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April 1, 2019

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Re: *In the Matter of the PowerForward Distribution System Planning Workgroup*, Case No. 18-1596-EL-GRD

Dear Ms. Troupe:

In accordance with the Commission's February 27, 2019 Finding and Order in this case, I am enclosing the Current-State Assessment report of Ohio Power Company (AEP Ohio). For convenience, AEP Ohio combined the Current-State Assessment report with the Grid Architecture Status report – with the Grid Architecture component addressed in Section 3 and the Current State and Planning Assessment component in Section 4. AEP Ohio's combined report was also filed in Case No. 19-794-EL-GRD.

Thank you for your attention to this matter.

Respectfully Submitted,

//s/ Steven T. Nourse

AEP Ohio

PowerForward Initial Assessment Report

April 1, 2019

An AEP Company

BOUNDLESS ENERGY[SM]

AEP Ohio PowerForward Initial Assessment Report

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Glossary of Terms

AMI Advanced metering infrastructure

ANSI American National Standards Institute

BEV Battery electric vehicle

CAIDI Customer average interruption duration index

CEUD Customer energy usage data

CIM Common information model

CIRC Cybersecurity Intelligence & Response Center

COTA Central Ohio Transit Authority

CRES Competitive retail electric service

DAC Distribution automation controller

DACR Distribution automation circuit reconfiguration

DC Direct current

DDC Distribution dispatch center

DER Distributed energy resources

DERMS Distributed energy resource management system

DG Distributed generation

DMS Distributed management system

DR Demand response

DRMS Demand response management system

DWG Data and the modern grid workgroup

EDI Electronic data interchange

EDACS Enhanced digital access communication system

EDU Electric distribution utility

EE Energy efficiency

ESP Electric security plan

ES-ISAC Electric sector information sharing and analysis center

EV Electric vehicle

EVSE Electric vehicle supply equipment

FERC Federal Energy Regulatory Commission

HAN Home area network

IDP Integrated distribution planning

IDR Interval data recorder

IED Intelligent electronic device

IHD In home displays

IOP Interoperability Plans

IT Information technology

kW Kilowatt

kWh Kilowatt hour

MORPC Mid-Ohio Regional Planning Commission

NARUC National Association of Regulatory Utility Commissioners

NIST National Institute of Standards and Technology

ODOT Ohio Department of Transportation

OHA Ohio Hospital Association

OMS Outage management system

PCT Programmable thermostat

PHEV Plug-in hybrid electric vehicle

PUCO Public Utilities Commission of Ohio

PV Photovoltaic

PWG Distribution system planning workgroup

RER Renewable energy resource

RTP Real-time pricing

RTPda Real-time pricing with double auction

SAIDI System average interruption duration index

SAIFI System average interruption frequency index

SCADA Supervisory control and data acquisition

SGDP Smart grid demonstration project

SVC Supervisory control

TOU Time of use

UCS Utility communication System

U.S. DOE U.S. Department of Energy

VAR Volt-ampere reactive

VVC Volt/VAR control

VVO Volt/VAR optimization

AEP Ohio PowerForward Initial Assessment Report

1 EXECUTIVE SUMMARY

AEP Ohio has been a leader in implementing Grid Modernization and Smart Grid technologies in both scope and scale for the past decade. Beginning in 2009, AEP Ohio participated in the DOE Smart Grid Demonstration Project (SGDP). The Project included technology including Advanced Metering Infrastructure (AMI), Distribution Management System (DMS), Distribution Automation Circuit Reconfiguration (DACR), Volt VAR Optimization (VVO), and Customer Programs (CP). The project combined these technologies with two-way customer communication and information sharing, demand response, dynamic pricing, and consumer products, such as plug-in Electric Vehicles (EVs), Home Area Networks (HANs) and smart appliances. In addition, the Project incorporated comprehensive cybersecurity capabilities, interoperability, and a data assessment that, with grid simulation capabilities, made the demonstration results an adaptable, integrated solution for AEP Ohio for both new and legacy systems.

DERs and Microgrids are a proven way to improve service quality, lower energy consumption, and save money for customers. AEP Ohio has shown great interest and is well positioned to determine where to deploy innovative technologies like large scale DER and microgrids in areas that provide the best benefit to the distribution grid and to the customers. Such efforts would significantly jump-start the work necessary to define the platform and interfaces and to accelerate the delivery of a marketplace available to others. However, lack of a clear definition of DER ownership and how ownership will affect rate-payers has created uncertainty.

With the Smart Grid Demonstration Project (SGDP) and the Phase 2 deployment combined, this technology is being deployed across a sizable portion of the distribution grid to drive financial benefits, positively impact customer service and customer satisfaction, improve meter field personnel safety, and reduce environmental impacts. The goal is to apply the lessons learned during the SGDP and integrate a suite of advanced grid technologies into the existing electric network to improve service quality and reliability, lower energy consumption, increase customer control in energy consumption, and save money for our customers.

AEP Ohio understands the PUCO's concept of the distribution grid as a platform with well-defined interfaces and a regulatory environment that will allow for the deployment of the electric distribution grid's next generation platform seamlessly and cost-effectively to customers. The comparison used by the PUCO of the electric distribution grid next generation platform to the iPhone platform is a useful metaphor to discuss the challenges faced.

One of the strengths of any platform is the well-defined and well-regulated interfaces that are necessary to connect and provide services on that platform. Vendors who wish to develop applications for such a platform must conform to the published interface specification, comply with data storage rules and adhere to guidelines defining safety, application performance, business rules, design principles, and legal obligations of the application developer.[1] Platform vendors lay out rules clearly to ensure all developers understand their obligations. Prior to release of an application to the marketplace, extensive testing must be performed to ensure compliance and that the application does not have unintended behaviors that could jeopardize the safety and performance of the platform. Platform vendors disable applications that violate the interface specifications and guidelines in any way and can be remove violating applications from the marketplace.

It is critical to establish clear interface specifications and guidelines for those who wish to connect to the distribution grid platform defined in the PowerForward roadmap. It is recommended that the PUCO working groups establish testing requirements for vendors to demonstrate compliance with the interface specifications and guidelines. While deployed, mechanisms to monitor the behavior and performance of the application and its effect upon the stability of the distribution grid should be required. Further, rules need to be established for disconnecting applications from the grid should monitoring determine that the application is disruptive to the safety and stability of the grid platform. This must include mechanisms for emergency disconnection to avoid critical outages. As the PUCO has stated, the first tenet of PowerForward must be "Do No Harm." The shared goal must be to maintain the delivery of safe, reliable electric service at fair prices while the industry advances in grid modernization.[2]

Unlike the present public perception of technical platform providers who control their respective platforms and marketplace, the PUCO has a history of strong regulatory oversight of and cooperation with the EDUs in achieving its policy goals. Its ability to create and interpret regulations and set tariffs provides a set of tools to ensure both development of the next generation electric distribution grid platform and preservation of the marketplace it serves. This oversight should continue, but the PUCO should favorably consider the contributions and capabilities of AEP Ohio and other EDUs to help address the challenges of defining and building a standard platform and a new market.

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[1] See Apple's App Programming Guide, https://developer.apple.com/library/archive/documentation/iPhone/Conceptual/iPhoneOSProgrammingGuide/Introduction/Introduction.html#//apple_ref/doc/uid/TP40007072-CH1-SW1, Apple's iOS Data Storage Guidelines, https://developer.apple.com/icloud/documentation/data-storage/index.html, and Apple's App Store Review Guidelines, https://developer.apple.com/app-store/review/guidelines/

[2] PowerForward, Ohio Public Utilities Commission, A roadmap to Ohio's Electricity Future, pp 8

1.1 Message to the reader:

This document addresses the PUCO's request to respond to the PowerForward roadmap and related Finding and Orders to provide a grid architecture status report as well as a current state planning assessment. AEP Ohio discusses the experience and investment in innovative technology deployed in the distribution grid architecture and provides an assessment and review of AEP Ohio's current planning process. Consistent with the PowerForward process used to date, AEP Ohio's general commentary and statements in response to the PowerForward roadmap are made in the spirit of a creative and collaborative discussion involving the potential future state of regulation; consequently, nothing in this report can be used to restrict any future position, argument or statement of the Company. Throughout this document there are many abbreviations used. Please reference the Glossary of Terms in the front of the report for clarification.

2 INTRODUCTION

On March 8, 2017, the Public Utilities Commission of Ohio ("PUCO" or "Commission") announced the launch of PowerForward initiative as an endeavor to focus on grid modernization. It held a series of three sessions, each lasting several days, and listened to 127 speakers and received approximately 100 hours of education on the challenges and concerns with grid modernization.[3] The results have been the establishment of the PUCO's PowerForward roadmap and the establishment of working groups to plan the steps necessary to implement this roadmap. In addition, the PUCO requested that each EDU doing business in the state of Ohio file two initial assessment reports, the first providing a Grid Architecture Assessment and the second a Current State Planning Assessment report by April 1, 2019. Since AEP Ohio's current state includes many of the elements of the grid architecture assessment, the company combined both reports into a single document to comply with the Commission's directives.

Section 3 describes AEP Ohio's initial assessment of many aspect of the current Grid Architecture. It details the Smart Grid initiatives that AEP Ohio has already undertaken implementing grid modernization efforts. Section 4 describes the Current State and Planning Assessment. It provides information on AEP Ohio's perceived strengths and weaknesses, an accounting of key Smart Grid technology currently deployed in the grid, a detailed explanation of the current planning process and examples of current and future collaboration efforts undertaken by AEP Ohio.

3 GRID ARCHITECTURE

Figure 1 (below) describes the DOE Next generation Distribution Platform. This serves as the model that the PUCO references in the PowerForward roadmap. It identifies the core components needed to establish a cyber-physical platform for the modern grid and the layering of the cyber-physical platform with a market platform and associated applications. The U.S. DOE refers to this layering of application on top of the cyber-physical platform as the "logical technology stack."

A cyber-physical platform is a mechanism controlled or monitored by computer-based algorithms, tightly integrated with the Internet and its users. In cyber-physical systems, physical and software components are interdependent, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a lot of ways that change with context. The following sections discuss how AEP Ohio implements the cyber-physical platform and related logical technology stack.

