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Massachusetts Grid Modernization Program Year 2023 Evaluation Report: Advanced Distribution Automation (ADA)

Prepared for:

EVERSOURCE   nationalgrid   Unitil

Massachusetts Electric Distribution Companies

Submitted by:

Guidehouse Inc.
125 High Street
Suite 401
Boston, MA 02110

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guidehouse.com

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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 enhance reliability, facilitate integration of DERs, and provide other grid and customer benefits.

This evaluation focuses on the progress and effectiveness of the Massachusetts Department of Public Utilities (Department) preauthorized ADA investments for each EDC toward meeting the Department's grid modernization objectives for Program Year (PY) 2023.

Evaluation Process

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

The original Evaluation Plan developed by Guidehouse[1] was submitted to the Department by the EDCs on May 1, 2019 in dockets D.P.U. 15-120/15-121/15-122. Modifications to this original Evaluation Plan were required to enable evaluation of PY 2022 through PY 2025. These modifications included an 1) extension of the evaluation window from the four year term spanning 2018 – 2021[2] (hereon referred to as Term 1) to incorporate the new four year term spanning 2022 – 2025 (hereon referred to as Term 2), 2) revisions required to reflect the new Term 2 investment activity, and 3) revisions required to remove Infrastructure Metrics and increase the number of ADA and M&C case studies included in evaluation. Modifications to the original Evaluation Plan were filed on February 7, 2024.[3] The modified Evaluation Plan has been used to develop the analysis and evaluation provided below in this document.

National Grid ADA projects are expected to reduce the number of customer outages and customer minutes of interruption. The evaluation focuses on the ADA investments' impact on

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

[2] The Department approved the EDC's Term 1 GMPs on May 10, 2018 in D.P.U. 15-120/15-121/15-122,. In that Order, the Department 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 Department issued an order extending the 3-year grid modernization plan investment term to a 4-year term, which introduced a 2021 program year. In addition, on July 1, 2020, Eversource filed a request for an extension of the budget authorization associated with grid modernization investments. That was docketed as D.P.U. 20-74 The 2018-2021 GMP term results provided for Eversource reflect this updated filing.

[3] On February 7, 2024, Eversource, National Grid, and Unitil filed evaluation plans with the Department for the period spanning 2022-2025 in dockets D.P.U. 21-80/21-81/21-82.

"Reducing the Effects of Outages" as part of the Department's grid modernization objective[4] "(1) optimize system performance (by attaining optimal levels of grid visibility, command and control)." Table 1 illustrates the key metrics relevant for the ADA evaluation.

Table 1. ADA Evaluation Metrics

Metric	ADA Evaluation Metrics
PM-10	Number of customers that benefit from GMP-funded Distribution Automation devices
PM-NG-1	Main line customer minutes of interruption saved
Case Study**	Case studies to illustrate how reliability is being improved, investigating: • ADA performance during blue sky days • ADA performance during excludable major events days • ADA performance during missed or undesirable operations • ADA performance on worst-performing circuits

PM – performance metric

* Denotes that generating the metric is EDC responsibility

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

Source: Guidehouse Stage 3 Evaluation Plan filed February 7, 2024; Stamp Approved Performance Metrics outlined in D.P.U. 21-80/21-81/21-82, (Feb. 1, 2024)

Data Management

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

Table 2 summarizes data sources used throughout the ADA evaluation for PY 2023. Section 3.1 and Section 4.1 detail each of the data sources used for the assessment of Performance Metrics and Case Studies, respectively.

Table 2. ADA Data Sources

Data Source	Description
2022 Grid Modernization Plan Annual Report[5]	Baseline customer minutes of interruption information from National Grid's appendix to the *2022 GMP Term Report* (filed April 24, 2022). Data was used as the reference to PM-related data within the 2023 GMP Annual Report Appendices and verify no changes have occurred to the circuit-level baseline numbers between 2022 and 2023.

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[4] D.P.U. 15-120/15-121/15-122, at 106 (2018). The Department's grid modernization objectives include "(1) optimize system performance by attaining optimal levels of grid visibility, command and control, and self healing; (2) optimize system demand by facilitating consumer price-responsiveness; and (3) interconnect and integrate distributed energy resources." Id.

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

Data Source	Description
2023 Grid Modernization Plan Annual Report[6]	All PM-related data are taken from National Grid's appendix to the 2023 GMP Term Report (filed from these 2023 GMP Annual Report Appendices. In addition, data was compared to the data submitted by the EDCs to the Department in the 2022 Grid Modernization Plan Term Reports and associated Appendix 1 filings. The evaluation team confirmed the consistency of the data from the various sources and identified any differences.

Source: Guidehouse analysis

Key Findings and Recommendations

Table 3 presents the results for the ADA-specific Performance Metrics: Numbers of Customers that Benefit from GMP Funded Distribution Automation Devices, and Average Main-Line Customer Minutes of Interruption.

Table 3. ADA Performance Metrics Summary

PM	National Grid
PM-10: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Over 177,000 (13%) National Grid customers benefitted from ADA devices. This is a 5 percentage-point increase from PY 2022, where Guidehouse identified over 113,000 (8%) of National Grid customers benefiting from ADA devices.
PM-NG1: Main Line Customer Minutes of Interruption Saved	Main-line CMI for circuits with ADA decreased (improved) 46% in PY 2023 from baseline. This is a 12 percentage-point increase from PY 2022, where Guidehouse identified a 35% improvement in CMI from baseline.*

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

Source: Guidehouse analysis of National Grid PY 2023 Appendix 1 document

Table 4 summarizes key findings related to Guidehouse's ADA case studies.

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[6] Massachusetts Electric Company and Nantucket Electric Company d/b/a National Grid, Grid Modernization Annual Report for Calendar Year 2023. Received by Guidehouse on May 14, 2024.

Table 4. Summary of Case Study Findings for ADA Investment Area

Key Findings
1. National Grid ADA FLISR schemes are operating as designed in the majority of the 39 cases observed for PY 2023. Approximately, 90% (35 out of 39) had successful FLISR operations. Case studies were performed for six out of the 35 instances where FLISR had successful operations.
2. For the case studies reviewed that had successful operations, FLISR restored customers in under one minute (the Massachusetts threshold for a sustained interruption). This resulted in customers experiencing a momentary interruption instead of a sustained interruption. Guidehouse also observed for these case studies and based on the estimated reduction in CMI, that the successful FLISR operations improved CMI by over 50%.
3. Guidehouse observed four instances where National Grid's ADA FLISR schemes did not operate as expected. Case studies were performed on three of the four instances where FLISR failed to operate as expected. Based on the case studies, National Grid determined that mis-operations were due to FLISR schemes receiving bad data or a result of improper installation and programming.

Source: Guidehouse analysis

Guidehouse submits the following recommendations for EDC consideration in PY 2023:

1. National Grid ADA FLISR schemes are operating as designed in the majority of the 39 cases observed for PY2023.
   a. Recommendation: Continue to evaluate and deploy ADA FLISR based on high risk feeder locations.
   b. Recommendation: To validate proper FLISR operation and mis-operation failure rates, continue case studies for Term 2 investments.

2. Based on the case studies, National Grid determined that mis-operations were due to FLISR schemes receiving bad data or a result of improper installation and programming.
   a. Recommendation: To maximize reliability savings from GMP ADA, National Grid should verify that the quality control process used for FLISR configuration is appropriate. Without the configuration error that prevented a recloser to receive the command to close in Case Study #6, FLISR would have had a successful operation and a portion of the customers in the feeder affected would have likely experienced an outage less than a minute.
   b. Recommendation: National Grid should have the voltage sensors configured to automatically alarm in ADMS (SCADA) if they malfunction or go out of an acceptable voltage range. Additionally, FLISR equipment that has been identified out of service should be considered high priority for repairment and placement back into service. In Case Study #8, if bad data from a voltage sensor had been identified and corrected, the FLISR scheme would have not aborted operations and a percentage of customers would have experienced a momentary outage instead of a sustained outage.
   c. Recommendation: National Grid has updated their construction standard to help assure equipment is being installed properly. Since it is possible previous installations may have been installed incorrectly, a special field inspection should be performed. In Case Study #9, the FLISR scheme would have had a successful operation and avoided a sustained outage if the PTR had been installed and programmed correctly.

Guidehouse

1. Introduction to Massachusetts Grid Modernization

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

1.1 Massachusetts Grid Modernization Plan Background

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

1.1.1 Grid Modernization Term 1 (2018-2021)

On May 10, 2018, the Department issued its Order approving the EDCs' GMPs for 2018-2020 in dockets D.P.U. 15-120/15-121/15-122.[7,8] In the Order, the Department preauthorized grid-facing investments over three years (2018-2020) for each EDC and adopted a three-year (2018-2020) regulatory review construct for preauthorization of grid modernization investments. On May 12, 2020, the Department issued an Order[9] extending the three-year grid modernization plan investment term to a four-year term, which introduced a 2021 program year.

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

- Monitoring and Control (M&C)

- Advanced Distribution Automation (ADA)

- Volt/VAR Optimization (VVO)

- Advanced Distribution Management Systems/Advanced Load Flow (ADMS/ALF)

- Communications/IoT (Comms)

- Workforce Management (WFM)

A certain level of spending for each of these GMP Investment Areas was preauthorized by the Department, with the expectation they would advance the achievement of Department's grid modernization objectives:[10]

- Optimize system performance by attaining optimal levels of grid visibility command and control, and self-healing;

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

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

[9] D.P.U. 15-120; D.P.U. 15-121; D.P.U. 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).

[10] D.P.U. 15-120/15-121/15-122, at 106 (2018).

- Optimize system demand by facilitating consumer price responsiveness; and

- Interconnect and integrate distributed energy resources (DER).

For Term 1, the Department's preauthorized budget for grid modernization varied by Investment Area and EDC. Eversource originally had the largest preauthorized budget at $133 million, with ADA and M&C representing the largest share ($44 million and $41 million, respectively). National Grid's preauthorized budget was $82.2 million, with ADMS representing over 50% ($48.4 million). Unitil's preauthorized budget was $4.4 million and VVO made 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.[11] The budget extension, approved by the Department on February 4, 2021,[12] included $14 million for ADA, $16 million for ADMS/ALF, $5 million for Communications, $15 million for M&C, and $5 million for VVO.[13] These values are included in the Eversource total budget by Investment Area in Table 5.

Table 5. Term 1 (2018-2021) Preauthorized Budget, $M

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

Source: D.P.U. 15-120/15-121/15-122 (2018); D.P.U. 20-74 (2021).

1.1.2 Grid Modernization Term 2 (2022-2025)

On July 2, 2020, the Department issued an Order[14] that triggered further investigation into modernization of the electric grid. In the order, the Department required that the EDCs file a grid modernization plan on or before July 1, 2021. In accordance with this order, the EDCs filed grid modernization plans for a 4-year period spanning 2022-2025 (hereby referred to as Term 2).[15] In these plans, the EDCs outlined continued investment in the areas that received investment during Term 1 (referred to as Track 1 Investment Areas), and investment in new Investment Areas (Track 2 Investment Areas).

