Survey of Technologies and Cost Estimates for Residential Electricity Services

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Abstract

This survey contains a sample of the available technologies for implementing residential electricity services. Brief overviews of several products, along with estimates for their costs are presented. The primary focus is on two services: Automated Meter Reading (AMR), and Load Management. Cost estimates for other services, including real time pricing, remote connect/disconnect, and automated billing are not separately listed since many of these services are included with AMR and Load Management systems. This is not a comprehensive review of all available technologies or manufacturers, but is intended to provide a general understanding of the potential for implementation of residential services. The estimation of the costs associated with implementing these technologies should be treated as a general baseline, since actual costs will vary greatly. The lack of a mature market for these products allows for great variances in implementation costs, depending upon implementation sizes, contract lengths, and negotiations and relationships with suppliers.

The residential services surveyed here can be implemented by any electricity service provider (ESP), which includes utilities and electricity retailers.

Keywords: Residential Services, Retail Electricity, Load Management, Automated Meter Reading, Cost Estimates

I. AUTOMATED METER READING (AMR)

AMR technology at the residential level is rapidly growing. AMR allows immediate savings by eliminating the need for manual meter readers to travel to each site. It also cuts costs and improves customer service by reducing errors, eliminating billings based upon estimated usage, improving load profiling, and enabling additional services such as real time pricing and load management. Most AMR systems also include the ability to monitor water and gas consumption, and may include capabilities for Internet or cable TV services.

Retrofitting existing meters with an AMR attachment is the fastest, lowest cost method to implement AMR service. AMR retrofits are available for as little as $10 per device. Alternatively, traditional meters can be replaced entirely by an AMR meter for around $100. Most AMR devices have two-way communications capability, but some are able to transmit only. Additional features that may be included in AMR meters and retrofits are: remote connect/disconnect, tampering alarms, outage notification, and power quality measurement.

There are three major types of AMR communications networks: Cellular, Power line Carrier (PLC), and Telephone/Internet. Cellular AMR utilizes the same technology as cellular telephone networks (although different frequencies are used). The meter device sends a cellular signal to a local cellular station that collects the data from multiple meters. The data is then passed along to a regional cell and from there to a server. The server stores the data in a database. The database can then be used for load profiling, automated billing, and other services. The advantages of Cellular AMR technology are that it is reliable, proven, and relatively inexpensive. The main disadvantage is that it requires investment in the cellular infrastructure.

Power Line Carrier (PLC) AMR sends data over the existing power transmission lines. This technology is appealing because no new communications network needs to be built, and the lines are already owned by the utility in most cases. In addition, some utilities have already implemented PLC networks for SCADA. Additional, expensive equipment is necessary in some cases, however, to enable the data from the households to bypass transformers and capacitor banks that would otherwise wipe them out. Also, while PLC has been used for SCADA, the need to transmit a great deal more data from a vast number of meters makes the implementation of Power Line Carrier AMR difficult, and it has yet to be implemented on a large scale.

The third major communications network currently used is the standard telephone/internet network. These AMR devices utilize modems to connect to servers and transmit their data. This requires the consumer to have a phone line available, and in some cases a computer that is continuously powered up. The advantages to these systems are that they utilize the existing telephone/internet infrastructure, making installation fast, cheap, and easy. The disadvantage is that it requires the use of the consumer's telephone line or Internet connection, or an additional line.

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Other AMR communications systems include satellite, broadband, and microwave. Virtually any communications network can be adapted to transmit meter data. It is only necessary to create a compatible communications device to retrofit existing meters. Currently, the use of these alternative communications networks is not widespread.

A. AMR Manufacturers: The following are three examples of manufacturers of AMR devices.

CellNet Data Systems, Inc. is a leading provider of AMR services. CellNet has contracts for over 7 million meters and is growing rapidly. CellNet builds the communications network and installs AMR retrofit devices on existing meters. CellNet pays for the installation costs in exchange for long-term contracts for their service. CellNet then consolidates the meter data and delivers it to the utility/service provider. The cost of the CellNet service varies, but a reasonable estimate for an implementation of a few thousand meters is around $1 per meter per month. The total number and geographical density of the customers served will cause variations in this price. CellNet uses a cellular network and also provides data management software. [2]