[3] PowerForward, pp 4

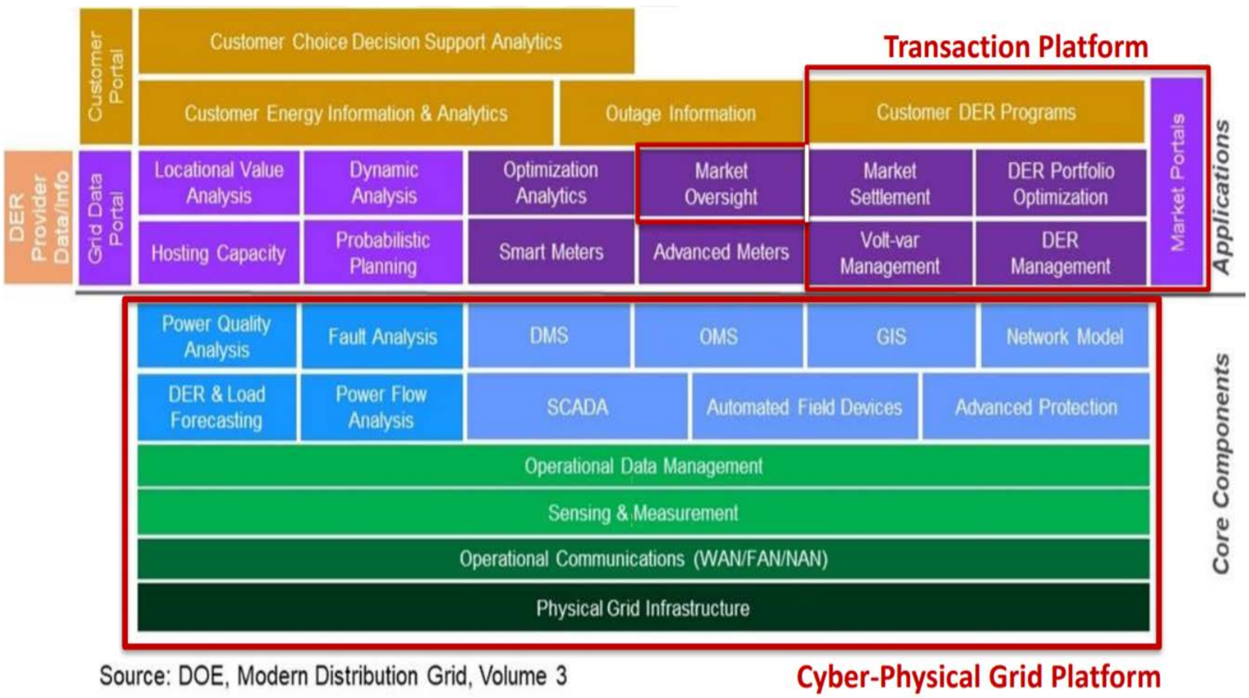

Figure 1: DOE Next Generation Distribution System Platform & Applications (Objects outlined in red are future considerations)[4]

3.1 Cyber-Physical Platform (Introducing the Broad Architecture)

AEP Ohio has implemented many of the components in the cyber-physical platform including the Physical Grid Infrastructure connected and communicating over a set of communication networks including AMI, SCADA, cellular and others. The data gathered from each system provides more visibility for distribution grid operators and planning. Since 2009, AEP Ohio has introduced multiple technology enhancements to the infrastructure of the AEP Ohio distribution grid area. The following technologies are currently being deployed, including:

- Advanced Metering Infrastructure (AMI)
- Distribution Automation Circuit Reconfiguration (DACR)
- Volt VAR Optimization (VVO)

The following technologies proved effective during the Smart Grid Demonstration Project Phase 1 and are currently being evaluated for deployment:

[4] U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid Report Volume III: Decision Guide (June 28, 2017) (DOE Report Vol. III), pp 26.

- Customer Programs (CP)
- Home Area Networks
    - ePCT – Enhanced Programmable Communicating Thermostat
- Time of Use (TOU)
- Smart Street Lighting

The addition of the above technologies served as the foundation to enable and expand two-way communication with devices deployed in the network and directly with customers to allow for customer programs and products. The introduction of these technologies also required comprehensive cybersecurity and interoperability capabilities for both new and legacy systems.

Underlying it all, the interconnectedness of the smart grid opens opportunities for cybersecurity threats to utility networks many of which could be difficult to pinpoint and address. During the AEP Ohio's Smart Grid deployment, it used various tools, processes, and concepts to deter and detect a variety of these threats, including:

- Location
- Investigation
- Minimization of impact
- Mitigation

Additionally, the cybersecurity team continually learned and adapted to attackers' techniques, tactics, and procedures[5].

3.2 Logical Technology Stack

The logical technology stack facilitates the integration of competitive market solutions on top of the cyber-physical platform. It intends to make data available to third party entities without such entities requiring direct access to the underlying physical grid infrastructure. The best example of this is a Competitive Retail Electric Supplier (CRES) obtaining meter billing data from the EDU such as AEP Ohio. As of March 21, 2019, there are 92 CRES providers registered to do business in AEP Ohio's service territory. In February 2019, AEP Ohio made available to the CRES providers access up to 2 years of customers AMI Interval data. In accordance with the Ohio Administrative Code, a CRES provider must provide a signed letter of authorization from the customer to AEP Ohio to be able to download the interval data. Customers can also give permission directly to AEP Ohio for a CRES Provider to download the interval data via their online account on

[5] U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid Report Volume III: Decision Guide (June 28, 2017) (DOE Report Vol. III).

AEPOhio.com. AEP Ohio committed to make available the AMI interval data for CRES billing purposes, with letter of authorization, via EDI transactions.

Additionally, in February 2019, AEP Ohio started using actual interval data for AMI TOU customers for PJM settlement detailing the customer's actual usage, rather than an hourly estimate based on standard load shapes. Essentially, this will allow CRES providers to pay capacity and energy charges based on actual customer usage, rather than based on standard load shapes and provide for more accurate PJM settlements. This provides CRES providers equal ability to provide incentives and rewards to customers for changes in their usage behavior.

3.3 Level of Coordination between different technology platforms

Many of the newly deployed technologies still being deployed benefit from integration of their data streams (see Figure 2 below.) For example, VVO is currently operating without the benefit of AMI data integrated into the solution. Adding AMI data to the VVO application enhances the efficiency of the VVO solution with the addition of thousands of available data points in the grid. Likewise, AMI meters feed the outage management System (OMS) with power loss notifications to provide faster outage detection and better outage notification reports to facilitate root cause Analysis.

As AEP Ohio has more interconnections, sensors, and data collection devices on the distribution grid, the benefit of this data will increase. Data shared between applications has the potential to enhance the interoperability of AEP Ohio systems. During the SGDP Phase 1 trial, integration required significant manual effort and end-to-end verification of the data. Implementation of integration standards and updates to software systems will simplify the task of integration and make the data available to more applications.

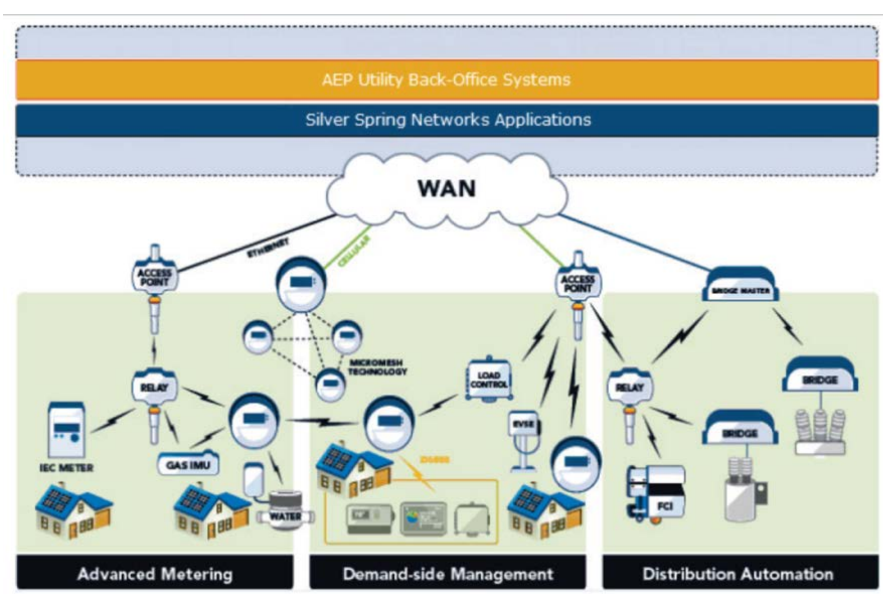

Figure 2: Distribution Network and Data Control

With the installation of AMI meters and other advance sensors, AEP Ohio now is collecting more data with the potential to provide deeper insight into the performance of the distribution grid. With future software upgrades, analytic programs can mine the collected data to provide insights to potential trouble spots requiring maintenance. This is an area that AEP Ohio is considering for future enhancements. As AEP Ohio enhances the grid, the analytics capability will increase to use predictive analytics from the AMI data and other sources to identify potential problems before they become real problems.

3.4 Uniform Platform (Multiple market opportunities within one service area)

AEP Ohio understands the PUCO's vision that the future of the grid in Ohio is a series of uniform distribution grid platforms, each controlled by the respective EDUs. As such, AEP Ohio is participating in the Data and the Modern Grid Workgroup (DWG) to address the many issues necessary to accomplish this vision. While this work has just begun, AEP Ohio agrees with the PUCO's interest in exploring the prospect of providing customers with near real-time access to their own Customer Energy Use Data (CEUD), which is supported by AEP Ohio's AMI technology choices and customer HAN adoption. AEP Ohio also appreciates the PUCO's interest in addressing the issue of customer privacy, ensuring that all customers can exercise some level of choice with respect to sharing their data with third parties, and ensuring that policies and procedures are established to ensure safety and security of that data.

Toward these ends, 100% of the residential AMI meters are deployed by AEP Ohio with HAN access technology (Zigbee) installed. AEP Ohio has also conducted trials with customers utilizing HAN in-home displays (IHDs) and programmable thermostats (PCTs) to provide users with the capability to monitor and control their home energy use.

During AEP Ohio's participation in the DOE Smart Grid Demonstration Project, AEP Ohio offered Real-Time Pricing with double auction (RTPda) project as an experimental, collaborative research project between American Electric Power (AEP), AEP Ohio, Battelle, and Pacific Northwest National Laboratory (PNNL). Branded as SMART Choice℠, the RTPda program offered participating customers an opportunity to take advantage of variable electric prices over the course of a billing cycle. The RTPda customer program gave customer choices to effectively manage their own power usage in a more intelligent and informed manner. The program offered a complete demand response system that collected real-time market prices, so customers could self-manage their power usage based on market price and comfort settings they controlled on their thermostats.

Results of this study were positive with the findings confirming the basic premise correlating reduction of short-term energy use with price increases and conversely, increase in energy use with price decreases. From a system impact point of view, simulations show that with a 35% penetration of RTPda households can obtain a load reduction of about 5% for a 3.5-hour system peak event. For a 2-hour local, feeder peak event can obtain a nearly 8% load reduction. Regarding the impact on 5-minute wholesale energy purchases, the field data analysis indicates that, if there were no congestion events, overall energy consumption by the average RTPda household could be reduced by over 5% and wholesale costs could similarly be reduced by 5% compared with the average non-responsive control group household. Simulations of the same wholesale impacts report an average of 1.2% reduction in energy consumption per household and 2.5% reduction in wholesale energy costs.

3.5 Enable Collaboration

With the development of a uniform platform for the electrical grid, it is valuable that the utility companies begin working more closely together. One mechanism to increase collaboration between all participants in the PowerForward roadmap are collaboration meetings such as the one AEP Ohio has attended since the start of the Phase 2 deployment. AEP Ohio has participated in a quarterly meeting to share information and work collaboratively with stakeholders. The meeting is known as “The Collaborative” and includes representatives from the PUCO, Smart Energy Water, the Environmental Defense Fund, ICS Energy, the Office of the Ohio Consumers’ Counsel, and the Environmental Law & Policy Center. The purpose of these meetings is to address questions and concerns raised by the members. The PUCO’s working groups to address the technical needs are an opportunity to focus on areas of potential collaboration including whether EDUs can share some of the investment costs of the cyber-physical platform.

3.6 Next Gen Distribution System

3.6.1 Field Automation

VVO

Similar to traditional voltage regulation methods, conceptual approaches to achieve VVO and the commercial systems to implement them vary widely. As part of the AEP Ohio Smart Grid Demonstration Project, two separate VVO systems were deployed. Because VVO technology was evolving, commercial vendors had no ready-to-go system in place. AEP Ohio selected two vendors to gain experience installing the technology and to quantify the energy efficiency and demand reduction results.

