

# SMART NETWORKS FOR GAS UTILITY SYSTEMS

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## ABSTRACT

There was once a time when you could get a car in any color...as long as it was black. They had frames, running boards and 15 horsepower engines. Who could ever need more? Just like the auto industry has adapted from this original approach to meet the demands of consumers, regulators and shareholders, the gas industry must do the same. Automated meter reading – also known as AMR or AMI – provides that opportunity. This paper will compare and contrast AMR and AMI for gas utilities and provide important areas for gas utilities to consider when adopting or upgrading wireless meter technology.

## GENERAL DEFINITIONS

Since most gas meters are mechanical devices, Automated Meter Reading (AMR) and Advanced Meter Infrastructure (AMI) technologies utilize a radio device attached to the gas meter's index. These devices typically record a fixed amount of gas use by recording the number of times a gear-based magnet passes a fixed reed switch – just as the meter index visually indicates usage.

AMR (Automated Meter Reading) is a system that uses lower-power radio-based transmitters to record gas consumption and report the meter reading at the time of interrogation by a reading device.

AMI (Advanced Meter Infrastructure) incorporates a network communications system with radio-based transmitters or transceivers that report a variety of data, including but not limited to meter readings, to the utility daily and/or enable the utility to interact with the meter or other devices at the point of service with no human intervention.

Depending on the radio architecture employed, the radios can be lower or higher power. The difference between these types of systems lies within the functionality.

## BENEFITS AND LIMITATIONS OF AMR VS. AMI

AMR systems were first deployed in the early-mid 1970s and greatly enhanced meter reading efficiency. Early “walk-by” systems enabled meter readers to use an electronic reading “gun” to collect readings in a fraction of the time compared to visual reading. What's more, it virtually eliminated inaccuracies related to human error from recording the reading to inputting the data at the office. As radio technology improved, drive-by systems were developed, which use a vehicle-mounted recording device to gather readings even faster. With the advent of the computer modem and lowering cost of technology, some telephony-based systems “called” the utility at a set point each month and delivered the reading directly to the utility billing system.

<u>Benefits</u>	<u>Limitations</u>
<ul style="list-style-type: none"><li>• Low Cost</li><li>• Efficiency/Accuracy</li><li>• One Reading</li></ul>	<ul style="list-style-type: none"><li>• Low functionality</li><li>• Requires staff interface</li><li>• No history detail</li></ul>

The deployments of AMI systems began in the early 2000s, and were mainly driven by the advances in electricity monitoring and development of the “smart grid” for better management of existing electrical systems and increasing consumer power demand. A fixed-base AMI system is a network of collectors that gives utilities the ability to communicate with meters and other devices remotely, drastically reducing operating expenditures when compared to deploying teams of field personnel on a monthly or bi-monthly basis to read meters or perform other routine, non-revenue-generating tasks. Forward-thinking gas utilities are already reaping benefits from the volume of meter reading information alone – and they're using that information to better inform, educate and engage customers for greater consumer satisfaction. As advances in gas distribution technology take form and data provided by AMI systems grows, companies will learn even more to advance both their service and businesses in general.

<u>Benefits</u>	<u>Limitations</u>
<ul style="list-style-type: none"> <li>• Incrementally lower reading cost</li> <li>• Hourly usage information</li> <li>• Remote communication</li> <li>• Reduce labor cost</li> <li>• Reduced vehicle upkeep and liability costs</li> <li>• High efficiency/accuracy</li> <li>• Upgradable</li> <li>• Detailed information/improved system analytics</li> <li>• Accommodates a growing list of applications</li> </ul>	<ul style="list-style-type: none"> <li>• Higher infrastructure cost</li> <li>• May require non-traditional partnerships with other utilities</li> </ul>

## **APPROACHES**

### **RANGE & INFRASTRUCTURE**

AMR and AMI networks are comprised of three basic components.

