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Load Research White Paper

Developed by AEIC's Load Research Committee
Performance Leadership Sub-Committee

The Role of Load Research in Automated Meter Infrastructure/Meter Data Management Initiatives

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ABSTRACT
Advanced Metering Infrastructure (AMI) and Meter Data Management (MDM) systems are becoming more the standard than the exception in today's utility industry. This paper provides some key points to consider as to how Load Research will not only interact with, but will be integral to extracting the strategic benefits of these systems. The topic of sampling is also addressed and what role it will play in an AMI/MDM world.

Introduction

Many electric utilities are pursuing Advanced Metering Infrastructure (AMI) and Meter Data Management (MDM) initiatives. The primary business drivers for these projects include: the need to address aspects of the Energy Policy Act of 2005 (EPAct), the Energy Independence Act of 2007 (and the state investigations it requires), a desire to promote energy efficiency, and the goal of managing distribution systems more effectively. In many companies, Load Research groups have been actively involved in the development of corporate strategy related to AMI/MDM. In others, Load Researchers have been called into the process after decisions have been made and are being asked to meet major new data management requirements.

This paper presents some background information about AMI/MDM activities, and describes some of the new technologies and processes along with their potential impacts on Load Research. Included are: discussions about the various utility business drivers for AMI/MDM; implications for Load Research sampling procedures; new communications, validation, editing estimation, and meter data management requirements; and some case studies from companies that have initiated AMI and/or MDM projects.

What Are Automated Meter Infrastructure And Meter Data Management?

In order to bring clarity to this AMI/MDM discussion, it is important to define certain terms. There has been some confusion about this topic in the industry, since each interested party has developed their own interpretation of the EPAct requirements and technology options. A set of working definitions for key terms is provided in Appendix A. The industry has not reached consensus about certain definitions, since regulators, equipment vendors, consultants and utility groups each have a slightly different perspective on the actions and investments that should be made to achieve national AMI/MDM objectives. For this paper, the following two statements, which are generally agreed on, will be used.

AMI (Automated Metering Infrastructure)

An AMI system consists of various components and adds value primarily by enabling two-way communication between customers and utilities.

AMI or "advanced metering" is defined as a metering system that records customer consumption (and possibly other parameters) hourly – or more frequently – and that provides for daily – or more frequent – transmittal of measurements over a communication network to a central collection point. AMI includes the communications hardware, software, and associated system and data management software, that creates a network between advanced meters and

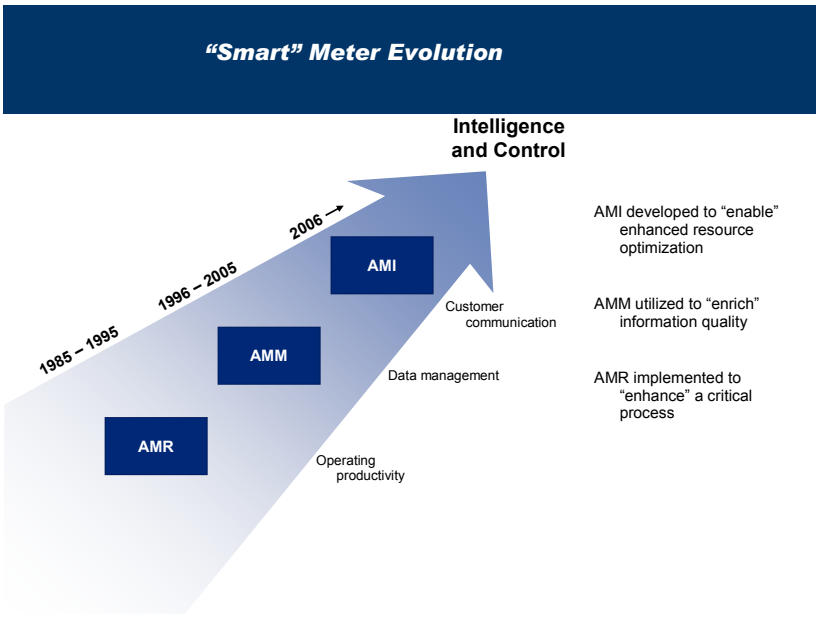
utility business systems. It allows collection and distribution of information to customers and other parties, such as competitive retail providers, in addition to providing it to the utility itself.