After the initial evaluations, AEP Ohio deployed the PCS Utilidata VVO system. The PCS system provided command and control for S&C Electric Company's IntelliCAP® capacitor controllers and for Cooper CL6-B voltage regulator controllers while monitoring EOL voltages. Cooper CL6-B controllers operated both circuit voltage regulators and line voltage regulators. IntelliCAP controllers operated switched capacitor banks. The integrated system provided voltage and VAR support to flatten and lower a circuit’s voltage profile while promoting unity power factor.[6]

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[6] U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid Report Volume III: Decision Guide (June 28, 2017) (DOE Report Vol. III), pp 315.

Based on experience with VVO deployment on 17 circuits in the Smart Grid Demonstration Project, AEP Ohio requested and was approved to move forward with a Phase 2 deployment of VVO on an additional 160 circuits within 72 months of approval. That deployment is in progress now.

By enabling AEP Ohio to deliver energy at lower acceptable voltage levels, VVO provides an overall reduction in energy consumption on circuits where the technology is installed. AEP Ohio expects to achieve an overall average VVO energy efficiency gain of 3 percent. This figure is based on both pre-deployment modeling of Phase 1 as well as measurement of actual data post Phase 1 deployment. Relative to other technologies, a 3 percent energy reduction is significant. AEP Ohio estimates that VVO will enable energy efficiency savings of $210 million in overall bill savings related to the VVO deployment for the 15-year business case period.

DACR

AEP Ohio's implementation of DACR has greatly increased the grid's resiliency. While DACR does not fully prevent storm-related outages, it decreases the customer impact of existing outages. AEP Ohio has deployed DACR technology 88 circuits to date. These systems detect outages, many of which are storm-related. After an outage alert, a DACR system in the field sends a message detailing configuration changes to the Distribution Dispatch Center (DDC) to update the Distribution Management System (DMS) and the Outage Management System (OMS). This reconfiguration occurs within two minutes.

During storms it is necessary to locate multiple fault locations, make repairs, and switch customers back into service after repairs are complete. DACR, in addition with DMS and OMS, can enable the DDC operators to view outage locations and monitor how the DACR system isolated the problem areas. This visualization allows the DDC operators to perform remote switching to restore service in addition to what the DACR logic can accomplish automatically. DDC operators perform remote switching without dispatching distribution line crews to the switch locations expediting restoration of service to the customer[7].

The Smart Grid Phase 2 project is deploying DACR technology on a total of 250 circuits that have the characteristics of being best positioned to yield reliability improvements. This deployment targeted reduction of CMI by up to 30 percent over the three-year average for the deployed circuits, which is approximately the midpoint of the achieved CMI reductions reported by the U.S. Department of Energy (DOE) in December 2012 for utilities that had prior experience with automated feeder switching. This could yield more than 21 million CMI per year on circuits serving more than 330,000 customers in the affected areas.

The DACR technology allows circuits to respond to outage conditions by utilizing nearby circuits to automatically reconfigure the local area distribution system. Testing indicates

[7] U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid Report Volume III: Decision Guide (June 28, 2017) (DOE Report Vol. III), pp 186.

customers are less likely to experience sustained service interruptions with circuits that have implemented the DACR technology. Overall, the goal at AEP Ohio is to minimize the number of customers impacted.

Through testing done to date, AEP Ohio has determined that DACR provides more accurate and timely determination of faulted circuit sections and the ability to remotely restore isolating devices after completion of repairs. AEP Ohio's DACR deployments for 2012 through 2018 have shown the following results:

- SAIFI: 17.6% better - a savings of over 200.5K customer interruptions during the period.
- SAIDI: 12.8% better - a savings of over 16.6M customer minutes of interruption

AEP Ohio expects further improvements to both SAIFI and SAIDI statistics as more circuits are placed under DACR control.

AMI

With automated meter reads, AMI has nearly eliminated estimated bills, improving billing accuracy. AMI yields a typical monthly read rate of 99.9 percent, leading to greater billing accuracy and improved customer satisfaction.

AMI leads to better customer service. For instance, when a customer wants to terminate service, the AMI meter is read remotely, and a final bill sent without delays caused by manual reads. Similarly, AMI meters equipped with a remote service switch enable power to be turned on or off remotely. As a result, a customer moving in may have service turned on in minutes, rather than waiting days.

AMI provides customers with the ability to view their energy consumption at 15-minute intervals. This data gives customers a better understanding of their consumption behavior. The availability of this data also enables customers to participate in energy efficiency and peak demand reduction programs. These programs are designed to reduce energy and peak demand, thereby allowing customers to benefit through energy savings.

AMI also provides billing and customer service efficiencies that enabled AEP Ohio to quickly address inquiries. Customer experience fewer billing issues from continual meter reads and the elimination of estimated meter reads through AMI. Company representatives have near real-time access to meter data that helps them discuss actual usage information with customers. When a customer calls about power loss, the near real-time access also enables the company to determine whether the power loss is due to an outage or to an issue on the customer side of the meter, such as a blown house breaker fuse.

From a reliability perspective, when an AMI meter detects a loss of voltage, a message is sent indicating the customer has lost power. Messages that successfully reached AEP Ohio's internal systems are used in conjunction with customer telephone calls to predict the extent of the outage. Also, meters are queried (pinged/polled) to get an indication of whether a customer has power. This indication is useful to troubleshoot customer issues and to verify restoration following an outage.

From a safety perspective, because crews can remotely determine whether a meter has power, crew exposure and safety are improved. Also, due to AMI, fewer meter readers are required in the field, which reduces physical meter reading efforts and, thus, reduces safety issues.

With remote capabilities, the number of miles driven by metering and service personnel is reduced. In addition, there are environmental benefits associated with reduced vehicle emissions because of reduced vehicle miles traveled.

Substation Automation

AEP Ohio believes optimizing assets is essential to save money in both the maintenance and operation of the grid costs. One technology AEP Ohio has been introducing into substations to improve the optimization of the assets are intelligent electronic devices (IEDs) connected via SCADA and reporting information back to the DDC. The IEDs monitor and facilitate the exchange of both operational and non-operational data. Operational data is referred to as 'supervisory control and data acquisition' (SCADA). These are instantaneous values of the power system that provide key insight into data points such as volts, amps, MW, MVAR, breaker status, and switch position. Operators use such information to monitor and control the circuit breakers, relays, capacitors, and line voltage regulators in the substation in real-time. The capability of automated substations allows for a rapid response that may result in the avoidance of large-scale incidences.

IEDs located within the substations also monitor non-operational data such as waveforms and event summaries. While this data is not as time-critical, it is essential for the longevity of the substation itself. The analysis of this data may allow predictive measures on when equipment failure may occur or insight into ways to further optimize performance of the grid.

Today AEP Ohio has IEDs and SCADA networks in a majority of its substations (See Table 3 in section 4.4.1 below for details.) Planned substation construction projects include upgrades to IEDs and SCADA connectivity and possible installation of additional sensors to improve the reliability of the distribution grid.

With implementation of VVO, DACR, and AMI, AEP Ohio has made major improvements to field automation. VVO allows for automated voltage control of circuits across the grid, not only lowering cost for customers, but also providing great insight at the line voltage levels and load at each transformer and better control of circuit voltages. Simultaneously, VVO control decreases wear on voltage regulator tap changers (see Figure 3, below) by reducing the number tap changes per day[8]. DACR technology increases grid reliability and lowers customer outage time by automatically isolating damaged/faulted line

[8] Measurement and Verification Analysis Report of the AdaptiVolt™ Volt/VAR Optimization System at Gahanna Substation 16 March 2011 – 13 April 2012

sections. AMI meters collect and report detailed data on load and voltage conditions on the distribution grid. AEP Ohio is interested in using the data collected by these technologies as input to a future implementation of analytical software to provide the capability to do predictive maintenance on the distribution grid.

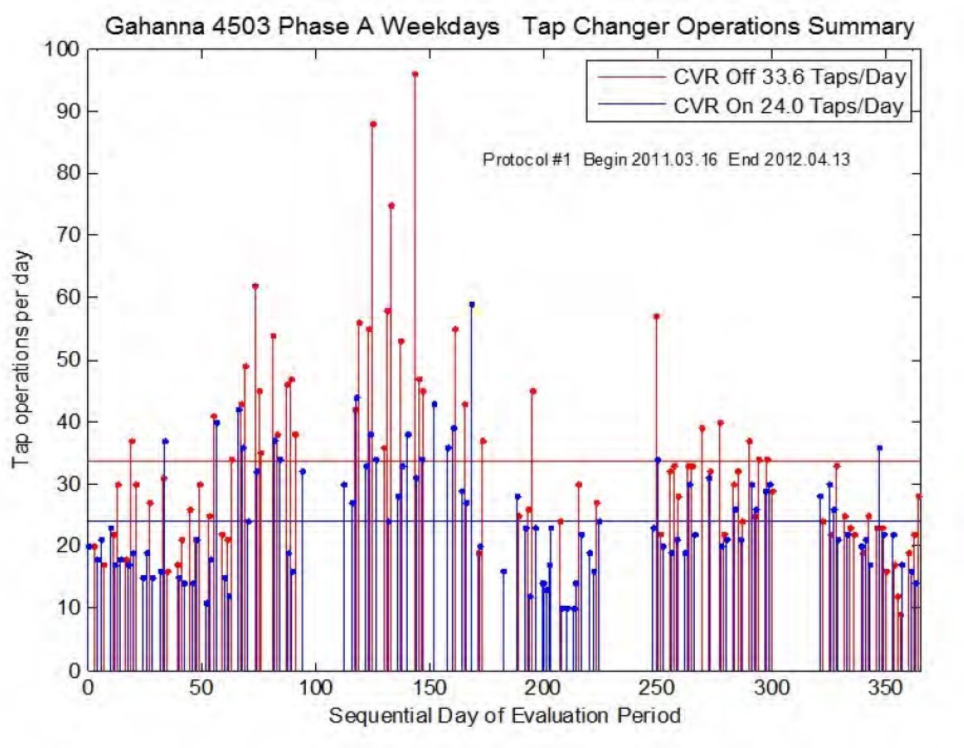

Figure 3: VVO reductions in Voltage Regulator Tap Changes

3.6.2 Operational Communications Infrastructure

AEP Ohio recognizes that an updated communication infrastructure is essential to interconnect the smart devices such as meters, sensors and IEDs deployed in the network. As technologies are evaluated, AEP Ohio has considered solutions that either provide or utilize a standard communication interface as a priority. Standards chosen for communications networks such as the AMI system can ideally share valuable data among many applications. This is a critical piece of interoperability. The speed, reliability, and security of a communications network(s) will determine the range of applications installed onto the smart grid. However, there is not a "one size fits all" solution when it comes to determining which communication network is best suited to the specific application task.

Likewise, communications to the Field Area Network device is adopting new standards as new devices deployed. The WAN interconnection is primarily based on wireless technologies utilizing the latest protocols such as IPv6. Operations personnel monitor the telecommunication networks remotely 24x7 to ensure good communications to devices. AEP Ohio is currently deploying field devices using LTE (Long Term Evolution) technologies on public networks.

AEP Ohio continues to invest in additional communication infrastructures for workforce communication as well such as replacing its aging Enhanced Digital Access Communication System (“EDACS”) system with a Next-Generation Unified Communications System (NextGen UCS). The NextGen UCS not only provides more secure and reliable voice communications, but additionally provides data connectivity to the Mobile Data Computers (MDCs) in Company vehicles. This enables Company employees and contractors to utilize distribution applications in the field, to complete dispatching and switching task more efficiently and with better coordination. The NextGen UCS also meets AEP Ohio cybersecurity standards to prevent malicious parties from penetrating the Communications System.