- An endpoint, which is a radio mounted on the gas meter or other field-based device (valve, etc.).
- A collector, which is either handheld or vehicle based in the case of AMR, or a field-based gateway that wirelessly relays information between the utility and a series of endpoints. Finally,
- A centralized interface, at the utility, that is used to collect and disseminate information throughout the utility's information systems.

Depending on the system (AMR vs. AMI), the coverage range can be limited to proximity to a person or vehicle for walk-by or drive-by AMR to hundreds of miles through a fixed-base AMI system. Covering large distances requires sophisticated communications network. Three architectural approaches include mesh, point-to-multipoint two-way radio networks and cellular. Let's look at the differences in these network configurations.

### **MESH VS. POINT-TO-MULTIPOINT VS. CELLULAR**

Mesh networks are comprised by a series of peer devices that respond to a local collector, either directly or in a peer-to-peer relationship, over unlicensed, public radio frequencies. Since they utilize public frequencies, mesh networks are prohibited from generating more than one watt of output, so their signal range is limited, thus increasing the infrastructure required to relay information back to the utility. They maintain their signal strength over long distances by increasing the number of collectors in the network and passing information from device to device. Each "hop" uses additional bandwidth for each transmission because the data hops from node to node and requires a new slice of spectrum for each step. If one device fails, some self-healing mesh networks simply use the next nearest device to pass the information on.

