Smart Grid System Report

Course Number: EE-02-700

PDH: 3

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I. Overview

This course is designed to provide an update on the status of smart grid deployments nationwide, technological developments, and barriers that may affect the continued adoption of the technology. The report has been reviewed by the Federal Smart Grid Task Force, a group of 11 agencies, chaired by DOE, that meets to coordinate federal smart grid activities and includes representatives from the National Institute of Standards and Technology (NIST), the Federal Energy Regulatory Commission (FERC), and the U.S. Department of Homeland Security.

II. Introduction

The U.S. electric grid is undergoing significant transformation from the introduction of digital technologies, policies encouraging the growth of renewable and distributed energy resources, and increasing engagement of electricity customers and businesses in both managing and producing energy. Large public and private investments made under the American Recovery and Reinvestment Act (ARRA) have advanced smart grid technology deployments, providing real-world data on technology costs and benefits along with best practices. Deployments are delivering results, where we are seeing improvements in grid operations, energy efficiency, asset utilization, and reliability.

The smart grid involves the application of digital technologies and information management practices and is a core ingredient in the ongoing modernization of the electricity delivery infrastructure. The rate of smart grid technology adoption varies across the nation and depends largely on state policies, incentives, and technology experience levels. Today, we see a growing number of utilities that have begun successful smart grid deployments and are now grappling with a new set of technical, regulatory, and financial challenges that mark an industry undergoing change. In many cases, utilities have begun with small-scale tests and pilot

programs before moving to larger-scale deployments to appropriately evaluate the technology and ensure management and regulatory approval for continued investment.

To help characterize the current smart grid environment, this course provides a concise overview of the following:

- **Smart Grid Deployment Status:** Smart grid deployment progress and emerging benefits, specifically in advanced metering infrastructure, customer systems, transmission, and distribution.
- **Cross-cutting Technologies:** Government and industry activities to ensure progress in communications, cybersecurity, and interoperability.
- **Trends and Challenges Shaping Future Deployment**: An evolving understanding of technology costs and benefits, the integration of distributed energy assets and resources, and changing business and regulatory approaches that meet requirements for a more sophisticated, reliable grid involving greater participation by customers and third parties in energy management and generation.

III. Smart Grid Deployment Status

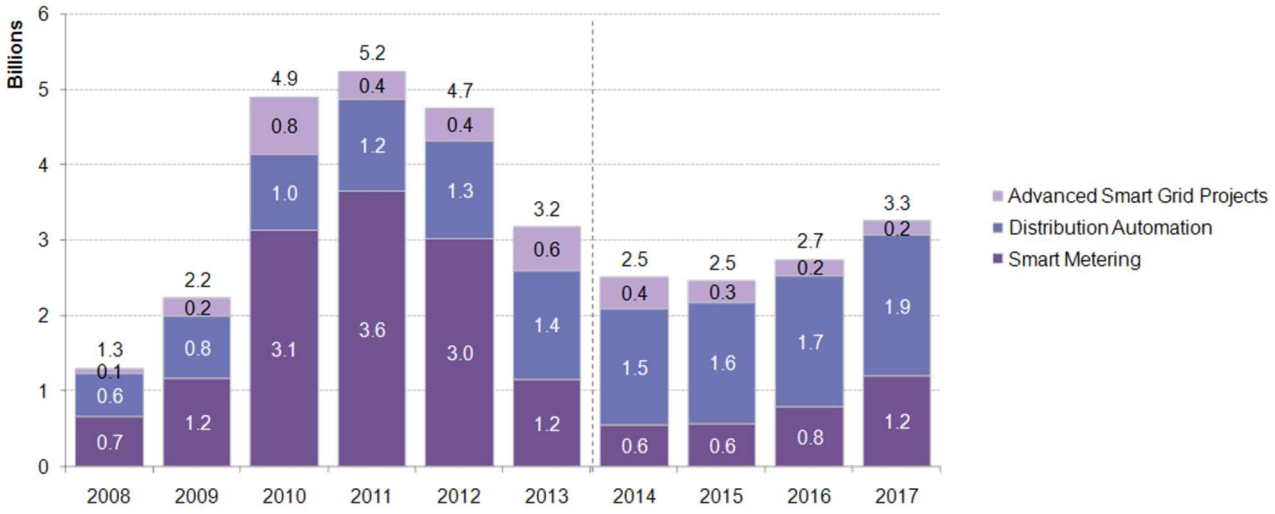
Smart grid systems consist of digitally based sensing, communications, and control technologies and field devices that function to coordinate multiple electric grid processes. A more intelligent grid includes the application of information technology systems to handle new data and permit utilities to more effectively and dynamically manage grid operations. The information provided by smart grid systems also enables customers to make informed choices about the way they manage energy use.