3.7 New Distribution Technologies

There are other areas of new technologies that AEP Ohio has proposed in filings before the PUCO. Table 1 below highlights some of the investments in new innovative technology that AEP Ohio proposed to use to update and modernize the distribution grid and provide benefits to AEP Ohio’s customers. Many of these fit within the definition of the PUCO’s next generation platform for the electric distribution grid. AEP Ohio is investigating each of these technologies but has not made a commitment regarding deployment on some of the technologies as noted in the table.

TECHNOLOGY	PHASE	STATUS
AMI	1	Complete
	2	Deployment
	3	Filing Pending
VVO	1	Complete
	2	Deployment
	3	Filing Pending
DACR	1	Complete
	2	Deployment
	3	Filing Pending
Energy Storage	Pilot	Ongoing
	Future	In Development
Customer Programs	Pilot	Ongoing
	Future	In Development
Electric Transportation	Pilot	Ongoing
	Future	In Development
Micro Grid	Future	In Development
Smart Lighting	Future	In Development
Next Gen. Utility Comm. System	Future	Pending Approval
Operational	Future	In Development
Sensing & Measurement	Future	In Development
Fiber Optic	Current	Planned Upgrades
	Future	In Development

Table 1: AEP Ohio Distribution Technology Interests

3.7.1 Energy Storage

Energy storage placed throughout the grid, by itself or in the form of a microgrid (see Figure 4), can help smooth out the bimodal peaks of the current load demand. AEP Ohio defines a microgrid as DERs in addition to energy storage that supplies a specific area of customers. Microgrids can increase grid reliability as well as compensating for demand load increases due to EV charging at peak hours.

It is known that the peak electricity usage is in the morning, before most go off to work, and in the evening when they return. However, peak solar generation is somewhere between the morning and evening period and peak wind is between the evening and morning period. Energy Storage smooth out these “valleys” between peak PV generation and peak usage.

Figure 4: Microgrid

In addition to optimizing DER generation, energy storage can provide back-up for one or more customers in an islanded section of the grid during an outage. Locations that cannot spare a moment of outage can pull “emergency power” from nearby batteries in the event of an interruption to the distribution grid. With the rise of EV adoption, EV energy storage retain excess power and could provide that power to the grid when necessary. In the future, it is possible each house will have at least one energy storage pack to “island” critical circuits in their homes in the event of an outage. This could provide great benefit to those with home-bound medical illnesses that require life support equipment. AEP Ohio has the greatest vision into the grid and can identify where the most critical locations where new microgrids should be installed to optimize grid operation.

3.7.2 Interoperability

AEP Ohio’s Smart Grid Demonstration Project determined that interoperability is not an implementation technology, but rather a goal to be accomplished. AEP Ohio defined an interoperability plan (IOP) to accomplish two goals. The first goal was to develop a plan to use to ensure interoperability among all systems, devices, and data sources. The second goal was to document the extent to which the first goal succeeded.

For the interoperability of the back office, the primary goal was to implement systems in such a way to protect against cascading failures. To accomplish this, the SGDP team implemented a communication standard and drove compliance to that standard. AEP Ohio engaged Electric Power Research Institute (EPRI) to assist in creating the Interoperability Plan. For this exercise, the team defined an interface as a pairing of systems or actors. This resulted in the creation of multiple use cases and multiple interfaces.

The IOP test plan was organized by topic, such as Demand Response, Distribution Grid Management, and AMI. Each topic contained a set of use cases analyzed to discover the number and purpose of interfaces involved with each topic. The team assessed each interface to determine whether a relevant standard existed, with emphasis on the standards enumerated in National Institute of Standards and Technology (NIST) Special Publication 1108, NIST Framework and Roadmap for Smart Grid Interoperability Standards. The team then assessed the interfaces to determine relevant standards for implemented by AEP Ohio and/or by its vendors in a manner that allowed for standards compliance testing.

Interoperability's two-phase testing approach combined lab and field testing to obtain a complete Project evaluation. The first phase involved extensive lab testing of technologies by exercising their full range of functions. The second phase involved field tests with a limited base of consumers. This approach determined the functionality, reliability, security and overall system interoperability.

Because IOP affected several different technologies, there was not a single approach for the cumulative group. Each Project technology area had a unique approach for implementing interoperability. However, some common themes prevailed through most of the Project area, such as Common Information Model (CIM) messaging. Several topic areas implemented Common Information Model compliant messages as a means of communication between systems. By implementing CIM-compliant messaging, a standard message format was defined to exchange information between new and legacy systems, allowing for interoperability beyond AEP Ohio systems. This was part of the back-office strategy for interoperability.

The barriers to interoperable implementation of smart grid technologies consisted of the varying maturity of vendor products. Most Project interfaces were CIM and ANSI standards compliant. The SGDP team submitted applications for CIM standardization for some interfaces.

Overall, the integration of devices into AEP Ohio systems proved to be interoperable. Although the integration processes were manual and required significant effort and end-to-end verification of every data point from the field to the back office, they were successfully implemented. AEP Ohio mitigated resource requirements by using a single communications protocol, limiting device types, and creating internal data exchange standards.

3.7.3 Time of Use Rates

Time-of-use (TOU) rates can provide many benefits to customers and the system. By charging customers different rates at different times of the day, customers can reduce their electric bills by changing their behavior so that they accomplish electric-intensive tasks during times of reduced system demand and lower market prices. For example, a residential customer on a TOU rate may reduce his or her electric bill by running certain energy-intensive appliances at night, when rates are lower. In general, this shifting of energy consumption from periods of high prices and greater system demand leads to a more efficient power system reducing reliance on less efficient peaking capacity and increasing usage of more efficient base load resources. Importantly, the benefits of TOU rates are not limited to the customers who elect these rates. When customers on TOU rates are given incentives to lower their usage during times of peak system demand, this reduces demand for the entire system. That can turn into lower capacity costs for all customers.

The AEP Ohio's gridSMART® Demonstration project conducted a TOU trial and offered trial customers two TOU programs: SMART Shift^{SM} and SMART Shift Plus^{SM}. SMART Shift^{SM} offered 2-tier pricing with no equipment requirements. Customers were informed of the rates during each of the tier pricing periods and allowed to make their own choices to shift their energy usage to take advantage of the tier pricing. SMART Shift Plus^{SM} offered 3-tier pricing as well as an in-home display (IHD) to provide real-time energy use information and feedback from AEP Ohio on current energy pricing and an optional programmable control thermostat (PCT) which allowed automatic scheduled adjustments to the thermostat settings for heating and cooling. In addition, SMART Shift Plus^{SM} could have up to 15 critical peak pricing events per year, each lasting up to 5 hours. See Table 2 below for details.

Rate Level	Hours
Low	Midnight - 7 a.m. 9 p.m. - Midnight And Weekends
Medium	7 a.m. - 1 p.m. 7 p.m. - 9 p.m.
High	1 p.m. - 7 p.m.
CPP	As called - up to 5 hours each event and up to 15 events per year

Table 2: SMART Shift Plus Pricing Tiers

AEP Ohio learned a great deal about customer acceptance of TOU during this trial and made this information available to the PUCO and to the public in the final technical report.[9] The GridSmart® phase 2 project laid out a TOU Transition plan to allow CRES Providers to offer TOU Rates. AEP Ohio will continue to work with the stakeholders to determine the next steps in this process.

3.7.4 Electric Transportation

The electric mobility revolution is continuing to accelerate throughout the world. This transformation is important to enable the sustainable economy of the future as increased EV adoption promises substantial benefits to consumers, ratepayers, utilities, the environment, and economic development for communities. It will also have substantial impacts on many major industries, including the electric utility industry. As EV adoption increases, it will present both challenges and opportunities for AEP Ohio, such as the potential for substantial increase in customer electricity consumption and demand, a need to manage operational grid impacts, and a new frontier of engagement with customers.

AEP Ohio is uniquely positioned to support our customers' adoption of electric transportation. We are working to identify and deploy technologies, solutions, and programs to meet our ultimate objective: Increasing adoption of electric transportation in our service territory and providing charging options that optimize the use of the grid for the benefit of all customers. This effort will require engagement in multiple areas, including our internal fleet transformation, customer outreach and education, encouraging off-peak charging, increasing public infrastructure, and engaging with our legislative and regulatory stakeholders to ensure equitable opportunities for all customers.

AEP Ohio's initial engagement with EVs began a decade ago under the Smart Grid Demonstration Project. As part of that project, AEP Ohio deployed 36 electric vehicle supply equipment (EVSE) charging stations. Thirteen 120V electrical outlets were installed among four workplace locations for Level 1 (L1) charging. Additionally, 23 Level 2 (L2) EVSEs were installed in a combination of residential, workplace, and public locations. The L2 EVSEs had technology embedded to collect charging data and that data was collected and analyzed. AEP Ohio also collaborated with the Electric Power Research Institute (EPRI) to implement an onboard vehicle data acquisition system to gather vehicle performance information on the EVs for both charging and driving events.[10]

At the time of this project, adoption rates of EVs were not at a point where they appeared to have a significant impact on transformer loading. Adoption rates are now increasing at a substantial rate. Additionally, the charging rate (kW demand) at which the majority of EVs charge has increased. And EV adoption is often geographically clustered, so grid

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[9] U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid Report Volume III: Decision Guide (June 28, 2017) (DOE Report Vol. III).

[10] U.S. DOE, Office of Electricity Delivery & Energy Reliability, Modern Distribution Grid Report Volume III: Decision Guide (June 28, 2017) (DOE Report Vol. III), pp 261-262.

impacts will occur in areas with higher adoption rates. All these factors are ongoing considerations for the utility. AEP Ohio must maintain the distribution system to meet the needs of an expanding EV marketplace. We are uniquely situated to manage impending demand impacts on the grid. AEP Ohio can optimize existing fixed grid assets by managing load impact by offering our customers options and rates that encourage the efficient use of the grid, while improving reliability and resilience. These efforts can also be integrated with ongoing grid modernization activity.

Lack of charging infrastructure is a critical barrier to the electrification of transportation. Policymakers can utilize the inherent and unique attributes and capabilities of regulated electric utilities to help jumpstart and support development of EV charging infrastructure. Currently, AEP Ohio is implementing an incentive program launched in August 2018 to rebate business customers 80 to 100% of the eligible costs to deploy publicly available DC Fast Chargers and 50 to 100% of Level 2 Chargers. This program requires deployments to be networked and will make data about charging patterns available for analysis and reporting for four a four-year term. AEP Ohio believes that the current program is a great first-step in helping to support EV adoption by supporting EV charging deployments with our customers. To build on that foundation, AEP Ohio aspires to continue to support needs of our customers as they continue to adopt electric transportation options at an increasing rate.

Specifically, AEP Ohio aspires to engage more fully with customers to provide residential and workplace charging options, as this is where the majority of EV charging occurs, and where optimizing charging with the grid is most relevant.

Also, EV corridor charging is critical to address range anxiety issues of drivers and support greater EV adoption. Based on previous discussions, EV corridor charging planning calls for a coordinated approach and must include regional planning agencies such as ODOT, OEPA, MORPC, and COTA, as well as other stakeholders that are focused on public EV charging initiatives (e.g., Electrify America, etc.) to ensure that we achieve customer-focused and viable solutions to best design long-distance electric transportation routes. As a result, AEP Ohio has been exploring the possibility of building DC fast charging stations to support these needs.

AEP Ohio looks forward to the opportunity to discuss with the Commission and interested stakeholders ways that we can continue to support the electric transportation market to achieve positive outcomes for all.

