NARUC
National Association of Regulatory Utility Commissioners

Regulator's Financial Toolbox: Advanced Metering Infrastructure - Unlocking Resilience

Brief

The National Association of Regulatory Utility Commissioners (NARUC) Center for Partnership and Innovation (CPI) Regulators' Financial Toolbox series explores the types of financial tools utility regulators can use to support integration of electricity system technologies that benefit the public interest. This brief was prepared by Chris Villarreal (Plugged In Strategies) and Kerry Worthington (NARUC) and is based upon work supported by the Department of Energy under Award Number DE-OE0000818.[1] *The speakers' presentations and recordings can be found at www.naruc.org/cpi-1/electricity-system-transition/valuation-and-ratemaking/.*

On March 2, 2021, NARUC CPI hosted a webinar on Advanced Metering Infrastructure (AMI), featuring opening remarks from moderator Commissioner Talina Mathews, Kentucky Public Service Commission, and presentations from Florida Power & Light, Utilidata, the Connecticut Public Utilities Regulatory Authority (PURA), and Plugged In Strategies. The webinar and this accompanying brief addresses:

- What AMI is and does; and how it may be different than other assets
- Benefits of AMI and typical challenges in the electric utility sector
- Status of adoption and barriers
- Regulatory approaches to considering AMI
- Resources for commissioners and commission staff with more information about AMI

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What is Advanced Metering Infrastructure (AMI)? Is it Different than Other Assets?

The ability of AMI to act as a multipurpose sensor is a new development within utility metering, particularly electricity metering. AMI is typically the combination of two technologies:

The Meter:	A Communication Component:
To measure consumption; often in kilowatt-hours (kWh).	To transmit usage data and other information collected by the meter to the utility over time.

Prior electricity metering infrastructure was unable to read and store grid-related data, and unable to transmit this information to the utility in near-real time.[2] AMI is able to collect significantly more data than prior metering infrastructure; today's AMI can collect and store near-real-time information on kilowatts (kW), kilowatt-hours (kWh), voltage, current, and volt-amps reactive. This information can be used by the utility for purposes such as billing, customer programming, or grid monitoring. With customer consent, data can be shared with third parties to analyze the data and offer new solutions for grid, utility, and customer needs and benefits. As AMI technologies continue to mature, more uses of data are being discovered.

Increasingly, AMI is being viewed as a foundational component of a modern electricity system: as a source of data and a communication network. As shown in the image below, AMI is part of a network of new technologies that are bringing increased visibility and analytics into the distribution system. [3]

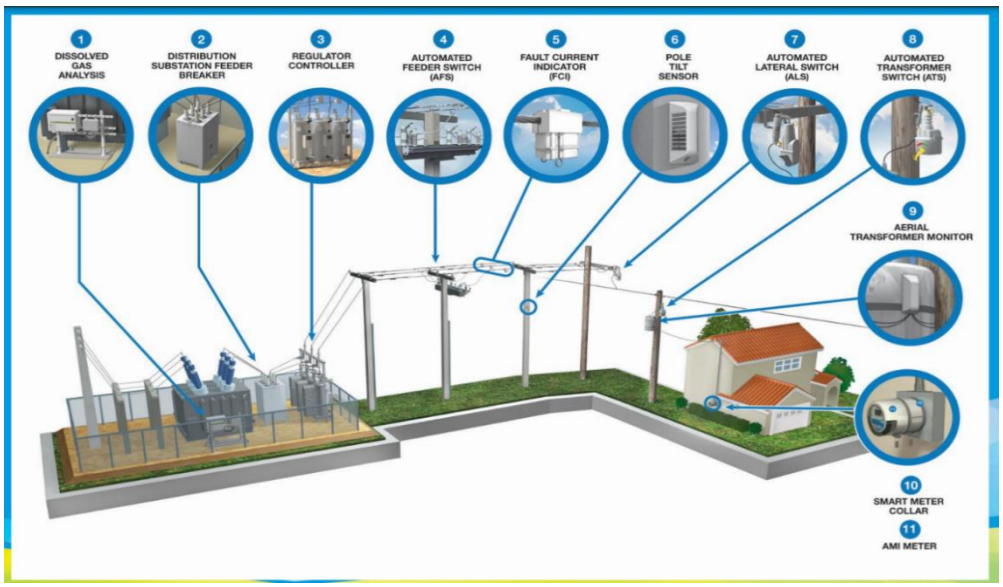

Figure 1. Image of Florida Power and Light technology and communication across its distribution system.

