Better Smart Meters

How to improve on the Advanced Metering Infrastructure (AMI) to the benefit of all

Executive Summary

Solid-state meters are becoming a part of daily life. There are reports of concern and direct health effects from their deployment.

Opt-out programs cannot solve all problems, the choice of base technology is central to an appropriate solution. Some choices of technology may reduce the number of people choosing the opt-out program.

A first step is to evaluate how frequently there is an actual need to communicate with each meter. It may be less than expected.

There are meters available which report the electrical consumption by the hour, yet only need a daily or monthly download. Many other functions can be performed with infrequent communication with the household meters, such as outage detection, voltage monitoring and demand side management functions, if considered during planning.

Frequent communication with each household electrical meter requires a more complex infrastructure and may be less acceptable to the public.

Improved technologies can be developed if there is a demand for it. Much can be accomplished with software upgrades to existing models, at a moderate cost.

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1. Introduction

The smart meters, and their simpler cousins, will soon be ubiquitous in many parts of the world. They will be mounted on the walls of homes, apartments, offices and schools, often in close proximity to where people spend hours every day.

As these devices are generally mandatory, the requirements for their safety are higher than for regular consumer products that people can choose to use or not use.

Opt-out programs may alleviate some problems and concerns, but they are not a universal solution. Where people live in close proximity, or certain communication technologies are used, an opt-out program may not solve the problem.

The new meters have an expected lifetime of about twenty years and comprise an investment of billions of dollars in the U.S. alone. The Electric Power Research Institute (EPRI) has estimated the total cost of the Smart Grid to be $165 billion dollars over the next twenty years.

With such investments, it makes sense to use the safest technologies available to make sure it is not later considered a costly mistake, as research on health effects catch up.

There is a wide selection of technologies available from several vendors. Most of the meters have embedded computer systems which can be upgraded with new versions of software later on, which means that some features can be added at a moderate cost.

This document lists a number of features that presently exist or could be added to existing and new meters, which are better choices for the public health and safety. Implementing these features does not guarantee that the meters will be safe and acceptable to all people, but they are improvements. There will probably still be a need for an opt-out program, but the need should be less. Some of the technologies may be used as part of an opt-out program.

Incorporating these suggestions may alleviate much public concern.

2. Improved Front Panel Information

Most modern meters include a small LCD screen, which is controlled by the built-in microprocessor. Some meters simply display the currently accumulated watt-hours, just as the analog meters do. Other meters flash various numbers, such as the current rate of consumption. On most meters, the display could be used to display more information, which may only require a software upgrade.

It is standard for data communications equipment to have indicator lights (LEDs) showing when the equipment is transmitting. Smart meters should too, using the LCD panel.

Such information would allow the resident to see when and how often the meter actually transmits. If the meter malfunctions and transmits continuously, the indicator can help pinpoint the failing meter.

This feature can also allow the resident to know if the meter is used as a relay, which generates more traffic.

The display could cycle through a series of information lines, each displayed in turn. Besides billing information, the following could be displayed, when applicable:

- TRANSMITTER OFF
- RELAY OFF
- HAN OFF

When actually transmitting it could display:

- TRANSMITTING
- RELAYING

This allows the ratepayer to know the current status of the meter and how often it transmits. Where an opt-out program includes turning some features off, it allows for verification. Verification is essential for peoples' peace of mind, and may also catch some of the occasional mishaps and failures.

3. Encrypted Communication

There is a real threat to the infrastructure from cyber attacks, whether by terrorists or hackers. A virus attack could shut down electricity to large areas or to targeted sites. There could also be tampering with the data, so customers are overbilled or the utility loses revenue.

It is possible that an attack would set a wireless meter to transmit 100% of the time, which both is a health hazard and could cause disruption of the metering system for a whole area.

Other attacks may turn off the power to a household, and it can only be turned back on by an on-site visit by a technician. If a hundred thousand meters are affected, it will take weeks to restore power. See the work of Anderson & Fuloria at Cambridge University for details.

There is also a privacy and security issue, if it is possible to snoop data from a particular meter. Such information could be used to find out when the house is occupied or not, for use by burglars and abductors.

The encryption system must be strong and verified by qualified third parties.

4. Reduce Transmission Rates

4.1 Introduction

How often a meter transmits is to some degree a matter of choice. There are even cases where meters transmit without serving a purpose.

The Federal Energy Regulatory Commission (FERC) defines the Advanced Metering Infrastructure (AMI) as:

> *Meters that measure and record usage data at hourly intervals or more frequently, and provide usage data to both customers and energy companies at least once daily.*
>
> *Source: A Policy Framework for the 21 Century Grid, Executive Office of The President of The United States, June 2011*

This statement says that once-a-day transmissions are sufficient to meet the official goals. The same document also says that there is “no one-size-fits-all approach to deploying standards-compliant smart grid technology.

