Massachusetts Grid Modernization Program Year 2020 Evaluation Report: Advanced Distribution Automation (ADA)

Massachusetts Electric Distribution Companies

Submitted by:

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Introduction

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

This evaluation focuses on the progress and effectiveness of the Massachusetts Department of Public Utilities (DPU) preauthorized ADA investments for each EDC toward meeting the DPU's grid modernization objectives for Program Year (PY) 2020.

Evaluation Process

The DPU requires a formal evaluation process, including an evaluation plan and evaluation studies, for the EDCs' preauthorized GMP investments. Guidehouse (formerly Navigant Consulting, Inc.)[1] is completing the evaluation to help ensure a uniform statewide approach and to facilitate coordination and comparability of evaluation results. The evaluation's objective is to measure the progress made toward the achievement of 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 Navigant Consulting (now Guidehouse) was submitted to the DPU by the EDCs in a petition for approval on May 1, 2019. Modifications to this original Evaluation Plan were made to 1) request changes to the reporting schedule to accommodate Performance Metrics data availability timing, as discussed in response to DPU EP-1-1 submitted on February 6, 2020[2], and 2) to extend the Grid Modernization term period from the original 3 year term to a 4 year term as ordered by the DPU in its May 12, 2020 Modifications to the original Evaluation Plan were submitted to the DPU by the EDCs in a petition for approval on December 1, 2020. The modified Evaluation Plan has been used to develop the analysis and evaluation provided below in this document.

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

[1] Guidehouse LLP completed its acquisition of Navigant Consulting, Inc, in October of 2019. The two brands are now combined as one Guidehouse.

[2] Submitted to Massachusetts DPU 15-120, 15-121, 15-122

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

Table 1. ADA Evaluation Metrics

Metric Type	ADA Evaluation Metrics	ES	NG
IM	System Automation Saturation*	✓	✓
IM	Number of Devices or Other Technologies Deployed	✓	✓
IM	Cost for Deployment	✓	✓
IM	Deviation between Actual and Planned Deployment for the Plan Year	✓	✓
IM	Projected Deployment for the Remainder of the 3-Year Term	✓	✓
PM	Numbers of Customers that Benefit from GMP-Funded Distribution Automation Devices	✓	✓
PM	Grid Modernization Investments' Effect on Outage Durations	✓	✓
PM	Grid Modernization Investments' Effect on Outage Frequency	✓	✓
PM	Eversource Customer Outage Metric	✓	
PM	National Grid Specific Metric: Impact of ADA Investments on Customer Minutes of Interruption (CMI) for Main-Line Interruptions		✓
Other	Case Studies	✓	✓

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

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

Source: Guidehouse Stage 3 Evaluation Plan filed December 1, 2020

The EDCs shared the data supporting the Infrastructure Metrics, Performance Metrics and Case Studies with the evaluation team. Guidehouse presents results from analysis of Infrastructure Metrics data in Section 3.2 and the Performance Metrics Data in Section 4.2.

Data Management

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

Table 2 summarizes data sources used throughout the evaluation of ADA in PY2020. Section 3.1.1 provides further details each of the data sources.

Table 2. ADA Data Sources

Data Source	Description
2019 Grid Modernization Plan Annual Report[4,5,6]	Planned device deployment and cost information from each EDC's appendix to the 2019 GMP Annual Report (filed April 1, 2020). Data is used as the reference to track progress against the GMP targets and is referred to as the GMP Plan in summary tables and figures throughout the report.
2020 Grid Modernization Plan Annual Report[7,8,9]	All PM-related data are from these 2020 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 2020 Grid Modernization Plan Annual 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. Estimated device deployment information and estimated spend for PY2021 were provided at the most granular level. Data is referred to as EDC Data in summary tables and figures throughout the report.
Eversource's 2021 DPU-Filed Plan[10]	Eversource's GMP Extension request, which was approved by the DPU on February 4, 2021. Includes budgets for PY2021 deployment at the Investment Area level. This data source is included in the "EDC Plan" for Eversource planned spend at the Investment Area level.

Source: Guidehouse analysis

Guidehouse reviewed all data provided upon receipt and conducted a detailed QA/QC of data inputs used in analysis of Infrastructure Metrics and Performance Metrics. These QA/QC steps include checks to confirm each of the required data inputs are accounted for and can be incorporated into analysis. Additional information about the QA/QC process is covered in Section 4.1.2.

[4] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Plan Annual Report 2019. Submitted to Massachusetts DPU on April 1, 2020 as part of DPU 15-120

[5] NSTAR Electric Company d/b/a Eversource Energy, Grid Modernization Plan Annual Report 2019. Submitted to Massachusetts DPU on April 1, 2020 as part of DPU 15-122

[6] Fitchburg Gas and Electric Light Company d/b/a Unitil, Grid Modernization Plan Annual Report 2019. Submitted to Massachusetts DPU on April 1, 2020 as part of DPU 15-121

[7] 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 DPUD.P.U. 21-30

[8] 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 DPUD.P.U. 21-30. Note: Inconsistencies in calculations and definitions were discovered and Eversource updated the Appendix 1 in May 2021. The updates were provided to Guidehouse.

[9] 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 DPUD.P.U. 21-30

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

Findings and Recommendations

Table 3 summarizes the Infrastructure Metrics results for each EDC's ADA investment area through PY 2020. Eversource met its device deployment targets in three out of four of ADA device categories, while remaining under the DPU-pre-authorized budget cap. National Grid encountered COVID-19-related delays to its field construction and planned outage schedules, impacting the 2020 ADA progress and spend. National Grid re-accelerated its pace in late 2020 with 19 ADA devices deployed, and plans to complete its GMP targets in 2021.

Table 3. ADA Infrastructure Metrics Summary

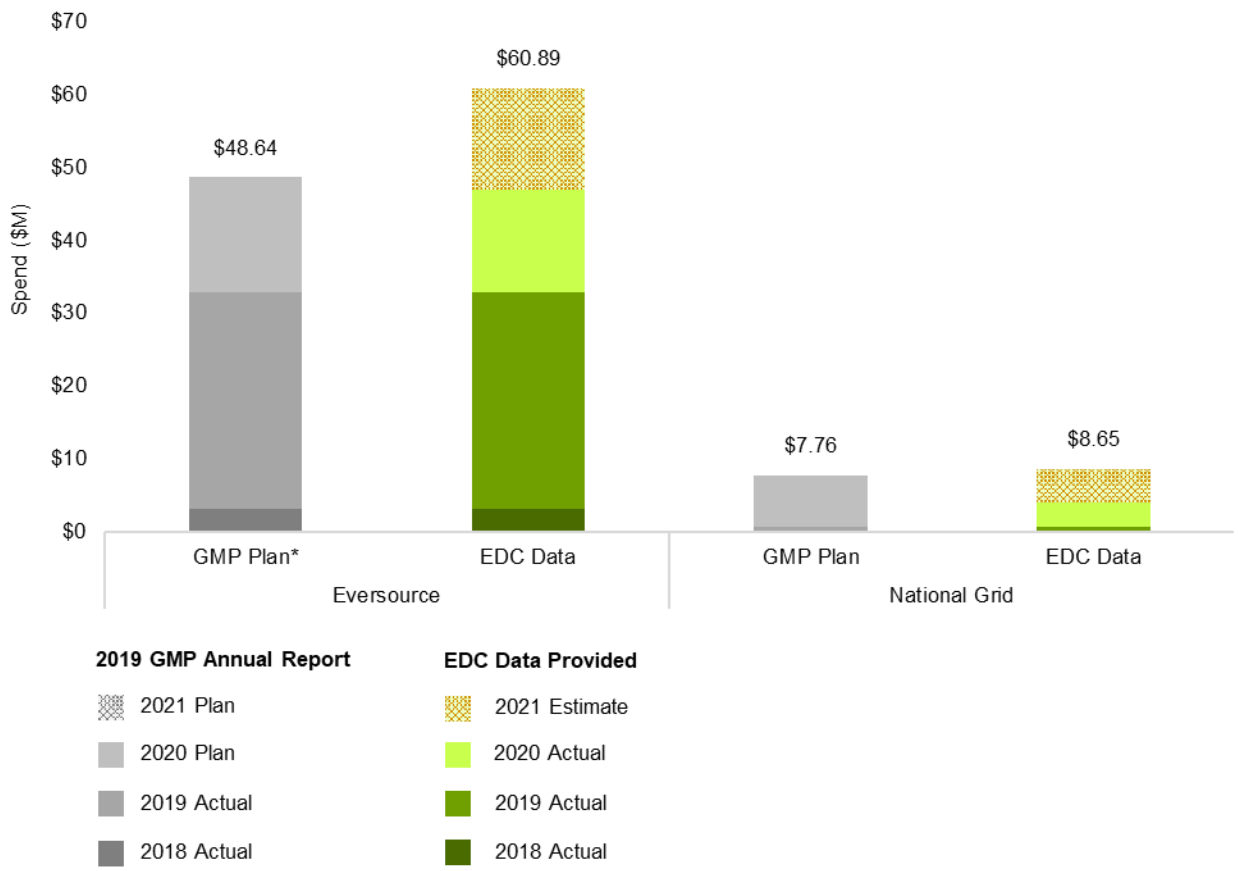
Infrastructure Metrics			Eversource	National Grid
GMP Plan Total, 2018-2020		Devices	448	82
		Spend, $M	$62.64*	$7.76
EDC Data Total, 2018-2021		Devices	602	101
		Spend, $M	$60.89	$8.65
IM-4	Number of Devices or Other Technologies Deployed through PY2020	# Devices Deployed	451	21
		% Devices Deployed	101%	26%
IM-5	Cost for Deployment through PY2020	Total Spend, $M	$46.89	$4.00
		% Spend	96%	52%
IM-6	Deviation Between Actual and Planned Deployment for PY2020	% On Track (Devices)	102%	26%
		% On Track (Spend)	89%	47%
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	151	80
		Spend Remaining, $M	$14.00	$4.65

*Includes the Eversource Planned spend for PY2021, set forth the in the GMP Extension and Funding Report, filed on July 1, 2020 and approved on February 4, 2021.

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Figure 1 differentiates between the original planned spend per the 2019 GMP Annual Report and the actual/estimated spend based on the EDC data provided.

Figure 1. ADA Spend Comparison (2018-2021, $M)



*Includes the Eversource Planned spend for PY2021, set forth the in the GMP Extension and Funding Report, filed on July 1, 2020 and approved on February 4, 2021.

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Table 4 summarizes key findings related to Guidehouse's ADA evaluation for each EDC.

Table 4. Summary of Infrastructure Metrics Findings for ADA Investment Area

EDC	Summary of Findings
Eversource	• Eversource exceeded its 2020 deployment targets for three out of four ADA technologies. • Eversource largely met its 2018-2020 ADA plan, and the 2021 ADA plan continues momentum attained in the initial 3-year ADA deployment. • ADA deployment and costs are both tracking closely to the plan filed by Eversource on April 1, 2020. • Eversource performed significant pre-planning and built organizational capacity to deploy GMP devices, which has helped its program stay on schedule and on budget. • For one technology (4kV auto-restoration underground loops), Eversource installed and commissioned devices in 2019 with SCADA capability. It is performing engineering and research to add auto-reclosing loop functionality to that scheme. The functionality is taking longer than planned and is expected to be achieved in 2021 after which both auto-reclosing loop schemes will be fully commissioned. This new technology is a cutting-edge deployment for Eversource and lessons learned will be applied to future ADA investments.
National Grid	• National Grid selected feeders with poor reliability performance and high potential customer benefits for ADA investments. • National Grid commissioned two fault location isolation and service restoration (FLISR) schemes in late 2020 and began construction on six more. It plans to continue the momentum and commission those six FLISR schemes in first quarter of 2021. • National Grid installed some of its ADA devices at strategic tie points between circuits. Tie reclosers have enhanced reliability and redundancy benefits for customers. • National Grid carried over 2020 work to 2021 due to COVID-19-related delays. • National Grid plans to operate GMP ADA devices using a public cellular network until a new GMP-funded communication network is available. National Grid is developing its communications strategy and expects to begin deploying a new Field Area Network (FAN) in 2022. • Some rework may be required if National Grid determines it needs to transfer from a public cellular FAN to a private FAN.

Source:Guidehouse analysis

Table 5, Table 6, and Table 7 summarize the Performance Metric Results for the ADA Investment Area in PY2020. Table 5 shows the results for the Performance Metric that analyzes the Effect on Outage Duration (CKAIDI) and Table 6 shows the results for the Effect on Outage Frequency (CKAIFI). In both tables, the baseline and PY2020 results are summarized for both system-wide circuits and ADA circuits. Table 7 presents the results for the ADA-specific Performance Metrics: Numbers of Customers that Benefit from GMP Funded Distribution Automation Devices and Average Zone Size (Eversource-specific metric).

Table 5. ADA Performance Metrics Summary: CKAIDI

	2015-2017 Avg. CKAIDI (Baseline)				2020 CKAIDI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
Eversource								
Total Circuits	2,083	2,083	175	175	2,083	2,083	175	175
Weighted Average	134	106	160	140	238	238	294	294
Std. Dev.*	136	103	159	141	288	288	366	366

*Standard Deviation is based on the simple average

Source: Guidehouse analysis of 2020 GMP Annual Report Appendix 1

Table 6. ADA Performance Metrics Summary: CKAIFI

	2015-2017 Avg. CKAIFI (Baseline)				2020 CKAIFI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
Eversource								
Total Circuits	2,083	2,083	175	175	2,083	2,083	175	175
Weighted Average	1.0	0.9	1.3	1.2	1.2	1.2	1.4	1.4
Std. Dev.*	0.7	0.7	0.8	0.8	1.0	1.0	1.1	1.1

*Standard Deviation is based on the simple average

Source: Guidehouse analysis of 2020 GMP Annual Report Appendix 1

Table 7. ADA Performance Metrics Summary: ADA-Specific Metrics

	Eversource	National Grid
Numbers of Customers that Benefit from DA Devices	196,434	8,883
Average Change in Zone Size: ADA Circuits	241	N/A

Source: Guidehouse analysis of 2020 GMP Annual Report Appendix 1

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

Table 8. Summary of Performance Metrics Findings for ADA Investment Area

PM	Eversource	National Grid
PM-12: Grid Modernization investments' effect on outage durations	Outage duration for ADA circuits for PY2020 was significantly longer than Baseline. However, this metric is not able to discern whether ADA investments impacted the annual reliability performance.*	N/A – no ADA devices were commissioned in the first half of PY2020 or prior
PM-13: Grid Modernization investments' effect on outage frequency	Outage frequency for ADA circuits for PY2020 was significantly higher than Baseline. However, this metric is not able to discern whether ADA investments impacted the annual reliability performance.*	N/A – no ADA devices were commissioned in the first half of PY2020 or prior

PM-11: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Almost 200,000 Eversource customers benefitted from ADA devices commissioned through PY2020.	Almost 9,000 National Grid customers benefitted from ADA devices commissioned through PY2020.
PM-ES2: Protective Zone: Average Zone Size per Circuit	The average zone size on circuits with ADA devices commissioned through PY2020 decreased by about 250 customers. This is a significant improvement.	N/A – Eversource specific metric
PM-NG1: Main Line Customer Minutes of Interruption Saved	N/A – National Grid specific metric	N/A – no ADA devices were commissioned in the first half of PY2020 or prior
Case studies	Case studies showed improvements in reliability from ADA devices evaluated.	Case studies showed improvements in reliability from ADA devices evaluated.

*Program Year 2020 generally had much worse reliability performance on a system-wide basis across all three EDCs, and evidence suggests that this was due to the size and frequency of storm conditions throughout the year.
Source: Guidehouse Analysis

Guidehouse submits the following recommendations for EDC consideration in PY2021:

1) The CKAIDI and CKAIFI reliability related Performance Metrics as defined have deficiencies in measuring the effectiveness of Grid Modernization Investments. Many factors unrelated to the Grid Modernization investments will affect these metrics in any given year, and it is not possible to distinguish among these factors using the metrics. For example, the variation in storm activity between years can cause significant changes in these metrics, as apparently happened in PY2020. Also, the need for three years of baseline data excludes circuits that have been reconfigured over time, reducing the pool of circuits that can be compared to a baseline value.

    a. Recommendation: Given the difficulty of the Performance Metrics PM-12 and PM-13, as defined, to help determine the efficacy of grid modernization investments in meeting the Departments goals, it would be useful to reassess and perhaps refine the metric definitions to better assess the investments' impact on reliability performance.
    b. Recommendation: Additional Performance Metrics should be explored to determine if it is possible to capture the actual reliability performance attributable to the investments. Exploration could include:
        i. Reviewing the data and techniques necessary to understand the relationship between circuit reliability and weather conditions, vegetation management cycles and other reliability drivers that are independent of the grid modernization investments.
        ii. Expanding the use of case studies to cover a greater proportion of the investments—more outage cases examined on more circuits (see Recommendation 4a below).
        iii. Leveraging new processes and collecting data to more efficiently perform outage case studies, and perhaps extrapolate these results to a broader set of circuits to understand investment performance with more certainty.

iv. Comparing number of customers out and customer minutes of interruption (CMI) that occurred, with the number of customers out and CMI that would have occurred without Grid Modernization investments.

2) The use of currently defined CKAIDI and CKAIFI reliability related Performance Metrics—which are circuit level metrics—has increasing challenges over time as circuits get re-configured or retired and new circuits are constructed. The comparability of each circuit in the program year to its baseline 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 after year as more circuits change due to ongoing operation of the system.

    a. Recommendation: Explore metrics that are robust to these operating changes to help ensure that Grid Mod investment assessment based on these metrics are not misleading, and that they are able to better capture the impact of the investment.

