The Smart Meters:
What are the different types, how do they work and what are the health issues?

The mechanical meters for electricity, gas and water are being replaced with new digital meters in much of the industrialized world. The more advanced models are called smart meters, while the simple models are called AMR meters. They are all causing health concerns, especially among those who are electro hypersensitive (EHS). This article describes the different types of meters, what the problems with them are and why the utilities promote them.

Executive Summary

There are several types of electronic meters available. Some are read monthly, while others transmit data every few seconds.

The concerns are both about the meters which transmit using wireless and those which transmit across the electrical wires in the house and neighborhood.

The wireless method can be similar to having a wireless network in the house or a cell phone which is in constant use, but not against the head. This is fine for some, while others cannot live with it.

The meters transmitting via the electrical wires produce “dirty electricity”, which turns all the household wiring throughout the neighborhood into unintentional antennas. It may also radiate up into a house from stray currents running in the soil.

The wireless transmitters have stronger signals, but transmit only from a few places. The power line communication system emits weaker signals but is everywhere, and is harder to mitigate.

All digital meters have electronics inside. On some models, electronic components create powerful dirty electricity which has been a problem for the resident.

The trend is to transmit more often than in the recent past, where many systems only transmitted once a month or once a day.

Many of the meters being installed today can later be programmed to transmit more frequently and perform more functions. Some models are modular, with the ability to swap out the transmitter with a later model or a different type.

The different technologies available offer trade-offs between what features are currently wanted by the utility and what the impacts are on the public health.

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1. Introduction

This article is concerned only with the health issues with the new meters. The other areas of concern, such as privacy, pirating and ethical/accurate billing are not addressed.

When contacting the utilities and public officials, it is essential to be well-informed to be taken seriously. This document provides the foundation for communicating effectively with the authorities.

Some readers may think the author is promoting smart meters when they read the first part of this article. That is not the case, the author only recognizes that there are some benefits to them, and wishes to provide an accurate, balanced picture of the issues.

There are problems enough, understanding them is easier when knowing what the meters are used for, which is described in the following.

The current big push is to replace the electrical meters. The replacement of meters for gas and water is happening much slower as there is currently no government interest in doing so.

This article focuses on the electrical meters, though much of the information also applies to digital gas and water meters.

2. Why are these meters being installed?

The U.S. government has given large grants to utilities to install smart meters. In some countries, such as Sweden, the government has essentially mandated they be installed. In many cases, the utility companies are also interested on their own, though the investment cost has slowed them down.

The reasons for installing these meters may be:

- they are much cheaper to read
- they allow the electricity to be cheaper at off hours
- they encourage using less electricity
- they encourage shifting usage to off-peak hours
- they are more accurate (when working correctly)
- the utilities have better usage information
- they allow the utility to better manage the grid
- they allow more solar and wind power to be used

- they help locate line breaks
- disconnect/reconnect of service is much simpler

Not all meters have all these functions. It is up to the utility which will be available.

The following sections describe what the meters do in terms of these reasons. Later, we'll look more closely at how they communicate, which is the main concern of this paper.

2.1 The new meters are cheaper to read

There is a large cost savings in no longer needing employees to visit each meter once a month. With the old meters, a meter reader comes by once a month and reads off the number. In many cases, this is done from a car, where the meter's dial is photographed using a camera with a tele-lens. The digital photo is then inspected at a central location, by a person who enters the number into a computer. In some areas, the meter reader must walk to each meter, which takes a lot of staff time. In older houses in Europe and the eastern United States, the meters are located inside people's houses, making reading them manually very time consuming.

The new meters require much less staff. One type is read from a car that drives through the neighborhood without stopping. One manufacturer boasts that a single person can read off 100,000 meters in a day with this method.

Other types of meters communicate directly with the utility home office, without any meter readers at all.

One rural utility serving 20,000 households has stated they could eliminate their three meter reading jobs at a savings of $65,000 a year (one meter reader was retiring, the two others would be given other duties).

2.2 Customer education for energy savings

Some utilities have a web site where customers can see how their consumption of electricity changes by the hour — sometimes even by the minute.

The idea is that customers will be able to see how cranking up the air conditioner in the afternoon affects their monthly bill. How deferring running the clothes dryer to off-hours might save them money.

This may get people to use less electricity during the peak hours, where the utilities have to use expensive power plants to cover the peak electrical usage. It can save the utility money if the usage of electricity is more even across the day.

Utilities typically offer this information a day later, as they receive the data during a nightly download from the smart meter. More sophisticated smart meter networks, which communicate very frequently, may offer the customer the information in nearly real-time.

Another educational tool is a wall display, which shows the consumption of electricity in real-time, as well as how much has been used that day. The wall display gets the information directly from the smart meter mounted on the house.

2.3 The utility gets better information

Managing an electrical grid is like walking a tightrope. The grid must be in perfect balance at all times between what the consumers use and what the power plants produce. When they fail, we have brownouts where the voltage gets too low, which can damage household electronics and appliances. Or we may see total blackouts.

