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A Strategy for Modernizing the Electric Grid

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SUMMARY

There are several factors that affect the energy industry today and consequently will influence how a grid modernization strategy should be shaped. In recent years there has been a rapid development of new technologies that has led to new and evolving customer needs and expectations. Utilities are seeing more progressive policies and regulatory requirements evolving to support clean energy deployment and the need to decarbonize. The rise in both renewable resourced based distributed generation and new load combined with the growing frequency of extreme weather events have increased the variability of system load profiles, requiring utilities to enhance their capabilities to manage and predict a much wider range of possible events to safeguard the resiliency and reliability of the electric distribution system.

National Grid's vision of grid modernization is a fundamental component of its overall Future of Electric vision, it includes a faster and more agile grid that has sufficient monitoring and control to reliably manage an increasingly complex and dynamic distribution system. In addition, new grid operator tools and solutions are needed to leverage new types of customer Distributed Energy Resources (DER).

Utilities must accommodate the rapidly changing technological trends and customer expectations impacting the electric distribution system. Today, significant change is occurring across the energy industry due to evolving customer needs and expectations, driven by the increased adoption of "smart" customer devices (e.g., networked EV chargers, HVAC controls, smart inverters) that can actively manage energy use in customers' homes and businesses. Current ways of interconnecting DER into the existing electric distribution system infrastructure are becoming increasingly difficult and expensive and must be replaced with new ways to integrate DERs into the system

Executing on this future vision involves electric utilities transitioning from a simple one-way to a bi-directional power flow company that manages an increasingly dynamic and complex distribution system. Utilities will need to refine their control systems to manage the high penetration of unmanaged DER. Later a Distributed Energy Resource Management System (DERMS) will be needed for more granular control, which will enable the transition from interconnecting DER to Integrating it.

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As customer needs and priorities evolve, utilities will need to implement advanced control systems, and to deploy more digital assets that provide real-time system visibility (e.g., voltage, power flow, asset condition) and improve response time. Strategic Grid Modernization investments will be essential to avoid over sizing the system for extreme and rare events and will allow for greater customer satisfaction and a more reliable electric grid.

KEYWORDS

Grid Modernization Strategy, Optimizing System Performance, Optimizing System Demand, Transitioning from Interconnecting DER to Integrating DER.

On July 1st National Grid submitted its five-year Grid Modernization strategic plan for the years 2022 to 2026. The strategy was designed to achieve three objectives set forward by the Massachusetts Department of Public Utilities (MA DPU).
The Objectives aim to: (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.[1]

The objectives reflect a future electric grid enabled to integrate and optimize various energy resources to successfully deliver on the climate and energy goals of the Commonwealth.
The first stage of the Company's grid modernization journey was designed around building foundational technologies. The Company invested in an Advanced Distribution Management System (ADMS) that enables the Company to achieve real time command and control of assets connected on its distribution system
The ADMS represents the center point that other grid solutions were to be controlled through and build upon. The company invested in Conservation Voltage
Reduction (CVR) through Voltage and VAR optimization (VVO) to reduce energy demand and lower costs to customers. The Company also invested in a Fault Location, Isolation and Service Restoration (FLISR) to improve system reliability and designed to reduce customer outage time and increased customer satisfaction. Feeder Monitors (FM) investments were included to offer feeder level visibility allowing advanced distribution planning solutions designed to reduce upgrade cost.

With significant change occurring across the energy industry due to evolving customer behavior and expectations, driven by the increased adoption of DER
including solar, energy storage, and electric vehicles, and "smart" technologies, such as advanced building controls that can actively manage energy use in customers' homes and businesses. National Grid focused the next stage of its GMP a round optimizing the system for two-way flow of information and energy to manage the distribution system with more granularity, including more real-time visibility, automation and control of the distribution system and customer end-use devices, and increased ability to receive and communicate energy usage, pricing, and other information to customers.

Several Nations and local governments have committed to net zero emissions by 2050, in the Commonwealth of Massachusetts aggressive interim greenhouse gas ("GHG") emission limits were signed into a comprehensive climate legislation on March 2021, which will accelerate the energy transition. In December 2020, the Commonwealth also released its 2050 Decarbonization Roadmap ("2050 Roadmap"),[2] which offers a glimpse into the long-term future of the electric grid. The charts in Figure 1, Future Energy Demand and Supply, project that by 2050 wind and solar will account for more than 80% of energy generation in Massachusetts, and that there will be rapid growth in the relative load share from emerging technologies such as EVs, conversion loads, and space and water heaters.