3.7.5 Micro Grids

A microgrid is a small-scale power grid that can operate independently (called “islanding”) or in conjunction with an area’s main electrical grid. The critical components of a microgrid are an energy storage system and smart controls that can island the microgrid and keep power flowing within the microgrid using energy stored in the energy storage. Microgrids sometimes also include small-scale generation such as solar arrays, wind turbines, or small gas-fired generators that can supplement the energy and capacity provided by energy storage systems during islanding.

In normal conditions, a microgrid is interconnected to the electric distribution system and operates as a part of that system. During normal conditions, critical facilities on a microgrid will be served by a mix of energy from the distribution grid and energy from the energy storage or small-scale generation installed as part of the microgrid. The microgrid may also back feed energy over the grid, serving other loads. When there is an outage on the distribution grid, however, the microgrid's smart controls will island the microgrid from the wider distribution system. When islanding, the microgrid's smart controls will use the microgrid's batteries and small-scale generation to keep electricity flowing to the critical facilities within the microgrid. When service is restored to the grid, the microgrid will revert to the standard interconnection with the distribution system.

AEP Ohio anticipates that locations for microgrids would include critical community assets such as fire and police stations, medical facilities, social service agencies, emergency shelters, water and sewer infrastructure facilities, grocery stores, and gas stations. Site selection factors may evolve over time but should include the following:

- Criticality of the customer loads that would benefit from the microgrid deployment – for example, whether the load is a hospital or public safety building.
- Amount of customer load (size, type, etc.)
- The amount of existing backup generation already available for the customer loads
- The historic reliability of the circuit serving the customer loads (i.e., 3-year average SAIDI)

Microgrids provide numerous customer and societal benefits:

1. Improved resiliency and reliability for critical infrastructure. The primary purpose of a microgrid is to maintain electric service to critical facilities during outages. Extended outages are possible due to severe weather events. By placing critical facilities such as police and fire stations, disaster shelters, other health and safety facilities on microgrids, power can be maintained during outages to provide emergency services and to support the wider population during extended outages.

2. Reduced system peak demands. Microgrids can also reduce peak system demand by using energy stored in energy storage system and from small-scale generation to serve the microgrid load during peak hours. Reduction in peak system demand can lead to cost-saving system benefits.

3. Integration of intermittent renewable generation. One of the most significant obstacles to the deployment of renewable generation is the fact that solar, wind, and other renewable generators are generally non-dispatchable. Whether the generator can provide power to grid or not depends upon the weather. Microgrids help address this problem – and thereby promote the deployment of renewable resources – by incorporating energy storage in an integrated system with renewable generation. Using smart controls, the microgrid can use its renewable generation to recharge its energy storage system or feed power back to the grid during times of peak renewable power generation; but, critically, it can also draw on its energy storage system to augment its power needs during times of diminished renewable generation.

4. Clean energy generation and reduced emissions. Additionally, because they use renewable generation with an energy storage system, microgrids provide significant environmental benefits and can be used for compliance with renewable portfolio standards and environmental regulations targeting greenhouse gas emissions.

5. Ancillary services. Microgrids can also help meet ancillary requirements (i.e., load following, spinning reserves). Energy storage systems can quickly increase and decrease energy output, allowing them to compete in the ancillary services market. Utilizing an energy storage system, microgrids can provide both demand response and, potentially, ancillary services to the PJM market.

Although there are third-party vendors that install private microgrid systems, these private microgrids are installed behind the utility meter and benefit a single customer. AEP Ohio does not believe microgrids deployed by EDUs compete with private systems, but instead offers a different product: A utility-owned microgrid installed in front of the meter. Such utility owned microgrids place multiple customers on the same microgrid and interact with the utility's distribution grid in ways that private microgrid systems cannot – for example, by integrating with the utility's distribution system to maximize the benefits of demand response and sectionalizing.

3.7.6 Smart Lighting

Street and area lights are one of the most common outdoor improvements seen throughout the AEP Ohio service territory. They increase safety for AEP Ohio's customers when utilizing all forms of transit and are proven to reduce crime in areas where they are present and functioning.[11] The current street and area lights owned by AEP Ohio utilize high pressure sodium vapor (HPS) and metal halide light fixtures and are controlled by rudimentary photocells. These technologies are less energy efficient than what is available on the market today and are also costlier to maintain.

Currently, AEP Ohio relies on routine maintenance by field workforce, as well as customer calls, to identify and replace lights that are no longer functioning. Smart Lighting Controls automatically send notifications over a two-way communication system, so that a utility, such as AEP Ohio, is instantly aware of any lighting issues and can respond accordingly before a customer concern arises. These Smart Lighting Controls also enable considerable functionality enhancements and energy efficiency advantages, including more granular lighting-level control based on a wider variety of scenarios. Light-Emitting Diode (LED) lighting fixtures use significantly less energy than current legacy fixtures, while providing the same or greater lighting intensity (as measured in lumens). The light

[11] Painter, Kate. "The influence of street lighting improvements on crime, fear and pedestrian street use, after dark." Landscape and urban planning 35.2 (1996): 193-201. Smart Lighting Controls and LED Technology

quality of LED lights also provides greater visual clarity resulting in increased safety to the public.

If AEP Ohio were to deploy Smart Lighting Controls on company-owned street and area lights, it is possible to realize additional operational and energy efficiencies, while providing increased safety and security to the public and its employees. AEP Ohio would also consider further efficiency gains by upgrading a subset of these lights with LED fixtures to demonstrate the considerable energy efficiency potential of LED lighting for company-owned assets.

Smart Lighting Controls and LED lighting enables optimized operation and energy efficiency using two-way communications technology. The following benefits are anticipated through Smart Lighting Controls and LED lighting deployment in the DTIP program:

1. Safety and Security. Street and area lighting provide a valuable public benefit through the reduction in crime and increase in road safety that they provide. Through the deployment of Smart Lighting Controls, AEP Ohio would automatically be notified of any gaps in lighting coverage that would otherwise impact safety and security in the affected area and be able to schedule prompt replacement where required. As a result, the public safety benefits of company-owned street and area lights will be consistently maintained, and customer satisfaction will increase from this improved maintenance capability.

2. Energy Efficiency. Smart Lighting Controls provide several functions that can increase the energy efficiency of company-owned street and area lighting. When combined with the benefits and complimentary functionality of LED light fixtures, energy savings of up to 80% can be achieved in certain use case scenarios. Existing street light controls cannot alert when there is a malfunctioning light fixture that remains on during the day. These 'day burners' lead to increased costs for all lighting customers by wasting energy and contributing to peak demand. Smart Lighting Controls can automatically send an alert for these types of malfunctions. While AEP Ohio would not immediately use some of the Smart Lighting Control functionality, these controls also enable diming and seasonal timing, such that company-owned street and area lights can be dimmed or turned on/off based on ambient mood lighting, vehicle/bike/pedestrian activity, and other environmental factors. Additionally, because LED light fixtures typically provide brighter light than current legacy fixtures, LED fixtures can be dimmed to further reduce energy consumption, while still maintaining the same level of lighting coverage.

3.7.7 Next Gen Utility Communication System

A workforce Communication System is critical to the day-to-day operation of a distribution grid. It provides a reliable voice connection for Company employees and contractors to perform their duties safely and efficiently in the field. The current Communications System operated by AEP Ohio, known as the Enhanced Digital Access Communication System ("EDACS"), has progressed beyond its operational life causing outages that create a substantial disruption in operational activities. EDACS can no longer consistently meet the requirements of a utility-grade Communications System to maintain the safety of employees and to help ensure the reliability of the distribution grid during emergencies and natural disasters.

A deployment of reliable voice and data communications in the field with the NextGen UCS will enable EDUs like AEP Ohio to achieve additional operational efficiencies, while providing increased safety and security to the public and its employees.

The NextGen UCS enables more streamlined operations and grid reliability by combining voice and data communications with a redundant infrastructure. The following benefits are anticipated through NextGen UCS deployment in the DTIP program.

1. Improved Workforce Efficiency. The dual voice and data communications capabilities of the NextGen UCS include new functionality that enables Company employees and contractors to be more efficient. The NextGen UCS allows centralized dispatchers to communicate with many people simultaneously, which will help crews and dispatchers operate more effectively. The increased bandwidth will enable the Company to monitor fleet telemetry, such as vehicle fuel-efficiency, and idle time to increase operational savings. The NextGen UCS may also be used to transmit data from substations with limited data requirements, which can reduce the number of truck rolls needed to monitor these assets.

2. Increased Functionality and Safety During Emergencies. The NextGen UCS infrastructure is designed to provide resiliency and specific functionality for emergency and natural disaster situations. NextGen UCS communication tower sites will maintain several days' worth of standby power and maintain enough bandwidth to support increased communications traffic in emergency situations. These towers are also architected to provide backup redundancy if towers in a different part of the AEP Ohio service territory become inoperable in the case of a storm event or other natural disaster. The NextGen UCS also increases workforce safety by enabling personnel to send a "mayday" signal in the case of a health issue or impending danger. The "mayday" signal sends GPS coordinates to dispatchers so that the nearest appropriate field personnel can respond to the situation. A similar "all call" alert can also be sent by dispatchers to the entire field workforce to notify them of critical situations. Fleet telemetry sent from workforce vehicles over the NextGen UCS can also be used to promote safe driving behavior and eliminate inefficient driving behavior.

3. Cybersecurity. The NextGen UCS ensures that the communications of the Company workforce and data sent from the field are secure and protected from access by unauthorized individuals. This system satisfies the AEP Ohio cybersecurity standards.

3.7.8 Distribution Security Technology

In 2009 AEP's Smart Grid Demonstration Project, Lockheed Martin collaborated with AEP Ohio to develop the Palisade™ suite of tools based on the intelligence management approach. Palisade enabled cybersecurity analysts to manage alerts, detections, mitigations, and courses of action in a single application. This centralization of investigative activities greatly reduced the amount of time analysts needed to filter through noise. These tools allowed analysts to focus their time on extracting actionable intelligence and using this intelligence to detect active threats on the network.

The team launched a threat and information sharing portal to foster a secure environment allowing the sharing of cyber threat intelligence among the utility industry, this has been fully incorporated into the ES-ISAC (Electric Sector Information Sharing and Analysis Center).

During the 2009 Smart Grid Demonstration project, further issues were resolved with updated meter management software. The cybersecurity team determined that there was a need for a recurring assessment of network security due to the continually evolving environment with the addition of new devices, updated firmware, and updated software. This process has continued.

AEP Ohio has embraced these core security components and lessons gleaned from the trial as integral parts of the cyber-physical platform, implementing security at all levels including: physical infrastructure (e.g. wires, transformers, switches), advanced protection and controls, sensing and situational awareness, operational communications, and planning tools and models (e.g. DERs & load forecasting, power flow analysis). The resulting cyber-physical platform is the foundation needed to support applications associated with an operational markets platform, which will be driven, in part, by evolving state policy objectives on grid modernization. These technologies and approaches will be part of the "uniform platform" for the state of Ohio. This will allow for a standard environment for adding additional technologies to improve and expand market opportunities regardless of service territory.