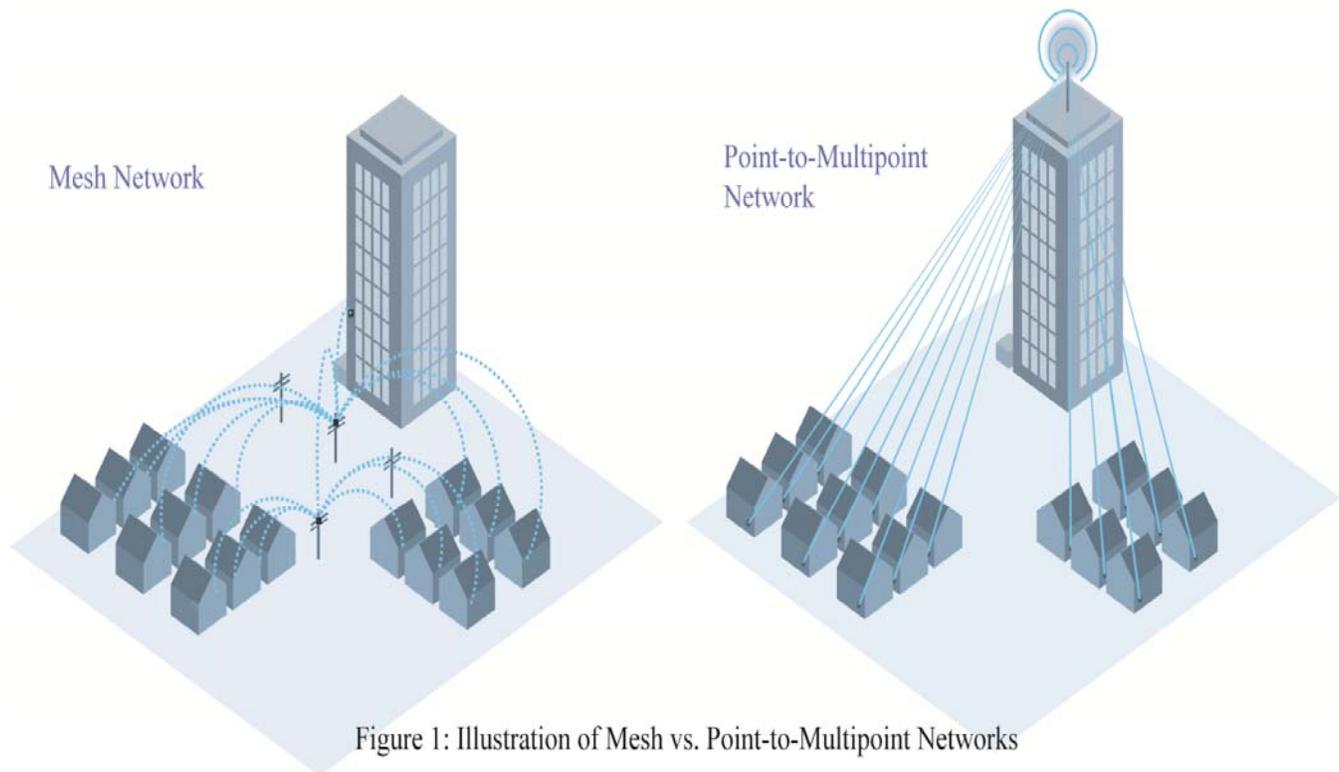


Figure 1: Illustration of Mesh vs. Point-to-Multipoint Networks

Using unlicensed, public frequencies has its own pros and cons. The available frequencies are filled with traffic – ranging from baby monitors, garage door openers and basically any low-power radio device in a home or office. This radio traffic, or noise, can slow, interrupt or otherwise affect the signal coming from an AMI device. Imagine trying to pass a message person to person across a crowded football stadium during a game.

Point-to-multipoint systems use licensed radio spectrum systems which enable the use of higher power radios to optimize performance. Licensed frequencies are purchased radio bands and protected by the Federal Communications Commission, which makes them virtually interference-free and untroubled by crowded channels. Because of this, licensed spectrum signals routinely reach many times the distance of mesh signals. Using the football stadium analogy, a point-to-multipoint network would be similar to having a walkie-talkie conversation between private stadium boxes.

Cellular networks operate on the existing cellular telephone network that is used by consumers today. This type of network relies heavily on public cellular carriers, such as AT&T, Verizon, T-Mobile, Sprint and others for general system maintenance and upgrades, whereas the meter-based radio acts as another “cell phone” on the network. The meters transmit information in short bursts throughout the day, as with mesh or point-to-multipoint. It’s important to note that, as of this writing, a cellular option has not been developed exclusively for gas utilities and instead relies on an electricity meter backbone.

The factors that affect a utility’s choice of a wireless network are highly influenced by an organization’s resources, goals and challenges. In practice, a combination of mesh and private/point-multipoint approaches may exist across a utility’s different applications or even within them as projects scale and grow.

## **BENEFITS TO GAS UTILITIES**

Natural gas utilities have a significant opportunity to utilize wireless meter communications to successfully transition into the utility of the future. When a utility’s business plan based on improving operational efficiency throughout the organization – not just faster meter readings – they will see the benefit of investing in a robust and secure communications network that connects, monitors and controls devices to the network, analyzes data gathered to provide actionable intelligence and proactively communicates with their customer base.

Wireless communications networks, the ability to connect monitor and control devices to that network, and the software that turns the data into business intelligence will deliver the benefits that drive the bottom line results.

## **BUSINESS CASE**

Advancements in wireless meter communications, positive deployment case studies and advancements in standards are helping to reduce the reluctance of some natural gas utilities to invest in the technology. Stable, sophisticated platforms requiring minimal infrastructure allow for system upgrades without disrupting service and higher efficiencies in operational costs and human capital are creating a compelling business case to justify the investment.

It should be noted that gas utilities do not have the same needs of an electric utility, and the business case for gas AMI must be developed using different criteria. Electric utilities have the fundamental need to generate the electrons at the time of use. Therefore, they have an incentive to build a “smart grid” to assist in matching the supply to the demand at various hours of the day and conditions. Electric utilities also have the inherent issues of power outages due to the complex electricity infrastructure that is generally above ground and subject to damage. A “smart grid” is a tool to assist in the management of common and frequent outages in portions of their systems.

What factors should gas utilities consider when planning their wireless meter communications networks? Which should they weigh most heavily? Now that we’ve established the radio qualities and architectural considerations that differentiate each approach, we will note which of these and other top considerations most impact the performance of a wireless network.