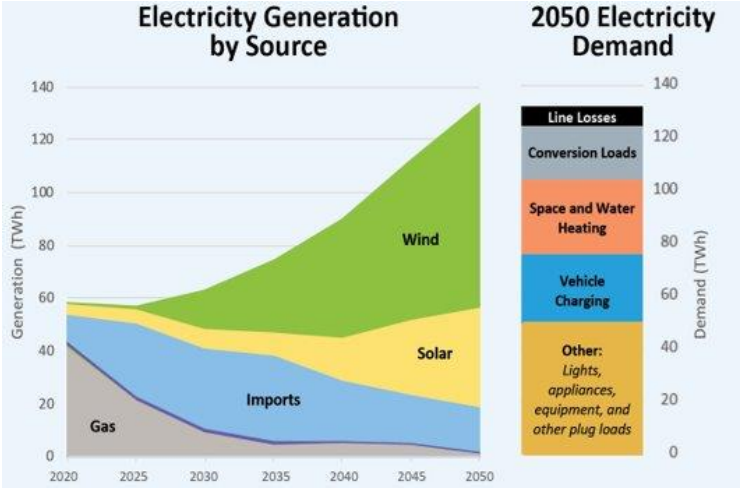

Figure 1: Future Energy Demand and Supply[2]

In December 2020, the Commonwealth also released its interim 2030 Clean Energy and Climate Plan ("2030 CECP"), which supports "a more dynamic, bidirectional distribution system [which] will allow for greater electrification and minimize the cost of integrating DERs."[3]

Furthermore, FERC Order No. 2222 ("FERC O2222"), issued in September 2020, requires that wholesale markets allow all DERs to participate in markets under a unified set of rules so the resources can be aggregated and optimized. Changes to wholesale market access rules will allow far greater participation of DERs at the Independent System Operator-New England ("ISO-NE").

These policies and objectives dovetail with the Company's vision of a modern electric grid, as they characterize a system designed around optimal integration of various DERs, both generation and load, to deliver the Commonwealth's clean energy and climate goals while also maintaining an affordable and reliable electric system for customers.

With the addition of DER to the system, load profiles are expected to change more drastically and become more unpredictable with higher penetration of intermittent DG (such as solar) and emerging load technologies (such as EV chargers), and with the increasing frequency of natural disasters and extreme weather events. This likely will result in the need for more granular short-term (e.g., week-ahead to intra-day) load and generation forecasting at the distribution asset level. Short-term forecasting will be required to support identification of distribution system constraints in advance, increasing the Company's ability to optimally develop, plan and execute system reconfiguration, switching orders and activation of DER programs to secure the distribution system. The Company envisions these granular forecasts will be incorporated into its ADMS load flow and distribution state estimation applications to enhance its simulation capability and insight on future system state predictions. The Company is also considering how these forecasts can enable and expand its DER programs, including existing demand response programs, to address localized system constraints.

Executing on this future vision involves National Grid's evolution from a simple one-way to a bi-directional power flow company that manages an increasingly dynamic and complex

distribution system. The Company envisions refining its control systems to manage the high penetration of unmanaged DERs. Initially, some of this control will be enabled through an ADMS, but ultimately, as customer DER penetration grows, additional features designed to manage customer DER such will be needed for more granular control, which will enable the Company to streamline DER interconnections and reduce costs for customers.

As the electric distribution system evolves, the Company will need to implement more control systems like ADMS and DERMS, and to deploy more digital assets that provide real-time system visibility (e.g., voltage, power flow, asset condition) and improve response time. With these grid modernization investments, the Company will utilize granular system data to make "real-time" system dispatch decisions, ensuring that the distribution system is efficient, safe and reliable with significantly higher levels of DERs. Additionally, with the full-scale deployment of AMI, the Company will transform the way it delivers energy, empowering customers and taking further meaningful steps to achieve shared clean energy goals.

The Grid Modernization Roadmap ("Roadmap") outlines the Company's proposed timing for its grid modernization investments over the next ten years and includes other related programs/ initiatives that support the full universe of grid modernization investments.

The Company's approach to modernize its electric distribution system goes beyond the scope of this GMP and includes proposals for energy storage and EV charging infrastructure deployment. It also builds off of and complements the Company's current efforts in supporting programs/ initiatives, including its participation in the Massachusetts Technical Standard Review Group to implement the updated IEEE-1547 standards, its research and development work on smart inverters in its Solar Phase II and III Programs, and its proposal for integrated transmission and distribution planning studies and long-term forecasting work in D.P.U. 20-75. See Figure 2, Grid Modernization Roadmap.