[2] While the focus of this Brief is on electricity metering, AMI is also currently used for natural gas and water metering, but in far fewer numbers.

[3] "Regulators' Financial Toolbox: AMI – Unlocking Resilience," NARUC Center for Partnerships and Innovation, Presentation by Florida Power & Light at slide 7 (March 2, 2021) ("NARUC AMI Webinar"). Available at: https://pubs.naruc.org/pub/869556D6-155D-0A36-3124-1B7A7C5CA2E7.

What does AMI offer to utilities, customers, and the system?

Utility AMI installations can offer a variety of benefits, both to customers and the utility. For customers, AMI can help improve their understanding of their consumption patterns, change how they use electricity to save money, and provide data about impacts from investments like rooftop solar. On the utility side, benefits include being able to read the meter remotely for faster identification of outages and restoration (i.e., resilience), operational efficiency, and increasingly, the opportunity to offer new rate design and customer programs. Overall, AMI helps to build the foundation for a more intelligent distribution system.

Restoration and Resilience: One benefit frequently identified by utilities is how AMI can support better resilience of the utility system. A recent report by the National Institute on Standards and Technology (NIST) looked at the resilience and reliability benefits of AMI across Florida in response to Hurricane Irma.[4] NIST estimates that those areas of Florida with AMI and associated interoperability investments resulted in 112 million fewer hours without power for Florida's customers, which resulted in an estimated savings of $1.7 billion.[5] NIST's analysis shows that the role of AMI, when paired with other investments, provides significant resilience benefits in response to a severe weather event, such as Hurricane Irma. NIST notes that estimating these benefits has been a challenge because other operational benefits may not be sufficiently visible to the public or utility regulators.

Florida Power & Light (FPL) uses advanced technology, including AMI, across its service territory to give the company better visibility into operations of the distribution system. With AMI, FPL is able to restore power faster because FPL knows when and where there are outages. FPL also uses the real-time and predictive sensor capabilities of AMI to better plan necessary repairs before an outage occurs.[6]

Operational Efficiency: Estimates from Utilidata show significant savings when AMI is used to operate the electricity system more efficiently, notably when the utility leverages AMI data into its operations. Utilidata estimates show more than 3% energy savings and peak demand reductions, a 50% increase in hosting capacity, and benefits associated with better fault identification, targeted shutoffs, and leveraging data from AMI.[7] Operational efficiency should improve customer benefits because AMI's sensoring abilities provide greater visibility into the system, can identify anomalies early, and provide the utility and customers with grid-edge solutions and opportunities. AMI is also a key enabler of conservation voltage reduction programs, which allow utilities to run a local system at lower voltages – saving money because utilities do not need to generate, procure, or buy higher levels of electricity to compensate for line losses.

Emerging Operational and Analytical Opportunities: Several utilities have noted that they uncovered new benefits from AMI that were not part of the initial business case presented to the Commission. For example, as an early adopter of AMI, FPL first relied upon benefits

[4] "Quantifying Operational Resilience Benefits of the Smart Grid," NIST, C. O'Fallon, NIST Technical Note 2137 (February 2021). Available at: https://doi.org/10.6028/NIST.TN.2137.
[5] *Ibid.* at p. 2.
[6] NARUC AMI Webinar, Presentation by FPL at slide 6.
[7] NARUC AMI Webinar, Presentation by Utilidata at slide 3.

associated with better billing, such as reductions in estimated bills and better revenue collection. However, over time, FPL identified additional and substantial benefits, such as remote connect and reconnection, using AMI as a platform on which to build new capabilities, and utilizing the data to perform more advanced data analytics and incorporating those results into operations and business practices. Oncor, which is a transmission and distribution utility in Texas, has described a variety of uses and benefits from AMI that were not initially identified in their original business case. Oncor now uses their AMI system to develop System Average Interruption Duration Index (SAIDI) information, provide better asset management and monitor the health of those assets, and conduct transformer load forecasting.[8]

When utilities leverage the data generated by AMI, they can conduct analytics that provide enhanced insight into operations in real-time and over time which can enable the utility to better forecast and operate its system more effectively and efficiently in response to changing customer demands, growth of DER, and aging infrastructure. By using this information, a utility can become more alert to when and where DER show up, better identify and inform its system planning, and provide customers and their agents with additional details about their consumption patterns to right-size technologies and programs for their premises.

