Case Study: Developing a Smart Grid Roadmap for a Regional Utility Company

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Abstract

WPPI Energy (formerly Wisconsin Public Power Inc.) is a Joint Action Agency serving 51 customer-owned electric utilities in three Midwestern states with annual revenues close to $1/2 billion. WPPI Energy leverages collective buying power for energy purchases and has increasingly started to use its central organizational role for joint actions that obtain synergies and offset costs on behalf of its members. Recently, WPPI Energy established a task-force to examine what impacts developments in smart grid technologies and strategies should have on its operations, as well as on its members. WPPI Energy is in the process of developing a cross-organizational smart grid strategy and roadmap, including impact on its flexible rate plans, billing, customer information systems (CIS), automated metering infrastructure (AMI), and the role that distribution automation (DA) should play, as well as business case considerations for investments in these areas. Due to WPPI Energy's regional nature, interoperability and information security are very important considerations at a number of levels within the future smart grid strategy.

This paper reviews some activities undertaken to develop the roadmap, including assessment of the current situation, looking at best practices for similar organizations, assessing potential technology areas, identifying areas of most potential investment value, and developing a roadmap to guide the path forward.

1. INTRODUCTION

The issues facing today's utility companies are formidable. After operating virtually unchanged since their formation, utilities today need to assimilate new technologies, billing methods, and operational functions in order to meet the existing and expected needs of the industry. At the center of this revolution is the smart grid. While many specific manifestations of the smart grid are yet to be realized, most everyone agrees in its goals. Those goals are to create a more efficient and operationally robust power distribution system that provides new, better, and more timely information to both utility personnel and end customers.

Many large utilities are working to develop and implement a smart grid infrastructure. However, the needs are not limited to large utilities. In order to achieve the ambitious goals of the national smart grid[1] the capabilities need to be ubiquitous. This presents a potential problem for smaller utilities where economies of scale are less favorable to technology implementation and investment. WPPI Energy is a regional utility company structured as a Joint Action Agency (JAA) based in Sun Prairie, WI. It includes as members 50 small municipals and one cooperative distribution utility, referred to below as *distribution utilities*. As such, WPPI Energy represents a microcosm of the needs and issues of smart grid implementation for municipals across the U.S. Implementation of systems across 52 different organizations (51 members and the WPPI Energy organization itself) makes standards and interoperability not only desirable, but absolutely critical for success.

Many utilities list *interoperability* as a desired goal. For WPPI Energy and it member utilities, interoperability is absolutely essential. Without some level of interoperability and interface standardization, the necessary integrations between member utility AMI, CIS, OMS, and other systems into WPPI Energy's centralized meter data management and demand response systems will represent an unmanageable, if not totally insurmountable, integration task. As shown in Figure 1-1 below, without some form of interoperability strategy, the potential number of individual systems integrations could quickly become unmanageable.

