***how u.s. government investment in smart grid technologies compares to the estimated spending needed for a nationwide grid***

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## Overview

Many in the electricity industry agree that transforming current U.S. electricity infrastructure to a Smart Grid – automating transmission, distribution, and metering systems – could make electricity quality and delivery more reliable and efficient while saving money for consumers. However, there is a great deal of uncertainty over the cost to develop and deploy a Smart Grid. Many studies predict that upgrading existing U.S. electricity infrastructure will be expensive. A 2004 EPRI report estimated it would cost $165 billion to develop Smart Grid infrastructure through 2020 [1]. In 2011, EPRI updated this estimate to between $338 and $476 billion [2]. A 2008 Brattle Group report estimated that expanding transmission and distribution with Smart Grid capability would cost $880 billion [3]. Recognizing a need for initiative, the U.S. Department of Energy (U.S. DOE) U.S. DOE is assisting to deploy smart grid technology across the United States via the Smart Grid Investment Grant (SGIG) and Smart Grid Demonstration (SGD) programs as part of the American Recovery and Reinvestment Act (ARRA). The SGIG and SGD programs awarded $4.5 billion to more than 140 recipient teams to focus on advanced metering infrastructure, distribution, transmission, equipment manufacturing, customer systems, and cross-cutting projects. With cost share, the programs are worth over $9 billion. The U.S. DOE SGIG and SGD programs will accelerate the modernization of the power grid by investing in technologies that incorporate sensors, communications, and information processing systems and controls. SGIG program participants are reporting costs associated with installing smart grid assets, and this data can gain insight into suitable expectations for Smart Grid development costs. This paper examines major studies of Smart Grid infrastructure cost to understand their predictions, and compares ARRA SGIG spending and expected outcomes to those of the EPRI and Brattle Group studies. The SGIG data presented in this paper is a snapshot of progress through Q3 2011. The program extends through 2015. We expect cost uncertainty to decrease as more data is collected. Readers should bear in mind that this data is preliminary, partial data from the SGIG program.

## Methods

A meta-analysis of anticipated EPRI and Brattle Group estimated Smart Grid costs provide insight into the technologies and infrastructure necessary to develop and deploy a Smart Grid over the next 20 years. By comparing the U.S. DOE SGIG technology portfolio to these studies, we can gain insight into the magnitude of the contribution that the U.S. DOE SGIG program is making to the Smart Grid. Lastly, we can discuss how the SGIG program provides a platform for additional development to create a Smart Grid with two-way communication and automation, making the case for government investment to accelerate technology deployment and enabling advanced services via the electricity grid.

## Results

Our analysis focuses on advanced metering infrastructure (AMI) costs, for two reasons. First, only AMI cost estimation methods were comparable between the EPRI and The Brattle Group studies. Second, the SGIG program technology portfolio did not completely align with the EPRI study technology portfolio because the SGIG program is installing technologies relevant to the state of today’s power infrastructure and the EPRI study technology portfolio focuses on developing an automated Smart Grid by 2030. We compared the EPRI and The Brattle Group studies to understand their methods to estimate the cost of developing a nationwide smart grid, and found that only their AMI analyses are comparable to one another. Both studies examine the cost to develop AMI, whereas their approaches differ when it comes to estimating the cost of future transmission and distribution systems. The Brattle Group study examines cost to expand transmission and distribution systems at historic (2001-2006) rates and costs. The EPRI study does not examine expansion costs for transmission and distribution systems, it estimates the cost to add Smart Grid capability to existing transmission and distribution infrastructure as well as additional expected infrastructure growth (assuming 0.68%/year load growth.) A comparison of The Brattle Group and EPRI AMI cost analyses shows that though both studies examine the cost to deploy AMI by 2030, The Brattle Group assumes lower technology penetration rates and higher costs per meter than the EPRI study. As a result, EPRI and The Brattle Group estimates of AMI deployment costs are $155.1 billion - $419.2 billion, and $19 billion - $27 billion, respectively. The EPRI study assumes an 83% adoption rate by customers, and The Brattle Group assumes that a maximum of 30% of residential customers and 50% of commercial and industrial (C&I) customers will receive AMI. The Brattle Group’s “realistic” assumption of residential customer and C&I customer adoptionrates are 18% and 30%, respectively.