3) Current metrics do not provide an understanding of how M&C and ADA investments facilitate easier interconnection, or more capacity, of DER added to the system

    a. Recommendation: Consider developing additional metrics and/or performing pilot projects that utilize the installation of ADA and M&C investments at DER locations to understand the value or benefits that are provided. This would provide actual data on the effectiveness of these investments to support DER integration.

4) Case studies show detailed functioning and impact of GMP devices, and they are proving to be a useful tool in understanding the effectiveness of the Grid Modernization investments. Based on case studies performed, the ADA investment is yielding reliability and service delivery benefits to customers for each of the EDCs.

    a. Recommendation: Continue to perform case studies in future evaluations, and increase the use of case studies where practicable, to analyze the mitigation of customer outages and help determine the effectiveness of Grid Modernization investments in improving reliability and service delivery.

    b. Recommendation: Continue the deployment of ADA technologies as part of the Grid Modernization Program and continue to monitor progress (including through amended or additional metrics to be determined by the Department).

1. Introduction to Massachusetts Grid Modernization

This section includes a brief background to the Grid Modernization Evaluation process and an overview of the Advanced Distribution Automation (ADA) investment area and specific ADA evaluation objectives. Subsequent sections address the specific evaluation processes and findings, for which these objectives provide context.

1.1 Massachusetts Grid Modernization Plan Background

On May 10, 2018, the Massachusetts Department of Public Utilities (DPU) issued its Order[11] regarding the individual Grid Modernization Plans (GMPs) filed by the three Massachusetts electric distribution companies (EDCs): Eversource, National Grid, and Unitil.[12,13] 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[14] extending the 3-year GMP investment term to a 4-year term, including 2018-2021. The company-specific GMP budget caps did not change with the term extension. On July 1, 2020 Eversource filed a request for an extension of the budget authorization associated with grid modernization investments. The budget extension was approved by the DPU on February 4, 2021.

The preauthorized GMP investments should advance the achievement of DPU's grid modernization objectives:

- 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)

As part of the GMPs, the DPU determined the need for a formal evaluation process for the preauthorized GMP investments (including an evaluation plan and studies) to help ensure that the benefits are capitalized on and achieved with greater certainty.

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)

[11] Massachusetts DPU 15-120; DPU 15-121; DPU 15-122 (Grid Modernization) Order issued May 10, 2018

[12] 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.

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

[14] 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)

- Communications/IoT (Comms)
- Workforce Management (WFM)

This report focuses on the ADA Investment Area. Guidehouse developed similarly structured evaluation reports for each of the other Investment Areas.

1.1.1 Investment Areas

Table 9 summarizes the preauthorized GMP investments.

Table 9. Overview of Investment Areas

Investment Area	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
Advanced Distribution Automation (ADA)	Isolation of outage events with automated backup for 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/Advanced Load Flow (ADMS and ALF)	New capabilities in real-time system control with investments in developing accurate system models and enhancing SCADA and outage management systems to control devices for system optimization and provide support for distribution automation and VVO with high penetration of distributed energy resources (DER)	Enables high penetration of DER by supporting the ability to control devices for system optimization, ADA, and VVO
Communications/IoT (Comms)	Fiber middle mile and field area communications systems	Enables the full benefits of grid modernization devices to be realized
Workforce Management (WFM)	Investments to improve workforce and asset usage related to outage management and storm response	Improves the ability to identify damage after storms

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

The Massachusetts DPU preauthorized budget for grid modernization varies 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/ALF 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.[15] The budget extension, approved by the DPU

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

on February 4, 2021,[16] includes $14 million for ADA, $16 million for ADMS/ALF, $5 million for Communications, $15 million for M&C, and $5 million for VVO. These values are included in the Eversource total budget by Investment Area in Table 10.

Table 10. 2018-2021 GMP 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	-	$0.00	$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

The DPU added flexibility to these budgets based on changing technologies and circumstances. For example, EDCs can shift funds across the different preauthorized investments if they supply a reasonable explanation for these shifts. The following subsections discuss these evaluation goals, objectives, and the metrics to be used.

1.1.2 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 ensure a uniform statewide approach and to facilitate coordination and comparability. The evaluation's objective is to measure the progress made toward the achievement of DPU's grid modernization objectives. The evaluation uses the DPU-established Infrastructure Metrics, Performance Metrics, and Case Studies that illustrate the performance of specific technology installations to determine if the investments meet the DPU's GMP objectives.

1.1.3 Metrics for Evaluation

The DPU-required evaluation involves Infrastructure Metrics and Performance Metrics for each investment area. In addition, Guidehouse added selected case studies for some Investment Areas (e.g., ADA) as part of the evaluation to show how the technology has performed in specific instances (e.g., in remediating the effects of a line outage).

1.1.3.1 Infrastructure Metrics

The Infrastructure Metrics assess the deployment of the GMP investments. Table 11 summarizes the Infrastructure Metrics.

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

Table 11. 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 Deployed and In Service**	Measures how the EDC is progressing with its GMP from an equipment and/or device standpoint.	All IAs	Evaluator
IM-5	**Cost for Deployment**	Measures the associated costs for the number of devices or technologies installed; designed to measure how the EDC is progressing under its GMP.	All IAs	Evaluator
IM-6	**Deviation Between Actual and Planned Deployment for the Plan Year**	Measures how the EDC is progressing under its GMP on a year-by-year basis.	All IAs	Evaluator
IM-7	**Projected Deployment for the Remainder of the Four-Year Term**	Compares the revised projected deployment with the original target deployment as the EDC implements its EDC.	All IAs	Evaluator

IM = Infrastructure Metric, IA = Investment Area
Source: Guidehouse review of Infrastructure Metric filings

1.1.3.2 Performance Metrics

The Performance Metrics assess the performance of all the GMP investments. Table 12 summarizes the Performance Metrics used for the various Investment Areas. This report discusses Performance Metrics that pertain specifically to the ADA Investment Area.

Table 12. 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

Metric		Description	Applicable IAs	Metric Responsibility
PM-2	**VVO Energy Savings**	Quantifies the energy savings achieved by VVO using the baseline established for the circuit against the annual circuit load with the intent of optimizing system performance.	VVO	All
PM-3	**VVO Peak Load Impact**	Quantifies the peak demand impact VVO/CVR has on the system with the intent of optimizing system demand.	VVO	All
PM-4	**VVO Distribution Losses without Advanced Metering Functionality (AMF) (Baseline)**	Presents the difference between circuit load measured at the substation via the SCADA system and the metered load measured through advanced metering infrastructure.	VVO	All
PM-5	**VVO Power Factor**	Quantifies the improvement that VVO/CVR is providing toward maintaining circuit power factors near unity.	VVO	All
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/ALF, 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-11	**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

Metric		Description	Applicable IAs	Metric Responsibility
PM-12	**Grid Modernization Investments' Effect on Outage Durations**	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.	M&C, ADA	All
PM-13	**Grid Modernization Investments' Effect on Outage Frequency**	Provides insight into how M&C investments can reduce outage frequencies (CKAIFI). Compares the experience of customers on M&C-enabled circuits as compared to the prior three-year average for the same circuit.	M&C, ADA	All
PM-ES1	**Advanced Load Flow – Percent Milestone Completion**	Examines the fully developed ALF capability across Eversource's circuit population.	ADMS/ ALF	ES
PM-ES2	**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-NG1	**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 three-year average for the same circuit.	ADA	NG

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

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

This report discusses Performance Metrics that pertain specifically to the ADA Investment Area.

1.1.3.3 Case Studies

The evaluation team developed a Case Study approach to provide more insight into the actual operation of the GMP devices and to illustrate how these investments provide customer reliability and operational benefits. The impacts of GMP devices on system reliability metrics can be difficult to discern due to the range of factors that affect these metrics. Storm conditions, vehicle accidents and other factors drive reliability from year to year. This is especially likely if the device has less than several years of operation to affect the metric. The case studies illustrate the benefits provided by GMP devices during outage events. This approach

investigates outage events on specific circuits where the utility used GMP equipment to address the outage. The approach also allows for comparison between what did occur due to the presence of the GMP device and what would have likely happened had the GMP investment not been made.

1.2 ADA Investment Area Overview

Eversource and National Grid are investing in ADA. Unitil does not have preauthorized ADA investments in its GMP. These investments will enable a greater level of distribution grid automation and are expected to result in improved electric system reliability. As identified in the *2019 Grid Modernization Annual Report* filed by the EDCs on April 1, 2020, ADA investments are planned to total to $70.4 million from 2018 to 2021:

- $62.6 million by Eversource[17]
- $7.8 million by National Grid

The following subsection discusses EDC-specific approaches to ADA.

1.2.1 EDC Approach to ADA

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

Eversource's investments include new overhead recloser installations, underground oil switch replacements, and the creation of underground auto-reclosing loops.

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

Table 13 summarizes these GMP ADA devices and technologies.

[17] Total planned spend includes $14 million in addition to the 2019 GMP Annual Report total, as set forth in the "GMP Extension and Budget" filing on July 1, 2020.

Table 13. Devices and Technologies Deployed Under ADA Investment

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

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

1.3 ADA Evaluation Objectives

This evaluation focuses on the progress and effectiveness of the DPU preauthorized ADA investments for each EDC toward meeting the DPU's grid modernization objectives. Table 14 illustrates the key Infrastructure Metrics and Performance Metrics relevant for the ADA evaluation.

Table 14. ADA Evaluation Metrics

Metric Type	ADA Evaluation Metrics	ES	NG
IM	System Automation Saturation	✓	✓
IM	Number of Devices or Other Technologies Deployed	✓	✓
IM	Cost for Deployment	✓	✓
IM	Deviation between Actual and Planned Deployment for the Plan Year	✓	✓
IM	Projected Deployment for the Remainder of the 3-Year Term	✓	✓
PM	Numbers of Customers that Benefit from GMP-Funded Distribution Automation Devices	✓	✓
PM	Grid Modernization Investments' Effect on Outage Durations	✓	✓
PM	Grid Modernization Investments' Effect on Outage Frequency	✓	✓
PM	Protective Zone: Average Zone Size per Circuit	✓	
PM	Main Line Customer Minutes of Interruption Saved		✓
Other	Case Studies**	✓	✓

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

* Denotes that generating the metrics is EDC responsibility

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

Source: Guidehouse Stage 3 Evaluation Plan filed December 1, 2020

The EDCs provided the data supporting the Infrastructure Metrics and Performance Metrics as well as for case studies to the evaluation team. The results from the analysis of Infrastructure Metrics, Performance Metrics, and Case Study data are presented in Sections 3.2, 4.2, and 5, respectively. The Infrastructure Metrics analysis measures whether the investments are taking place on the projected schedule and budget. The Performance Metrics analyses provide insight into the reliability impacts due to grid modernization investments. The Case Studies facilitate understanding of the reliability improvement mechanisms and performance at select feeder locations.

Table 15 summarizes the ADA evaluation objectives and associated research questions. The scope of the ADA evaluation includes tracking the ADA infrastructure deployment against the plan and evaluating the impact on system reliability.

Table 15. ADA M&V Research Questions

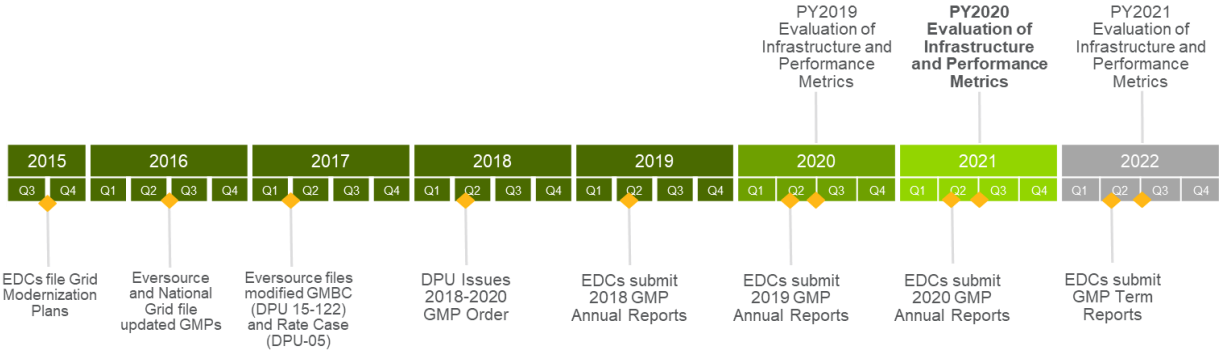
ADA M&V Research Questions
1. Are the EDCs progressing in deployment of their ADA investments according to their GMPs?
2. What factors, if any, are affecting the deployment schedule of ADA equipment?
3. What is the cost of deploying various types of ADA equipment?
4. What is the effect of ADA investments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

Source: Guidehouse Stage 3 Evaluation Plan filed December 1, 2020

2. ADA Evaluation Process

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

Figure 2. ADA Evaluation Timeline



Source: Guidehouse review of the DPU orders and GMP process

2.1 Infrastructure Metrics Analysis

Guidehouse annually assesses the progress of each EDC toward enabling ADA devices and technologies. Table 16 highlights the Infrastructure Metrics that were evaluated and their associated calculation parameters.

Table 16. Infrastructure Metrics Overview

Infrastructure Metrics			Calculation
IM-4	Number of devices or other technologies deployed thru. PY2020	# Devices Deployed	$\sum_{PY=2018}^{2020}(Devices\ Commissioned)_{PY}$
		% Devices Deployed	$\frac{\sum_{PY=2018}^{2020}(Devices\ Commissioned)_{PY}}{\sum_{PY=2018}^{2019}(Devices\ Commissioned)_{PY}+(Planned\ Devices)_{PY2020}}$
IM-5	Cost through PY2020	Total Spend, $M	$\sum_{PY=2018}^{2020}(Actual\ Spend)_{PY}$
		% Spend	$\frac{\sum_{PY=2018}^{2020}(Actual\ Spend)_{PY}}{\sum_{PY=2018}^{2019}(Actual\ Spend)_{PY}+(Planned\ Spend)_{PY2020}}$
IM-6	Deviation Between Actual and Planned Deployment for PY2020	% On Track (Devices)	$\frac{(Devices\ Commissioned)_{PY2020}}{(Planned\ Devices)_{PY2020}}$
		% On Track (Spend)	$\frac{(Actual\ Spend)_{PY2020}}{(Planned\ Spend)_{PY2020}}$

IM-7	Projected Deployment for 2021	# Devices Remaining	$(Devices\ Planned)_{PY2021}$
		Spend Remaining, $M	$(Planned\ Spend)_{PY2021}$

Source: Guidehouse

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

- Reviewed the EDC data to ensure the information provided accurately reflected their progress through PY2020 (see Section 3.1.2, "Data QA/QC Process")
- Interviewed representatives from each EDC to understand the status of the ADA investments, including:
    - Updates to their planned ADA investments
    - Reasons for deviation between actual and planned deployment and spend

2.2 Performance Metrics Analysis

Performance Metrics were evaluated for each EDC, focusing on the reliability metrics (CKAIDI and CKAIFI) at the circuit level. Table 17 describes the Performance Metrics to be used in the PY2020 evaluation.

Table 17. ADA Performance Metrics Overview

Performance Metrics		EDC	Description
PM-11	Number of Customers that Benefit from GMP-Funded Distribution Automation Devices	All	Provides insight into how many customers have benefitted from the installation of ADA devices. Compares the automated zone size on GMP ADA-enabled circuits as compared to the previous 3-year average for the same circuit.
PM-12	Grid Modernization Investments' Effect on Outage Durations	All	Provides insight into how ADA devices reduce the duration of outages (CKAIDI). Compares the experience of customers on GMP ADA-enabled circuits as compared to the previous 3-year average for the same circuit.
PM-13	Grid Modernization Investments' Effect on Outage Frequency	All	Provides insight into how ADA investments can reduce outage durations (CKAIDI). Compares the experience of customers on GMP ADA-enabled circuits as compared to the previous 3-year average for the same circuit.
PM-ES2	Protective Zone: Average Zone Size per Circuit	ES	Measures Eversource's progress in sectionalizing circuits into protective zones designed to limit outages to customers located within the zone.

PM-NG1	Main Line Customer Minutes of Interruption Saved	NG	Measures the impact of ADA investments on the CMI for main line interruptions. Compares the CMI of GMP ADA-enabled circuits to the previous 3-year average for the same circuit.

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

2.3 Case Study Analysis

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

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

3. ADA Infrastructure Metrics

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

3.1 Data Management

Guidehouse worked with the EDCs to collect data to complete the ADA evaluation and the assessment of Infrastructure Metrics. The following subsections highlight the data sources and data QA/QC processes used by the team 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 toward the GMP metrics. The following sections summarize the data sources.

3.1.1.1 2019 Grid Modernization Plan Annual Report

Guidehouse used the planned device deployment and cost information from each EDCs' *2019 GMP Annual Reports*, which were filed on April 1, 2020. Additionally, Guidehouse included Eversource's planned spending for PY2021 by investment area as filed in the *2021 Grid Modernization Program Extension and Funding Report*, which was approved by the DPU on February 4, 2021.[18] These filings served as the sources for planning data in this report and are referred collectively as the GMP Plan for each EDC in summary tables and figures throughout this report.

Table 18 provides a legend of the different planned and actual quantities reviewed and specifies the color/shade used to represent each in the remainder of the report.