A single daily transmission is much less problematic than an update every 15 seconds. It is important to consider how frequent the communication really needs to be.

The actual bandwidth needed for the “last mile” transmission to customer meters is modest (see comments of Utilities Telecom Council and Edison Electric Institute in GN Docket 09-51, June 8, 2009 on www.fcc.gov)

4.2 Ratepayer Information

One purpose of very frequent transmissions is that the ratepayer may look at the electrical consumption in nearly real-time, using the utility website or an in-house display. This might encourage the ratepayer to save electricity, or move energy-intensive tasks to off-peak hours.

If the ratepayer does not use these features, there may not be the need for frequent transmissions.

If the in-house display is turned off, the meter should not transmit to it. The meter could detect when the in-house display is on by a signal sent from the display panel when it is turned on and every four minutes thereafter. If no signal is received for five minutes, the meter ceases to transmit to the in-house display.

The same principle can be use if the ratepayer uses her private computer to receive the information from the meter.

If the ratepayer uses the utility's web site to view the consumption, the meter can be instructed to transmit frequently, but only while needed. The website then actively displays the consumption. The utility server can send a signal to the meter through the AMI infrastructure instructing the meter to transmit frequently. The meter must receive signals to continue the frequent transmissions. If it has not received such a signal for five minutes, if reverts back to its regular schedule.

If a ratepayer is not interested in using these features, the system does not need to have the ability to communicate this frequently. This could be part of an opt-out program, or simply automatic based on the ratepayer's non-use.

4.3 Billing Information

The information needed for billing and statistical uses can be transmitted much less frequently. The meter can store time-stamped data throughout the day and transmit it sometime after midnight, (perhaps even less frequently, as the amount of data transmitted is small).

Some meters are presently read on a monthly basis, where a utility vehicle drives through the neighborhood with a receiver. In some cases, a meter reader walks by with a handheld device.

In some systems, the receiving device sends out a signal which prompts the nearby meters to transmit, while they do not transmit the rest of the time.

In other systems, there is not prompting. The meters transmit every few seconds all the time, whether here is a receiver present or not. Such systems are best avoided.

The drive-by systems cannot feasibly deliver data more often than a few times a month, so they may eventually be phased out, but the example illustrates there is often a choice.

4.4 Detections of Outages

One reason for frequent transmissions from the meters is to detect and locate power outages. This can be done by polling the meters or a simple time-out function when a meter hasn't transmitted for some time.

Some meters have the ability to transmit a distress signal in the brief moment while the line voltage drops. This technology will make frequent transmissions unnecessary for outage detection.

Outage detection may be best served by a dedicated monitoring device, located in each neighborhood. This device can then have a battery backup system and a more reliable communication system.

4.5 Demand Side Management

Demand Side Management may include simple Time-of-Use billing rates or more advanced methods.

Time-of-Use can rely on a meter's built-in processor to tabulate the consumption depending on the time of day. This is presently done with just one monthly download of billing data.

More advanced methods will require some communication with the utility server. These communications are generally initiated by the server, not the meters. Such communications can generally be rare, such as during a need to curtail consumptions. If the ratepayer does not participate in such a program, such communication is not needed.

Technologies are being developed to automatically curtail consumption without any need for communication with the utility. One example is designed by Jacob Østergaard at the Technical University of Denmark. This device monitors the network frequency and turns down or off a refrigerator or other appliance when it senses a power shortage.

4.6 Remote Disconnect, Updates, Etc.

The need to perform a remotely controlled disconnect/ reconnect of service is a rare occurrence that is not time critical. It does not require frequent communication.

Remote updating/ programming of the meter, downloading of new software, etc, can be done nightly.

4.7 Default Settings

The default settings when a meter is installed, or its software is upgraded, are very important.

The default setting should be the least communicating. Any sort of optional features, such as a Home Area Network (HAN), should be turned off by default.

Ratepayers who do not use the various available features, such as an HAN, should not have to find out on their own how to turn it off. This is a problem with some DSL internet services, where the wireless feature is on by default. The customer who prefers to connect by a cable has to make a significant effort to get the transmitter turned off.

5. Use More Benign Communication Technologies

The use of wireless and power line communication (PLC) technologies are problematic for residential use. Of the two, the PLC technologies may be the most problematic, as they are not localized to the meter. Instead, the “dirty electricity” travels on all wires throughout the neighborhood, even to homes without such meters. The wires are turned into very large low-powered antennas. It is difficult, if not impossible, to mitigate PLC technologies.

A more benign technology is to use a telephone land line. The meter can use a dialup modem every night, using the residential phone line, the way some pay-per-view systems do.

For more frequent communication, the meter would probably need a dedicated phone line. A central computer can then dial the meter’s number several times a day to download the data.

A less desirable method from a public health point is to use meters with built-in cell phone modems (GPRS). If the meter is placed on a pedestal in the yard, or on a garage, that would make this method more acceptable.