MDM (Meter Data Management)

An MDM system is a key component of advanced metering and central to the capturing of the key benefits to be derived from advanced metering. MDM systems provide a database repository that automates and streamlines the complex process of collecting meter data from multiple collection technologies and delivers the data in an appropriate format to a utility billing system. Research Reports International (May 2007). *The Role of Enabling Technologies in Demand Response*, p 39.

The following chart shows the industry's evolution from manual meter data gathering to the emergence of intelligent systems offering a variety of data management controls and improved data gathering and quality.

Chart 1: "Smart" Meter Evolution



Source: Booz | Allen | Hamilton

What Are The Business Drivers For AMI/MDM?

Many utilities have initiated AMI/MDM initiatives in order to comply with current or anticipated regulatory requirements, as well as market drivers (Table 1).

Table 1: Advanced Metering Market Drivers

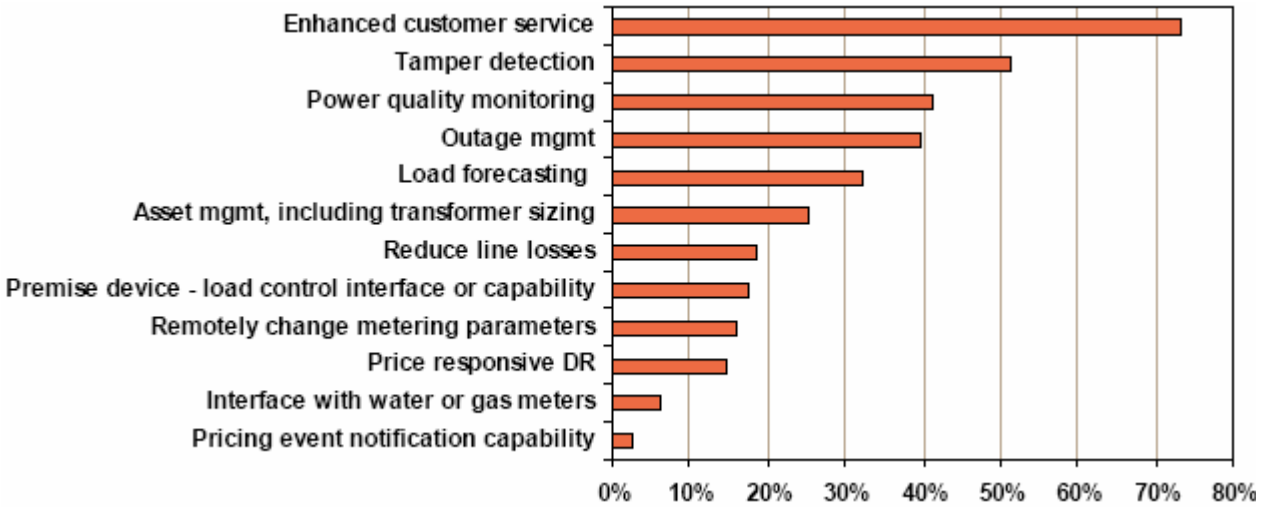
Rank	Driver	1-2 Years	3-4 Years	5-7 Years
1	Energy Policy Act of 2005	High	High	High
2	Changing Mindset of Utilities	Medium	Medium	Medium
3	Reduced Operational Costs of Next Generation AMR	Medium	Medium	Medium
4	Improved Accuracy of AMR System	Medium	Medium	Low
5	Improved Load Forecasting Using AMR Data	Medium	Medium	Low
6	Better Outage Management	Medium	Medium	Low
7	Better Utilization of Human Resources	Medium	Medium	Low
8	Successful Implementation In Diverse Conditions	Medium	Medium	Low
9	Retaining Large-Customers Has Become Top-Priority	Medium	Low	Low

