Massachusetts Grid Modernization Program Year 2022 Evaluation Report: Monitoring and Control (M&C)

Massachusetts Electric Distribution Companies

Submitted by:

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Reference No.: 219514
June 30, 2023

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Introduction

As a part of the Grid Modernization Plan (GMP), the Massachusetts Electric Distribution Companies (EDCs) are investing to enable Monitoring and Control (M&C) on selected circuits across their distribution networks. These investments should enhance grid visibility and control capabilities to increase reliability, facilitate integration of DERs, and provide other grid and customer benefits.

This evaluation focuses on the progress and effectiveness of each EDC's preauthorized M&C investments toward meeting the Department of Public Utilities (DPU) 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 an 1) 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 M&C evaluation by EDC.

[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.

Table 1. M&C Evaluation Metrics

Type	M&C Evaluation Metrics	ES	NG	UTL
IM-4	Number of Devices or Other Technologies Deployed and In Service	✓	✓	✓
IM-5	Cost for Deployment	✓	✓	✓
IM-6	Deviation Between Actual and Planned Deployment for the Plan Year	✓	✓	✓
IM-7	Projected Deployment for the Remainder of the GMP Term	✓	✓	✓
PM-11	Grid Modernization Investments' Effect on Outage Durations	✓	✓	✓
PM-12	Grid Modernization Investments' Effect on Outage Frequency	✓	✓	✓
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 M&C 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 M&C evaluation for PY 2022. Section 3.1.1 details each of the data sources.

Table 2. M&C 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

Table 3 summarizes the Term 1 Infrastructure Metrics results for each EDC's M&C 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. Term 1 M&C Infrastructure Metrics Summary

Infrastructure Metrics			Eversource
GMP Plan Total, PY 2018-2022		Devices	560
		Spend, $M	$67.82
IM-4	Number of devices or other technologies deployed PY 2018-2022*	# Devices Deployed***	558
		% Devices Deployed	100%
IM-5	Cost for Deployment PY 2018-2022*	Total Spend, $M	$64.29
		% Spend	95%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	96%
		% On Track (Spend)	59%
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 each EDC's M&C Investment Area through PY 2022.

Table 4. Term 2 M&C Infrastructure Metrics Summary

Infrastructure Metrics			Eversource	National Grid**	Unitil
GMP Plan Total, PY 2022-2025		# Devices Planned	249	128	5
		Spend, $M	$65.80	$4.14	$1.28
EDC Data Total, PY 2022-2025		# Devices Planned	249	106	6
		Spend, $M	$65.12	$4.14	$1.18
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed	0	10	0
		% Devices Deployed	0%	8%	0%
IM-5	Cost for Deployment thru PY 2022	Total Spend, $M	$1.93	$0.97	$0.10
		% Spend	3%	23%	8%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	0%	31%	0%
		% On Track (Spend)	12%	99%	13%
IM-7	Projected Deployment for the Remainder of the Term	# Devices Remaining	249	96	6
		Spend Remaining, $M	$63.19	$3.17	$1.08

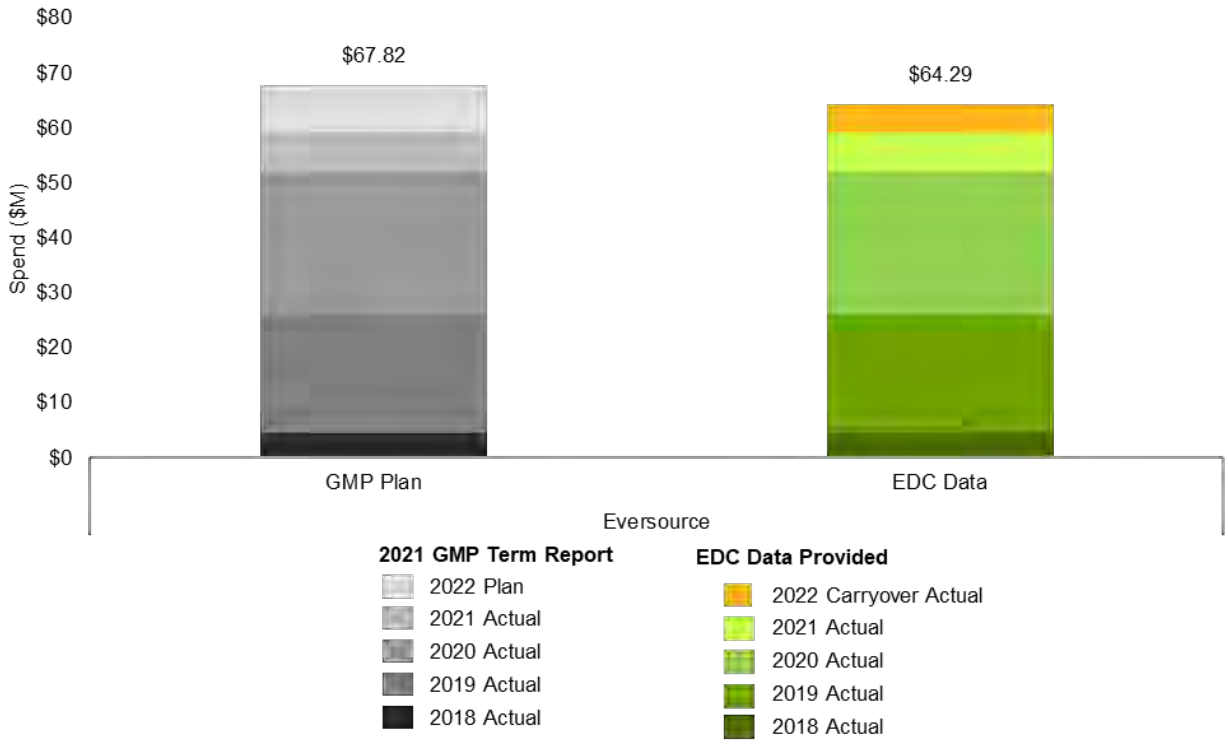
*Note that "Deployed" here refers to commissioned devices. For full definitions of deployment stages, see Docket 20-46 Response to Information Request DPU-AR-4-11, September 3, 2020.

** 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

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

Figure 1. M&C Term 1 Spend Comparison (2018-2022, $M)

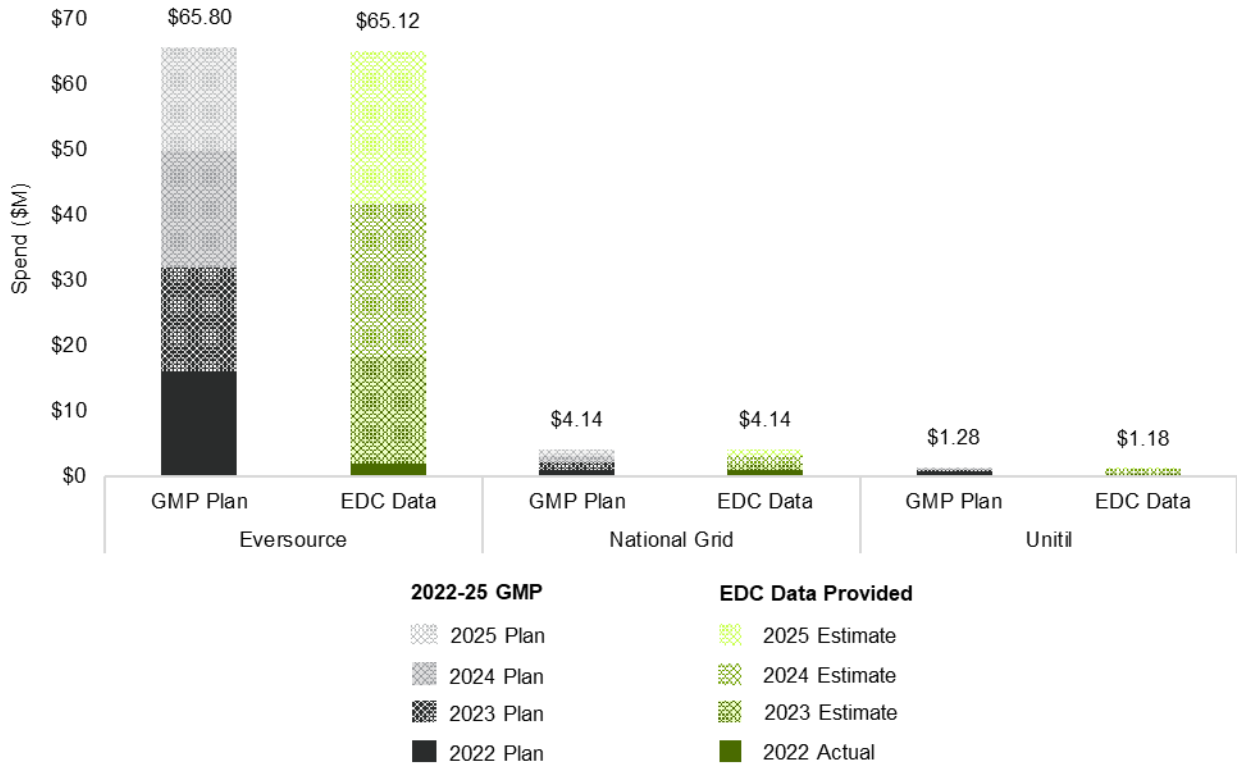


Note: Includes the Eversource planned spend on activity from 2021 that was transferred to 2022, set forth in Eversource's 2021 GMP Term Report, filed on April 1, 2022.

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 for each EDC.

Figure 2. M&C 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 M&C deployment evaluation for each EDC.

Table 5. Summary of Infrastructure Metrics Findings for M&C Investment Area

EDC	Summary of Findings
Eversource	• Across all device types, Eversource's Term 1 device deployment through PY 2022 (Table 33, IM-4) aligned closely with their 2022 GMP Plan (within ~3%), with only 4 kV Circuit Breaker SCADA tracking below plan. • Eversource Term 1 deployment costs were ~10% under planned spend for Microprocessor Relays, and only ~2% over plan spend for 4 kV Circuit Breaker SCADA. • No Term 2 device deployment and very little spend occurred for Eversource in PY 2022.

EDC	Summary of Findings
National Grid	• National Grid's M&C progress is behind PY 2022 plans, due largely to the vendor discontinuing the feeder monitor model, requiring the identification of a new vendor. National Grid has revised plans for the remainder of Term 2 in order to meet deployment goals.
Unitil	• Unitil's M&C progress in PY 2022 is behind plans as a result of long-lead procurement delays, Unitil's re-evaluation of the OMS/AMI integration process, as well as certain deployment plans being on hold until the late 2022 DPU approval of 2022-2025 GMPs. Considering this delay, Unitil plans to deploy unspent PY 2022 funds in 2023 - 2025 to continue work on both substation SCADA retrofit and OMS/AMI integration.

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 M&C 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 2021 results are summarized for both system-wide circuits and M&C circuits. The Unitil metric of Customer Minutes Saved per Outage was not analyzed as the AMI-OMS integration is not complete.

Table 6. M&C Performance Metrics Summary: CKAIDI

Eversource M&C	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	369	369	2,284	2,284	369	369
Total Circuits with Non-zero Customers	1,443	1,443	247	247	1,443	1,443	247	247
% Zero CKAIDI	19%	19%	21%	21%	27%	33%	30%	35%
Average CKAIDI	128	103	95	89	177	74	75	61
Simple Avg. CKAIDI	97	78	80	76	147	62	64	49
Change from Baseline (Baseline - Plan Year)					-49	29	20	28
% Change from Baseline					-38%	28%	21%	31%
Std. Dev.	146	115	102	87	358	101	94	80

National Grid M&C	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	136	136	1,141	1,141	136	136
Total Circuits with Non-zero Customers	816	816	114	114	816	816	114	114
% Zero CKAIDI	2%	3%	0%	1%	16%	17%	4%	6%
Average CKAIDI	226	112	175	108	140	100	174	134
Simple Avg. CKAIDI	206	107	175	102	131	95	168	128
Change from Baseline (Baseline - Plan Year)					86	12	1	-25
% Change from Baseline					38%	11%	1%	-23%
Std. Dev.	264	86	167	65	165	109	165	135

Unitil M&C	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	44	44	11	11	44	44	11	11
Total Circuits with Non-zero Customers	30	30	9	9	30	30	9	9
% Zero CKAIDI	0%	3%	0%	11%	17%	17%	22%	22%
Average CKAIDI	146	56	206	69	61	48	112	112
Simple Avg. CKAIDI	148	55	192	62	55	44	77	77
Change from Baseline (Baseline - Plan Year)					86	8	94	-44
% Change from Baseline					59%	15%	46%	-63%
Std. Dev.	96	36	61	43	65	62	82	82

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

Source: Guidehouse analysis of 2022 GMP Annual Reports Appendix 1

Table 7. M&C Performance Metrics Summary: CKAIFI

Eversource M&C	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	369	369	2,284	2,284	369	369
Total Circuits with Non-zero Customers	1,443	1,443	247	247	1,443	1,443	247	247
% Zero CKAIFI	19%	19%	21%	21%	27%	33%	30%	35%
Average CKAIFI	0.98	0.92	0.83	0.82	1.22	0.91	0.86	0.71
Simple Avg. CKAIFI	0.68	0.64	0.62	0.61	0.92	0.63	0.64	0.50
Change from Baseline (Baseline - Plan Year)					-0.24	0.01	-0.03	0.11
% Change from Baseline					-25%	1%	-4%	13%
Std. Dev.	0.76	0.70	0.60	0.58	1.28	0.99	0.93	0.79

National Grid M&C	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	136	136	1,141	1,141	136	136
Total Circuits with Non-zero Customers	816	816	114	114	816	816	114	114
% Zero CKAIFI	2%	3%	0%	1%	16%	17%	4%	6%
Average CKAIFI	1.02	0.92	1.01	0.93	1.04	0.91	1.39	1.21
Simple Avg. CKAIFI	0.88	0.79	0.89	0.83	0.87	0.77	1.29	1.13
Change from Baseline (Baseline - Plan Year)					-0.02	0.01	-0.39	-0.28
% Change from Baseline					-2%	1%	-38%	-30%
Std. Dev.	0.65	0.60	0.56	0.52	1.03	0.89	1.12	0.97

Unitil M&C	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	44	44	11	11	44	44	11	11
Total Circuits with Non-zero Customers	30	30	9	9	30	30	9	9
% Zero CKAIFI	0%	3%	0%	11%	17%	17%	22%	22%
Average CKAIFI	1.55	0.87	2.07	1.02	0.97	0.61	1.32	1.32
Simple Avg. CKAIFI	1.62	0.87	2.12	0.99	0.88	0.56	0.91	0.91
Change from Baseline (Baseline - Plan Year)					0.58	0.25	0.75	-0.30
% Change from Baseline					38%	29%	36%	-29%
Std. Dev.	0.86	0.54	0.65	0.63	1.10	0.67	0.82	0.82

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

Source: Guidehouse analysis of 2022 GMP Annual Reports Appendix 1

Table 8 summarizes key findings related to Guidehouse's M&C Performance Metrics evaluation for each EDC.

Table 8. Summary of Performance Metrics Findings for M&C Investment Area

PM	Eversource	National Grid	Unitil
PM-12: Grid Modernization investments' effect on outage durations	Outage duration for M&C circuits w/o EMEs for PY 2022 decreased compared to baseline.*	Outage duration for M&C circuits w/o EMEs for PY 2022 increased compared to baseline.*	Outage duration for M&C circuits w/o EMEs increased compared to baseline.*
PM-13: Grid Modernization investments' effect on outage frequency	Outage frequency for M&C circuits w/o EMEs for PY 2022 was lower than baseline.*	Outage frequency for M&C circuits w/o EMEs for PY 2022 was higher than baseline. *	Outage frequency for M&C circuits w/o EMEs for PY 2022 increased from baseline.*
PM-UTL1: Customer Minutes of Outage Saved per Circuit	N/A – Unitil specific metric	N/A – Unitil specific metric	The OMS/AMI Integration is not complete; this metric cannot yet be evaluated.

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

Source: Guidehouse Analysis

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

1. On non-EME days, Eversource circuits with M&C investment showed lower (improved from baseline) average outage duration, whereas National Grid and Unitil circuits with M&C showed slightly higher (worse) average outage duration. Including EME days, Eversource, National Grid and Unitil performed better than baseline.
    - Recommendation: continue tracking and monitoring this investment area to 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). Case studies (discussed below) can provide additional insight.

2. On non-EME days, Eversource circuits with M&C investment showed lower (improved from baseline) average outage frequency, whereas National Grid and Unitil circuits with M&C showed slightly higher (worse) average outage frequency. Including EME days, Eversource and National Grid both performed slightly worse than baseline, and Unitil slightly better.
    - Recommendation: continue tracking and monitoring this investment area to 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). Case studies (discussed below) can provide additional insight.

3. Based on case studies performed, the M&C investment is yielding reliability and service delivery benefits to customers of each of the EDCs.

- 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.

4. National Grid is using M&C devices for load balancing, enhancing the penetration of DERs, and deferring capital upgrades. These functions are directly serving the Department's objectives for Grid Modernization by improving the efficiency of power delivery and facilitating DER interconnections.

5. For National Grid, the evaluation process validated that the feeder monitor sensor investment improves situational awareness, but at this time the impact on reducing outage duration or number of customers affected during an outage is not clear. This finding was made previously, but bears repeating.
   - Recommendation for National Grid: Develop programs to use the feeder monitor sensors to identify and review momentary outages to predict causes which could mitigate future outages.

6. Unitil is increasingly utilizing substation M&C SCADA capability and incorporating SCADA in work processes. In PY 2022, Unitil used GMP M&C capability to remotely restore power to customers, but did not use M&C for outage notification, as seen in Case Study 5.4.1. In PY 2023, Unitil is using GMP M&C for outage restoration as well as outage notification (as seen in Case Study 5.4.2 where outage start time is based on SCADA outage notification time). This should add beneficial impacts.

7. Since Unitil's M&C investments are focused on the substation, circuit power restoration work is still predominantly manual, as evident in the two Unitil case studies.
   - Recommendation for Unitil: evaluate the benefits and costs of M&C and automation investments outside the substation.

8. 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 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 successful device operation).[12]

[12] 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 Monitoring and Control (M&C) Investment Area and specific M&C 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[13] regarding the individual Grid Modernization Plans (GMPs) filed by the three Massachusetts EDCs.[14,15] 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[16] 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:

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

[14] 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.

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

[16] 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.[17] The budget extension, approved by the DPU on February 4, 2021,[18] included $14 million for ADA, $16 million for ADMS/ALF, $5 million for Communications, $15 million for M&C, and $5 million for VVO.[19] These values are included in the Eversource total budget by Investment Area in Table 9.

Table 9. 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[20] 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

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

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

[19] 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.

[20] 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).

as Term 2).[21] In these plans, the EDCs outlined continued investment in the areas that received 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 10 and Table 11 summarize the DPU pre-authorized GMP investments.

Table 10. 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

[21] 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.

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

Table 11. 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[22] and November 30, 2022, [23] 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

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

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

preauthorized track one budget is $9.1 million with VVO making up more than 50% ($5.4 million).

Table 12. 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.[24] 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 13 summarizes the Infrastructure Metrics.

Table 13. 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

[24] 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-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
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[25]

1.1.5.2 Performance Metrics

The Performance Metrics assess the performance of all the GMP investments. Table 14 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 14. 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

[25] 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-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
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

Metric		Description	Applicable IAs	Metric Responsibility*
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
PM-UTL1	**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.[26]

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 M&C Investment Area Overview

As a part of the grid modernization efforts, the EDCs are making investments to advance their M&C capabilities and enhance network visibility, with the goal of delivering optimized system

[26] 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

performance, higher reliability, and greater DER integration. Table 15 summarizes the preauthorized budget for the M&C Investment Area for the first and second GMP terms.

Table 15. GMP Preauthorized Budget for M&C, $M

Period	Eversource	National Grid	Unitil	Total
Term 1 (2018 – 2021)	$56.00	$8.00	$0.35	**$64.75**
Term 2 (2022 – 2025)	$76.30	$4.10	$1.10	**$81.50**

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

1.2.1 EDC Approach to M&C

Each EDC has a unique approach to their M&C Investment Area. Through Term 1, Eversource and Unitil were focused on expanding SCADA on substations and distribution networks, while National Grid had focused on deploying feeder monitors on its distribution network. Unitil had an additional investment focused on integrating its advance metering infrastructure (AMI) data with its outage management system (OMS).

Moving into Term 2, Eversource elected to continue its investment in both substation automation and Power Quality Monitoring, with National Grid continuing its deployment of mainline feeder monitors and Unitil continuing its AMI-OMS integration and further deploying its SCADA on substations and reclosers.

Table 16 defines the devices and technologies that each EDC has deployed as part of M&C investment. Sections 3 (Infrastructure Metrics), 4 (Performance Metrics), and 5 (Case Studies) below discuss specifics related to each EDCs' goals and objectives in the M&C Investment Area, while Section 2 below explains the evaluation process.