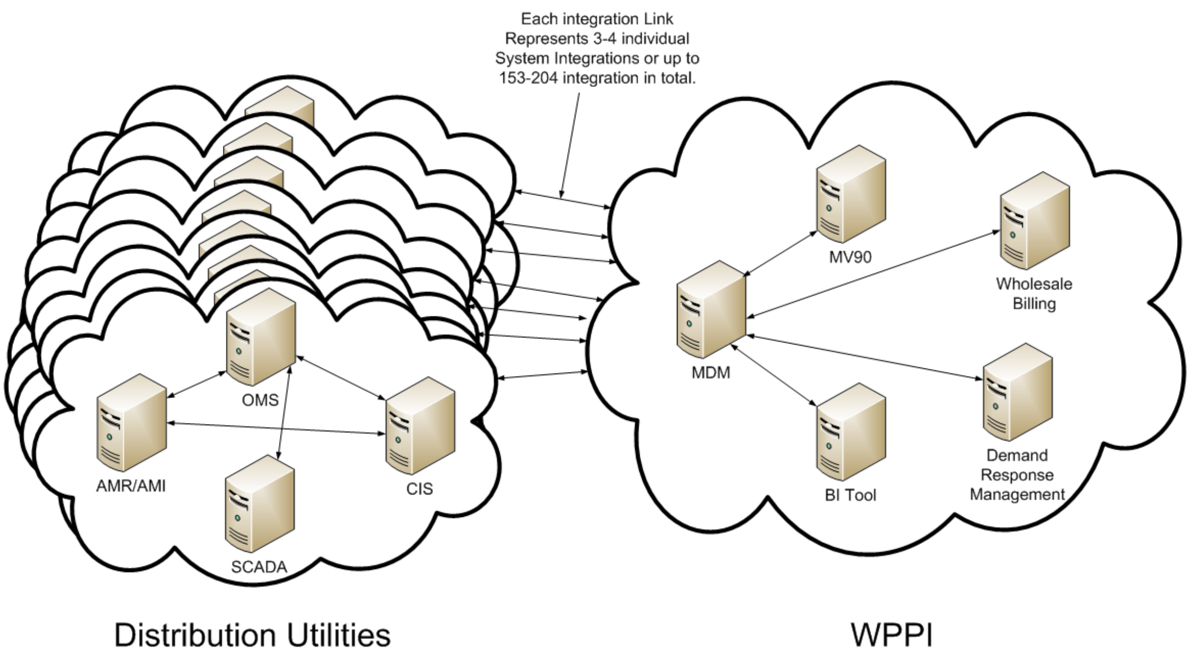

Figure 1-1: Potential Integration Points Between Member Distribution Utility Systems and WPPI Energy

Earlier this year, WPPI Energy began a study to develop a smart grid roadmap. The roadmap needed to take into consideration the needs of individual organizations and WPPI Energy as a whole. While the needs of the individual distribution utilities were similar to those of individual utilities across the country, the expected needs of WPPI Energy were:

- To enable more flexible and dynamic rate programs;
- To create better peak load shifting and shaving capabilities; and
- To capture, analyze, and utilize the impending new data that will be available via individual distribution utility technology implementations.

WPPI Energy began their study by forming a smart grid task-force with representatives from nine of their member utilities. The selection criteria for this group were based on the individual utility interest as well as willingness and ability to participate. The task-force comprised of a cross section of the membership, with geographic dispersion and both large and small utilities represented. After the committee was formed, WPPI Energy commissioned a survey of their membership in order to establish the "as-is" state of their systems, as well as identify the perceived barriers to technology implementation.

The initially expected foundation of the system was to have individual member utility level AMI systems that would report their data to a WPPI Energy level Meter Data Management System (MDMS). This MDMS would have a multi-organizational approach that would allow individual utilities to take advantage of MDM features while allowing WPPI Energy to view usage data in the aggregate for analysis and decision-making purposes. At the core of this foundation was the requirement that these systems provide interoperability.

2. ASSESS CURRENT SITUATION

The survey was one of the tools used to collect a broad range of information from the membership, including current technology status, as well as interest in specific technology areas. Other information sources were also useful, including specific information collected on the status of AMR/AMI deployment, and EIA data on energy usage and meter counts by customer class for members. Locational marginal pricing (LMPs) and aggregated load data across WPPI Energy was also collected. A few useful examples of the survey results and other data are shown below.

2.1. Communications Technologies

The members were asked to identify all communications and monitoring technology types used to collect or control data for the various applications. The survey allowed members to choose more than one type for an application, e.g., members used wireless radio and fiber optics to read large power meters.

Table 2-1. Communication Technologies in Use by Members

What communication technologies do you use to monitor, control and/or collect data for the following applications, if any?							
Answer Options	none	analog telephone	radio/ wireless	power line carrier	microwave	fiber optics	Response Count
Substation or distribution SCADA	16	14	12	0	0	14	50
Large power metering	24	15	12	0	0	3	49
Residential electric metering	22	0	27	1	0	2	50
Water metering	25	0	27	0	0	0	51
						answered question	51
						skipped question	0

As was evidedent by the member responses, most of the members had some form of substation communication, but only half of the membership used any type of remote communciation technology to customer meters, including larger commercial meters and residential meters.

