circuits on average in PY 2022. *	Outage frequency for ADA circuits in PY 2022 was 23% better than baseline for non-EME days and 14% better for EME days. ADA circuits performed better than system-wide circuits on average in PY 2022. *
PM-11: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Almost 255,000 (19%) Eversource customers benefitted from ADA devices.	Over 113,000 (8%) National Grid customers benefitted from ADA devices.
PM-ES2: Protective Zone: Average Zone Size per Circuit	The average zone size on circuits with ADA devices decreased by 231 customers in PY 2022 from 2018.	N/A – Eversource specific metric

PM	Eversource	National Grid
PM-NG1: Main Line Customer Minutes of Interruption Saved	N/A – Nat. Grid specific metric	Main-line CMI for circuits with ADA decreased (improved) 35% in PY 2022 from baseline. *
Case studies	Case studies showed that ADA investments have been yielding reliability improvements for customers.	Case studies showed that ADA investments have been yielding reliability improvements for customers.

* Note: This metric is not able to readily discern whether change in this metric was due to ADA investment or other factors.

Source: Guidehouse Analysis

Table 41 shows the actual metrics data points for system-wide circuits for non EME days, which provides a backdrop for understanding the performance of ADA circuits below in the report.

Table 41. Baseline vs. PY 2022 Reliability without EMEs

EDC	CKAIDI/CKAIFI Metric	Baseline	PY 2022
Eversource	Weighted Average CKAIDI	103	74
	Weighted Average CKAIFI	0.92	0.91
National Grid	Weighted Average CKAIDI	112	100
	Weighted Average CKAIFI	0.92	0.91

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse Analysis

Examining performance for system-wide circuits when EMEs are *included* can also provide insight into the impact of major storms during the program year. Customer-weighted average CKAIDI and CKAIFI metrics with EMEs for PY 2022 were generally worse than they were for the Baseline years (2015-2017); however, for National Grid, the average CKAIDI metric was better than baseline, as shown in Table 42.

Table 42. Baseline vs. PY 2022 Reliability with EMEs

EDC	CKAIDI/CKAIFI Metric	Baseline	PY 2022
Eversource	Weighted Average CKAIDI	128	177
	Weighted Average CKAIFI	0.98	1.22
National Grid	Weighted Average CKAIDI	226	140
	Weighted Average CKAIFI	1.02	1.04

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse Analysis

Analysis Approach: The following approach was developed to provide additional insight into the EDC Performance Metrics that were published by the EDCs in their PY 2022 Annual Reports, Appendix 1. The circuit-level data provided by the EDCs was used to evaluate the metrics. The evaluation approach has three elements:

1. Baseline and Program Year System-wide and ADA circuit comparisons: The evaluation team compared the baseline and program year data across the entire system and for

circuits receiving ADA investments (see Section 4.1.3 for details). Statistical averages for these circuit groupings were used to make simple comparisons, and standard deviations were calculated to provide insight into the variability compared with the average values. For PM-12 (change in CKAIDI) and PM-13 (change in CKAIFI), the system-wide metric baseline was compared against the program year metric using reliability bins. This facilitates a general understanding of where the ADA investments fit into the context of the overall system metric performance and to compare changes in metrics for ADA circuits to those of system-wide circuits.

2. Before and after comparison: For PM-12 and PM-13, the program year performance was compared to the baseline performance for all circuits within the system. " ox-and-whisker" plots[43] are used to illustrate the distribution of data across the entire system and for circuits receiving ADA investments.[44]

3. Difference in differences: The difference in system-wide circuits change from baseline vs. ADA circuits change from baseline was calculated to understand if there is any discernable reliability improvement on the ADA circuits. This change is defined as "average metric for ADA circuits minus average metric for system-wide circuits."

The sections below leverage the three steps listed above to provide additional insights into the impacts of ADA investments. In addition, ancillary metrics are used for informative purposes. For clarity, a subset of those metrics is defined below.

Weighted Average refers to the customer weighted average, e.g., CKAIDI or CKAIFI weighted by average annual number of customers on the circuit and averaged over circuits for the year. The weighted average is computed using 2017 customer counts for the baseline, and 2022 customer counts for the Program Year.

Standard Deviation of CKAIDI or CKAIFI values is computed to provide an indication of the variability in these metrics for the year(s) in question. A high value relative to the averages described above tends to indicate high variability and prevents us from drawing strong conclusions about changes in the average values. Standard deviation is also weighted by customer counts.

Total Circuits with Non-Zero Customers only counts circuits that serve customer loads under normal conditions. It excludes backup circuits, express circuits between substations, etc. The CKAIDI/CKAIFI analysis only considers circuits with non-zero customers.

% Zero is the proportion of circuits with non-zero customers that had zero CKAIDI/CKAIFI in the 3 baseline years (for the baseline) or in 2022 (for the program year). This value for the baseline comprises circuits that have not experienced any outages in any of the 2015-2017 years, while this value for the program year comprises circuits that did not experience any outages in 2022.

[43] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 1st- through-3rd quartiles in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the 1st and 3rd quartiles) or the maximum/minimum value within the range if it falls within 1.5x the IQR. The "x" indicates the sample average. Data points that fall outside 1.5x the IQR are not shown on the graph.

[44] Note that the DPU Guidance defines the change as " a seline – Program Year" which means that positive values of this metric indicate reliability improvement—which may be counter intuitive as CKAIDI or CKAIFI metrics fall with improvement.

4.2.1. PM-12: Effect on Outage Duration (CKAIDI)

Metric PM-12, Reliability-Focused Grid Modernization Investments' Effect on Outage Duration (CKAIDI), was developed to try to provide insight on how GMP devices impact outage duration and is intended to track performance improvements over time. Per the DPU Stamp Approved GMP Performance Metrics Guidance:

> *This metric will compare the experience of customers on GMP DA-enabled circuits as compared to the prior three-year average for the same circuit. This metric will provide insight into how DA can reduce the duration of outages (by tracking and reporting) the following:*
>
> - *Circuit level SAIDI for the program year*
> - *Three-year average SAIDI for 2015, 2016, and 2017*
> - *Comparison of the current year SAIDI with the three-year historic average: AVERAGE(CKAIDI 2015, CKAIDI 2016, CKAIDI 2017) – PY CKAIDI = if greater than 0, positive impact*

The EDCs provided the CKAIDI metric in their Appendix 1 filings. As discussed in Section 4.1.3, circuits with ADA investments through PY 2022 and prior are included in the analysis. Analysis of this metric for each EDC is presented in the following subsections.

4.2.1.1. Eversource Analysis

The analysis of the CKAIDI metric for Eversource is presented in the subsection below.

In comparison to the baseline, ADA circuits in PY 2022 had a 58-minute improvement in average CKAIDI without EMEs. System-wide circuits showed a 29-minute improvement in CKAIDI without EMEs in 2022 from the baseline. ADA circuits are included in the system-wide results. Eversource reported having deployed ADA on system-wide circuits from non-GMP funds (including oil switch replacement and overhead recloser deployment), which would have contributed to system-wide reliability improvement.

However, an increase in average CKAIDI with EMEs for both ADA circuits and system-wide circuits from the baseline to PY 2022 likely indicates the impact of significant EME storm activity (note that the baseline CKAIDI with EMEs is a three-year average which "masks" individual major events in a single year).

The CKAIDI standard deviation with EMEs increased from baseline, while the CKAIDI standard deviation without EMEs decreased, highlighting the impact of EMEs on system reliability metrics. However, the standard deviation is on the same order of magnitude as the weighted average, providing some indication that the change in the weighted average is not simply statistical noise, but an actual improvement in non-EME performance during the program year.

System-wide and ADA circuit counts: Table 43 is structured with CKAIDI ranges, or "bins", to provide insight about the range of outage durations across circuits in the system, and to show where circuits selected for ADA investment fall within these bins. For the ADA circuits (green bars indicate number of circuits in bin), more circuits were in the "low CKAIDI" (0-50) bin than in the baseline, for both non-EME and EME days.

Approximately 19% of system-wide and 2% of currently deployed ADA circuits had experienced no outages at all during the baseline period. Circuits experiencing no outages increased in PY 2022 for both system-wide and ADA circuits.

Table 43. Eversource Baseline and PY 2022 CKAIDI Distribution

Eversource ADA	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIDI Statistics								
Total Circuits	2,284	2,284	289	289	2,284	2,284	289	289
Total Circuits with Non-zero Customers	1,443	1,443	260	260	1,443	1,443	260	260
% Zero CKAIDI	19%	19%	2%	2%	27%	33%	4%	10%
Average CKAIDI	128	103	149	131	177	74	190	72
Simple Avg. CKAIDI	97	78	145	127	147	62	175	77
Change from Baseline (Baseline - Plan Year)					-49	29	-41	58
% Change from Baseline					-38%	28%	-28%	45%
Std. Dev.	146	115	149	135	358	101	382	88
CKAIDI Range	**No. of Circuits in Range**							
0	275	276	4	4	395	482	11	26
0 - 50	449	490	64	70	450	492	108	121
50 - 150	413	446	105	112	260	279	70	71
150 - 250	154	142	39	39	106	95	20	21
250 - 350	72	52	28	26	76	50	15	13
350 - 450	38	21	11	2	31	20	8	3
450 - 550	19	7	4	2	32	16	6	3
550 - 650	6	1	0	1	22	4	6	1
650 - 750	7	3	2	2	12	0	4	0
750 - 850	6	3	2	1	7	3	1	0
850 - 950	2	1	0	0	7	1	1	1
950 - 1050	1	1	1	1	7	0	2	0
1050 - 1300	1	0	0	0	10	0	3	0
1300 - 1550	0	0	0	0	4	0	2	0
1550 - 1800	0	0	0	0	6	1	1	0
1800 - 2050	0	0	0	0	4	0	0	0
2050 - 3050	0	0	0	0	13	0	2	0
> 3050	0	0	0	0	1	0	0	0

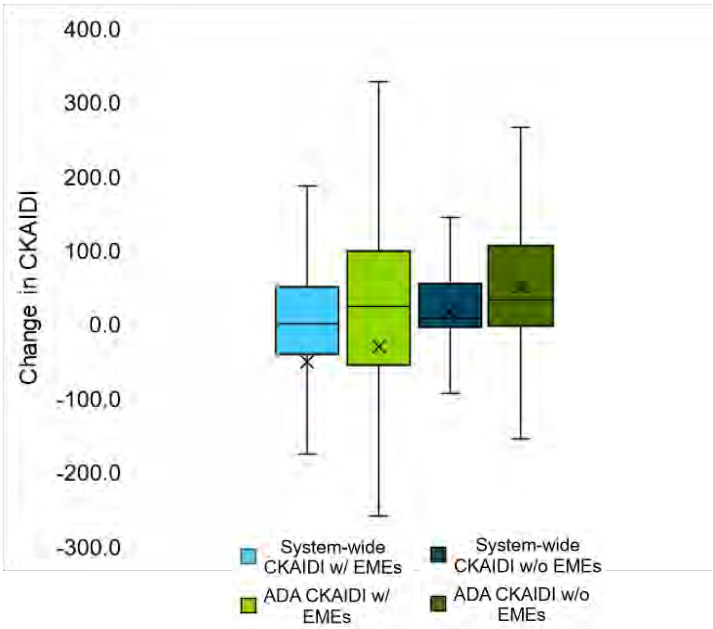
Note: EME = Excludable Major Events. CKAIDI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

Before and after comparison: A simple graphical summary of the statistical change in CKAIDI is shown in Figure 17 below, which uses the "box-and-whisker" format.[45] This chart compares the difference in CKAIDI between baseline and PY 2022, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the DPU Stamped Approved formula of Baseline CKAIDI – Program Year CKAIDI, so a positive change indicates improved performance in the Program Year.