Table 16. Devices and Technologies Deployed Under M&C Investment

EDC	Device/ Investment Type	Description	Term
Eversource	Microprocessor relays*	Includes advanced overcurrent protection, pushbutton controls for the breakers, safety hot line tagging, reclosing, breaker failure, and under-frequency load-shedding schemes.	1 2
	4 kV Circuit Breaker SCADA*	Provides real-time visibility to loading conditions on the 4 kV circuits that are among the most heavily loaded on Eversource's distribution system.	1 2
	Recloser SCADA	Addition of communications capability so the device can be centrally monitored and controlled from the dispatch center.	1
	Padmount Switch SCADA	Addition of a radio package to enable communications and central monitoring.	1
	Network Protector SCADA	Provides real-time network load data and additional telemetric information.	1
	Power Quality Monitors	Provides remote access and storage of power quality meter data for Eversource system planning, protection, and controls engineering to evaluate disturbance events and share information with customers.	1 2
National Grid	Feeder Monitors	Installation of interval power monitoring devices on feeders where National Grid does not have distribution information.	1 2
Unitil	Substation SCADA	The installation and interconnection of a SCADA terminal unit at the site, the establishment of communications between the terminal unit and the remotely located SCADA master system, and the associated programming to implement desired functions.	1 2
	Recloser SCADA	Addition of communications capability so the device can be centrally monitored and controlled from the dispatch center.	1 2
	AMI-OMS Integration	The deployment of software that analyzes AMI status changes and relevant data points, detects suspect outages, and reports them as such to the OMS.	1 2

***** Within Term 2, Microprocessor relays and 4 kV Circuit Breaker SCADA are aggregated and reported together as "Substation Automation"

Source: Guidehouse

1.3 M&C Evaluation Objectives

This evaluation focuses on the progress and effectiveness of the DPU preauthorized M&C investments for each EDC toward meeting the DPU's grid modernization objectives. Table 17 illustrates the key Infrastructure Metrics and Performance Metrics relevant for the M&C evaluation.

Table 17: M&C Evaluation Metrics

Type	M&C Evaluation Metrics	ES	NG	UTL
IM	System Automation Saturation*	✓	✓	✓
IM	Number and Percent of Circuits with Installed Sensors*	✓	✓	✓
IM	Number of Devices or Other Technologies Deployed and In Service	✓	✓	✓
IM	Cost for Deployment	✓	✓	✓
IM	Deviation Between Actual and Planned Deployment for the Plan Year	✓	✓	✓
IM	Projected Deployment for the Remainder of the 4-Year** Term	✓	✓	✓
PM	Grid Modernization Investments' Effect on Outage Durations	✓	✓	✓
PM	Grid Modernization Investments' Effect on Outage Frequency	✓	✓	✓
Other	Case Studies***	✓	✓	✓

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

* Denotes that generating the metric is EDC responsibility

** Note that the original 3-year term was extended to a 4-year term by the DPU in 2020.

*** 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 M&C investments.

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

The EDCs provided the data supporting the Infrastructure Metrics and Performance Metrics to the evaluation team. Section 3 through Section 5 present the results from the analysis of Infrastructure Metrics, Performance Metrics, and case study analysis. The Infrastructure Metrics analysis measures whether the investments are taking place on the projected schedule and budget. The Performance Metrics analysis provides 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 18 summarizes the M&C evaluation objectives and associated research questions. The scope of the M&C evaluation includes tracking the M&C infrastructure deployment against the plan and evaluating the impact on system reliability.

Table 18. M&C Evaluation Objectives and Associated Research Questions

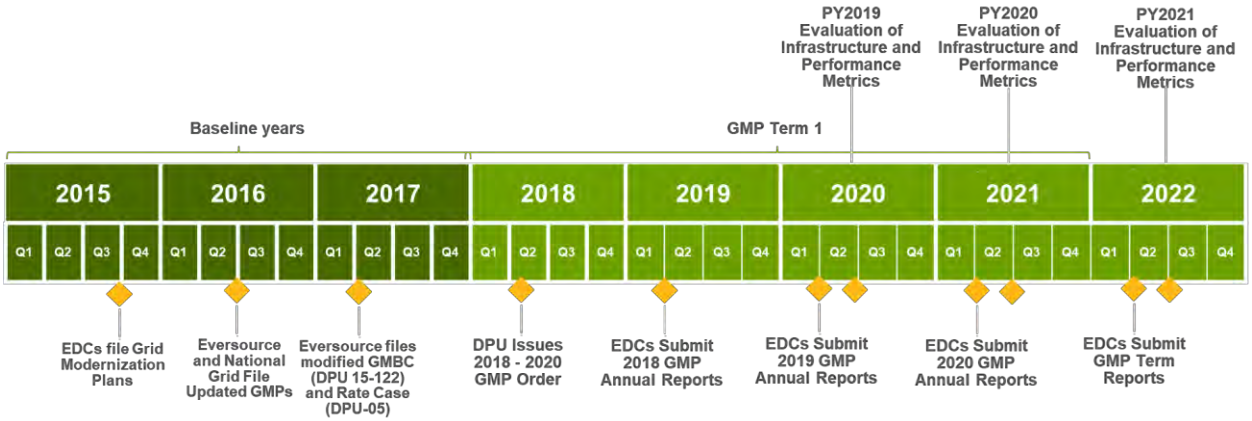
Associated Research Questions	IM	PM
1) Are the EDCs progressing in deployment of their M&C investments according to their GMPs?	✓	
2) What factors, if any, are affecting the deployment schedule of M&C equipment?	✓	
3) What is the cost of deploying various types of M&C equipment, including SCADA retrofits and microprocessor relays?	✓	
4) What is the effect of M&C investments on key reliability metrics, such as SAIDI and SAIFI?		✓

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

2. M&C Evaluation Process

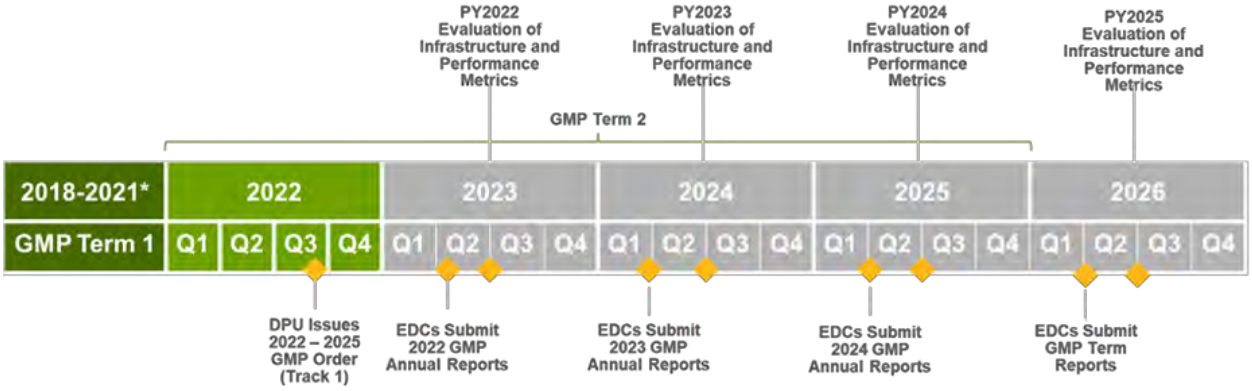
This section presents a high-level overview of the Guidehouse methodologies for the evaluation of Infrastructure and Performance Metrics as well as Case Studies. Figure 3 highlights the Term 1 filing background and timeline of the GMP Order and the evaluation process, and Figure 4 indicates the expected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

Figure 3. M&C Evaluation Timeline Term 1



Source: Guidehouse review of the DPU orders and GMP process

Figure 4. M&C Evaluation Timeline Term 2



Note: M&C Evaluation Timeline for Term 2 does not incorporate Term 1 evaluations in PY 2022
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 M&C devices and technologies on their feeders. Table 19 and Table 20 highlight the evaluated Infrastructure Metrics and their associated calculation parameters for both terms.

Table 19. 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	$\frac{\sum_{PY=2018}^{2021}(Devices\ Commissioned)_{PY} + Devices\ Commissioned_{CY2022(T1)}}{\sum_{PY=2018}^{2021}(Devices\ Commissioned)_{PY} + (Planned\ Devices)_{CY2022(T1)}}$
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 20. Term 2 Infrastructure Metrics Overview – All EDCs

Infrastructure Metrics			Calculation
IM-4	Number of devices or other technologies deployed thru. PY 2022	# Devices Planned	$(Devices\ Commissioned)_{PY2022}$
		% 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	$(Actual\ Spend)_{PY2022}$

Infrastructure Metrics			Calculation
		% Spend	$\frac{(Actual\ Spend)_{PY2022}}{\sum_{PY=2022}^{2025}(Planned\ Spend)_{PY}}$
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 below provides the results from the evaluation of Infrastructure Metrics. To evaluate Infrastructure Metrics, Guidehouse:

- Reviewed the data provided by the EDCs to confirm their progress through PY 2022 and to assess their progress against planned deployment and spend outlined in prior GMP filings (see Section 3.1.2, “Data QA/QC Process”)
- Interviewed representatives from each EDC to understand the status of the M&C investments, including:
    - Updates to their planned M&C 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 21 describes the Performance Metrics included in the PY 2022 evaluation.

Table 21. M&C Performance Metrics Overview

Performance Metric		EDC	Description
PM-12	Grid Modernization Investments’ Effect on Outage Durations	All	Provides insight into how M&C investments can reduce outage durations (CKAIDI). Compares the experience of customers on GMP M&C-enabled circuits as compared to the previous three-year average for the same circuit.
PM-13	Grid Modernization Investments’ Effect on Outage Frequency	All	Provides insight into how M&C investments can reduce outage frequencies (CKAIFI). Compares the experience of customers on M&C-enabled circuits with the prior three-year average for the same circuit.

Performance Metric		EDC	Description
PM-UTL1	Customer Minutes of Outage Saved per Circuit	UTL	Tracks time savings from faster AMI outage notification than customer outage call, leading to faster outage response and reduced customer minutes of interruption.

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 including storm conditions. This is especially likely if the device has less than several full years of operation to affect the metric. The case studies help to 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. 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.

The team performed six case studies for the M&C evaluation: two for Eversource, two for National Grid and two for Unitil. Section 5 examines the details of the analysis and the results.

3. M&C Infrastructure Metrics

Assessment of the Infrastructure Metrics included Infrastructure Metric data collection and QA/QC, assessment of M&C deployment progress for each EDC, and determination of conclusions 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*[27,28,29], 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 22 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 22. 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

[27] 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.
[28] 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.
[29] 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 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).[30] 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 23 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 23. 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.

[30] 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 24 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. [31,32,33] The evaluation team confirmed the consistency of the data from the various sources and reconciled any differences.

Table 24. 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 25 and Table 26 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.

[31] 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.
[32] 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.
[33] 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 25. 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 26. 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 M&C Investment Area in the following subsections.

3.2.1 Statewide Comparison

This section discusses the anticipated scope of M&C 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, M&C investments have impacted about 18% of total EDC customers and 13% of feeders. Table 27 summarizes the number of feeders and customers covered by GMP M&C investments spanning 2018 through 2022.

Table 27. Number of Massachusetts Feeders and Customers Covered by M&C Investment

M&C Impact	Eversource		National Grid		Unitil	
	Feeders	Customers	Feeders	Customers	Feeders	Customers
Systemwide Total	2,284	1,352,952	1,126	1,327,260	33	30,607
2018-2022 Commissioned	304	242,196	140	231,698	11	10,295
% System Total	13%	18%	12%	17%	33%	34%

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

3.2.1.2 Term 1 Infrastructure Metrics Results

At the request of Eversource, Guidehouse provided analysis of Eversource's Term 1 spend and deployment. Table 28 summarizes the Infrastructure Metrics results for Eversource's M&C Investment Area through PY 2022. Subsequent sections explain each EDC's progress and plans in greater detail.

Table 28. Term 1 2022 Infrastructure Metrics for M&C

Infrastructure Metrics			Eversource
GMP Plan Total, PY 2018-2022*		# Devices Planned	560
		Spend, $M	$67.82
IM-4	Number of devices or other technologies deployed thru PY 2018-2022*	# Devices Deployed***	558
		% Devices Deployed	100%
IM-5	Cost for Deployment thru PY 2018 – 2022*	Total Spend, $M	$64.29
		% Spend	95%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	96%
		% On Track (Spend)	59%
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.

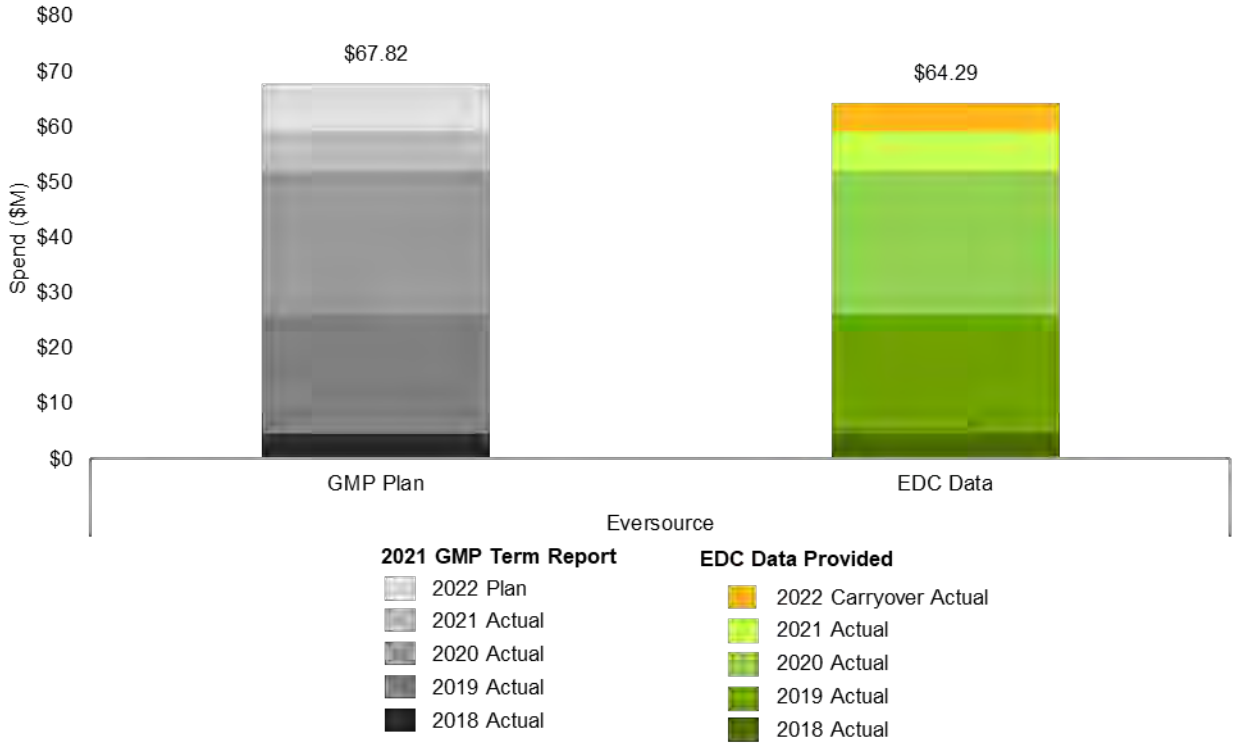
Source: Guidehouse analysis of 2021 GMP Term Reports and 2022 EDC Data

Actual device deployment in PY 2022 was on target and spend was lower than planned for Eversource, primarily due to savings associated with work completed by internal field engineering rather than by contracted resources.

Eversource total units deployment over the 4-year Term closely matched plan. Total spend over 4-year Term was slightly below plan (see IM-4 and IM-5 in Table 33).

Figure 5 compares planned versus actual spend on M&C for Eversource.

Figure 5. Term 1 M&C Spend Comparison (2018-2022, $M)



Note: Includes the Eversource planned spend on Term 1 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

3.2.1.3 Term 2 Infrastructure Metrics Results

Table 29 summarizes the Infrastructure Metrics results for each EDC's M&C Investment Area through PY 2022. Subsequent sections explain each EDC's progress and plans in greater detail.

Table 29. Term 2 2022 Infrastructure Metrics for M&C

Infrastructure Metrics		Eversource	National Grid**	Unitil
GMP Plan Total, PY 2022-2025	# Devices Planned	249	128	5
	Spend, $M	$65.80	$4.14	$1.28
EDC Data Total, PY 2022-2025	# Devices Planned	249	106	6
	Spend, $M	$65.12	$4.14	$1.18
IM-4	# Devices Deployed	0	10	0

Infrastructure Metrics			Eversource	National Grid**	Unitil
	Number of devices or other technologies deployed thru PY 2022	% Devices Deployed	0%	8%	0%
IM-5	Cost for Deployment thru PY 2022	Total Spend, $M	$1.93	$0.97	$0.10
		% Spend	3%	23%	8%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	0%	31%	0%
		% On Track (Spend)	12%	99%	13%
IM-7	Projected Deployment for the Remainder of the Term	# Devices Remaining	249	96	6
		Spend Remaining, $M	$63.19	$3.17	$1.08

*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.

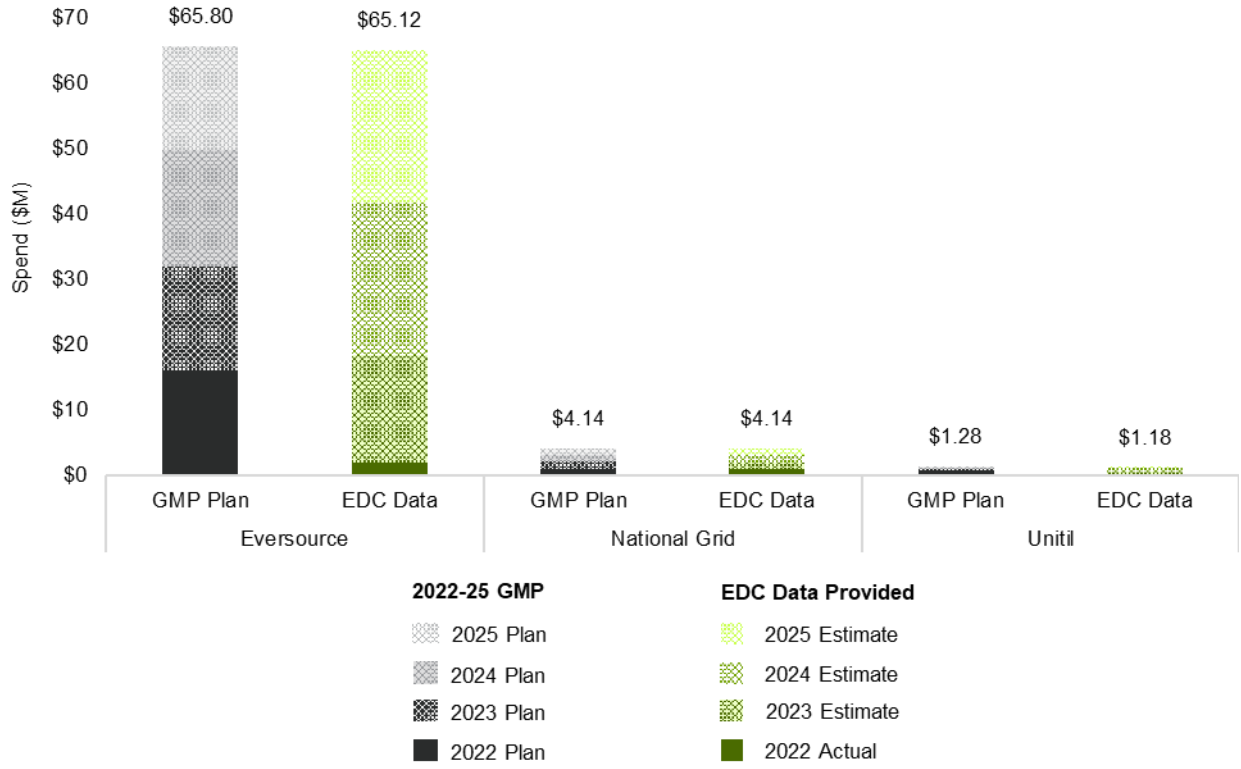
Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Overall device deployment and spend fell short of plans for all three EDCs, largely due to a pause in deployment while awaiting approval from the DPU to proceed with the proposed plan. Eversource focused most spend and deployment on completing Term 1 carryover investments, with no device deployment and very little spend occurring for Term 2 in PY 2022. National Grid planned to deploy 32 M&C Feeder Monitor devices in PY 2022 but deployed 10 devices due to delays in procurement. Unitil reported delays in device deployment and corresponding spend (see IM-6 in Table 43) due to lead delays for protection relays and LTC equipment, with deployment now planned for 2023.

The estimated units deployment for the 4-year Term is below the previous plan. There was little PY 2022 device deployment across the three EDCs, with National Grid reporting higher deployment than the other EDCs (see IM-4 in Table 29). Eversource and Unitil spent far less in PY 2022 than indicated in the previous plan, whereas National Grid reported spend as being on-track in PY 2022 relative to plans (see IM-6 in Table 29).

Figure 6 compares the GMP plans and EDC data totals and year-over-year spending for each EDC.

Figure 6. Term 2 M&C 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 GMP Term Reports and 2022 EDC Data

3.2.2 Eversource

This section discusses Eversource's M&C investment progress through PY 2022 in two dimensions:

- Term 1 Progress: a comparison of progress Eversource made in 2022 against its Term 1 plans detailed in its *2021 GMP Term Report*. These results consider only the deployment and spending that were planned in 2021 and that were carried over into 2022.
- Term 2 Progress: a comparison of progress Eversource made towards its 2022 plans outlined in its *2022-2025 GMP Plan.* These results do not consider deployment or spending that were planned in 2021 as part of Term 1 and that were carried over into 2022.