2.2. Current Services

The members were also surveyed on the services they currently offered. The services were sorted by the most common to the least common for all members, as shown in Table 2-2.

Table 2-2. Services Currently Offered by Members

Does your utility currently perform or offer any of the following services?					
Answer Options	Yes		No		Response Count
Time of use rates (commercial/ large power)	37	74%	13	26%	50
Time of use rates (residential)	21	42%	29	58%	50
Distribution system power quality monitoring (delivery PQ)	19	38%	31	62%	50
Geographic information system (GIS) mapping	18	36%	32	64%	50
Renewable energy net metering applications	16	33%	33	67%	49
Distribution automation (e.g., auto transfer)	3	6%	46	94%	49
Current limiting for non-payment	2	4%	48	96%	50
Direct load control (e.g., water heaters, A/C)	2	4%	48	96%	50
Outage management (automated)	2	4%	48	96%	50
Remote disconnect/reconnect	2	4%	48	96%	50
			answered question		50
			skipped question		1

As shown in the table, most members had some form of time-of-use (TOU) rate plan in place for commercial and industrial customers, but a lower percentage were using variable pricing for residential customers. Given that two-way communication to meters was not deployed broadly, the use of services that leverage capability such as remote disconnect was currently very limited.

2.3. Current AMR/AMI Infrastructure Assessment

As part of the initial assessment, the current state of AMI and AMR deployments among the membership was also assessed, and is shown in Table 2-3, where the member names have been changed to "utility #n," rather than list the actual member names.

Table 2-3. Current Member AMI/AMR Deployments

	# AMR meters				# AMI meters			
Distribution Utility	Residential	Commerical	Industial	Total	Residential	Commerical	Industial	Total
Utility # 1	9,475	540	-	10,015	-	-	-	-
Utility # 2	1,159	236	1	1,396	-	-	-	-
Utility # 3	-	-	-	-	-	-	-	-
Utility # 4	759	232	-	991	-	-	-	-
Utility # 5	-	6	-	6	-	-	-	-
Utility # 6	-	-	-	-	-	-	-	-
Utility # 7	-	-	-	-	-	-	-	-
Utility # 8	-	-	-	-	-	-	-	-
Utility # 9	-	-	-	-	-	-	-	-
Utility # 10	-	-	-	-	-	-	-	-
Utility # 11	674	105	-	779				-
Utility # 12	1,165	1	-	1,166	-	-	-	-
Utility # 13	-	-	-	-				-
Utility # 14	5,777	486	-	6,263	-	-	-	-
Utility # 15	1,124	196	-	1,320	-	-	-	-
Utility # 16	40	1	-	41	-	-	-	-
Utility # 17	-	-	-	-	-	-	-	-
Utility # 18	-	-	-	-	-	-	-	-
Utility # 19	12,573	1,536	9	14,118	-	-	-	-
Utility # 20	990	197	-	1,187	-	-	-	-
Utility # 21	175	6	1	182	-	-	-	-
Utility # 22	1,297	235	-	1,532	-	-	-	-
Utility # 23	-	-	-	-	-	-	-	-
Utility # 24	7,172	89	12	7,273	-	-	-	-
Utility # 25	2,200	-	-	2,200	-	-	-	-
Utility # 26	-	-	-	-	-	-	-	-
Utility # 27	-	-	-	-	-	-	-	-
Utility # 28	-	-	-	-	-	-	-	-
Utility # 29	1,159	237	-	1,396	-	-	-	-
Utility # 30	-	-	-	-	-	-	-	-
Utility # 31	1,000	105	-	1,105	-	-	-	-
Utility # 32	1,900	165	1	2,066	-	-	-	-
Utility # 33	-	-	-	-	7,536	1,126	8	8,670
Utility # 34	-	-	-	-	-	-	-	-
Utility # 35	-	-	-	-	-	-	-	-
Utility # 36	-	-	-	-	-	-	-	-
Utility # 37				-				-
Utility # 38	-	-	-	-	-	-	-	-
Utility # 39	2,079	458	2	2,539	-	-	-	-
Utility # 40	5,146	448	-	5,594	-	-	-	-
Utility # 41				-	-	-	-	-
Utility # 42	7,574	827	3	8,404	-	-	-	-
Utility # 43	1,926	383	-	2,309	-	-	-	-
Utility # 44	232	34	-	266	-	-	-	-
Utility # 45	-	-	-	-	-	-	-	-
Utility # 46	792	-	-	792	-	-	-	-
Utility # 47	4,446	428	3	4,877	-	-	-	-
Utility # 48	-	-	-	-	-	-	-	-
Utility # 49	36	7	-	43	-	-	-	-
Utility # 50	485	61	1	547	-	-	-	-
TOTAL	71,355	7,019	33	78,407	7,536	1,126	8	8,670