[45] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 1st through 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the 1st and 3rd quartiles) or the maximum/minimum value within the range if it falls within 1.5x the IQR. The "x" indicates the sample average. Data points that fall outside 1.5x the IQR are not shown on the graph for visualization purposes.

Figure 17. Eversource Outage Duration Performance Metric Results



Change with EMEs	Change in System-wide CKAIDI w/ EMEs	Change in ADA CKAIDI w/ EMEs
Count	1,443	260
% No Change	16%	0%
Average Change in CKAIDI	-50	-30
Standard Deviation	336	339
Median Change in CKAIDI	0	24

Change without EMEs	Change in System-wide CKAIDI w/o EMEs	Change in ADA CKAIDI w/o EMEs
Count	1,443	260
% No Change	17%	0%
Average Change in CKAIDI	16	50
Standard Deviation	138	162
Median Change in CKAIDI	7	33

Note: EME = Excludable Major Events. Change in CKAIDI is reported as minutes. Change in CKAIDI is calculated as defined by the DPU PM Guidance: 2015-2017 Avg. CKAIDI – 2022 CKAIDI = if greater than zero, positive impact. Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

CKAIDI without EMEs improved more for ADA circuits than for system-wide circuits, indicating an improved performance on the ADA circuits on average.[46] Looking at the median change in CKAIDI, 50% of ADA circuits reflected at least a 33-minute improvement in outage duration, compared to the baseline which had a median change of 7 minutes.

The average system-wide CKAIDI with EMEs worsened in PY 2022 over the baseline. For the selected ADA circuits, CKAIDI with EMEs decreased by less than for system-wide circuits, indicating a better performance on the ADA circuits on average. However, the bottom quartile of change for the ADA circuits is larger than that for system-wide circuits, signifying that ADA circuits had a greater proportion of circuits with worse performance in 2022.

However, the standard deviation of the change in CKAIDI for each group is significantly larger—several times larger – than the average change in CKAIDI itself, providing an indication that the change in the average is of limited statistical significance, and not indicative of any clearly discernible trend in CKAIDI. As indicated above, there are many potential reasons for these changes and many factors impacting this metric. The impact of the ADA investment in operation is not discernable using the metric itself, as discussed previously.

Difference in differences: The differences in the change in CKAIDI (baseline to 2022) between the system-wide average and the average for circuits with ADA investments are shown in Table

[46] Note that the "whiskers" extend further for the circuits with ADA investments because there are fewer ADA circuits that experienced zero change in CKAIDI. As a result, the IQR for these circuits is larger than the IQR range of the whole system

44. The change in CKAIDI with EME for ADA circuits was greater than the system-wide circuits, and while the same was true for CKAIDI without EME, both system-wide and ADA circuits showed improvement w/o EMEs. Although the standard deviation for these samples is larger than the CKAIDI changes (as discussed above), 2022 was a year with improved reliability for both system-wide and ADA circuits without EME. The reduced performance of ADA circuits during major excludable events can be partially explained by the fact that a small subset of ADA circuits had much larger outage durations than in the baseline, which led to a skewed average change metric.

Table 44. Eversource CKAIDI Difference in Differences

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIDI w/ EMEs	-50	-30	20
Change in CKAIDI w/o EMEs	16	50	34

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

Erosion of Baseline: As mentioned in section 4.1.3.1, 1% of Eversource system-wide circuits and 10% of Eversource ADA circuits had to be excluded from this metric, because circuits had been retired, reconfigured or split since 2017. The comparability of each circuit in the program year to its baseline, as defined in the DPU approved metric, depends on that circuit not having been reconfigured or significantly changed (e.g., a normally open switch between circuit segments is changed to operate as normally closed, changing the customer counts and outage measurements on that circuit). The number of circuits that are comparable between baseline and program year is reduced year over year as more circuits are reconfigured, leading to an erosion of metric baseline over time.

Major Events in the Baseline: An aspect of PM-12 is the methodology of averaging CKAIDI over 3 years, which masks the impact of single-year EMEs, as it is unlikely for the same circuit to be affected by an EME three years in a row. Thus, when comparing a single-year CKAIDI with EME to the baseline, the change in CKAIDI is likely to indicate the presence or absence of qualifying EME days.

4.2.1.2. National Grid Analysis

The analysis of the CKAIDI metric for National Grid is presented in the subsection below.

National Grid ADA circuits experienced a 38-minute improvement without EMEs on average in PY 2022 from baseline. This is a 30% improvement from baseline, greater than system-wide circuits, where CKAIDI showed a 11% improvement from baseline without EMEs. Average CKAIDI with EMEs improved for both ADA circuits and system-wide from the baseline in PY 2022.

The CKAIDI standard deviation for system-wide circuits decreased from baseline for EME days and increased for non-EME days. CKAIDI standard deviation for ADA circuits decreased for both EME and non-EME days. Also, the standard deviation is on the same order of magnitude as the weighted average, providing some indication that the change in the weighted average is

not simply statistical noise, but an actual improvement in non-EME performance during the program year.

System-wide and ADA circuit counts: Table 45 is structured with CKAIDI ranges, or "bins", to provide insight about the range of outage durations across circuits in the system, and to show where circuits selected for ADA investment fall within these bins. For the ADA circuits (green bars indicate number of circuits in bin), more circuits were in the "low CKAIDI" bins (0, 0 – 50) in PY 2022 than in the baseline, for both non-EME and EME days. There were fewer circuits with CKAIDI greater than 1,000 during EME days in PY 2022 than in baseline; this is true for both system-wide and ADA circuits.

Table 45. National Grid Baseline and PY 2022 CKAIDI Distribution

National Grid ADA	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIDI Statistics								
Total Circuits	1,141	1,141	61	61	1,141	1,141	61	61
Total Circuits with Non-zero Customers	816	816	36	36	816	816	36	36
% Zero CKAIDI	2%	3%	0%	0%	16%	17%	3%	3%
Average CKAIDI	226	112	336	127	140	100	134	89
Simple Avg. CKAIDI	206	107	332	129	131	95	137	94
Change from Baseline (Baseline - Plan Year)					86	12	202	38
% Change from Baseline					38%	11%	60%	30%
Std. Dev.	264	86	318	80	165	109	155	67
CKAIDI Range	**No. of Circuits in Range**							
0	20	22	0	0	129	136	1	1
0 - 50	195	256	6	7	242	277	8	10
50 - 150	267	336	9	16	219	236	16	16
150 - 250	141	131	5	10	109	100	7	9
250 - 350	61	47	2	3	50	35	1	0
350 - 450	33	13	4	0	27	13	2	0
450 - 550	22	7	3	0	10	5	0	0
550 - 650	20	0	2	0	8	5	0	0
650 - 750	10	0	1	0	6	3	1	0
750 - 850	7	1	1	0	6	1	0	0
850 - 950	12	3	1	0	1	1	0	0
950 - 1050	5	0	0	0	2	1	0	0
1050 - 1300	18	0	2	0	0	0	0	0
1300 - 1550	3	0	0	0	2	1	0	0
1550 - 1800	0	0	0	0	2	0	0	0
1800 - 2050	1	0	0	0	1	1	0	0
2050 - 3050	1	0	0	0	1	1	0	0
> 3050	0	0	0	0	1	0	0	0

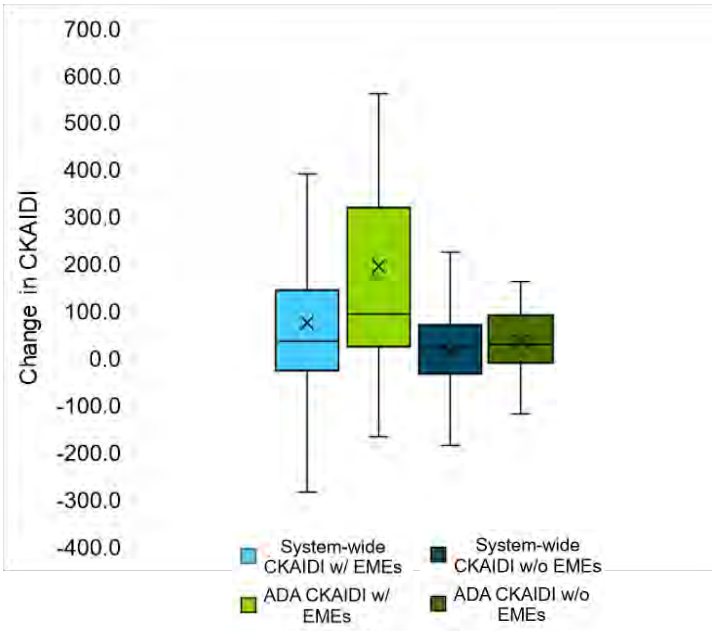
Note: EME = Excludable Major Events. CKAIDI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

Before and after comparison: A simple graphical summary of the statistical change in CKAIDI is shown in Figure 18 below, which uses the "box-and-whisker" format.[47] This chart compares

[47] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 1st through 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the 1st and 3rd quartiles) or the maximum/minimum value within the range if it falls within 1.5x the IQR. The "x" indicates the sample average. Data points that fall outside 1.5x the IQR are not shown on the graph for visualization purposes.

the difference in CKAIDI between baseline and PY 2022, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the DPU Stamped Approved formula of Baseline CKAIDI – Program Year CKAIDI, so a positive change indicates improved performance in the Program Year.

Figure 18. National Grid Outage Duration Performance Metric Results



Change with EMEs	Change in System-wide CKAIDI w/ EMEs	Change in ADA CKAIDI w/ EMEs
Count	816	36
% No Change	1%	0%
Average Change in CKAIDI	75	195
Standard Deviation	331	258
Median Change in CKAIDI	36	92

Change without EMEs	Change in System-wide CKAIDI w/o EMEs	Change in ADA CKAIDI w/o EMEs
Count	816	36
% No Change	2%	0%
Average Change in CKAIDI	12	35
Standard Deviation	176	82
Median Change in CKAIDI	22	29

Note: EME = Excludable Major Events. Change in CKAIDI is reported as minutes. Change in CKAIDI is calculated as defined by the DPU PM Guidance: 2015-2017 Avg. CKAIDI – 2022 CKAIDI = if greater than zero, positive impact. Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

The average system CKAIDI with EMEs decreased in PY 2022 over the baseline. For the selected ADA circuits, CKAIDI with EMEs decreased with significantly greater magnitude, indicating better performance on the ADA circuits on average.