SGIG program participants may have reported their anticipated costs by customer class, but the real costs that they incur to purchase and install meters are not categorized by customer class. The data show the reported meter costs, as of Q3 2011, for 43SGIG program participants. One participant was deemed a statistical outlier and was eliminated from this analysis. In most cases, the participants have not completed their meter deployment but have fully installed a communications system, backhaul, and equipment identified as “other.” The 43 participants are comprised of 13 municipal utilities, 18 investor-owned utilities, and 11 cooperative utilitiesThe average cost to buy and install a is $224 per meter, with a standard deviation of $83 per meter. There appears to little difference in average meter purchase and installation cost by utility type, average meter costs ranges from $219 to $279 per meter. However, costs are most uncertain for cooperative utilities and municipal utilities, due to the smaller scale of their deployments. EPRI residential meter and commercial meter costs are $80-$140 per meter and $120-$500 per meter, respectively. Brattle Group residential meter costs are $300 per meter and commercial meter costs are $1,500 per meter.

We performed additional detailed analysis of EPRI study and SGIG program costs was performed. The EPRI study and SGIG program provide insight into installation costs by meter type. The EPRI study provides a detailed breakdown of installation costs per endpoint– AMI network and backhaul equipment, head end software and integration, and system initiation and management – for which the SGIG program does not have detailed comparison data. The SGIG program lends insight into communication system costs per meter. Based on the EPRI report data, it can be assumed that the communication system costs included in the EPRI study are $10-$40 per residential meter and $1,380-$4,500 per C&I meter. We compared EPRI communication costs to SGIG program communication costs. It appears that SGIG program costs agree with reported EPRI residential communication costs. This agreement reflects the fact that the majority of SGIG program installed meters are residential meters. Besides communication costs, the EPRI study also accounts for backhaul system and “other” costs. The SGIG program has data to compare to both. The SGIG program reported costs to date also provide insight into the cost of AMI backhaul systems. We compared the SGIG program participants’ reported costs to date to EPRI’s reported backhaul costs. The costs are in agreement. The SGIG program also provides insight into the “other” costs associated with AMI deployment. EPRI reports these “other” costs as “various.” The SGIG program provides a detailed look into the considerable uncertainty related to these “other” costs, broken down by utility type. 22 SGIG participants reported “other” costs. No negative costs were reported; the range of costs reported by participants is large. We opted not to extract statistical outliers in order to represent the full uncertainty in the data for the small sample set. Using the AMI asset costs reported by SGIG program participants, we are able to calculate the cost of deploying AMI to adoption levels assumed by the EPRI and The Brattle Group studies. We also calculate cost to deploy AMI according to utility type, and customer class. These comparisons will be presented in our final analysis.

## Conclusions

The U.S. DOE SGIG and SGD programs comprise a very small part of the work needed to develop a nationwide Smart Grid. However, the result of this spending is not trivial. Immediate results of the U.S. DOE SGIG and SGD programs are the installation and deployment of a portion of the infrastructure needed for a nationwide Smart Grid. Longer term decisions made in the public and private sector to deploy additional assets and electricity services could be based on the lessons learned and insights into the economic, environmental, and social benefits gained from this government sponsored deployment.

We are able to estimate AMI installation costs on a nationwide basis using SGIG reported costs. We used these unit costs to estimate the cost to deploy AMI at SGIG program costs observed through Q3 2011. Readers should be aware that the SGIG program continues through 2015, this data represents preliminary and partial results for the program. The data provide detailed insight into the cost to deploy AMI assets, and AMI cost per utility type. The SGIG program results provide additional insight into costs by offering greater detail on cost by utility type, communication system type, and customer class per utility. We summarize these costs in our results, but recommend updating them throughout the SGIG program for greater accuracy.

## References

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