Source: Frost & Sullivan

As mentioned above, there are many different business drivers for these projects, including: the need to address aspects of EPAct, the Energy Independence Act of 2007 (and the state investigations it requires), a desire to promote energy efficiency, and the goal of managing distribution systems more effectively. In addition, there are real business justifications for the significant investments needed to implement wide-scale AMI/MDM (Chart 2). Some business benefits that have been cited are:

- Reduction in labor and O&M costs associated with on-site meter reading
- Increased Customer Satisfaction, which includes:
  - Providing more data online for the customers
  - Improving one-call resolution by providing the Customer Service Representative and account managers current data at their disposal
  - Providing better outage and restoration information
  - Allowing automatic connect and disconnect activities
  - Reduced contact with the customer (by the monthly meter reader)
- Distribution asset savings (transformer sizing)
- Revenue protection and enhancement
- Technology enabled Real-Time Prices, which allow customers to actively manage their electricity costs by changing their behavior
- Automated energy management capabilities, which allow utilities to manage their networks more efficiently
- Increased energy efficiency, which should help reduce the need for network reinforcements
- Targeted demand response programs, which can defer the need for asset replacement.

Chart 2: Reported Uses of AMI Systems



Source: FERC

What Are The Impacts Of AMI On Load Research Groups?

AMI is gaining strength as the new technological platform for utility metering and data collection. Many utilities have begun evaluating the various benefits of this technology and the impact it will have on their current business processes and IT infrastructure. From a Load Research perspective, implementation of AMI systems brings with it the idea that additional customer information will be retrieved and maintained.

A key component of any AMI platform is an MDM system. The MDM is the hub for storing and managing the volume of customer metering data collected by AMI. It will also be responsible for the delivery of this data to the various downstream business functions (i.e.; Billing, Load Research, T&D Planning, EE programs, etc.). In addition, interval data will be available for the majority, if not all, of a utility's metered locations. This influx of data has potential benefits and challenges for Load Research departments. The MDM system is the area of any AMI system that will have the greatest impact on Load Research groups. Having a thorough understanding of the data that is available and how it relates to a particular account, meter, service point, etc. in an MDM system is required for Load Research to effectively access, obtain and utilize this volume of data. Potential impacts and things to consider are:

- **MDM system development** - It is imperative that Load Research groups be actively involved with the development and testing of MDM systems.

- **Validation, Editing & Estimation (VEE)** - Robust interval data management and VEE has traditionally been a unique skill set of Load Research. Does Load Research relinquish this responsibility to the business unit responsible for MDM system operation?

- **Integration with Load Research analysis systems** - Will data be automatically "pushed" to a Load Research group or will there be a user interface to pull data as required? Will additional Load Research employee skill sets be required to interface with the MDM system? How will this impact Load Research's ability to acquire data in a timely manner to support business activities/functions?

- **Data Management** - Some Load Research organizations have their own data management systems. Will the MDM system replace a data management system or will an interface be required to receive data? Will additional resources be required to manage the data for Load Research?

- **MDM System Access** – What, if any, access will the Load Research group have to the MDM system? Because most MDM systems are responsible for providing billing data, there is the tendency to be very particular about who or what departments have access to the system.

These are just a few major impacts to be considered as companies begin implementing AMI systems. For some utilities' Load Research organizations, this will be a simple transition while with others it can result in a significant departmental adjustment to interface with current operation. The relationships Load Research has with IT, Billing, Marketing and other organizations within the company will likely influence the long term resolution of these impacts.

Will AMI Replace The Need For Load Research Sampling?