The average change in CKAIDI for circuits with ADA on non-EME days was also better than the system-wide change for PY 2022, which provides additional indication of improved performance on the ADA circuits on average. In particular, 50% of ADA circuits reflected at least a 29-minute improvement in outage reduction, compared to the baseline which had a median change of 22 minutes.

However, the standard deviation of the change in CKAIDI for each group is larger than the average change in CKAIDI itself, and thus the average may not indicate a clear directional trend in CKAIDI.

Difference in differences: The differences in the change in CKAIDI (baseline to 2022) between the system-wide average and the average for circuits with ADA investments are shown in Table 46. The change in CKAIDI for ADA circuits was greater than the change in system-wide circuits for EME days, but less for non-EME days. Although the standard deviation for these samples is larger than the CKAIDI changes (as discussed above), 2022 was a year with improved reliability on both system-wide and ADA circuits. The improved performance of ADA circuits during major

excludable events indicates that ADA investments may have had a positive effect on reliability in outage conditions.

Table 46. National Grid CKAIDI Difference in Differences

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIDI w/ EMEs	75	195	120
Change in CKAIDI w/o EMEs	12	35	23

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

Erosion of Baseline: As mentioned in section 4.1.3.1, 19% of National Grid system-wide circuits and 35% of National Grid ADA circuits had to be excluded from this metric, because circuits had been retired, reconfigured or split since 2015.The comparability of each circuit in the program year to its baseline, as defined in the DPU approved metric, depends on that circuit not having been reconfigured or significantly changed (e.g., a normally open switch between circuit segments is changed to operate as normally closed, changing the customer counts and outage measurements on that circuit). The number of circuits that are comparable between baseline and program year is reduced year over year as more circuits are reconfigured, leading to an erosion of metric baseline over time.

Major Events in the Baseline: An aspect of PM-12 is the methodology of averaging CKAIDI over 3 years, which masks the impact of single-year EMEs, as it is unlikely for the same circuit to be affected by an EME three years in a row. Thus, when comparing a single-year CKAIDI with EME to the baseline, the change in CKAIDI is likely to indicate the presence or absence of qualifying EME days.

4.2.2. PM-13: Effect on Outage Frequency (CKAIFI)

Metric PM-13, Reliability-Focused Grid Modernization Investments' Effect on Outage Frequency (CKAIFI), provides insight on how GMP devices impact outage duration and will track the improvements over time. Per the DPU Stamp Approved GMP Performance Metrics Guidance:

> *This metric will compare the experience of customers on GMP DA-enabled circuits as compared to the prior three-year average for the same circuit. This metric will provide insight into how DA can reduce the frequency of outages (by tracking and reporting) the following:*
>
> - *Circuit level SAIFI (CKAIFI) for the program year*
> - *Three-year average SAIFI (CKAIFI) for 2015, 2016, and 2017*
> - *Comparison of the current year SAIFI (CKAIFI) with the three-year historic average: AVERAGE(CKAIFI 2015, CKAIFI 2016, CKAIFI 2017) – PY CKAIFI = if greater than 0, positive impact*

The EDCs have provided the CKAIFI metric in their Appendix 1 filings. As discussed in Section 4.1.3, circuits with ADA investments through PY 2022 and prior are included in the analysis.

Analysis of this metric for each EDC is presented in the following subsections and align closely with the previous metric (PM-12: Impact on Outage Duration).

4.2.2.1. Eversource Analysis

The analysis of the CKAIFI metric for Eversource is presented in the subsection below.

Compared to the baseline, ADA circuits had a 11% lower CKAIFI in PY 2022 on non-EME days, indicating some improved performance. CKAIFI with EME worsened slightly (15%) for ADA circuits in 2022 from baseline.

System-wide circuits (which include GMP circuits) showed a 1% improvement in CKAIFI without EMEs, and a 25% worsening of CKAIFI with EMEs in PY 2022 from baseline. Eversource reports having rolled out non-GMP automation on system-wide circuits (including oil switch replacement and overhead reclosers) which may have impacted the reliability metrics.

The system average CKAIFI with EMEs from the baseline to PY 2022 increased, however the reverse is true for CKAIFI without EMEs. This indicates that EMEs had an impact on system reliability in PY 2022.

The percentage difference in CKAIFI with EMEs between the baseline and PY 2022 is smaller than the percentage difference in CKAIDI, thus the average frequency of customer outages did not increase as much as the average duration did in 2022.

The CKAIFI standard deviation also increased, indicating increased variability in CKAIFI across system circuits. However, the standard deviation is on the same order of magnitude as the weighted average, providing some indication that the change in the weighted average is not simply statistical noise, but an actual improvement in non-EME performance during the program year.

System-wide and ADA circuit counts: Table 47 is structured with CKAIFI ranges, or “bins”, to provide insight about the range of outage durations across circuits in the system, and to show where circuits selected for ADA investment fall within these bins. For the ADA circuits (green bars indicate number of circuits in bin), more circuits were in the “low CKAIFI” bins (0 – 0.25) than in the baseline, for both non-EME and EME days.

Similar to CKAIDI, the proportion of system-wide circuits with zero CKAIFI in the baseline is higher than that of ADA circuits. This provides some indication that these less reliable circuits were targeted more for ADA investment.[48]

[48] Eversource’s 2018 GMP Annual Report contains the following text about methodology of choosing circuits for GMP investments: *Circuit reliability based on historical SAIDI and SAIFI from 2015, 2016 and 2017 was also considered when selecting circuits for investment.*

Table 47. Eversource Baseline and PY 2022 CKAIFI Distribution

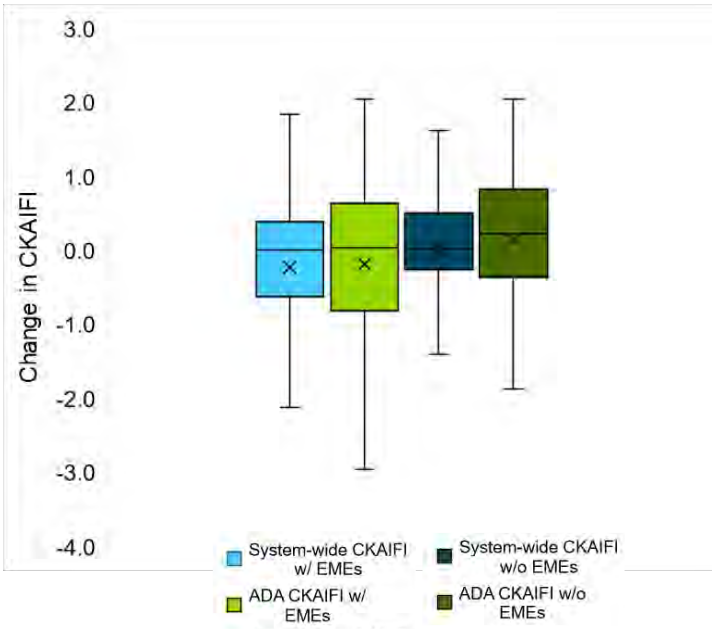
Eversource ADA	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIFI Statistics								
Total Circuits	2,284	2,284	289	289	2,284	2,284	289	289
Total Circuits with Non-zero Customers	1,443	1,443	260	260	1,443	1,443	260	260
% Zero CKAIFI	19%	19%	2%	2%	27%	33%	4%	10%
Average CKAIFI	0.98	0.92	1.15	1.11	1.22	0.91	1.32	0.99
Simple Avg. CKAIFI	0.68	0.64	1.05	1.01	0.92	0.63	1.25	0.87
Change from Baseline (Baseline - Plan Year)					-0.24	0.01	-0.17	0.12
% Change from Baseline					-25%	1%	-15%	11%
Std. Dev.	0.76	0.70	0.77	0.73	1.28	0.99	1.33	1.03
CKAIFI Range	**No. of Circuits in Range**							
0	278	279	4	4	395	482	11	26
0 - 0.25	187	192	27	30	273	310	56	70
0.25 - 0.75	471	486	82	81	180	176	60	60
0.75 - 1.25	250	255	65	66	213	225	39	38
1.25 - 1.75	128	132	31	38	107	75	23	15
1.75 - 2.25	79	59	29	21	90	77	23	25
2.25 - 2.75	26	22	12	11	51	37	15	9
2.75 - 3.25	13	11	6	6	43	30	8	7
3.25 - 3.75	8	6	3	2	28	12	8	4
3.75 - 4.25	2	1	1	1	18	11	4	5
4.25 - 4.75	0	0	0	0	13	2	2	0
4.75 - 5.25	0	0	0	0	16	5	8	1
5.25 - 5.75	0	0	0	0	5	0	1	0
5.75 - 6.25	0	0	0	0	3	0	1	0
6.25 - 6.75	0	0	0	0	1	1	1	0
6.75 - 7.25	0	0	0	0	4	0	0	0
7.25 - 7.75	0	0	0	0	3	0	0	0
> 7.75	1	0	0	0	0	0	0	0

Note: EME = Excludable Major Events. CKAIFI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

Before and after comparison: A simple graphical summary of the statistical change in CKAIFI is shown in Figure 19 below, which uses the "box-and-whisker" format.[49] This chart compares the difference in CKAIFI between baseline and PY 2022 for each circuit, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the DPU Stamped Approved formula of Baseline CKAIFI – Program Year CKAIFI, so a positive change indicates improved performance in the Program Year.

[49] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 1st through 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the 1st and 3rd quartiles) or the maximum/minimum value within the range if it falls within 1.5x the IQR. The "x" indicates the sample average. Data points that fall outside 1.5x the IQR are not shown on the graph for visualization purposes.

Figure 19. Eversource Outage Frequency Performance Metric Result



Change with EMEs	Change in System-wide CKAIFI w/ EMEs	Change in ADA CKAIFI w/ EMEs
Count	1,443	260
% No Change	16%	0%
Average Change in CKAIFI	-0.24	-0.19
Standard Deviation	1.20	1.33
Median Change in CKAIFI	0.00	0.03

Change without EMEs	Change in System-wide CKAIFI w/o EMEs	Change in ADA CKAIFI w/o EMEs
Count	1,443	260
% No Change	17%	0%
Average Change in CKAIFI	0.01	0.14
Standard Deviation	0.91	1.05
Median Change in CKAIFI	0.01	0.22

Note: EME = Excludable Major Events. Change in CKAIFI is reported as minutes. Change in CKAIFI is calculated as defined by the DPU PM Guidance: 2015-2017 Avg. CKAIFI – 2022 CKAIFI = if greater than zero, positive impact. Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

Without EMEs, average system-wide CKAIFI changed very little in PY 2022 relative to the baseline period, with some improvement for ADA CKAIFI. With EMEs, the average change in both system-wide and ADA CKAIFI worsened, with ADA still performing better than system wide circuits. However, the standard deviation of the change in CKAIFI for each group is significantly larger—several times larger–than the average change in CKAIFI itself, providing an indication that the change in the average is of limited statistical significance, and not indicative of a clearly discernible trend in CKAIFI. There are many potential reasons for these changes and many factors impacting this metric. The impact of the ADA investment in operation is one of the factors but is not discernable using the metric itself.