3.2.2.1 Overview of GMP Deployment Plan

Eversource's M&C Term 1 Investment Area goals and objectives included:

- Increasing the amount of data that is collected by the existing SCADA system for enhanced analytical capabilities (e.g., load flow analysis)
- Increasing reliability by enabling crew dispatch to remotely isolate faulted cable sections, restoring power to customers

To achieve these goals, Eversource is deploying a range of M&C devices on its distribution network. Table 30 details the technologies and devices that are being implemented as part of Eversource's M&C Investment Area.

Table 30. Eversource M&C Devices and Technologies

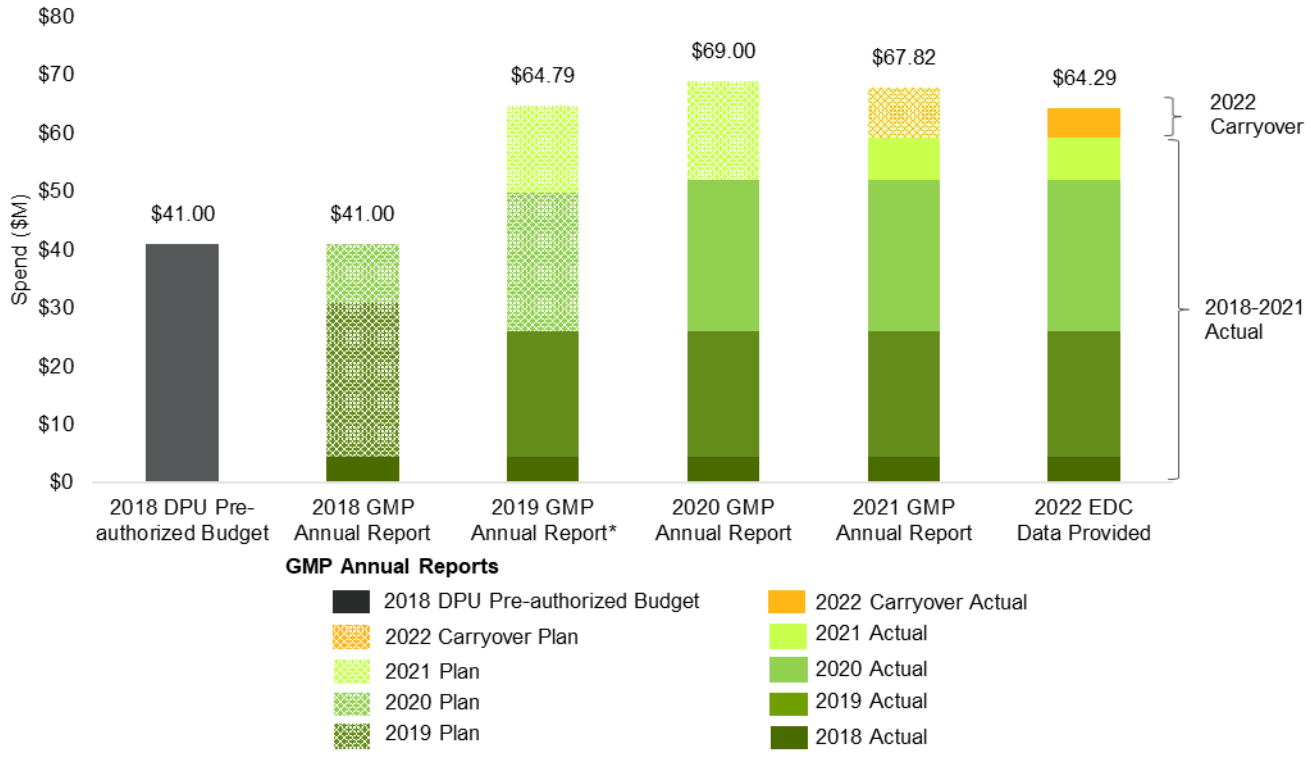
Device/Investment Type	Description
Microprocessor Relays	Includes advanced primary overcurrent protection, pushbutton controls for the breakers, safety hot line tag, reclosing, breaker failure, and under-frequency load-shedding schemes.
4 kV Circuit Breaker SCADA	Provides real-time visibility of loading conditions on the 4 kV circuits that are among the most heavily loaded on Eversource's distribution system.
Recloser SCADA	Addition of communications capability so the device can be centrally monitored and controlled from the dispatch center.
Padmount Switch SCADA	Addition of a radio package to enable communications and central monitoring.
Network Protector SCADA	Provides real-time network load data and remote control capability to underground network.
Power Quality Monitors	Provide remote access and storage of power quality meter data for the Eversource system planning, protection, and controls engineering to evaluate disturbance events and share information with customers.

Source: Guidehouse analysis of GMP Annual Reports and EDC Data

3.2.2.2 Term 1 M&C Deployment Plan Progression

Figure 7 shows the progression of Eversource's M&C deployment plans from DPU-approval in 2018 through PY 2022.

Figure 7. Term 1 Eversource M&C Planned vs. Actual Spend (2018–2022, $M)



**Note that Eversource received pre-authorization from the DPU for another $15 million in spending for its M&C Investment Area in late 2020.*

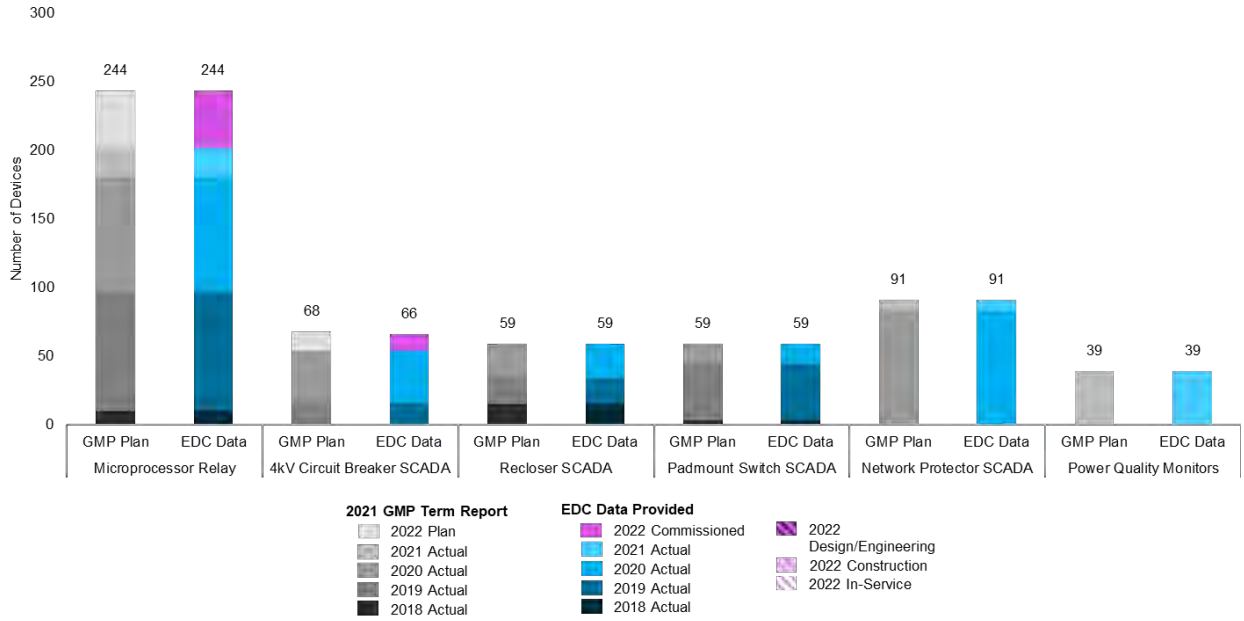
Source: Guidehouse analysis of DPU Order (May 10, 2018), 2018-2021 GMP Term Reports, Eversource GMP Extension and Funding Report filed on July 1, 2020, and *2022 EDC Data*

During PY 2022, Eversource spent about $3 million less than the PY 2022 planned Term 1 spend. Microprocessor relays account for almost the entirety of the underspend, primarily due to savings associated with work completed by internal field engineering resources rather than by contracted resources. Overall 4-year actual spending was slightly under the 4-year planned spending indicated in the 2021 GMP Term Report.

3.2.2.3 Term 1 M&C Device Type Progress through PY 2022

Overall, the number of M&C devices deployed by Eversource was only slightly short of plans for PY 2022. Figure 8 shows the progress and details of each device type for the 2018-2022 period. Eversource actively deployed Microprocessor Relays and 4kV Circuit Breaker SCADA in PY 2022, having finished the other four M&C device deployment programs for GMP Term 1 by PY 2021. Eversource finished the Microprocessor Relay deployment program in PY 2022. Only 4kV Circuit Breaker SCADA was carried over into 2023. Twelve of the fourteen planned 13.8kV line feeders for the 4kV Circuit Breaker SCADA system were commissioned in PY 2022.

Figure 8. Term 1 M&C Eversource Planned vs Actual Deployment (2018–2022, Unit Count)



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

The EDC Data presented in Figure 8 is also shown in tabular form in Table 31 to provide the specific deployment units in each category.

Table 31. Term 1 Eversource M&C Deployment Progress (2018-2022)

	Micro-processor Relay	4kV Circuit Breaker SCADA	Recloser SCADA	Padmount Switch SCADA	Network Protector SCADA	Power Quality Monitors
2018-2022 Total	**244**	**66**	**59**	**59**	**91**	**39**
Engineering/Design during PY 2022*	0	0	0	0	0	0
Construction during PY 2022*	0	0	0	0	0	0
In-Service during PY 2022*	0	0	0	0	0	0
Commissioned in PY 2022	42	12	0	0	0	0
Commissioned in PY 2021	22	0	0	0	8	39
Commissioned in PY 2020	83	38	25	15	83	0
Commissioned in PY 2019	87	16	19	41	0	0
Commissioned in PY 2018	10	0	15	3	0	0

*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.

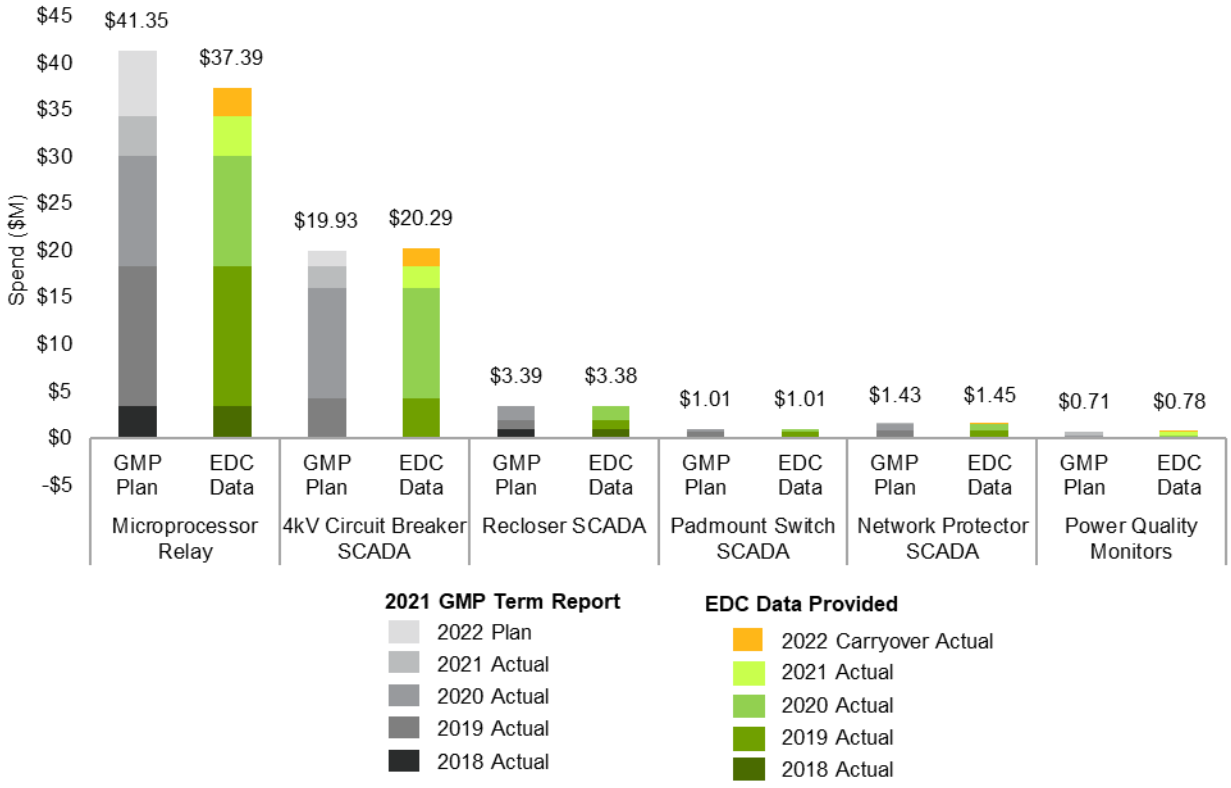
Source: Guidehouse analysis of 2021 GMP Term Report and 2022 EDC Data

Eversource deployed 42 Microprocessor Relays in PY 2022, a total of 244 devices, in line with the GMP plan. Spending was less than estimated due to savings associated with work

completed by internal field engineering rather than by contracted resources. The 4kV Circuit Breaker SCADA program was ended with fewer devices deployed than planned due to an unplanned transformer failure at STA 34 that caused an interruption to work. Higher spend for the 4kV Circuit Breaker SCADA program was largely driven by longer execution times due to unforeseen conditions at STA 34, including asbestos contaminated wires and unexpected crane work.

Figure 9 shows Eversource's corresponding planned versus actual spend over the 2018-2022 Term period, broken out by device type. Spending in PY 2022 did not correlate with number of devices deployed and varied between the two active device programs. PY 2022 spending on Microprocessor Relays was slightly under half of plan, the savings driven by the usage of internal engineering resources rather than contractors. Overall 4-year spend in addition to 2022 spend on Microprocessor Relays is therefore lower than planned. 4kV Circuit Breaker spend in PY 2022 is slightly above planned spend, driven by unexpected site conditions leading to longer execution times at STA 34.

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



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

The EDC Data presented in Figure 9 is also shown in Table 32 to provide the specific dollar spend in each category.

Table 32. Term 1 Eversource M&C Total Spend Comparison (2018–2022, $M)

	Microprocessor Relay	4kV Circuit Breaker SCADA	Recloser SCADA	Padmount Switch SCADA	Network Protector SCADA	Power Quality Monitors
2018-2022 Total	**$37.39**	**$20.29**	**$3.38**	**$1.01**	**$1.45**	**$0.78**
PY 2022 Actual	$3.03	$2.03	$0.00	$0.00	$0.02	$0.06
PY 2021 Actual	$4.27	$2.33	$0.00	$0.00	$0.00	$0.50
PY 2020 Actual	$11.74	$11.76	$1.53	$0.29	$0.56	$0.21
PY 2019 Actual	$14.99	$4.09	$0.89	$0.62	$0.87	$0.00
PY 2018 Actual	$3.36	$0.08	$0.96	$0.11	$0.00	$0.00

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

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

Microprocessor Relays

Eversource used much of PY 2022 completing its microprocessor relay deployment, with all planned devices deployed in PY 2022. Microprocessor relay deployment in PY 2022 matched GMP plan while spend was lower than projected, due to the usage of internal field engineering rather than contracted resources, with total term spend expected to be lower than the previous plan. Eversource was able to complete work and commission a total of 42 microprocessor relays in PY 2022.

4 kV Circuit Breaker SCADA

Eversource completed twelve of its fourteen planned units of 4 kV circuit breaker SCADA units in PY 2022. Two units were delayed due to a transformer failure at STA 34 which interrupted construction. While actual deployment of 4 kV circuit breaker SCADA units for PY 2022 was lower than projected, total Term 1 spending is higher than plan due to longer execution phases caused by unforeseen STA 34 site conditions.

Recloser SCADA

Recloser SCADA deployment was completed in PY 2020. Therefore Eversource did not have deployment and spend in PY 2022.

Padmount Switch SCADA

Padmount switch SCADA deployment was completed in PY 2020. Therefore Eversource did not have deployment and spend in PY 2022.

Network Protector SCADA

Network Protector SCADA was completed in PY 2021. Therefore Eversource did not have deployment and spend in PY 2022.

Power Quality Monitors

Power Quality Monitor investments for Term 1 were completed in PY 2021. Therefore Eversource did not have deployment and spend in PY 2022. Further investment is planned for Power Quality Monitors during Term 2 and will be summarized in Section 3.2.2.4 through Section 3.2.2.7.

3.2.2.4 Term 1 Infrastructure Metrics Results and Key Findings

Table 33 presents the Infrastructure Metrics results through PY 2022 for each device type related to Eversource's M&C Investment Area.

Table 33. Term 1 2022 Eversource Infrastructure Metrics for M&C Devices

Infrastructure Metrics			Micro-processor Relay	4kV Circuit Breaker SCADA	Recloser SCADA	Padmount Switch SCADA	Network Protector SCADA	Power Quality Monitors
GMP Plan Total, 2018-2022		# Devices Planned	244	68	59	59	91	39
		Spend, $M	$41.35	$19.93	$3.39	$1.01	$1.43	$0.71
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed	244	66	59	59	91	39
		% Devices Deployed	100%	97%	100%	100%	100%	100%
IM-5	Cost for Deployment. thru PY 2022	Total Spend, $M	$37.39	$20.29	$3.38	$1.01	$1.45	$0.78
		% Spend	90%	102%	100%	100%	101%	109%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	100%	86%	N/A	N/A	N/A	N/A
		% On Track (Spend)	43%	121%	N/A	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	0	0
		Spend Remaining, $M	$0.00	$0.00	$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 Reports and 2022 EDC Data

Eversource's device deployment through PY 2022 (Table 33, IM-4) tracked within 3% of 2022 GMP Plan across all device categories, with only 4KV Circuit Breaker SCADA tracking below 100% of plan. Recloser and Padmount Switch SCADA were both completed in PY 2020, and Network Protector SCADA and Power Quality Monitors were completed in PY 2021, as described above, and therefore did not have deployment and spend in PY 2022.

Costs did not directly correlate to number of devices deployed, with Microprocessor Relays about 10% under planned spending and 4KV Circuit Breaker SCADA about 2% over prior plan spending. Network Protector SCADA and Power Quality Monitors tracked 30 to 40% below prior plan. Recloser and Padmount Switch SCADA were both completed in PY 2020, and Network Protector SCADA and Power Quality Monitors were completed in PY 2021, as described above, and therefore did not have deployment and spend in PY 2022.

3.2.2.5 Term 2 M&C Deployment Plan Progression

As stated in its GMP 2021 Plan, Eversource is dedicating roughly $61 million toward substation automation during the 2022-2025 Term 2 period. The goal of this program is to increase the penetration of advanced remote telemetry devices in substations. These devices would provide system operators with remote visibility and control of power flows on the grid required to optimize system conditions regardless of local penetrations of load and generation. In bulk substations, many feeders still rely on older electromechanical relay technology that does not allow for remote operations, such as application of fast-trip and lock-out settings for worker safety or changes in protection settings. Plans to deploy a DMS are amplifying the importance of real-time telemetry. To address these concerns, Eversource's Substation Automation Program has two components:

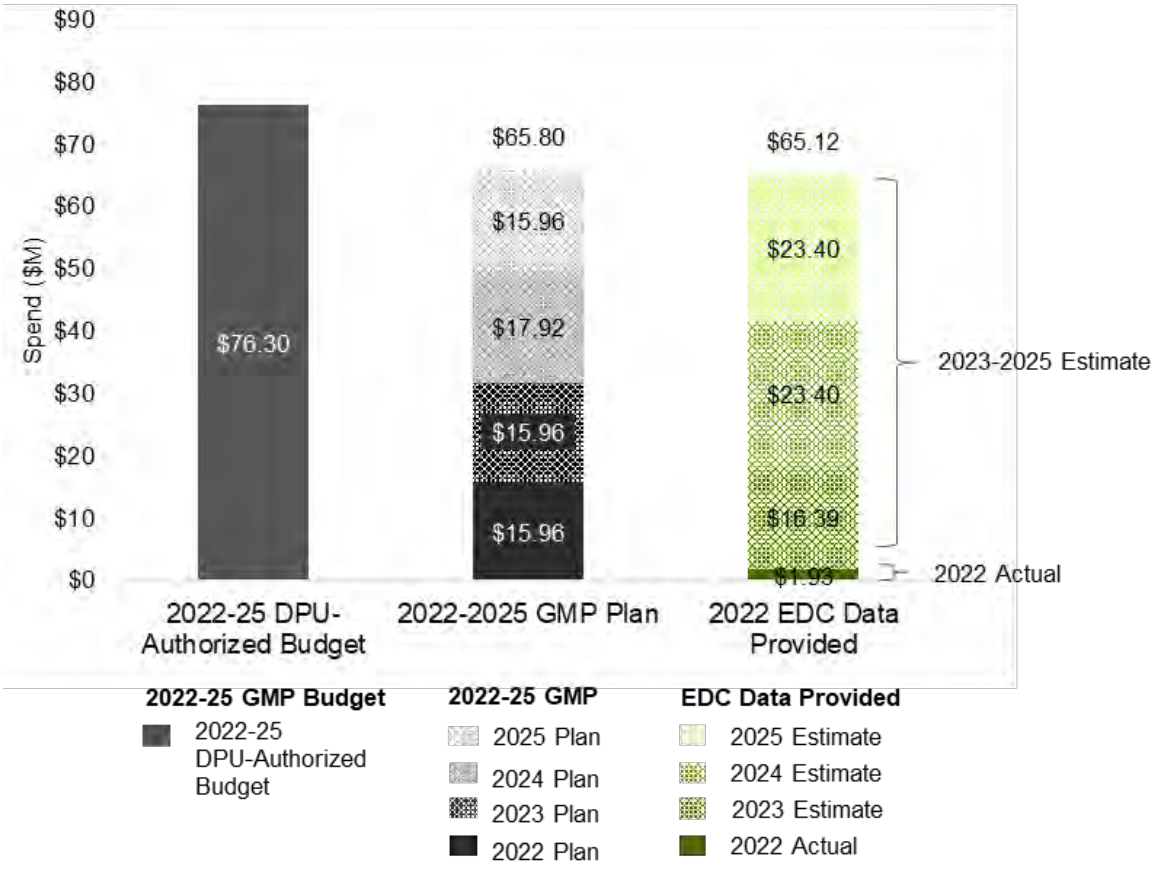
1.) Eversource will continue its program to replace older relay technology with current microprocessor relay technology for 190 additional feeders at bulk substations across Massachusetts. These relays will be equipped with incremental remote monitoring capability to enable more timely engineering analysis of system events.