As advanced metering infrastructure (AMI) becomes prevalent, some have suggested that it will replace the need for Load Research sampling. The theory is that when interval metering is available on 100% of customers, analysis can be performed using data from everyone, so statistical analyses will not be needed. While there may be rare cases where this is feasible, for most cases complete data is not available and statistically representative samples will continue to be the appropriate analysis approach.

The most obvious reason to continue to utilize samples is the simple fact that the AMI system will not cover the entire population of customers. As such, only utilizing data from a portion of the population will introduce a natural bias into your data. For example, if the AMI system does not cover one section of the service territory, simply not collecting data on these customers can skew the view of the population, as customers in a particular geographic area may have very different use patterns than those of other customers in the service territory.

Another reason relates to the amount of data that will need to be manipulated if summation is used instead of samples. Even though Load Researchers pride themselves on the amount of data they are able to manipulate, handling interval data for five million customers for an entire test year may simply be more than the Load Researcher, or the MDM can reasonably deal with. Summation reports are the key, but one must ensure these reports are within the scope of the MDM project. Too often reporting is the first process fatality when projects near completion deadlines and budget cuts.

Sampling is also a cost effective way of estimating customer load characteristics without having to maintain costly data storage and retrieval infrastructure. In addition, AMI/MDM system deployments take several years, so one must consider what you are going to do in the interim. Load Research sampling techniques will continue to play an important role during the planning; deployment; and full operation of AMI/MDM systems. Sampling techniques will also play an expanded role in the measurement and verification of demand-side programs that are enabled by AMI/MDM. Looking towards the future, sampling techniques will play an increasing role in developing demand-side products.

Another, more intriguing, reason to not throw out the statistics books just yet, relates to the end-use studies that will be enabled by AMI. Even if there is no longer a need to statistically sample customer meters, there will still be sampling opportunities around the customer's end-use within the home. As the home area network (HAN) evolves and the end-use measurement devices come down in price, it is possible that Load Researchers will be able to determine the usage profile of various appliances and plug loads within the house. This data, overlaid with customer data, such as the number of energy efficiency measures applied in the home, can begin to provide some real insight into customer usage patterns.

What Communications Protocols Are Being Developed?

While there has been much talk about an "open standard" for AMI systems, that standard will not truly be determined until there is an open AMI system that is commercially available. While the emerging standard communications protocol appears to be leaning toward the ANSI C12.22 protocol, willingness of vendors to adopt this protocol remains to be seen. One issue that remains is how this impacts data acquisition for a Load Research professional. The ultimate goal of Load Research is to obtain complete and accurate data. This could potentially be accomplished through the functionality of the AMI and the MDM system implemented by the utility, making the standard protocol irrelevant to the Load Research professional.

There are many technologies available for communication with meters in the field, including: power line carrier (PLC), broadband over power line (BPL), fixed networks (radio frequency – both licensed and unlicensed), satellite, cellular, and land line. Each of these technologies has advantages and disadvantages for interval data retrieval (however, due to the broadness of the topic, discussion of those advantages and disadvantages is not included in the scope of this paper). It is important that Load Research is involved with the selection and implementation of the utility's AMI system. This isn't always possible so it is imperative that Load Research professionals familiarize themselves with the utility's choice of AMI. Load Research groups should take pains to be involved in the early stages of the utility's AMI development and implementation in order to identify and mitigate potential problems and how they relate to interval data collection.

It is important that flexibility be built into any AMI to accommodate a variety of data collection methods. While the ideal technology would be able to serve any and all end user's specific needs, it is unrealistic to assume that that flexibility can be built into the programming. Most likely, individual users will need to modify some of the programs and data collection methods, after the initial data collection and storage, to meet their needs. In addition, there will most likely remain the need for different data collection methods. For example, while AMI may work in an urban environment, the need for drive by readings may still exist in rural areas.