Difference in differences: The differences in the change in CKAIFI (baseline to 2022) between the system-wide average and the average for circuits with ADA investments are shown in Table 48. The change in CKAIFI with and without EMEs for circuits with ADA investments was better than the system-wide circuits. However, the standard deviation for these samples is much larger than the change in CKAIFI, indicating that the difference is likely not statistically significant and is more probably a factor of randomness in the metric data than any type of trend. It is difficult to conclude how much positive (or negative) impact the ADA investments had on this metric for Program Year 2022.

Table 48. Eversource CKAIFI Difference in Differences

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIFI w/ EMEs	-0.24	-0.19	0.05

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIFI w/o EMEs	0.01	0.14	0.13

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

Erosion of Baseline: As mentioned in section 4.1.3.1, 1% of Eversource system-wide circuits and 10% of Eversource ADA circuits had to be excluded from this metric, because circuits had been retired, reconfigured or split since 2017. The comparability of each circuit in the program year to its baseline, as defined in the DPU approved metric, depends on that circuit not having been reconfigured or significantly changed (e.g., a normally open switch between circuit segments is changed to operate as normally closed, changing the customer counts and outage measurements on that circuit). The number of circuits that are comparable between baseline and program year is reduced year over year as more circuits are reconfigured, leading to an erosion of metric baseline over time.

Major Events in the Baseline: An aspect of PM-13 is the methodology of averaging CKAIFI over 3 years, which masks the impact of single-year EMEs, as it is unlikely for the same circuit to be affected by an EME three years in a row. Thus, when comparing a single-year CKAIFI with EME to the baseline, the change in CKAIFI is likely to indicate the presence or absence of qualifying EME days.

4.2.2.2. National Grid Analysis

The analysis of the CKAIFI metric for National Grid is presented in the subsection below.

ADA circuits showed a 23% improvement in CKAIFI without EMEs, and a 14% improvement of CKAIFI with EMEs in PY 2022 from baseline. System-wide circuits w/o EMEs showed better performance in 2022 from baseline, while system-wide circuits with EMEs showed a worsening performance (2%).

The CKAIFI standard deviation increased, indicating increased variability in CKAIFI across system circuits. The standard deviation is on the same order of magnitude as the weighted average, providing some indication that the change in the weighted average is not simply statistical noise, but an actual improvement in non-EME performance during the program year.

System-wide and ADA circuit counts: Table 49 is structured with CKAIFI ranges, or “bins”, to provide insight about the range of outage durations across circuits in the system, and to show where circuits selected for ADA investment fall within these bins. The number of ADA circuits (green bars) in the lower bins (< 0.75) seem to have increased slightly on non-EME days in PY 2022, indicating movement towards better performance on these circuits. However, the number of ADA circuits w/EMEs in the upper bins (> 2.25) seem to have slightly increased, indicating worse performance on these circuits for PY 2022.

Similar to CKAIDI, the proportion of system-wide circuits with zero CKAIFI in the baseline is higher than that of ADA circuits. This provides some indication that these less reliable circuits were targeted more for ADA investment.

Table 49. National Grid Baseline and PY 2022 CKAIFI Distribution

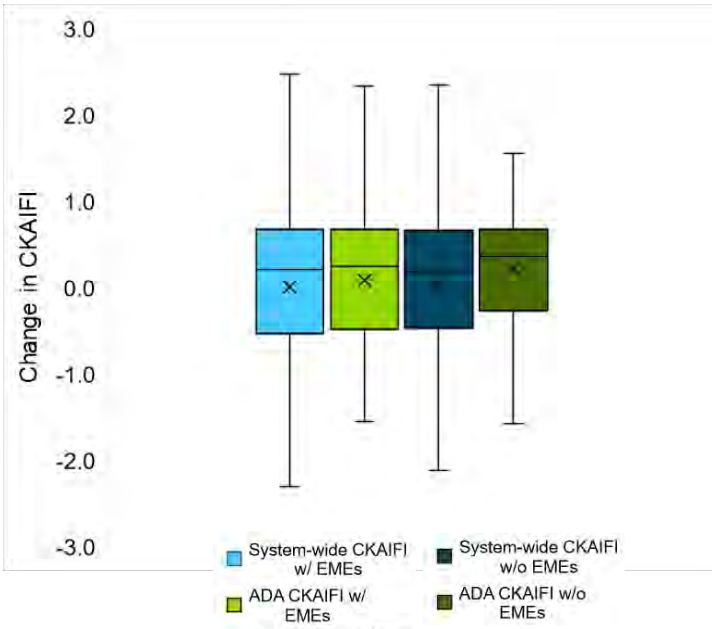
National Grid ADA	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIFI Statistics								
Total Circuits	1,141	1,141	61	61	1,141	1,141	61	61
Total Circuits with Non-zero Customers	816	816	36	36	816	816	36	36
% Zero CKAIFI	2%	3%	0%	0%	16%	17%	3%	3%
Average CKAIFI	1.02	0.92	1.21	1.11	1.04	0.91	1.03	0.85
Simple Avg. CKAIFI	0.88	0.79	1.17	1.08	0.87	0.77	1.10	0.87
Change from Baseline (Baseline - Plan Year)					-0.02	0.01	0.17	0.26
% Change from Baseline					-2%	1%	14%	23%
Std. Dev.	0.65	0.60	0.68	0.64	1.03	0.89	0.95	0.69
CKAIFI Range	**No. of Circuits in Range**							
0	20	23	0	0	131	138	1	1
0 - 0.25	83	103	2	2	206	220	8	9
0.25 - 0.75	298	318	7	10	109	119	9	10
0.75 - 1.25	222	212	13	11	162	158	4	5
1.25 - 1.75	123	105	7	8	68	69	8	7
1.75 - 2.25	42	37	5	3	59	54	2	2
2.25 - 2.75	21	14	1	2	33	24	1	1
2.75 - 3.25	5	3	1	0	25	20	0	1
3.25 - 3.75	2	1	0	0	11	7	2	0
3.75 - 4.25	0	0	0	0	5	5	1	0
4.25 - 4.75	0	0	0	0	0	0	0	0
4.75 - 5.25	0	0	0	0	2	0	0	0
5.25 - 5.75	0	0	0	0	2	0	0	0
5.75 - 6.25	0	0	0	0	2	1	0	0
6.25 - 6.75	0	0	0	0	0	0	0	0
6.75 - 7.25	0	0	0	0	1	1	0	0
7.25 - 7.75	0	0	0	0	0	0	0	0
> 7.75	0	0	0	0	0	0	0	0

Note: EME = Excludable Major Events. CKAIFI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

Before and after comparison: A simple graphical summary of the statistical change in CKAIFI is shown in Figure 20 below, which uses the "box-and-whisker" format.[50] This chart compares the difference in CKAIFI between baseline and PY 2022 for each circuit, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the DPU Stamped Approved formula of Baseline CKAIFI – Program Year CKAIFI, so a positive change indicates improved performance in the Program Year.

[50] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 1st through 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the 1st and 3rd quartiles) or the maximum/minimum value within the range if it falls within 1.5x the IQR. The "x" indicates the sample average. Data points that fall outside 1.5x the IQR are not shown on the graph for visualization purposes.

Figure 20. National Grid Outage Frequency Performance Metric Result



Change with EMEs	Change in System-wide CKAIFI w/ EMEs	Change in ADA CKAIFI w/ EMEs
Count	816	36
% No Change	1%	0%
Average Change in CKAIFI	0.00	0.07
Standard Deviation	1.07	0.94
Median Change in CKAIFI	0.21	0.24

Change without EMEs	Change in System-wide CKAIFI w/o EMEs	Change in ADA CKAIFI w/o EMEs
Count	816	36
% No Change	2%	0%
Average Change in CKAIFI	0.02	0.20
Standard Deviation	0.98	0.76
Median Change in CKAIFI	0.18	0.35

Note: EME = Excludable Major Events. Change in CKAIFI is reported as minutes. Change in CKAIFI is calculated as defined by the DPU PM Guidance: 2015-2017 Avg. CKAIFI – 2022 CKAIFI = if greater than zero, positive impact. Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

The average system-wide CKAIFI changed very little in PY 2022 relative to the baseline period. For the selected ADA circuits, the average change in CKAIFI was better than system-wide, indicating that ADA circuits performed better than system wide circuits. However, the standard deviation of the change in CKAIFI for each group is significantly larger—several times larger–than the average change in CKAIFI itself, providing an indication that the change in the average is of limited statistical significance, and not indicative of a clearly discernible trend in CKAIFI.

Difference in differences: The differences in the change in CKAIDI (baseline to 2022) between the system-wide average and the average for circuits with ADA investments are shown in Table 50. Relative to system-wide circuits, ADA circuits reflected an improvement in average CKAIFI with and without EMEs. However, the standard deviation for these samples is larger than the change in CKAIFI, indicating that the difference is likely not statistically significant and is more probably a factor of randomness in the metric data than any type of trend. It is difficult to conclude how much positive (or negative) impact the ADA investments had on this metric for Program Year 2022.

Table 50. National Grid CKAIFI Difference in Differences

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIFI w/ EMEs	0.00	0.07	0.07
Change in CKAIFI w/o EMEs	0.02	0.20	0.18

Note: Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

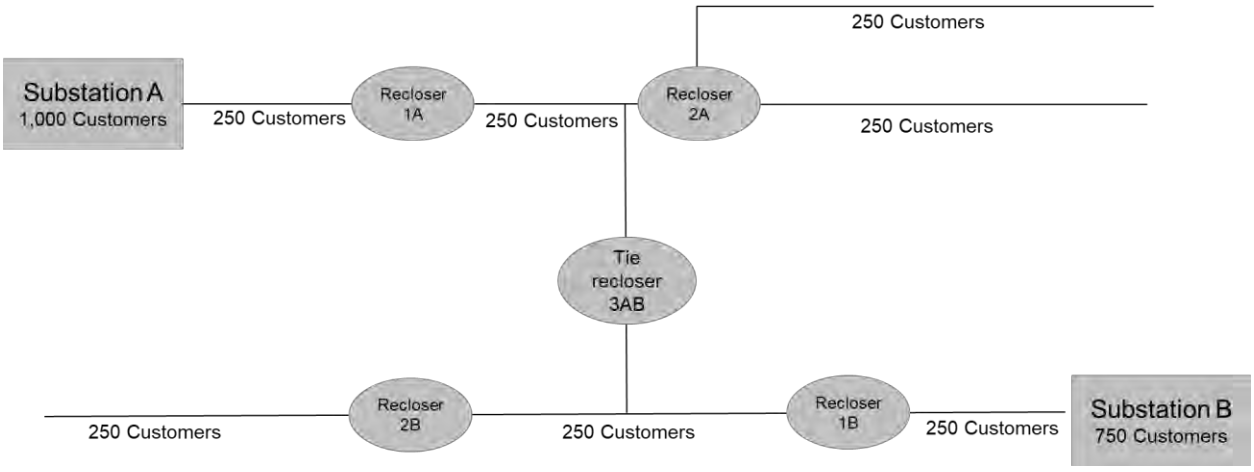
Erosion of Baseline: As mentioned in section 4.1.3.1, 19% of National Grid system-wide circuits and 35% of National Grid ADA circuits had to be excluded from this metric, because circuits had been retired, reconfigured or split since 2015. The comparability of each circuit in the program year to its baseline, as defined in the DPU approved metric, depends on that circuit not having been reconfigured or significantly changed (e.g., a normally open switch between circuit segments is changed to operate as normally closed, changing the customer counts and outage measurements on that circuit). The number of circuits that are comparable between baseline and program year is reduced year over year as more circuits are reconfigured, leading to an erosion of metric baseline over time.