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[11] Eversource's request for an extension of the budget authorization was docketed as D.P.U. 20-74.

[12] D.P.U. 20-74 (2021).

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

[14] Investigation by the Department of Public Utilities on its own Motion into the Modernization of the Electric Grid – Phase Two, D.P.U. 20-69 (2020).

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

Table 6 summarizes the Department pre-authorized Term 2 GMP investment areas, which includes Track 1 and Track 2 investments, and EDC-reported Department objectives that are addressed by each of the investment areas. Table 7 provides more detail on the new Track 2 grid modernization investments excluding Advanced Metering Infrastructure (AMI).[16]

Table 6. Overview of Term 2 Investment Areas

Investment Area	Term	Description	Department Objectives		
			Optimize System Performance	Optimize System Demand	Integrate DER
Advanced Distribution Automation (ADA)	1 2	National Grid-only investment for Term 2. ADA allows for isolation of outage events with automated restoration of unaffected circuit segments	✓		
Advanced Distribution Management Systems (ADMS)	1 2	New capabilities in real-time system control with investments in developing accurate system models and enhancing Supervisory Control and Data Acquisition (SCADA) and outage management systems (OMS) to control devices for system optimization and provide support for distribution automation and VVO with high penetration of DER.	✓	✓	✓
Advanced Load Flow (ALF)	1 2	Eversource-only investment for Term 2 to integrate, into a single software, both their existing Distributed Generation (DG) tools and customer interconnection portal. Eversource also plans to use a simulation of locational load and generation based on variables such as customer behavior and energy market prices.	✓	✓	✓
Communications/IoT (Comms)	1 2	Fiber middle-mile, field area communications systems and IT	✓	✓	✓

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[16] AMI is not included in the scope of evaluation, as there are no Performance Metrics tied to the deployment of AMI during the 2022-2025 GMP Term, and progress of the AMI deployment is projected to be limited during the course of the term.

Investment Area	Term	Description	Department Objectives		
			Optimize System Performance	Optimize System Demand	Integrate DER
Distributed Energy Resources Management System (DERMS)	2	Software that forms the hub of DER management functions and integrates with other applications such as a Demand Response Management System ("DRMS") and ADMS, to create the DERMS Platform. Includes two demonstration projects proposed by National Grid to test new tools, and plans for Unitil to install ground-fault overvoltage protection and make voltage regulator and load tap chamber upgrades (DER Mitigation).	✓	✓	✓
Monitoring and Control (M&C)	1 2	Remote monitoring and control of devices in the substation for circuit monitoring or online devices for enhanced visibility outside the substation	✓		✓
Volt/VAR Optimization (VVO)	1 2	Control of line and substation equipment to optimize voltage, reduce energy consumption, and increase hosting capacity	✓	✓	✓
Workforce Management (WFM)	1 2	Unitil-only investment for Term 2 to improve workforce and asset utilization related to outage management and storm response	✓		

Source: Grid Mod RFP – SOW (Final 8-8-18).pdf; 2022-2025 EDC Grid Modernization Plans; Guidehouse

Table 7. Overview of Term 2, Track 2 Investments

Investment	Investment Area	EDC	Description
Interconnection Automation	ALF	Eversource	Eversource-only investment for Term 2 to integrate, into a single software, both their existing Distributed Generation (DG) tools and customer interconnection portal.

Investment	Investment Area	EDC	Description
Probabilistic Power Flow Modeling	**ALF**	**Eversource**	Eversource-only investment that can provide simulation of locational load and generation based on variables such as customer behavior and energy market prices.
Distributed Energy Resources Management System	**DERMS**	**All EDCs**	Software that forms the hub of DER management functions and integrates with other applications such as a Demand Response Management System ("DRMS") and ADMS, to create the DERMS Platform.
Dynamic DER Interface	**DERMS**	**Eversource**	This investment will upgrade the existing communication and control capability at Eversource and customer-owned large inverter-based DER facilities. These enhancements will enable the DER assets to be commissioned and integrated into the Company's eECS/ADMS/DERMS control platform to provide real-time monitoring and control capabilities to system operators in support of VVO and other optimization algorithms.
Advanced Short-Term Load Forecasting	**DERMS**	**National Grid**	Improve granular short-term forecasting capabilities to address substation and circuit constraints.
Active Resource Integration	**DERMS**	**National Grid**	Field test a new flexible interconnection option that could enable the Company to accelerate DG interconnections and increase the energy production of DGs per unit of system capacity.
Local Export Power Control	**DERMS**	**National Grid**	Explore the net zero thermal impact capabilities of customer owned Power Control Systems as a tool to lower interconnection costs and expedite interconnection timelines by reducing the need for distribution impact studies for such DER facilities.
DER Mitigation	**DERMS**	**Unitil**	Implement overvoltage protection improvements on the 69 kV side of several distribution substations to mitigate the risk of ground-fault overvoltages. The implementations include modifications to substation and sub-transmission line surge protection, and the addition of voltage transformers and overvoltage relaying schemes where necessary.

Source: 2022-2025 EDC Grid Modernization Plans.

The Department issued an order approving a preauthorized budget for Track 1 investments on October 7, 2022 and an order approving a preauthorized budget for Track 2 investments on November 30, 2022, [17] in D.P.U. 21-80/21-81/21-82. The preauthorized budget for grid modernization varies by Investment Area and EDC. National Grid has the largest preauthorized budget at $331.8 million, with Communications and VVO representing the largest share ($103 million and $76 million, respectively). Eversource's preauthorized budget is $197.4 million, with

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

M&C representing about 50% ($76.3 million). Unitil's preauthorized track one budget is $10.3 million with VVO making up more than 50% ($5.4 million).

Table 8. Term 2 (2022-2025) Preauthorized Budget, $M

Investment Areas	Eversource	National Grid	Unitil	Total
ADA	--	$37.70	--	**$37.70**
ADMS*	$21.90	$61.00	$1.50	**$84.40**
ALF	$5.00	-	-	**$5.00**
Comms	$38.00	$102.80	$0.82	**$141.62**
DERMS	$16.00	$31.00	$1.20	**$48.20**
M&C	$76.30	$4.10	$1.10	**$81.50**
VVO	$40.40	$76.40	$5.40	**$122.20**
WFM	--	--	$0.25	**$0.25**
IT/OT	--	$18.80	--	**$18.80**
Total	*$197.60*	*$331.80*	*$10.27*	*$539.67*

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

Note: The Term 2 preauthorized budget presented excludes Program Management and M&V dollars that were preapproved for each of the three EDCs.

Source: Department Order on Previously Deployed Technologies, D.P.U. 21-80/21-81/21-82 (2022), and Department Order on New Technologies, D.P.U. 21-80/21-81/21-82 (2022).

1.1.3 Evaluation Goals and Objectives

The Department requires a formal evaluation process (including an evaluation plan and evaluation studies) for the EDCs' preauthorized GMP investments. Guidehouse is completing the evaluation to enable a uniform statewide approach and to facilitate coordination and comparability.

The evaluation measures the progress made toward the achievement of Department's grid modernization objectives. It uses the Department-established Performance Metrics, as well as Case Studies that illustrate the performance of specific technology deployments, to help determine if the investments are meeting the Department's GMP objectives.[18]

1.1.4 Metrics for Evaluation

The Department-required evaluation involves Performance Metrics and Case Studies of grid modernizing investments. Case studies apply exclusively to the ADA and M&C investment areas as part of the evaluation to help facilitate understanding of how the technology performs in specific instances (e.g., in remediating the effects of a line outage).

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[18] The evaluation of GMP investments no longer includes analysis of Infrastructure Metrics (IMs) per the Order, Hearing Officer Memorandum, D.P.U. 21-80/21-81/21-82 (2023).

1.1.4.1 Performance Metrics

The Performance Metrics assess the performance of all the GMP investments. Table 9 summarizes the Performance Metrics used for the various Investment Areas. This report discusses Performance Metrics that pertain specifically to the ADA Investment Area.

Table 9. Performance Metrics Overview

Metric		Description	Applicable IA	Metric Responsibility*
PM-1	VVO Baseline	Establishes a baseline impact factor for each VVO-enabled circuit which will be used to quantify the peak load, energy savings, and greenhouse gas (GHG) impact measures.	VVO	All
PM-2	VVO Energy Savings	Quantifies the energy savings achieved by VVO using the baseline established for the circuit against the annual circuit load with the intent of optimizing system performance.	VVO	All
PM-3	VVO Peak Load Impact	Quantifies the peak demand impact VVO/CVR has on the system with the intent of optimizing system demand.	VVO	All
PM-4	VVO Distribution Losses without Advanced Metering Functionality (Baseline)	Quantifies the improvement that VVO/CVR is providing toward minimizing distribution line losses.	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 Circuits and Substations with DMS Power Flow and Control Capabilities	Examines the deployment and data cleanup associated with deployment of ADMS, primarily by counting and tracking the number of circuits and substations per year.	ADMS/ ALF	All

Metric		Description	Applicable IA	Metric Responsibility*
PM-9	Control Functions Implemented by Circuit	Examines the control functions of DMS power flow and control capabilities, focused on the control capabilities including VVO-CVR and FLISR.	ADMS/ ALF	All
PM-10	Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Shows the progress of ADA investments by tracking the number of customers that have benefitted from the installation of ADA devices.	ADA	NG
PM-ES-1	Advanced Load Flow – Percent Milestone Completion	Examines the fully developed ALF capability across Eversource's circuit population.	ADMS/ ALF	ES
PM-UTL1	Customer Minutes of Outage Saved per Circuit	Tracks time savings from faster AMI outage notification than customer outage call, leading to faster outage response and reduced customer minutes of interruption.	M&C	UTL
PM-NG-1	Main Line Customer Minutes of Interruption Saved	Measures the impact of ADA investments on the customer minutes of interruption (CMI) for main line interruptions. Compares the CMI of GMP ADA-enabled circuits to the previous 3-year average for the same circuit.	ADA	NG

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

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

Source: Stamp Approved Performance Metrics outlined in D.P.U. 21-80/21-81/21-82, (2024).

1.1.4.2 Case Studies

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

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

1.2 ADA Investment Area Overview

ADA investments will enable a greater level of distribution grid automation and are expected to result in improved electric system reliability, with investments able to quickly respond to outages and minimize customer interruption during outages. Eversource and National Grid both invested in ADA during Term 1, and only National Grid is continuing investment in ADA in Term 2. Unitil does not have preauthorized ADA investments in its GMP. As such, National Grid is the only EDC that is included in the Performance Metrics and case study analyses.

Table 10 summarizes the preauthorized budget for the ADA investment area for Term 1 and Term 2.

Table 10. GMP Preauthorized Budget for ADA, $M

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

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

The following subsection discusses National Grid's approach to ADA.