Status of adoption and barriers

By the end of 2020, there were an estimated 107 million smart meters installed covering 75% of U.S. households, according to the Edison Foundation Institute for Electric Innovation.[9] Typically, utilities seek approval for AMI investments, in advance, from the utility commission to gain assurance that the costs to implement AMI will be recoverable through rates. A 2020 U.S. Department of Energy analysis of utility AMI proceedings found that some applications included a detailed business case with costs and benefits, some only included costs, some only included benefits, and some did not include costs or benefits.[10]

Several utility applications over the past years have been rejected by regulators. Utah, New Mexico, Kentucky, Virginia, and Massachusetts have each rejected AMI applications from one or more of the utilities in their state. Often, the regulator has stated they do consider AMI as an important component of the future distribution system, but the utility has not presented a complete case with enough detail to give the regulator a sufficient record on which to approve the investment. In essence, the question posed by regulators today is not whether AMI provides benefits, rather, regulators are looking for detailed, strategic plans about current and future uses of AMI.

ACEEE identified a number of barriers to greater approval of AMI applications. In particular, they noted that utilities, as regulated monopolies, have an inherent bias against sharing data with third parties and they do not have an incentive to sell less of their product.[11] ACEEE also identified regulatory barriers such as need for regulators to ensure that the investment has adequate cybersecurity protections, that

[8] Oncor Presentation to Arkansas Public Service Commission (September 4, 2019). http://www.apscservices.info/DER/documents/AMSARKDOEVOE20190906Oncor.pdf

[9] "Electric Company Smart Meter Deployments: Foundation for a Smart Grid (2021 Update)," Edison Foundation (April 2021). https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_Smart_Meter_Report_April_2021.ashx

[10] "AMI In Review: Informing the Conversation," U.S. Dept. of Energy, Advanced Grid Research at p. 25 (July 2020).

[11] "Leveraging Advanced Metering Infrastructure to Save Energy," ACEEE at p. 31 (January 27, 2020).

customer privacy is protected, and that utility costs may be substantial while customer benefits may not be equitable across a customer class.[12]

Additionally, the U.S. Department of Energy (2020) has shown that regulators are looking for more information from utility applications. This information is sought by regulators as they take a deeper look into proposed investment to understand the capabilities of the investment, the potential use cases of AMI, and to ensure that there is sufficient information in the record for regulators to rule upon.[13]

Going forward, gaining regulatory approval of AMI replacements might become even more challenging. Utilities may be prone to focus on realizing operational savings, which accrue more directly to utilities and their shareholders than to customers. The original wave of AMI investments will be coming to the end of its useful life in the next few years. With those original investments already accounting for and claiming utility operational benefits and efficiencies, approvals for AMI will likely be contingent upon newer and broader uses that are articulated with clear visions and objectives (e.g., as part of a new distribution system with greater amounts of DER) and savings opportunities for customers. This situation will require utilities to look deeper into how AMI can provide additional benefits, some of which will directly accrue to the customer or areas not within the utility control, making a cost-benefit analysis more challenging. For regulators, this evolution might mean relying on more hard-to-quantify benefits, including expanded use of data analytics, to justify investment in AMI.

> Due to the dynamic nature of the communication component and phased integration of benefits, the costs for implementing and maintaining AMI are not as straightforward as with previous meters (such as analog meters).
>
> New ways to address the nuance include detailing a cost-benefit analysis, performance-based incentives, and separating the hardware and software cost proposals. Commissions have also opened proceedings to gather information on best practices for implementation.

Related, Utilidata notes that AMI does not easily work within a traditional cost-benefit analysis. Utility perspectives and cost-benefit analyses leverage historical data and may not sufficiently identify and quantify future AMI benefits. To address these concerns, Utilidata recommends that costs for AMI applications be split between the meter and software costs. The meter, as hardware, has a set of costs that are known, whereas software costs will evolve over time. As more advanced analytics enable utilities – and customers and third parties – to have greater understanding of usage impacts on the system, utilities may want to replace software packages more often than expected. Utilidata also notes that performance-based ratemaking could be an option for regulators, which could add rewards or

[12] *Ibid.* at p. 32-33.
[13] "AMI In Review," at p. 11 (July 2020).

penalties for achieving or failing to meet certain targets related to AMI rollout or achievement of future benefits.[14]