2.) Eversource will continue its program to add relays with remote telemetry to 55 high priority 4 kV feeders in eastern Massachusetts.

Eversource will also be dedicating $4.8 million towards its ongoing Power Quality Monitoring program during the 2022-2025 Term 2 period. Power Quality Monitors program provides remote access and storage of continuous power quality data, so that detailed information from disturbance events can be evaluated by Eversource Distribution Engineering, System Planning and Protection and Controls Engineering, to determine root causes and potential remediation needs. Eversource recognizes that modern equipment and processes are increasingly sensitive to small disturbances and is committed to working collaboratively to identify cost effective solutions to minimize the consequences of these disturbances. The modern distribution system will effectively utilize and accommodate DERs and continue to support the various automation devices and systems that will allow for further visibility and command and control of the system to reduce customer interruptions and increase reliability.

Figure 10 shows the progression of Eversource's Term 2 M&C deployment plans through PY 2025.

Figure 10. Term 2 Eversource M&C Planned vs. Actual Spend (2022–2025, $M)



Source: Guidehouse analysis of DPU Order on Previously Deployed Technologies (October 7, 2022), 2021 DOER Responses, and *2022 EDC Data*

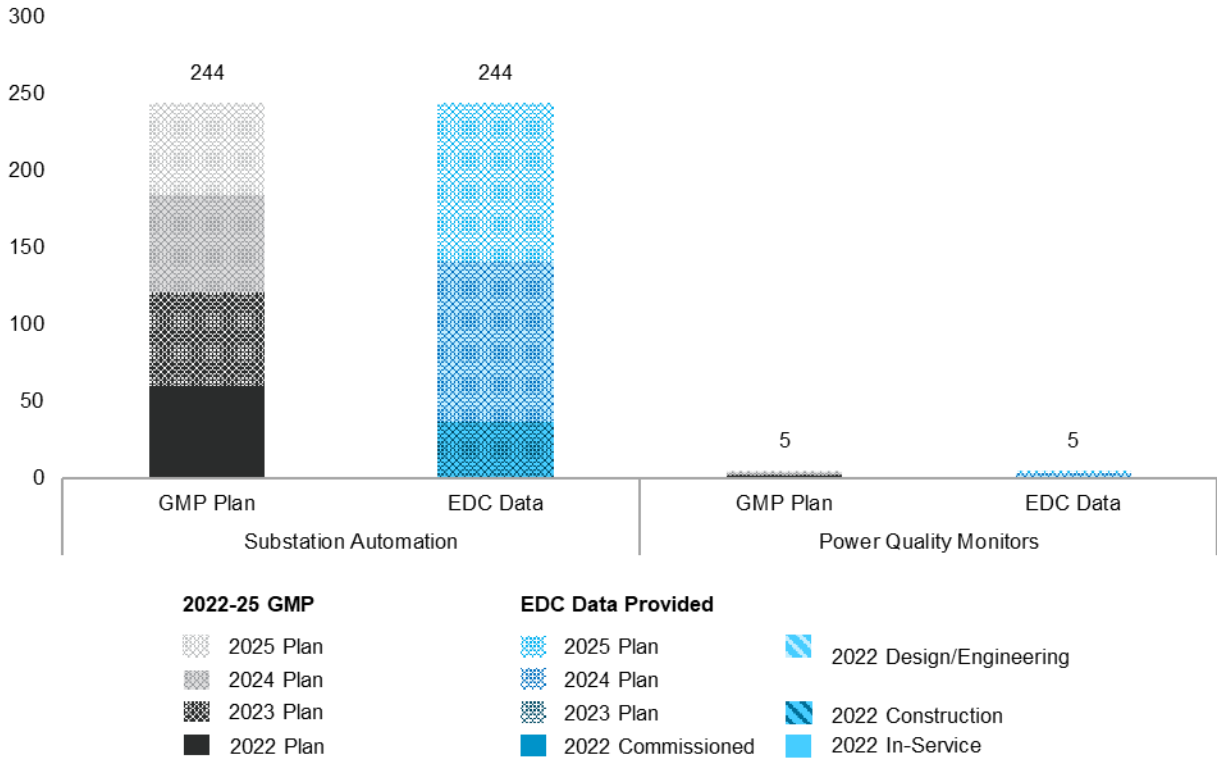
During PY 2022, Eversource spent about $14 million less than PY 2022 planned spend, with most of the remaining amount being carried over into 2023. Substation Automation and Power Quality Monitors account for the entirety of the Term 1 investment into 2023. Overall 4-year actual spending was under the 4-year planned spending indicated in the 2021 GMP Term Report.

3.2.2.6 Term 2 M&C Device Type Progress through PY 2022

Overall, the number of Eversource M&C devices deployed was below plans for PY 2022. Figure 11 shows planned versus actual device deployment progress for PY 2022, as well as planned investment for PY 2023 through PY 2025.

Deployment for Substation Automation was paused while waiting for program approval by the DPU. Eversource focused on planning, engineering and design activities as well as procurement packages to ensure deployment could begin in 2023.

Figure 11. Term 2 Eversource M&C Planned vs Actual Deployment (2022-2025, Unit Count)



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

Eversource plans to increase the number of deployments for Substation Automation between 2023 and 2025, with expectations to still meet GMP Plan despite no deployment occurring in PY 2022.

The EDC Data presented in Figure 11 is also shown in tabular form in Table 34 to provide the specific deployment units in each category.

Table 34. Term 2 Eversource M&C Deployment Progress

	Substation Automation	Power Quality Monitors
2022-2025 Planned Deployment	**244**	**5**
PY 2025 Planned	104	2
PY 2024 Planned	104	3
PY 2023 Planned	36	0
Commissioned in PY 2022	0	0
In-Service during PY 2022	0	0
Construction during PY 2022	0	0
Engineering/Design during PY 2022	132	0

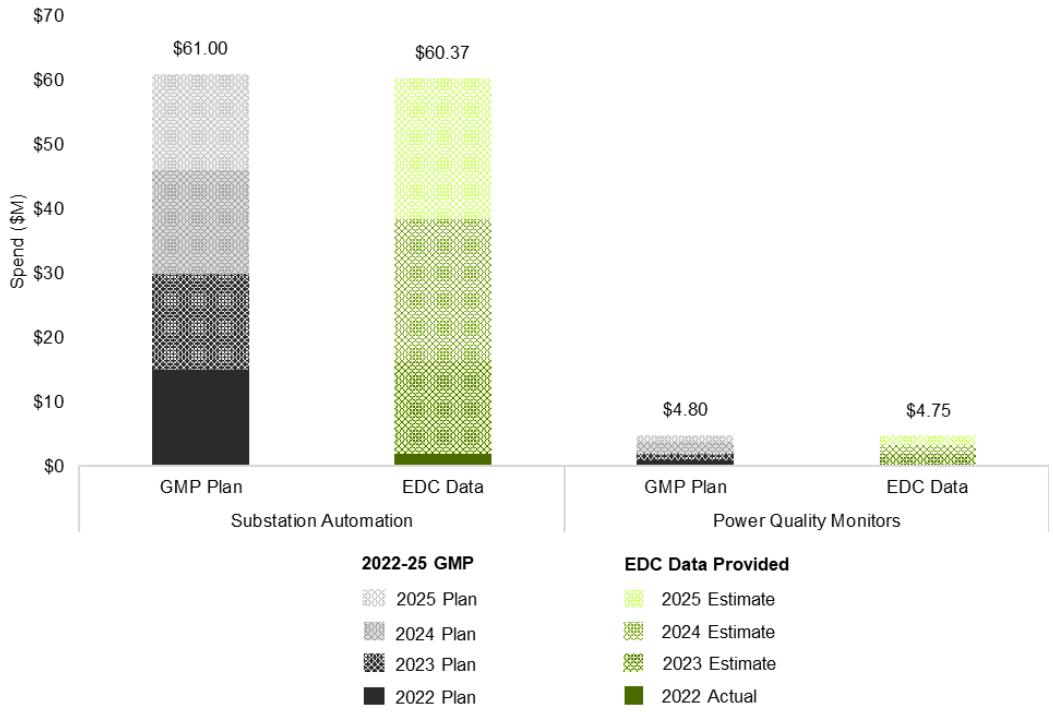
Source: Guidehouse analysis of 2022 EDC Data

Eversource did not complete deployment of any Substation Automation devices or Power Quality Monitors in PY 2022. All spend in PY 2022 was focused on the engineering/design of Substation Automation projects.

Figure 12 shows Eversource's corresponding planned versus actual spend for PY 2022, as well as planned investment for PY 2023 through PY 2025, broken out by device type.

Spend in PY 2022 was lower than planned while Eversource awaited DPU guidance. Overall 4-year spend, with PY 2022 included, on Substation Automation is lower than plans, with lack of deployment in PY 2022. Eversource expects to meet the original planned spend for both device types over the Term 2 duration.

Figure 12. Term 2 Eversource M&C Spend Plan vs. Actual (2022-2025, $M)



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

The EDC Data presented in Figure 12 is also shown in Table 35 to provide the specific dollar spend in each category.

Table 35. Term 2 Eversource M&C Total Spend Comparison (2022-2025, $M)

	Substation Automation	Power Quality Monitors
2022-2025 Planned Spend	**$60.37**	**$4.75**
PY 2025 Planned	$22.00	$1.40
PY 2024 Planned	$22.00	$1.40
PY 2023 Planned	$14.44	$1.95
PY 2022 Actual	$1.93	$0.00

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

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

Substation Automation

Deployment for Substation Automation was paused while waiting for program approval by the DPU. Eversource focused on planning, engineering and design activities as well as procurement packages for a total of 132 feeders to ensure deployment could begin in 2023. Thus, Substation Automation spend for PY 2022 was lower than projected.

Power Quality Monitors

Eversource did not plan any deployment or spend for Power Quality Monitors in PY 2022. Term spending is expected to meet the previous plan. Overall deployment totals are the same as the 2021 GMP Plan, while total spending is only slightly lower than planned.

3.2.2.7 Term 2 Infrastructure Metrics Results and Key Findings

Table 36 presents the Infrastructure Metrics results through PY 2022 for each device type in Eversource's M&C Investment Area.

Table 36. Term 2 2022 Eversource Infrastructure Metrics for M&C Devices

Infrastructure Metrics*			Substation Automation	Power Quality Monitors
GMP Plan Total, 2022-2025		# Devices Planned	244	5
		Spend, $M	$61.00	$4.80
EDC Data Total, 2022-2025		# Devices Planned	244	5
		Spend, $M	$60.37	$4.75
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed	0	0
		% Devices Deployed	0%	0%
IM-5	Cost for Deployment. thru PY 2022	Total Spend, $M	$1.93	$0.00
		% Spend	3%	0%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	0%	0%
		% On Track (Spend)	13%	N/A
IM-7	Projected Deployment for the Remainder of the Term	# Devices Remaining	244	5
		Spend Remaining, $M	$58.44	$4.75

*The metric names have been slightly changed here to clarify the time span used in analysis.
Source: Guidehouse analysis of 2021 DOER Responses and 2022 EDC Data

Eversource's device deployment through PY 2022 (Table 36, IM-4) was 0% of 2022 GMP Plan for Substation Automation while Eversource awaited DPU approval. No deployment was planned for Power Quality Monitors.

Actual spend in PY 2022 was entirely for the engineering/design phase of Substation Automation Projects, with overall spend less than 85% of prior plan spending. No spend was planned for Power Quality Monitors.

3.2.3 National Grid

This section discusses National Grid's planned and actual M&C investment progress through PY 2022.

3.2.3.1 Overview of GMP Deployment Plan

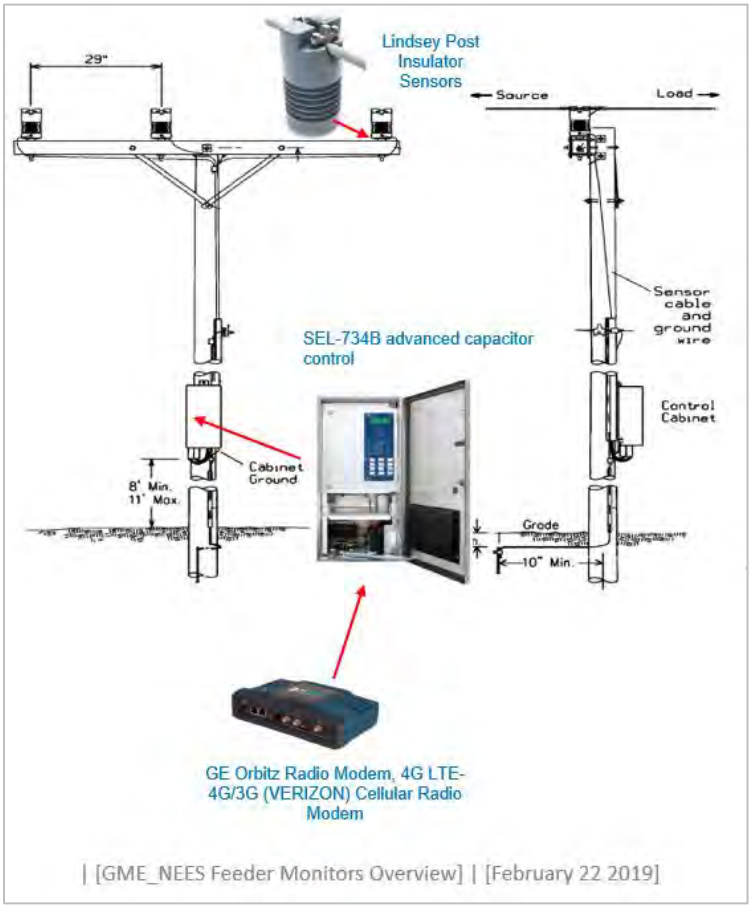
National Grid's Term 1 M&C Investment Area goals and objectives included:

- Provide critical data for operations and distribution designers by providing near real-time voltage, current, and power monitoring information to the operations control center
- Focus on overhead feeders within the distribution system and substations with minimal to no existing SCADA

The achieve these goals, National Grid installed interval power monitoring devices on overhead feeders within its distribution system. The feeder monitors will be installed outside the substation fence for increased visibility. Information is transmitted cellularly every 5 minutes. Figure 13 shows a detailed schematic of how the EDC will implement the technology. Each circuit location includes three sensors (one per phase) and one control box with a communications package.[34]

[34] For GMP accounting purposes, National Grid is counting this configuration as a single device deployed on a circuit. Guidehouse adopted this definition in the evaluation for consistency.

Figure 13. Feeder Monitor Schematic



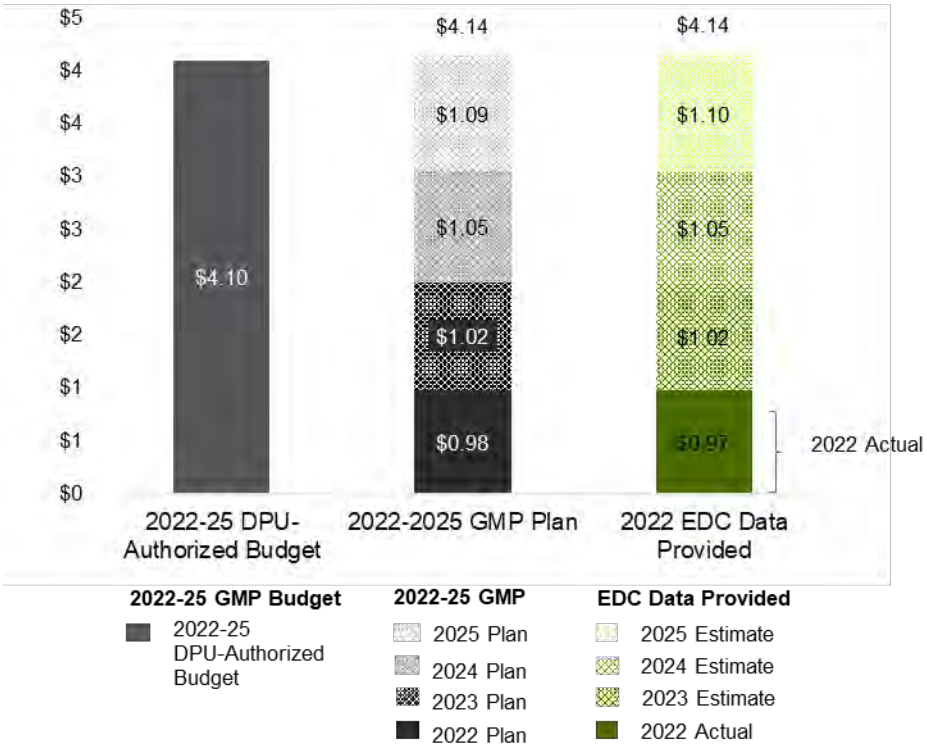
Source: National Grid

National Grid's Term 2 M&C investments focus solely on the continued deployment of feeder monitor projects. Achieving stated GMP 2021 goals will require interval monitoring on all primary distribution feeders, at least at the head of the feeder (i.e., at or near the substation) to ensure compliance with voltage and protection requirements as customer DER adoption grows. National Grid stated in its 2022-2025 GMP that it will be dedicating $3.43 million during the Term 2 period to its feeder monitor program.

3.2.3.2 Term 2 M&C Deployment Plan Progression

Figure 14 shows how National Grid's Term 2 M&C deployment spend has progressed in 2022.

Figure 14. Term 2 National Grid's M&C Planned and Actual Spend Progression, $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

National Grid deployment was below plan and spend in line with plans for 2022. Progress was affected by a number of factors:

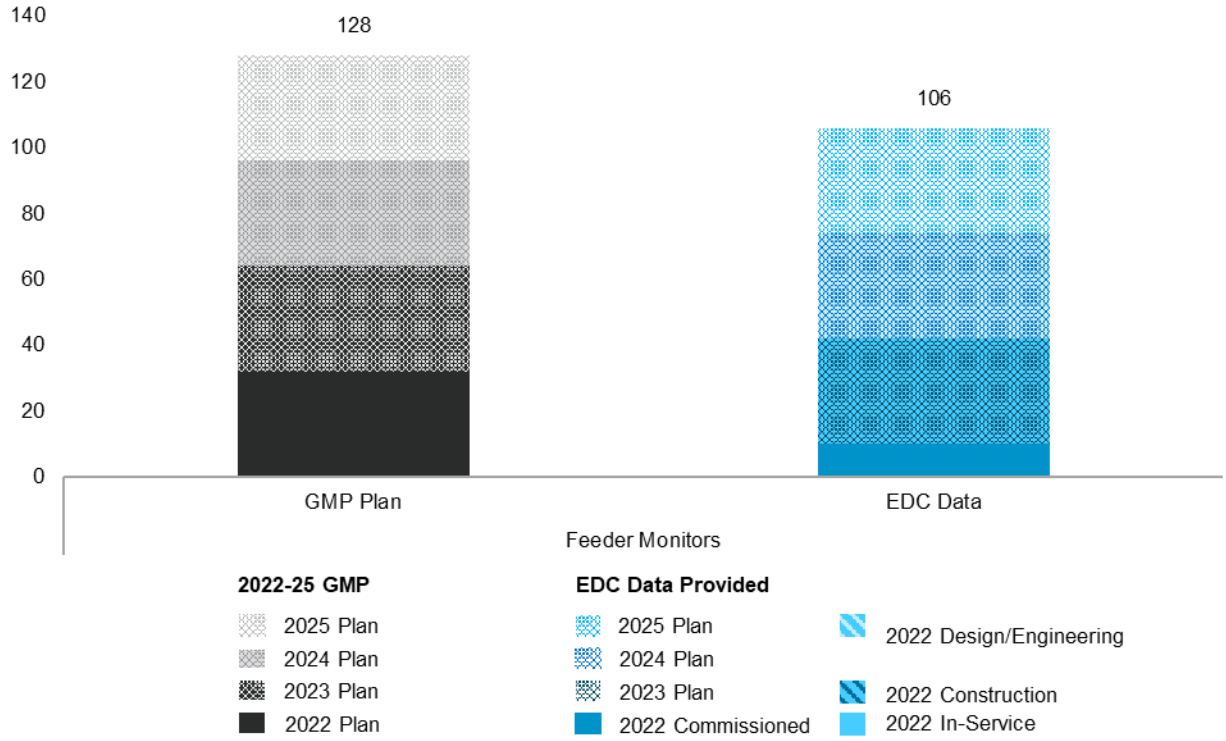
- National Grid's resourcing constraints led to shortfall of in-house planning and engineering resources to draw on, so National Grid needed to supplement in-house resources with incremental resources to maintain GMP progress.
- In addition, National Grid's feeder monitor vendor discontinued the model, requiring National Grid to identify and transition to a new vendor. In some cases, work that had previously passed the engineering/design phase required re-design.
- Lastly, procuring materials continues to be difficult for National Grid. Longer vendor lead times, observed during PY 2021, continued into PY 2022, with Line Sensors and Regulators most affected by delays.