1.2.1 National Grid 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.

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

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

1.2.1.1 National Grid Overview of GMP Deployment Plan

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

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

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

Figure 1 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 1. 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.

Guidehouse

National Grid has integrated lessons learned from the ADA demonstration pilot in its Worcester Smart Energy Solutions Pilot into the 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 lost communications to the field device, devices would continue to operate without control room knowledge or interaction. Switches changing position without control knowledge was determined not to be the best approach going forward.

After deliberating with several vendors, National Grid adopted a centralized ADA model instead. A centralized ADA model brings field device data back through the communications network, performs centralized decision-making and issues the commands to reclosers.

Table 11 summarizes these GMP ADA devices and technologies. Sections 3 (Performance Metrics) and 4 (Case Studies) below discuss specifics related to each EDC's goals and objectives in the ADA Investment Area, while Section 2 below explains the evaluation process.

Table 11. National Grid Devices and Technologies Deployed Under ADA Investment

Device/ Investment Type	Description	Term
New Overhead Recloser Locations	New SCADA-enabled overhead recloser installations at new locations to increase auto-sectionalizing capability and reduce customer zone size.	1 2
New Overhead Recloser Locations with Ties	New SCADA-enabled overhead recloser installations at new locations with ties to adjacent feeders, to add power supply redundancy and increase switching options.	1 2
Feeder Monitors	Installation of interval power monitoring devices on feeders to aid in fault location where National Grid does not have distribution information.	1 2

Source: Guidehouse

1.3 ADA Evaluation Objectives

National Grid ADA projects are expected to reduce the number of customer outages and customer minutes of interruption. The evaluation will focus on the ADA investments' impact on "Reducing the Effects of Outages" as part of the Department's grid modernization objective[19] "(1) optimize system performance (by attaining optimal levels of grid visibility, command and control)." Table 12 illustrates the key metrics relevant for the ADA evaluation.

Table 12. ADA Evaluation Metrics

Metric	ADA Evaluation Metrics
PM-10	Number of customers that benefit from GMP-funded Distribution Automation devices
PM-NG-1	Main line customer minutes of interruption saved

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[19] D.P.U. 15-120/15-121/15-122, at 106 (2018). The Department's grid modernization objectives include "(1) optimize system performance by attaining optimal levels of grid visibility, command and control, and self healing; (2) optimize system demand by facilitating consumer price-responsiveness; and (3) interconnect and integrate distributed energy resources." Id.

Metric	ADA Evaluation Metrics
Case Study**	Case studies to illustrate how reliability is being improved, investigating: • ADA performance during blue sky days • ADA performance during excludable major events days • ADA performance during missed or undesirable operations • ADA performance on worst-performing circuits

PM – performance metric

* Denotes that generating the metric is EDC responsibility

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

Source: Guidehouse Stage 3 Evaluation Plan filed February 7, 2024;

The EDCs provided the data supporting the Performance Metrics as well as for case studies to the evaluation team. The Performance Metrics analyses provide insight into the reliability impacts of grid modernization investments. The Case Studies facilitate understanding of the reliability improvement mechanisms and performance at select feeder locations. Table 13 summarizes the ADA evaluation objectives and associated research questions.

Table 13. ADA Evaluation Research Questions

Evaluation Research Questions
1. How many customers, circuits, and substations are currently benefiting from GMP ADA investments?
2. How has reliability (measured in customer minutes of interruption) improved for GMP ADA circuits since the 2015-2017 baseline period?
3. What is the effect of ADA investments on reliability for the following cases?   a. Blue sky[20]   b. Excludable major events (EME)   c. Missed or undesirable operations   d. Worst-performing circuits[21]
4. Is the ADA equipment operating as designed for the following cases?   a. Blue sky   b. Excludable major events (EME)   c. Missed or undesirable operations   d. Worst-performing circuits

*Source: Guidehouse Stage 3 Evaluation Plan filed February 7, 2024; Guidehouse*

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[20] Blue sky refers to those days where no storms or severe weather conditions that impact system reliability above a reliability threshold occur (i.e., less than 10,000 customers out of service).

[21] Worst-performing circuits is a term that refers to an electric utility's distribution 10 worst-ranked reliability circuits.

2. ADA Evaluation Process

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

Figure 2. Term 1 Evaluation Timeline
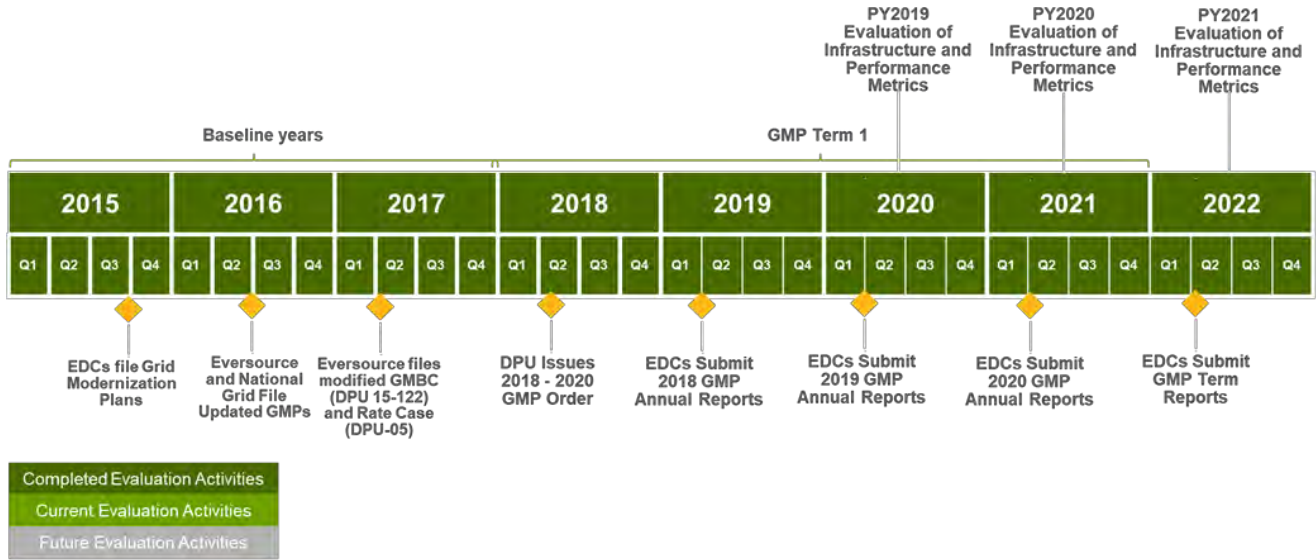
Source: Guidehouse review of the DPU orders and GMP process

Figure 3. Term 2 Evaluation Timeline
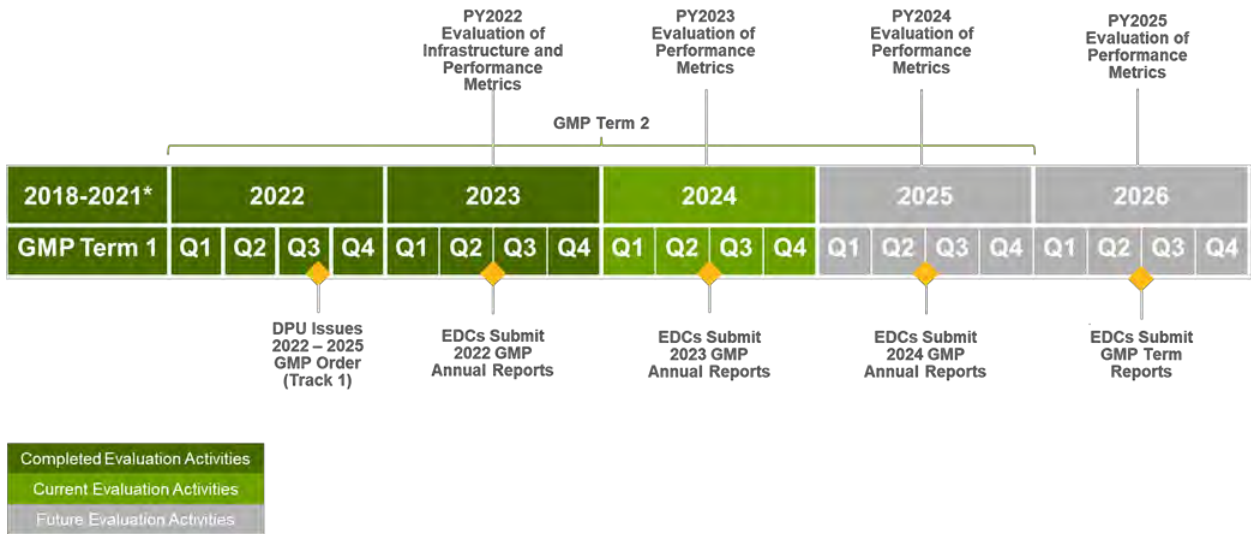
Source: Guidehouse review of the DPU orders and GMP process

2.1 Performance Metrics Analysis

Performance Metrics were evaluated for National Grid for PY 2023. Table 14 describes the Performance Metrics used in the PY 2023 evaluation.

Table 14. ADA Performance Metrics Overview

Performance Metrics		EDC	Description
PM-10	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-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 outlined in D.P.U 21-80/21-81/21-82, (Feb. 1, 2024)*

2.2 Case Study Analysis

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

For the case study analysis, in accordance with the Department Memorandum on Performance Metrics and Reporting[22] directive to increase the number of case studies included in evaluation, Guidehouse has targeted completing eight case studies per year for PY 2023, PY 2024, and PY 2025. All case studies will be conducted for National Grid, as Eversource is no longer considering ADA in its Term 2 GMP. The final number of cases that are ultimately included in the analysis will depend on grid conditions observed during the program year.

Case study information provided to Guidehouse was for all applicable ADA operations by National Grid. In its November 9 memorandum, the Department directed that evaluation consider case studies that include excludable major events, distributed generation backflow instances, or power surge instances, and whether and how the grid-facing investments helped restoration in these instances. The Department also directed that evaluation consider case

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[22] The Department Memorandum on Performance Metrics and Reporting was filed November 9, 2023 under Department dockets D.P.U. 21-80, 21-81, and 21-82.

studies for the worst-performing circuits, and whether grid-facing investments were utilized to improve performance. As such, during the review of all data, Guidehouse conducted a final selection of cases that appropriately represented ADA performance and considered each of the requested investigation areas.

After reviewing all data received, Guidehouse selected nine case studies for inclusion in this PY 2023 evaluation. Section 2.2.1 summarizes the selection approach that led to inclusion of the case studies profiled in this evaluation.

2.2.1 Case Study Selection Approach

The ADA investments are expected to reduce the number of customer outages and customer minutes of interruption. As such, the case studies focused on the ADA investments' impact on "Reducing the Effects of Outages" as part of the Department's grid modernization objective[23] "(1) optimize system performance (by attaining optimal levels of grid visibility, command and control)." In order to select ADA case studies for analysis, Guidehouse used the following evaluation questions to inform prioritization of events for further analysis:

- Did ADA operate in a correct and desirable manner?