The electricity industry spent an estimated total $18 billion for smart grid technology deployed in the United States during the 4-year period of 2018 through 2021. Smart grid investments under the ARRA accounted for nearly half—approximately $8 billion—during the same time frame.

As shown in Figure 2, annual smart grid spending nationwide hit a high of $5.2 billion in 2011, coincident with peak deployment spending from the cost-shared ARRA projects, and declined toward an annual level of $2.5 billion. The decline in investment is largely due to reduced spending for advanced metering infrastructure (AMI), which was heavily influenced by ARRA funding. However, industry analysts expect annual spending on distribution system smart grid technologies to gradually increase from $1.2 billion yearly to $1.9 billion, with decreased spending down to $1.2 billion) for AMI. In comparison, total capital investments by investor-owned utilities (in 2012 dollars) in electricity delivery systems averaged $8.5 billion annually for

transmission system upgrades and $17 billion annually for distribution system upgrades from 2018–2021.

Figure 2. Baseline U.S. Smart Grid Spending 2008-2017 (Historical and Forecast)



Source: BNEF 2014

Joint federal and private expenditures under ARRA totaled $6.3 billion from the 99 Smart Grid Investment Grants (SGIG), which represent the largest portion of ARRA investments. Between 2009 and 2015, DOE and the electricity industry will jointly invest more than $7.9 billion in the SGIG projects, which involve more than 200 electric utilities and other organizations to modernize the electric grid, strengthen cybersecurity, improve interoperability, and collect an unprecedented level of data on smart grid operations, benefits, and utility impacts (DOE 2013a). In the same time frame, an additional $1.6 billion in cost-shared funding will support energy storage demonstrations and regional demonstrations to assess emerging smart grid concepts (DOE 2014a). Another $100 million in federal funding has supported 52 smart grid workforce training projects in the same time frame.

Estimates of overall spending required to fully implement the smart grid vary. The Electric Power Research Institute (EPRI) estimates that spending of $338-$476 billion over a 20-year period is required to fully implement the smart grid, including preliminary estimates of $82-$90 billion for transmission systems and substations, $232-$339 billion for distribution systems, and $24-$46 billion for consumer systems. The Brattle Group estimates that total transmission and distribution investment may need to reach nearly $900 billion (nominal) by 2030 to meet forecast electricity demand .

To get a more detailed understanding of current smart grid status, the following sections provide an overview of deployment in four key technology application areas—AMI, customer

systems, distribution, and transmission—along with emerging benefits from recent deployments.

Advanced Metering Infrastructure (AMI)

Technology Adoption

AMI encompasses smart meters, the communications networks that transmit meter data to the utility at regular intervals (hourly or shorter), and the utility office management systems (such as meter data management systems) that receive, store, and process the meter data. Usage data from AMI systems can also be sent directly to building energy management systems, customer information displays, and smart appliances. About 46 million smart meters are in place in the United States today (IEE 2013). An estimated 65 million smart meters will be installed nationwide by 2015 (IEE 2012), accounting for more than a third of the approximate 145 million U.S. meters (of all types) in use today (EIA 2013b; FERC 2013). ARRA project deployments will contribute more than 16 million smart meters when they are complete in 2015 (DOE 2013a).

Nearly 75% of AMI installations to date have occurred in only 10 states and D.C., where on average more than 50% of customers now have smart meters (DOE 2013b). AMI investments have been driven largely by state legislative and regulatory requirements for AMI, ARRA funding, and by specific cost recovery mechanisms in certain regions. AMI requires significant investment, and adoption barriers remain for utilities where the business case for AMI is not clear and where prior investments in older metering technology (such as automated meter reading) may present stranded costs. Concerns over meter safety, costs, and consumer privacy protections are being addressed, and enhanced consumer education is a key part of the solution.

Benefits

AMI enables a wide range of capabilities that can provide significant operational and efficiency improvements to reduce costs, including:

- Remote meter reading and remote connects/disconnects that limit truck rolls.
- Tamper detection to reduce electricity theft.
- Improved outage management from meters that alert utilities when customers lose power.
- Improved voltage management from meters that convey voltage levels along a distribution circuit.
- Measurement of two-way power flows for customers who have installed on-site generation such as rooftop photovoltaics (PV).
- Improved billing and customer support operations.

Purchase this course to see the remainder of the technical materials.