From AEP's Corporate Accountability Report – New threats and security risks for the electric power grid are constantly emerging as we continue to connect a greater variety of internet-connected devices also referred to as the Internet of Things (IoT). This includes sensors, routers, drones and smart devices that are essential to a modern grid, 24/7 business transactions and data transfers. New mobile apps and services that we develop or procure for customers and increasing reliance on cloud-based programs will increase external connectivity to our network, creating new entry points for potential attackers and posing new challenges for grid security. It is up to each utility to be prepared to contain and minimize the consequences of cyber and physical security incidents.[12]

We recognize that technology is rapidly changing and that we must keep pace to stay relevant with customers, modernize the grid and become more efficient in our work. But the fact remains that the growth of smart energy devices, which are increasingly decentralized and interconnected, create more entry points for threats to cause harm. Breaches can come from anywhere, even a trusted contractor connecting to the AEP Ohio network. We've put a new security access program in place to monitor and manage these connections while providing controlled access that allows us to get our work done. And, we have a new procurement policy prohibiting the purchase of anything that requires connecting to the network without first following steps to protect the system. We are

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[12] 2018 AEP Corporate Accountability Report, https://www.aepsustainability.com/

proactively considering possible ways attackers could breach our systems and preparing for recovery if it occurs through policies, procedures and technology, as well as educating our workforce about the growing threat.

AEP Ohio learns from and takes actions based on real-world scenarios. Our Defense in Depth approach to cyber and physical security allows us to deal with threats in real time. These strategies include: monitoring, alerting and emergency response; employee education; forensic analysis; disaster recovery; and criminal activity reporting. We also maintain critical partnerships with the public sector, peers and other industries. Through rapid notification and response when attacks and disasters are underway, we can reduce the impact of cyberattacks and avoid or mitigate the damage before the full effect of the threat is realized.

AEP Ohio is gaining insight from a working group established in 2018 to vet IoT technology that would be, or is already, in place to ensure better security against cyber risks. The goal is to align business units with consistent processes and policies to ensure security across the enterprise.

Further, at AEP Ohio the security culture is based on EVERY employee, contractor, and vendor working together to ensure that AEP Ohio is a safe and secure company and taking responsibility to ensure their actions support that mission.[13] AEP Ohio's security best practices are based upon the Cyber Kill Chain, a seven step systematic process to target and engage an adversary to create desired effects based on a U.S. military targeting doctrine, and modified by Lockheed Martin for cybersecurity (see Figure 5.) The Cyber Kill Chain defines the steps of this process as find, fix, track, target, engage, assess threats against AEP Ohio. The Cyber Kill Chain seeks to disrupt the progression of the threat before it can do damage.

[13] "American Electric Power, Enterprise Security Program Overview"", Stanley Partlow, Vice President & Chief Security Officer, AEP, March 20, 2018

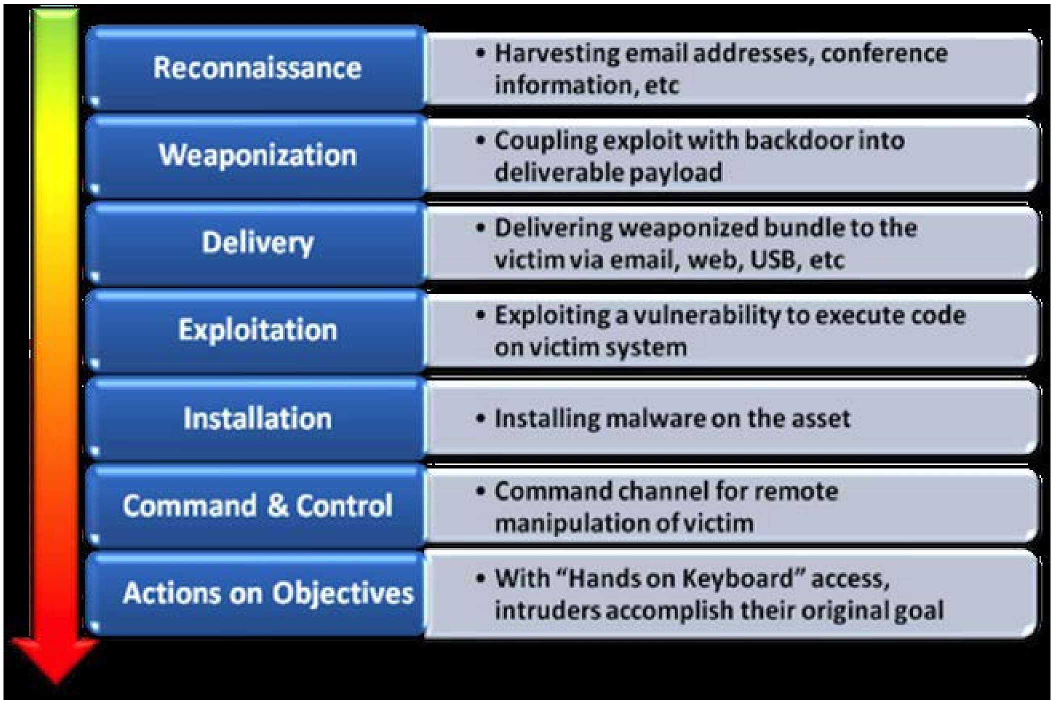

Figure 5: Cyber Threat Kill Chain

Beyond the individual and corporate security awareness, AEP has established a Cybersecurity Intelligence & Response Center (CIRC) (See Figure 6) consisting of a Tier 1 Cyber Security Desk that provides a first level of response to reports of security threats and actively monitors and performs triage on alerts from cybersecurity monitoring systems. After confirming an active threat, it is escalated to a Tier 2 Advance Threat Mitigation Team who works to resolve the problem. In addition to other activities, The Tier 2 team also works to lead cybersecurity incident response and reporting, forensics and electronic discovery in support of HR, Ethics, Legal investigations, performs threat intelligence sharing/collaboration with AEP Business Units, government and industry partners, and compiles and reports metrics pertaining to AEP Ohio's current cyber threat landscape.

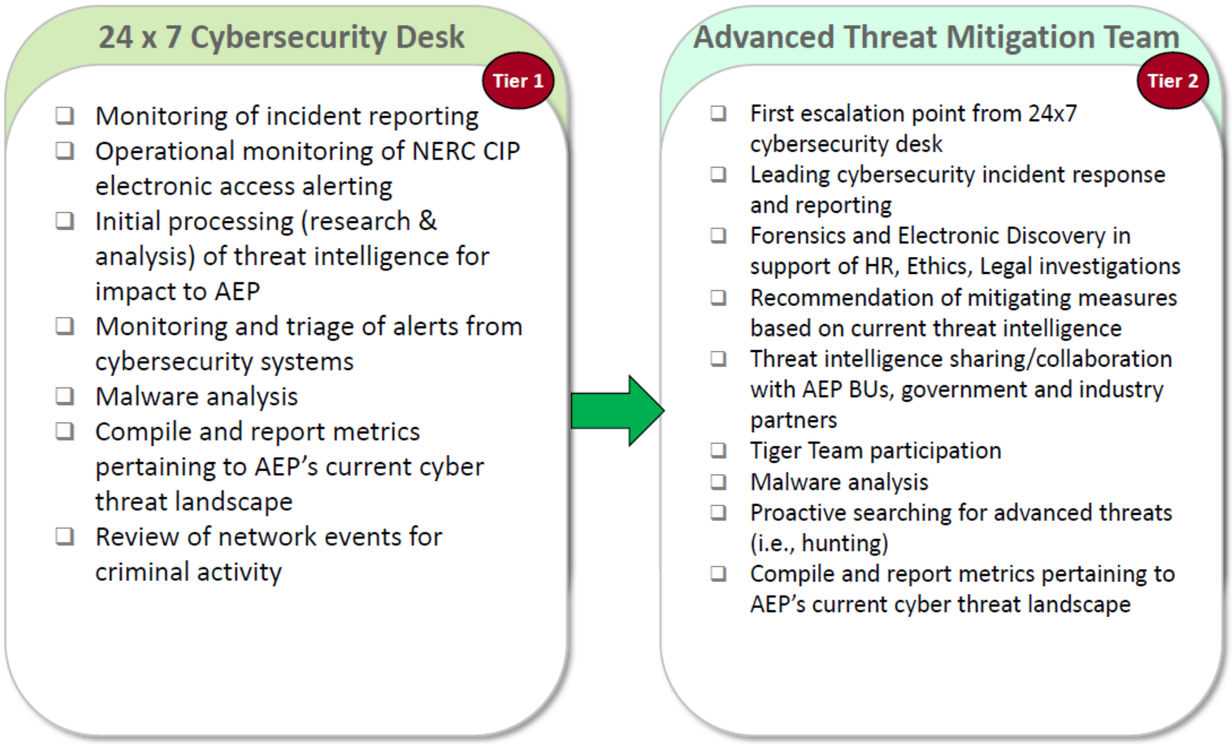

Figure 6:Cybersecurity Intelligence & Response Center

AEP continues to strive to enhance the cyber-physical platform interoperability, security, and consumer protection. AEP Ohio will continue to use the CIRC and dedicated security and privacy experts to review smart grid technologies and equipment to ensure strict standards are met and will continue to place emphasis on building interoperability, security, and privacy into future deployments.

3.7.9 Operational Analytics

AEP Ohio is interested in utilizing the data provided by AMI meters and VVO and DACR sensors to improve the operational function of the distribution grid. While data is valuable to the applications deployed, proper interpretation of the data provides additional uses and applications. The ability to visualize and analyze data on a dashboard or map allows utility operators to visually explore vast amounts of data and quickly uncover insights and relationships that would have otherwise gone unnoticed. Data analytics, when applied to a utility setting, can save both time and money in the form of diagnostic time, truck rolls, and overall outage time. The increasing number of sensors and data points throughout the grid can either create an increasingly precise vision for grid operators, or a jumble of confusing data. AEP Ohio is investing in dashboards to help with analytics. While this is a major advance, this use of data is only a beginning.

AEP Ohio is interested in testing analytics to improve management of the distribution grid and utilize the data to improve asset optimization, outage management, and customer engagement. In addition, advanced analytics may provide insights on how best to accommodate energy source diversification associated with increase in DER interconnection requests. As the amount of DER installations increases, the current power flow models used at the distribution level could benefit from the additional data and analytical products. AEP Ohio's goal is to use advanced data analytics to determine how to keep power reliably flowing throughout the grid in an efficient manner that benefits both the utility and the customer.

Additionally, AEP Ohio is interested in the use of data analytics to improve maintenance. Currently, scheduled maintenance and inspections for grid equipment is expensive and time consuming. Data analytics can save money and increase reliably such as predicting when an asset needs replacing. For example, it is possible to analyze voltage data and determine a pending distribution transformer failure. Analysis at this level would allow AEP Ohio to conduct proactive maintenance and could potentially extend the life existing assets rather than replacing equipment based upon a maintenance schedule that utilizes a calculated asset lifespan. The overall goal is to conduct predictive maintenance in a manner that minimizes outages and provides faster and more proactive customer service.

3.7.10 Sensing and Measurement

The Smart Grid technology that AEP Ohio is currently deploying in the grid includes several new types of sensors that enable not just the primary services such as meter reading, volt/VAR optimization and circuit reconfiguration, but the data provided enables new services. AEP Ohio continues to evaluate new Smart Sensors to enhance the measurement available from the distribution grid.

At the utility level, advanced sensing and measurement tools will supply expanded data to power-system operators and planners. This will include information about the following:

- Power Factor
- Quality of Power Throughout the Grid
- Phasor Relationships (WAMS)
- Equipment Healthy & Capacity
- Meter Tampering & Power Theft
- Intrusion of Vegetation
- Fault Alerts & Location

Software systems deployed with Smart Grid technologies collect, store, analyze, and process the data that the sensors provide. The processed data is passed to the existing and new utility information systems that carry out the many core functions of the business (e.g., billing, planning, operations, maintenance, customer service, forecasting, statistical studies, etc.).

As AEP Ohio defines new requirements to monitor the distribution grid, meters and other measurement sensing points will require updates to collect additional measurement parameters. The architecture of an updated distribution grid must allow for dynamically adding these collection parameters to the deployed meter and sensor configurations without effecting critical services.