- What was the impact of the ADA investment on customers?

Using these guiding questions, Guidehouse followed a four-step process to select and evaluate ADA case studies for National Grid.

1. Guidehouse first requested all 2023 OMS outage data from National Grid.
   - National Grid provided 2023 feeder events that included relevant outage data (e.g., outage date, feeder impacted, number of customers impacted, event description).

   - National Grid provided FLISR event summary and mis-operation writeups. These writeups supplemented the OMS outage data as it included information such as restoration steps and times, FLISR scheme that operated, and number of customers that were restored through FLISR and/or manual switching.

2. Guidehouse filtered the 2023 OMS dataset for outages that had the text 'FLISR' in the event description field, which reduced the feeder event list to 39 unique event IDs that occurred after FLISR was commissioned.
   - Out of the 39 events, eight occurred during major event days (MEDs) and 31 occurred during blue sky days.

3. Guidehouse then individually narrowed down the potential MED and blue sky case studies.
   - Out of the eight potential MED case studies candidates:

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[23] D.P.U. 15-120/15-121/15-122, at 106 (2018). The Department's grid modernization objectives include "(1) optimize system performance by attaining optimal levels of grid visibility, command and control, and self healing; (2) optimize system demand by facilitating consumer price-responsiveness; and (3) interconnect and integrate distributed energy resources." Id.

- o One candidate was excluded due to complexity of substations and circuits involved in a transmission outage;

- o One candidate was excluded due to customer count data discrepancies between the OMS and National Grid FLISR databases that were not resolved in time to evaluate the study;

- o One candidate was excluded due to FLISR operating correctly but no customers restored given that the adjacent feeder had lost power around the same time during this major storm event; and

- o One candidate was excluded due to limited availability of event context/description.

- This process resulted in four MED case studies selected for evaluation.

- Out of the 31 potential blue sky case studies candidates:

  - o Four candidates were identified as mis-operations or undesirable FLISR operations, of which three were studies that Guidehouse had recommendations for National Grid and were selected for evaluation.

  - o Three candidates were events on worst-performing circuits (WPC). One of these candidates was an event where the fault did not occur on a WPC, but rather the WPC picked up another circuit, and was thus excluded from evaluation.

  - o This process resulted in five total blue sky case studies selected for analysis (three mis-operations case studies and two WPC case studies).

After narrowing down the candidate case studies, Guidehouse drafted nine total ADA case studies for National Grid's evaluation. These nine case studies are presented in Section 4.2.

3. ADA Performance Metrics

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

3.1 Data Management

This section discusses the data sources used for the PM evaluation and summarizes the QA/QC steps, and selection of circuits used in the PY 2023 analysis.

3.1.1 Data Sources

2023 Grid Modernization Plan Annual Report Appendix 1: On May 13, 2024, National Grid submitted its draft Appendix 1 document. The Appendix 1 document contains feeder-level data for all feeders within each EDC's territory, and all PM-related data presented below are from the document. This document contains baseline and program year data for all circuits for National Grid. Key baseline and program year data from the Appendix 1 document that were utilized in this analysis include:

- Customer Counts
- Number of Customers that Benefit from GMP Investments
- Main Line Customer Minutes of Interruption

3.1.2 Data QA/QC Process

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

- Comparison of PY 2022 Appendix 1[24] and PY 2023 Appendix 1 documents to ensure baseline data entries match.

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

- Comparison of circuit lists between baseline and PY 2023 to identify circuits that did not serve any customers in either the baseline period (2015-2017) or PY 2023.

The QA/QC process revealed no large discrepancies in baseline values provided in the PY 2022 and PY 2023 Appendix 1 documents. In addition, there were 259 circuits affected by decommissioning and/or reconfigurations between the baseline (2015-2017) and program year (2023). These circuits were excluded from the analysis to avoid over- or understating changes in customer minutes of interruption between the baseline period and PY 2023.

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

3.1.3 Circuit Selection

Guidehouse provides findings for all circuits (systemwide) and for circuits that received ADA investments by the end of 2023. To provide results for the stamp-approved metrics as currently defined, Guidehouse provides findings for circuits with ADA devices installed during 2018 through 2022 as well as the whole of 2023.

The evaluation team identified several circuits for National Grid that had been reconfigured, split, or decommissioned between the baseline and program year. As a result of these changes, a comparison of CMI was either not possible or deemed to be potentially misleading and these circuits were excluded from the analysis. Similar measures were taken to ensure that other performance metrics were calculated using a consistent circuit list between the baseline and the program year.[25] In addition, the evaluation team removed circuits that did not serve customers, and also removed circuits that did not have data in the baseline period or PY 2023. Ultimately a larger percentage of ADA circuits were removed from the analysis as compared to system-wide circuits.

National Grid commissioned ADA devices in PY 2020 through PY 2023. Table 15 shows circuits with ADA devices commissioned through PY 2023. Of the 83 circuits that received ADA devices through the end of PY 2023, 54 (65%) were retained for use in analysis of CMI. System-wide, 801 (70%) of the 1,146 circuits were retained for use in analysis of CMI.

Table 15. National Grid Circuits Included in Analysis

National Grid Circuits	System-Wide	ADA Commissioned Through PY 2023
Total Circuit Count	1,146	83
Circuits for Mainline Customer Minutes of Interruption Saved		
Circuits Included in Analysis	801	54
% of Total Circuits Included In Analysis	70%	65%

Note: Circuits included in analysis do not include circuits that are networked, spare, reconfigured, split, decommissioned, served zero customers, or circuits that do not have reliability data available during the baseline period or program year.
Source: Guidehouse analysis of National Grid Appendix 1 documents for PY 2022 and PY 2023

3.2 ADA Performance Metrics Analysis and Findings

Evaluation of the performance metrics 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.

Table 16 provides a high-level summary of the results for each performance metric.

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[25] A comparison of system wide baselines between this report and the PY 2022 PM Evaluation Report shows differences in the baseline circuit list, which is expected given changing customer counts and changes in circuit configurations.

Table 16. Summary of Findings for ADA Investment Area

PM	National Grid
PM-10: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Over 177,000 (13%) National Grid customers benefitted from ADA devices. This is a 5 percentage-point increase from PY 2022, where Guidehouse identified over 113,000 (8%) of National Grid customers benefiting from ADA devices.
PM-NG1: Main Line Customer Minutes of Interruption Saved	Main-line CMI for circuits with ADA decreased (improved) 46% in PY 2023 from baseline. This is a 12 percentage-point increase from PY 2022, where Guidehouse identified a 35% improvement in CMI from baseline. *

* Note: This metric is not able to readily discern whether change in this metric was due to ADA investment or other factors.
Source: Guidehouse analysis of National Grid Appendix 1 documents for PY 2022 and PY 2023

Table 17 summarizes the number of feeders and customers covered by GMP ADA investments spanning 2018 through 2023. Across National Grid's service territory in Massachusetts, ADA investments have impacted about 13% of total EDC customers and 7% of feeders.

Table 17. Number of Massachusetts Feeders and Customers Covered by ADA Investment

ADA Impact	National Grid	
	Feeders	**Customers**
Systemwide Total	1,146	1,343,163
2018-2023 Commissioned	83	177,554
% System Total	7%	13%

Source: Guidehouse analysis of National Grid PY 2023 Appendix 1 document

3.2.1 PM-10: 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 clarity and consistency. A specific example and explanation are provided below:

Figure 4. Example One-Line Diagram of Grid Modernization Devices
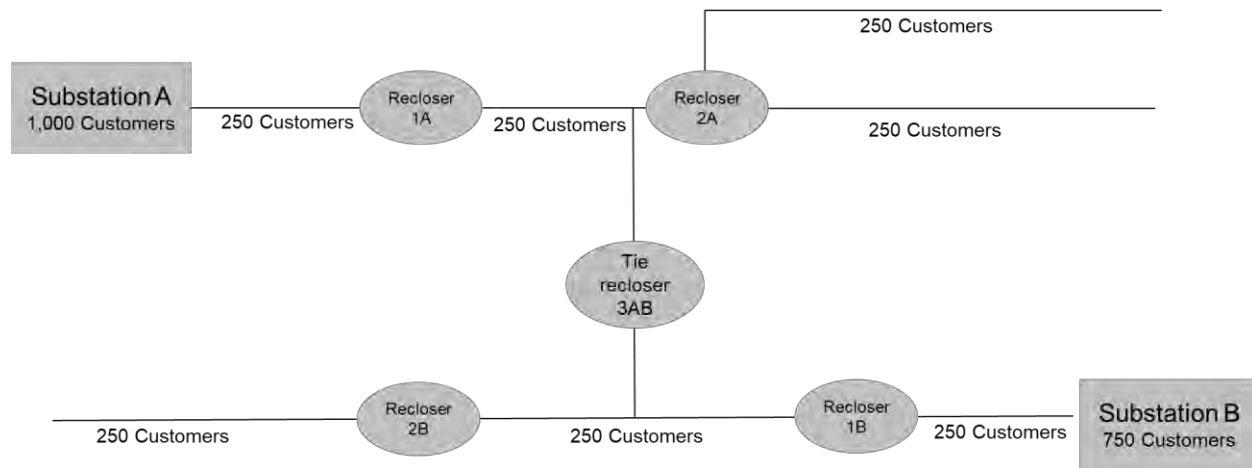
Source: Guidehouse and EDCs

Broadly speaking, all customers within the zone in which a recloser is placed benefit from the device. In Figure 4, if Recloser 1A was installed in 2023 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 4, if Tie Recloser 3AB was installed in 2023 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 circuit-specific count of customers benefiting from ADA investments was calculated by National Grid, as detailed data is required to calculate this metric for each circuit with ADA devices commissioned in PY 2023 or prior. Guidehouse then calculated the total number of circuits, average number of customers benefiting per circuit, and total number of customers benefiting from ADA devices using provided circuit-level data. All circuits with ADA devices installed any time in 2023 or prior were "eligible" to be included in the evaluation of this metric.

3.2.1.1 Metric Results

The number of customers that benefit from ADA devices is reported in Appendix 1 of National Grid's GMP Annual Report. The number of customers that benefit is non-zero only for circuits that had sectionalizing devices installed. Through PY 2023, these devices were installed on 54 National Grid circuits. Table 18 shows the average number of customers that benefitted as well as the total across all 54 circuits. As of the end of PY 2023, 177,554 National Grid customers (13% of total customers) benefitted from ADA devices.

Table 18. Number of National Grid Customers that Benefitted from GMP ADA Devices

Summary Statistics	
Total Circuits with DA Installed	54
Average Number of Customers Benefiting per circuit	2,139
Total Number of Customers Benefiting from DA Devices	177,554
Percent of Total Customers that Benefit from DA Devices	13%

Source: Guidehouse analysis of National Grid PY 2023 Appendix 1 document

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

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

- Historical customer minutes of interruption for mainline interruptions
- Calendar year customer minutes of interruption for mainline interruptions

The evaluation of this National Grid-specific metric includes only circuits where ADA was commissioned in 2018 through 2023. The baseline is defined as the average of 2015, 2016 and 2017. Main-line CMI should decrease over time with increased deployment of ADA, indicating increased reliability.