This balancing act will become more complicated in the future when there will be more power coming from wind turbines, solar power plants and other sources.

Having more detailed information about how electricity is consumed helps with these balancing acts.

Some models of the meters monitor the line voltage and report it to the utility. This information can be used to decide where to upgrade or reconfigure their distribution lines, which means more reliable and better service to their customers.

In some cases, the line voltage is reported every few seconds and is used to detect line problems or power shortages as they are happening.

2.4 The utility can better manage consumption

The consumption of electricity varies across the day and night. The least electricity is consumed late at night, while the most is used on hot summer afternoons when air conditioners are running everywhere.

The power companies have to use special plants that can rapidly increase and lower their power output to meet these afternoon peaks. These plants are much more expensive to operate than those plants that run 24 hours a day.

If the utility can slow the rise of such peaks, or even remove the top some, that helps lower their cost. It can also help prevent brownouts and outages.

As more renewable energy is put on the grid, it becomes more complicated to manage supply and demand. If the wind suddenly stops blowing in an area with big wind farms, the utilities will have to find a replacement immediately, or there will be a blackout. If they can lower the electrical use dramatically for just a few minutes, that may give them enough time to get some of their peak plants up to full speed.

The smart meters can help with this problem in at least three ways:

- time-of-use billing
- dynamic pricing
- load shedding

The time-of-use billing is already in use in many places. Instead of having a fixed rate for electricity, the rate depends on the time of the day. The electricity will then cost more in the afternoon than in the morning, encouraging people to use the clothes dryers and air conditioners less in the afternoon when the power companies have to produce electricity more expensively.

In the future, we may see a more advanced version where the price of electricity fluctuates unpredictably. The meter constantly receives information on the current price from the utility company and the customer can then decide whether to defer doing a load of laundry, or turn down the a/c. In the future, special versions of thermostats, clothes dryers, refrigerators and water heaters will be able to communicate with the electrical meter and based on the current price of electricity, they may turn themselves down or off.

Electric cars can use the information to only charge their batteries when the price of the electricity is the lowest.

The person living in the house or apartment will have the choice whether to use these features or not. The utility will only provide the current price of electricity via the smart meter. It is up to the person whether to set the thermostat to use the information, and save money.

Equipment that should not be turned off, such as medical equipment, will not be affected.

The use of dynamic pricing will require the purchase of new thermostats and other devices. Some new appliances will have the electronics built in, while older ones can possibly be retrofitted. The use of them will most likely be voluntary, as it would be impossible to force people to program their thermostats, and probably unlawful as well. Instead, lower prices on electricity will make people convert over time.

The new appliances will likely have these features turned on by default, and many people may not even know they are active.

A more controversial issue with the smart meters is that they could be used to turn off certain equipment in people's homes. If a utility company finds itself short on power, because a power plant had a sudden failure or the wind stopped blowing at several large wind farms, they will have to shed consumption or they will have brownouts or blackouts. What they may do today is rolling blackouts, where they disconnect whole neighborhoods or areas for awhile, then disconnect another area for awhile, while the first area gets their power back.

The idea with the smart meters is that instead of causing total blackouts, they only turn off some things that are not essential. It is much less disruptive to have heating/cooling, hot water, etc., turned off for an hour or two, than having a total blackout for that period.

The meters will not be able to turn off individual appliances if they are not modified for it, so the owner of a home or business will have the choice.

The shedding of loads may be done by setting the price of electricity so high anyone's smart meter-enabled appliances will turn themselves off. But then there is the ethical issue of what price should people pay for electricity used by light bulbs and medical equipment during such an emergency.

These smart grid functions are still being developed, both technically and politically.

2.5 Faster to recover from a blackout

When a blackout does happen, it is hard on the utility to restore the power again. When they throw the power back on, everything starts at the same time. Air conditioners, water heaters and refrigerators all start up together, creating a tremendous power surge on the grid, so the utility can only restore power to smaller areas, one at a time. This is called "cold load pickup". If the water heater and air conditioner could be instructed to wait a few minutes after the power was restored, the utility can restore power much sooner to the next area.

2.6 Faster locating power outages

Some smart meters can help the utility discover and locate power outages. Otherwise, the utility has to rely on customers to call to report an outage, and then send out a crew to try to locate it. With some models of smart meters, the utility may be able to locate the cause within a couple of minutes so a crew can be dispatched directly to the site, saving much time.

There are a variety of methods used.

Some utilities receive frequent "hello, I'm alive" reports from each smart meter, sometimes every 15 seconds. These are sometimes called "beacons". If a meter has not reported in for awhile, an alarm is generated.

If an outage is reported by a customer, the utility can send out signals ("pings") to all meters in the area. Those not reporting back are assumed to be without power.

Some models of meters are able to transmit a distress signal after the power has been lost.