Table 18. Deployment Categories Used for the EDC Plan

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

Source: 2021 Plan (Applicable to Eversource only) is sourced from the "2021 Grid Modernization Program Extension and Funding Report," filed July 1, 2020; Other plan and actual data is sourced from the EDCs' 2019 GMP Annual Report Appendix 1 filed April 1, 2020.

[18] Note the plan filed did not provide data at the Device Type level, only at the aggregate Investment Area level. Thus, this data is only included in the GMP Plan when the totals by investment area are presented.

3.1.1.2 EDC PY2020 Device Deployment Data Template

Guidehouse collected device deployment data using standardized data collection templates (e.g., the All Device Deployment workbook) for all EDCs in January-February 2021. The data collected provides an update of planned and actual deployment, in dollars and device units, through the end of PY2020. Data from this source are referred to as EDC Data in summary tables and figures throughout the report. Table 19 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 2020 Grid Modernization Plan Annual Reports and associated Appendix 1 filings.[19,20,21] The evaluation team confirmed the consistency of the data from the various sources and reconciled any differences.

Table 19. All Device Deployment Data File Versions for Analysis

EDC	File Version
Eversource	Received 2/18/2021
National Grid	Received 2/24/2021
Unitil	Received 1/21/2021

Source: Guidehouse

The EDC device deployment data (collected primarily 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 team also collected current implementation stage of the work order (commissioned, in-service, construction, or design/engineering), the commissioned date (if applicable), and all cumulative costs associated with the work order. Planned device deployment information and estimated spend for PY2021 was provided at the most granular level (circuit or substation) where available. Table 20 summarizes the categories used for the planned and actual deployment and spend from the EDC Data; it also specifies the color and pattern used in bar graphs to represent each in the remainder of the report.

Table 20. EDC Device Deployment Data

Representative Color	Data	Description
Device Deployment Data		
	2021 Estimate	Remaining units planned for 2021 where work will begin in 2021
	2020 Design/ Engineering	Detailed design and engineering is in progress but the device is not yet in construction
	2020 Construction	Field construction is in progress but the device is not yet in-service

[19] 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

[20] 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

[21] 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

Representative Color	Data	Description
	2020 In-Service	Device is installed and is used and useful but not yet commissioned to enable all grid modernization functionalities
	2020 Commissioned	Device is fully operational with all grid modernization functionalities, and thus is considered deployed in PY2020
	2019 Actual	Actual devices commissioned in 2019
	2018 Actual	Actual devices commissioned in 2018
Spend Data		
	2021 Estimate	Projected 2021 spend
	2020 Actual	Actual 2020 spend[22]
	2019 Actual	Actual 2019 spend[23]
	2018 Actual	Actual 2018 spend

Source: Guidehouse analysis

3.1.2 Data QA/QC Process

To ensure 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

Guidehouse reviewed all data provided for Infrastructure Metrics analysis upon receipt of requested data. The following sections detail the data QA/QC process.

3.2 Deployment Progress and Findings

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

[22] The 2020 actual costs shown in the tables and figures include only capital spending and do not include operations and maintenance (O&M) spending. This has been done to maintain consistency and comparability with the EDC's 2020 Annual GMP Filings (Appendix 1 required format). O&M spending information is included separately in Section **Error! Reference source not found.**.

[23] The 2019 and 2018 spending reported by the EDCs in the Annual Reports (and in the Appendix 1) included the associated O&M costs as well as Capital costs. The O&M costs are small relative to the capital costs for ADA so were not removed from the analysis.

3.2.1 Statewide Comparison

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

3.2.1.1 Impact on Massachusetts

Across the three EDCs in Massachusetts, ADA investments have impacted about 12% of total EDC customers and 6% of feeders. Table 21 summarizes the number of feeders and customers covered by GMP ADA investments spanning 2018 through 2020.

Table 21. Number of Massachusetts Feeders and Customers Covered by ADA Investment

ADA Impact	Eversource		National Grid		Total	
	Feeders	**Customers**	**Feeders**	**Customers**	**Feeders**	**Customers**
Systemwide Total	2,350	1,399,076	1,112	1,342,182	3,462	2,741,258
2018-2020 Installed	235	382,342	16	43,095	251	425,437
% System Total	10%	27%	1%	3%	7%	16%

Source: Guidehouse analysis of 2020 GMP Annual Report Appendix 1

3.2.1.2 Infrastructure Metrics Results

Table 22 summarizes the Infrastructure Metrics results for each EDC's ADA investment area through PY2020. Sections 3.2.2 through 3.2.3 explain each EDC's progress and plans in greater detail.

Table 22. ADA Infrastructure Metrics Summary

Infrastructure Metrics			Eversource	National Grid
GMP Plan Total, 2018-2020		Devices	448	82
		Spend, $M	$62.64*	$7.76
EDC Data Total, 2018-2021		Devices	602	101
		Spend, $M	$60.89	$8.65
IM-4	Number of Devices or Other Technologies Deployed through PY2020	# Devices Deployed	451	21
		% Devices Deployed	101%	26%
IM-5	Cost for Deployment through PY2020	Total Spend, $M	$46.89	$4.00
		% Spend	96%	52%
IM-6	Deviation Between Actual and Planned Deployment for PY2020	% On Track (Devices)	102%	26%
		% On Track (Spend)	89%	47%
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	151	80
		Spend Remaining, $M	$14.00	$4.65

**Includes the Eversource Planned spend for PY2021, set forth the in the GMP Extension and Funding Report, filed on July 1, 2020 and approved on February 4, 2021.*

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Based on reported data, Eversource made significant progress in ADA device deployment in 2020. It exceeded deployment targets in three out of four ADA technology categories, carrying over work in the fourth category to 2021. National Grid commissioned two FLISR schemes in late 2020 and began construction on six more. National Grid carried over some 2020 work to 2021 due to COVID-19-related delays.

Figure 3 highlights planned versus actual spend in ADA for each of the EDCs. The sections that follow include detailed differences between planned and actual spend.

Figure 3. ADA Spend Comparison (2018-2021, $M)

Note: Includes the Eversource Plan for 2021, set forth the in the GMP Extension and Budget filing on July 1, 2020

Source: Guidehouse analysis of DPU Order (May 10, 2018), 2019 GMP Annual Reports, GMP Extension and Budget filing (July 1, 2020), and 2020 EDC Data

In addition to the capital costs in Figure 3, Eversource incurred approximately $0.11 million in O&M costs toward the ADA investment area in PY2020 and approximately $0.54 million toward Administration and Regulatory costs across the GMP investments in PY2020. National Grid incurred approximately $0.01 million in O&M costs toward the ADA investment area in PY2020. National Grid also incurred approximately $1.79 million toward Administration and Regulatory costs across the GMP investments in PY2020.

3.2.2 Eversource

This section discusses Eversource's ADA investment progress through PY2020 and estimated PY2021 progress.

3.2.2.1 Overview of GMP Deployment Plan

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

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

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

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

Table 23. Eversource GMP ADA Technologies

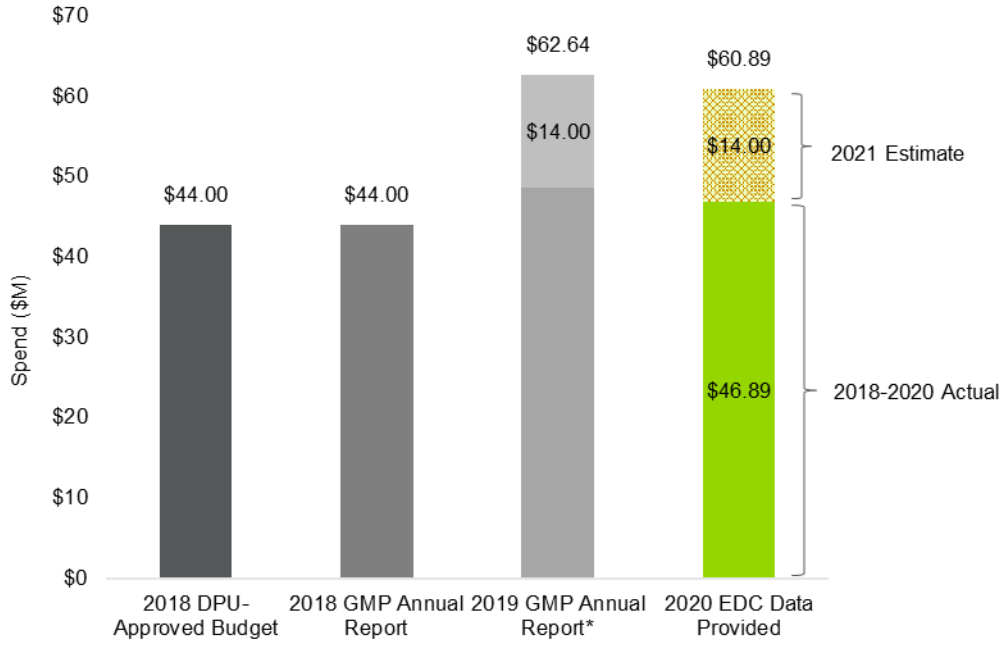
Overhead ADA	Underground ADA
(1) New Recloser Locations	**(3) 4kV Oil Switch Replacement**
New SCADA-enabled overhead recloser installations at new locations to increase auto-sectionalizing capability and reduce customer zone size.	New SCADA-enabled switches that replace century-old, oil-filled underground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

Source: Guidehouse analysis of 2019 GMP Annual Reports and discussions with Eversource

3.2.2.2 ADA Deployment Plan Progression

Figure 4 shows the progression of Eversource's ADA deployment plans from DPU-approval in 2018 through PY2020. Eversource's ADA program has remained close to the 2018 DPU-approved 3-year plan. Eversource has largely met its 2018-2020 ADA plan, and the 2021 ADA plan is above and beyond the original 3-year ADA plan.

Figure 4. Eversource ADA Planned and Actual Spend Progression, $M



**Includes the Eversource Planned spend for PY2021, set forth the in the GMP Extension and Funding Report, filed on July 1, 2020 and approved on February 4, 2021.*

Source: Guidehouse analysis of DPU Order (May 10, 2018), 2019 GMP Annual Reports, GMP Extension and Budget filing (July 1, 2020), and EDC Data

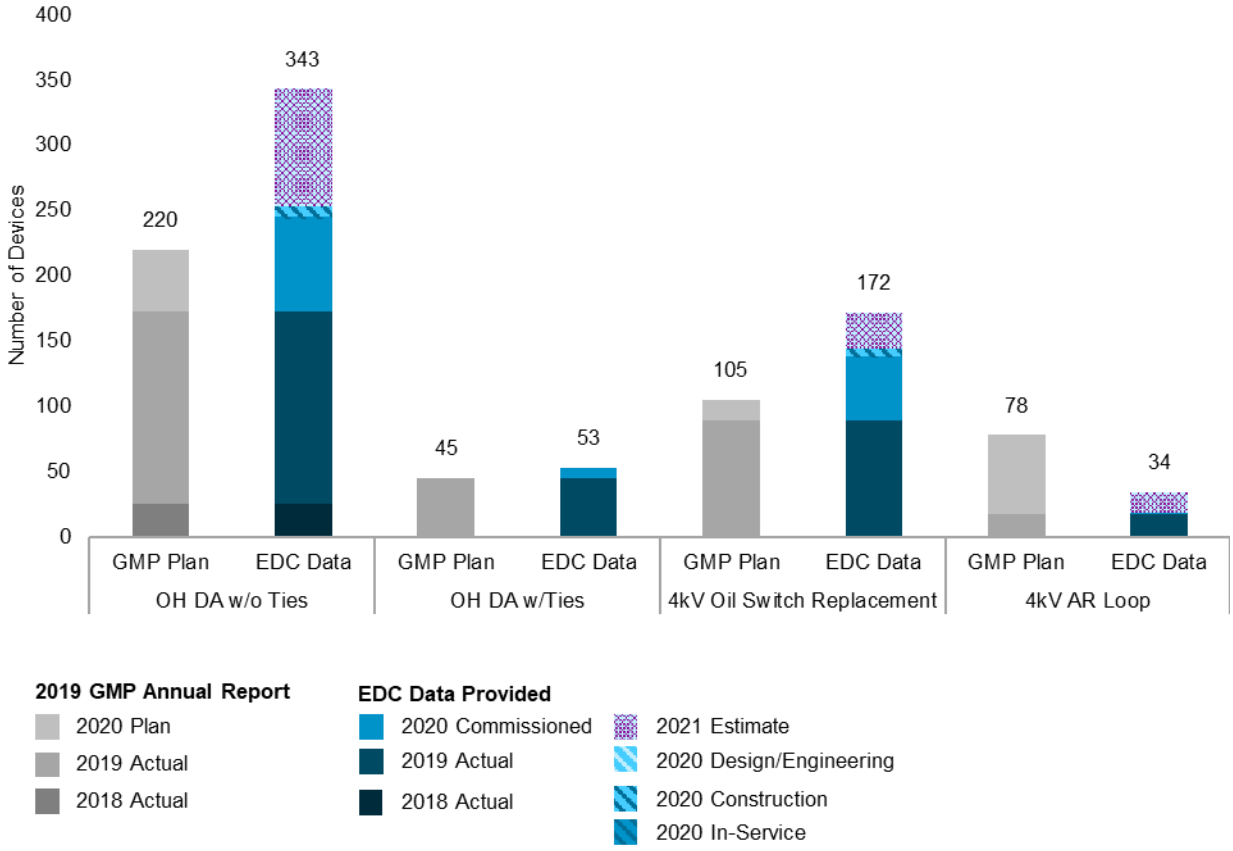
3.2.2.3 ADA Investment Progress Through PY2020

As the 2019 evaluation report notes, Eversource scaled up its base operations and mobilized to deploy GMP devices. This allowed Eversource to exceed its 2019 deployment targets for all four ADA technologies. In 2020, Eversource continued the momentum and exceeded its 2020 deployment targets for three out of four ADA technologies. Figure 5 and Table 24 show that Eversource significantly exceeded deployment plans for overhead ADA with and without ties in 2020. It also exceeded oil switch replacement targets in 2020.

Deployment targets for 4 kV underground auto-restoration loops were not met in 2020. Eversource deployed 17 devices in 2019 toward the underground 4 kV loop scheme investment. These substation and related field devices located in manholes were installed, in service, and SCADA commissioned. However, a software limitation prevented the devices from operating together in an automated loop scheme configuration. Eversource paused construction on the second loop scheme until it resolves the technical challenge with the first pilot scheme. In 2020, Eversource conducted engineering and research to resolve the issue.

Figure 5 shows Eversource's planned versus actual device deployment progress over the 2018-2021 period. The EDC Data is presented in Figure 5 and the quantified numbers are shown in Table 24.

Figure 5. Eversource ADA Device Deployment Comparison (2018-2021)



*Note: the Eversource Plan for 2021, set forth in the GMP Extension and Budget filing on July 1, 2020 did not provide device or spend data at the device type level, only at the aggregate Investment Area level. The numbers shown here reflect the 3-year plan.

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Table 24. Eversource ADA Plan and Actual Device Deployment (2018-2021)

	Overhead DA without Ties	Overhead DA with Ties	4 kV Oil Switch Replacement	4 kV AR Loop
2018-2021 Total	**343**	**53**	**172**	**34**
PY2021 Estimate[24]	90	0	28	16
Engineering/Design during PY2020	0	0	0	1
Construction during PY2020	8	0	6	0

[24] This excludes the devices planned for 2021 that are already in engineering/design, construction, or in-service phases as of the end of PY2020.

In-Service during PY2020	2	0	1	0
Commissioned in PY2020	70	8	48	0
Commissioned in PY2019	148	45	89	17
Commissioned in PY2018	25	0	0	0

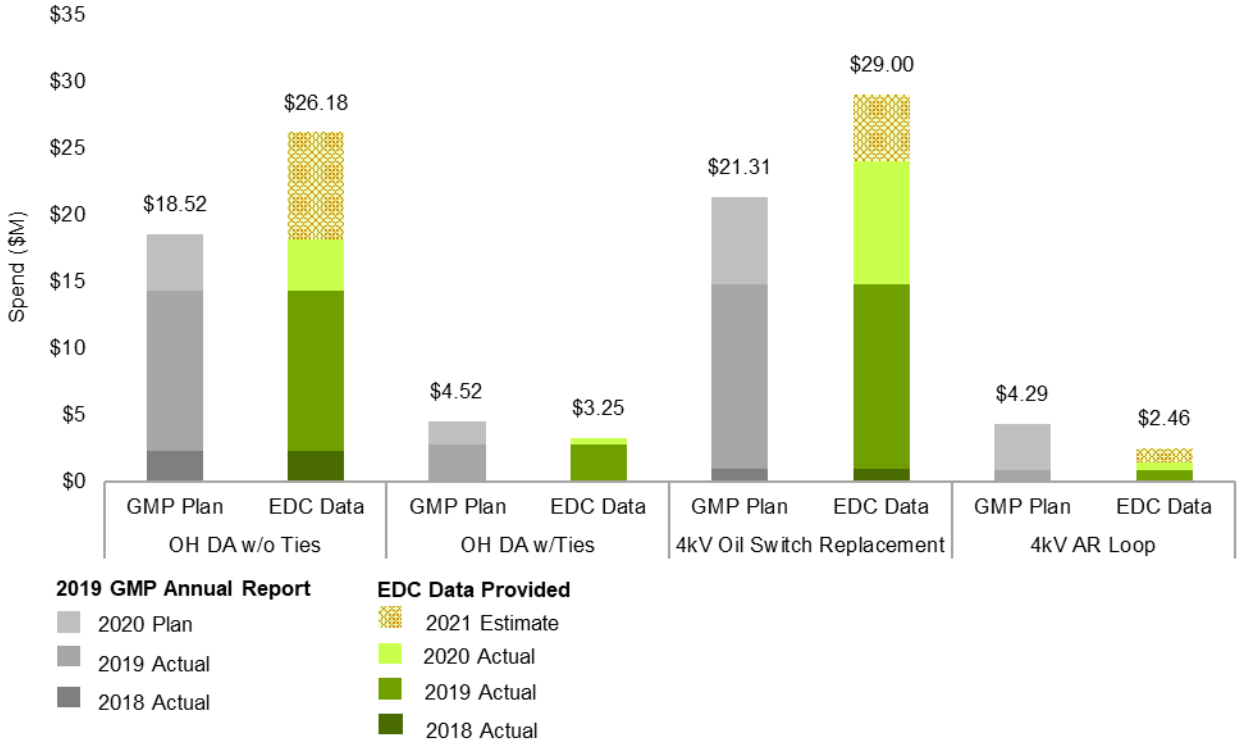
*Note: the Eversource Plan for 2021, set forth the in the GMP Extension and Budget filing on July 1, 2020 did not provide device or spend data at the device type level, only at the aggregate Investment Area level. The numbers shown here reflect the 3-year plan.