Hunt Technologies, Inc. produces the Turtle AMR system. This system is designed for rural, isolated customers to provide low, cost, daily meter readings. The Turtle system utilizes Power Line Carrier technology, but has a slow data transmission rate due to the ultra low bandwidth system it employs. The Turtle system is able to transmit meter data only once per day on average due to the slow transmission rate. Hunt claims that each meter can transmit data for great distances (160 miles or more), making their system well suited for customers in isolated, hard to reach areas. The Turtle system costs around $20,000 for the communications system and software (includes installation). The Turtle meter retrofitting devices cost an additional $10 per meter (approximate). [3]

Leach Industries produces the AmronII a retro device ($45) and the AmronII meter ($50-90 depending upon options). These devices are compatible with telephone, broadband, and cellular communications systems. They also have the ability to monitor water, gas, etc. via input modules. Leach offers outage notification, remote connect/disconnect, tamper alarms, and other add-ons to their meters. They also provide free data management software, including load profiling, with purchase of their products. [4,5]

II. Load Management Systems

Load Management systems allow for remote control of heating and air conditioning, appliances, lighting, and other electrical systems. At times of peak demand and/or high spot prices for electricity, load management allows the consumer or the ESP to respond by reducing loads. Typical load management systems involve setbacks for thermostats on heating and air conditioning systems and water heaters. Any other electrical device can be included, such as washers, dryers, and dishwashers.

The ESP contracts with the consumer to allow for load reduction at peak times. In exchange, the consumer receives a discount on their bill, either through a lower rate per KWh, a rebate, or another pricing mechanism. Consumers can normally manually override the load reductions from a control device within their home.

There are many manufacturers of products that can be used for load management systems. Most of these products were initially designed to allow homeowners to program and/or remotely control their household electrical devices. An ESP can easily adapt these controls for use in a load management system. Many of these systems utilize existing telephone/internet networks to remotely program and control household electrical devices. A residential load management system costs between $400 and $700 per household. (Puget Sound estimates the system used in their pilot program cost $200 to $250 per household – see below) This does not include any infrastructure an ESP would need to build in order to oversee the system.

A popular home control communications protocol is known as X10. This protocol is designed to create a standard method for communicating via household wiring to device controls. There are hundreds of manufacturers of X10 products and a myriad of devices available. X10 is easily controlled via a computer and can be remotely administered via the Internet. An X10 system could easily be adopted and adapted for use by an ESP to implement load management.

III. Other Services

The following are additional value added services that may be offered to residential electricity users. Many of these services are included in AMR and load management systems, or can easily be added to these systems.

1) Real Time Pricing

Real time pricing allows consumers to react to changes in the price of electricity. There are many time of use pricing options available. These range from simply having peak and off peak time periods with single charges per KWh, up to multiple pricing levels depending upon the demand and/or spot price. Implicit in any RTP scheme is the need for an AMR system to measure usage on a near real time basis.

This survey found no commercially available systems solely for residential RTP, presumably because it is included as a component in other systems. AMR systems typically have two-way communications capability included. Most of the Load Management systems surveyed included the capability to signal when demand/pricing was high or when the ESP was using the system to reduce load. The costs of implementing Time of Use pricing schemes includes the costs of AMR and, depending on the sophistication of the system, the costs of some type of load management system. This may be as simple as a display device that notifies the customers of the current load status – low, medium, high, and critical.

2) Automated Billing

Automated Billing capability is included with the software for most of the AMR and load management systems. Both the issuing of bills and the receipt of payments are easily automated, reducing costs to the retailer, and improving service for the customer. Costs for a stand alone automated billing system will vary greatly depending upon the current systems in place and the design of the system to be implemented. Using the automated billing functionality that is included with AMR or load management systems will require little or no additional costs.

3) Home Security

The communications capabilities of AMR and load management systems allow for the ability to include alarm notification for home security systems. The controls used in load management systems can also be used to control a home security system.

4) Outage Notification

Automatic outage notification is included with the majority of AMR systems. Instantaneous and accurate information about the exact location and size of an outage can reduce the costs associated with pinpointing the origin of an outage and reduce response times. This enables an utility/service provider to minimize the total outage times on the power grid.

Power line carrier based AMR obviously may not able to send an outage notification signal, but the loss of signal from a unit indicates possible loss of power.

5) Remote Connect/Disconnect

Eliminates need for serviceperson to turn power on and off. Also instantaneous, which eliminates customers waiting to have their service turned on. AMR products include remote connect/disconnect as a standard or add on feature.