Regulatory Process and Examples

Most utilities seek approval by their regulators to install AMI. This process may include the utility providing an estimate of costs and benefits, although this is not always true.[15] Ensuring that the utility provides sufficient details to show costs, benefits, and what the customer can achieve is increasingly an important consideration for regulatory review of AMI, as discussed above.[16]

Kentucky Public Service Commissioner Talina Mathews noted the importance of a utility detailing the uses, opportunities, and a clear identification of costs and benefits (see text box, "Kentucky Snapshot"). When presented with an AMI investment decision from a utility, state commissions are asking for greater information about the applications, akin to justifying an expenditure to the utility's CFO.[17] Additionally, regulators not only want to see specifics about utility benefits, but increasingly, regulators are looking for information on customer enablement and education around AMI. To address this gap, some states have opened broad, generic proceedings to look at AMI, and other technologies, to better understand their capabilities and expectations. For example, Connecticut opened its Equitable Modern Grid initiative, which envisions AMI as a key component of enabling system-wide decarbonization; having a more resilience, reliable, and secure grid; advancing affordability of service; and supporting the

Connecticut Snapshot

Connecticut has a proceeding – Docket No. 17-12-03RE02 – that is considering what level of technical detail is necessary for AMI proposals,[A] how necessary AMI is to support customer actions, what cost and benefit details are necessary to review proposals, and how the utility is planning to integrate AMI with its existing systems. Part of this process included asking the utilities to submit initial proposals for investing in AMI.

One utility has an automated meter reading (AMR) system, so many of the operational benefits around efficient billing and reduction in meter readers, has already been accounted for, so their proposal looks at a combination of traditional AMI benefits (better outage management and restoration) with more advanced capabilities around distributed intelligence.[B]

Connecticut is also looking at the resilience benefits of AMI in the same docket. One service territory tends to have nested outages and is gathering information to better understand how AMI can reduce not only outages, but also nested outages. Nested outages occur when power is restored to a feeder, but customers on the line continue to experience outages (often out of the sightline of a repair crew). They expect that AMI will provide the utility with better information about their customers and location on the distribution system so that nested outages can be avoided.

[A] Connecticut PURA Interim Order at 12.

[B] "Advanced Metering Infrastructure Business Case and Implementation Plan," Eversource Energy, before Connecticut Public Utilities Regulatory Authority, Docket No. 17-12-03RE02 (July 31, 2020). http://www.dpuc.state.ct.us/DOCKCURR.NSF/8e6fc37a54110e3e852576190052b64d/2ea5aad2d7ee96af852585b6005ac03a/$FILE/AMI%20Business%20and%20Implementation%20Plan%20ES%20200731%20FINAL.pdf

[14] NARUC AMI Webinar, presentation by Utilidata at slide 5.
[15] AMI In Review at p. 25.
[16] *Ibid.* at p. 29.
[17] *Ibid.* at p. 14.

growth of a new green economy.[18] Nevertheless, understanding the customer benefits is vital to reviewing and approving potential AMI submissions as discussed above.

What's Next

As resilience continues to be a focus of utility investments and regulatory policy, AMI can play a large role in complementing other resilience actions by utilities. However, to enable resilience, AMI proposals must provide sufficient detail for regulators to understand specifics about utility applications of AMI, the role that data and AMI communication networks play to support resilience, and how customers will benefit.

Kentucky Snapshot

A few rural cooperatives in Kentucky launched AMI programs with smart grid funding through the American Recovery and Reinvestment Act (ARRA). Some of the meters are reaching the end of their useful life and will soon need to be replaced. At the time, benefits proposed to the commission included fewer meter readers and remote connections and disconnections in rural service territory areas. Since implementation, the cooperative utilities have also leveraged AMI for payment programs, such as pre-payment options, and giving customers the ability to check their usage. Some customers have lowered their bills as a result of having such information.

Among investor-owned utilities, one successfully received a certificate of public convenience and necessity (CPCN) for AMI; however, not all utilities have. Common pitfalls among AMI applications have included:

- limited details on the benefits, uses, application, costs, and timeline;
- limited stakeholder engagement;
- limited customer communication and pilots;
- limited regulatory education; and
- limited planning for other regulatory considerations, such as new rate structures, data access and security, costs and life expectancy of the meters and related communication equipment and software, reliability/resilience benefits, and justification of the benefits and costs.

Conversely, one positive example of customer education included a Kentucky utility conducting a pilot that demonstrated to customers that the smart meter was reading the same as the analog meter. In that case, the smart meters were better received by the customers of the utility.