Table 19 shows the baseline (2015-17) and PY 2023 average main-line CMI for system-wide and ADA circuits for National Grid. In the baseline period, ADA circuits had almost double the average CMI compared to system-wide circuits, suggesting that ADA investments were targeted towards circuits with high CMI. In PY 2023, ADA and system-wide circuits had more similar CMI, which indicates that ADA investments may have been effective in reducing CMI.

ADA circuits show a 53% improvement in CMI in 2023 from the baseline, in contrast to system-wide circuits whose CMI improved by only 7% in 2023 from baseline. Moreover, the standard deviation increased for system-wide circuits but decreased for ADA circuits between the baseline period and PY 2023. The standard deviation is the same order of magnitude as the average CMI, indicating that the change in CMI is not likely simply statistical noise but an actual improvement in reliability. The difference-in-differences (percentage ADA improvement minus percentage systemwide improvement) indicates a 46% improvement in CMI that can be attributed to ADA.

Table 19. Baseline and PY 2023 Average Main-Line Customer Minutes of Interruption (CMI) for National Grid

| ADA	Average Customer Minutes of Interruption (2015-2017)		Customer Minutes of Interruption 2023	
	System-Wide Circuit	ADA Circuit	System-Wide Circuit	ADA Circuit
Statistics				
Total Circuits	801	54	801	54
% Circuits with Zero CMI	25%	11%	51%	46%
Average CMI	75,608	110,251	70,331	51,973
Change from Baseline			5,277	58,278
% Change from Baseline			7%	53%
Std. Dev.	132,331	179,127	206,532	110,172
CMI Range	**No. of Circuits in Range**			
0	202	6	407	25
0 - 10000	123	12	74	6
10000 - 20000	62	5	38	3
20000 - 30000	43	2	28	3
30000 - 40000	33	6	18	3
40000 - 50000	39	2	20	1
50000 - 60000	21	0	11	0
60000 - 70000	19	1	5	1
70000 - 80000	21	0	9	1
80000 - 90000	15	3	14	2
90000 - 100000	13	1	15	3
100000 - 110000	16	1	5	0
> 110000	180	15	140	6

Note: Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of National Grid PY 2023 Appendix 1 document

Before and after comparison: A simple graphical summary of the statistical change in main-line CMI is shown in Figure 5 below, which uses the "box-and-whisker" format.[26] This chart compares the difference in CMI between baseline and PY 2023 for each circuit, for both the system-wide and the selected ADA circuits. The change shown below is calculated per the Department stamp-approved formula of Baseline CMI – Program Year CMI, so a positive change indicates improved performance in the Program Year relative to baseline.

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

Figure 5. National Grid Statistical Change in National Grid Main-Line CMI from Baseline
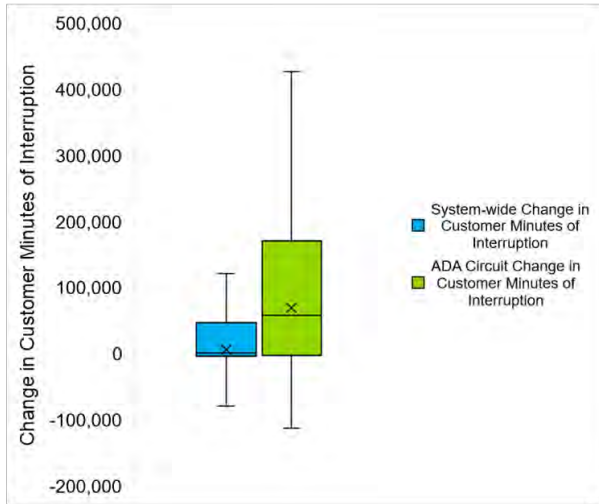
	Change in System-wide Circuits	Change in ADA Circuits
Count	801	54
% No Change	19%	2%
Average Change in CMI	5,317	68,161
Standard Deviation	205,032	179,482
Median Change in CMI	647	57,450

Note: Baseline is updated each year based on circuits included in analysis.
Source: Guidehouse analysis of 2023 GMP Annual Report Appendix 1

The average CMI for ADA circuits decreased by 68,161 minutes between the baseline years and PY 2023, which is greater than the system-wide average change in CMI of 5,317 minutes. The average change in CMI of ADA circuits was reduced by over 12 times the system-wide average, indicating that ADA investments had an impact in decreasing the main line customer minutes of interruption. The median change in ADA circuits was 57,450 minutes, compared to a smaller change in system-wide (647 minutes), also indicating that ADA investments had an impact in decreasing the main line customer minutes of interruption.

4. ADA Case Studies

This section features nine case studies performed for the ADA investment area for National Grid. The case studies highlight the operation and role of specific GMP investments in specific events. The case studies are intended to supplement the performance metrics evaluation by capturing nuances not apparent through aggregate reliability data. Guidehouse acknowledges stakeholder and EDC comments stating case studies be made less technical and more user-friendly.[27] In response, we have updated the case study format to include high level summaries and made them more accessible to a broader audience.

4.1 Data Sourcing and Management

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

- Outage Management System (OMS) records for circuits where GMP-funded ADA and/or M&C devices have been commissioned in the GMP period. OMS records show customer counts, fault locations, outage start/end times, devices operated, outage cause, weather conditions, and other vital information relevant to outages

- Written comments by dispatchers and crews elaborating on the cause of the outage and actions taken in response

- One-line circuit diagrams showing circuit configuration with the locations of GMP M&C and ADA devices

- Notifications, alerts and alarms received from SCADA-enabled devices related to device operations and circuit telemetry

- Follow-up conversations with EDCs to further understand the sequence of events, reconstruct the corrective actions taken and estimate benefit or time savings resulting from GMP investments

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

To fully reconstruct the restoration steps in each case study, Guidehouse studied OMS records and identified the fault location and device locations on circuit diagrams. Guidehouse then constructed a probable sequence of device operation and corroborated it with SCADA data and EDC follow-up questions, making reasonable assumptions where details were incomplete. For

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

simplicity, Guidehouse selected cases where GMP device operation was clearly distinguishable and not combined with external factors such as loss of transmission supply.

4.2 National Grid Case Studies

Based on the selection process in Section 2.2.1, Guidehouse developed the case studies (CS) presented in Table 20 to illustrate the effectiveness of the ADA investment in improving reliability. The case studies investigate the ADA performance during blue sky days, excludable major event days, missed or undesirable operations, and on worst-performing circuits if applicable.

Table 20. Selected PY 2023 ADA Case Studies

	Case Study	Blue Sky	Excludable Major Events	Missed or Undesirable Operations	Worst-Performing Circuits
CS1	ADA Investment Restores Power to Customers in Haverhill	✓			✓
CS2	ADA Investment Restores Power to Customers in Beverly	✓			✓
CS3	ADA Investment Prevents Outage to Customers in Boxford		✓		
CS4	ADA Investment Restores Power to Customers in Haverhill		✓		
CS5	ADA Investment Restores Power to Customers in Beverly		✓		
CS6	ADA Investment Programming Error Found and Corrected in Holbrook	✓		✓	
CS7	ADA Investment Restores Power to Customers in Beverly		✓		
CS8	ADA Automatic FLISR Operation Aborted in Malden	✓		✓	
CS9	ADA FLISR Operation Failed due to Installation Errors in Attleboro	✓		✓	

Source: Guidehouse analysis

4.2.1 CS1 – ADA Investment Restores Power to Customers in Haverhill
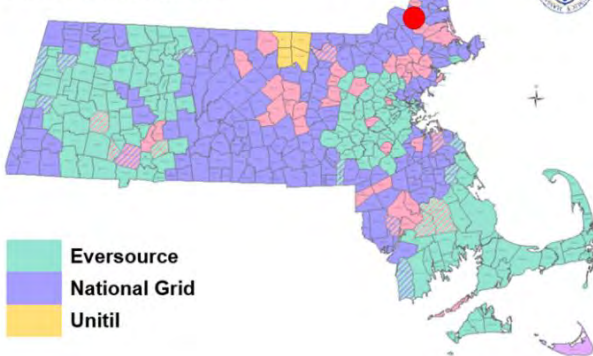
Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

Event Date Time

February 4, 2023, 6:07:22 am

Event Classification

Blue Sky; Worst-performing Circuit

Cause

Substation - Low Oil Level Transformer

Affected Feeders

14-76L1, 14-76L3

Number of Customers (and Time) Restored

FLISR : 671 (48 seconds)

Manual Switching 14-76L1: 592 (6 minutes), 1,111 (6 minutes), 141 (11 minutes)

Manual Switching 14-76L3: 65 (6 minutes), 64 (11 minutes)

4.2.1.1 Description

On February 4, 2023, extremely cold temperatures impacted the oil level in the Whitter Substation transformer causing the transformer to lock out (shut down), resulting in the loss of supply that affected 800 customers on feeder 14-76L3, and 1,844 customers on feeder 14-76L1.

A GMP-funded FLISR scheme automatically operated to restore power to 671 customers on feeder 14-76L3 in 48 seconds. The FLISR scheme accomplished this restoration by opening a GMP ADA recloser on the feeder and closing another GMP ADA "tie" switch connecting to an adjacent feeder, transferring customers from the affected feeder to the adjacent feeder.

National Grid performed remote and manual switching to restore remaining customers affected by the substation transformer outage. Without the FLISR scheme, all 2,644 customers would have experienced a sustained outage.

4.2.1.2 Outage Restoration Steps
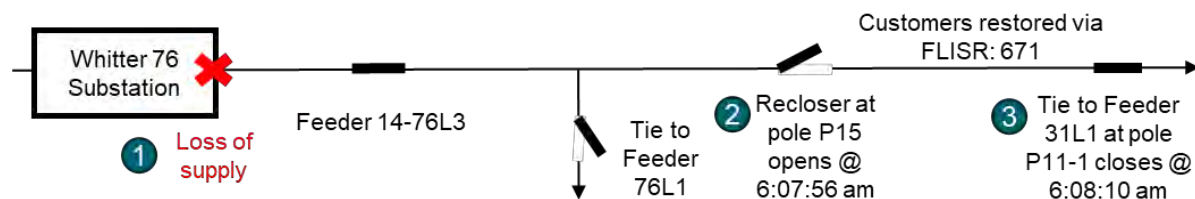
① On 2/4/2023 at 6:07:22 am, a transformer at Whitter Substation locks out due to low oil level from extremely cold weather. The initial 14-76L3 outage affected 800 customers.

② FLISR opened feeder 14-76L3 recloser due to the loss of voltage at 6:07:56 am.

③ FLISR closed tie recloser to adjacent feeder 31L1 at 6:08:10 automatically, restoring 671 customers in 48 seconds. 129 customers on feeder 14-76L3 were still affected.