### **Top Gas Utility Business Case Components:**

#### **Field Labor**

1. Labor cost reduction for collecting readings
2. Reduction of repeat field visits to meters to correct readings
3. Reduce field visits to meters to collect off cycle meter readings
4. Elimination of high meter reader turnover (hiring & training)

#### **Back Office Labor**

1. Accuracy of meter readings
2. Consistency of meter readings
3. Reduction of calls due to billing errors
4. Lower back office cost for meter reading exceptions

#### **Customer Use**

1. Confidence in readings
2. Ability to view more frequent usage information than monthly
3. Establish correlation between their behaviors to their natural gas usage

To accomplish this business case, the network selection process will include the following components:

### **The Top Factors to Consider Include:**

1. Cost
2. Privacy and Security
3. Reliability
4. Redundancy
5. Range
6. Signal to Noise Ratio/Interference
7. Latency
8. Interoperability
9. Scalability
10. Resistance to obsolescence
11. Ruggedness in weather
12. Geographic challenges

[These factors are detailed in Appendices A & B]

## Realized Savings:

### Manual Meter Reading

(1 million customers read monthly - Appendix B)

Labor	\$5,521,849
Benefits	\$1,932,647
Vehicle Ownership/operation	\$1,703,864
Annual Savings	\$9,158,360

### Off-cycle Meter Readings

(23% of total meters – 230,000) (a)

Labor	\$1,035,347
Benefits	\$ 302,371
Vehicle Ownership/operation	\$ 319,475
Annual Savings	\$1,717,193

**Total Annual Savings \$10,875,553**

[These factors are detailed in Appendix C]

## IMPROVED OPERATIONS

Each year, gas utilities dispatch thousands of orders to shut off residential service for safety, move-outs (a) or lack of payment. If service personnel can't access the meter, an additional trip is required, further increasing operational costs. In the near future, expansion of wireless meter communication and applications will make it possible to perform these functions remotely. These devices are available today as add-on options - such as remote gas shutoff devices. Future meters will be available with integrated radios that offer a wide range of options such as disconnect and reconnect; distribution pressure monitoring; gas leak detection; internal meter intelligence, and alarm capabilities will all play a significant role in improving efficiency and safety for the utility and its customers.

### Examples: Disconnection

One gas utility in the Midwestern United States schedules more than 50,000 shut-offs per year – 20,000 of which are indoor installations.

Another gas utility averages 60,000 disconnects annually that cost the company \$42 million in operations & maintenance expense. A conservative 1% reduction would save nearly \$250,000.

The ability to shut off natural gas service during a structural fire is invaluable to the safety and security of rescue personnel. In some cases where the gas meter or street valve is inaccessible, it's simply too dangerous to attempt to save the structure. The ability to remotely disconnect offers immeasurable savings in this situation.

### Example: Cathodic Protection

Looking ahead, utilities may be able to integrate an AMI network with cathodic protection (CP) monitoring systems. Since the AMI system is built to receive input data from a source, a system application could be used to collect voltage information from CP monitoring systems for centralized control and increased system integrity. How much can this contribute to the bottom line? Consider that overall corrosion costs are an estimated at \$276 billion in the United States and \$2.2 trillion worldwide.

## IMPROVED CUSTOMER SERVICE

Detailed information on-hand results in immediate satisfaction for the customer and avoids the need to send service personnel to investigate concerns. For the customer service representative, the ability to answer an inquiry on the first call gains the customer's respect and establishes a feeling of trust. The representative can then help the consumer determine ownership of the situation through civil discussion of the circumstances surrounding the inquiry. Without this trust, the customer may make several additional calls or enlist the help of a consumer advocate in the media – which in itself may create a larger a public relations situation.

### Example: Customer high bill complaint

An Atmos Energy representative received a high bill complaint call. With daily or hourly reading information on hand, she was able to advise the customer of the time and date when the usage began and stopped. The customer insisted they were out of town. Considering the load used to generate that usage, it was determined that a pool heater was in use. After further investigation at

home, the customer called back and advised that the bill was in fact correct, and their teenage son had thrown a pool party while they were out of town. The son wasn't happy, but the customer was. This one example avoided a billing audit, a service call to investigate the premises, a possible meter change-out, accuracy investigation and report. All of which would have totaled \$730.