Major Events in the Baseline: An aspect of PM-13 is the methodology of averaging CKAIFI over 3 years, which masks the impact of single-year EMEs, as it is unlikely for the same circuit to be affected by an EME three years in a row. Thus, when comparing a single-year CKAIFI with EME to the baseline, the change in CKAIFI is likely to indicate the presence or absence of qualifying EME days.

4.2.3. PM-11: Numbers of Customers that Benefit from GMP Funded Distribution Automation Devices

The goal of this metric is to track the number of customers that have benefitted from the installation of ADA devices. At a high-level, a customer is counted as benefitting from an ADA device when their zone size has been reduced. The evaluation team worked with the EDCs to determine a more detailed definition for this metric to provide clarify and consistency. A specific example and explanation are provided below:

Figure 21. Example One-Line Diagram of Grid Modernization Devices



Source: Guidehouse and EDCs

Broadly speaking, all customers within the zone in which a recloser is placed benefit from the device. In Figure 21, if Recloser 1A was installed in 2022 as part of the GMP and all other devices previously existed, then 500 customers benefitted from the installation of this device. All customers between the new device and the next connective device benefit. In this case, that is 250 customers on each side of the device for a total of 500 customers.

The customers that benefit from tie reclosers are counted in the same way. In Figure 21, if Tie Recloser 3AB was installed in 2022 as part of the GMP and all other devices previously existed, then 500 customers benefitted from the installation of this device. The 500 customers include the 250 customers between Recloser 1A and 2A and the 250 customers between Recloser 2B and 1B. This is a very conservative method of estimating the number of customers that benefit from a tie recloser, as in many cases the majority of customers on affected circuit may benefit from this addition.

The metric calculation was performed by the EDCs, as detailed data is required to calculate this metric for each circuit with ADA devices commissioned in Program Year 2022 or prior. Unlike the Performance Metrics for outage duration and frequency, the timing of the commissioning of the ADA device is not relevant for evaluation. Thus, all circuits with ADA devices installed any time in 2022 or prior are "eligible" to be included in the evaluation of this metric.

4.2.3.1. Eversource Analysis

The number of customers that benefit from ADA devices is reported in Appendix 1 of the Eversource's Annual GMP Report. The number of customers that benefit is non-zero only for circuits that had sectionalizing devices installed. Through PY 2022, these devices (OH Reclosers and Ties) were installed on 225 Eversource circuits. Table 51 shows the average and total number of customers that benefitted across all 225 circuits. As of the end of 2022, 254,626 customers (19% of total customers) benefitted from ADA devices.

Table 51. Number of Eversource Customers that Benefitted from GMP ADA Devices

Summary Statistics	
Total Circuits with DA Installed	225
Average Number of Customer Benefiting per circuit	1,132
Total Number of Customers Benefiting from DA Devices	254,626
Percent of Total Customers that Benefit from DA Devices	19%

Source: Guidehouse Analysis of Eversource 2022 GMP Annual Report Appendix 1

4.2.3.2. National Grid Analysis

The number of customers that benefit from ADA devices is reported in Appendix 1 of the National Grid's Annual GMP Report. The number of customers that benefit is non-zero only for circuits that had sectionalizing devices installed. Through PY 2022, these devices (OH Reclosers and Ties) were installed on 47 National Grid circuits. Table 52 shows the average number of customers that benefitted as well as the total across all 47 circuits. As of the end of PY 2022, 113,311 National Grid customers (8% of total customers) benefitted from ADA devices.

Table 52. Number of National Grid Customers that Benefitted from GMP ADA Devices

Summary Statistics	
Total Circuits with DA Installed	47
Average Number of Customer Benefiting per circuit	2,411
Total Number of Customers Benefiting from DA Devices	113,311

Summary Statistics	
Percent of Total Customers that Benefit from DA Devices	8%

Source: Guidehouse Analysis of National Grid 2022 GMP Annual Report Appendix 1

4.2.4. PM-ES2: Eversource Customer Outage Metric: Average Zone Size

The goal of this Eversource-specific metric is to track the progress in sectionalizing circuits into protective zones via the deployment of ADA devices. A zone size is defined as the number of customers located between sectionalizing devices. The average zone size for the whole circuit is the average number of customers in each protective zone on that circuit. Over time with increased deployment of ADA devices, the average zone size should decrease, which increases the overall reliability of the circuit and the system.

Table 53 shows the baseline (2018) and Program Year 2022 average zone size of the system-wide and ADA circuits for Eversource. For this Performance Metric, the group of ADA circuits is defined as any circuit with an ADA device commissioned during PY 2022 or prior. Table 53 is structured with zone size ranges, or "bins", to provide insight into the range of zone sizes across the system, and to show where circuits selected for ADA investment fall within these bins. ADA circuits in the 2018 baseline had an average zone size substantially larger than system-wide circuits. ut ADA circuits' zone size decreased to a similar size as system wide circuits in PY 2022. The standard deviation of zone size has also significantly decreased, indicating that there is less variability in the number of customers per zone. These combined observations suggest that ADA investments were targeted towards circuits with a larger zone sizes and succeeded in reducing it.

Table 53. Baseline and PY 2022 Average Zone Size Customer Count

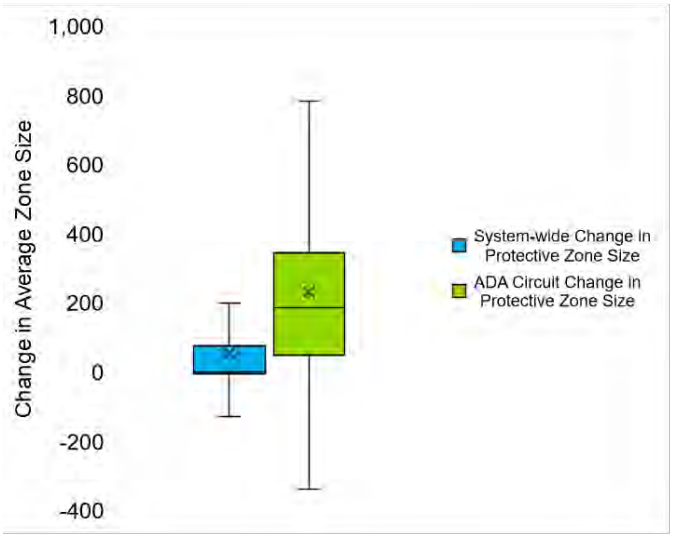
Eversource ADA	Average Protective Zone Size Baseline (2018)		Average Protective Zone Size 2022	
	System-Wide Circuit	ADA Circuit	System-Wide Circuit	ADA Circuit
Average Protective Zone Size Statistics				
Total Circuits	1,757	281	1,757	281
% Zero	14%	6%	0%	0%
Simple Average	312	551	277	353
Std. Dev.	352	370	283	213
Range				
0	247	17	0	0
0 - 100	433	13	571	18
100 - 200	174	16	255	44
200 - 300	182	28	280	76
300 - 400	161	34	208	53
400 - 500	145	38	142	31
500 - 600	87	22	95	27
600 - 700	80	27	55	11
700 - 800	66	23	49	8
800 - 900	53	13	32	5
900 - 1000	41	15	25	5
1000 - 1100	25	10	16	3
> 1100	63	25	29	0

Note: Some circuits did not have any zone size information available. Only circuits with zone-size information in either the baseline period or PY 2022 were included in the analysis.

Source: Guidehouse Analysis of Eversource's 2022 GMP Term Report Appendix 1

A simple graphical summary of the statistical change in average zone size customer count is shown in Figure 22 below, which uses a "box-and-whisker" format.[51] This chart compares the difference in the average zone size customer count between baseline and Program Year 2022 for each circuit, for both the system-wide circuits and the selected ADA circuits.[52]

Figure 22. Change in Average Zone Size Customer Count



	Change in System-wide Circuits	Change in ADA Circuits
Count	1757	281
% No Change	12%	5%
Average Change in Zone Size	54	231
Standard Deviation	221	286
Median Change in Zone Size	0	185

Note: Some circuits did not have any zone size information available. Only circuits with zone-size information in either the baseline period or PY 2022 were included in the analysis.

Source: Guidehouse analysis of 2021 GMP Term Report Appendix 1

The average zone size per circuit for ADA circuits decreased by 231 customers, compared to a system-wide average change in zone size of 54 customers. ADA investments had a major impact in decreasing the zone size customer counts.

4.2.5. PM-NG1: National Grid Reliability-Related Metric: Main Line Customer Minutes of Interruption Saved

Main Line Customer Minutes of Interruption Saved is a metric designed to measure the effectiveness of ADA investments. The DPU-defined calculation approach requires tracking of:

Historical customer minutes of interruption for mainline interruptions

Calendar year customer minutes of interruption for mainline interruptions

The evaluation of this National Grid-specific metric follows the same criteria for circuits included in the analysis as PM-12 and PM-13, i.e., a circuit where ADA was commissioned through 2022 or prior was considered an "ADA circuit". The baseline is defined as the average of 2015, 2016

[51] The "box-and-whisker" plot shows divides the sample into quartiles. The lower and upper "whiskers" indicate the lowest and highest values in the range, and the boxes show the 1st through 3rd quartile in the sample. The "x" indicates the sample average.

[52] Note that the DPU Guidance defines the change as " a seline – Program Year" which means that positive values of this metric indicate reliability improvement—the opposite of what you would expect for improvement in Zone Size, which falls with improvement.

and 2017. Main-line CMI should decrease over time with increased deployment of ADA, indicating increase reliability.

Table 54 shows the baseline and Program Year 2022 main line customer minutes of interruptions (CMI) saved of the system-wide and ADA circuits for National Grid. The standard deviation is on the same order of magnitude as the weighted average, providing some indication that the change in the weighted average is not simply statistical noise, but an actual improvement in performance during the program year.

Table 54 shows the baseline (2015-17) and PY 2022 average main-line CMI for system-wide and ADA circuits for National Grid. ADA circuits show a 35% improvement in CMI in 2022 from the baseline, in contrast to system-wide circuits whose CMI improved by only 3% in 2022 from baseline.

Moreover, standard deviation increased for system-wide circuits but decreased for ADA circuits. The standard deviation is the same order of magnitude as the average CMI, indicating that the change in CMI is not likely simply statistical noise but an actual improvement in reliability.

In baseline period, ADA circuits had almost double the average CMI compared to system-wide circuits, suggesting that ADA investments were targeted towards circuits with high CMI. In PY 2022, ADA and system-wide circuits had more similar CMI, which further indicates that ADA investments reflected potential effectiveness in reducing CMI.