3.2.3.3 Term 2 M&C Device Type Progress through PY 2022

National Grid's Term 2 M&C investment plan consists of Feeder Monitor deployment. Delays in Feeder Monitor procurement coupled with delays in Term 1 commissioning resulted in only 10 units deployed in PY 2022 out of the original 32 units planned for PY 2022. Figure 15 shows

planned versus actual device deployment progress for PY 2022, as well as planned investment for PY 2023 through PY 2025.

Figure 15. Term 2 National Grid M&C Device Deployment (2022–2025)



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

Some devices that were planned for deployment in PY 2022 were still in the engineering/design phase at the end of the year, while others were in the construction phase. National Grid plans on allocating spend in the 2023 to 2025 period to commission devices originally planned for PY 2022 and complete deployments to help meet previously planned device deployment goals.

The EDC Data presented in Figure 15 is also shown in tabular form in Table 37, to provide the specific deployment units in each category.

Table 37. Term 2 National Grid M&C Planned and Actual Device Deployment (2022-2025)

	Feeder Monitors (M&C)
2022-2025 Planned Deployment	**106**
PY 2025 Planned	32
PY 2024 Planned	32
PY 2023 Planned	32
Commissioned in PY 2022	10
In-Service during PY 2022	0
Construction during PY 2022	19
Engineering/Design during PY 2022	32

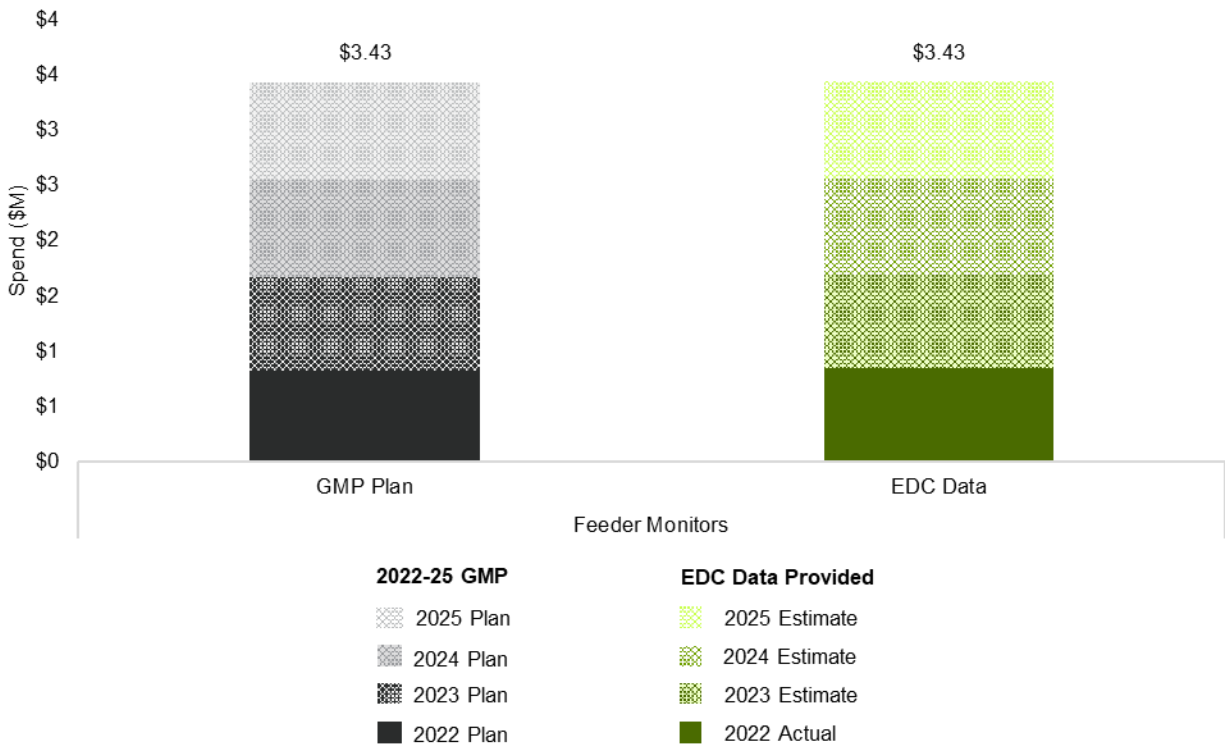
Source: Guidehouse analysis of 2022 EDC Data

National Grid deployed 10 Feeder Monitor devices in PY 2022, short of the plan of 32 devices, due largely to National Grid's primary vendor discontinuing the previously used model of feeder monitor. National Grid was able to identify a new vendor successfully in PY 2022. The remaining 22 planned devices are either in engineering/design or construction phases and are expected to be commissioned in 2023.

National Grid's new Term 2 total deployment plan (based on EDC Data) is now 22 feeder monitors fewer than its prior plan from 2021 term report. National Grid expects to complete the remaining 96 feeder monitors between 2023 and 2025. Feeder monitor spending in PY 2022 was about 2% over planned spend with 32 devices in engineering and 19 in construction, out of the remaining 96.

Figure 16 shows National Grid's planned versus actual spend for PY 2022, as well as planned investment for PY 2023 through PY 2025.

Figure 16. Term 2 National Grid M&C 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

The EDC Data presented in Figure 16 is also shown in Table 38 to provide the specific dollar spend in each category. Spending in PY 2022 was in line with plans despite deployment delays and shortfalls observed due to ongoing supply chain issues. Term 2 plan for PY 2023 – PY 2025 is expected to be in-line with pre-authorized amounts outlined for M&C.

Table 38. Term 2 National Grid M&C Total Spend Comparison (2022–2025, $M)

	Feeder Monitors (M&C)
2022-2025 Planned Spend	**$3.43**
PY 2025 Planned	$0.88
PY 2024 Planned	$0.87
PY 2023 Planned	$0.85
PY 2022 Actual	$0.84

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 2022 EDC Data

3.2.3.4 Term 2 Infrastructure Metrics Results and Key Findings

Table 39 presents the Infrastructure Metrics results through PY 2022 for National Grid's feeder monitor deployment.

Table 39. Term 2 2022 National Grid M&C Infrastructure Metrics Findings

Infrastructure Metrics*			National Grid M&C**
GMP Plan Total, PY 2022-2025		# Devices Planned	128
		Spend, $M	$4.14
EDC Data Total, PY 2022-2025		# Devices Planned	106
		Spend, $M	$4.14
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed	10
		% Devices Deployed	8%
IM-5	Cost for Deployment thru PY 2022	Total Spend, $M	$0.97
		% Spend	23%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	31%
		% On Track (Spend)	99%
IM-7	Projected Deployment for the Remainder of the Term*	# Devices Remaining	96
		Spend Remaining, $M	$3.17

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

** 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

Overall, National Grid's M&C progress is short of what was planned for PY 2022. The shortfall was largely due to the vendor discontinuing the feeder monitor model, requiring the identification of a new vendor. Costs slightly outpaced the units deployed in PY 2022, driven largely by preparation work for 2023-2025 accelerated device deployment, although total spend was in line with plans. National Grid projects no further changes to planned spend at this time, with total planned spend in line with the pre-authorized budget for M&C.

3.2.4 Unitil

This section discusses Unitil's planned and actual M&C investment progress through PY 2022.

3.2.4.1 Overview of GMP Deployment Plan

Unitil's M&C Term 1 Investment Area goals and objectives included the following:

- Provide remote monitoring of conditions on the electric system (e.g., voltage, current)
- Provide remote control of equipment and functions (e.g., circuit breakers/reclosers, transformer load tap changers, capacitor banks)
- Enable technologies required for other GMP projects (e.g., ADMS/ALF, VVO)
- Improve integration of outage information from meters into the OMS outage prediction engine to enhance outage prediction process, reduce false positives, and enhance outage location detection

To achieve these goals, Unitil implemented substation SCADA and AMI data integration with their OMS. Table 40 describes these technologies.

Table 40. Unitil M&C Devices and Technologies

Investment Type	Description
Substation SCADA	The installation and interconnection of a SCADA terminal unit at the site, the establishment of communications between the terminal unit and the remotely located SCADA master system, and the associated programming to implement desired functions.
Recloser SCADA	Addition of communications capability so the device can be centrally monitored and controlled from the dispatch center.
AMI-OMS Integration	The deployment of software that analyzes AMI status changes and relevant data points, detects suspected outages, and reports them as such to the OMS.

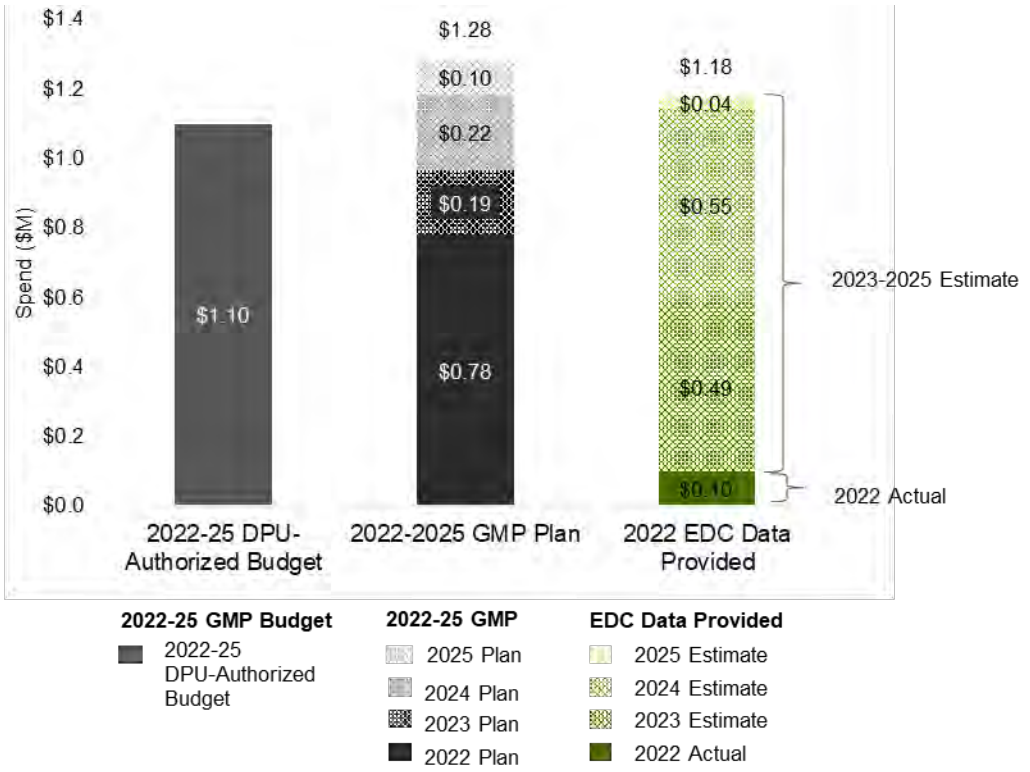
Source: Guidehouse

In Term 2, Unitil will continue both investments: substation SCADA rollout as well as continued AMI/OMS integration.

3.2.4.2 Term 2 M&C Deployment Plan Progression

Figure 17 shows the progression of Unitil's M&C Term 2 deployment plans from DPU pre-authorization in PY 2022 through PY 2025.

Figure 17. Term 2 Unitil M&C Planned and Actual Spend Progression, $M



Source: Guidehouse analysis of DPU Order (October 7, 2022), 2021 DOER Responses and *2022 EDC Data*

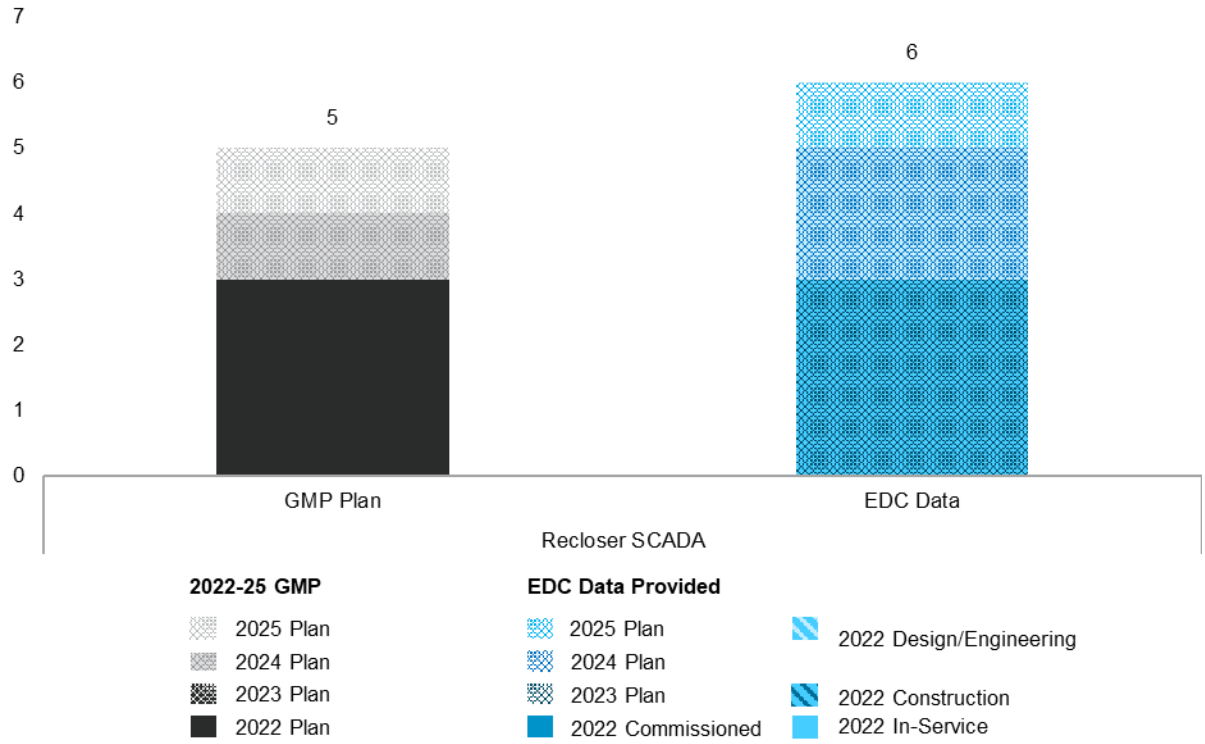
Deployment and spend for 2022 investments was below initial plans, with Unitil spending $0.10M on M&C deployment compared to its plan of $0.78M. This lower spend was driven primarily by long-lead procurement times for protection relays and LTC equipment as well as certain deployment plans being on hold until the late 2022 DPU approval of 2022-2025 GMPs. Until has increased planned spend in 2023 and 2024 to achieve planned deployment and spend targets outlined in GMP plan.

3.2.4.3 Term 2 M&C Device Type Progress through PY 2022

Figure 18 shows Unitil's planned versus actual device deployment progress for PY 2022, as well as planned investment for PY 2023 through PY 2025. In PY 2022, Unitil's progress toward substation SCADA retrofitting[35] and OMS/AMI integration was lower than planned, largely due to long-lead times for protection relays and LTC equipment as well as re-evaluation of the OMS/AMI integration process. The OMS/AMI integration plan is not quantified on a unit basis and so does not appear in the device deployment figures or tables.

[35] Note the investment referred to as "Substation SCADA Retrofit" is labeled as "Recloser SCADA" in all figures and tables to align with the nomenclature of the DPU-approved device/technology types.

Figure 18. Term 2 Unitil M&C Device Deployment Comparison (2022–2025)



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

The EDC Data presented in Figure 18 is also shown in tabular form in Table 41, to provide the specific deployment units in each category.

Table 41. Term 2 Unitil M&C Deployment Progress

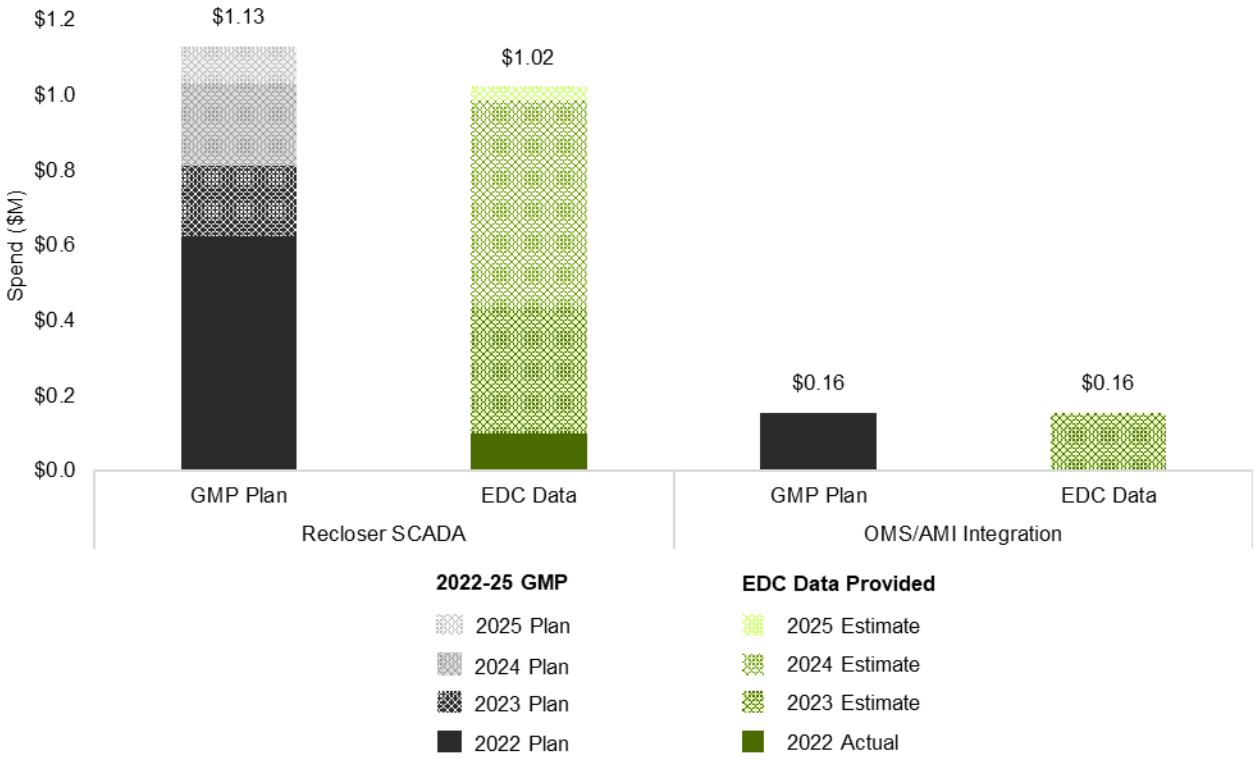
	Recloser SCADA
2022-2025 Planned Deployment	**6**
PY 2025 Planned	1
PY 2024 Planned	2
PY 2023 Planned	3
Commissioned in PY 2022	0
In-Service during PY 2022	0
Construction during PY 2022	3
Engineering/Design during PY 2022	2

Source: Guidehouse analysis of 2022 EDC Data

The PY 2022 spend for both SCADA and OMS/AMI integration was deferred, primarily due long-lead times for protection relays and LTC equipment as well as the OMS/AMI process being re-evaluated due to a vendor discontinuing device support. Unitil plans on spending additional funds in 2023 through 2025 to meet previously planned device deployment.

Figure 19 shows Unitil's planned versus actual spend for PY 2022, as well as planned investment for PY 2023 through PY 2025.

Figure 19. Term 2 Unitil M&C Plan vs. Actual (2022-2025, $M)



Source: Guidehouse analysis of DOER Responses and 2022 EDC Data

The EDC Data presented in Figure 19 is also shown in Table 42 to provide the specific dollar spend in each category.