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Eversource spending is tracking closely to plan (as filed in Eversource 2019 Annual Report). Actual spending from 2018-2020 came slightly lower than plan, despite deployment targets being exceeded in three out of four investment categories. Figure 5 shows that Eversource deployed more overhead DA devices than planned while underspending on overhead DA costs. During 2020, Eversource continually evaluated its GMP portfolio costs and determined that overhead DA unit costs were coming out lower than projected. It decided it could deploy additional 4 kV oil switch units while remaining within the pre-approved budget cap. That led Eversource to direct funds to the 4 kV oil switch investment and replace 3 times more oil switches than planned in 2020.

Figure 6 shows Eversource's planned versus actual spend over the 2018-2021 period. The EDC Data Figure 6 presents is also shown in Table 25.

Figure 6. Eversource ADA Spend Comparison (2018-2021, $M)



*Note: the Eversource Plan for 2021, set forth the in the GMP Extension and Budget filing on July 1, 2020 did not provide device or spend data at the device type level, only at the aggregate Investment Area level. The numbers shown here reflect the 3-year plan.

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Table 25. Eversource ADA Plan and Actual Spend (2018-2021, $M)

	Overhead DA without Ties	Overhead DA with Ties	4 kV Oil Switch Replacement	4 kV AR Loop
2018-2021 Total	**$26.18**	**$3.25**	**$29.00**	**$2.46**
PY2021 Estimate	$8.00	$0.00	$5.00	$1.00
PY2020 Actual	$3.84	$0.46	$9.19	$0.57
PY2019 Actual	$12.07	$2.80	$13.88	$0.89
PY2018 Actual	$2.27	$0.00	$0.93	$0.00

*Note: the Eversource Plan for 2021, set forth the in the GMP Extension and Budget filing on July 1, 2020 did not provide device or spend data at the device type level, only at the aggregate investment area level. The numbers shown here reflect the 3-year plan.

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

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

The following sections provide a detailed evaluation of each ADA technology.

Replacement of Underground 4 kV Oil Switches

This investment is focused on modernizing legacy underground switches in Boston and Cambridge. Installed in 1920-1940, these switches represent some of the oldest assets in Eversource's distribution grid and are not suited to serving the densely populated hubs of Boston and Cambridge. These switches (Figure 7, left panel) cannot be automated or provide remote communication. They require a fault to be traced to one of many manholes, which is often inaccessible and requires lengthy repairs. For these reasons, Eversource accelerated this program, replacing 89 switches in 2019 ahead of the planned 67. In 2020, Eversource replaced 48 oil switches, 3 times the plan. This investment continues to be a priority in 2021 with 35 oil switch replacements planned.

The new GMP devices, called vacuum fault interrupters (VFI), perform better than legacy devices in terms of improving customer reliability and ease of operation (Figure 7, right panel). The new switches are SCADA-enabled and capable of automatically isolating faults and restoring sections of the grid within seconds. Once the fault zone is isolated, Eversource crews can quickly access the fault location for repairs. The result is an expected reduction in the duration and extent of outages in Boston and Cambridge. Additionally, these devices will integrate with and allow for future automation..

Underground oil switch replacement is complex, in part due to high customer density and inaccessibility of manholes. Outages must be carefully planned to minimize customer impact. Despite these challenges, Guidehouse determined that the Eversource deployment is ahead of schedule.

Figure 7. Old Oil-Filled Switches (Left) and New VFI Switches (Right)

Source: Eversource

4 kV Underground Auto-Reclosing Loops

In its 2018 GMP annual report, Eversource proposed retrofitting its underground 4 kV VFI switches to enable remote control and automation. Eversource reconfigured this program to include a new technology for creating auto-restoration loops. This program represents a cutting-edge ADA technology deployment for Eversource.

Auto-reclosing loops will enable field ties with underground circuits in an automated switching scheme to add redundancy and backup power supply to customers. Eversource uses a Schweitzer (SEL) distribution automation controller system to bring in data from field devices at one 4 kV substation and communicate information back to the SCADA system. The results of this project will inform future ADA deployments.

Eversource found underground auto-reclosing loops to be challenging to design and deploy. Eversource installed one scheme in 2019, placing 17 devices in service with SCADA capability. This met the original plan. In 2020, it encountered software and communications issues in commissioning auto-restoration loop functionality for this scheme. Eversource has been conducting research and engineering to resolve the issue and plans to commission the scheme in 2021. After the technical challenge with the first scheme are resolved, it plans to install and commission a second planned scheme in 2021.

New Overhead Reclosers

Eversource is installing pole-top reclosers at new locations along its overhead distribution lines (Figure 8). Adding new recloser locations reduces zone sizes and increases sectionalizing capability with expected reliability benefits for customers within the new zone created.

Eversource exceeded its 2019 target for overhead recloser installations. In 2020 it overcame control and protection coordination issues in the southeast Massachusetts area and again exceeded 2020 deployment targets.

Figure 8. Eversource Overhead Recloser

Source: Eversource

New Overhead Reclosers with Feeder Ties

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

Eversource planned 38 overhead tie recloser devices in the original 3-year GMP term. It commissioned 45 in 2019, exceeding its 3-year target 1 year ahead of time. It commissioned an additional eight tie reclosers in 2020 (against plan of zero). This investment is complete and no more overhead ties are planned in 2021.

3.2.2.4 Infrastructure Metrics Results and Key Findings

Table 26 presents the Infrastructure Metrics results through PY2020 for each investment type related to Eversource's ADA investment area.

Table 26. Eversource ADA: Infrastructure Metrics Summary

Infrastructure Metrics			Overhead DA without Ties	Overhead DA with Ties	4 kV Oil Switch Replacement	4 kV AR Loop
GMP Plan Total, 2018-2020*		Devices	220	45	105	78
		Spend, $M	$18.52	$4.52	$21.31	$4.29
EDC Data Total, 2018-2021		Devices	343	53	172	34
		Spend, $M	$26.18	$3.25	$29.00	$2.46
IM-4	Number of Devices or Other Technologies Deployed through PY2020	# Devices Deployed	243	53	137	18
		% Devices Deployed	110%	118%	130%	23%
IM-5	Cost for Deployment through PY2020	Total Spend, $M	$18.18	$3.25	$24.00	$1.46
		% Spend	98%	72%	113%	34%
IM-6	Deviation Between Actual and Planned Deployment for PY2020	% On Track (Devices)	149%	N/A	300%	2%
		% On Track (Spend)	92%	26%	141%	17%
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	100	0	35	16
		Spend Remaining, $M	$8.00	$0.00	$5.00	$1.00

*Note: the Eversource Plan for 2021, set forth the in the GMP Extension and Budget filing on July 1, 2020 did not provide device or spend data at the device type level, only at the aggregate investment area level. The numbers shown here reflect the 3-year plan

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

A summary of Guidehouse's evaluation findings for Eversource follow:

- Eversource's ADA circuit selection criteria included minimizing customer zone sizes, targeting poor reliability areas, and minimizing cost.
- Eversource performed significant pre-planning and built organizational capacity to deploy GMP devices on schedule and on budget, relative to the Plan filed on April 1, 2020.
- Eversource exceeded 2020 deployment targets for three out of four of its ADA investment types. Eversource also exceeded 3-year deployment targets over the original 2018-2020 GMP term for those three investments.
- The underground auto-restoration loop scheme is first-of-a-kind technology for Eversource. Eversource successfully commissioned 18 devices but encountered software and communication issues in getting the devices to operate as a loop scheme. It is performing engineering and research to overcome the challenge in 2021, after which two auto-restoration loop schemes will be commissioned. Lessons learned will be used to inform future ADA investments.
- Eversource 2018-2020 ADA deployment costs were slightly lower than projected, despite exceeding device deployment targets for most investment types. Eversource continually monitored its portfolio spend and adjusted its 2020 plan accordingly, deciding to deploy more ADA devices than planned.

3.2.3 National Grid

3.2.3.1 Overview of GMP Deployment Plan

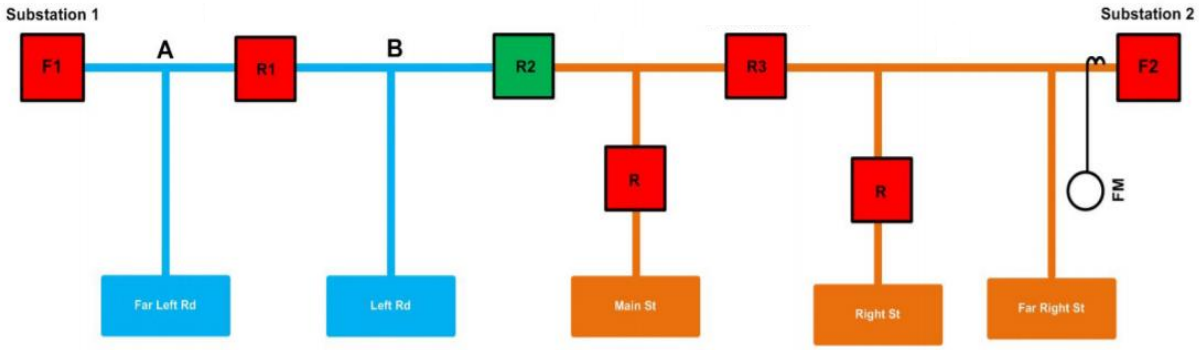
With its ADA investments, National Grid's objective is to improve grid reliability by adding automation and control capabilities at new and existing overhead feeder locations. In 2020, National Grid added Feeder Monitors to its ADA program for more granular fault location capabilities at strategic locations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

National Grid can communicate with some of the existing reclosers on the distribution system but cannot remotely operate these devices to restore power to customers. With the GMP ADA investments, National Grid will add control and automation capability on existing reclosers and add new recloser locations. The ADA program includes replacing manual tie points between adjacent feeders with remote-controlled automated switches.

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

Figure 9 illustrates the benefit of reliable ADA investments on National Grid's distribution grid. It depicts National Grid's distribution feeders, substations, and reclosers. If a fault occurs at point A, F1 (substation breaker) will lock out and R1 (a recloser switch) will automatically open. The entire blue zone will experience loss of power supply from substation 1. With ADA, R2 (a recloser switch that ties two feeders together) would sense loss of power and close automatically. This would restore power to customers in zone B, which would then be supplied from substation 2 instead of substation 1. This process isolates the effects of a fault to the smallest possible section of the grid, in this case, Far Left Road.

Figure 9. National Grid's Illustrative ADA Scheme



Source: National Grid

National Grid expects the benefits of ADA to include:

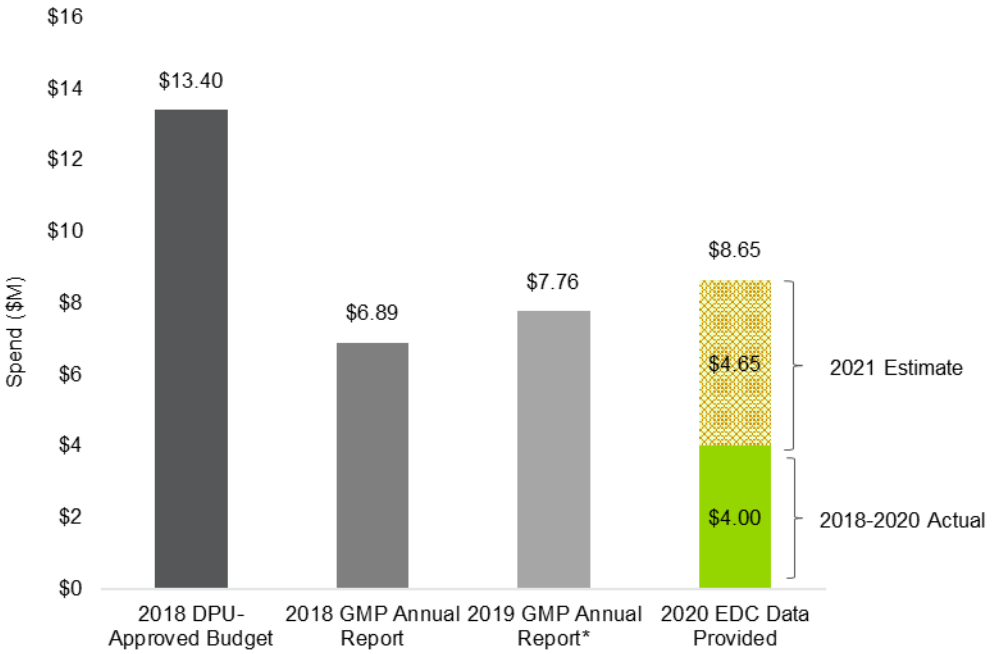
- **Optimizing system performance:** National Grid anticipates a 25% reduction in main-line customer minutes of interruption (CMI) on the individual feeders targeted for the ADA deployment.
- **Optimizing system demand:** The additional operational data collected by the automated switches will support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

National Grid is integrating lessons learned from the ADA demonstration pilot in its Worcester Smart Energy Solutions Pilot into the Massachusetts GMP ADA program. National Grid learned that the distributed, localized ADA operating model in Worcester was too difficult to operate and maintain. In the Worcester pilot, when the SCADA system (EMS) lost communications to the field device, devices would continue to check for faults and operate without control room interaction. After deliberating with several vendors, National Grid adopted a centralized ADA model instead. A centralized ADA model brings field device data back through the communications network, performs centralized decision-making and issues the commands to reclosers.

3.2.3.2 ADA Deployment Plan Progression

Figure 10 shows the progression of National Grid's ADA deployment plans from DPU-approval in 2018 through PY2020. National Grid scaled back its ADA plan in 2019 from 2018 pre-approved budget amount. COVID-19-related impacts influenced 2020 deployment. National Grid plans to carry over 2020 planned ADA budget to 2021.

Figure 10. National Grid ADA Planned and Actual Spend Progression, $M



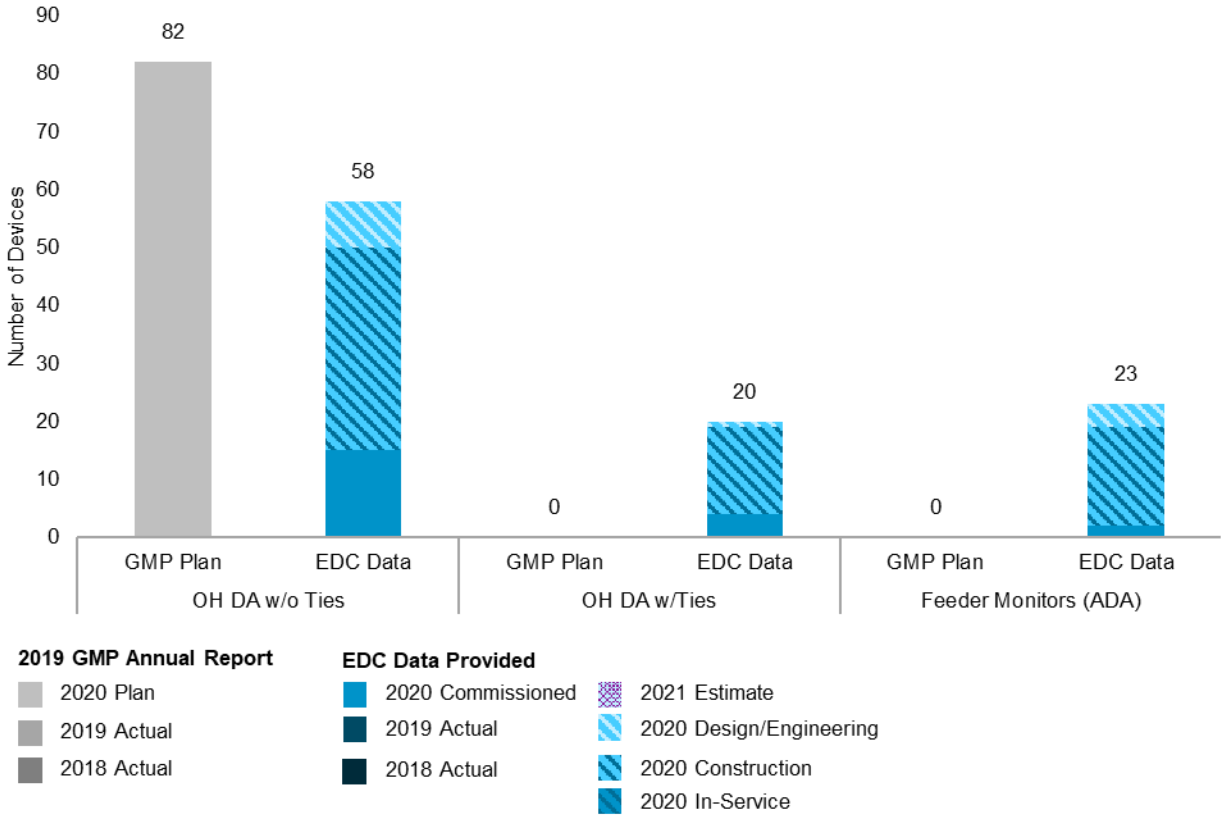
Source: Guidehouse analysis of DPU Order (May 10, 2018), 2019 GMP Annual Reports, GMP Extension and Budget filing (July 1, 2020), and EDC Data

3.2.3.3 ADA Investment Progress Through PY2020

Figure 11 summarizes National Grid's ADA deployment progress to date. In 2020, National Grid commissioned two FLISR schemes at Stoughton and East Boxford, respectively. Both feeders were targeted for poor reliability performance. Each FLISR scheme consists of overhead recloser devices that work together with pre-programmed logic to quickly isolate a fault to the smallest possible section of the grid. National Grid installed feeder monitors in 2020 for granular fault location and enhanced FLISR operation. It trained its control center workforce in using the FLISR automation functionality.