National Grid then performed remote and manual switching to restore customers that remained out of service (i.e., 1,844 customers on feeder 14-76L1, 129 customers on feeder 14-76L3) due to the substation transformer lock out in 11 minutes or less.

4.2.1.3 Estimated Reduction in Customer Minutes of Interruption (CMI)

Customers on feeder 14-76L3 that were restored through FLISR experienced a 48-second outage which represents zero CMI. For the remaining customers on feeder 14-76L3 that were restored manually, 65 customers were restored in 6 minutes and 64 customers restored in 11 minutes, resulting in CMI of approximately 1,094.

Without GMP ADA, Guidehouse assumes that customers that were restored via FLISR would have experienced an estimated 30-minute outage. The estimate is based on troubleshooter travel time during a blue sky day and restoration via manual switching (remote switching not available). When comparing the manual switching restoration to ADA FLISR, the estimated reliability reduction in CMI on feeder 14-76L3 is 20,130 customer minutes (671 customers times 30 minutes). On this specific outage, the FLISR operation resulted in an approximate 95% improvement in CMI (20,130 divided by 21,224).

4.2.2 CS2 – ADA Investment Restores Power to Customers in Beverly

Electricity Providers by Municipality
Commonwealth of Massachusetts

Eversource
National Grid
Unitil
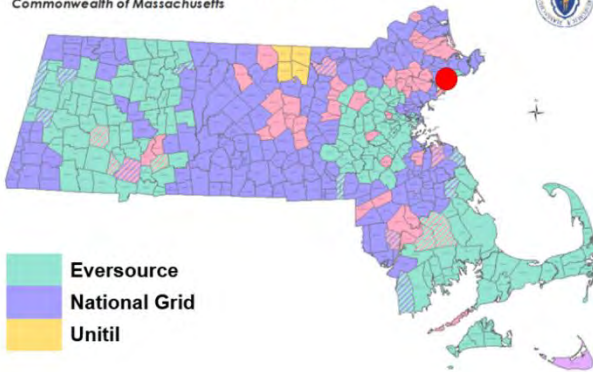
Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

Event Date Time

September 5, 2023, 8:04:01 pm

Event Classification

Blue Sky; Worst-performing Circuit

Cause

Unknown, Main Line Conductor Down

Affected Feeders

12-18L2

Number of Customers (and Time) Restored

FLISR : 912 (7 seconds)

Repairs & Manual Switching: 33 (5 hrs, 16 min), 563 (24 min), 135 (1 hr, 11 min)

4.2.2.1 Description

On September 5, 2023, a circuit breaker out of North Beverly Substation tripped and reclosed due to a down primary conductor (i.e., A Phase down) which affected 601 customers supplied from that phase.

FLISR opened a pole top recloser (PTR) on feeder 12-18L2 momentarily dropping 492 customers fed from B & C Phase and closed a PTR at a tie feeder location automatically restoring 912 customers in approximately seven seconds.

After the automatic FLISR operation was complete, National Grid performed manual switching to restore additional customers and isolate the area for repairs. Without the FLISR scheme, all 601 customers fed from A Phase would have experienced a sustained outage interruption.

4.2.2.2 Outage Restoration Steps
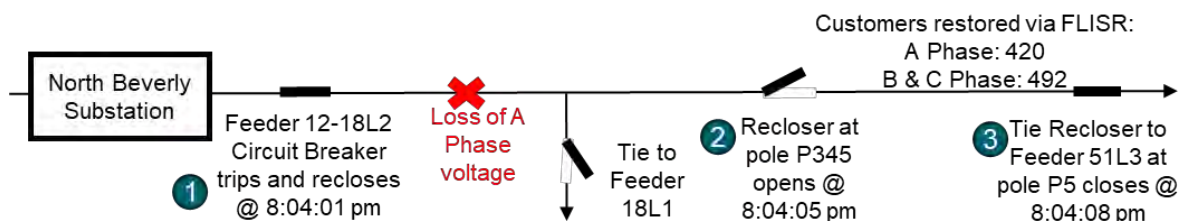
1. On 9/5/2023 at 8:04:01 pm, a feeder circuit breaker at North Beverly tripped and reclosed due to A Phase down. Initial outage affected ~601 customers fed from A Phase.

2. After four seconds, FLISR opened a PTR on feeder 12-18L2 due to the loss of voltage affecting the ~492 remaining customers fed from B & C Phase.

3. After three additional seconds, FLISR closed tie PTR to the adjacent feeder 51L3 automatically restoring 912 customers (420 customers on A Phase and 492 customers on B&C Phase).

Manual switching was then performed to repair and restore all customers that were still out of service.

4.2.2.3 Estimated Reduction in CMI

The customers on A Phase of Feeder 12-18L2 that were restored through FLISR, experienced a 7-second outage which represents zero CMI. For the remaining customers on A Phase, repairs and manual switching were performed to restore power, resulting in a CMI of approximately 33,556.

Without GMP ADA, Guidehouse assumes that customers restored via FLISR would have experienced an estimated 30-minute outage. This estimate is based on troubleshooter travel time during a blue sky day and restoration via manual switching (remote switching not available). When comparing the manual switching restoration to ADA FLISR, the estimated reliability reduction in CMI on feeder 12-18L2 is 12,600 customer minutes (420 customers on A Phase times 30 minutes). On this specific outage, the successful FLISR operation resulted in an approximate 27% improvement in CMI (12,600 divided by 46,156).

4.2.3 CS3 – ADA Investment Prevents Outage to Customers in Boxford

Electricity Providers by Municipality
Commonwealth of Massachusetts

Legend:
- Eversource
- National Grid
- Unitil
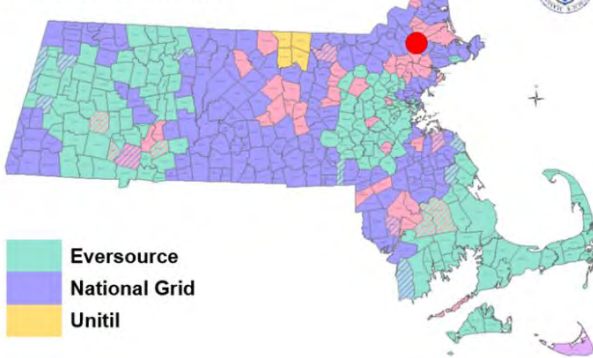
Event Date Time	September 8, 2023, 3:06:24 pm
Event Classification	Major Event Day – Major Storm
Cause	Lightning, Failed Conductor
Affected Feeders	14-56L3
Number of Customers (and Time) Restored	FLISR : 288 (36 seconds)
	Manual Switching not required

Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

4.2.3.1 Description

During a major storm event on September 8, 2023, lightning caused loss of C Phase voltage on feeder 14-56L3. The feeder circuit breaker opened and reclosed. FLISR successfully operated and transferred customers to an adjacent feeder resulting in no sustained outage. Based on this successful FLISR operation, 288 customers on C Phase experienced a momentary interruption of 36 seconds.

A National Grid crew patrolled and found a no load section of spacer cable phase burnt off between two poles. On September 10, 2023, manual switching was performed to de-energize the area, make repairs to the overhead wire, and restore the feeder to its normal configuration.

4.2.3.2 FLISR Scheme Steps
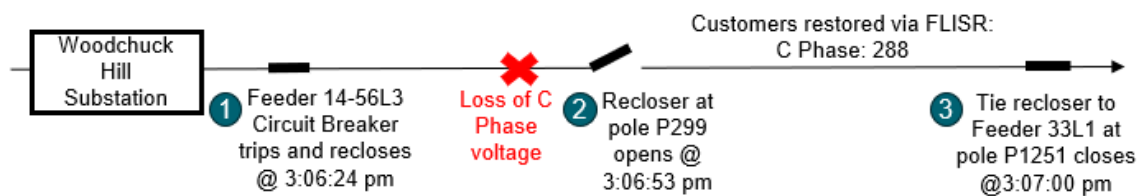
1. On 9/8/2023 at 3:06:24 pm, a feeder circuit breaker at Woodchuck Hill Substation operated and reclosed.

2. FLISR opened recloser on feeder 14-56L3 due to the loss of C Phase voltage at 3:06:53 pm.

3. FLISR closed tie recloser to the adjacent feeder 33L1 at 3:07:00 pm, automatically transferring 288 C Phase customers in 36 seconds.

On 9/10/2023, planned manual switching was performed to de-energize 175 customers for about 30 minutes and make repairs to burnt overhead wire.

### 4.2.3.3 Estimated Reduction in CMI

Due to the successful operation of FLISR, 288 customers experienced only a momentary interruption of 36 seconds.

Upon patrolling, National Grid found spacer cable burnt off between two poles. Repairs to overhead cable were performed on September 10, 2023, and it required National Grid to de-energize 175 customers for about 30 minutes.

Without GMP ADA, Guidehouse assumes that the 288 customers that were picked up by FLISR on September 8, 2023 would have experienced an estimated 90-minute outage. This estimate is based on troubleshooter travel time during major storm conditions, repairs, and manual switching (remote switching not available). When comparing the manual restoration to ADA FLISR, the estimated reliability reduction in CMI on feeder 14-56L3 is 25,920 customer minutes (288 customers times 90 minutes).

4.2.4 CS4 – ADA Investment Restores Power to Customers in Haverhill

Electricity Providers by Municipality
Commonwealth of Massachusetts

Eversource
National Grid
Unitil
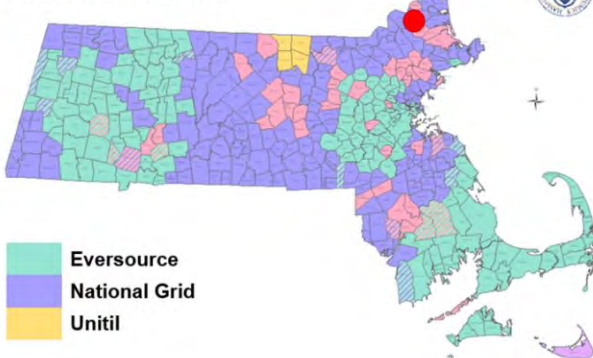
Event Date Time
September 12, 2023, 12:07:18 am

Event Classification
Major Event Day – Major Storm

Cause
Tree – broken limb on main line

Affected Feeders
14-76L1

Number of Customers (and Time) Restored

FLISR : 1,708 (41 seconds)

Manual Switching: 141 (2 hr, 33 min)

Source: Guidehouse (map from
https://www.mass.gov/doc/electricity-providers/download,
*Accessed May 31, 2024)*

4.2.4.1 Description

During a major storm event on September 12, 2023, a broken tree branch contacted primary wires causing feeder 14-76L1 circuit breaker to lock out. The initial outage affected 1,849 customers.