[18] *Investigation Into Distribution System Planning of the Electric Distribution Companies*, Interim Decision, Connecticut Public Utilities Regulatory Authority, Docket No. 17-12-03 at p. 1 (October 2, 2019). http://www.dpuc.state.ct.us/dockcurr.nsf/0/98b91b64d734d3368525848700598fe1/$FILE/171203-100219%20InterimDecision.pdf

Resources For Commissioners and Commission Staff with More Detailed Information about AMI

Resource Name and Publisher	Brief Description	Weblink	Date
AMI in Review: Informing the Conversation U.S. Department of Energy	A goal of this report is to help inform the public, utilities, state commissions, and consumer advocates about AMI, and to help stakeholders understand each other's perspective in order to	https://www.smartgrid.gov/documents/voe_series/voe-ami-in-review-informing-the-conversation	2020
"How many smart meters are installed in the United States, and who has them" - EIA FAQ U.S. Energy Information Administration	This FAQ contains AMI data and links to more EIA-collected AMI data.	https://www.eia.gov/tools/faqs/faq.php?id=108&t=3	2020
Voices of Experience - Leveraging AMI Networks and Data U.S. Department of Energy	The information in this guide came directly from the people in the industry who are deploying the technology, discovering new opportunities, and wrestling with the challenges presented by AMI.	https://www.smartgrid.gov/document/VOE_Leveraging_AMI_Networks_Data	2019
At a Glance: AMI-Enabled Customer Benefits U.S. Department of Energy	This document provides a list of customer benefits enabled by AMI.	https://www.smartgrid.gov/document/DOE_VOE_FS2_AMI_Enabled_Customer_Benefits	2019
At a Glance: How Utilities are Using AMI Beyond Meter Reading U.S. Department of Energy	This document provides a list of operational uses for AMI data.	https://www.smartgrid.gov/document/DOE_VOE_FS2_AMI_Beyond_Meter_Reading	2019
FERC 2019 Assessment of Demand Response and Advanced Metering Federal Energy Regulatory Commission	This report is the Federal Energy Regulatory Commission staff's (Commission staff's) fourteenth annual report on demand response and advanced metering required by section 1252(e)(3) of the Energy Policy Act of 2005 (EPAct 2005). The	https://www.ferc.gov/sites/default/files/2020-04/DR-AM-Report2019_2.pdf	2019
NREL and San Diego Gas & Electric Company National Renewable Energy Laboratory	San Diego Gas & Electric Company (SDG&E®) and NREL are collaborating to evaluate advanced metering infrastructure (AMI)- based controls for grid operations.	https://www.nrel.gov/docs/fy19osti/72334.pdf	2018

Resources For Commissioners and Commission Staff with More Detailed Information about AMI

Resource Name and Publisher	Brief Description	Weblink	Date
Advanced Metering Infrastructure and Customer Systems - Results from the Smart Grid Investment Grant Program U.S. Department of Energy	This report shares key results and benefits from the 70 SGIG projects implementing AMI and customer system technologies, and also documents lessons learned on technology installation and implementation strategies.	https://www.energy.gov/sites/prod/files/2016/12/f34/AMI%20Summary%20Report_09-26-16.pdf	2016
Minnesota Power - AMI Behavioral Research - Final Report Seventhwave Minnesota Power	Minnesota Power's Smart Grid Investment Grant project (SGIG) involved the installation of advanced metering infrastructure (AMI) and explored the application of distribution automation. The project was aimed at improving	https://www.energy.gov/sites/prod/files/2017/01/f34/MN_Power_CBP_FinalEvaluationReport_09302016.pdf	2016
Lakeland Electric - Smart Metering Infrastructure Initiative - Final Report Lakeland Electric	This final evaluation report summarizes results from Lakeland Electric's two-year 3-Period Time of Use (TOU) program called "Shift-to-Save" (STS). Lakeland Electric had undertaken this study as part of a full system wide deployment of advanced	https://www.energy.gov/sites/prod/files/2016/10/f33/Lakeland-Electric-Consumer-Behavior-Study-Final-Evaluation-Report.pdf	2015
Final Progress Report for OE ARRA Smart Grid Demonstration Program U.S. Department of Energy	This report provides an analysis of the business case for the smart grid based on an aggregation of the analyses of the Department of Energy (DOE) Smart Grid demonstration programs.	https://www.energy.gov/sites/prod/files/2016/12/f34/Activity%206%20Report_Public_Version_051415%20FINAL.pdf	2015
Electricity Subsector Cybersecurity Capability Maturity Model (ES-C2M2) U.S. Department of Energy	The ES-C2M2 provides a mechanism that helps organizations evaluate, prioritize, and improve cybersecurity capabilities. The ES-C2M2 evaluation tool allows organizations to evaluate their cybersecurity practices against ES-C2M2	https://www.energy.gov/sites/prod/files/2014/02/f7/ES-C2M2-v1-1-Feb2014.pdf	2014
AMI: Beyond Meter Reading U.S. Department of Energy	This presentation contains five compiled success stories about using AMI data for the smart grid.	https://www.energy.gov/sites/prod/files/2016/12/f34/Session_5_AMI_Beyond_Meter_Reading.pdf	2014
AMI-Based Load Research - KIUC Demonstration NRECA	This report describes the development of the AMI system, the background for load research activities, the sense of accomplishment from the use of the system, and the expectations for	https://www.energy.gov/sites/prod/files/2016/10/f34/NRECA_DOE_AMI-Based_Load_Research-KIUC_Demo_May_2014.pdf	2014