Wide-area monitoring, protection and control schemes continue to integrate digital relays, advanced communications and new algorithms in their software controllers. As the system evolves, integration of the data provided by sensors of all sorts deployed within the distribution grid enables the development of additional services and capabilities.

3.7.11 Fiber Optics

Throughout the grid, telecom is the key to developing a smart grid system. AEP Ohio already has substantial fiber optics system deployed able to handle 1 Gbps at the substation and 10 Gbps on the backbone network. Existing substation SCADA network topology connectivity is upgraded from single point-to-point topology to redundant fiber links to multiple locations when construction projects are scheduled for each substation. In addition, AEP Ohio continues to explore additional fiber deployment opportunities.

4 CURRENT STATE AND PLANNING ASSESSMENT

4.1 Ability to Integrate new proposed technologies

Since early 2009, AEP's Ohio operating company has been working on evaluating and adopting Smart Grid technologies. The first effort was the Smart Grid Demonstration Project (SGDP) in an area located in northeast Columbus, Ohio. After completing the DOE Smart Grid Demonstration Project of advanced metering infrastructure (AMI), distribution automation circuit reconfiguration (DACR) and Volt-VAR optimization (VVO), AEP Ohio filed for and began deployment of its Smart Grid Phase 2 project to expand the implementation of AMI, DACR and VVO beyond northeast Columbus to additional locations throughout AEP Ohio's service area. The Smart Grid Phase 2 projects were used to refine the deployment processes and roll these technologies out in large scale.[14] Through these efforts, AEP Ohio has gained extensive experience and demonstrated capability to integrate and adopt new technologies into the Electric Distribution Grid. AEP Ohio is confident in its ability to meet the deployment and integration challenges presented by the PowerForward initiatives of deploying technology to create a modernized grid platform to provide new services and market opportunities to AEP Ohio's customers.

4.2 Strengths

The 10 years of experience in Smart Grid technology deployments under the PUCO approval have provided AEP Ohio's staff with the knowledge and skills necessary to plan, engineer, integrate and execute the deployment of new technologies. During this period, the culture of AEP Ohio has shifted from a legacy Electric Utility provider to a dynamic, innovative work force full of problem solvers. The maintenance, repair and operations teams have gained valuable experience in what it takes to install, operate and maintain new technologies in the field. AEP Ohio employees report they feel it has been an exciting time to work at AEP Ohio and the employees are looking forward to new challenges.[15]

AEP Ohio's customer education programs have led the way in each deployment. Customer education efforts include mass media and social media outreach, public exhibitions of new the technology at fairs, schools and public spaces, (Figure 8) as well as direct mailing information to customers. Further, AEP Ohio has developed a customer web portal and the IT'SYOURPOWER^{SM} phone app (Figure 7) that allows customers to view their usage, opt in for notifications on applications such as high bill alerts, and control smart devices within their home.[16] Every step of the way, AEP Ohio has worked to include the customer in educating and enabling them with the Smart Grid technologies.

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[14] AEP Ohio Grid Modernization Report, March 1, 2017

[15] Feedback from internal survey of AEP employees, February 20-25, 2019

[16] "Data: The Ohio Experience, Advanced Metering Infrastructure (AMI),)", Krystina Schaefer, Chief of Grid Modernization & Security, PUCO, March 20, 2018

Figure 7: IT'S YOUR POWER App and Smart Thermostat

Figure 8: AEP Ohio Smart Grid Community Education Outreach

Most importantly, AEP Ohio's team is constantly striving to improve the planning and deployment capabilities around Smart Grid technologies. AEP Ohio understands the customer benefits these new technologies bring and is currently planning the full deployment of AMI to all customers and continuing deployment of DACR and VVO where it brings improvement to the grid.

4.3 Opportunities

AEP Ohio's experience deploying Smart Grid technologies over the past decade has highlighted the need to upgrade or augment the legacy IT infrastructure. The design of legacy IT platforms could not anticipate all of today's cybersecurity requirements. These systems will continue to be a concern for integration efforts with new requirements to integrate with more potential partners and share customer energy use data. Unfortunately, addressing the legacy IT infrastructure is costly. It may be helpful during ratemaking discussions for stakeholders to explore options and mechanisms to recover future expenditures necessary to address the necessary changes to these software systems.

One issue holding back grid modernization is the unclear definition of whether EDUs can own DER assets. Such narrow definitions of innovative technologies prevent the adoption of key capabilities such as microgrids to provide additional stability and resiliency to the grid. Relying on external partners for such capabilities is inadequate because such a partner does not bear the burden to maintain the grid reliability standards such as SAIFI and SAIDI. This can compromise the reliability of the grid for the customers. In addition, external partners also have divergent financial goals from the EDU that often drive the decision to locate microgrids and DERs in areas that do not contribute to the overall stability of the grid and can, in fact, introduce instability under certain conditions. AEP Ohio endorses the PUCO's consideration to permit EDU market participation behind the meter to provide a market in underserved areas.[17] The PUCO is encouraged to define new rules that encourage designed solutions in an open market to provide improvements to grid stability.

[17] PowerForward, pp 20, 23

4.4 Key Items

4.4.1 System characteristics

AMI coverage

AEP Ohio currently has approximately 1.5 million meters installed throughout its service territory. Of this total, AEP Ohio converted approximately 132,000 meters to AMI in the Smart Grid Demonstration Project. Testing and initial deployment during this trial proved the current AMI technology AEP Ohio chose is capability for urban and suburban deployment areas and the Smart Grid Phase 2 project deployment targeted 904,000 meters that met the criteria of being in relatively proximity to one another. To date AEP Ohio's Smart Grid Phase 2 deployment has installed 640,000 of the additional 904,000 meters planned for a total of 772,000 meters installed. Completion of Phase 2 deployment will bring the total number of installed AMI meters across the service territory to 1,036,000 AMI meters or approximately 2/3rd of AEP Ohio's total meter base. AEP Ohio is not tracking the percentage of load switched to AMI meters during this deployment. Meter deployments for Phase 2 are scheduled to complete by EOY 2019.

AEP Ohio has been evaluating the AMI meter and networking technologies performance to determine how best to serve the remaining customers in more rural areas in the most cost-effective manner possible while delivering maximum benefits. AEP Ohio is planning to file for a new Smart Grid Phase 3 AMI deployment utilizing an AMI solution within the next 3 months. That deployment will replace the approximately 500,000 meters remaining within AEP Ohio's territory with an AMI meters over the next two to three years.

Figure 9: AMI Meter Installations

IDR coverage

The Phase 2 deployment will replace all meter-based interval data recording (IDR) meters with AMI capable meters. However, SCADA circuits augment much of the IDR coverage and data collection. These SCADA circuits will remain in use for the foreseeable future. In addition to the specific IDR meters, all AMI meters deployed are collecting 15-minute interval data. AEP Ohio is in the process of evaluating the benefits and process needed to fold the AMI meter interval data to supplement IDR data in the load forecasts.

For large customers, a web portal that allows C&I customers to access and view their interval data is expected to be available in the Fall of 2019.

Number of SCADA circuits

Please refer to Table 3 below for a summary of Station and Circuit SCADA deployed within AEP Ohio's distribution grid.

Stations	Total
Stations with Active Distribution Circuits in Ohio	525
Distribution Stations in Ohio with at least 1 Active Circuit with SVC	321
Distribution Stations in Ohio with at least 1 Active Circuit with Analog Data	320
Distribution Stations in Ohio with at least 1 Active Circuit with Manual Only	154
Circuits	**Total**
Active Distribution Circuits in Ohio	1610
Active Distribution Circuits in Ohio with SVC	1184
Active Distribution Circuits in Ohio without SVC	426
Active Distribution Circuits in Ohio with Analog Data	1174
Active Distribution Circuits in Ohio without Analog Data	436
Active Distribution Circuits in Ohio with Manual Only	296
Active Distribution Circuits in Ohio with SVC and Analog Data	1157
Active Distribution Circuits in Ohio with Analog Data and Manual Only	4
Active Distribution Circuits in Ohio without SVC, Analog Data, or Manual Only	117
Percentages	**Total %**
Percent Active Distribution Circuits with SVC	73.54
Percent Active Distribution Circuits with Analog Data	72.92
Percent Active Distribution Circuits with SVC and Analog Data	71.8

Table 3: AEP Ohio Station and Circuit SCADA

Number of circuits and substations serving critical facilities

Refer to Table 4: Critical Service Category List (below) for an understanding of how AEP Ohio designates a critical facility. Using this definition, virtually all 1610 circuits and 525 substations serve one or more critical facilities.

Critical Service Facility	Priority
RR Crossings	T1
Traffic Lights	T1
Aviations	T1
Hospitals	T1
Fire Stations	T1
Police Stations	T1
Prisons	T1
Cell Phone Towers	T2
TV/Radio Towers + Station	T2
Water Treatment Plant	T1
Sewage Treatment Plant	T1
Corp of Engineers	T1
Schools	T2
EMS	T1
Government Buildings	T2

Table 4: Critical Service Categories

4.5 Overview of the distribution planning

Please see Figure 10 below for an understanding of the general flow of the planning process. AEP Ohio's Distribution Planning Process is completed annually with a focus on creating the next 10 years planning budget and creating the next 10 years distribution construction plan. The most accurate budget and construction plans are associated with the next 3-5 years. Additional planning cycles may be necessary mid cycle to address new, unplanned requests from large customers. In all cases, the planning process starts with a detailed analysis of the peak season loads for all transformers and circuits for the previous 5 years and plus a forecast for load growth based upon historical trends and analysis of anticipated new customer growth. Load forecast meetings are scheduled with AEP Ohio Operations and Customer Service teams to validate and review forecasted load growth for the areas. During the load forecast meetings block load growth in excess of trended forecast is identified. A new subdivision planned for construction, a new manufacturing facility or a new major chain supermarket would be examples of block growth that would need to be added to the forecast to ensure accuracy.

Load forecasts, estimated costs, and construction plan data is imported into an internally developed planning tool and analyzed by the Distribution System Planning group to produce high level budget plans to address expected load growth for the next 10 years. The tool highlights circuits and transformers that are projected to hit a loading rate of 90% in yellow on the tool, while those circuits and transformers projected to hit 100% are highlighted in red.

Meetings are held at least annually with Transmission & AEP Ohio Operations personnel to review the forecast and the planned construction projects. Plans are reviewed for crossover opportunities and get buy-in from all stakeholders in the plans. Those circuits and transformers identified with high loads are prioritized on the construction list and targeting for construction 2-3 years out so that solutions can be implemented before they hit 100% load capacity. Some of the circuit and station projects are developed and prioritized based on reliability improvements needs in the area.

The Distribution System Planning group develops high level prioritized budget forecasts for these projects and then works with senior leaders within AEP Ohio for allocation of funds for the next 3-5 calendar years.

Distribution Planning Process

1. Planning populates load forecast with the latest peak season metering data.
2. Planning hosts load forecast meetings with AEP Ohio Operations personnel to validate and create a supportable load forecast.
3. Planning reviews load, and reliability impacts to the station and circuit and develop high-level solutions.
4. Where applicable Planning reviews existing Smart Grid deployments, new Smart Grid deployment plans and develops cost effective upgrades, proactive station equipment installation to allow for efficient Smart Grid deployments. This is important to prevent legacy systems from having unplanned outages and more efficient station project construction.
5. Planning develops high-level budget forecasts ...then works with AEP Ohio for allocation of funds.
6. T&D planning hosts meeting to discuss upcoming Transmission and Distribution project work plans to determine any crossover opportunities and narrow down solutions (T&D review).