A GMP-funded FLISR scheme automatically operated to restore power to 1,708 customers in 41 seconds. The FLISR scheme accomplished this restoration by opening a GMP ADA recloser along a feeder and closing another GMP ADA "tie" recloser connecting to an adjacent feeder, effectively transferring customers from one feeder to an adjacent feeder.

National Grid made repairs and then closed feeder 14-76L1 circuit breaker to restore customers that remained out of service. When the circuit breaker was closed, there was a failed insulator arcing near the substation. National Grid then performed switching (e.g., opened circuit breaker and transferred customers to adjacent feeder 14-76L3) to restore power to 141 customers in approximately two hours and 33 minutes. Without the FLISR scheme, all 1,849 customers would have experienced a sustained outage.

4.2.4.2 Outage Restoration Steps
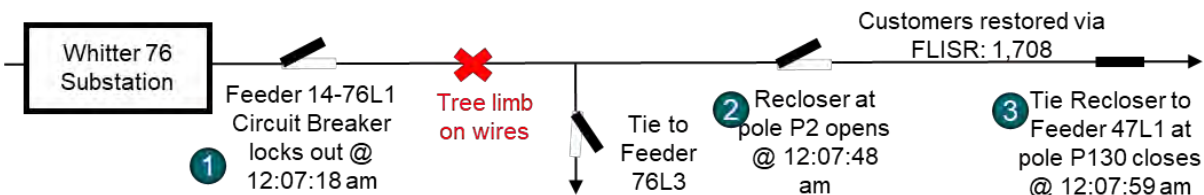
1. On 9/12/2023 at 12:07:18 am, a feeder circuit breaker at Whitter Substation locked out due to broken tree limbs on the main line. The initial outage affected 1,849 customers.

2. FLISR opened a recloser on feeder 14-76L1 due to the loss of voltage at 12:07:48 am.

3. FLISR closed the tie recloser to the adjacent feeder 47L1, automatically restoring 1,708 customers at 12:07:59 am. 141 remaining customers were still affected.

National Grid then made repairs at two damaged locations. First damaged location was to remove tree limbs and second damage location was to replace a bad insulator. Once repairs were completed, manual switching restored the remaining customers in approximately two hours and 33 minutes (153 minutes).

4.2.4.3 Estimated Reduction in CMI

Customers on feeder 14-76L1 that were restored through FLISR experienced a 41-second outage which represents zero CMI. For the outage event, National Grid reported a CMI of approximately 21,625 based on the sustained interruption that the remaining customers experienced while repairs and manual switching were performed.

Without GMP ADA, Guidehouse assumes that customers restored via FLISR would have experienced an estimated 153-minute outage. This estimate is based on troubleshooter travel time during a major event day, repairs, and manual switching (remote switching not available). When comparing the manual switching restoration to ADA FLISR, the estimated reliability reduction in CMI on feeder 14-76L1 is 261,324 customer minutes (1,708 customers times 153 minutes). On this specific outage, the successful FLISR operation resulted in an approximate 92% improvement in CMI (261,324 divided by 282,949).

4.2.5 CS5 – ADA Investment Restores Power to Customers in Beverly
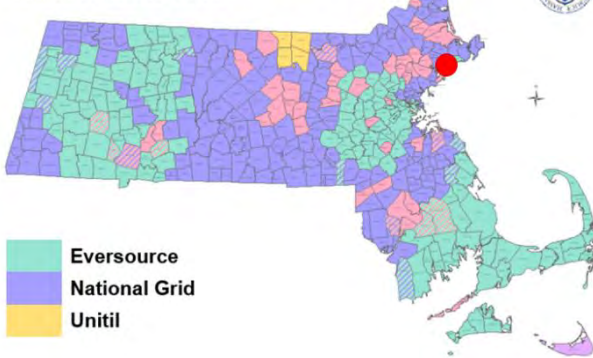
Event Date Time	September 16, 2023, 2:24:12 pm
Event Classification	Major Event Day – Major Storm
Cause	Tree – broken limb took conductors down
Affected Feeders	12-51L3
Number of Customers (and Time) Restored	FLISR : 1,098 (31 seconds)
	Manual Switching: 928 (3 hrs, 2 min)

Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

4.2.5.1 Description

During a major storm event on September 16, 2023, a tree limb took down primary conductors on feeder 12-51L3 fed by the East Beverly Substation. This caused the circuit breaker to lock out, affecting 2,026 customers.

A GMP-funded FLISR scheme automatically operated to restore power to 1,098 customers in 31 seconds. The FLISR scheme accomplished this restoration by opening a GMP ADA recloser along the feeder and closing another GMP ADA "tie" recloser connected to an adjacent feeder, effectively transferring customers from one feeder to an adjacent feeder.

After the automatic FLISR operation was complete, National Grid performed manual switching to isolate the area for repairs and restore power to the remaining 928 customers in three hours and two minutes. Without the FLISR scheme, all 2,026 customers would have experienced a sustained outage.

4.2.5.2 Outage Restoration Steps
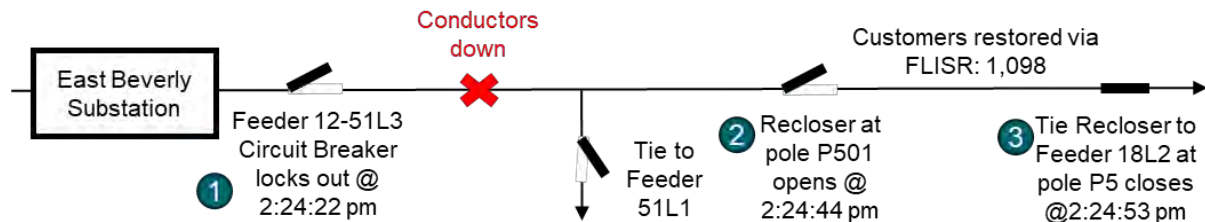
1   On 9/16/2023 at 2:24:22 pm, a feeder circuit breaker at East Beverly Substation locked out due to broken tree limbs. The initial outage affected 2,026 customers.

(2) FLISR opened a recloser on feeder 12-51L3 due to the loss of voltage at 2:24:44 pm.

(3) FLISR closed a tie recloser to adjacent feeder 18L2 automatically restoring 1,098 customers at 2:24:53 pm.

National Grid performed manual switching to isolate the area for repair and all customers were restored by 5:26 pm.
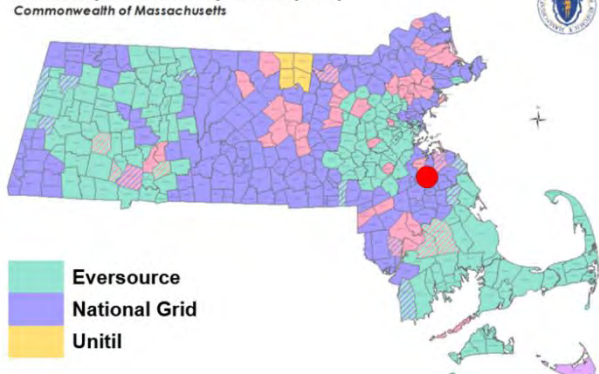
4.2.5.3 Estimated Reduction in CMI

Customers on feeder 12-51L3 that were restored through FLISR experienced a 31-second outage which represents zero CMI. For the remaining customers on feeder 12-51L3, manual switching was performed to restore 768 and 49 customers in 43 minutes and 50 minutes, respectively. An additional 111 customers were restored through repairs and manual switching in five hours and 16 minutes. This resulted in a CMI of approximately 70,550.

Without GMP ADA, Guidehouse assumes that customers that were restored via FLISR would have experienced an estimated 90-minute outage. This estimate is based on troubleshooter travel time during a major event day and restoration via manual switching (remote switching not available). When comparing the manual switching restoration to ADA FLISR, the estimated reliability reduction in CMI on feeder 12-51L3 is 98,820 customer minutes (1,098 customers times 90 minutes). On this specific outage, the FLISR operation resulted in an approximate 58% improvement in CMI (98,820 divided by 169,370).

4.2.6 CS6 – ADA Investment Programming Error Found and Corrected in Holbrook

Event Date Time
December 11, 2023
Event Classification
Blue Sky; Misoperation
Cause
Tree Broken Limb on Mainline; FLISR Configuration Error
Affected Feeders
07-2W2
Number of Customers (and Time) Restored
FLISR : N/A
Manual Restoration: 388 (2 hours, 21 minutes), 488 (2 hours, 26 minutes)

Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

4.2.6.1 Description

On December 11, 2023, a circuit breaker locked out due to a tree limb across conductors. FLISR isolated the damaged zone by opening a pole top recloser (PTR) but failed to close the tie PTR to restore customers.

At the time of the event, National Grid manually restored 876 customers after approximately two hours and 20 minutes.

4.2.6.2 National Grid Remediation

National Grid, upon further investigation found that there was a FLISR configuration error that caused the tie recloser to not receive the command to close. National Grid has since corrected this configuration error. This event happened three weeks after the FLISR scheme went into service on the feeder.

National Grid advised that they performed a follow-up which involved checking that other FLISR schemes do not have the same configuration error.

4.2.6.3 Recommendations

To maximize reliability savings from GMP ADA, Guidehouse recommends that National Grid verify that the quality control process used for FLISR configuration is appropriate. Without the configuration error, a portion of the 876 customers would have likely experienced an outage of less than a minute.

4.2.7 CS7 – ADA Investment Restores Power to Customers in Beverly

Electricity Providers by Municipality
Commonwealth of Massachusetts

Eversource
National Grid
Unitil
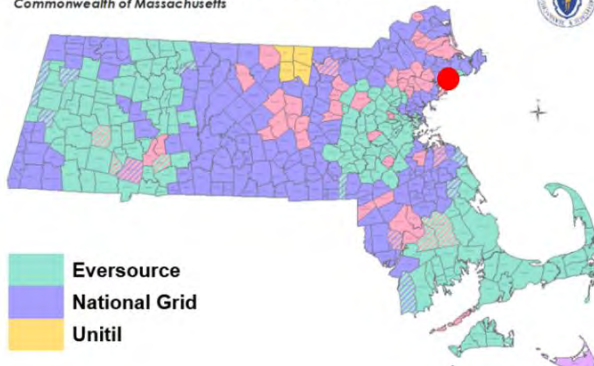
Event Date Time
December 18, 2023, 10:48:20 pm

Event Classification
Major Event Day – Major Storm

Cause
Tree – broken limb on wires

Affected Feeders
12-51L3

Number of Customers (and Time) Restored
FLISR : 1,026 (38 seconds)
Manual Switching: 887 (5 hrs, 35 min)

Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

4.2.7.1 Description

During a major storm event on December 18, 2023, tree branches contacted primary wires on feeder 12-51L3 fed by the East Beverly Substation. This caused the circuit breaker to lock out affecting 1,913 customers.

A GMP-funded FLISR scheme automatically operated to restore power to 1,026 customers in 38 seconds. The FLISR scheme accomplished this restoration by opening a GMP ADA recloser along a feeder and closing another GMP ADA "tie" recloser connecting to an adjacent feeder, effectively transferring customers from one feeder to an adjacent feeder.