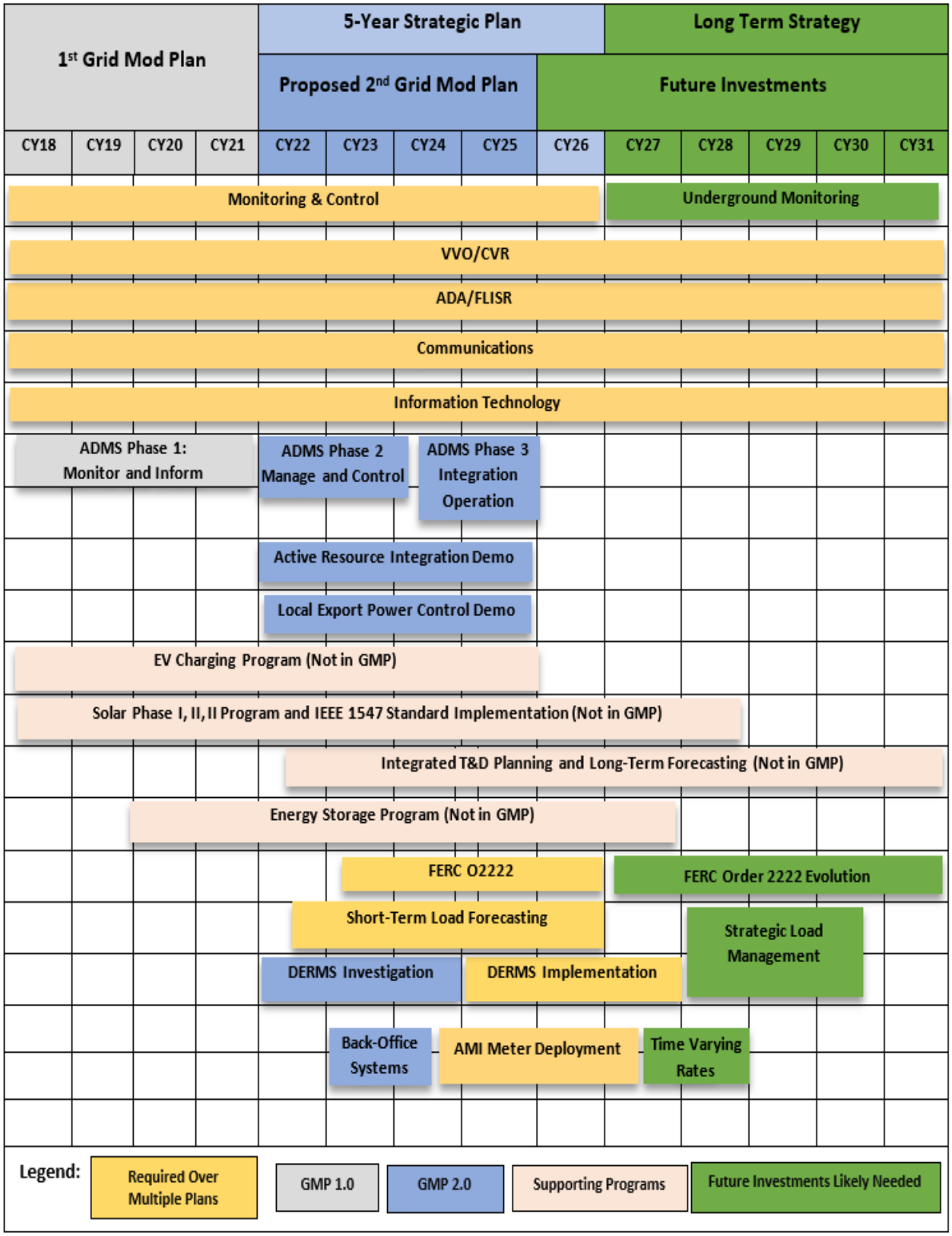

Figure 2: Grid Modernization Roadmap

Grid modernization is not a single, one-time project. The term "grid modernization" encompasses an array of investments needed over time as the electric distribution grid evolves.

The initial investments in the Company's first GMP were focused on laying the foundational components of a modern grid. The proposed investments in the Company's second GMP are focused on integrating these components into a holistic system and unlocking and optimizing their capabilities. Investments in the foundational components are proposed to continue in the second GMP and in the following years as the Company enables these capabilities on key feeders and substations across the Company's service territory. Proposed investments in the second GMP also focus on integrating the Company's system with its customers' DERs and end-use devices to allow the Company to efficiently leverage grid modernization functionalities and new technologies, programs, and services to meet evolving customer expectations and grid needs. To better communicate and interact with customer DERs and to facilitate DER interconnection, new tools and capabilities are required. As such, this second GMP proposes new investments to support implementation of FERC O2222, advanced short-term load forecasting, a DERMS investigation, DERMS Implementation, and two demonstration projects. The second GMP also includes investments in back-office systems and AMI metering to enable full-scale deployment of AMI.

The Roadmap beyond CY 2026 is intended to guide the development of future investment plans. The form and function of the distribution system is evolving and is expected to change significantly over the next several years. The Company anticipates the need to adapt and adjust its plans in later years considering several factors, including the actual pace of DER penetration over time and the corresponding system impacts as determined through the Company's on-going distribution planning processes, the availability of new grid modernization technologies, and the evolution of policies and regulatory proceedings.

Conclusion

By 2030, households and businesses will be connected to millions of DERs, smart devices, and other innovative technologies that have yet to be invented. Customers may also experience more extreme weather conditions and outages due to climate change. It is for this reason that utilities must continue to implement critical, foundational investments across their distribution system to unlock the advanced capabilities to prepare for this new reality. Utilities must interact with grid and customer devices in real-time in order to optimize generation and demand, while at the same time maintaining reliability of the distribution system under the increasing challenges of unpredictable and dynamic conditions. Failure to invest in the proper technologies will be very costly in the long run for interconnecting DER. It is for these reason that Grid Modernization must be a center element in any utilities long term clean energy strategy.

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[2] Massachusetts Office of Energy and Environmental Affairs, (Massachusetts 2050 Decarbonization Roadmap, December 2020, pages 24)

[3] Massachusetts Office of Energy and Environmental Affairs, (Massachusetts 2030 Clean Energy Climate Plan, December 2020, pages 43)