Figure 11 shows National Grid's planned versus actual device deployment progress over the 2018-2021 period. The EDC Data in Figure 11 is also shown in Table 27.

Figure 11. National Grid ADA Device Deployment Comparison (2018-2021)



Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Table 27. National Grid ADA Plan and Actual Device Deployment (2018-2021)

	Overhead DA without Ties	Overhead DA with Ties	Feeder Monitors (ADA)
2018-2021 Total	**58**	**20**	**23**
PY2021 Estimate[25]	0	0	0
Engineering/Design during PY2020	8	1	4
Construction during PY2020	35	15	17
In-Service during PY2020	0	0	0
Commissioned in PY2020	15	4	2
Commissioned in PY2019	0	0	0
Commissioned in PY2018	0	0	0

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

[25] This includes the devices planned for 2021 that are not yet in engineering/design, construction, or in-service phases as of the end of PY2020.

Of the 19 overhead reclosers commissioned in 2020, four reclosers were deployed at tie points between circuits. These tie reclosers are noted as the new investment type “OH DA w/ Ties” in Figure 11. Installing reclosers at strategic locations that tie two feeders together increases the redundancy and reliability benefits of ADA investments. Tie reclosers allow customers to be supplied from alternate sources and allow for load to be shifted between circuits, increasing the number of possible FLISR switching operations. National Grid installed tie reclosers at existing tie locations that do not need new line installations. It anticipates performing limited reconductoring work to ensure load shifting between feeders is possible without overloading.

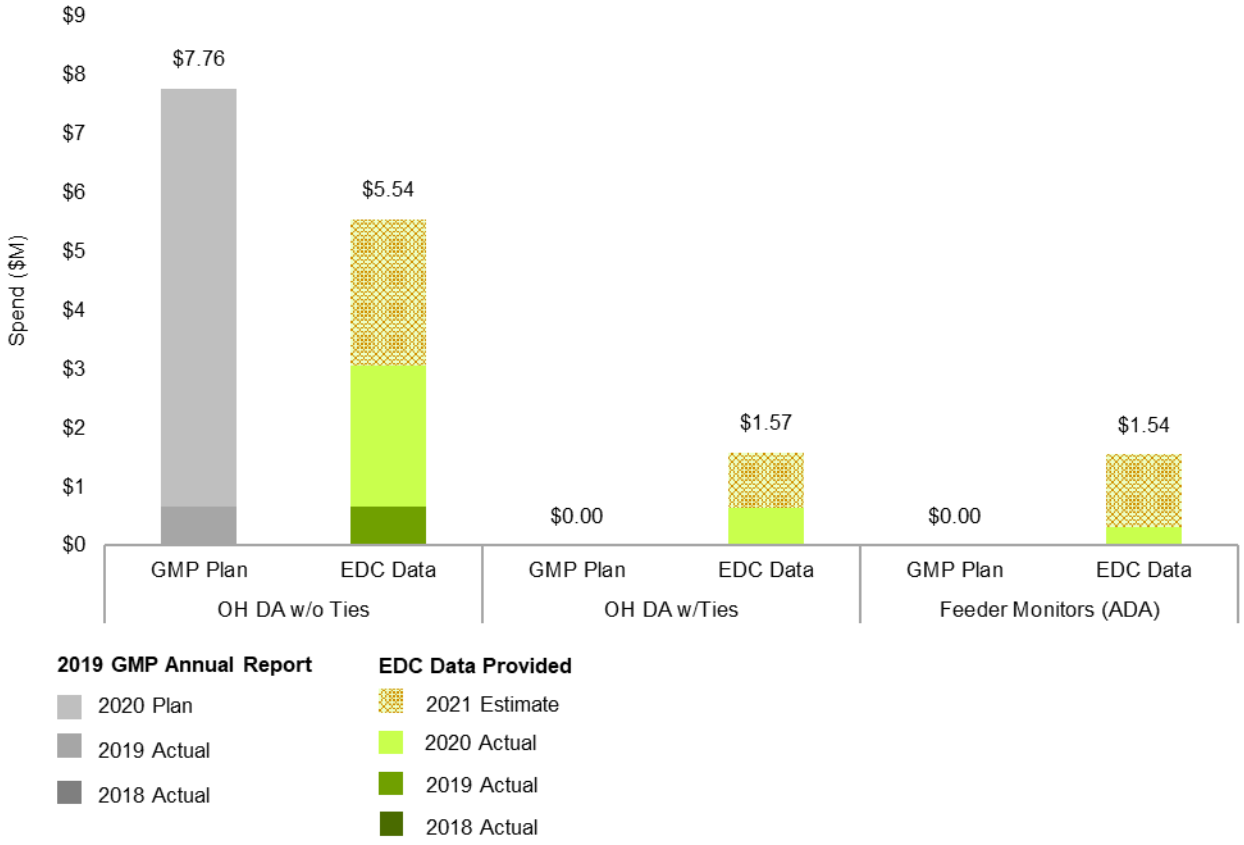
In 2020, National Grid also finished the engineering and design of 50 additional overhead reclosers, corresponding to six additional FLISR schemes. Construction began on those devices in 2020 and the schemes will be commissioned in the first quarter of 2021.

As the 2019 evaluation report notes, National Grid’s 2019 deployment was delayed and 2019 ADA targets were pushed to 2020. In 2020, National Grid’s ADA progress was impacted by the COVID-19 pandemic. During the first half of 2020, National Grid adapted its work practices to social distancing protocols so that certain field reporting locations had 20%-25% reduction in crews. These resource limitations led to delays in ADA construction schedules. Additionally, National Grid decided after the initial coronavirus outbreak to limit the use of planned outages, since many residential customers were working at home. Limited use of planned outages also delayed ADA construction schedules. In the second half of 2020, National Grid gained momentum, deploying two FLISR schemes and beginning construction on several more.

While deployment is currently behind schedule, National Grid’s implementation schedule indicates 2020 planned work will be carried over to 2021.

Figure 12 shows National Grid’s planned versus actual spend over the 2018-2021 period. The EDC Data in Figure 12 is also shown in Table 28.

Figure 12. National Grid ADA Spend Comparison (2018-2021, $M)



Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Table 28. National Grid ADA Plan and Actual Spend (2018-2021, $M)

	Overhead DA without Ties	Overhead DA with Ties	Feeder Monitors (ADA)
2018-2021 Total	**$5.54**	**$1.57**	**$1.54**
PY2021 Estimate	$2.50	$0.93	$1.22
PY2020 Actual	$2.39	$0.64	$0.32
PY2019 Actual	$0.65	$0.00	$0.00
PY2018 Actual	$0.00	$0.00	$0.00

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

National Grid's ADA spend through 2020 is in line with device deployment progress over the same period.

Figure 13 illustrates National Grid's pole-top reclosers and controls, which include G&W Viper Overhead Reclosers and SEL control cabinets. National Grid plans to install three to four reclosers on chosen circuits. It plans to migrate to an ADMS in the coming years, at which point it may use a DMS FLISR application in place of its current NovaTech OrionLX substation automation platform. (See Guidehouse's *2019 ADMS Evaluation Report* for more detail.)

Figure 13. National Grid Pole-top Reclosers and Controls

Source: National Grid

National Grid plans to operate the ADA devices it installed in 2020 using its public cellular network. It will use fiber optics (Wide Area Network), where available, as the backhaul for data transfer. National Grid recognizes that cellular may not be the preferred technology to operate grid-controlling assets like reclosers, especially in major outage events. Cellular may be hampered by busy signals and relatively slow data transfer speeds and may require backup power. National Grid is developing its communications strategy to modernize its communication network as proposed in the GMP. It expects to select a strategy for its FAN in 2022. When the new communications network is established, some rework may be required to integrate it with the existing ADA devices. (See Guidehouse's *2020 Communications Evaluation Report* for more detail.)

3.2.3.4 Infrastructure Metrics Results and Key Findings

Table 29 presents the Infrastructure Metrics results through PY2020 for each investment type related to National Grid's ADA investment area.

Table 29. National Grid ADA: Infrastructure Metrics Summary

Infrastructure Metrics			Overhead DA without Ties	Overhead DA with Ties	Feeder Monitors (ADA)
GMP Plan Total, 2018-2020		Devices	82	0	0
		Spend, $M	$7.76	$0.00	$0.00
EDC Data Total, 2018-2021		Devices	58	20	23
		Spend, $M	$5.54	$1.57	$1.53
IM-4	Number of devices or other technologies deployed through PY2020	# Devices Deployed	15	4	2
		% Devices Deployed	18%	N/A	N/A
IM-5		Total Spend, $M	$3.04	$0.64	$0.32

Infrastructure Metrics			Overhead DA without Ties	Overhead DA with Ties	Feeder Monitors (ADA)
	Cost for Deployment through PY2020	% Spend	39%	N/A	N/A
IM-6	Deviation Between Actual and Planned Deployment for PY2020	% On Track (Devices)	18%	N/A	N/A
		% On Track (Spend)	34%	N/A	N/A
IM-7	Projected Deployment for the Remainder of the GMP Term	# Devices Remaining	43	16	21
		Spend Remaining, $M	$2.50	$0.93	$1.22

Source: Guidehouse analysis of 2019 GMP Annual Reports and 2020 EDC Data

Guidehouse's Infrastructure Metrics evaluation findings for National Grid follow:

- National Grid targeted feeders with poor reliability performance for ADA investments.
- National Grid's 2019 ADA deployment targets were pushed to 2020. In late 2020, National Grid commissioned two FLISR schemes and began construction on six more. It plans to continue the momentum and commission those six FLISR schemes in first quarter of 2021.
- National Grid installed some of its ADA devices at strategic tie points between circuits. Tie reclosers should have enhanced reliability and redundancy benefits for customers.
- National Grid carried over 2020 work to 2021 due to COVID-19-related delays.
- National Grid plans to operate GMP ADA devices using a public cellular network to keep projects moving forward. National Grid recognizes the need for a new GMP-funded communication network and is developing its communications strategy accordingly.
- Some rework may be required if National Grid determines it needs to transfer from a public cellular FAN to a privately owned FAN.

4. ADA Performance Metrics

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

4.1 Data Management

This section discusses the data sources used for the Performance Metric evaluation and summarizes the Quality Assessment and Quality Control (QA/QC) steps, and selection of circuits used in the PY20 analysis.

4.1.1 Data Sources

2020 Grid Modernization Plan Annual Report Appendix 1[26,27,28]**:** On April 1, 2021 each EDC submitted Appendix 1 along with its Annual Report. The Appendix 1 contains feeder-level data for all feeders within each EDC's territory. All PM-related data presented below are from these 2020 GMP Annual Report Appendices. These documents contain baseline and program year data for all circuits for each EDC. Key data from these Appendices that were utilized in this analysis include:

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

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

4.1.2 Data QA/QC Process

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

[26] 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

[27] 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: Inconsistencies in calculations and definitions were discovered and Eversource updated the Appendix 1 in May 2021. The updates were provided to Guidehouse.

[28] 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

- 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 PY2019 and PY2020 Appendix 1 filings to ensure baseline reliability data match.

During this QA/QC process, the evaluation team identified issues in both the Eversource and National Grid Appendix 1 filings that required adjustments and updates:

Eversource: A formula error for a portion of circuits in Eversource's SQI filing lead to inaccurate Appendix 1 CKAIDI/CKAIFI values. Eversource updated the SQI filing and these updated values were used in the analysis below.

National Grid: The changes in CKAIDI/CKAIFI for several Nantucket circuits were calculated with an outdated data source. Additionally, National Grid discovered an error in the 2017 SQI filing, which resulted in the baseline CKAIDI/CKAIFI values being incorrect. National Grid updated both the 2017 SQI values and the Appendix 1 values for the Nantucket circuits and the evaluation team used the updated values for the analysis.

4.1.3 Circuit Selection

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, the evaluation team determined that the use of the technology for at least one-half of the full program year could provide insight into the impacts of the GMP investments.[29]

The evaluation team reviewed the installation and commissioning timing for the various investments to understand when during the 2020 Program Year the devices were installed. For the CKAIDI/CKAIFI metrics (PM-12 and PM-13), circuits with *at least* a half year with the technology commissioned and in service were selected for inclusion in the analysis. This includes circuits with devices installed during 2018, 2019, as well as the first half of 2020. All circuits receiving ADA investments were included in the remaining performance metrics.

The evaluation team also identified a number of circuits for each EDC which 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

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

be potentially misleading and these circuits were excluded from the analysis. Similar measures were taken to ensure that other performance metrics were calculated using a consistent circuit list between the baseline and the program year.[30]

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

4.1.3.1 Eversource Circuits

Eversource commissioned ADA devices throughout PY2018, PY2019, and PY2020. Table 30 shows circuits with ADA devices commissioned through the first half of 2020. It also shows number of circuits not included in the analysis largely due to the reconfiguration of circuits between the baseline and PY2020, as discussed above. A smaller percentage of ADA circuits were not included in the analysis for the same reasons.

Table 30. Eversource Circuits Included in Analysis

Eversource Circuits	System-Wide	ADA Commissioned Prior to H2 2020
Total Circuit Count	2,350	181
Circuits Included in Analysis	2,083	175
% of Total Circuits Included In Analysis	89%	97%

Source: Guidehouse analysis of GMP Annual Reports and EDC Data

4.1.3.2 National Grid Circuits

National Grid began commissioning ADA devices during PY2020. However, no ADA Devices were commissioned during the first half of 2020, so for the reasons discussed above the Performance Metrics were not evaluated for National Grid's ADA investments.

4.2 ADA Performance Metrics Analysis and Findings

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

Results Summary: Table 31 provides a high-level summary of the results for each performance metric and EDC.

[30] A comparison of system wide baselines between this report and the PY 2019 PM Evaluation Report shows only minor differences in the baseline circuit list, which is expected given changing customer counts and changes in circuit configurations.

Table 31. Summary of Findings for ADA Investment Area

PM	Eversource	National Grid
PM-12: Grid Modernization investments' effect on outage durations	Outage duration for ADA circuits for PY2020 was significantly longer than Baseline. However, this metric is not able to discern whether ADA investments impacted the annual reliability performance.*	N/A – no ADA devices were commissioned in the first half of PY2020 or prior
PM-13: Grid Modernization investments' effect on outage frequency	Outage frequency for ADA circuits for PY2020 was significantly higher than Baseline. However, this metric is not able to discern whether ADA investments impacted the annual reliability performance.*	N/A – no ADA devices were commissioned in the first half of PY2020 or prior
PM-11: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Almost 200,000 Eversource customers benefitted from ADA devices commissioned through PY2020.	Almost 9,000 National Grid customers benefitted from ADA devices commissioned through PY2020.
PM-ES2: Protective Zone: Average Zone Size per Circuit	The average zone size on circuits with ADA devices commissioned through PY2020 decreased by about 250 customers. This is a significant improvement.	N/A – Eversource specific metric
PM-NG1: Main Line Customer Minutes of Interruption Saved	N/A – National Grid specific metric	N/A – no ADA devices were commissioned in the first half of PY2020 or prior
Case studies	Case studies showed improvements in reliability from ADA devices evaluated.	Case studies showed improvements in reliability from ADA devices evaluated.

*Program Year 2020 generally had much worse reliability performance on a system-wide basis across all three EDCs, and evidence suggests that this was due to the size and frequency of storm conditions throughout the year.
Source: Guidehouse Analysis

PY 2020 Reliability: CKAIDI and CKAIFI metrics for PY2020 were significantly worse than they were for the Baseline years (2015-2017). Evidence suggests that PY2020 was a bad storm year for all three EDCs, negatively impacting system-wide reliability performance including that of circuits with ADA installed.

A simple system-wide comparison between the baseline years (2015-2017) and PY2020 shows worse reliability performance in 2020 across all EDCs—without specific consideration of GMP investment (including M&C and ADA investments). As shown in Table 32, customer weighted average CKAIDI more than doubled for all 3 EDCs.

Table 32: Baseline vs PY2020 Reliability

EDC	CKAIDI/CKAIFI Metric	Baseline	PY2020
Eversource	Weighted Average CKAIDI	106	233
	Weighted Average CKAIFI	0.93	1.16
National Grid	Weighted Average CKAIDI	119	298
	Weighted Average CKAIFI	0.91	1.27
Unitil	Weighted Average CKAIDI	66	135
	Weighted Average CKAIFI	1.06	1.61

Note: Reliability data shown is without Excludable Major Events (EMEs).