Table 54. Baseline and PY 2022 Average Main-Line Customer Minutes of Interruption (CMI) for National Grid

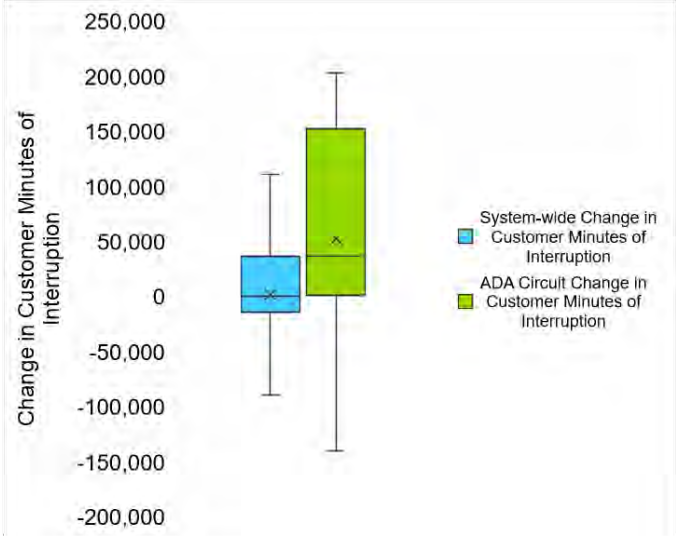
National Grid ADA	Average Customer Minutes of Interruption (2015-2017)		Customer Minutes of Interruption 2022	
	System-Wide Circuit	ADA Circuit	System-Wide Circuit	ADA Circuit
Customer Minutes of Interruption Statistics				
Total Circuits	816	36	816	36
% Circuits with Zero CMI	26%	3%	51%	36%
Average CMI	68,857	164,583	66,778	106,936
Change from Baseline			2,078	57,647
% Change from Baseline			3%	35%
Std. Dev.	115,067	134,180	141,512	129,356
CMI Range	**No. of Circuits in Range**			
0	212	1	413	13
0 - 10000	148	3	75	0
10000 - 20000	57	2	33	3
20000 - 30000	43	0	23	0
30000 - 40000	33	1	10	0
40000 - 50000	40	0	18	0
50000 - 60000	24	0	9	0
60000 - 70000	18	2	15	3
70000 - 80000	18	1	12	0
80000 - 90000	16	1	14	1
90000 - 100000	16	0	15	0
100000 - 110000	16	1	14	3

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse Analysis

Before and after comparison: A simple graphical summary of the statistical change in main-line CMI is shown in Figure 23 below, which uses the "box-and-whisker" format.[53] This chart compares the difference in CMI between baseline and PY 2022 for each circuit, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the DPU Stamped Approved formula of Baseline CMI – Program Year CMI, so a positive change indicates improved performance in the Program Year.

Figure 23. National Grid Statistical Change in National Grid Main-Line CMI from Baseline



	Change in System-wide Circuits	Change in ADA Circuits
Count	816	36
% No Change	19%	0%
Average Change in CMI	2078	57647
Standard Deviation	148749	172846
Median Change in CMI	38	36163

Note: Baseline is updated each year based on circuits included in analysis.

Source: Guidehouse analysis of 2022 GMP Annual Report Appendix 1

The average change in CMI for ADA circuits decreased by 57,647 minutes, which is significantly greater than the system-wide average change in CMI of 2,078 minutes. The average change in CMI of ADA circuits was reduced by over 20 times the system-wide average, indicating that ADA investments had an impact in decreasing the main line customer minutes of interruption.

The median change in ADA circuits was 36,163 minutes, compared to a smaller change in system-wide (38 minutes).

[53] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 1st through 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the 1st and 3rd quartiles) or the maximum/minimum value within the range if it falls within 1.5x the IQR. The "x" indicates the sample average. Data points that fall outside 1.5x the IQR are not shown on the graph for visualization purposes.

5. ADA Case Studies

This section features seven case studies performed for the ADA investment area: four for Eversource and three for National Grid. The case studies highlight the operation and role of specific GMP investments in specific events. The case studies are intended to supplement the performance metrics evaluation by capturing nuances not apparent through aggregate reliability data. Guidehouse acknowledges stakeholder and EDC comments stating case studies be made less technical and more user-friendly[54]. In response, we have updated the case study format to include high level summaries and made them more accessible to a broader audience.

5.1. Data Sourcing and Management

Guidehouse requested and used a combination of the following data from EDCs in order to perform case studies:

- Outage Management System (OMS) records for circuits where GMP-funded ADA and/or M&C devices have been commissioned in the GMP period. OMS records show customer counts, fault locations, outage start/end times, devices operated, outage cause, weather conditions, and other vital information relevant to outages
- Written comments by dispatchers and crews elaborating on the cause of the outage and actions taken in response
- One-line circuit diagrams showing circuit topography and locations of GMP M&C and ADA devices
- Notifications, alerts and alarms received from SCADA-enabled devices related to device operations and circuit telemetry
- Follow-up conversations with EDCs to further understand the sequence of events, reconstruct the corrective actions taken and estimate benefit or time savings resulting from GMP investments

Guidehouse selected case studies where comments by control center dispatchers and/or crews indicated GMP device involvement and included a detailed narrative of events leading to and following an outage. ADA case studies involved piecing together multiple restoration steps for each outage event. The first set of steps typically involves rapid restoration via automated and coordinated operation of multiple ADA devices. The second set of steps usually involves remote device operation by a control center dispatcher to further reduce customer count. The final restoration step is typically longer in duration and involves field repairs.

To fully reconstruct the restoration steps in each case study, Guidehouse studied OMS records and identified the fault location and device locations on circuit diagrams. Guidehouse then constructed a probable sequence of device operation and corroborated it with SCADA data and EDC follow-up questions, making reasonable assumptions where details were incomplete. For simplicity, Guidehouse selected cases where GMP device operation was clearly distinguishable and not combined with external factors such as loss of transmission supply. In the case of Eversource, where both GMP-funded and non-GMP funded ADA devices often operate in

[54] Joint Comments of Massachusetts Electric Company and Nantucket Electric Company each d/b/a National Grid, NSTAR Electric company d/b/a Eversource Energy, and Fitchburg Gas and Electric Company d/b/a Unitil on Metrics, and New Metrics Proposals, DPU 21-80, 21-81 and 21-82, p. 4

conjunction, Guidehouse selected cases where GMP-funded devices played a clear and direct role in restoration.

5.2. National Grid Case Studies

5.2.1. National Grid ADA Investment Rapidly Restores Power to Customers on Mink Street

5.2.1.1. Summary Overview

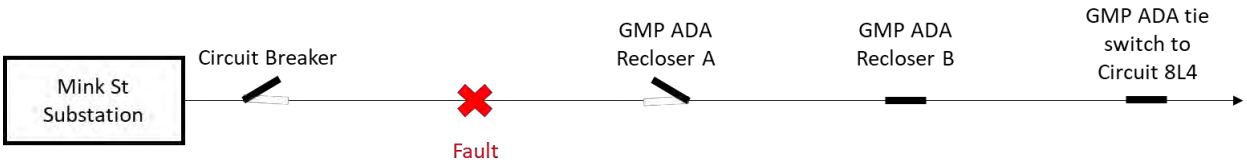
This case study involves GMP ADA devices on National Grid's Mink Street circuit, operated automatically by a FLISR scheme. FLISR schemes are designed to be "self-healing", isolating a fault to a subset of customers and supplying the remaining customers from an adjacent circuit. FLISR schemes, when operating automatically, can restore power in under or close to one minute (the Massachusetts threshold for a sustained outage).

In this case, the GMP ADA FLISR scheme worked as expected, restoring power to 1,755 customers automatically in 38 seconds. Without FLISR, these 1,755 customers would have experienced a sustained outage. The Mink Street circuit has historically had poor reliability, missing state reliability targets for two years in a row. Without the FLISR scheme, which was commissioned in 2022, the Mink Street circuit may have missed its reliability target for a third year.

5.2.1.2. Description

National Grid commissioned the GMP-funded FLISR scheme on Mink Street in October, 2022. Shortly thereafter, on November 26, 2022, a vehicle collided with a pole on a main distribution line causing the circuit breaker to lock out, and power failure for all 2,675 customers served by the Mink Street circuit. The FLISR scheme automatically operated to restore power to 1,755 customers in 38 seconds. The FLISR scheme accomplished this restoration by opening a GMP ADA Recloser ("A" in Figure 24) along the circuit and closing another GMP ADA "tie" switch connecting to a neighboring circuit. This operation isolated the fault to a section of the circuit and supplied two sections of the circuit from an adjacent circuit (Figure 24).

Figure 24: One Line Schematic Diagram of Mink Street Circuit 7L4



Source: Guidehouse analysis of 2022 EDC data

After the automatic FLISR operation was complete, National Grid crews performed repairs and manually restored power to 838 additional customers after 98 minutes. The remaining 82 customers were restored after 323 minutes of repairs. Without the FLISR scheme, all 2,675 customers would have experienced a sustained outage.

5.2.2. National Grid ADA Investment Rapidly Restores Power to Customers in the Town of Beverly

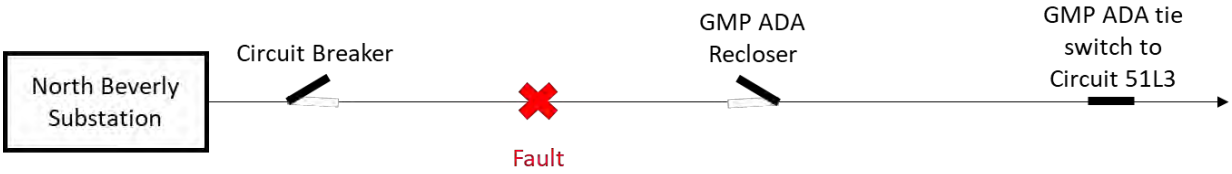
5.2.2.1. Summary Overview

National Grid's GMP-funded ADA devices in Beverly, Massachusetts operated as designed when a thunderstorm hit Massachusetts on July 25, 2022. The GMP-funded FLISR scheme automatically operated ADA devices to restore power to 907 affected customers in 15 seconds. These 907 customers would otherwise have experienced a sustained outage.

5.2.2.2. Description

Massachusetts experienced severe thunderstorms on July 25, 2022. In Beverly, Massachusetts, a tree fell on a main distribution line and caused the circuit breaker to lock open (Figure 25), causing power failure to 1,634 customers served by the North Beverly circuit. The fault triggered the FLISR scheme to automatically operate ADA switches. The GMP ADA Recloser (Figure 25) opened, limiting the outage to a section of the circuit. A GMP ADA tie switch then closed and connected 907 customers to a nearby circuit. These 907 customers were automatically restored in 15 seconds, having been isolated from the fault by the FLISR scheme. The remaining 727 customers in the fault zone were without power for 73 minutes until repairs were completed and the main power supply line was restored.