Given that there was high interest on the part of WPPI Energy and many of its members to examine new, variable pricing strategies, some ability to consistently meter and monitor the impacts of such programs will be important. One of the key potential benefits to be examined in the business assessment for WPPI Energy is that of system-wide demand response. Thus, some future consistency in metering infrastructure will be important.

3. IDENTIFY AREAS OF MOST POTENTIAL VALUE

Various smart grid investment areas were examined for potential benefits to WPPI Energy and its membership. Part of establishing the value to WPPI Energy members was the notion that the "smart grid" is not a single technology or approach. Rather, it is a combination of technologies and potential approaches that, taken together, make the current grid "Smart" and enable a number of benefits. As such, a number of potential smart grid technologies were examined, and those most promising for near term implementation benefits were examined in more detail.

Broadly, this list included:

- Advanced Metering Infrastructure:
  - Generally considered to be a "foundational" technology for the smart grid, as it enables much of the usage (and other) data collection upon which other smart grid functions are built (however, some argue that AMI does not need to be *foundational*).
  - Provides for connection of premise informational, monitoring, and control technology upon which demand response and advanced load control functions can be built.
- Distribution Automation.
- Advanced Transmission Systems (e.g., PMUs, FACTS—AC Transmission—devices, Fault Current Limiting).
- Utility Operational Information Technology Systems (e.g., energy management systems, data management systems, or outage management systems).

The technology systems above can be used to implement a very broad range of potentially beneficial functions, from collecting metering information to advanced concepts such as adaptive protection. Based on the situation assessment, members' current direction, and the future capabilities thought to be the most suitable for joint action, metering infrastructure was selected as the most suitable initial focus.

The business assessment for metering infrastructure examined the following two promising areas:

- Demand Response (DR) and Energy Efficiency (EE) improvements; and
- Operational Efficiency gains.

These items received the focus for the near term roadmap and business case analysis. In addition, developing a technology roadmap that could minimize interoperability costs and maximize future flexibility was considered a critical pre-requisite for future efforts.

3.1. Estimating Benefits: Example of DR Value for Alternate Technology Approaches

The estimated value of demand response provides a good example of one of the areas examined for potential benefit important in the business case.

To determine the potential demand response value of various technology options, information from other DR studies in Midwestern states was performed to estimate peak load reductions and energy savings from the alternatives. Various pricing schemes were evaluated (e.g., TOU alone, TOU with CPP, Critical Peak Rebate), as well as "technology assisted" demand response (e.g., HAN technology including an IHD or a PCT). Load curve impact results from two previous studies are shown below, one using information only and the other using a PCT to help automate the demand response.