Due to the need for a variety of collection methods, MDM will play an important role in the distribution of that data. The MDM translates the data into a uniform format, which makes the data more user friendly for all end users. Ideally, the capability to customize aggregation with complete flexibility, combined with sample point information that previously was unavailable, will allow for a more seamless integration with billing and other corporate systems. As is the case with AMI, it is important that Load Research be involved in the early planning stages of MDM design due to the fact that future Load Research needs will need to be anticipated and

considered, including the increased sample population data requiring additional interval data accommodation, the resultant increased storage space requirements and the potential reconfigurations that may be necessary. Load Research needs to ensure that the MDM developers are aware of their potential future needs.

While AMI/MDM may reduce labor and O&M costs in some areas, it may increase costs in others. Although the interval data is readily available, there are costs to analyze it. The data used for the Load Research sample is validated and edited much more diligently than it would be otherwise. While parts of this process are automated and productivity improvements are anticipated, the annual cost to validate and edit interval load data must be considered.

Other costs to consider are computer costs. Computer storage and processing power may be inexpensive, but there is cost involved. Storing interval data for a population of several thousand customers may be manageable with the various software systems available, but AMI may soon be targeted to residential customers, which for many utilities number in the millions.

Summary

Until recently, the terms AMI and MDM were virtually unknown in the utility industry, but they are fast becoming recognized as the "state-of-the-art" in data collection and manipulation. Because Load Research is such a vital part of the utility business, it is imperative that AMI/MDM decision makers consider the needs of Load Research when implementing these complex systems. Meter data from the AMI and MDM systems is just that – data. Companies rely on the expertise of Load Research to translate this data into usable information so both the company and customers can begin to realize the benefits of these very expensive projects.

Load Researchers need to take a proactive role to remain abreast of new technologies the company is investigating and how they might impact their area, including (and especially) an AMI or MDM project. By keeping abreast of management activities, Load Researchers ensure that they will get in on the front end of the decision making process regarding technologies, software and hardware that will significantly impact their areas and ultimately, the company. Load Research plays a key role in the transition process of implementing AMI/MDM systems. Serious consideration should be given as to where Load Research resides within the organization to maximize the strategic value of AMI and MDM systems.

APPENDIX A

AMI/MDM Definitions

(Unless otherwise noted, definitions are taken from Appendix A of FERC's staff report – "Assessment of Demand Response and Advanced Metering 2007")

Advanced Meter (or Smart Meter): - A system including measurement devices and a communication network, public and/or private, that records customer consumption [and possibly other parameters] hourly or more frequently and that provides for daily or more frequent transmittal of measurements to a central collection point. *(Source: FERC-727 and FERC-728)*

Advanced Metering Infrastructure (AMI): AMI or "advanced metering" is defined as a metering system that records customer consumption [and possibly other parameters] hourly or more frequently and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection point. AMI includes the communications hardware and software and associated system and data management software that creates a network between advanced meters and utility business systems and which allows collection and distribution of information to customers and other parties such as competitive retail providers, in addition to providing it to the utility itself.

Automated Meter Reading (AMR): automatic or automated meter reading -- allows meter read to be collected without actually viewing or touching the meter with any other equipment. One of the most prevalent examples of AMR is mobile radio frequency whereby the meter reader drives by the property, and equipment in the car receives a signal sent from a communication device under the glass of the meter.

Fixed Network: A fixed network refers to either a private or public communication infrastructure which allows the utility to communicate with meters without visiting or driving by the meter location.

Home-Area Network (HAN): Network contained within a user's home that connects a person's digital devices, from multiple computers and their peripheral devices to telephones, VCRs, televisions, video games, home security systems, "smart" appliances, fax machines and other digital devices that are wired into the network.

Interval Data: Interval data is a fine-grained record of energy consumption, with readings made at regular intervals throughout the day, every day. Interval data is collected by an interval meter, which, at the end of every interval period, records how much energy was used in the previous interval period. Common forms of interval data include 15-minute data and hourly data.