Figure 25: One Line Schematic Diagram of the 18L2 Circuit in North Beverly



Source: Guidehouse analysis of 2022 EDC data

5.2.3. National Grid ADA Investment Rapidly Restores Power to Customers in the Town of Franklin

5.2.3.1. Summary Overview

National Grid's FLISR operation in Franklin, Massachusetts on October 12, 2022 performed a sophisticated operation, supplying power to three sections of a circuit from three adjacent circuits. In total, the GMP ADA FLISR scheme restored power to 3,048 customers in 52 seconds. 64 customers experienced a sustained outage lasting 91 minutes while crews performed repairs. In the absence of ADA investment, all 3,048 customers would have experienced a sustained outage.

5.2.3.2. Description

3,112 customers lost power in Franklin, Massachusetts on October 12, 2022 just after 11 pm, after animal contact with overhead lines. National Grid had commissioned GMP-funded ADA devices connecting the Franklin circuit to neighboring circuits, adding a redundant supply of power. The ADA-funded FLISR scheme opened reclosers downstream of the fault location,

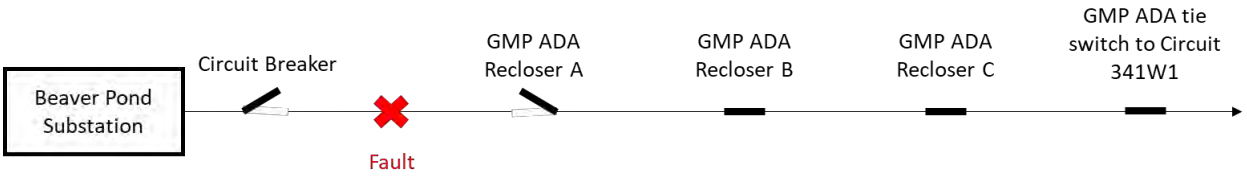
effectively isolating the fault to a subset of customers. The majority of customers were then supplied through an adjacent circuit.

The GMP-funded FLISR scheme performed a sophisticated operation in under one minute, automatically restoring power to three different sections of the circuit. Specifically:

- A circuit section with 1,011 customers was energized in 42 seconds, due to the tie switch closing in Figure 26
- A second section of the circuit with 1,257 customers was energized in 49 seconds due to GMP ADA Recloser C closing in Figure 26
- A third section of the circuit with 780 customers was energized in 52 seconds due to GMP ADA Recloser B closing in Figure 26

The 64 customers in the fault zone where animal contact had occurred were without power for 91 minutes. After crews performed repairs, the circuit was returned to normal conditions.

Figure 26: One Line Schematic Diagram of Circuit 334W5



Note: GMP Devices are in bold with an asterisk (*)
Source: Guidehouse analysis of 2022 EDC data

5.3. Eversource Case Studies

5.3.1. Eversource Uses ADA and M&C for Emergency Response in Springfield

5.3.1.1. Summary Overview

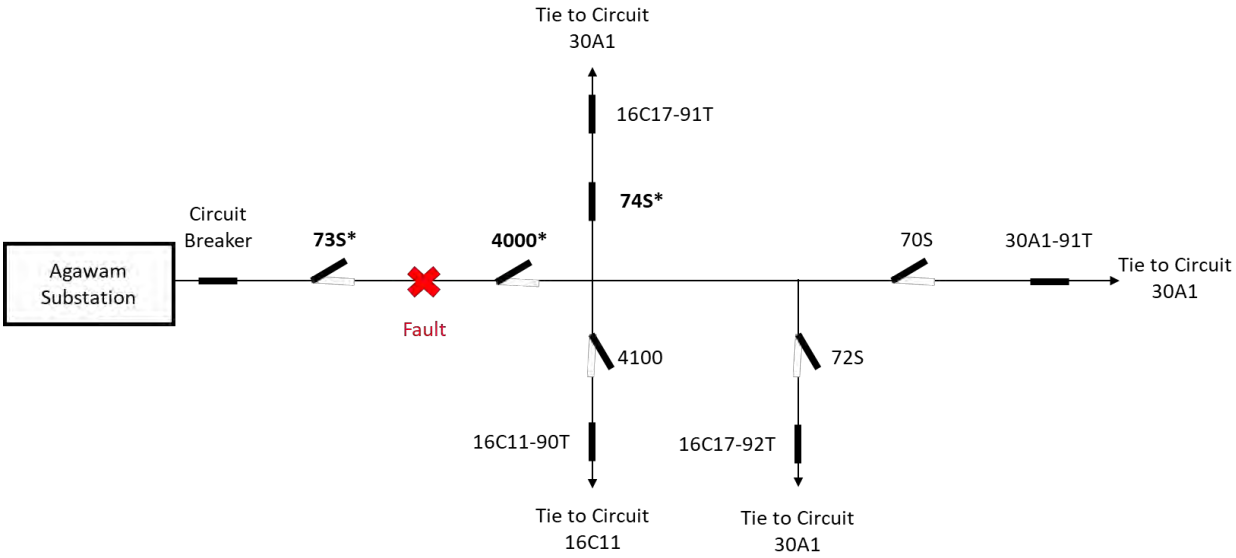
This joint M&C and ADA case study illustrates how ADA and M&C devices can serve different and complementary functions during an outage event. The Eversource ADA loop scheme operated as designed, restoring power to the majority of customers in 52 seconds. The loop scheme supplied power to four sub-sections of the circuit from four different tie switches to adjacent circuits, a sophisticated operation. Then, the Eversource operators used a GMP M&C device to remotely deenergize the damage location.

5.3.1.2. Description

On April 5, 2022 at 12:30pm, a car collided with a pole in Springfield in western Massachusetts. Overhead wires broke and fell to the ground, making the area hazardous. The fault triggered Eversource's ADA loop scheme which automatically opened a recloser, 73S, causing a power failure to all 2,374 customers served by the circuit 16C17. 73S was a GMP ADA-funded sectionalizing recloser (**bold** with an asterisk in Figure 27) that operated as designed in this scenario. Next, the ADA loop scheme rapidly reenergized 2,374 customers in one minute by closing four "tie" switches that connected the circuit to adjacent circuits.

After the initial automated restoration, Eversource operators further responded to the emergency by using GMP-funded M&C capability. They remotely opened the M&C SCADA sectionalizing switch 4000 to deenergize the hazardous area within 9 minutes of the accident, making it safe. Without M&C, it would have taken longer to deenergize the hazardous area manually. Eversource crews performed repairs to the damage location and installed backup generation while repairs were performed. See Figure 27 for a schematic of the devices that operated on circuit 16C17.

Figure 27: One Line Schematic Diagram of Circuit 16C17



Note: GMP Devices are in bold with an asterisk (*)

Source: Guidehouse analysis of 2022 EDC data

5.3.2. Eversource Uses ADA to Reduce Customers Affected by Outage in Deerfield

5.3.2.1. Summary Overview

Eversource's GMP ADA-funded device in Deerfield operated as designed, avoiding a circuit-wide outage and isolating the fault to a subset of customers. Eversource then remotely opened this device to restore a further subset of customers while repairs were ongoing, shortening the duration of the outage.

5.3.2.2. Description

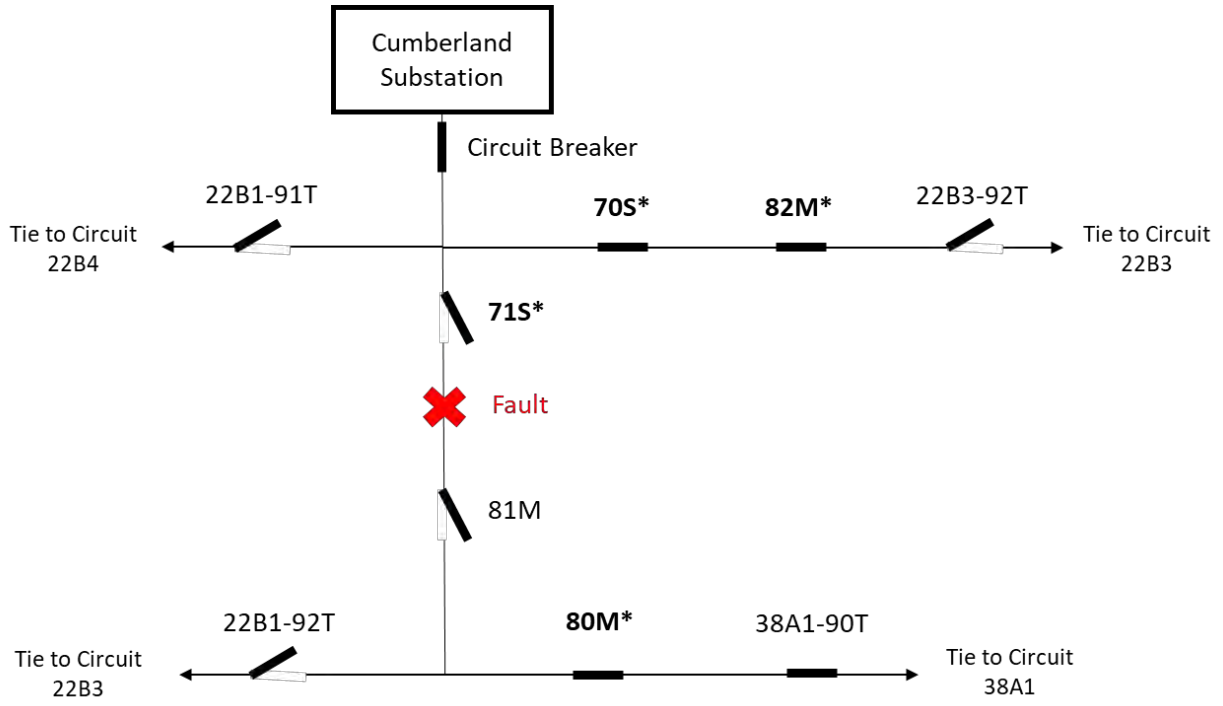
On June 25, 2022 in Deerfield, Massachusetts, a car collided with a pole and damaged overhead distribution lines. Eversource had commissioned an ADA loop scheme on this circuit (22B1). The fault triggered the GMP-funded ADA device 71S to automatically open and isolate the fault. Had the GMP device 71S not opened, the circuit breaker would have locked out, causing a circuit-wide outage to 1,220 customers. In this case, the initial outage was limited to 615 customers.

A few seconds later, the ADA loop scheme automatically opened another sectionalizing switch 81M and closed a "tie" switch. (These devices were not GMP-funded but operated similarly to

GMP ADA devices.) This automatic operation isolated the fault and restored power to 370 customers in one minute.

Eversource crews arrived at the fault location and further isolated the fault by manually opening (lifting) "taps" on either side of the fault. Then, control center operators remotely closed the GMP device 71S to restore another 54 customers after 56 minutes, while repairs were ongoing. Without remote SCADA capability, manual operation would have further delayed restoration for these 54 customers. While 71S was an ADA-funded device, it was operated similar to an M&C device using SCADA control capability.

Figure 28: One-Line Schematic Diagram of Circuit 22B1



Note: GMP Devices are in bold with an asterisk (*)
Source: Guidehouse analysis of 2022 EDC data

5.3.3. Eversource Uses ADA to Rapidly Restore Power to Customers in the City of Agawam

5.3.3.1. Summary Overview

Eversource's automated loop scheme operated as designed during an outage in the city of Agawam, restoring power to 2,130 customers in less than one minute. Three tie switches, one of them a GMP-funded ADA device, restored power automatically in one minute to sections of the circuit by supplying them from nearby circuits.