Source: Guidehouse Analysis.

The CKAIDI and CKAIFI related metrics were also impacted when a number of significant storms did not meet the predefined criteria for an Excludable Major Event. For instance, Unitil notes that in 2020, 5 storm events with SAIDI greater than 7.5 minutes did not meet the EME criteria, while only 1 such event occurred during the baseline years 2015-2017. Likewise, National grid experienced 7 events in which specific circuits exceeded 5,000 total customer outage hours, but only 1 event met the criteria for an EME, and Eversource had no qualifying EMEs despite a number of significant storms. CKAIDI/CKAIFI values calculated without EMEs indicate noticeably worse performance compared to the baseline.

Analysis Approach: The following approach was developed to provide additional insight into the EDC Performance Metrics were published by the EDCs in their PY2020 Annual Report Appendix 1. The circuit-level data provided by the EDCs was used to evaluate the metrics. The evaluation approach has three elements:

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

2. Before and after comparison**:** For PM-12, PM-13, and PM-ES2 the program year performance was compared to the baseline performance for all circuits within the system.

"Box-and-whisker" plots[31] are used to illustrate the distribution of data across the entire system and for circuits receiving ADA investments.[32]

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

The sections below leverage the three steps listed above to provide additional insights into the impacts of ADA investments. In addition, ancillary metrics are used for informative purposes. For clarity, a subset of those metrics 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 2020 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.

- % Zero is the proportion of circuits that had zero CKAIDI/CKAIFI in the 3 baseline years (for the baseline) or in 2020 (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 2020. This value is included for informative reasons, as circuits that have experienced no outages in the program year provide no opportunity for the ADA investment to help improve reliability.

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

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

[31] 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.

[32] Note that the DPU Guidance defines the change as "Baseline – Program Year" which means that positive values of this metric indicate reliability improvement—the opposite of what you would expect for improvement in CKAIDI or CKAIFI metric (which fall with improvement).

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, only circuits with ADA investments in the first half of 2020 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 ADA circuit counts: Table 33 is structured with CKAIDI ranges, or "bins", to provide insight about the range of outage durations across circuits in the system, and to show where circuits selected for ADA investment fall within these bins. Approximately 37% of system-wide and 2% of ADA circuits experienced no outages at all within the baseline period. This difference indicates that Eversource targeted circuits that experienced outages in the baseline period for ADA investments. [33] The percentages of circuits with no outages increased slightly in PY2020 for both system-wide and ADA circuits.

An increase in system average CKAIDI from the baseline to PY2020 indicates decreased reliability at the system level. 2020 was a "worse" reliability year than the baseline as seen by the Weighted Average CKAIDI in Table 33, which is nearly twice that of the baseline. This difference is primarily driven by the higher number of storms that disproportionately affected Eversource's MA Northern and MA Southern circuit divisions. The increase in outage duration can also be seen by looking at the higher number of circuits with CKAIDI greater than 450 in Program Year 2020 compared with the same circuits during the baseline period.

The CKAIDI standard deviation also increased significantly, indicating increased variability in CKAIDI across circuits in the system. 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 degradation in performance during the program year. The customer weighted average CKAIDI is greater than the simple average, indicating that the circuits with longer outages tended to have above average number of customers.

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

Table 33. Eversource Baseline and PY2020 CKAIDI Distribution

Eversource ADA	2015-2017 Avg. CKAIDI (Baseline)				2020 CKAIDI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIDI Statistics								
Total Circuits	2,083	2,083	175	175	2,083	2,083	175	175
% Zero	37%	37%	2%	2%	46%	46%	7%	7%
Weighted Average	134	106	160	140	238	238	294	294
Simple Average	80	63	162	142	129	129	285	285
Std. Dev.	136	103	159	141	288	288	366	366
Range								
0	777	778	3	3	966	966	13	13
0 - 50	491	535	36	38	358	358	25	25
50 - 150	448	491	69	76	300	300	54	54
150 - 250	182	166	26	29	133	133	20	20
250 - 350	84	63	26	21	95	95	17	17
350 - 450	44	27	8	2	59	59	13	13
450 - 550	20	10	1	2	34	34	4	4
550 - 650	13	3	1	0	30	30	6	6
650 - 750	9	5	1	2	16	16	2	2
750 - 850	9	3	3	1	22	22	4	4
850 - 950	3	1	0	0	11	11	5	5
950 - 1050	1	1	1	1	16	16	5	5
1050 - 1300	1	0	0	0	19	19	3	3
1300 - 1550	1	0	0	0	8	8	2	2
1550 - 1800	0	0	0	0	7	7	1	1
1800 - 2050	0	0	0	0	3	3	0	0
2050 - 3050	0	0	0	0	5	5	1	1
> 3050	0	0	0	0	1	1	0	0

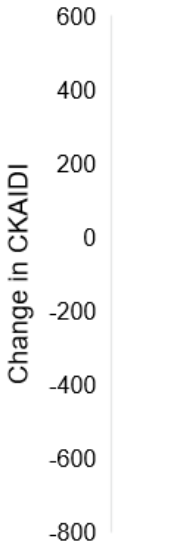
Note: EME = excludable major events. CKAIDI of zero indicates circuit did not experience any outages.

Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

Before and after comparison: A simple graphical summary of the statistical change in CKAIDI is shown in Figure 14 below, which uses the "box-and-whisker" format.[34] This chart compares the difference in CKAIDI between baseline and Program Year 2020, for both the system-wide and ADA circuits.

[34] 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 14. Impact in Outage Duration Performance Metric Results



	Change in System-wide CKAIDI w/ EMEs	Change in ADA CKAIDI w/ EMEs
Count	2,083	175
% No Change	35%	1%
Average Change in CKAIDI	-49	-123
Standard Deviation	276	391
Median Change in CKAIDI	0	-22

	Change in System-wide CKAIDI w/o EMEs	Change in ADA CKAIDI w/o EMEs
Count	2,083	175
% No Change	35%	1%
Average Change in CKAIDI	-65	-142
Standard Deviation	272	380
Median Change in CKAIDI	0	-34

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 – 2020 CKAIDI = if greater than zero, positive impact.
Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

The average system-wide CKAIDI increased in Program Year 2020 over the baseline. For the selected ADA circuits, CKAIDI increased significantly more than for system-wide circuits, indicating a worsening performance on the ADA circuits on average.[35] In particular, the bottom quartile of change for the ADA circuits is much larger than that for system-wide circuits, signifying that ADA circuits had a greater proportion of circuits with worse performance in 2020.

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

Difference in differences: The differences in the change in CKAIDI (baseline to 2020) between the system-wide average and the average for circuits with ADA investments are shown in Table 34. The change in CKAIDI for circuits with ADA investments was greater than the system-wide circuits. Although the standard deviation for these samples is larger than the CKAIDI changes (as discussed above), 2020 was clearly a bad year for CKAIDI on ADA circuits. It is difficult to conclude how much positive (or negative) impact the ADA investments had on this metric for Program Year 2020. Some of the reduced performance in the year is likely explained by the fact that many of the worse performing ADA circuits (as seen in the higher bins

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

in Table 10) also have above average customer counts, increasing the customer weighted average CKAIDI for the year.

Table 34. Eversource CKAIDI Difference in Differences

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIDI w/ EMEs	-49	-123	-74
Change in CKAIDI w/o EMEs	-65	-142	-77

Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

Erosion of Baseline: As mentioned in section 4.1.3.1, 11% of Eversource system-wide circuits and 3% of Eversource ADA circuits had to be excluded from this metric, because circuits had been retired, reconfigured or split since 2017. The comparability of each circuit in the program year to its baseline, as defined in the DPU approved metric, depends on that circuit not having been reconfigured or significantly changed (e.g., a normally open switch between circuit segments is changed to operate as normally closed, changing the customer counts and outage measurements on that circuit). The number of circuits that are comparable between baseline and program year is reduced year over year as more circuits are reconfigured, leading to an erosion of metric baseline over time. In PY2020 only Eversource had ADA circuits that were excluded from analysis on this basis, but Guidehouse expects this issue to emerge for National Grid in future years.

4.2.1.2 National Grid Analysis

National Grid did not deploy any ADA devices in the first half of 2020 or prior, thus the evaluation team did not assess this Performance Metric for National Grid.

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

Metric PM-12, Reliability-Focused Grid Modernization Investments' Effect on Outage Frequency (CKAIFI), provides insight on how GMP devices impact outage duration and will track the improvements over time. Per the DPU Stamp Approved GMP Performance Metrics Guidance:

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

The EDCs provided the CKAIFI metric in their Appendix 1 filings. As discussed in Section 4.1.3, only circuits with ADA investments commissioned in the first half of 2020 and prior are included in the analysis. Analysis of this metric for each EDC is presented in the following subsections and align closely with the previous metric (PM-12: Impact on Outage Duration).

4.2.2.1 Eversource Analysis

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

System-wide and ADA circuit counts: Table 35 is structured with CKAIFI ranges, or "bins," to provide insight about the range of outage durations across the system, and to show where circuits selected for ADA investment fall within these bins. Similar to CKAIDI, the proportion of system-wide circuits with zero CKAIFI in the baseline is higher than that of ADA circuits. This provides some indication that these less reliable circuits were targeted more for ADA investment.[36]

An increase in system average CKAIFI from the baseline to PY2020 indicates decreased reliability at the system level in 2020. However, the percentage difference in CKAIFI between the baseline and PY2020 is not as large as the difference in CKAIDI, suggesting the average frequency of customer outages may not have increased as much as the average duration did in 2020, again indicating longer outages affecting larger numbers of customers per circuit.

The CKAIFI standard deviation also increased, indicating increased variability in CKAIFI across system circuits. However, the standard deviation is on the same order of magnitude as the weighted average, providing some indication that the change in the weighted average is not simply statistical noise, but an actual degradation in performance during the program year. The customer weighted average CKAIDI is significantly greater than the simple average, indicating that the circuits with more frequent outages tended to have above average number of customers.

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

Table 35. Eversource Baseline and PY2020 CKAIFI Distribution

Eversource ADA	2015-2017 Avg. CKAIFI (Baseline)				2020 CKAIFI (Program Year)			
	System-wide		ADA Circuits		System-wide		ADA Circuits	
	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs	w/ EMEs	w/o EMEs
CKAIFI Statistics								
Total Circuits	2,083	2,083	175	175	2,083	2,083	175	175
% Zero	38%	38%	2%	2%	48%	48%	7%	7%
Weighted Average	1.0	0.9	1.3	1.2	1.2	1.2	1.4	1.4
Simple Average	0.5	0.5	1.2	1.1	0.6	0.6	1.2	1.2
Std. Dev.	0.7	0.7	0.8	0.8	1.0	1.0	1.1	1.1
Range								
0	782	783	3	3	993	993	13	13
0 - 0.25	206	212	12	13	279	279	22	22
0.25 - 0.75	520	536	45	46	162	162	30	30
0.75 - 1.25	266	273	43	43	281	281	40	40
1.25 - 1.75	153	159	28	34	106	106	24	24
1.75 - 2.25	90	70	25	20	90	90	12	12
2.25 - 2.75	35	27	11	9	56	56	13	13
2.75 - 3.25	17	14	4	5	47	47	11	11
3.25 - 3.75	9	7	4	2	26	26	4	4
3.75 - 4.25	3	2	0	0	16	16	4	4
4.25 - 4.75	1	0	0	0	10	10	2	2
4.75 - 5.25	0	0	0	0	9	9	0	0
5.25 - 5.75	0	0	0	0	4	4	0	0
5.75 - 6.25	0	0	0	0	2	2	0	0
6.25 - 6.75	0	0	0	0	1	1	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	1	0	0	0	1	1	0	0

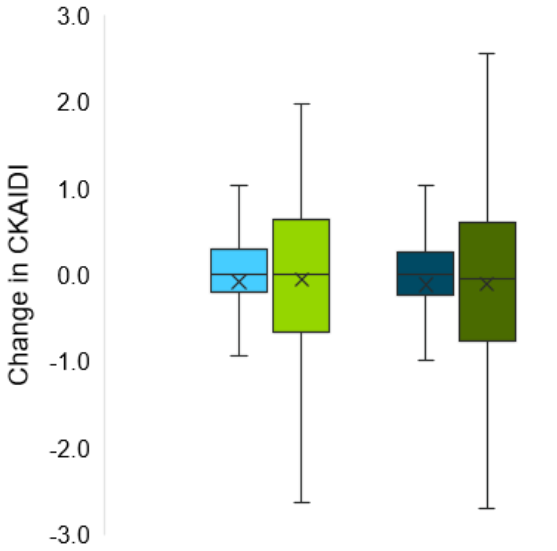
Note: EME = excludable major events. CKAIFI of zero indicates circuit did not experience any outages

Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

Before and after comparison: A simple graphical summary of the statistical change in CKAIFI is shown in Figure 15 below, which uses the "box-and-whisker" format.[37] This chart compares the difference in CKAIFI between baseline and Program Year 2020 for each circuit, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the DPU Stamped Approved formula of Baseline CKAIFI – Program Year CKAIFI, so a positive change indicates improved performance in the Program Year.

[37] 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 15. Impact in Outage Frequency Performance Metric Results



	Change in System-wide CKAIFI w/ EMEs	Change in ADA CKAIFI w/ EMEs
Count	2,083	175
% No Change	35%	1%
Average Change in CKAIFI	-0.1	0.0
Standard Deviation	0.9	1.1
Median Change in CKAIFI	0.0	0.0

	Change in System-wide CKAIFI w/o EMEs	Change in ADA CKAIFI w/o EMEs
Count	2,083	175
% No Change	35%	1%
Average Change in CKAIFI	-0.1	-0.1
Standard Deviation	0.9	1.1
Median Change in CKAIFI	0.0	0.0

Note: EME = excludable major events. Change in CKAIFI is calculated as defined by the DPU PM Guidance: 2015-2017 Avg. CKAIFI – 2020 CKAIFI = if greater than zero, positive impact.

Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

The average system-wide CKAIFI changed very little in PY2020 relative to the baseline period. The average change in CKAIFI increased only slightly for both system wide and ADA circuits. The similar change in CKAIFI indicates that ADA circuits performed neither better nor worse than system wide circuits. However, the standard deviation of the change in CKAIFI for each group is significantly larger—several times larger–than the average change in CKAIFI itself, providing an indication that the change in the average is of limited statistical significance, and not indicative of a clearly discernible trend in CKAIFI. There are many potential reasons for these changes and many factors impacting this metric. The impact of the ADA investment in operation is one of the factors but is not discernable using the metric itself.

Difference in differences: The differences in the change in CKAIFI (baseline to 2020) between the system-wide average and the average for circuits ADA investments are shown in Table 36. The change in CKAIFI for circuits with ADA investments was the same as the system-wide circuits. However, the standard deviation for these samples is much larger that the CKAIFI changes indicating that the difference is likely not statistically significant and is more probably a factor of randomness in the metric data than any type of trend. It is difficult to conclude how much positive (or negative) impact the ADA investments had on this metric for Program Year 2020.

Table 36. Eversource CKAIFI Difference in Differences

	System-Wide Circuits	ADA Circuits	Difference in Differences (ADA - System-Wide)
Change in CKAIFI w/ EMEs	-0.1	0.0	0.0
Change in CKAIFI w/o EMEs	-0.1	-0.1	0.0

Note: Due to rounding, manual calculations of Difference in Differences will not precisely match calculated numbers provided in this table.

Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

Erosion of Baseline: As mentioned in section 4.1.3.1, 11% of Eversource system-wide circuits and 3% of Eversource ADA circuits had to be excluded from this metric, because circuits had been retired, reconfigured or split since 2017. The comparability of each circuit in the program year to its baseline, as defined in the DPU approved metric, depends on that circuit not having been reconfigured or significantly changed (e.g., a normally open switch between circuit segments is changed to operate as normally closed, changing the customer counts and outage measurements on that circuit). The number of circuits that are comparable between baseline and program year is reduced year over year as more circuits are reconfigured, leading to an erosion of metric baseline over time. In PY2020 only Eversource had ADA circuits that were excluded from analysis on this basis, but Guidehouse expects this issue to emerge for National Grid in future years.

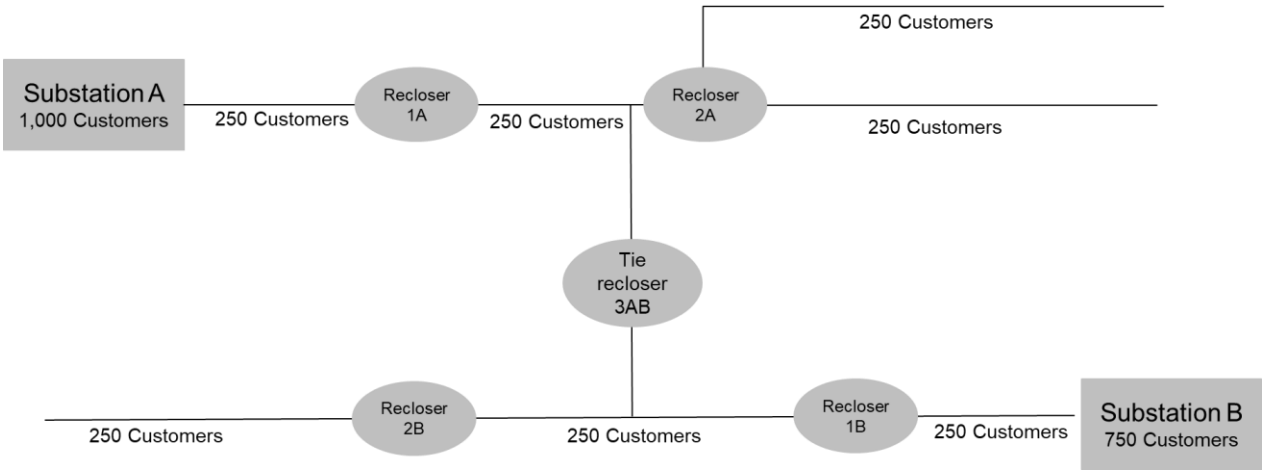
4.2.2.2 National Grid Analysis

National Grid did not deploy any ADA devices in the first half of 2020 or prior, thus the evaluation team did not assess this Performance Metric for National Grid.