How much time and operational dollars does your company spend on high bill complaints? How many are justified complaints? At Atmos Energy, the implementation of an AMI system that provides hourly reading information has already reduced service calls by 30% for one service area, which equals \$70,000 savings to the bottom line. Full system deployment is projected to save an additional \$5 million annually.

#### **Plan "B"**

Disaster planning is a key component of good operations plans. A wireless meter communications system can offer significant benefits for service disconnection or restoration and system information during a crisis.

**High/low pressure** – devices that monitor pressure can automatically shut down service and alert the gas utility to the situation, enabling near immediate response by the utility.

**Loss of communication** – some wireless systems offer the ability to transition from walk-by to drive-by to fixed base. The ability to migrate from platform to platform enables the gas utility to transition on a planned schedule. For example, a fixed base system that loses communications due to a downed tower can access device information via walk-by or drive-by.

Wireless systems enable near-seamless operation in the event of prolonged outages. Battery backup at collectors facilitate readings during short term power failures, and endpoints can record and store up to 35 days of hourly readings and other information.

**Service outage** – Although rare for a gas utility, the wireless communications system can alert the company to situations and assist in deploying resources to solve the outage before it becomes a larger situation.

#### **BENEFITS TO THE CUSTOMER**

Natural gas utilities are beginning to offer customers more detailed information about their bills – and more opportunities are on the horizon. While online portals are most common, some electric utilities are going a step further by sharing consumption information through home energy monitoring devices, similar to a thermostat. This information empowers customers to learn as much as they choose about their usage and the impact it has on their bill. Over time, customers learn how behavioral changes can lower their bill, conserve energy and reduce their overall carbon footprint.

#### **Residential:**

Atmos Energy is currently gathering hourly meter reads from their AMI system and posting a daily read to the customer information system (CIS) daily. The utility is experiencing a daily read success rate of more than 99 percent. The customer's daily consumption and meter readings are available for them to view online through the previous day [see example in Appendix D]. Some customers in one service territory check their usage almost daily and are adjusting their consumption for conservation.

#### **Commercial:**

Wireless meter communication now provides smaller companies with the benefits that only were available to large companies. Gathering detailed usage information for a restaurant location, for example, once required an investment of roughly \$3,500. With wireless meter communications, it's "included" in the service offering from the utility. Combined with a Web portal, the data derived from these systems can assist small companies in operations planning and conservation. Improving their business and lowering their costs. Depending on rate structures, this information may also enable new options for utility sales and marketing to build customized cost structures that improve satisfaction and/or reward businesses with better pricing plans.

#### **SELLING IT UP THE CHAIN OF COMMAND**

##### **What else can be done with network and volume of information?**

The heart of AMI is data. And we're only scratching the surface with how we can use this information to provide better service to our customers and returns to our shareholders, overall. The data from AMI systems is staggering, and management of this information is more than a full-time task for IT analysts throughout the industry. How staggering? This year, the amount of data generated by AMI systems in North America will consume well over 11 petabytes of information and that number will more than double by 2015.

Information gathered by the system gives operations staff greater insight into resource allocation thanks to a better understanding of system performance. Service and billing departments can now resolve questions over the phone on the first call from a customer. One utility has used their wireless communications system to eliminate a three-day lag between the date of a meter reading and when the bill is sent to the customer, thus improving meter-to-cash process time. Meter reads required to open or close an account can be executed remotely, reducing the burden on field personnel and inconvenience to the consumer. And personnel, once required for non-revenue generating tasks can now be redeployed to other areas of the company, where their knowledge and experience can be utilized for improving operations.

A gas utility should seek a system that offers flexibility over the life of the product. Most natural gas utilities, if automated at all, currently have legacy walk-by or drive-by systems with limited functionality that may be nearing the end of their lifecycle. A wireless communications system that can support their walk-by/drive-by meter reading needs today with the ability to transition to a fixed-base meter reading system in the future will ensure their operations will be able to keep pace with changes in their business.