Meter Data Management Systems: Meter data management provides utilities a place to store meter data collected from advanced meters. Utilities that install AMI usually invest in meter data management to provide storage for the large number of meter readings that will be collected each year per meter. Meter data management can also translates raw meter data into systems, such as billing, customer service, etc., that require meter data transformed in a particular way.

Real Time Pricing (RTP): A retail rate in which the price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity. RTP prices are typically known to customers on a day-ahead or hour-ahead basis.

Smart Grid: Real-time visualization technologies on the transmission level and smart meter and communications technologies on the distribution level that enable demand response, distributed energy systems (generation, storage, thermal), consumer energy management systems, distributed automation systems and smart appliances.

Time-of-use (TOU) Rate: A rate with different unit prices for usage during different blocks of time, usually defined for a 24 hour day. TOU rates reflect the average cost of generating and delivering power during those time periods. Daily pricing blocks might include an on-peak, partial-peak, and off-peak price for non-holiday weekdays, with the on-peak price as the highest price, and the off-peak price as the lowest price.

ZigBee: A wireless network used for home, building and industrial control. It conforms to the IEEE 802.15.4 wireless standard for low data rate networks. With a maximum speed of 250 Kbps at 2.4 GHz, ZigBee is slower than Wi-Fi and Bluetooth, but is designed for low power so that batteries can last for months and years. The typical ZigBee transmission range is roughly 50 meters, but that can vary greatly depending on temperature, humidity and air quality. *(Source: PCMag.com/encyclopedia)*

APPENDIX B

Case Study #1: Oncor Electric Delivery

1. What AMI and MDM components are being implemented?

   Oncor Electric Delivery will be deploying three technologies in its service territory. Deployment of these technologies is being determined by geography and economics.

   a. Power Line Carrier (PLC) is currently being deployed in the rural areas and the areas that are adjacent to the rural areas to give a contiguous technology and to reduce the types of meters in a geographic area. There are currently approximately 400,000 meters deployed. The network is owned and operated by Oncor.

   b. Broadband over Power Line (BPL) is currently being deployed in the Dallas / Ft. Worth metropolitan area. There are currently approximately 35,000 meters deployed. A third party will own and operate the communication network to the meter and Oncor will own the meter.

   c. Radio Frequency (RF) mesh network will be deployed in the fringe area between the BPL and PLC and some cities with large meter counts that will not receive BPL. There are no meters currently deployed. The network is owned and operated by Oncor.

   Oncor has installed (Oct 2006) Energy IP, an MDM system, by eMeter. This system is interfaced with the billing system and will be interfaced with future Outage Management Systems and Distribution Management Systems.

2. What were the key business drivers?

   Prior to the Advanced Meter Rulemaking by the Public Utility Commission (PUC) of Texas the key driver was to use capital expenditures to free-up operation expenditures (meter reading, field service) for reallocation to activities that are closer to the customer (improved reliability and service quality).

   Since the initial deployment (started in 2005), the Texas legislature has passed a law that allows a utility to surcharge for advanced metering. The PUC of Texas passed the Advanced Meter Rulemaking on May 10, 2007 that specified the functionality of the AMI system in order for it to qualify for the surcharge. Some of the basic requirements are:

   a. 15-minute interval data for all non-IDR meters.
   b. Disconnect ability in every meter less than, or equal to, 200 amps
   c. Communication pathway from the Retail Electric Provider (REP) to the customer for pricing signals, pre pay information, load control, etc.
   d. Communications device (ZigBee, Home Plug, etc) in the meter to communicate consumption data and REP communication into the home. Utility does not own the in-home device.
   e. Access through a web portal to provide meter data to the REP and customer and to manage REP communications to the customer.

3. How has the implementation of AMI impacted the Load Research group?

At this time there has been no impact. However, in light of the Advanced Meter Rulemaking, there will be questions that will need to be addressed in the future. Installation of a newly designed sample has just been completed which is expected to be in place for three to four years. Progress toward the requirement of 15-minute interval data for all meters will certainly dictate decisions for sampling and/or census going forward.