Table 42. Term 2 Unitil M&C Total Spend Comparison (2022–2025, $M)

	Recloser SCADA	OMS/AMI Integration
2022-2025 Planned Spend	**$1.02**	**$0.16**
PY 2025 Planned	$0.04	$0.00
PY 2024 Planned	$0.55	$0.00
PY 2023 Planned	$0.33	$0.16
PY 2022 Actual	$0.10	$0.00

Source: Guidehouse analysis of DOER Responses and 2022 EDC Data

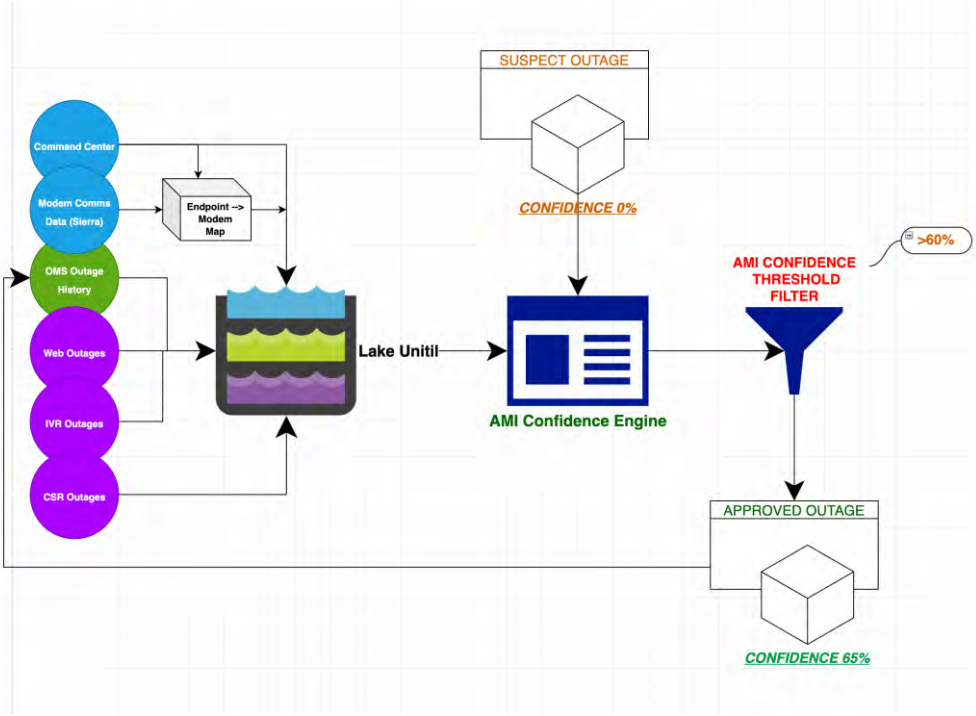
The following sections discuss each technology in greater detail.

OMS/AMI Integration

Unitil re-evaluated its OMS/AMI integration process in PY 2022 after its primary vendor discontinued support for Landis & Gyr PLX technology. Unitil issued an RFP to assess vendor

options, with the new vendor expected to be chosen in Q2 2023. Unitil will continue progress towards building out the OMS/AMI integration in 2023, with planned completion in either 2025 or 2026.

Figure 20. OMS/AMI Integration: Confidence Engine and Filter Schematic



Source: Unitil

Unitil's plan to build out the outage confidence engine leverages three types of data:

- Confirmed outage data from OMS, including past outage history
- Low level signal to noise data from collectors
- Weather and temperature data

In addition to incorporating the above types of data, Unitil's next steps include building out the database, finalizing an initial version of the confidence engine, and developing the user interface.

Actual spend on this effort for PY 2022 was deferred, and total term spending, is on track to be less than the prior plan. Total spending estimate is not expected to change.

Substation SCADA Retrofit

The substation SCADA retrofit initiative involves upgrade of existing SCADA or addition of new SCADA to distribution substations. This initiative supports the ADMS deployment, which determined the timeline and workplan for the GMP term.

In PY 2022, Unitil performed engineering/design work for the Canton Street substation and construction work for the Princeton Road substation. Unitil could not complete deployment of

Recloser SCADA in PY 2022 as planned due to vendor lead-times for protection relays and LTC equipment.

Actual spend for PY 2022 was lower than planned due to long-lead procurement issues. Total spend is on track to be lower than the prior plan. This is primarily due to an increase in cost estimates. Unitil did not commission any substation SCADA retrofits; however, 3 substation SCADA retrofits are their construction phase and are planned to be completed in 2023.

Beyond 2023, Unitil expects to deploy the remaining 3 substation SCADA devices in 2024 and 2025. The work is largely prioritized by relative impact, which includes metrics of substation size, load, and number of customers.

3.2.4.4 Term 2 Infrastructure Metrics Results and Key Findings

Table 43 presents the Infrastructure Metrics results through PY 2022 for the two technologies included in Unitil's M&C Investment Area.

Table 43. Term 2 Unitil M&C Infrastructure Metrics Findings

Infrastructure Metrics*			Recloser SCADA	OMS/AMI Integration
GMP Plan Total, PY 2022-2025		# Devices Planned	5	0
		Spend, $M	$1.13	$0.16
EDC Data Total, PY 2022-2025		# Devices Planned	6	0
		Spend, $M	$1.02	$0.16
IM-4	Number of devices or other technologies deployed thru PY 2022	# Devices Deployed	0	0
		% Devices Deployed	0%	N/A
IM-5	Cost for Deployment thru PY 2022	Total Spend, $M	$0.10	$0.00
		% Spend	9%	0%
IM-6	Deviation Between Actual and Planned Deployment for PY 2022	% On Track (Devices)	0%	N/A
		% On Track (Spend)	16%	N/A
IM-7	Projected Deployment for the Remainder of the Term	# Devices Remaining	6	0
		Spend Remaining, $M	$0.92	$0.16

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

Source: Guidehouse analysis of DOER Responses and 2022 EDC Data

Unitil's progress in PY 2022 and total spend were lower than anticipated, as a result of long-lead procurement delays, the re-evaluation of the OMS/AMI integration process, and some activities being on hold until late 2022 DPU approval of 2022-2025 GMPs. However, Unitil plans to deploy these funds in 2023 to continue work on both substation SCADA retrofit and OMS/AMI integration through 2025.

4. M&C Performance Metrics

Guidehouse's assessment of the Performance Metrics included Performance Metric data collection, data QA/QC, data analysis for each of the three EDCs, and determination of findings and conclusions from the analysis.

4.1 Data Management

This section discusses the data sources used for the Performance Metric evaluation and summarizes the Quality Assessment and Quality Control (QA/QC) steps, as well as the 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 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.

[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] 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.
[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.

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[39]. The QA/QC process involved the following:

- Check that the change in CKAIDI/CKAIFI and average zone sizes were properly calculated using the Stamp Approved Metric's definition. Note: DPU Stamp Approved Metric Guidance defines this as "BASELINE – PROGRAM YEAR"
- Comparison of circuits with GMP investments in the Appendix 1 filing and the work order data collected during the Infrastructure Metric analysis.
- Comparison of PY2021 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.

4.1.3 Circuit Selection

Guidehouse provides CKAIDI and CKAIFI findings for all circuits (systemwide) and for circuits that received M&C investments by the end of 2022. The key reliability metrics involving outage duration (CKAIDI) and frequency (CKAIFI) are annual metrics, and impacts to these metrics from GMP investments would only be seen if the investments were installed for sufficient time on a particular circuit to impact outages that drive these annual metrics. The approach most likely to detect metric impacts from the investments would be to wait until the investment had been commissioned for several full years on the circuit before attempting to understand its impact on these metrics. However, to provide results for the stamp-approved metrics as currently defined, Guidehouse provides findings for CKAIDI and CKAIFI for circuits with M&C devices installed during 2018 through 2021 as well as the whole of 2022.[40]

The evaluation team also 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 of PM-12 and PM-13. 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]

[39] 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

[40] PY 2022 reliability metrics provided are inclusive of M&C 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 M&C circuits for circuits that received M&C 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.

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

4.1.3.1 Eversource Circuits

Eversource commissioned M&C devices from PY 2018 through PY 2022. Table 44 shows circuits with M&C 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. This resulted in the removal of a similar percentage of system-wide and M&C circuits from the analysis.

Table 44. Eversource Circuits Included in Analysis

Eversource Circuits	System-Wide through PY 2022	M&C Commissioned through PY 2022
Total Circuit Count	2,284	369
Circuits Included in Analysis	1,443	247
% of Total Circuits Included In Analysis	63%	67%

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

4.1.3.2 National Grid Circuits

National Grid commissioned M&C Feeder Monitor devices in PY 2019 through PY 2022. Table 45 shows circuits with M&C 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. This resulted in the removal of a smaller percentage M&C circuits from the analysis relative to system-wide circuits.

Table 45. National Grid Circuits Included in Analysis

National Grid Circuits	System-Wide through PY 2022	M&C Commissioned through PY 2022
Total Circuit Count	1,141	136
Circuits Included in Analysis	816	114
% of Total Circuits Included In Analysis	72%	84%

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

4.1.3.3 Unitil Circuits

Table 46 shows circuits with M&C devices commissioned through PY 2022. Unitil did not commission any new M&C investments on circuits in PY 2022, as the program was paused for

the full program year. 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. This resulted in the removal of a smaller percentage M&C circuits from the analysis relative to system-wide circuits.

Table 46. Unitil Circuits Included in Analysis

Unitil Circuits	System-Wide through PY 2022	M&C Commissioned through PY 2022
Total Circuit Count	44	11
Circuits Included in Analysis	30	9
% of Total Circuits Included In Analysis	68%	82%

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 M&C Performance Metrics Analysis and Findings

Evaluation of the relevant 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 47 provides a high-level summary of the results for each performance metric and EDC. These results focus on metrics for M&C circuits excluding EMEs, as these are most likely to better reflect the performance of the M&C investments from year to year (i.e., removing the effects of major storms from the comparison, which can vary greatly from year to year).

Table 47. Summary of Findings for M&C Investment Areas

PM	Eversource	National Grid	Unitil
PM-12: Grid Modernization investments' effect on outage durations	Outage duration for M&C circuits w/o EMEs for PY 2022 decreased compared to baseline.*	Outage duration for M&C circuits w/o EMEs for PY 2022 increased compared to baseline.*	Outage duration for M&C circuits w/o EMEs increased compared to baseline.*
PM-13: Grid Modernization investments' effect on outage frequency	Outage frequency for M&C circuits w/o EMEs for PY 2022 was lower than baseline.*	Outage frequency for M&C circuits w/o EMEs for PY 2022 was higher than baseline. *	Outage frequency for M&C circuits w/o EMEs for PY 2022 increased from baseline.*
PM-UTL1: Customer Minutes of Outage Saved per Circuit	N/A – Unitil specific metric	N/A – Unitil specific metric	The OMS/AMI Integration is not complete; this metric cannot yet be evaluated.

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

Source: Guidehouse Analysis

Table 48 shows the actual metrics data points for system-wide circuits for non EME days, which provides a backdrop for understanding the performance of M&C circuits below in the report.

Table 48. 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
Unitil	Weighted Average CKAIDI	56	48
	Weighted Average CKAIFI	0.87	0.61

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

Source: Guidehouse analysis of GMP Annual Reports and EDC Data

Examining performance for system-wide circuits when EMEs are *included* can also provide insight into the impact of major storms during the program year. National Grid and Unitil, customer-weighted average CKAIDI and CKAIFI metrics with EMEs for PY 2022 were generally better than they were for the Baseline years (2015-2017); however, for Eversource, these metrics were worse than baseline, as shown in Table 49.

Table 49. 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
Unitil	Weighted Average CKAIDI	146	61
	Weighted Average CKAIFI	1.55	0.97

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

Source: Guidehouse analysis of GMP Annual Reports and EDC Data

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 M&C circuit comparisons: The evaluation team compared the baseline and program year data across the entire system and for circuits receiving M&C 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 M&C investments fit into the context of the overall system metric performance and to compare changes in metrics for M&C 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. "Box-and-whisker" plots[42] are used to illustrate the distribution of data across the entire system and for circuits receiving M&C investments.[43]

3. Difference in differences: The difference in system-wide circuits change from baseline vs. M&C circuits change from baseline was calculated to understand if there is any discernable reliability improvement on the M&C circuits. This change is defined as "average metric for M&C 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 M&C investments. In addition, ancillary metrics are used for informative purposes. For clarity, a subset of those metrics are 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. This is used alongside the Simple Average, e.g., simply averaging CKAIDI or CKAIFI values for the circuits for the year, to compare the extent to which higher customer count circuits were impacted by outages. A Weighted Average greater than a simple average indicates that circuits with higher customer counts were more impacted by outages. The weighted average is computed using 2017 customer counts for the baseline, and 2022 customer count 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. Total Circuits with Non-Zero Customers only counts circuits that serve customer loads under normal conditions., i.e., it excludes backup circuits, and express circuits between substations, etc. The CKAIDI/CKAIFI analysis only considers circuits with non-zero customers.
- % Zero is the proportion of circuits 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.

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

[42] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 2nd and 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the start of the 2nd and the end of the 3rd quartile) 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.

[43] Note that the DPU Guidance defines the change as "Baseline – 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.

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 M&C 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.

System-wide and M&C circuit counts: Table 50 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 M&C investment fall within these bins. The bars provide a visual indicator of number of circuits in bin.

Approximately 19% of system wide and 21% of currently deployed M&C circuits had experienced no outages at all during the baseline period; this number increased across the board in PY 2022.

In comparison to the baseline, M&C circuits in PY 2022 had a 28-minute improvement in average CKAIDI without EMEs. System-wide circuits showed a slightly greater improvement of 29 minutes in CKAIDI without EMEs in 2022 from the baseline (note that M&C circuits are included in the system-wide results.)

However, an increase in average CKAIDI with EMEs for 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 may tend to "mask" individual major events in a single year).

The CKAIDI standard deviation w/EMEs also increased significantly, indicating increased variability in CKAIDI across system-wide circuits. The standard deviation is large relative to the average values, indicating that the results have less statistical significance. The opposite is true for CKAIDI standard deviation w/o EMEs, where the lower PY 2022 standard deviation signifies that the results are likely to have more statistical significance.

Table 50. Eversource Baseline and PY 2022 CKAIDI Distribution

Eversource M&C	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	369	369	2,284	2,284	369	369
Total Circuits with Non-zero Customers	1,443	1,443	247	247	1,443	1,443	247	247
% Zero CKAIDI	19%	19%	21%	21%	27%	33%	30%	35%
Average CKAIDI	128	103	95	89	177	74	75	61
Simple Avg. CKAIDI	97	78	80	76	147	62	64	49
Change from Baseline (Baseline - Plan Year)					-49	29	20	28
% Change from Baseline					-38%	28%	21%	31%
Std. Dev.	146	115	102	87	358	101	94	80
CKAIDI Range	**No. of Circuits in Range**							
0	275	276	52	52	395	482	73	87
0 - 50	449	490	75	75	450	492	84	87
50 - 150	413	446	85	87	260	279	54	48
150 - 250	154	142	19	19	106	95	17	13
250 - 350	72	52	8	8	76	50	15	10
350 - 450	38	21	5	4	31	20	2	1
450 - 550	19	7	1	2	32	16	2	1
550 - 650	6	1	1	0	22	4	0	0
650 - 750	7	3	0	0	12	0	0	0
750 - 850	6	3	1	0	7	3	0	0
850 - 950	2	1	0	0	7	1	0	0
950 - 1050	1	1	0	0	7	0	0	0
1050 - 1300	1	0	0	0	10	0	0	0
1300 - 1550	0	0	0	0	4	0	0	0
1550 - 1800	0	0	0	0	6	1	0	0
1800 - 2050	0	0	0	0	4	0	0	0
2050 - 3050	0	0	0	0	13	0	0	0
> 3050	0	0	0	0	1	0	0	0

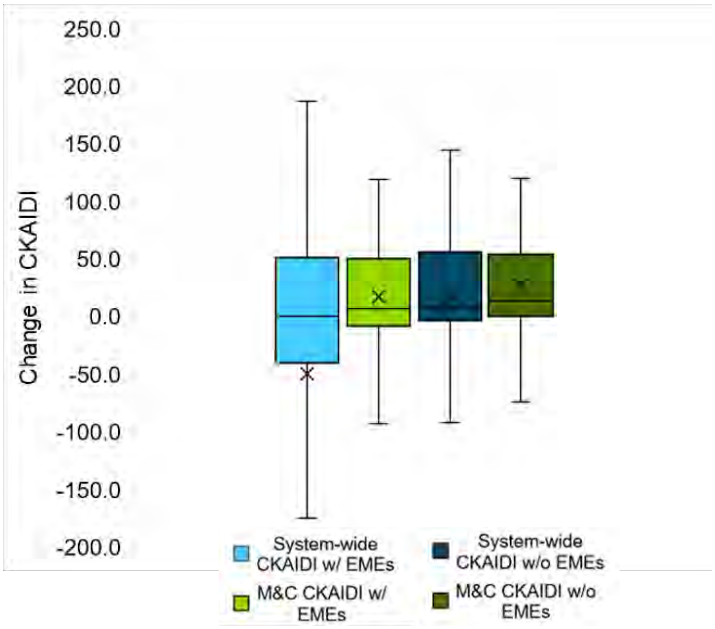
Note: EME = Excludable Major Events. CKAIDI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.

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 21 below, which uses the "box-and-whisker" format.[44] This chart compares the difference in CKAIDI between baseline and PY 2022, for both the system-wide and the selected M&C 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.

[44] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 2nd and 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the start of the 2nd and the end of the 3rd quartile) 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 21. Eversource Outage Duration Performance Metric Results



Change with EMEs	Change in System-wide CKAIDI w/ EMEs	Change in M&C CKAIDI w/ EMEs
Count	1,443	247
% No Change	16%	17%
Average Change in CKAIDI	-50	16
Standard Deviation	336	118
Median Change in CKAIDI	0	7

Change without EMEs	Change in System-wide CKAIDI w/o EMEs	Change in M&C CKAIDI w/o EMEs
Count	1,443	247
% No Change	17%	17%
Average Change in CKAIDI	16	27
Standard Deviation	138	96
Median Change in CKAIDI	7	13

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-wide CKAIDI with EMEs metric is negative (has worsened) in PY 2022 over the baseline. For the selected M&C circuits, CKAIDI with EMEs is positive, indicating a better performance than baseline on the M&C circuits on average. For non-EME days, both average system-wide and M&C are positive (better) relative to baseline, with M&C circuits improving by a greater amount.

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, indicating that the change in the average is of limited statistical significance, and not indicative of a clearly discernible trend in CKAIDI. As indicated above, there are many potential reasons for these changes and many factors impacting this metric. The M&C investment could be having a positive impact in operation, but as M&C investment is just one of the factors potentially effecting performance, the causality is not discernable using the metric itself.

Difference in differences: The differences in the change in CKAIDI (baseline to 2022) between the system-wide average and the average for circuits with M&C investments are shown in Table 51. The change in CKAIDI for system-wide circuits was greater than the circuits with M&C investments for EME days. As the standard deviation for these samples is larger than changes in CKAIDI with EME (as discussed above), it is difficult to discern how much positive impact the M&C investments had on this metric for PY 2022.

Table 51. Eversource CKAIDI Difference in Differences

	System-Wide Circuits	M&C Circuits	Difference in Differences (M&C - System-Wide)
Change in CKAIDI w/ EMEs	-50	16	66
Change in CKAIDI w/o EMEs	16	27	11

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, 3% of Eversource system-wide circuits and 1% of Eversource M&C 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: A shortcoming 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.

Feeder monitors provide visibility of real-time current and voltage, which are valuable to operators and planners. However, the feeder monitors are currently not used for fault identification and fault location. As the next step, National Grid plans to use feeder monitor data to reduce momentary interruptions and locating faults. For these reasons, National Grid's M&C investments, at this time, are not used to reduce outage duration or reduce the number of customers affected by an outage. The results presented below are consistent with this observation.

System-wide and M&C circuit counts: Table 52 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 M&C investment fall within these bins. The bars provide a visual indicator of number of circuits in bin.

System-wide circuits performed better than baseline for both EME and non-EME days. M&C circuits performed slightly better than baseline on EME days, but worse on non-EME days. Again, a relatively high standard deviation indicates high variability in the data, and thus the averages are not clear directional indicators.

For the M&C circuits (green bars), 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 M&C.