As natural gas utilities learn more about the benefits of an AMI system for their specific needs, the technology will continue to be adopted at a growing pace. Fixed-base communications networks, the ability to connect monitor and control devices to that network, and the software that turns the data into business intelligence will deliver the benefits that drive the bottom line results.

## Appendix A - Prioritizing AMR Considerations

Criteria	Importance	Rationale
Program Total Cost	High	Utilities need to show return on investment; most are able to make a business case for improved operational efficiencies, a reduced carbon footprint and improved customer satisfaction. The ability to roll out a program with the least intrusive infrastructure and minimal new equipment may be an advantage.
Privacy and Security	Medium	Rapid transfer of data into a handheld unit at a short range does not represent a significant increase in vulnerability of data compared to that of paper or online billing systems, but all programs must incorporate security protection policies that address identity theft and protect from malicious access to or sharing of personal information.  Residents and commercial accounts will see less interruption, no in-home access needed with an AMR system. Consumers may appreciate the assurance of a wireless network in which their data transmits to a single point of communication with the utility and where their data cannot be transmitted to or received by other points on a local communications network.
Reliability	High	Reliability of new systems must meet or exceed pre-AMR achievement levels and anticipate the potential for future reliability mandates or standards. Not only does this impact consumer satisfaction, but it can run up costs through the need for potential retrofits and/or testing to meet any newly-imposed reliability standards.
Redundancy	Low	The presence of a person with every piece of transmitting equipment means someone is there to immediately address any communications gaps. Getting another unit is a simple fix that addresses redundancy needs.
Range	Moderate	Transmissions will occur over short distances from meter to handheld meter reading device. To assure reduced mileage and increased efficiency in data collection times, it is important to select offerings with optimal range with low interference, allowing data collectors to receive clear readings from as far as several blocks away.
Signal to Noise Ratio/ Interference	Moderate to High	In an urban setting, even if a meter signal travels only a single city block to the meter reader's handheld device or vehicle, there may be multiple potentially intrusive signals that could distort or delay efficient, accurate readings. In residential settings, the increasing level of wireless technologies in homes presents an additional potential source of unwanted noise. Selecting a communication network that meets a particular utility's tolerance for noise and interference is important to consider before deployment.
Latency	Low	When a utility moves from analog meter data collection to automation, the increase in speed and accessibility to data is exponential; the minor differences in latency between automation solutions pale in comparison to the gains of any AMR program.
Interoperability	Very High	A community's investment is more secure when a system can communicate with multiple meter brands that may already be present and with systems that may be used in the future. Readiness to read home energy management devices would also be a benefit consumers may appreciate.
Scalability	Variable	AMR is inherently scalable when interoperability is addressed as noted above. The importance of scalability may vary depending on utility needs and resources. Careful pre-deployment analysis of network configuration needs will help ensure that potential growth points are anticipated and that the system deployed is flexible enough to expand as needed.
Resistance to obsolescence	Very high	Since AMR is often a region's first step into automated data collection and smart grid initiatives, satisfaction with the longevity of their investment and its ability to bring them future benefits is an important factor. Selecting rugged equipment based on open standards systems with high interoperability will help retain value on infrastructure investments.

Ruggedness for weather conditions (extreme heat, snow and ice, hurricane or tornado winds, flooding)	Moderate	Equipment must meet or exceed durability of pre-AMR options. Wireless networks can help drive customer satisfaction during power outages by delivering event news quickly to utility operations and potentially accelerating restoration.
Program Total Cost	High	Utilities need to show return on investment; most are able to make a business case for improved operational efficiencies, a reduced carbon footprint and improved customer satisfaction. The ability to roll out a program with the least intrusive infrastructure and minimal new equipment may be an advantage.
Geographic challenges	Low	Since a meter reader will travel shorter distances to read meters from a vicinity rather than to every endpoint, geographic challenges may be somewhat reduced by automating with handheld or drive-by devices. For example, limited mobility during bad weather events may be less of a disruption since meter readers will not have to get as close to read their assigned meters.