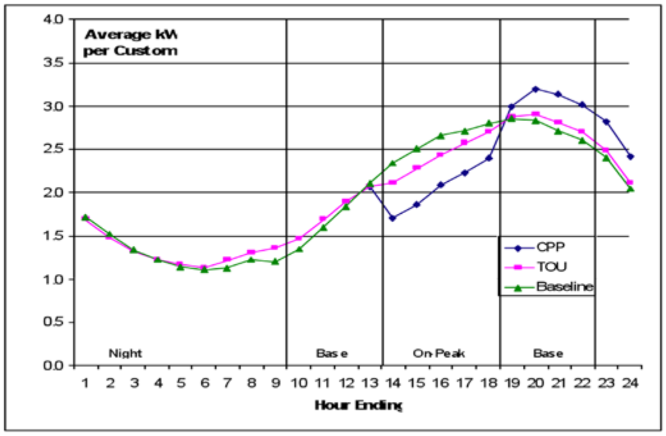

Figure 3-1. Hottest Summer Days: Information Only Group [2]

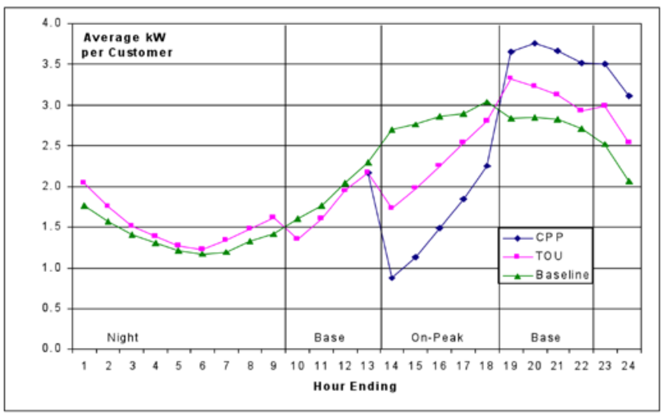

Figure 3-2. Hottest Summer Days: Technology Enhanced Group [2]

The results of these studies were used with the aggregated load data from WPPI Energy, as well as locational marginal pricing from the four Midwest ISO nodes in which WPPI Energy participates to estimate a per customer (by major customer type: residential, commercial, industrial) value from DR on these various alternative investments. An initial assessment of system-wide potential for cost savings indicated that substantial annual savings could be obtained based on reduced fuel purchases and deferred capacity costs. To obtain these savings, however, implementation of AMI infrastructure, MDMS, and variable pricing structure would have to be done across a significant portion of the membership.

3.2. Estimating Operational Efficiencies

Several AMI business cases that have been made public [3] estimate that expected operational efficiencies contribute the largest proportion of benefits in their cost-benefit case (e.g., 79% for PG&E, 72% for ConEd). Although these large AMI deployments may vary substantially from that which most WPPI Energy members could expect, they are indicators that operational efficiencies are likely to play a key role in any WPPI Energy business case for AMI. As such, a sample of member distribution utilities were asked to estimate operational savings that would accrue from an AMI investment. Since several members had already made business cases for AMR investment (see Table 2-3), the approach taken was to examine the *incremental* costs and benefits that AMI would bring beyond AMR, which was already largely understood. In this way, the business examination was simplified and the amount of work required by member utilities was minimized.

4. DEVELOP TECHNOLOGY ROADMAP

Technology areas that were determined to have the most promise for near term investment by WPPI Energy and its members are discussed below.

4.1. Advanced Metering Infrastructure

The results of the survey showed that the utilities had a wide array of meter reading technologies but virtually no AMI capable systems (see Figure 2-3). The following meter reading capabilities were identified:

- Most meter reading systems were handheld or drive-by based;
- A few fixed network systems existed, but they were not AMI-grade systems; and
- Only one utility was in the process of implementing an AMI capable system.