6) Tamper Alarms

Notify of tampering with metering equipment, standard on most AMR equipment.

7) Bundling with Water and Gas

AMR systems are capable of metering water and gas usage as a standard feature of most systems and as an add-on for others. Facilitates bundled billing, which reduces costs and adds value to consumers.

IV. Current Implementations

The following is a sampling of utilities and service providers offering residential services.

1) Puget Sound Energy

Puget Sound Energy in Washington State, a provider of electricity and natural gas, has implemented CellNet's AMR system for both electricity and gas meter reading. They have contracted for this service with CellNet for approximately $0.80 per meter per month. By the end of 2001, CellNet meters will serve over 1.3 million Puget Sound Customers. The existence of this infrastructure allows Puget Sound to save money on meter reading, billing,

and other areas, and to offer expanded services to their customers.

Puget Sound Energy completed a pilot test of their Home Comfort Control system in the spring of 2000. The Home Comfort Control system allows Puget Sound Energy to setback thermostats on heating, air conditioning, and water heaters during periods of peak load/high spot prices. A signal is sent to the control module in the home and an indicator light begins flashing before the setback takes place. Customers are able to manually override the setbacks via the control module in their homes. Under the terms of the pilot test, thermostats were setback six degrees for periods of up to four hours

Puget Sound's system utilizes CellNet AMR technology, in conjunction with load analysis software from Silicon Energy Inc., which analyzes loads and determines when setbacks should be activated. The thermostats used in the system were developed by Carrier Electronics, a division of Carrier Corporation.

Puget Sound estimated a cost of between $200 and $250 per household for installation of the Home Comfort Control system. The Home Comfort Control system utilizes Puget Sound's existing CellNet AMR network for communications. This, along with Puget Sound's supplier relationships may explain why their costs are much lower than the $400-700 per household found for most load management systems. Preliminary results indicate that customers were very satisfied with the system and did not find the setbacks to be overly intrusive. The incentives for the program included free programmable thermostats and between $50 and $100 depending upon the number of times the customer overrode the setback signals. An industry white paper will be released giving more detailed information in mid-September 2000. [6,7]

2) Otter Tail Power

Otter Tail Power Company in Minnesota offers contracts for load management that reduce off-peak electricity rates by twenty to thirty percent from the standard offer. In return, Otter Tail's customers agree to allow a portion of their load to be shed during peak demand or emergencies. Customers designate which appliances (water heaters, dishwashers, clothes dryers, etc) Otter Tail can control. Otter Tail offers leasing of load control equipment, along with $100 credit for re-wiring houses to accommodate the controller. Otter Tail gives an estimate of $650 for controller costs and claims that many of their customers are saving over $250 per year on their electricity bill. [8]

3) Georgia Power

Georgia Power, a subsidiary of Gulf Power - A Southern Company, offers the GoodCents Select program. Georgia Power charges $4.53 per month for service including AMR and load management, with a control thermostat for heat pumps, HVAC, water heaters, and pool pumps. This also includes surge protection service. Enrollment in the GoodCents Select program allows customers to receive a four tiered rate structure. This structure has pricing levels for low, medium, high, and critical demand levels.

Standard Rate: 5.7 cents/KWh (as of January 2000)
GoodCents Rates:

Demand Level	Cents/KWh	% Time in Effect
Low	3.5	27
Medium	4.6	53
High	9.3	19
Critical	29	1

The GoodCents system allows you to program your usage and designate appliances to shutdown or reduce load during selected demand levels.

Future expansion of the service to include Internet and cable TV service is enabled by the communications system installed for this service. [9]

4) OpenPlanet

Shikoku Electric Power Company in Japan has developed a system to provide information systems and control to a wide range of platforms. The OpenPlanet architecture enables data transfer and analysis from the residential to large-scale industrial levels. OpenPlanet can manage small household devices or major power system controls. The Java based architecture is standardized, scalable, and interoperable.

The OpenPlanet system utilizes the Internet, and can communicate with cell phones, PDAs, and

virtually any communications device. The installation of a one-chip microcomputer on any electronic device will allow OpenPlanet to interface with and control the device. Services enabled by OpenPlanet include: load management and analysis, outage monitoring, home security and alarms, home health care services, and education services.