Source: "Wireless Smart Grid Communications: A Mesh versus Point-to-Multipoint Comparison", © Sensus 2012

## Appendix B - Prioritizing AMI Consideration

Criteria	Importance	Rationale
Total Program Cost	Moderate and variable	Utilities need to show return on investment; most are able to make a business case for improved operational efficiencies, a reduced carbon footprint and improved customer satisfaction.
Privacy and Security	High	Consumers value secure data. Equipment damage could create disruption of service and increase repair costs.
Reliability	High	Reliability of new systems must meet or exceed pre-AMR achievement levels and future mandates/standards for increased reliability.
Redundancy	Moderate	Increased reliability may reduce need for greater investment in redundancy.
Range	High	Rural settings require great range; urban or suburban less so. In any scenario, greater range can mean reduced infrastructure costs.
Signal to Noise Ratio/ Interference	Very High	Vital in urban settings where commercial and emergency operations exist; in suburban settings where signals must be free from interference from home phone and Internet signals. Priority use of band could be a significant factor.
Latency	Low	Even with high latency, where signals may take a second or two, wireless communications bring vast improvement over formerly monthly availability of data.
Interoperability	Low to moderate	Current AMR systems tend to be self-contained; however to accommodate interaction with future home energy management systems, this will become more important. IP-based systems offer greatest likelihood of future interoperability.
Scalability	Variable	Areas of historically slow growth will require less scalability than a rapidly expanding region.
Resistance to obsolescence	Medium to high	Equipment should be designed to be upgradable using existing firmware, and should economically address future increases in bandwidth requirements so as to avoid obsolescence for years to come. In addition, the ability to have over-the-air programmability, whereby new features can be added without having to visit, let alone change out, the device, further improves resistance to obsolescence.
Ruggedness for weather conditions (extreme heat, snow and ice, hurricane or tornado winds, flooding)	Very High	Equipment must remain accurate and provide improvement in weather resistance over other choices. Needs may be highly variable based on local climate's tendency to disturbances such as extreme heat, snow and ice, hurricane or tornado winds, flooding and earthquakes.
Geographic challenges	Very High	Urban metering must accommodate obstructions from tall structures; rural metering must overcome distances including ability to cross impassable terrain such as swamps, ice, rivers, cliffs, mountains, protected wildlife areas or farmlands. Suburban metering may require addressing infrastructure site scarcities.

Source: "Wireless Smart Grid Communications: A Mesh versus Point-to-Multipoint Comparison", © Sensus 2012

**Appendix C – Off-Cycle Meter Reading Cost Savings**

**Analysis of Meter Reading Costs (direct only)**

A	B	C	D	E	F	G	H	I	J	K	L
Customers	Meters read (per man hour)	Monthly hours to read	Man hour per year	Man hours paid due to non-work time	Staffing level to meet demand	Average annual salary	Benefits	Vehicle	Total cost	Monthly Cost	Average cost per customer
1,000,000	45	22,222	266,667	375,587	181	\$5,521,849	\$1,932,647	\$1,703,864	\$9,158,360	\$763,197	\$0.76
Calculations:		=A/B	=C x 12	=D x 71%	=E/2080	=F x (\$30,580)	=G x 35%	=F x (\$9,436)	=F x (G+H+I)	=J/12	=K/A