4. Have new/different VEE procedures been developed as part of an MDM system?

   All Load Research 15-minute interval data is collected via remote interrogation by MV-90, and all VEE, as well as load data analysis, takes place there, as in years past.

   VEE processing of interval data will be enabled in the next version of the MDM system.

   All non-IDR billing and non-Load Research VEE for mandated 15 minute interval data collection will be performed there prior to presentation to the Meter Data Web Portal for end-use customer and competitive retailer viewing.

   At such time as Load Research or IDR billing interval data is collected via PLC or BPL, the data will first go to the MDM system and then transferred to MV-90. VEE will take place there prior to presentation for billing or use in the load data analysis system.

Case Study #2: DTE Energy

What AMI and MDM components are being implemented?

- DTE will begin deployment of a system wide AMI system beginning in Fall 2008 for all meter locations in both its electric company, Detroit Edison, and its gas company, MichCon. The system will include smart meter installations of over 4 million meters over a five year plan, comprised of nearly 2.8 million electric meters and 1.3 million gas meters throughout southeastern Michigan.

- The AMI system will be a Fixed Network with full ZigBee capability at every site and two way communication using Open Way communication. DTE will own and operate the entire system but rely on third party installers during deployment.

- Energy ICT has been chosen as the new DTE MDM system provider. The new EIServer system will provide a sub-system type environment for Load Research to conduct operations within MDM.

- Load Research is designated a Process Owner for the MDM system and has assisted in the development and testing of the system from inception.

What is the significance of AMI and MDM to Load Research at DTE and what are the expected impacts?

- Load Research will have its own area in the MDM system which is expected to change every aspect of how information will be extracted over the long run. The capability to customize aggregation with complete flexibility, combined with sample point information that previously was unavailable, will allow for a more seamless integration with billing and other

corporate systems. Applications ranging from sample design to production of core business products can be driven by tree structures aggregated by any number of customer characteristics found within MDM and corporate systems. The EIServer application GUI appears to be intuitively obvious, using a similar logic as the familiar directory folder and file tree structures used in Windows and Apple file managers. At this early stage, the MDM environment is not ready to exercise these capabilities but this functionality is expected by year end 2008.

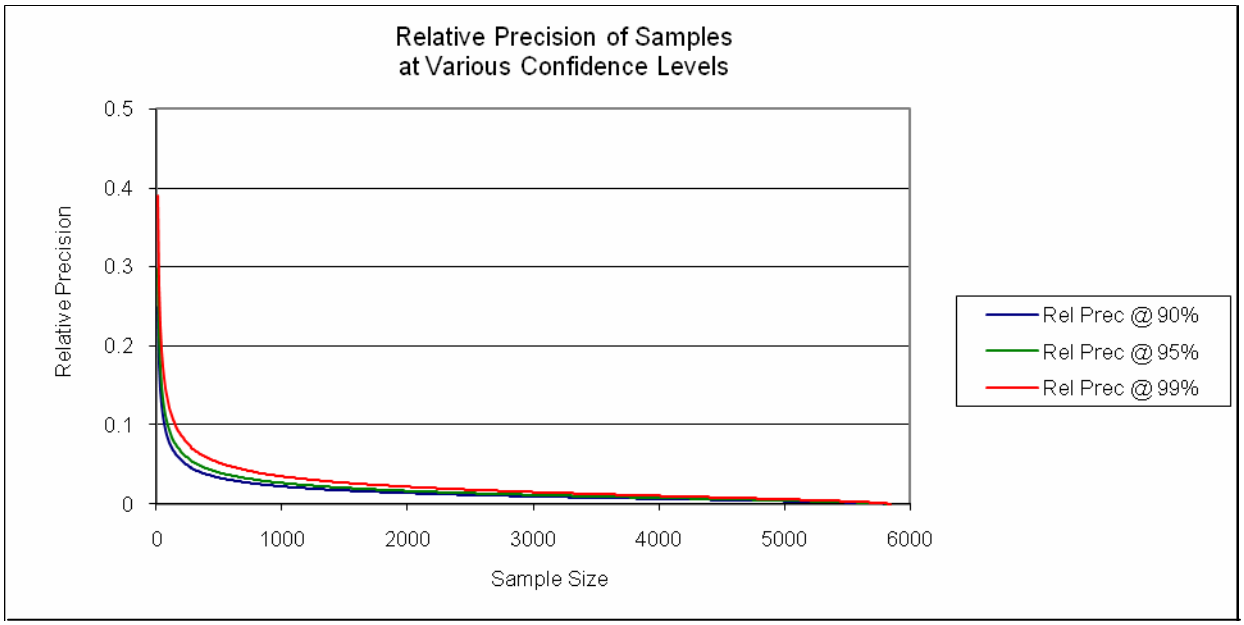
- New MDM system processes are expected to improve data reliability as well as provide additional capabilities to reduce the time needed to recover missing/incomplete interval data. Information such as real-time communication status and sample point information will help distinguish between data collection problem, and legitimate changes in a sample point's status. The goal is to use automated means to be able to verify a customer status against our billing system data mart. Also, checking a meters' communication status can be monitored via provided reports. More experience and training will be necessary to accomplish the automated export of report content and register properties.