Shikoku plans to install an OpenPlanet server device (a miniature computer called an Opus) in the meter of each of their customers. This device provides the interface to the OpenPlanet network (via the Internet), and will immediately allow Shikoku to provide the services available through this network. The Opus device can communicate via a home's existing power lines to any devices used within the home, there is no need for re-wiring or installation of in-home communications networks. [11,12]

5) Excelergy

Excelergy, based in Lexington, Massachusetts, provides Information Technology solutions for EPS's. Excelergy's Energymarketplace utilizes the Internet to provide automated billing and payments, energy usage information, and other services. Energymarketplace enables ESP's to deliver multiple services to their customers in a low cost, standard format. Customers can personalize their Energymarketplace web layout to deliver news, weather, billing, and usage information, plus other services offered by the ESP.

ESP's can also utilize Excelergy's e-ChoiceNet, which gives customers the ability to compare price and service options from different service providers. The costs of Excelergy's products depend upon service options and the interfaces with an ESP's legacy systems. [10]

V. Conclusions

Recent developments in the telecommunications industry have lowered the costs of communications, making services such as Automated Meter Reading and Load Management cost effective. In addition, these technologies facilitate the implementation of other services such as real time pricing, automated billing and outage notification, and remote connect/disconnect.

Communications via the internet are now seamless, ubiquitous, and have virtually no marginal cost. This development creates the potential for retail electricity services to provide economically efficient value added services. Previously, the costs of the services outlined in this paper were too high to be considered feasible [13].
Updated regulation which includes incentives for implementation of new, more efficient technologies is necessary. Instituting consumer choice by offering time of use or real time pricing or load management opportunities for residential customers, in combination with regulatory incentives for ESPs, will create demand for these services. Only then will the technologies that are currently available, but not utilized, be implemented in a wide scale basis. This will increase demand elasticity, benefiting not only consumers, but also producers. By defining the demand curve for electricity, utilities and independent power producers will be able to make better investment decisions in new power plants.

Real time pricing schemes can provide significant value to both consumers and service providers. By reducing daily peak loads, and leveling off load profiles, real time pricing can provide significant efficiency gains for electricity generation. In areas where deregulation has created real time electricity markets, such as California, this is especially true. . Implementing the services described above will provide benefits to both the supply and demand sides of the electricity market equation.

In times of peak loading, customers can reduce their demand if they are given the proper incentives. Allowing customers to be charged for their actual usage rather than an estimated load profile, will enable them to save money and electricity. The resulting reduction in peaking loads will reduce the usage in the most inefficient, high cost power plants which are currently used to meet demand peaks. This not only reduces prices, but also has positive environmental effects as well since most of these plants tend to produce higher levels of pollution than more efficient plants.

The absence of residential services prevents demand elasticity and leads to market failures such as those seen in California. Incentives to implement residential services such as automated meter reading are absent within many regulatory frameworks. Both ESPs and customers must be given the ability to benefit from the implementation of these services in order to create the incentives to implement them.

VI. Acknowledgments

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VII. Table of Cost Estimates for Residential Electricity Services

Service	Estimated Cost	Comments
AMR	$10-$100 /meter ($1300 for meters measuring power quality)	Meter only (no infrastructure costs for communications network)
	$1/meter/month (leasing)	Available from CellNet – includes delivery of meter info to ESP
Load Management System	$400 –700 /home	Allows homeowner and/or ESP to control appliances, HVAC etc remotely
	$2.50 - 4.50 /home/month	Leasing of system
Real Time Pricing	~$0	Included with AMR and load management. Can use current internet infrastructure
IT systems	varies	Depends on requirements, software - as low as $10,000 for AMR data handling

VIII. References

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IX. Biographies

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X. Relevant Web Sites

US Electric Utility Web Link List - www.electricityforum.com/links/usutil.htm

A Comprehensive listing of Energy Web Sties from EnergyUserNews - www.energyusernews.com/eun/files/html/eun_web_connections/0,2627,,00.html

GridWatch.com Links to Metering Companies - www.gridwatch.com/cproc.asp?cid=136

EPRI Meter Page (includes news, and links to meter manufacturers) - www.meterindustry.com

RioTronics Links to AMR Manufacturers - www.riotronics.com/interfacing/index.asp#AMR

Automatic Meter Reading Association (AMRA) Homepage - www.amrahq.com/

Metering International Online – www.metering.com

Essential.com Homepage (Energy Services Company) – www.essential.com

Utility.com Homepage (Energy Services Company) – www.utility.com