The lack of AMI capable systems within the WPPI Energy membership created opportunities for synergistic member activities. WPPI Energy's initial expectation was to play a minimal role in AMI technology selection. However, interoperability among multiple AMI technologies was seen as a suitable goal as more pragmatic issues emerged. This was due to the fact that many of the member utilities were very small with less than 2,000 customers. As such, these utilities had very limited staffs. This was especially true in the area of IT, where WPPI Energy had been able to help in some cases (e.g., approximately 30 of the member utilities had their CIS hosted by WPPI Energy). Therefore, the introduction of additional IT infrastructure to these utilities was challenging.

The potential solution was for WPPI Energy to host the AMI head end system in much the same way as it was providing CIS support. However, the CIS hosting was done through one system. Trying to provide this service to multiple utilities with multiple technologies would be challenging for WPPI Energy as well, as its IT resources are limited.

The end result of this analysis was that WPPI Energy would likely facilitate the qualification of two or three preferred AMI vendors. This would create the following advantages:

- AMI technology choices would be more fully qualified;
- WPPI Energy would be able to focus on specific systems for hosting purposes;
- Member utilities would likely achieve better pricing due to larger economies of scale across multiple utilities;
- Better efficiencies for common and centralized inventories would be created; and
- Interoperability between member utilities would be more readily achieved.

4.2. Meter Data Management

Meter Data Management was a relatively new concept to WPPI Energy and its member utilities, since none of them had readily experienced the large influx of data that an AMI system can create. However, the needs and advantages were readily embraced as the system features and capabilities were reviewed.

The approach for the MDM system was to implement a multi-organization instance that would allow individual utilities to take advantage of the system while allowing WPPI Energy to view a subset of the collected data from all of the organizations. This type of implementation was in service at other organizations (e.g., Independent Electricity System Operator—IESO, in Ontario) where there was a centrally mandated system that was required for interval data VEE processing. The advantages to this approach were believed to be:

- More cost effective for individual utilities.
- No additional IT overhead for individual utilities.
- Create centralized repository for:
    - Rate program design;
    - Demand Response measurement and verification; and
    - Overall load analysis.

Utilizing a centralized MDM solution represented a required integration with up to eventually 51 individual AMI/AMR systems along with any legacy MV90 implementations. If the individual utilities were free to choose their individual meter reading technologies, interoperability of these numerous integrations was once again essential. Only in this way was WPPI Energy able to get past the business of integration and on to the business of pricing programs and load analysis.

4.3. CIS Integration

As mentioned earlier, approximately 30 of the member utilities had their CIS hosted by WPPI Energy. This was a single CIS with a multi-organization implementation very similar to the expected MDM implementation. However, there were ten other individual CIS vendors among the remaining member utilities. Obviously, this was another degree of dimensionality not found in single utility systems. Likewise, these systems are of various vintages and the likelihood of standards adoption to create interoperability was unlikely.

For these reasons, an initial review of the existing CIS was recommended prior to more advanced technology implementation. The goals of this review were to:

- Reduce the number of CIS vendors so as to reduce the number of integrations;
- Eliminate vendors not capable of standards implementation; and
- Further reduce amount and breadth of IT expertise required.

4.4. Distribution Automation

Because of the individual and relatively small and isolated territories of the member utilities, the current expectation was that the opportunities for DA for many of these utilities were limited. In addition, it would be difficult in most cases for WPPI Energy to bring benefits to DA efforts through any type of joint action. Thus, although investigation and subsequent distribution automation recommendations were still under consideration, they had been given lower priority in the overall near-term roadmap effort.

4.5. Roadmap

As WPPI Energy and its members move forward with their smart grid efforts, the roadmap and priorities that had been developed will provide guidance and a coordinating influence on decision making. As each member organization examines technology decisions, the guidelines provided as part of the roadmap will offer choices that will help ensure that central coordination and efficiencies become possible. At the same time, member utilities will still have the flexibility to make their own, independent business decisions.

4.5.1. Near Term

In the immediate future, the number of integration points can be minimized by following the structure and guidelines presented in Figure 4-1 below.