Resources For Commissioners and Commission Staff with More Detailed Information about AMI

Resource Name and Publisher	Brief Description	Weblink	Date
Demand Reductions from the Application of Advanced Metering Infrastructure, Pricing Programs, and Customer-Based Systems - Initial Results U.S. Department of Energy	This report provides initial results from the SGIG projects that are implementing advanced metering, customer systems, and time-based rates to achieve one or more of the following demand-side objectives: (1) reducing electricity consumption during peak periods and (2) reducing overall electricity consumption, or achieving	https://www.energy.gov/sites/prod/files/2016/10/f33/peak_demand_report_final_12-13-2012_0.pdf	2012
Operations and Maintenance Savings from Advanced Metering Infrastructure - Initial Results U.S. Department of Energy	This report presents information about the SGIG AMI projects including the devices and systems being implemented, deployment progress, expected benefits, and initial results.	https://www.energy.gov/sites/prod/files/2016/10/f33/AMI_OM_report_final_12-13-2012.pdf	2012
Advanced Metering Infrastructure U.S. Department of Energy	The purpose of this document is to describe AMI and discuss how it contributes to the achievement of the overall Modern Grid vision.	https://netl.doe.gov/sites/default/files/Smartgrid/AMI-White-paper-final-021108--2--APPROVED_2008_02_12.pdf	2008
Advanced Metering Infrastructure Security Considerations U.S. Department of Energy	The purpose of this report is to provide utilities implementing Advanced Metering Infrastructure (AMI) with the knowledge necessary to secure that implementation appropriately.	https://www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/20-AMI_Security_Considerations.pdf	2007
Distributed Engineering Workstation/Integrated Systems Model (DEW/ISM) National Information Solutions Cooperative, Inc.	DEW provides over 30 applications for analysis, design, and control of electrical and other physical network systems. DEW allows all of its components (data sets and algorithms) to be reused by a new application, allowing new solutions to build on top of existing work. Users can review large quantities of data collected over	https://www.edd-us.com/dew-ism/	

Resources For Commissioners and Commission Staff with More Detailed Information about AMI

Resource Name and Publisher	Brief Description	Weblink	Date
Compendium for AMI in Review U.S. Department of Energy	As part of the analysis of regulatory filings, a database with over 250 relevant proceedings related to AMI deployment, cost recovery, commission rulemakings, smart grid reports, and other topics was developed. The report compiles information from the more than 640 documents that were reviewed.	https://www.smartgrid.gov/document/ami_compendium_compiled	
Recovery Act Reports and Other Materials: Smart Grid Investment Grant (SGIG) Advanced Grid Research	This database contains some of the resources listed in this spreadsheet, but it contains a wealth of information related to smart grids, thus containing bits of information indirectly related to AMI.	https://www.energy.gov/oe/recovery-act-reports-and-other-materials-smart-grid-investment-grant-sgig	2009-2016
Recovery Act Reports and Other Materials: Smart Grid Demonstration Projects (SGDP) Office of Electricity	This database contains some of the resources listed in this spreadsheet, but it contains a wealth of information related to smart grids, thus containing bits of information indirectly related to AMI.	https://www.energy.gov/oe/recovery-act-reports-and-other-materials-smart-grid-demonstration-projects-sgdp	2009-2015