Table 52. National Grid Baseline and PY 2022 CKAIDI Distribution

National Grid M&C	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	136	136	1,141	1,141	136	136
Total Circuits with Non-zero Customers	816	816	114	114	816	816	114	114
% Zero CKAIDI	2%	3%	0%	1%	16%	17%	4%	6%
Average CKAIDI	226	112	175	108	140	100	174	134
Simple Avg. CKAIDI	206	107	175	102	131	95	168	128
Change from Baseline (Baseline - Plan Year)					86	12	1	-25
% Change from Baseline					38%	11%	1%	-23%
Std. Dev.	264	86	167	65	165	109	165	135
CKAIDI Range	**No. of Circuits in Range**							
0	20	22	0	1	129	136	5	7
0 - 50	195	256	25	31	242	277	26	35
50 - 150	267	336	42	54	219	236	37	36
150 - 250	141	131	26	24	109	100	20	19
250 - 350	61	47	13	3	50	35	9	8
350 - 450	33	13	2	1	27	13	10	6
450 - 550	22	7	1	0	10	5	3	1
550 - 650	20	0	1	0	8	5	0	0
650 - 750	10	0	1	0	6	3	2	1
750 - 850	7	1	0	0	6	1	1	0
850 - 950	12	3	0	0	1	1	0	0
950 - 1050	5	0	0	0	2	1	1	1
1050 - 1300	18	0	3	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

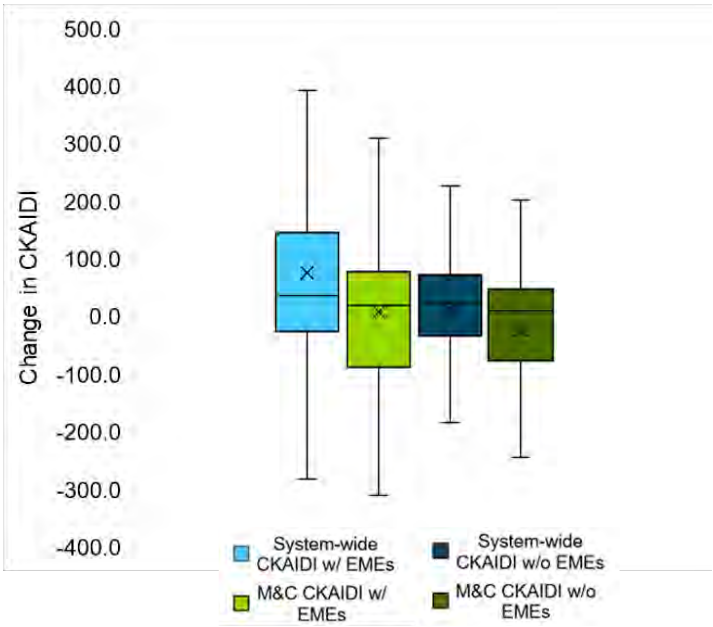
Note: EME = Excludable Major Events. CKAIDI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.

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 22 below, which uses "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 M&C 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 2nd through 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the start of the 2nd and the end of the 3rd quartile) 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 22. National Grid Outage Duration Performance Metric Results



Change with EMEs	Change in System-wide CKAIDI w/ EMEs	Change in M&C CKAIDI w/ EMEs
Count	816	114
% No Change	1%	0%
Average Change in CKAIDI	75	7
Standard Deviation	331	236
Median Change in CKAIDI	36	18

Change without EMEs	Change in System-wide CKAIDI w/o EMEs	Change in M&C CKAIDI w/o EMEs
Count	816	114
% No Change	2%	1%
Average Change in CKAIDI	12	-26
Standard Deviation	176	139
Median Change in CKAIDI	22	9

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

On average, the M&C circuits experienced a decrease in CKAIDI from the baseline to 2022 when including EME days, suggesting an improved performance during major storms. The positive median change value across all categorizations indicates that the majority of system wide and M&C circuits increased performance in 2022 as compared to the baseline. However, for M&C circuits, the average change in CKAIDI was worse than system average on both EME and non-EME days. In addition, the average change in CKAIDI without EMEs was negative while the median change in CKAIDI without EMEs was positive for M&C circuits. This is because there were several circuits for which the average change in CKAIDI without EMEs indicated a sizable worsening in CKAIDI between the baseline period and PY 2022, which caused the distribution of change in CKAIDI to skew negative (i.e., skew in a direction of less favorable results). Both results have been presented for transparency.

The standard deviation of the change in CKAIDI for each group is significantly 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.

Difference in differences: The differences in the change in CKAIDI (baseline to 2022) between the system-wide average and the average for circuits with M&C investments are shown in Table 53. The change in CKAIDI for circuits with M&C investments was less than the system wide circuits. As discussed above, this illustrates that the performance of the M&C circuits did not improve as much as that of an average system-wide circuit. Again, this data does not provide a clear indication of how the M&C investments themselves performed, as it is not possible to isolate the outage duration impacts using this metric.

Table 53. National Grid CKAIDI Difference in Differences

	System-Wide Circuits	M&C Circuits	Difference in Differences (M&C - System-Wide)
Change in CKAIDI w/ EMEs	75	7	-68
Change in CKAIDI w/o EMEs	12	-26	-37

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

Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

Major Events in the Baseline: A shortcoming 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.

4.2.1.3 Unitil Analysis

The analysis of the CKAIDI metric for Unitil is presented in the subsection below. Unitil's M&C investment consists of SCADA visibility and control in the substation. Substation SCADA enables Unitil to remotely monitor and manage distribution and transmission-level operations and outages.

Table 54 provides an overview of circuit performance during the baseline period and PY 2022.

Table 54. Unitil Baseline and PY 2022 CKAIDI Distribution

Unitil M&C	2015-2017 Avg. CKAIDI (Baseline)				2022 CKAIDI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	44	44	11	11	44	44	11	11
Total Circuits with Non-zero Customers	30	30	9	9	30	30	9	9
% Zero CKAIDI	0%	3%	0%	11%	17%	17%	22%	22%
Average CKAIDI	146	56	206	69	61	48	112	112
Simple Avg. CKAIDI	148	55	192	62	55	44	77	77
Change from Baseline (Baseline - Plan Year)					86	8	94	-44
% Change from Baseline					59%	15%	46%	-63%
Std. Dev.	96	36	61	43	65	62	82	82
CKAIDI Range	**No. of Circuits in Range**							
0	0	1	0	1	5	5	2	2
0 - 50	5	12	0	3	13	15	2	2
50 - 150	11	17	1	5	9	8	3	3
150 - 250	12	0	7	0	2	1	1	1
250 - 350	1	0	1	0	1	1	1	1
350 - 450	1	0	0	0	0	0	0	0
450 - 550	0	0	0	0	0	0	0	0
550 - 650	0	0	0	0	0	0	0	0
650 - 750	0	0	0	0	0	0	0	0
750 - 850	0	0	0	0	0	0	0	0
850 - 950	0	0	0	0	0	0	0	0
950 - 1050	0	0	0	0	0	0	0	0
1050 - 1300	0	0	0	0	0	0	0	0
1300 - 1550	0	0	0	0	0	0	0	0
1550 - 1800	0	0	0	0	0	0	0	0
1800 - 2050	0	0	0	0	0	0	0	0
2050 - 3050	0	0	0	0	0	0	0	0
> 3050	0	0	0	0	0	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

Average CKAIDI was better than baseline CKAIDI system-wide (both w/ and w/o EMEs), and for M&C circuits counting EME days, but worse for M&C circuits w/o EMEs. No EMEs occurred on M&C circuits during the program year. Circuits with M&C investments on non-EME days had a 44-minute increase in average CKAIDI, while system-wide circuits had an 8-minute decrease. The high standard deviation coupled with the low number of circuits with M&C investments indicate that this metric is not able to isolate the specific effect of M&C investment on the CKAIDI impacts.

Major Events in the Baseline: A shortcoming 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 frequency 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 M&C 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 the presentation structure aligns closely with that used 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.

System-wide and M&C circuit counts: Table 55 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 M&C investment fall within these bins.

Approximately 19% of system wide and 21% of currently deployed M&C circuits had experienced no outages at all during the baseline period. Circuits experiencing no outages increased significantly in PY 2022.

Relative to the baseline, both system-wide and M&C circuit average CKAIFI increased on EME days (metric is negative), and both decreased on non-EME days (metric is positive). This provide some indication of the impact EMEs on reliability performance in 2022.

The number of M&C circuits (green bars) in the lower bins (<1.75) seems to have improved slightly during 2022 on non-EME days, indicating movement towards improved performance on these circuits.

The CKAIFI standard deviation increased for both system-wide and M&C circuits, indicating increased variability in CKAIFI across 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 performance on non-EME days during the program year.

Table 55. Eversource Baseline and PY 2022 CKAIFI Distribution

Eversource M&C	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	369	369	2,284	2,284	369	369
Total Circuits with Non-zero Customers	1,443	1,443	247	247	1,443	1,443	247	247
% Zero CKAIFI	19%	19%	21%	21%	27%	33%	30%	35%
Average CKAIFI	0.98	0.92	0.83	0.82	1.22	0.91	0.86	0.71
Simple Avg. CKAIFI	0.68	0.64	0.62	0.61	0.92	0.63	0.64	0.50
Change from Baseline (Baseline - Plan Year)					-0.24	0.01	-0.03	0.11
% Change from Baseline					-25%	1%	-4%	13%
Std. Dev.	0.76	0.70	0.60	0.58	1.28	0.99	0.93	0.79
CKAIFI Range	**No. of Circuits in Range**							
0	278	279	52	52	395	482	73	87
0 - 0.25	187	192	32	32	273	310	50	55
0.25 - 0.75	471	486	78	79	180	176	47	40
0.75 - 1.25	250	255	48	48	213	225	35	35
1.25 - 1.75	128	132	23	23	107	75	16	10
1.75 - 2.25	79	59	10	9	90	77	8	12
2.25 - 2.75	26	22	2	3	51	37	5	1
2.75 - 3.25	13	11	2	1	43	30	7	6
3.25 - 3.75	8	6	0	0	28	12	3	1
3.75 - 4.25	2	1	0	0	18	11	1	0
4.25 - 4.75	0	0	0	0	13	2	2	0
4.75 - 5.25	0	0	0	0	16	5	0	0
5.25 - 5.75	0	0	0	0	5	0	0	0
5.75 - 6.25	0	0	0	0	3	0	0	0
6.25 - 6.75	0	0	0	0	1	1	0	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

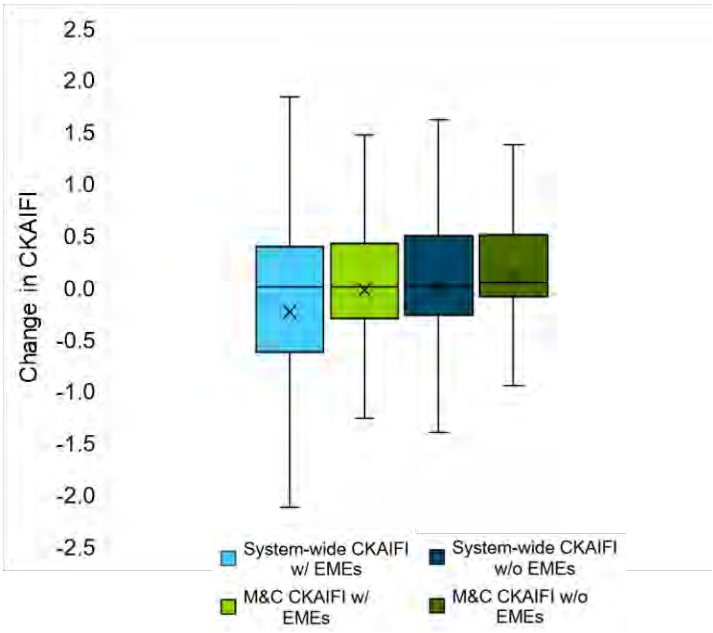
Note: EME = Excludable Major Events. CKAIFI of zero indicates circuit did not experience any outages. Baseline is updated each year based on circuits included in analysis.

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 23 below, which uses "box-and-whisker" format.[46] This chart compares the difference in CKAIFI between baseline and PY 2022, for both the system-wide and the selected M&C 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.

[46] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 2nd and 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the start of the 2nd and the end of the 3rd quartile) 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 23. Eversource Outage Frequency Performance Metric Results



Change with EMEs	Change in System-wide CKAIFI w/ EMEs	Change in M&C CKAIFI w/ EMEs
Count	1,443	247
% No Change	16%	17%
Average Change in CKAIFI	-0.24	-0.03
Standard Deviation	1.20	0.85
Median Change in CKAIFI	0.00	0.00

Change without EMEs	Change in System-wide CKAIFI w/o EMEs	Change in M&C CKAIFI w/o EMEs
Count	1,443	247
% No Change	17%	17%
Average Change in CKAIFI	0.01	0.11
Standard Deviation	0.91	0.72
Median Change in CKAIFI	0.01	0.04

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 w/o EMEs changed very little in PY 2022 relative to the baseline period, while the CKAIFI w/EMEs increased. For the selected M&C circuits, the change in CKAIFI indicates slight improvement of performance on the M&C circuits on average when compared to the change in CKAIFI of the 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 M&C 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 M&C investments are shown in Table 56. The change in CKAIFI was slightly positive (improved) w/o including EME days for both system-wide and M&C circuits, with M&C circuits showing a slightly better improvement. The change in CKAIFI was negative (worse) when including EME days for both, but M&C circuits fared better than system-wide circuits.

Table 56. Eversource CKAIFI Difference in Differences

	System-Wide Circuits	M&C Circuits	Difference in Differences (M&C - System-Wide)
Change in CKAIFI w/ EMEs	-0.24	-0.03	0.21
Change in CKAIFI w/o EMEs	0.01	0.11	0.10

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

Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

Given the metrics analysis above, it is difficult to conclude how much positive (or negative) impact the M&C investments had on customer reliability during for Program Year 2022.

While Eversource M&C investments provide useful information about outages and potentially help to reduce outage durations, M&C investments, by themselves, are not expected to prevent an outage from occurring. M&C investments when coupled with devices such as reclosers, padmount switchgear, network protectors, etc. can reduce overall outage times. As such, Eversource's M&C investments are expected to have little impact on CKAIFI which measures the frequency (number) of outages.

Erosion of Baseline: As mentioned in section 4.1.3.1, 3% of Eversource system-wide circuits and 1% of Eversource M&C 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: A shortcoming 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.

System-wide and M&C circuit counts: Table 57 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 M&C investment fall within these bins.

Average CKAIFI increased from baseline in PY 2022 for circuits with M&C investments on both EME and non-EME days. Compared to the baseline, CKAIFI on M&C circuits was 38% worse than baseline on EME days and 30% worse than baseline on non-EME days. Average system-wide performance was similar to the baseline, but showed higher variability in CKAIFI, as can be seen by the increased standard deviation.16% of system-wide circuits experienced no outages in PY 2022, despite the increased EME activity. This aligns with the observation that

there was greater variability in customers' outages for 2022, with some customers experiencing no outages while others noticeably more.

The 114 M&C circuits had a greater increase in average CKAIFI values than the system-wide CKAIFI values in PY 2022, indicating that these circuits performed comparatively worse. The CKAIFI standard deviation also increased significantly, indicating increased variability in CKAIFI across the system. The standard deviation values are comparable to the weighted averages, providing some indication that the change in the weighted average is not simply statistical noise, but an actual degradation in performance during the program year.

Table 57. National Grid Baseline and PY 2022 CKAIFI Distribution

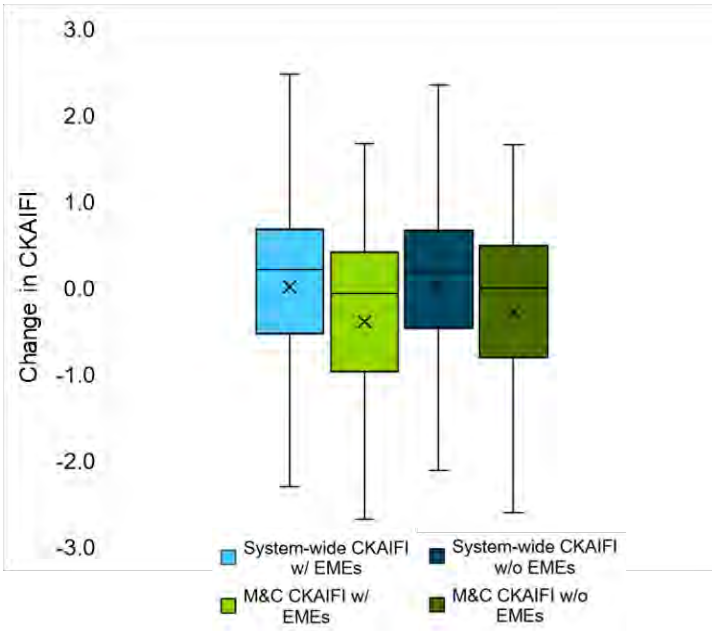
National Grid M&C	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIFI Statistics								
Total Circuits	1,141	1,141	136	136	1,141	1,141	136	136
Total Circuits with Non-zero Customers	816	816	114	114	816	816	114	114
% Zero CKAIFI	2%	3%	0%	1%	16%	17%	4%	6%
Average CKAIFI	1.02	0.92	1.01	0.93	1.04	0.91	1.39	1.21
Simple Avg. CKAIFI	0.88	0.79	0.89	0.83	0.87	0.77	1.29	1.13
Change from Baseline (Baseline - Plan Year)					-0.02	0.01	-0.39	-0.28
% Change from Baseline					-2%	1%	-38%	-30%
Std. Dev.	0.65	0.60	0.56	0.52	1.03	0.89	1.12	0.97
CKAIFI Range	**No. of Circuits in Range**							
0	20	23	0	1	131	138	5	7
0 - 0.25	83	103	13	14	206	220	18	20
0.25 - 0.75	298	318	39	41	109	119	23	25
0.75 - 1.25	222	212	32	33	162	158	17	19
1.25 - 1.75	123	105	19	16	68	69	17	17
1.75 - 2.25	42	37	10	9	59	54	12	10
2.25 - 2.75	21	14	1	0	33	24	10	6
2.75 - 3.25	5	3	0	0	25	20	4	5
3.25 - 3.75	2	1	0	0	11	7	5	3
3.75 - 4.25	0	0	0	0	5	5	1	1
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	1	0
5.75 - 6.25	0	0	0	0	2	1	1	1
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 24 below, which uses "box-and-whisker" format.[47] This chart compares the difference in CKAIFI between baseline and PY 2022, for both the system-wide and the selected M&C 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.

Figure 24. National Grid Outage Frequency Performance Metric Results



Change with EMEs	Change in System-wide CKAIFI w/ EMEs	Change in M&C CKAIFI w/ EMEs
Count	816	114
% No Change	1%	1%
Average Change in CKAIFI	0.00	-0.40
Standard Deviation	1.07	1.22
Median Change in CKAIFI	0.21	-0.07

Change without EMEs	Change in System-wide CKAIFI w/o EMEs	Change in M&C CKAIFI w/o EMEs
Count	816	114
% No Change	2%	2%
Average Change in CKAIFI	0.02	-0.30
Standard Deviation	0.98	1.14
Median Change in CKAIFI	0.18	-0.01

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 system-wide CKAIFI changed only slightly from the baseline to PY 2022, but in a positive direction. The change in CKAIFI for M&C circuits was larger, but in a negative direction (worsening performance). The magnitude of the difference in baseline and PY 2022 CKAIFI was greater for M&C circuits, indicating a worsening performance on the M&C circuits on average. The below-median average change value for M&C circuits signifies that the overall decreased performance is driven by a smaller subset of circuits with significantly higher CKAIFI in 2022.

Difference in differences: The differences in the change in CKAIFI between the system-wide average and the average for circuits with M&C investments are shown in Table 58. The change

[47] The "box-and-whisker" plot divides the sample into quartiles. The boxes show the 2nd and 3rd quartile in the sample. The lower and upper "whiskers" indicate 1.5 times the interquartile range (IQR) (difference between the start of the 2nd and the end of the 3rd quartile) 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.

in CKAIFI for circuits with M&C investments was worse than the system-wide circuits. It is difficult to conclude how much positive (or negative) impact the M&C investments had on this metric for PY 2022.

Table 58. National Grid CKAIFI Difference in Differences

	System-Wide Circuits	M&C Circuits	Difference in Differences (M&C - System-Wide)
Change in CKAIFI w/ EMEs	0.00	-0.40	-0.40
Change in CKAIFI w/o EMEs	0.02	-0.30	-0.32

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

Source: Guidehouse Analysis of 2022 GMP Annual Report Appendix 1

Major Events in the Baseline: A shortcoming 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.

4.2.2.3 Unitil Analysis

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

Unitil had 9 qualifying M&C circuits meeting the data availability criteria. Table 59 provides an overview of circuit performance during the baseline period and PY 2022.

Table 59. Unitil Baseline and PY 2022 CKAIFI Distribution

Unitil M&C	2015-2017 Avg. CKAIFI (Baseline)				2022 CKAIFI (Program Year)			
	System-wide		M&C Circuits		System-wide		M&C 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	44	44	11	11	44	44	11	11
Total Circuits with Non-zero Customers	30	30	9	9	30	30	9	9
% Zero CKAIFI	0%	3%	0%	11%	17%	17%	22%	22%
Average CKAIFI	1.55	0.87	2.07	1.02	0.97	0.61	1.32	1.32
Simple Avg. CKAIFI	1.62	0.87	2.12	0.99	0.88	0.56	0.91	0.91
Change from Baseline (Baseline - Plan Year)					0.58	0.25	0.75	-0.30
% Change from Baseline					38%	29%	36%	-29%
Std. Dev.	0.86	0.54	0.65	0.63	1.10	0.67	0.82	0.82
CKAIFI Range	**No. of Circuits in Range**							
0	0	1	0	1	5	5	2	2
0 - 0.25	1	3	0	0	6	8	2	2
0.25 - 0.75	5	9	0	3	8	8	0	0
0.75 - 1.25	5	9	1	1	3	5	2	2
1.25 - 1.75	5	6	2	3	4	3	2	2
1.75 - 2.25	6	2	2	1	0	0	0	0
2.25 - 2.75	5	0	3	0	0	0	0	0
2.75 - 3.25	3	0	1	0	3	1	1	1
3.25 - 3.75	0	0	0	0	0	0	0	0
3.75 - 4.25	0	0	0	0	1	0	0	0
4.25 - 4.75	0	0	0	0	0	0	0	0
4.75 - 5.25	0	0	0	0	0	0	0	0
5.25 - 5.75	0	0	0	0	0	0	0	0
5.75 - 6.25	0	0	0	0	0	0	0	0
6.25 - 6.75	0	0	0	0	0	0	0	0
6.75 - 7.25	0	0	0	0	0	0	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

In the baseline, M&C circuits have slightly higher CKAIFI values than the system-wide circuits. This was also true in PY 2022, where circuits with M&C investments reflect higher CKAIFI values than system-wide circuits. Compared to the baseline, average CKAIFI for both system-wide and M&C circuits mostly improved, with only M&C circuits on non-EME days worsening. However, due to the small sample size, limited conclusions can be drawn about any trends or impacts of M&C based on this metric.