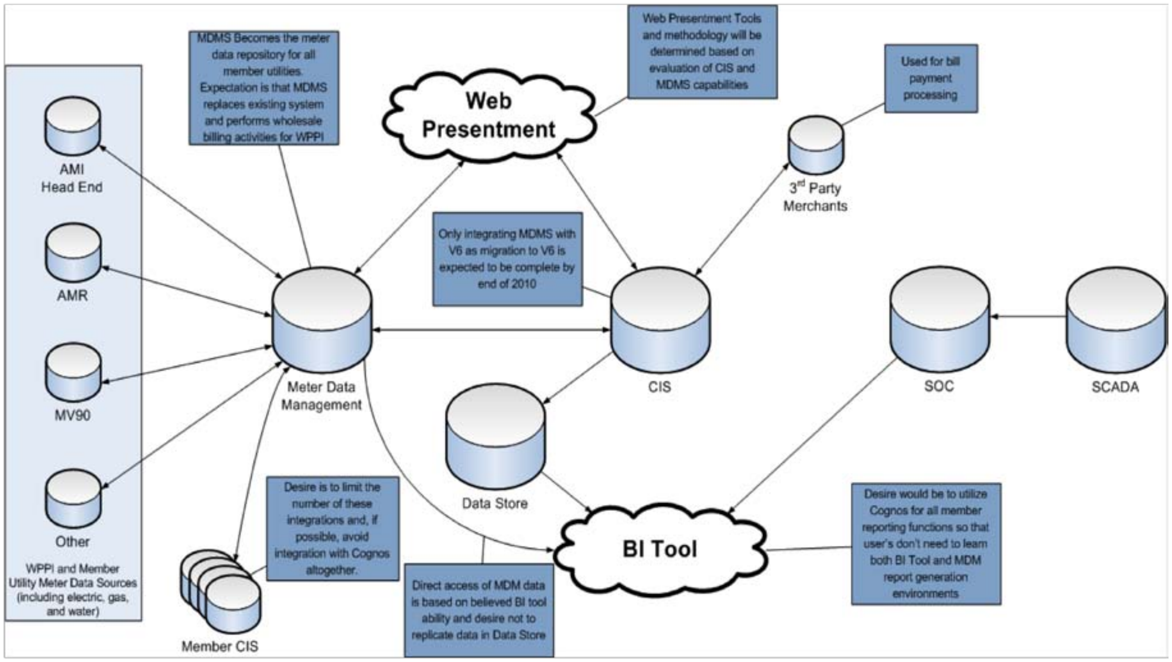

Figure 4-1: Near Term Interoperability Guidance

In addition, the smart grid roadmap consists of three specific activities:

- Review, evaluation, and consolidation of the number of individual CIS across the member utilities. This is believed to be an excellent and important opportunity that should be initiated immediately to minimize the possible number of integrations required when other technology deployment begins
- Evaluate and establish two to three preferred AMI technology vendors for deployment across the member utilities in order to establish not only common functionality but to help realize economies of scale and reduce implementation overhead.
- Evaluate and implement a centralized MDMS that can not only support the individual needs of the member utilities, but also enable more advanced rate programs, load analysis, and demand response.

4.5.2. Longer-Term Integrated Technology Vision

The following high-level technology integration "vision" is currently under consideration by WPPI Energy for the longer term.