After the automatic FLISR operation was complete, National Grid made repairs and performed manual switching to restore the remaining 887 customers in approximately five hours and 35 minutes. Without the FLISR scheme, all 1,913 customers would have experienced a sustained outage.

4.2.7.2 Outage Restoration Steps
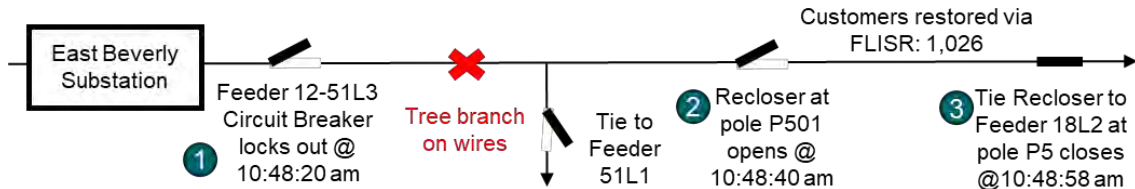
1. On 12/18/2023 at 10:48:20 am, a feeder circuit breaker at East Beverly Substation locked out due to tree branch on wires. The initial outage affected 1,913 customers.

2. FLISR opened a recloser on feeder 12-51L3 due to the loss of voltage at 10:48:40 am.

3. FLISR closed a tie switch to the adjacent feeder 18L2, automatically restoring 1,026 customers at 10:48:58 am.

The remaining 887 customers still affected had power restored in approximately five hours and 35 minutes.
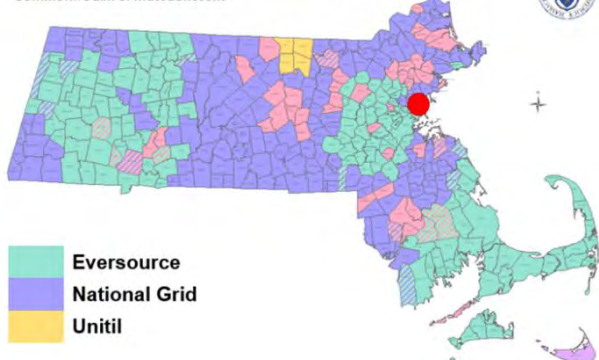
4.2.7.3 Estimated Reduction in CMI

Customers on feeder 12-51L3 that were restored through FLISR experienced a 38-second outage which represents zero CMI. The remaining customers that were restored via manual switching experienced a 335-minute outage (five hours and 35 minutes) which resulted in CMI of approximately 296,986.

Without GMP ADA, Guidehouse assumes that customers that were restored via FLISR would have experienced a 395-minute outage. This estimate was developed using the original manual restoration time of 335 minutes, with an additional 60 minutes for troubleshooter to travel time during a major storm event day. When comparing the manual switching restoration to ADA FLISR, the estimated reliability reduction in CMI on feeder 12-51L3 is 350,365 customer minutes (887 customers times 395 minutes). For this outage, the FLISR operation resulted in an approximate 54% improvement in CMI (350,365 divided by 647,351).

4.2.8 CS8 – ADA Automatic FLISR Operation Aborted in Malden

Electricity Providers by Municipality
Commonwealth of Massachusetts

Eversource
National Grid
Unitil

Source: Guidehouse (map from
https://www.mass.gov/doc/electricity-providers/download,
Accessed May 31, 2024)

Event Date Time	
December 24, 2023	
Event Classification	
Blue Sky; Misoperation	
Cause	
Cable Failure; Voltage Sensor Malfunction	
Affected Feeders	
12-16W6	
Number of Customers (and Time) Restored	
FLISR : N/A	
Manual Restoration: 2,367 (5 minutes), 1,524 (9 minutes), 1,719 (2 hours, 12 minutes)	

4.2.8.1 Description

On December 24, 2023, a circuit breaker locked out at Maplewood Substation due to a gateway cable fault. FLISR started to operate but failed to complete its operation to restore the customer outage.

National Grid performed an investigation and found that the pole mounted voltage monitor on the Melrose 25W4 feeder was reporting incorrect voltage readings on its A phase. The FLISR scheme is programmed to automatically abort operation when incorrect or bad data is received.

During the outage event, National Grid shut off the FLISR operation and picked up the affected customers via SCADA using pole top reclosers (PTRs).

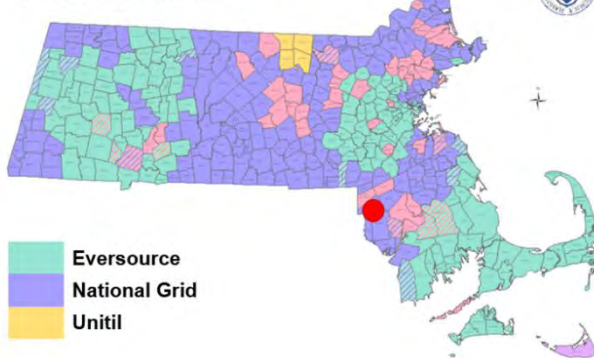### 4.2.8.2 National Grid Remediation

At the time of the event, National Grid manually restored 2,367 customers after five minutes, 1,524 customers after nine minutes, and 1,719 customers after two hours and 12 minutes. National Grid then investigated FLISR's failure to complete its operation and found that a pole mounted voltage monitor on Melrose 25W4 feeder was reporting incorrect voltage readings on A Phase. National Grid dispatch then shut off FLISR operation to pick up affected customers with SCADA usings PTRs.

4.2.8.3 Recommendations

Guidehouse recommends that voltage sensors readings be set up to automatically alarm in ADMS (SCADA) if they malfunction or go out of an acceptable voltage range.

4.2.9 CS9 – ADA FLISR Operation Failed Due to Installation Errors in Attleboro

Electricity Providers by Municipality
Commonwealth of Massachusetts

- Eversource
- National Grid
- Unitil

Source: Guidehouse (map from https://www.mass.gov/doc/electricity-providers/download, Accessed May 31, 2024)

Event Date Time

December 27, 2023

Event Classification

Blue Sky; Misoperation

Cause

Mainline Animal Contact; Incorrect PTR Installation; Incorrect Voltage Reading Settings

Affected Feeders

05-9L6

Number of Customers (and Time) Restored

FLISR : N/A

Manual Restoration: 904 (3 minutes), 660 (33 minutes)

4.2.9.1 Description

On December 27, 2023, a pole top recloser (PTR) locked out due to animal contact. The PTR did not properly operate and FLISR did not restore the customer outage.

National Grid upon investigation found that the PTR was installed incorrectly (i.e., the source side and the load side were reversed). They also found that the configuration settings in the PTR were incorrect, which could cause FLISR to fail to operate under certain scenarios.

During the outage event, National Grid performed SCADA/manual switching to restore power to affected customers.

4.2.9.2 National Grid Remediation

At the time of the event, National Grid manually restored 904 customers after three minutes and 660 customers after 33 minutes. National Grid then investigated FLISR's failure to complete its operation and found that a PTR was installed incorrectly on the feeder, noting that the source and load sides were reversed, and that settings uploaded to the PTR did not have the under-voltage timer enabled.

4.2.9.3 Recommendations

National Grid has updated their construction standard to help assure equipment is being installed properly. Since it is possible previous installations may have been installed incorrectly, Guidehouse recommends that a special field inspection should be performed to make sure that PTRs have been installed and programmed correctly.

5. Key Findings and Recommendations

5.1 Key Findings

Table 21 presents the results for the ADA-specific Performance Metrics: Numbers of Customers that Benefit from GMP Funded Distribution Automation Devices, and Average Main-Line Customer Minutes of Interruption.

Table 21. ADA Performance Metrics Summary

PM	National Grid
PM-10: Numbers of Customers that benefit from GMP funded Distribution Automation Devices	Over 177,000 (13%) National Grid customers benefitted from ADA devices. This is a 5 percentage-point increase from PY 2022, where Guidehouse identified over 113,000 (8%) of National Grid customers benefiting from ADA devices.
PM-NG1: Main Line Customer Minutes of Interruption Saved	Main-line CMI for circuits with ADA decreased (improved) 46% in PY 2023 from baseline. This is a 12 percentage-point increase from PY 2022, where Guidehouse identified a 35% improvement in CMI from baseline.*

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

Source: Guidehouse analysis of National Grid PY 2023 Appendix 1 document

Table 22 summarizes key findings related to Guidehouse's ADA case studies.

Table 22. Summary of Case Study Findings for ADA Investment Area

Key Findings
1. National Grid ADA FLISR schemes are operating as designed in the majority of the 39 cases observed for PY 2023. Approximately, 90% (35 out of 39) had successful FLISR operations. Case studies were performed for six out of the 35 instances where FLISR had successful operations.
2. For the case studies reviewed that had successful operations, FLISR restored customers in under one minute (the Massachusetts threshold for a sustained interruption). This resulted in customers experiencing a momentary interruption instead of a sustained interruption. Guidehouse also observed for these case studies and based on the estimated reduction in CMI, that the successful FLISR operations improved CMI by over 50%.
3. Guidehouse observed four instances where National Grid's ADA FLISR schemes did not operate as expected. Case studies were performed on three of the four instances where FLISR failed to operate as expected. Based on the case studies, National Grid determined that misoperations were due to FLISR schemes receiving bad data or a result of improper installation and programming.

Source: Guidehouse analysis

5.2 Recommendations

Guidehouse submits the following recommendations for EDC consideration in PY 2023:

1. National Grid ADA FLISR schemes are operating as designed in the majority of the 39 cases observed for PY2023.
   a. Recommendation: Continue to evaluate and deploy ADA FLISR based on high risk feeder locations.

    b.   Recommendation: To validate proper FLISR operation and mis-operation failure rates, continue case studies for Term 2 investments.

2. Based on the case studies, National Grid determined that mis-operations were due to FLISR schemes receiving bad data or a result of improper installation and programming.

    a.   Recommendation: To maximize reliability savings from GMP ADA, National Grid should verify that the quality control process used for FLISR configuration is appropriate. Without the configuration error that prevented a recloser to receive the command to close in Case Study #6, FLISR would have had a successful operation and a portion of the customers in the feeder affected would have likely experienced an outage less than a minute.

    b.   Recommendation: National Grid should have the voltage sensors configured to automatically alarm in ADMS (SCADA) if they malfunction or go out of an acceptable voltage range. Additionally, FLISR equipment that has been identified out of service should be considered high priority for repairment and placement back into service. In Case Study #8, if bad data from a voltage sensor had been identified and corrected, the FLISR scheme would have not aborted operations and a percentage of customers would have experienced a momentary outage instead of a sustained outage.

    c.   Recommendation: National Grid has updated their construction standard to help assure equipment is being installed properly. Since it is possible previous installations may have been installed incorrectly, a special field inspection should be performed. In Case Study #9, a FLISR scheme would have had a successful operation and avoided a sustained outage if the PTR had been installed and programmed correctly.

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