For apartment buildings, the meters are often mounted in a cluster. They could then be daisy-chained together using a dedicated wire line (USB, Ethernet or RS232) with one dedicated meter then relaying the information. The onward communication could be via whichever internet service is available for that building, i.e. DSL, coax or fiber. Another alternative is to use a fixed phone connection, or even a dialup phone connection. Where there are no other feasible alternatives, a directional wireless system could be used. The antenna could be mounted on the roof, with a cable going down to the bank of meters.

According to the National Cable and Telecom Association (NCTA), 92% of U.S. Households already have access to high-speed cable-based internet service. These providers often also serve businesses with a high need for reliability and security, such as banks and hospitals. These higher-grade services are ensured through service level agreements.

Using existing networks may be more cost-effective than installing a new dedicated system.

6. Use Dedicated Monitoring Devices

Instead of relying on household smart meters for monitoring the line voltage, power quality, power loss, etc, these functions can be moved to dedicated monitoring devices located in each neighborhood.

This device can be a part of the neighborhood access point that also collects data from the local electrical meters and forwards it.

A monitoring device can include a battery backup system and a variety of communication options, so it can continue to operate during emergencies.

7. Better In-house Displays

If an in-house display is used to show the actual consumption, there is a need for frequently transmitting that information from the meter. It may be needed to be updated every few seconds.

However, if the in-house display is turned off, there is no need for such transmissions at all. The in-house display should inform the smart meter when the transmissions are actually needed, i.e. by sending a brief signal.

- When first turned on
- Once every four minutes

If the meter has received no signal for five minutes, it simply stops transmitting. A more benign option is to use displays that are connected to the meter through a dedicated cable. Such a model is available from Landis+Gyr. However, this will not be practical in many cases, but could be an option where there is a special need.

8. Pre-paid Meters

One opt-out option offered to customers is a pre-paid meter, where the ratepayer uses a smart card to add to the balance in the meter. There is no direct communication between the utility and the meter.

These meters generally use an in-house display to inform the ratepayer about the status. The display console is also used to add more money. However, these displays typically communicate using wireless (usually Wi-Fi) or PLC, both of which are problematic, unless the meter stops transmitting when the display is turned off, as described earlier.

Another option is to use a meter with a dedicated wire line connection to the display. Such a meter is offered by Landis+Gyr under the name "Cashpower Jade". Such a meter could be offered as an opt-out option.

9. Choose Better Power Supplies

The electronics inside the meter run on a low voltage, which is provided by a switching power supply. This type of power supply produces transients and harmonics ("dirty electricity") in the kilohertz band, which travels on the wiring throughout the home, and sometimes even to the neighbors- especially if sharing a transformer.

Switch-made power supplies are found in many household devices and are not solely a problem for solid-state electric meters. However, people can be affected by them, and some choose not to have any in their homes for that reason, or they turn them off at night.

The amount of dirty electricity, produced by a switch-made power supply, varies greatly with the model. It makes sense to choose better models.

Power supplies of a lower grade may also leak more electricity onto the household grounding system, which can create an unbalanced power feed and ground currents.

The amount of dirty electricity can be measured using an oscilloscope and a spectrum analyzer. A Stetzer meter could be used for relative comparisons. Ground leaks are measured using an ammeter.

10. Built-in Shielding

Wireless meters radiate in all directions, not just in the direction of the receiver. The steel electrical panels used in North America provide some shielding, but not sufficiently. In some countries, non-metallic housing of breaker panels is used, which provides no shielding at all.

Some sort of shielding, and/or directional antenna, could be used to lower the radiation entering the household as much as possible. This does not address the cases where meters are facing close-by residences, or where the residents use outdoor spaces around the meter, such as a garden or balcony.

Shielding may not be sufficient to accommodate people who are particularly sensitive to wireless emissions. Shielding also does not address the dirty electricity that may be put on the electrical wires by the meter's transmitter module.

Shielding may interfere with the intended communication path, which may be resolved by using repeaters or other means. Shielding is thus more of a patch than a solution.

11. Power Line Filters

Communicating by sending pulses or high frequency signals across the power distribution lines, as well as the household wiring (PLC), is problematic.

The European multinational utility company, E.ON, has developed a line filter which dampens power line signals in the kilohertz range. It is installed next to the electrical meter on customer residences where there have been problems. The filters are not installed elsewhere, due to their substantial cost.

It is unlikely that filters will work for low-frequency pulsing PLC systems, such as the TWACS and Hunt's Turtle, since the problematic frequencies and harmonics are close to the power frequency.

The filters do not help on effects from the residential power lines along the roads (which act as giant unintentional antennas), nor do they help hypersensitive people when going to grocery stores or visiting other people. With wireless meters, the other end of a building may be fine, but with PLC systems some people may be trapped in their homes. There do not appear to be wholly satisfactory solutions to the problems with PLC technologies, and they should be used with great caution.

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