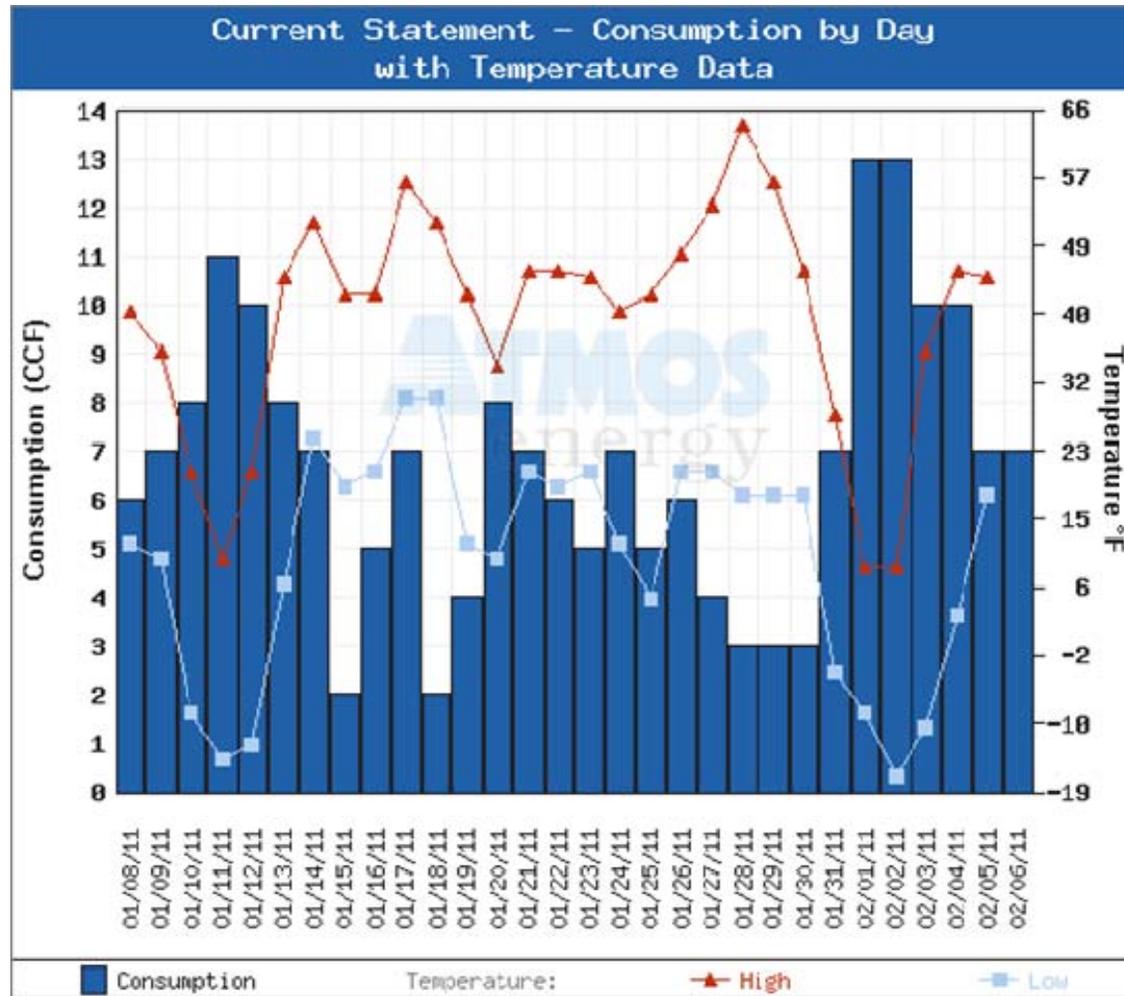
**Analysis of Off-Cycle Meter Reading Costs**

A	B	C	D	E	F	G	H	I	J	K	L
Monthly Orders	Meters read (per man hour)	Monthly hours to read	Man hour per year	Man hours paid due to non-work time	Staffing level to meet demand	Average annual salary	Benefits	Vehicle	Total cost	Monthly Cost	Average cost per customer
16,667	4	4,167	50,000	70,423	34	\$1,035,347	\$362,371	\$319,475	\$1,717,193	\$143,099	\$8.59
Calculations:		=A/B	=C x 12	=D x 71%	=E/2080	=F x (\$30,580)	=G x 35%	=F x (\$9,436)	=F x (G+H+I)	=J/12	=K/A

Annual Savings	<b>\$10,875,553</b>
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Source: Atmos Energy

Appendix D - Example of Customer Consumption as seen through Atmos Online Portal



Source: Atmos Energy