5.3.3.2. Description

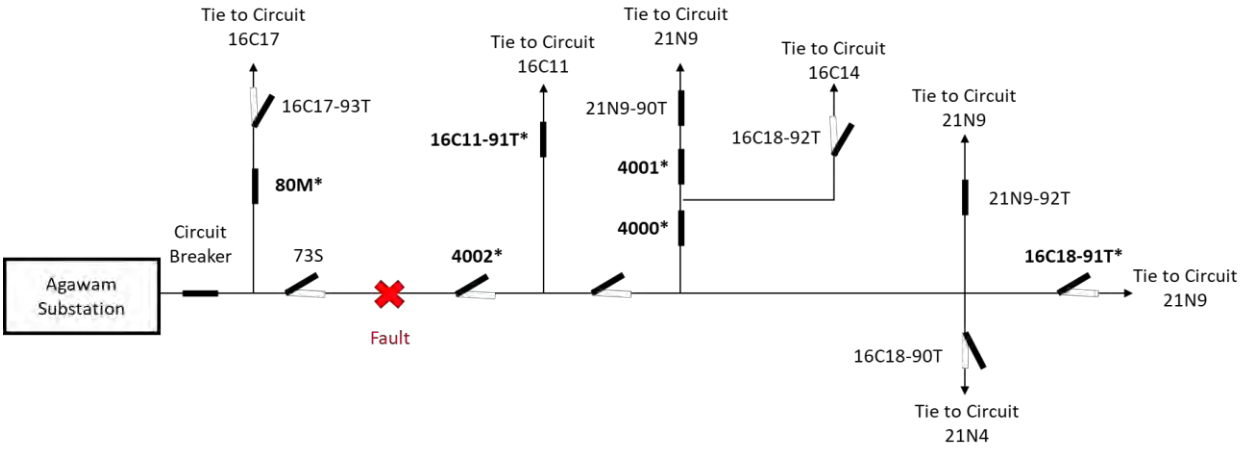
A car collided with a three-phase junction pole in the city of Agawam at 1:39 pm on October 13, 2022. The line damage caused the reclosing switch 73S (see Figure 29) to lock out (open),

triggering the ADA loop scheme to operate on circuit 16C18. The ADA loop scheme automatically and rapidly restored power to 2,130 customers by closing three tie switches (shown in Figure 29):

1. GMP ADA-funded tie switch 16C11-91T closed automatically, restoring power to 292 customers in 44 seconds
2. Tie switch 21N9-90T closed automatically, restoring power to 819 customers in 44 seconds
3. Tie switch 21N9-92T closed automatically, restoring power to 1019 customers in 54 seconds

After Eversource crews arrived on-site, they performed repairs and restored the remaining customers after a sustained outage. Without ADA operation, all affected 2,130 customers would have experienced long duration outages.

Figure 29: One-Line Schematic Diagram of Circuit 16C18



Note: GMP Devices are in bold with an asterisk (*)

Source: Guidehouse analysis of 2022 EDC data

5.3.4. Eversource Uses ADA to Rapidly Restore Power to West Springfield Customers

5.3.4.1. Summary Overview

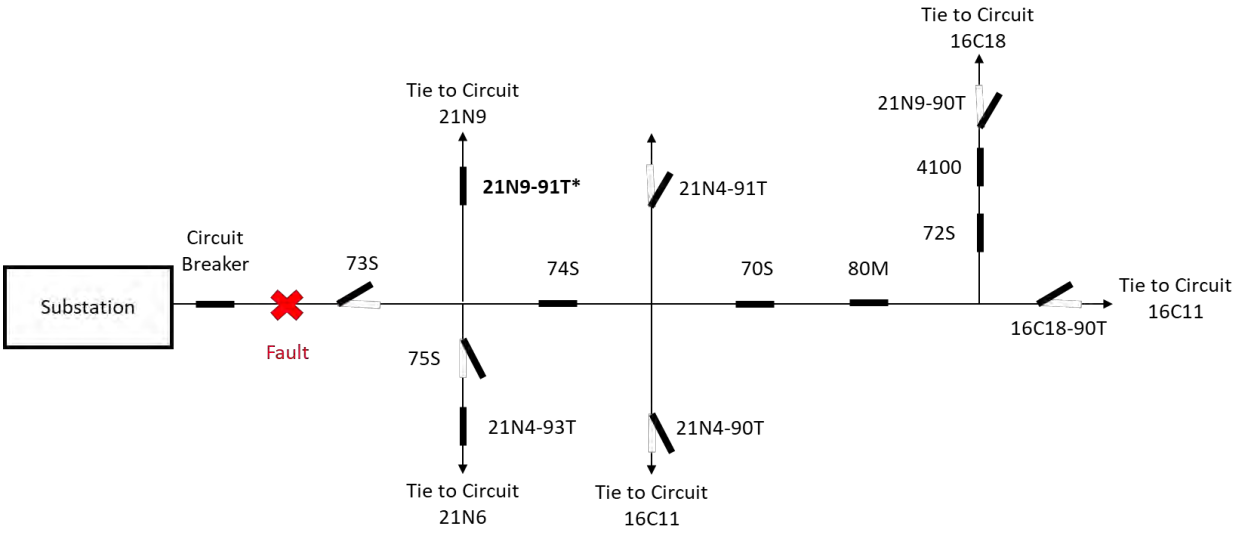
Eversource's ADA loop scheme operated as designed during an outage in West Springfield, Massachusetts. The automated scheme was able to restore power to all 2,223 customers affected by the outage in one minute, such that no customer experienced longer than a one-minute outage.

5.3.4.2. Description

On July 28, 2022, a large tree limb fell on a primary distribution line in West Springfield, Massachusetts. The tree caused line damage, interrupting power supply to all 2,223 customers served by the circuit 21N4. The loss of power triggered the ADA loop scheme to operate

automatically, opening the switch 73S and closing the tie switches 93T and 91T (all identified in Figure 30). These two tie switches, one of them a GMP-funded ADA device, restored power to all customers on the circuit automatically in one minute, such that no customer experienced longer than a one-minute outage. Without the automatic operation, these customers would have experienced a longer outage.

Figure 30: One-Line Schematic Diagram of Circuit 21N4



Note: GMP Devices are in bold with an asterisk (*)

Source: Guidehouse analysis of 2022 EDC data

6. Findings and Recommendations

Overall major takeaways from the PY 2022 ADA evaluation are provided below.

1. Both Eversource and National Grid circuits with ADA investment showed lower (improved) outage duration on average relative to the baseline (based on the defined metric) for non-EME days. For EME days, National Grid circuits with ADA investment also showed improved outage duration on average when compared to baseline years; however, for Eversource, this metric was worse than baseline.
    - Recommendation: Continue investment in this technology, but continue to monitor and try to verify the impacts (noting that the defined metric does not paint a complete picture as has been previously observed) on circuits receiving Term 2 investments as well as those that have received Term 1 investment (to understand the longer term impacts of the investments over time).

2. Both Eversource and National Grid circuits with ADA investment showed lower (improved) outage frequency on average relative to the baseline (based on the defined metric) for non-EME days. For EME days, National Grid circuits with ADA investment also showed improved outage duration on average when compared to baseline years; however, for Eversource, this metric was worse than baseline.
    - Recommendation: Continue investment in this technology approach, but continue to monitor and try to verify the impacts (noting that the defined metric does not paint a complete picture as has been previously observed) on circuits receiving Term 2 investments as well as those that have received Term 1 investment (to understand the longer term impacts of the investments over time).

3. Eversource ADA schemes are operating as designed in the majority of cases observed. In these cases, the schemes are able to restore power rapidly and automatically to multiple sections of a circuit. Eversource automated ADA operations typically take just under or just over one minute.
    - Recommendation: Eversource may consider fine-tuning ADA schemes to complete more operations in under (rather than just over) one minute. Outages under one minute are considered momentary and do not count towards SAIFI and SAIDI in Massachusetts. While this change would make minimal difference to customer experience, it would make a difference to Eversource's reliability performance metrics.
    - Recommendation: Eversource should consider ADMS-based FLISR for faster operation and restoration.
    - Recommendation: continue to explore case studies for Term 1 investments to validate operation.

4. Guidehouse observed a few instances where Eversource ADA schemes did not operate as expected, due to devices not operating or miscoordination. Eversource has a follow-up tracking system in place to address the issues observed in these cases.
    - Recommendation: Eversource should continue to monitor and follow up on each instance where ADA schemes did not perform the FLISR operation as designed.

5. National Grid's ADA FLISR schemes are operating as designed and proving effective in rapidly restoring power to customers after fault occurrence. In many cases, a few of which are highlighted in case studies, FLISR schemes have automatically restored power to customers in less than one minute (the Massachusetts threshold for a sustained outage).
    - Recommendation: National Grid should continue to evaluate more locations for ADA FLISR deployment.
    - Recommendation: continue to explore case studies for Term 1 investments to validate operation. Also, consider case studies for Term 2 investments to validate and verify their operation.

6. National Grid's ADA FLISR schemes are sophisticated in their ability to restore two or more sections of a circuit simultaneously, coordinating the operation of multiple (four or more) devices.

7. When designing the ADA FLISR schemes, National Grid has taken measures including reconductoring and circuit upgrades, which allow neighboring circuits to "carry" additional load during emergencies. Guidehouse observed one case where FLISR did not operate because a load transfer operation would have overloaded the rating of an asset.
    - Recommendation: National Grid should evaluate whether further system upgrades may be justified to allow load transfer in emergencies.

8. Guidehouse observed one instance where a National Grid ADA scheme operated as designed, but due to the location of the fault no customers were restored.
    - Recommendation: National Grid should evaluate the potential for further circuit sectionalization to reduce customer zone size.

9. The CKAIDI and CKAIFI reliability related Performance Metrics as defined have deficiencies in measuring the effectiveness of Grid Modernization Investments. These items have been pointed out as recommendations in Evaluation Reports from prior program years, and so the details are not repeated here. The case study approach addresses some of these shortcomings.
    - Recommendation: Continue to track these Performance Metrics, but also continue to perform case studies (for Term 1 and Term 2 investments as appropriate, as mentioned above) and explore other methods of isolating the

specific impacts of Grid Modernization investments (e.g., frequency of device operations). [55,56]

[55] The EDCs do have additional reliability metrics that are being tracked: National Grid has the *Mainline Customer Minutes of Interruption Saved* metric (PM-NG1), and Eversource has the *Protective Zone Average Zone Size per Circuit* metric (PM-ES2), which provide additional information about reliability performance. However, neither of these metrics directly isolates and measures the investments' performance impact on customer reliability vis a vis other factors that may impact reliability.

[56] We are aware that the EDCs are actively exploring additional methods to isolate reliability benefits. For reference, National Grid conducted additional analysis to understand how Grid Modernization investments are influencing system reliability and provided findings from this analysis within its 2022 GMP Annual Report filed April 24, 2023 under DPU docket 23-30.