Major Events in the Baseline: A shortcoming 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-UTL1: Unitil Reliability-Related Metric: Customer Minutes Saved per Outage

This metric tracks the time savings realized from faster AMI outage notification compared customer outage call. The metric seeks to quantify the impacts of Unitil's OMS/AMI integration through the reduced customer of minutes of interruption. The OMS/AMI integration has not been completed, and so this metric cannot yet be analyzed.

5. M&C Case Studies

This section features six case studies for the M&C investment area: two for Eversource, two for National Grid, and two for Unitil. 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 aggregated reliability data.

The case studies in this section explore a variety of use cases of M&C, including support in outage management, load balancing for system efficiency, facilitation of DER interconnections, etc. Guidehouse acknowledges stakeholder and EDC comments stating case studies be made less technical and more user-friendly[48]. 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. The OMS records show customer counts, fault locations, outage start/end times, devices operated, outage cause, weather conditions, and other information relevant to outages
- Written comments by dispatchers and crews elaborating the cause of the outage and actions taken in response
- SCADA 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 understand the sequence of events, corrective actions taken and estimate benefit or time savings resulting from GMP investments
- For M&C case studies not involving outages, Guidehouse requested supplemental information from EDCs including samples of data reported by GMP M&C devices, circuit conditions where the GMP device was installed, documentation of how the data was used in EDC analysis, and EDC actions taken in response to the analysis

[48] 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 Light Company d/b/b Unitil on Metrics, and New Metrics Proposals, DPU 21-80, 21-81 and 21-82, p. 4

5.2 Eversource

5.2.1 Eversource Uses M&C to Reduce Planned Outage Duration in Boston Metro Area

5.2.1.1 Summary Overview

Eversource used circuit breaker SCADA M&C investment to reduce planned outage time to customers in the town of Brookline in Boston metropolitan area. Eversource had commissioned circuit breaker SCADA capability to the underground 4kV circuit breaker. Previously, the circuit breaker had been manually operated with no remote telemetry or control capability.

5.2.1.2 Description

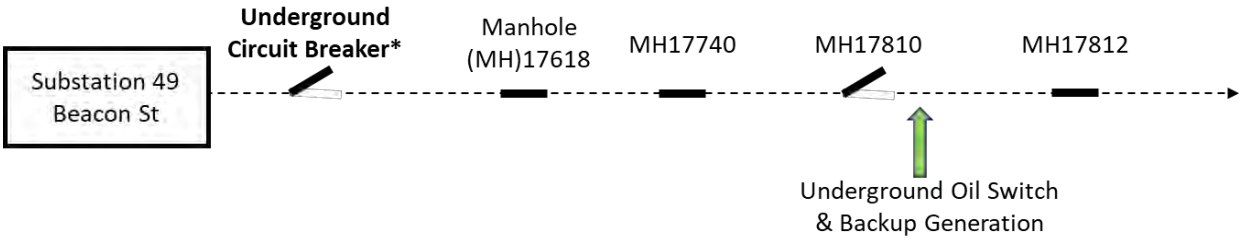
On December 5, 2022, Eversource had to perform substation repairs in the town of Brookline in the Boston metropolitan area. Eversource was utilizing a backup generator to supply power to Brookline customers while supply from the substation was interrupted. However, the backup generator started fluctuating during operation. Eversource underground crew and vendor technicians attempted repairs but determined that the faulty generator would have to be replaced with a second backup generator.

For customer load to be shifted to the second backup generator, Eversource had to open an underground oil switch (see Figure 25) and transfer the load to the second generator. The underground oil switch is a legacy device without any communication or remote functionality[49]. Eversource would have to switch off the circuit breaker, causing a planned outage to 475 customers supplied by the circuit 4912 in Brookline.

Eversource had commissioned M&C SCADA capability to the underground 4kV circuit breaker as part of the GMP M&C investment (**bold with an asterisk** in Figure 25). Using the M&C SCADA capability, Eversource operators remotely opened the circuit breaker. Crews at the oil switch location switched load to the new generator within 7 minutes. After 7 minutes, control center operators remotely closed the circuit breaker using M&C SCADA, restoring power to customers. Without M&C capability, the outage duration would have been longer as Eversource crews would have to open and close the circuit breaker manually.

[49] Note: Eversource has been replacing legacy oil switches in a multi-year program, though a few still remain in the field.

Figure 25: One Line Schematic Diagram of Circuit 4912



Source: Guidehouse analysis of 2022 EDC data

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

5.2.2.1 Summary Overview

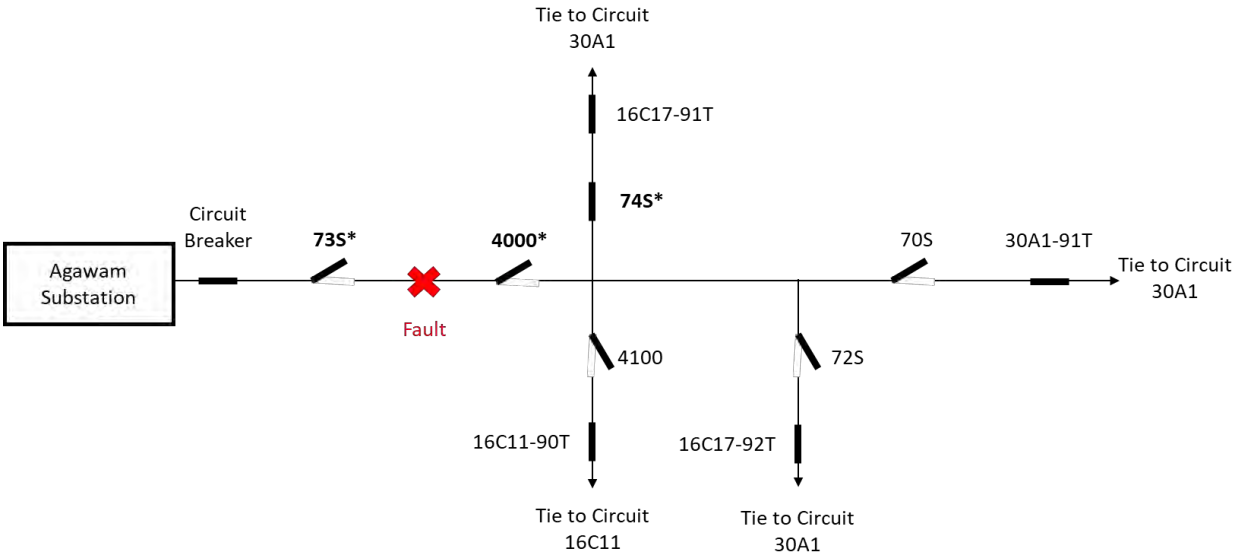
This joint M&C and ADA case study illustrates how ADA and M&C devices can serve different and complementary purposes during an event. The Eversource ADA loop scheme operated as designed, restoring power to the majority of customers in one minute. The loop scheme supplied power to four sub-sections of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

5.2.2.2 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 26) 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 26 for a schematic of the devices that operated on circuit 16C17.

Figure 26: 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 National Grid

5.3.1 National Grid Uses M&C to Facilitate Cost-Effective DER Interconnection

5.3.1.1 Summary Overview

One of the Department's objectives for GMP investment is the enhanced interconnection and integration of distributed energy resources (DER). National Grid used M&C feeder monitors in the town of Shutesbury to foster cost-effective development and interconnection of DER on the distribution grid. The feeder monitors allowed National Grid to model the system benefit of additional DER capacity and propose a cost allocation between the developer and ratepayers.

5.3.1.2 Description

National Grid had received five new interconnection applications for solar-plus-storage facilities in the Shutesbury area. The proposed DER installations, totaling 20 MW, would require expensive electric system upgrades before they could be safely and reliably connected, including underground manholes, transformers, switches and conductors[50].

Traditionally, a DER project developer would have to pay for electric grid upgrades needed for interconnection, even though the upgrades may allow for future DER projects to be interconnected without further upgrades. The DPU has identified high interconnection costs to

[50] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, D.P.U. 22-61, Responses to Attorney General's Second Set of Information Requests, Attachment AG 2-1-2 – REDACTED, Date: August 26, 2022

be an impediment to DER development[51], issuing Order 20-75-B in 2021 to "facilitate an equitable allocation of costs and remove barriers to the Commonwealth's progress to a clean energy future."

To comply with the DPU Order 20-75-B, National Grid used data from feeder monitors installed at the headend of the Shutesbury circuit (704W1). National Grid used the feeder monitor data to model the impacts of new DER on the system and determine the capacity benefit of the grid upgrade. Using the results of the analysis, National Grid was able to allocate the cost of system upgrades between the DER applicant and distribution customers. The DPU's Order 20-75-B provides that customers will be reimbursed over time from fees charged to future DER facilities that are able to interconnect due to the upgrades.

5.3.2 National Grid Uses M&C to Improve Power Delivery Efficiency and Defer Costs

5.3.2.1 Summary Overview

National Grid used M&C feeder monitors to increase the reliability and efficiency of power distribution in the town of Swansea. The feeder monitors also allowed National Grid to accommodate new customer load on Swansea circuits without costly capacity upgrades, thus lowering costs for customers. National Grid used feeder monitors to identify circuits that were 'imbalanced'. Imbalanced circuits have some equipment already fully loaded and unable to support further customer load, and other equipment lightly loaded and able to support additional customer load. Using the feeder monitors, National Grid 'rebalanced' or redistributed load and improved system efficiency. The benefits of feeder monitors in this case study were as follows:

- Allowed National Grid to identify heavily loaded areas and lower the risk of asset overload and power failure
- Allowed National Grid to connect new customer load to the Swansea distribution grid without investing in grid upgrades that would have been required in the absence of re-balancing
- Allowed National Grid to increase the efficiency of power delivery. Line losses are proportional to a square of the current. Rebalancing the three phases of the circuit lowered the current, thereby lowering line losses.

5.3.2.2 Description

The Swansea substation feeds five circuits. In 2020, National Grid commissioned M&C feeder monitors that enabled monitoring of three-phase loading on Swansea circuits[52]. National Grid discovered phase imbalance and overloading on two circuits, 11W82 and the 11W84. Each circuit comprises three phases (A, B and C) and customers "tap off" one of the three phases. The three phases are intended to serve roughly equal loads, but over time, more customers had

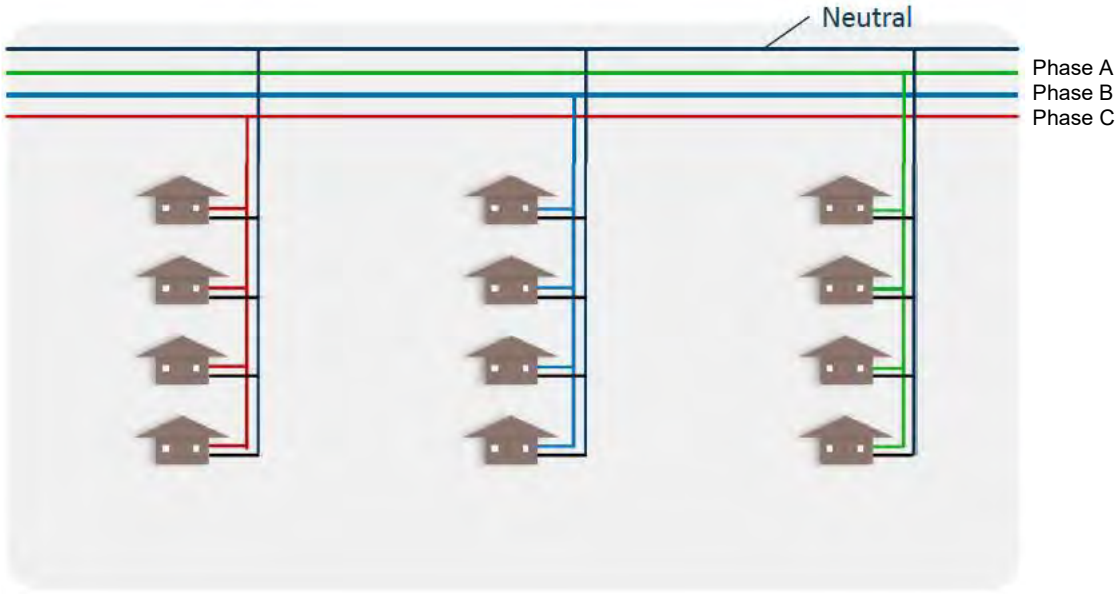
[51] Massachusetts DPU Order 20-75-B issued November 2021, accessed at URL: https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/14232299

[52] Note: The PY 2020 M&C Evaluation Report included a case study on another Swansea circuit, 11W83, describing how National Grid avoided overloading conditions.

been connected to one phase than the others. See Figure 27 for a schematic of a balanced circuit.

National Grid expected three new customer loads to come online in summer and fall of 2023 on circuits 11W82 and 11W84. The circuits did not have capacity to accommodate the load at the proposed locations without capital upgrades. However, the feeder monitors allowed National Grid to redistribute existing load among the three phases. This relieved the overloading condition and opened up capacity to connect more load. National Grid was able to defer expensive asset upgrades achieve efficiency and reliability improvements for customers.

Figure 27: Schematic of Customers Serviced from a Three-Phase Distribution Line



Note: Load on each phase is roughly balanced in this diagram (equal customers on each phase).
Source: Enerdynamics, The Electrical Distribution System

5.4 Unitil

5.4.1 Unitil Uses M&C for Faster Service Restoration in Lunenburg

5.4.1.1 Summary Overview

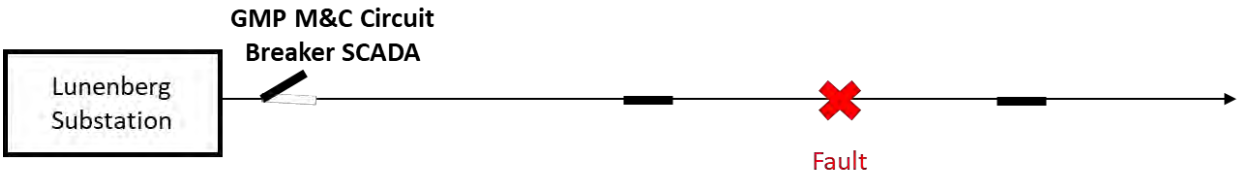
Unitil utilized GMP substation M&C capability to remotely restore power to customers during an outage in Lunenburg, Massachusetts. Remote M&C capability reduced crew travel and manual operation time, shortening the outage duration.

5.4.1.2 Description

On September 23, 2022 at 4:30pm, an uprooted tree caused damage to distribution poles and overhead lines on Page Street in Lunenberg, MA. The line damage caused the circuit breaker to lock out (open), and all 1,367 customers on circuit 30W30 lost power. Figure 28 shows the circuit breaker in the open state.

Unitil crews arrived on site to remove the tree and repair the damaged poles and wires. Once repairs were complete, Unitil used GMP-funded M&C substation SCADA to remotely restore power. Unitil control center operators remotely closed the circuit breaker that had locked out, restoring power to all customers. Before M&C, the circuit breaker had to be operated manually and did not have remote communication capability. Unitil had commissioned M&C SCADA capability at the circuit breaker located in the substation. The M&C operation resulted in a 10-minute outage savings to 1,367 customers, as it would have taken crews approximately ten minutes to travel to the substation and manually operate the device.

Figure 28: One Line Schematic Diagram of Circuit 30W30



Source: Guidehouse analysis of 2022 EDC data

5.4.2 Unitil Uses M&C to Shorten Outage Duration in Lunenburg

5.4.2.1 Summary Overview

Unitil utilized GMP substation M&C capability to remotely restore power to customers during a storm in Lunenburg, Massachusetts. M&C allowed Unitil to learn about the outage 2 minutes faster than the first customer call. During repairs, remote M&C capability reduced crew travel and manual operation time, shortening the outage duration.

5.4.2.2 Description

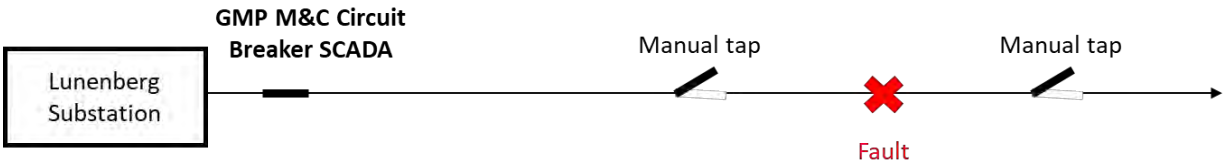
On March 2, 2023, strong winds in Lunenburg, Massachusetts caused overhead distribution lines to break off from the pole on Lancaster Avenue. All 1,354 customers served by the circuit 30W30 lost power. Unitil had commissioned GMP-funded M&C SCADA at the Lunenburg substation. Following the power failure, Unitil took three major steps to restore power:

Step 1 – Unitil's GMP-funded substation M&C device sent SCADA notifications of the circuit lockout to the control center at 7:25am. Unitil's control center received SCADA notification 2 minutes before the first customer call. Thus, Unitil began resolving the issue 2 minutes earlier with M&C capability than it would have otherwise. Thus, M&C saved all 1,354 customers 2 minutes of power interruption time.

Step 2 – Unitil crews arrived on the scene and proceeded to isolate the fault to reduce the number of customers affected. They manually opened pole-top devices on either side of the fault (illustrated by open taps in Figure 29). Then, crews asked control center operators to remotely close the circuit breaker. The circuit breaker (shown in Figure 29) had previously been a manual device but Unitil had added M&C capability using GMP funds. At 8:01am, Unitil operators remotely closed the breaker using M&C SCADA, restoring 129 customers between the substation and the fault. Without M&C SCADA, these 129 customers would have been without power for an additional 10 minutes while crews travelled to the substation and manually operated the device.

Step 3 – Unitil crews finished repairs and manually operated field devices to restore power to the remaining 1,225 customers. While the devices in Step 3 were manually operated, all the customers in Step 3 would have been interrupted for a longer time if in Step 2 crews had to travel to the substation and back. Thus, GMP M&C SCADA allowed crews to begin Step 3 faster, reducing outage time for 1,225 customers by 20 minutes.

Figure 29: One Line Schematic Diagram of Circuit 30W30



Source: Guidehouse analysis of 2022 EDC data

6. Key Findings and Recommendations

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

1. On non-EME days, Eversource circuits with M&C investment showed lower (improved from baseline) average outage duration, whereas National Grid and Unitil circuits with M&C showed slightly higher (worse) average outage duration. Including EME days, Eversource, National Grid and Unitil performed better than baseline.
    - Recommendation: continue tracking and monitoring this investment area to 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). Case studies (discussed below) can provide additional insight.

2. On non-EME days, Eversource circuits with M&C investment showed lower (improved from baseline) average outage frequency, whereas National Grid and Unitil circuits with M&C showed slightly higher (worse) average outage frequency. Including EME days, Eversource and National Grid both performed slightly worse than baseline, and Unitil slightly better.
    - Recommendation: continue tracking and monitoring this investment area to 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). Case studies (discussed below) can provide additional insight.

3. Based on case studies performed, the M&C investment is yielding reliability and service delivery benefits to customers of each of the EDCs.
    - 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.

4. National Grid is using M&C devices for load balancing, enhancing the penetration of DERs, and deferring capital upgrades. These functions are directly serving the Department's objectives for Grid Modernization by improving the efficiency of power delivery and facilitating DER interconnections.

5. For National Grid, the evaluation process validated that the feeder monitor sensor investment improves situational awareness, but at this time the impact on reducing outage duration or number of customers affected during an outage is not clear. This finding was made previously, but bears repeating.
    - Recommendation for National Grid: Develop programs to use the feeder monitor sensors to identify and review momentary outages to predict causes which could mitigate future outages.

6. Unitil is increasingly utilizing substation M&C SCADA capability and incorporating SCADA in work processes. In PY 2022, Unitil used GMP M&C capability to remotely

restore power to customers, but did not use M&C for outage notification, as seen in Case Study 5.4.1. In PY 2023, Unitil is using GMP M&C for outage restoration as well as outage notification (as seen in Case Study 5.4.2 where outage start time is based on SCADA outage notification time). This should add beneficial impacts.

7. Since Unitil's M&C investments are focused on the substation, circuit power restoration work is still predominantly manual, as evident in the two Unitil case studies.
    - Recommendation for Unitil: evaluate the benefits and costs of M&C and automation investments outside the substation.

8. 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 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 successful device operation).[53]

[53] 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.