Figure 10: Overview of AEP Ohio Planning Process

4.5.1 Distribution

All distribution of materials for planning meetings and communications are AEP Ohio internal Confidential only.

4.5.2 Duration

The planning process is a continual process. The Distribution System Planning group publishes initial load forecasts each December with final reviews of proposed projects held in the May timeframe. AEP Ohio is constantly examining forecast overloads and planning projects to mitigate the anticipated deficiencies. The Distribution System Planning group introduces plans to the stakeholders during the April-May timeframe for projects considered for construction during the next 3 to 5-year target timeframe. During these meetings the Distribution System Planning group solicits new input for the next cycle. Following review, the Distribution System Planning group updates the budget to add the approved projects, so the project teams can plan and execute the workplan.

4.5.3 Categories of projects that result from the planning process

The categories of projects that result for the planning process include:

- Substations
- Transformers
- Distribution circuits
- Transmission
- Telecoms
- Infrastructure

2019 Distribution and Smart Grid Capital Investment	% of Total Budget
Substations	17.4
Line Transformers	7.2
Customer Meters	10.1
Distribution Circuits & ROW	48.2
Transmission	0.0
Telecom	12.3
Infrastructure (buildings)	4.7
Total	**100%**

Table 5:AEP Ohio Distribution Work Plan Capital Expenditures

4.5.4 Planning assumptions

Growth rates are based upon load forecasts calculated from the trend analysis performed by a tool developed by AEP Ohio and reviewed with the Operations, Customer Service and local Technicians. These are based upon a 5-year linear aggregated growth rate with adjustments made to account for block load increases brought about by new customers.

Currently, AEP Ohio is evaluating the impact of the DER/DG interconnections on the forecast. To begin understanding the impact of DER/DG interconnections on forecast load growth curves we will need to have production data from the DER/DG in addition to the AMI and Net Metering. Many independent DER/DG projects are planned but later not pursued for various reasons. It is difficult for the EDU to plan its system around projects that may or may not come to fruition.

All AEP Ohio construction design is performed in compliance with the AEP Ohio Distribution Planning guide which defines the distribution planning criteria and the applicable IEEE and AEP Ohio standards for each project and key component considered in the design.

The purpose of the planning criteria is to help distribution planners to determine the most consistent, orderly expansion and reinforcement of the distribution system. AEP Ohio planners use good engineering judgement in evaluating and selecting alternative solutions that provide reliable and economic improvements in service to the customer. The Distribution System Planning group develops final system improvement plans by selecting the alternative that provides the best balance between improving customer satisfaction, economic expansion and available resources. Throughout the process emphasis on safety is paramount. Distribution plans need flexibility in the design process to maximize the opportunity for safe operation and maintenance of facilities and protection of the environment.

Solutions considered during the design process must address distribution reliability, current utilization of affected stations and circuits and which solutions best addresses the problems and provide for planned capabilities. AEP Ohio planners strive to find creative, alternative solutions that can address multiple problems if possible. For example, sometimes it is more cost effective to add a new substation instead of upgrading an existing substation if the location of the new substation solves loading issues on multiple feeders with the added benefit of increasing the reliability of the distribution network. Such an addition to the network also has the potential of making more circuits available for DACR capability.

The Distribution System Planning group considers new Smart Grid technologies such as AMI, VVO, and DACR as part of the normal planning cycle. While their impact on load forecast have yet to be determined, new construction plans take advantage of the benefits provided by Smart Grid technologies when planning capacity and reliability solutions.

4.5.5 DERS and forecasting methods

Customers must submit a standard application requesting interconnection service for all DER systems. Presently AEP Ohio considers DER requests based upon the size of the kW generation of the DER that is requesting interconnection applying OAC Rule 4901:1-22, Interconnection Service. Distribution System Planning services does not directly consider small (25 kW or less) interconnections for load forecasting efforts unless special circumstances warrant that review. Distribution System Planning does consider the impact of smaller DER systems on capacitor, reclosers or switching elements to improve grid stability. Review and approval for most of these small systems is typically within 3-5 business days of the properly completed submitted requests. Most of these systems are approved, installed, and online within a month from the submitted request barring construction delays.

For DER systems with more than 25 kW capacity, AEP Ohio’s Distribution System Planning group reviews each of these applications. Any application that appears to have significant impact would require a special planning study. The length of time to complete the studies and/or any mitigation needed to accommodate the safe interconnection of these DERs varies. These larger DERs and the aggregate of smaller DERs, when significant, are taken into consideration by the Distribution System Planning group during forecast planning of the distribution system.

To date, AEP Ohio has over 2,000 DER/DG systems interconnected on the grid with a total capacity of approximately 230.7 MW. Most of these system (approximately 76%) are small rooftop solar systems (Figure 11) which have a total capacity of approximately 12.5 MW. AEP Ohio is on track to approve and connect approximately 725 new DER/DG systems this year, primarily solar PV systems.

Figure 11: Residential Rooftop Solar dominates DER/DG Interconnect

4.5.6 Organization structure for planning and interconnection

The Distribution System Planning group has 8 full-time engineering personnel. This team drives the planning process and enlist the consultation and help from other departments as discussed in the process overview. The Distribution System Planning group also hires external contractors for impact studies when the normal work load is high. A significant increase in the number and size of DER Interconnection applications would drive the need for additional staffing within the Distribution System Planning group.

4.5.7 Descriptions of existing and planned energy efficiency and demand response programs

Planning efforts were required to launch the deployment of AMI and VVO but an enhanced planning methodology was required for the VVO deployment. AEP Ohio performed an engineering feasibility study which included an analysis showing the benefit-cost ratio of 2.8 on a cash basis and 2.0 on a net present value remained the same even with the additional investment on VVO. The team used an objective data driven approach to prioritize VVO circuits to determine the cost/benefit broken down by distribution circuits and substation to determine the total amount of investment that would be cost effective. AEP Ohio prioritized deployment timelines for selected circuits with OHA determining the implementation plan. AEP Ohio continues to work with OHA and the staff to determine which circuits are prioritized considering the benefit to the circuit in comparison to others and construction/staging considerations.

AEP Ohio is studying whether modifications to the planning process are necessary to use the data collected via AMI, VVO and additional energy efficiency programs to adjust the 5-year planning load forecast. However, since data collected from the meters at the feeder breaker currently supplies the data used in load forecasting, the effect of energy efficiency programs should be reflected to and recorded by the feeder breaker load meters which should reflect any slower rate of load growth on feeders implementing energy efficiency programs.

One undetermined area of potential impact to load forecast would be a high penetration of EV into the private market. However, there are currently no accepted models to predict the market penetration levels required for measurable impact on the load forecast. The immediate impact of EV penetration will be to local Operation and Maintenance as that group will feel the impact to local transformer and circuit infrastructure first. AEP Ohio will monitor and track these Operations incidents help refine the planning process.

To begin fully understanding the impact of DER/DG interconnections on forecast load growth curves we will need to have production data from the DER/DG in addition to the AMI Metering.

4.6 Collaboration

"A collaborative environment is crucial to the IDP process. Collaboration will enable new technologies to benefit the grid, and potentially result in lower implementation costs for beneficial NWAs through effective planning, asset optimization, and maximization of distribution system efficiencies."[18]

AEP Ohio has a proud tradition of collaborating with customers, vendors and utility industry leaders to deliver value for the customers. For example, during the DOE Smart

[18] PowerForward, pp 19

Grid Demonstration Project and into the Phase 2 deployment, AEP Ohio worked closely with several project collaborators including:

- AEP Ohio Energy Efficiency/Demand Response Collaborative
- American Electric Power Service Corporation
- National Institute of Standards and Technology
- The Office of the Ohio Consumers' Counsel
- PJM Interconnection LLC
- Public Utilities Commission of Ohio
- AEP Ohio Smart Grid Collaborative

4.6.1 Future scenarios for customer DERS adoption in Ohio

AEP Ohio is pursuing a demonstration microgrid project in the Columbus Smart City area and may develop others in our service area during the next three years. Although the exact specifications of each microgrid must be determined by the characteristics of the load to be served, AEP Ohio anticipates that a typical microgrid will consist of smart controls, an energy storage system, small-scale renewable energy resource (RER) generation systems and possibly existing non-RER generators sized to meet the load requirements.

4.6.2 Additional Collaborative Future scenarios for customers in Ohio

AEP Ohio has pledged to work with the City of Columbus to modernize the transportation network and reduce carbon emissions in both the transportation and electric power sectors. As part of the Smart Columbus commitments, AEP Ohio has pledged to add up to 300 "level 2 chargers" and 75 "DC fast chargers". To further incentivize customers, AEP Ohio sought and received approval from the PUCO to establish a rebate program for the hardware, network services and installation of the charging infrastructure for those 375 units. Officials believe it is the first approved rebate program for electric-vehicle charging in the Midwest[19]. The program offers incentives for site owners to install charging stations, with 10 percent of the stations to be located in low-income areas to ensure these areas are not left behind[20].

Another collaborative effort could be to work with Central Ohio Transit Authority to install charging stations, allowing them to introduce Electric-powered buses on their CBUS routes. As battery swapping technology becomes standard, a collaborative cost sharing agreement where COTA owned the busses and AEP Ohio owned the batteries and

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19 ColumbusCEO, "Innovation Spotlight: No Company is Making a Bigger Commitment to Smart Columbus than AEP", November 5, 2018, Melissa Kossler Dutton

20 Smart Energy Consumer Collaborative, https://smartenergycc.org/member-spotlight-aep-ohio/

charging/swap stations (Figure 12) would be beneficial to operating costs of the bus as it would spread the cost of the batteries across rate payers and lower the costs of operating and maintaining the buses. A similar collaboration with ODOT would be useful to put rapid charger stations along interstates to enable EV owners to extend the range of their electric vehicles.

Figure 12: Electric Bus with robotic swappable batteries

The technology around EV vehicles are advancing rapidly and solutions to battery range and charging/swapping technology has been significant in just the past few years and all indications are that this trend will continue and accelerate. It is important to begin to plan to meet the consumer and business needs around charging stations to enable wider adoption. The PUCO has the lead in fostering collaboration. Establishing the rules and guidelines governing the roles AEP Ohio and other EDUs follow to participate in collaborative open marketplace of EV charging solutions will determine how quickly the marketplace becomes viable.

4.6.3 Modifications to interconnection standards

To the extent the PUCO establishes working groups defining new interconnection and interoperability standards for DER and microgrid connections to the distribution grid in the future, AEP Ohio will work in a collaborative fashion with interested parties.

5 CONCLUSION

AEP Ohio supports many of the principles and visions outlined in the PUCO's PowerForward roadmap. It echoes many of the principles that the company has advocated for years. As Nicholas K. Akins, AEP chairman, president and chief executive officer stated "AEP is focused on modernizing the power grid, expanding renewable energy resources and delivering cost-effective, reliable energy to our customers. Our customers want us to partner with them to provide cleaner energy and new technologies, while continuing to provide reliable, affordable energy."[21] AEP Ohio is a leader in the implementation of most of the technologies outlined described in the report and desires to implement others.

AEP Ohio has the willingness and expertise to implement the technologies mentioned in the PowerForward roadmap. AEP Ohio firmly believes the PUCO can accelerate the integration of new technologies into the Distribution System platform by enabling the EDU's ability to participate in the renewable generation market. The Company is in a unique position to be able to efficiently integrate utility grade DG into the grid that makes sense for all customers, with the PUCO retaining regulatory control.

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[21] "AEP Ohio's Role in Energy Storage", Scott Osterholt, Director, Grid Modernization, March 7, 2018