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

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

Figure 16. Example One-Line Diagram of Grid Modernization Devices



Source: Guidehouse and EDCs

Broadly speaking, all customers within the zone in which a recloser is placed benefit from the device. In Figure 16, if Recloser 1A was installed in 2020 as part of the GMP and all other devices previously existed, then 500 customers benefitted from the installation of this device. All customers between the new device and the next connective device benefit. In this case, that is 250 customers on each side of the device for a total of 500 customers.

The customers that benefit from tie reclosers are counted in the same way. In Figure 16, if Tie Recloser 3AB was installed in 2020 as part of the GMP and all other devices previously existed, then 500 customers benefitted from the installation of this device. The 500 customers include the 250 customers between Recloser 1A and 2A and the 250 customers between Recloser 2B and 1B. This is a very conservative method of estimating the number of customers that benefit from a tie recloser, as in many cases the majority of customers on affected circuit may benefit from this addition.

The metric calculation was performed by the EDCs, as detailed data is required to calculate this metric for each circuit with ADA devices commissioned in Program Year 2020 or prior. Unlike the Performance Metrics for outage duration and frequency, the timing of the commissioning of the ADA device is not relevant for evaluation. Thus, all circuits with ADA devices installed any time in 2020 or prior are “eligible” to be included in the evaluation of this metric.

4.2.3.1 Eversource Analysis

The number of customers that benefit from ADA devices is reported in Appendix 1 of the Eversource’s Annual GMP Report. The number of customers that benefit is non-zero only for circuits that had sectionalizing devices installed. Through PY20, these devices (OH Reclosers and Ties) were installed on 174 Eversource circuits. Table 37 shows the average and total number of customers that benefitted across all 174 circuits. As of the end of 2020, over 196,000 Eversource customers (14% of total customers) benefitted from ADA devices.

Table 37. Number of Eversource Customers that Benefitted from GMP ADA Devices

Summary Statistics	
Total Circuits with DA Installed	174
Average Number of Customer Benefiting per circuit	1,129
Total Number of Customers Benefiting from DA Devices	196,434
Percent of Total Customers that Benefit from DA Devices	14%

Source: Guidehouse analysis of Eversource 2020 GMP Annual Report Appendix 1

4.2.3.2 National Grid Analysis

The number of customers that benefit from ADA devices is reported in Appendix 1 of the National Grid's Annual GMP Report. The number of customers that benefit is non-zero only for circuits that had sectionalizing devices installed. Through PY20, these devices (OH Reclosers and Ties) were installed on 4 National Grid circuits. Table 37 shows the average number of customers that benefitted as well as the total across all 4 circuits. As of the end of PY20, almost 9,000 National Grid customers (1% of total customers) benefitted from ADA devices. Note that National Grid only counted customers benefitting from ADA *schemes* when calculating this metric. In other words, National Grid did not count towards this metric customers benefitting from individual reclosers (that were not part of FLISR schemes).

Table 38. Number of National Grid Customers that Benefitted from GMP ADA Devices

Summary Statistics	
Total Circuits with DA Installed	4
Average Number of Customer Benefiting per circuit	2,221
Total Number of Customers Benefiting from DA Devices	8,883
Percent of Total Customers that Benefit from DA Devices	1%

Source: Guidehouse analysis of Eversource 2020 GMP Annual Report Appendix 1

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

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

Table 39 shows the baseline (2018) and Program Year 2020 average zone size of the system-wide and ADA circuits for Eversource. For this Performance Metric, the group of ADA circuits is defined as any circuit with an ADA device commissioned during PY2020 or prior. Table 39 is structured with zone size ranges, or "bins", to provide insight about the range of zone sizes across the system, and to show where circuits selected for ADA investment fall within these bins. The proportion of baseline zone sizes greater than 700 customers was higher for ADA circuits than the system-wide circuits, which illustrates that this metric was a key factor in selecting circuits for ADA investments.

The average zone size in the 2018 baseline for ADA circuits is nearly double that of system wide circuits but fell to a similar size as system wide circuits in 2020. The standard deviation of zone size has also significantly decreased, indicating that there is less variability in the number of customers per zone. These combined observations suggest that ADA investments were targeted towards circuits with a larger zone size and succeeded in reducing it.

Table 39. Baseline and PY2020 Average Zone Size Customer Count

Eversource ADA	Average Protective Zone Size Baseline (2018)		Average Protective Zone Size 2020	
	System-Wide Circuit	ADA Circuit	System-Wide Circuit	ADA Circuit
Average Protective Zone Size Statistics				
Total Circuits	1,637	220	1,637	220
% Zero	6%	1%	0%	0%
Simple Average	358	602	316	361
Std. Dev.	368	377	324	203
Range				
0	95	2	0	0
0 - 100	421	13	513	18
100 - 200	170	14	200	26
200 - 300	185	20	235	56
300 - 400	165	22	176	35
400 - 500	148	33	149	35
500 - 600	92	16	101	22
600 - 700	93	21	80	15
700 - 800	70	17	51	8
800 - 900	57	14	45	2
900 - 1000	45	17	28	1
1000 - 1100	27	8	18	1
> 1100	69	23	41	1

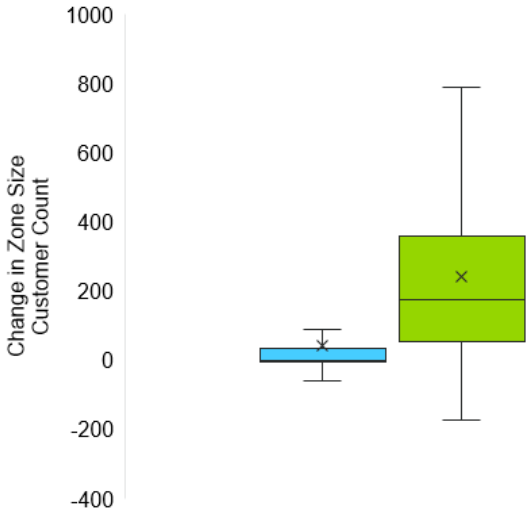
Source: Guidehouse Analysis of Eversource's 2020 GMP Annual Report Appendix 1

A simple graphical summary of the statistical change in average zone size customer count is shown in Figure 17 below, which uses a "box-and-whisker" format.[38] This chart compares the difference in the average zone size customer count between baseline and Program Year 2020 for each circuit, for both the system-wide circuits and the selected ADA circuits.[39]

[38] The "box-and-whisker" plot shows divides the sample into quartiles. The lower and upper "whiskers" indicate the lowest and highest values in the range, and the boxes show the 2nd and 3rd quartile in the sample. The "x" indicates the sample average.

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

Figure 17. Change in Average Zone Size Customer Count



	Change in System-wide Circuits	Change in ADA Circuits
Count	1637	220
% No Change	10%	1%
Average Change in Zone Size	43	241
Standard Deviation	193	268
Median Change in Zone Size	0	175

Source: *Guidehouse analysis of 2020 GMP Annual Report Appendix 1*

The average zone size per circuit for ADA circuits decreased by 241 customers. This average change in zone size is much greater than the system-wide average change in zone size of 43 customers. The average zone size of ADA circuits was reduced by nearly 6 times the system-wide average, indicating that ADA investments had a major impact in decreasing the zone size customer counts.

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

The evaluation of this metric follows the same criteria for circuits included in the analysis as PM-12 and PM-13. Thus, because National Grid did not deploy any ADA devices in the first half of 2020 or prior, the evaluation team did not assess this Performance Metric for Program Year 2020.

5. ADA Case Studies

Three case studies were performed for the ADA investment area: two for Eversource and one for National Grid. The case studies illustrate the operation and impacts of the GMP devices installed through PY 2020. The analyses were based on information from EDCs including OMS data, one-line diagrams, SCADA data, switching orders and discussions with EDCs. However, Guidehouse made certain reasonable assumptions to reconstruct the precise details of an outage event in cases where not all information was available.

5.1 Data Management

Case studies were performed using data from the outage management system (OMS), switching orders, SCADA data, circuit topology maps and one-line diagrams. The outage data contains details of outage events, such as location, timing, and customers affected, that were integral to understanding the role of the GMP device in resolving the outage. The One-Line Diagrams helped support the analysis by using visualization to better understand the operation of the relevant devices during the outage event. Supplemental information was obtained from the EDCs in some cases to reconstruct the details of an event.

5.2 Case Study 1: National Grid FLISR Scheme (Circuit 33L1)

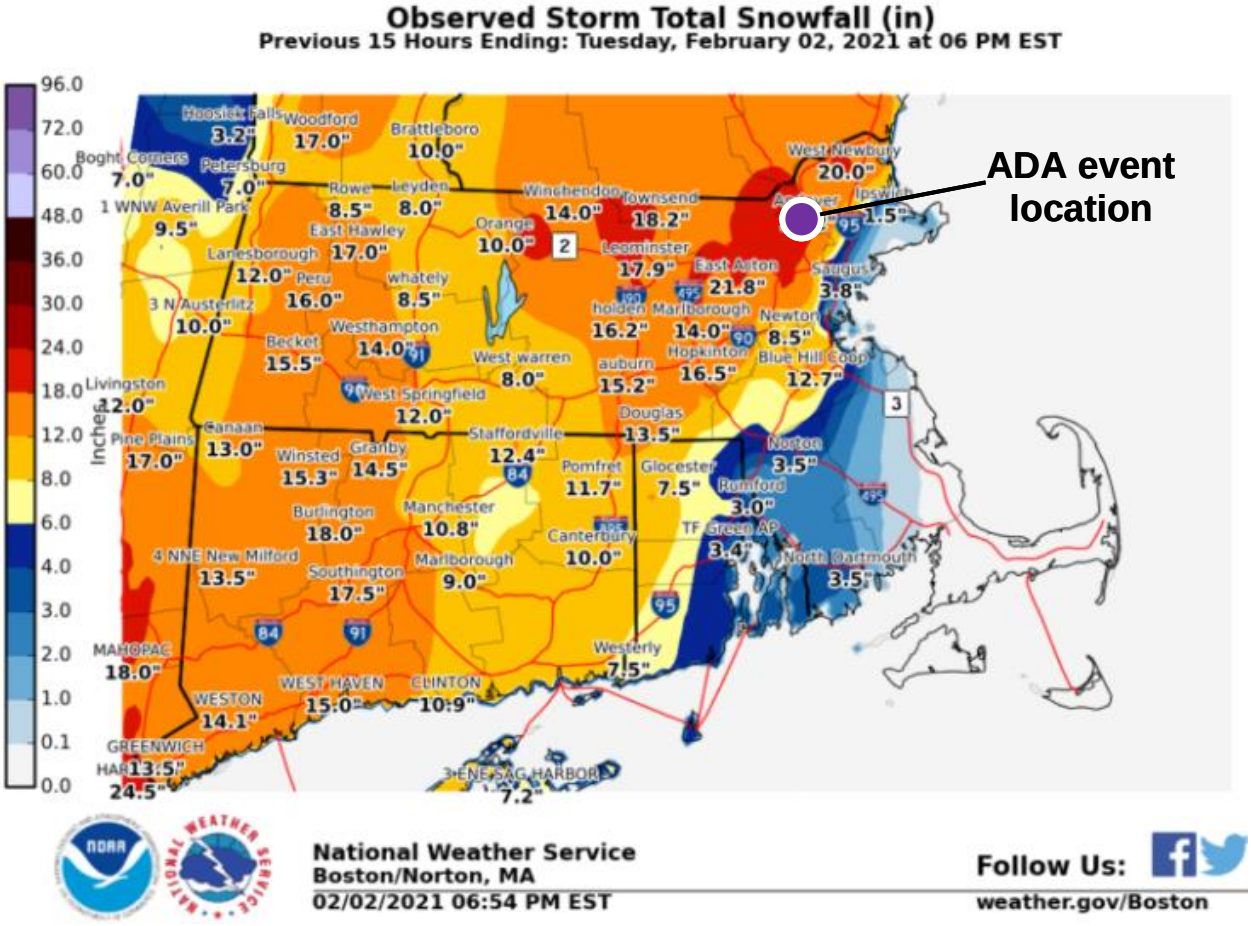
5.2.1 Background

This case study describes how a GMP-funded ADA FLISR scheme automatically operated during a winter storm to reduce customer outage duration. On February 2, 2021, a nor'easter brought 18-22 inches of snow to Merrimack Valley and other parts of Massachusetts (Figure 18), making driving perilous, causing power outages and closing down schools[40].

National Grid had commissioned a FLISR scheme in the Merrimack Valley months earlier as part of the Massachusetts GMP ADA program. The East Boxford circuit (33L1) has been one of National Grid's poorest-performing circuits in recent years in terms of customer interruptions. The FLISR scheme operated in the midst of the nor'easter to avoid a long duration power outage to approximately 400 customers in East Boxford.

[40] NBC Boston, February 2, 2021. URL: https://www.nbcboston.com/news/local/watch-live-noreaster-leaves-thousands-without-power-tuesday-morning/2291036/

Figure 18: The ADA FLISR Scheme serves an area worst hit by snow during the February 2021 nor'easter



Source: National Weather Service

5.2.2 Event Description

The outage occurred early on Tuesday, February 2nd, 2021 when a tree limb fell on all three phases of a main power line at location A (Figure 19), between the East Boxford (33L1) substation and the first downstream recloser (R1).

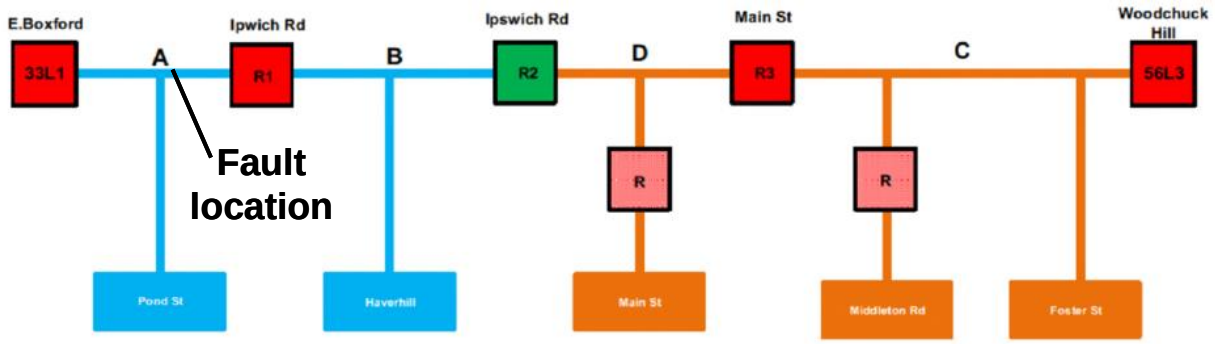
The following automatic switching sequence took place:

- The substation breaker at East Boxford Substation (33L1) sensed downstream fault and locked out. 989 customers lost power immediately (between 33L1 and R2 which is normally open).
- The loss of source-side voltage caused the recloser R1 to open automatically.
- The opening of R1 triggered National Grid's ADA FLISR logic to close the normally open recloser R2, a GMP ADA device that ties feeders together.
- The closing of R2 transferred 396 customers between R1 and R2 to the Woodchuck Hill Substation (56L3), restoring power to those customers.

- FLISR isolated the fault to smallest zone possible, between 33L1 and R1. The entire fault isolation and service restoration operation took approximately 20 seconds and was automatic, not requiring human intervention.

Effectively, the FLISR scheme restored service to 396 customers along Ipswich Road and Haverhill Road in 20 seconds. The remaining 593 customers were restored in 117 minutes after crews had repaired the fault. Without the FLISR scheme, all 989 customers would have experienced the full 117-minute outage.

Figure 19. One-Line Diagram of the ADA FLISR Scheme

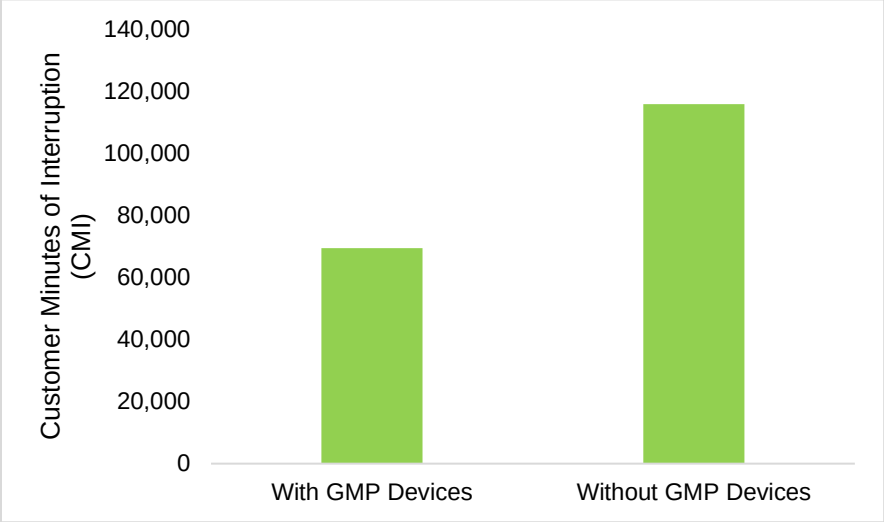


Source: National Grid

5.2.3 Benefit of Grid Modernization Investment

This case study illustrates the benefit of GMP devices in reducing customer outage time during a winter storm in Massachusetts. Without the GMP-funded FLISR scheme, the 396 customers that were restored in 20 seconds would have experienced approximately a 117-minute outage while manual switching and repairs were performed. The resulting savings in customer minutes of interruption (CMI) are shown in Figure 20. (Note CMI = number of customers interrupted *times* duration of interruption in minutes.)