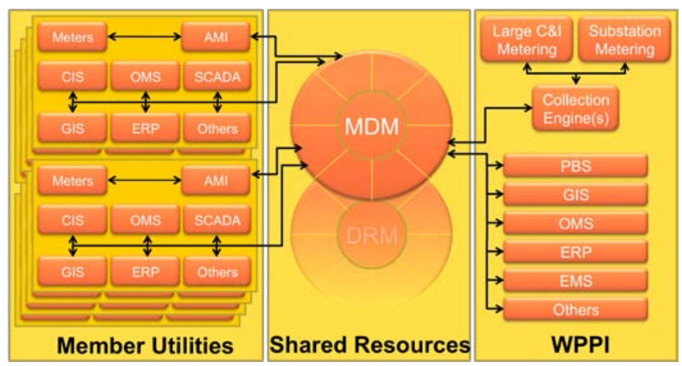

Figure 4-2. Integrated Technology Vision

As WPPI Energy and its member utilities move forward, it is likely that there will be additional synergies and cooperative opportunities that will enable each member utility to function independently while allowing WPPI Energy to operate as a virtual utility in those areas where it is most necessary. One of the reasons that this scenario is highly viable is that WPPI Energy and their member utilities have an extremely good and collaborative working relationship, which will be valuable for the future success of their joint, smart grid Roadmap.

References

[1] "Report to NIST on the Smart Grid Interoperability Standards Roadmap," Page 6. Prepared by EPRI (June 17, 2009).

[2] Communicating Thermostat for Residential Time of Use: Mary Klos, Jeff Erickson, Summit Blue Consulting.

[3] Examples include PG&E, ConEd, and SCE.

Biography

Erik Gilbert is a Senior Consultant at Summit Blue Consulting who focuses on smart grid technology, strategy, costs-benefits assessment, and helping clients with smart grid funding strategy. Mr. Gilbert has over 20 years of experience in development and management of networking products and protocols, as well as experience in strategic business assessment for technology solutions. In his most recent role, Mr. Gilbert served as Director of Smart-Energy Products for residential energy management system vendor Tendril Networks, Inc., where he defined and executed their hardware roadmap, including in-home energy displays, IP-to-HAN gateways, AMR/ERT-to-ZigBee bridges and other products. Previously, Mr. Gilbert held various management positions at Cisco Systems, Inc., where he built and launched a number of products. He created and drove the company's Managed Broadband Access program, enabling cable providers to offer billable services over common IP infrastructure. Mr. Gilbert's other experience includes associate work at the Bay Area venture capital firm Hummer Winblad Venture Partners and several years of technology strategy development with Ernst & Young Management Consulting. Mr. Gilbert holds a BS in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology and an MBA in Marketing from the University of California at Berkeley.

Mark Day assists utilities with their technology evaluations and supports the overall process from selection to implementation. As a systems engineer with over 27 years of data acquisition, supervisory, and remote control system experience, Mr. Day has over 19 years in the utility industry developing and integrating new technology solutions to meet changing industry needs. Mr. Day's experience as a participant in the product development cycle for AMI/smart metering, Demand Response, Home Area Networking, and Meter Data Management has given him a comprehensive understanding of these technologies and the impact they have on other systems. Mr. Day has a bachelor's degree from Carnegie Mellon University in Electrical Engineering. He is an active member of the Utilimetrics Education Committee and has presented numerous papers at various conferences, including Distributech, AMRA, and TechAdvantage.

Jake Oelke directs all customer service functions for WPPI Energy, including the development and delivery of customer and energy services for the WPPI Energy member utilities – focusing on energy efficiency programs, renewable energy initiatives, and distributed power generation projects. His responsibilities include business, commercial, industrial, and school facilities, reliability initiatives, power quality programs, construction plan reviews, technical training, and environmental offerings. Mr. Oelke is leading the member-based task-force to examine smart metering/smart grid technology issues. The task-force will recommend an organizational strategy to best capture the system benefits of these technologies. Earlier in his career, Mr. Oelke analyzed complex utility systems for resource planning and budget preparation purposes for Power System Engineering, Inc., in Madison, WI. Beginning as a consulting engineer, Mr. Oelke assisted electric cooperatives and municipal electric utilities with vital business functions, such as energy resource planning, distribution system engineering, retail rate analyses, demand-side management, and key account strategies. Mr. Oelke has a BS in Industrial Engineering from the University of Wisconsin – Platteville. He is a professional engineer registered in the State of Wisconsin, and is a certified energy manager recognized by the Association of Energy Engineers.