- Communication between the MDM system and Load Research applications (API and/or Web Service) is the critical piece to realizing this or any advantage of data integration. Currently DTE is developing the methods and the skill sets required to put this vital link in place.

Case Study #3: We Energies

Use of Samples at We Energies

At We Energies, 15-minute interval data has been collected on all large general secondary customers for over 25 years. There are over 6,500 such customers who consume a minimum of 30,000 kWh per month. A stratified sample of about 150 customers has served well to provide demand allocation parameters for cost-of-service studies. The sample was designed for 90/10 confidence and precision, which means there is a 90% probability that the peak demand estimated by this sample is within 10% of the actual peak demand of the population. The confidence and precision can be improved upon by enlarging the sample, but a point of diminishing returns is quickly reached. The graph below shows the relative precision of various sample sizes for We Energies' large general secondary class at 90%, 95% and 99% confidence levels.



Although the interval data is readily available, there are costs to analyze it. The data used for the Load Research sample is validated and edited much more diligently than it would be otherwise. While parts of this process are automated and productivity improvements are anticipated, the annual cost to validate and edit interval load data is estimated to be at least $50 per meter.

Other costs to consider are computer costs. Computer storage and processing power may be cheap these days, but they are not free. Storing interval data for a population of several thousand customers may be manageable with the various software systems available, but AMI may soon be targeted to residential customers, which for many utilities number in the millions.

In Michigan, We Energies' small customers who choose an alternate supplier may elect to use a normal energy-only meter, in which case their hourly energy is profiled, or they may choose to have an interval meter installed to record their actual hourly energy consumption. Those who choose to have an interval meter installed are charged an extra $75 per month. Much of the additional cost is due to the higher meter cost (which wouldn't apply if a decision is made for other reasons to install universal AMI), but a substantial portion of the cost is due to the data validation, handling and analysis.

For small populations (under a thousand), collecting, validating, editing and analyzing interval data for the entire population may be appropriate to get precise measurements of hourly consumption. For larger populations, however, using the entire population to analyze hourly data will continue to be prohibitively expensive. Furthermore, statistically representative samples can provide sufficient confidence and precision for most applications.

The advantages of AMI include management of the distribution system (such as outage detection and transformer sizing) and customer service (useful for response to high-bill complaints and automatic disconnection and reconnection). Utility management may decide to install universal AMI for these reasons. Replacing statistically representative Load Research samples, however, should not be a reason to install universal AMI.