Figure 20. Benefit of Grid Modernization Devices in Reducing Customer Minutes of Interruption



Source: Guidehouse

5.3 Case Study 2: Eversource Tie Recloser ADA (Circuit 21N9)

5.3.1 Background

This case study describes how a GMP-funded ADA loop scheme automatically operated during a winter storm to reduce customer outage duration. On October 7, 2020, western Massachusetts experienced a derecho event with thunderstorms, heavy rain and wind gusts up to 85 miles per hour. The National Weather Service classified it as one of the most severe storms in Massachusetts in 2020[41]. At one point during the storm, 225,000 Massachusetts customers were without power[42]. Eversource Massachusetts had more than 500 crews working to restore power, calling in help from New Hampshire, Ohio, Pennsylvania and Canada[43].

At 5:25pm on October 7, a tree limb fell on a 13.8 kV overhead line in Springfield, Massachusetts. Eversource had commissioned six automated overhead reclosers on the circuit (21N9) as part of the GMP ADA program. The circuit serves 3,294 customers. The loop scheme operated correctly in the midst of the storm to avoid a long duration power outage to approximately 680 customers in Springfield.

[41] MassLive.com. URL: https://www.masslive.com/weather/2020/10/oct-7-storm-in-massachusetts-that-caused-320-mile-damage-swath-was-one-of-the-strongest-severe-weather-events-of-2020-officials-say.html#:~:text=Oct.-,7%20storm%20in%20Massachusetts%20that%20caused%20320%2Dmile%20damage%20swath,events%20of%202020%2C%20officials%20say&text=The%20storm%20left%20a%20320,miles%20per%20hour%20at%20times.

[42] Boston.cbslocal.com. URL: https://boston.cbslocal.com/2020/10/07/strong-storms-knock-out-power-to-225000-in-mass/

[43] Masslive.com. URL: https://www.masslive.com/weather/2020/10/oct-7-storm-in-massachusetts-that-caused-320-mile-damage-swath-was-one-of-the-strongest-severe-weather-events-of-2020-officials-say.html#:~:text=Oct.-,7%20storm%20in%20Massachusetts%20that%20caused%20320%2Dmile%20damage%20swath,events%20of%202020%2C%20officials%20say&text=The%20storm%20left%20a%20320,miles%20per%20hour%20at%20times.

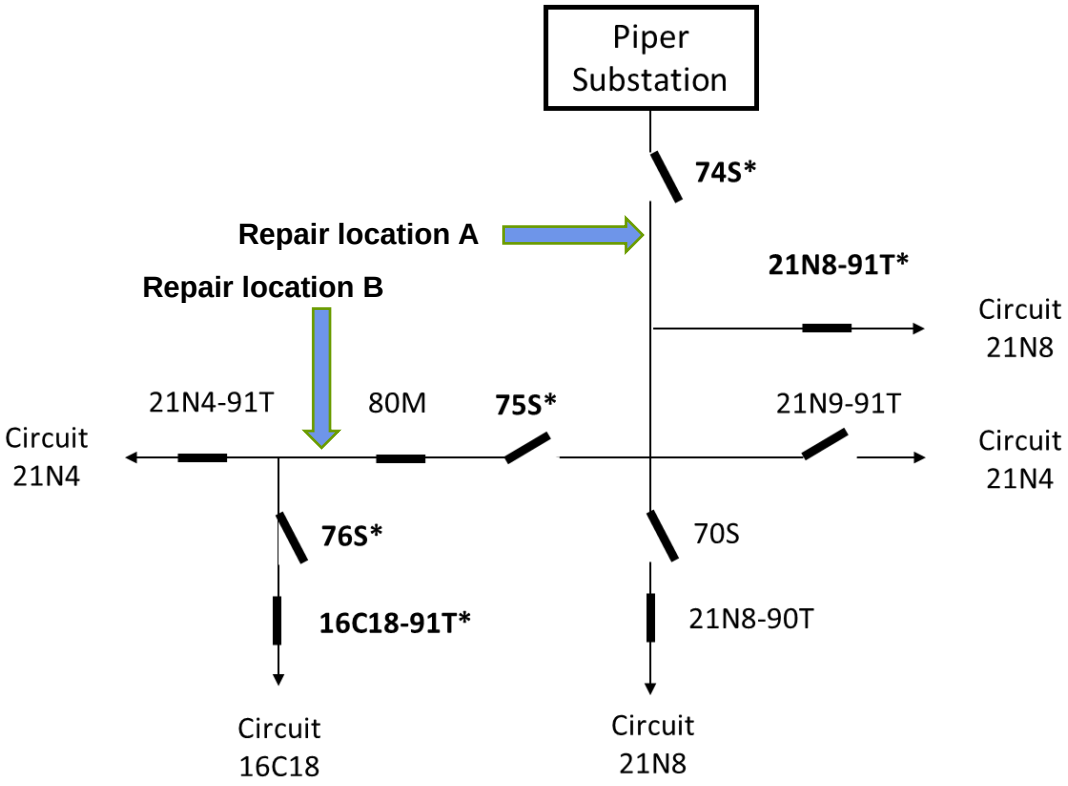
5.3.2 Event Description

The outage occurred at 5:19pm on October 7, 2021 when a tree limb fell on a 13.8 kV overhead line. Figure 21 shows a schematic diagram of repair locations and grid devices.

The following switching sequence took place:

- At 5:19pm, the GMP-funded overhead recloser 74S opened.
- At 5:20pm, the overhead recloser 70S also opened.
- The tie recloser 21N8-90T closed automatically.
- At 5:25pm, the GMP-funded overhead reclosers 75S and 76S were both opened in order to isolate the fault to a smaller zone. Both 75S and 76S are GMP-funded ADA devices.
- The opening of 76S triggered the tie recloser 16C18-91T to close automatically in one minute. Both 76S and 16C18-91T are GMP-funded ADA devices. The automated loop scheme operated correctly and as desired.
- The closing of 16C18-91T transferred 322 customers to an alternate supply source 16C18 (16C18).
- Eversource crews performed repair work at fault location A.
- At 6:36pm, Eversource control room operators closed 21N8-91T, a GMP-funded tie recloser, via supervisory switching. This step further restored power to 358 customers in 71 minutes (between 75S and 21N8-91T). These customers were now supplied from an alternate source (21N8) via the tie recloser.
- Eversource crews performed repair work at fault location B.
- At 9:07pm, Eversource operators cleared the fault and restored the circuit to normal operating conditions. 494 customers had experienced the full 222-minute outage.

Figure 21. One-Line Diagram (* indicates GMP-funded device)



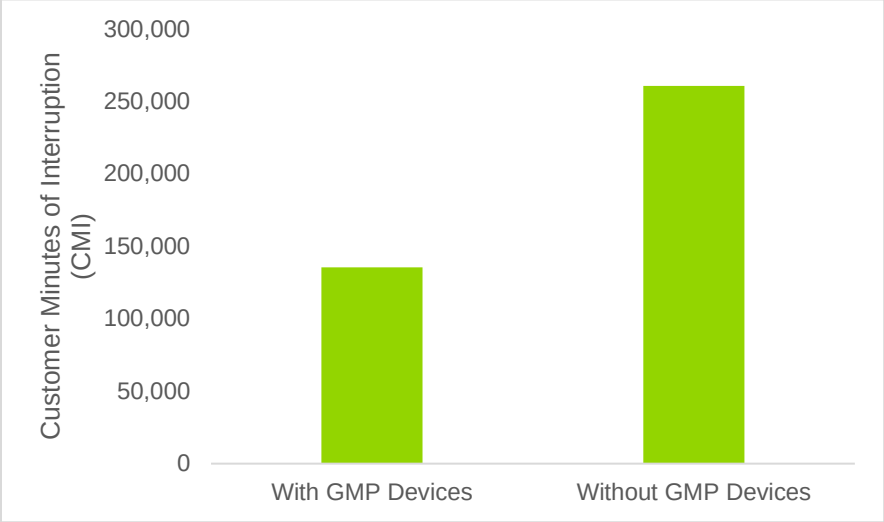
Source: Guidehouse analysis of Eversource One-Line Diagram

5.3.3 Benefit of Grid Modernization Investment

This case study illustrates the benefit of GMP devices in reducing customer outage times during a thunderstorm in Massachusetts. After Eversource learned of the fault, it performed switching to isolate the fault to the smallest zone possible. 322 customers were transferred to an alternate supply source while repairs were being performed. After Eversource had cleared repair location A, it restored power to 358 customers while repairs at location B were still underway.

Without the GMP ADA investment, Guidehouse estimates all 322+358=680 customers would have experienced a 222-minute outage. The resulting savings in customer minutes of interruption (CMI) are shown in Figure 22. (Note CMI = number of customers interrupted *times* duration of interruption in minutes.)

Figure 22. Benefit of Grid Modernization Devices in Reducing Customer Minutes of Interruption



Source: Guidehouse Analysis

5.4 Case Study 3: Eversource Recloser ADA (Circuit 19J1)

5.4.1 Background

This case study event took place on August 4, 2020, when Tropical Storm Isaias brought strong winds up to 60 mph and caused power outages to nearly 250,000 Massachusetts customers.[44] The case study describes how GMP-funded ADA investments and other non-GMP automated ADA devices were used to reduce customer zone size during an outage. The outage was caused by a vehicle colliding with a pole and breaking an overhead wire in Huntington in Western Massachusetts.

Circuit 19J1 is a long, rural circuit serving 1,561 customers including critical customers in Montgomery and Huntington, Massachusetts. Eversource had commissioned two ADA recloser devices and five M&C SCADA devices on circuit 19J1. There are also 5 other non-GMP ADA devices that were utilized during the outage events. The ADA devices helped to reduce the customer count of this outage event. ADA devices were also used to deenergize the incident location, making the area safe for first responders, repair crews and members of the public.

5.4.2 Event Description

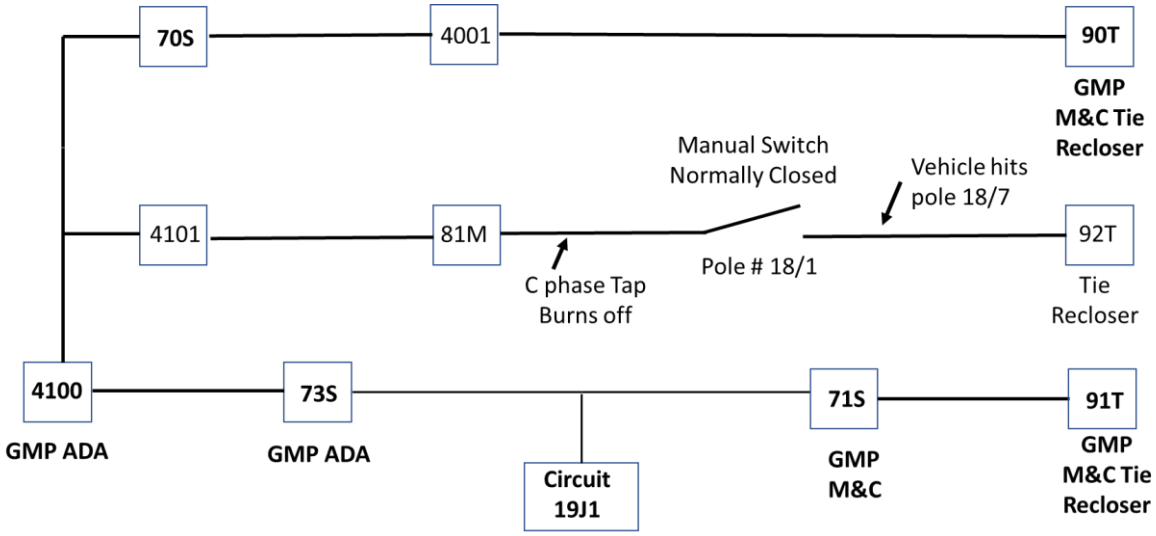
On August 4, 2020 at 8am, a vehicle collided with a pole at the location shown in Figure 23. The pole carried 3-phase 23 kV mainline overhead wire. The vehicle accident caused one of the three phases to burn open at a nearby pole location.

The following switching sequence took place:

[44] Masslive.com. URL: https://www.masslive.com/weather/2020/08/see-damage-from-tropical-storm-isaias-across-massachusetts-63-mph-winds-split-trees-and-downed-power-lines-reported-across-the-state.html

- Eversource operators determined that the fault location was downstream of the GMP ADA recloser 4100.
- Eversource operators used SCADA to open GMP ADA recloser 4100 remotely via supervisory switching.
- The opening of 4100 correctly triggered an automated loop scheme downstream. Recloser 81M opened and 92T closed. Recloser 70S opened and 90T closed, so that the maximum number of customers downstream of 70S were now supplied from an alternate source of power. 70S and 90T are GMP M&C devices.
- After about 12 minutes, Eversource operators determined that the fault was downstream of the sectionalizing device 81M. They remotely opened 81M and 92T to further isolate the fault location to a smaller zone.
- Once the damage location was isolated, operators closed 4100 using SCADA capability, restoring power to 405 customers between 4100, 81M, and 70S.
- After 67 minutes, crews manually opened a switch at pole #18/1 to isolate the fault zone even further, restoring 209 customers.
- 19 customers (to the right of 18/1) experienced a longer outage while crews replaced the pole and completed repairs.

Figure 23. One-Line Diagram



Source: Guidehouse analysis of Eversource One-Line Diagram

5.4.3 Benefit of Grid Modernization Investment

This case study illustrates the benefit of ADA in automating operation to reduce customer zone size and isolating a fault to a smaller section of the circuit during a major storm. Circuit 19J1 is a long circuit that taps off in multiple directions. Without ADA, operation of the circuit would be slow and difficult especially in storm conditions.

The case study also shows the benefit of SCADA-enabled devices in deenergizing a hazardous location to make the area safe for first responders, repair crew and the public. Without the ADA devices (GMP funded and non-GMP), it may have been necessary for the operators to open the

substation breaker in order to make the damage area safe for first responders, resulting in a complete circuit outage to 1,561 customers.

6. Recommendations

Guidehouse submits the following recommendations for EDC consideration in PY2021:

1) The CKAIDI and CKAIFI reliability related Performance Metrics as defined have deficiencies in measuring the effectiveness of Grid Modernization Investments. Many factors unrelated to the Grid Modernization investments will affect these metrics in any given year, and it is not possible to distinguish among these factors using the metrics. For example, the variation in storm activity between years can cause significant changes in these metrics, as apparently happened in PY2020.

    a. Recommendation: Continue to track these Performance Metrics, but to establish other methods of isolating the specific impacts of Grid Modernization investments.
    b. Recommendation: Additional Performance Metrics should be explored to determine if it is possible to capture the actual reliability performance attributable to the investments. Exploration could include:
        i. Reviewing the data and techniques necessary to understand the relationship between circuit reliability and weather conditions, vegetation management cycles and other reliability drivers that are independent of the grid modernization investments.
        ii. Expanding the use of case studies to cover a greater proportion of the investments—more outage cases examined on more circuits (see Recommendation 4a below).
        iii. Leveraging new processes and collecting data to more efficiently perform outage case studies, and perhaps extrapolate these results to a broader set of circuits to understand investment performance with more certainty.
        iv. Comparing number of customers out and customer minutes of interruption (CMI) that occurred, with the number of customers out and CMI that would have occurred without Grid Modernization investments.

2) The use of currently defined CKAIDI and CKAIFI reliability related Performance Metrics—which are circuit level metrics—has increasing challenges over time as circuits get re-configured or retired and new circuits are constructed. The comparability of each circuit in the program year to its baseline 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 after year as more circuits change due to ongoing operation of the system.

    a. Recommendation: Explore metrics that are robust to these operating changes to help ensure that Grid Mod investment assessment based on these metrics are not misleading, and that they are able to better capture the impact of the investment.

3) Current metrics do not provide an understanding of how M&C and ADA investments facilitate easier interconnection, or more capacity, of DER added to the system

    a. Recommendation: Consider developing additional metrics and/or performing pilot projects that utilize the installation of ADA and M&C investments at DER locations to understand the value or benefits that are provided. This would provide actual data on the effectiveness of these investments to support DER integration.

4) Case studies show detailed functioning and impact of GMP devices, and they are proving to be a useful tool in understanding the effectiveness of the Grid Modernization investments. Based on case studies performed, the M&C investment is yielding reliability and service delivery benefits to customers for each of the EDCs.

    a. Recommendation: Continue to perform case studies in future evaluations, and increase the use of case studies where practicable, to analyze the mitigation of customer outages and help determine the effectiveness of Grid Modernization investments in improving reliability and service delivery.
    b. Recommendation: Continue the deployment of ADA technologies as part of the Grid Modernization Program and continue to monitor progress (including through amended or additional metrics to be determined by the Department).