2.7 Easier to connect/disconnect service

When an apartment, house, office or retail shop is vacated, the electrical service is often disconnected. The service is then reconnected when the space is occupied again. The service may also be disconnected if the bills are unpaid for several billing cycles. Each disconnect and reconnect requires a utility truck and crew to go to the site and do the disconnect or reconnect.

Some smart meters have an electronic disconnect inside, which can be controlled from the utility company's office, without a crew going to the site.

2.8 The new meters can be more accurate

The old meters were totally mechanical. The magnetic field created by the current going through the meter turned a wheel inside the meter. The revolutions of this wheel were counted via a gear and displayed as electricity consumed. Very simple and reliable.

These mechanical meters do well for electricity that feeds well-designed electrical motors and regular light bulbs. But they do not accurately show electricity consumed by some types of electrical motors, fluorescent light bulbs and electronics, such as computers (this phenomenon is called "reactive power" and is too complicated to explain here).

The new digital meters are not fooled by fluorescent lights and electronic computers, but show the real consumption. Some people have seen their electrical bills go up a little after the meters were installed, but it really just means they got a free ride before. The reports of faulty meters that suddenly double or triple people's electrical bills are a totally different matter, of course.

3. The different types of meters

In industry parlance, every electrical meter is an "end point", regardless of model.

There are several types of meters available from different companies. Some of the meters can be upgraded or configured to function in various ways, so checking the model number on the meter may not tell the whole story.

In North America, some of the main smart meter vendors are Itron (Actaris, Schlumberger), Elster, Landis+Gyr/Toshiba, Aclara, ABB and Sensus Metering Systems.

The meters all look similar, but their capabilities vary widely. They fall into these broad categories:

- mechanical meters
- simple digital meters
- upgraded mechanical meters
- remotely read meters
- smart meters
- pre-pay meters

3.1 Mechanical meters

These are the meters that have been in use for a century. They work like a sort of electrical motor, with the current passing through the meter turning a wheel which runs a mechanical counter. They are simple and reliable, but they can only measure the total amount of electricity used over time. Anything more sophisticated will require an upgrade. This includes the time-of-use metering, where the rate is lowered at off hours.

Some of these meters can be upgraded with electronic add-ons (see later).

3.2 Simple digital meters

The plain digital meter is simply an electronic version of the traditional mechanical meter. Instead of a mechanical wheel, it records the electricity used by a sensor.

These meters are often used for simple time-of-day metering, where the price of electricity is lower at off hours.

A meter of this type may be read visually like the mechanical meter, or by using a port mounted on the front. It must be read by a meter reader, just as the mechanical meters. There is no wireless receiver or transmitter inside.

Most models have an infrared communication port on the front, which is used to read the meter and sometimes program it. The meter reader uses a wand, which is plugged into the port.

3.3 Upgraded mechanical meters

There are some vendors who sell upgrades to old mechanical meters. A small circuit board is typically fitted around the existing mechanical mechanism inside the meter housing. It may read the meter by counting the number of times the mechanical rotor turns, which is an accurate measure of the electricity consumed. The circuit board then transmits the data somehow. An example of such an upgrade is the one available from Hunt Technologies.

It may not be possible to see if a meter has been upgraded. The upgrades tend not to have a digital display.

The upgrades seem to use a variety of communication methods, though they tend to be less sophisticated.

3.4 Remotely read meters

Remotely read meters are generally referred to as Automated Meter Reading (AMR).

These meters work just like the plain digital meters just described, except they do not require a meter reader to walk or drive close to each meter. Some do not use meter readers at all. Instead, they can transmit their data. The common methods to transmit are via:

- telephone line
- radio
- cellular (GPRS)
- power line (PLC)
- wireless network (Wi-Fi, etc.)

Some models are referred to as Electronic Receiver Transmitter (ERT). These models are typically read from a vehicle that once a month drives through the neighborhood with a small radio receiver. A wireless computer receives the responses transmitted by the meters, as the vehicle passes by. One company boasts that one person can read off 100,000 meters a day this way.

Most of these meters transmit all the time, regardless of whether the meter truck is passing by or not. These are sometimes referred to as "bubble-up" meters.

Some meters have a receiver built in, which listens for a signal from a passing utility vehicle before it starts transmitting. These are sometimes referred to as "wake-up" meters.

Other models of meters can be programmed to transmit at a certain time, typically around midnight each day. These models may have a built-in phone modem by which they call up a computer. Or they connect to a base station in the local area, using a wireless transmitter or by sending signals over the power line. These seem to be less commonly used.

There are also models that transmit more frequently, sometimes as often as every 15 seconds. These meters use some sort of network that is either wireless or is carried over the power line. These are often real smart meters, but their full capabilities are often not in full use yet.

There is some overlap between the remotely read meters and real smart meters.

3.5 Smart meters

Smart meters are often referred to as Advanced Metering Infrastructure, AMI. Several sources define a smart meter as one that can communicate in both directions, i.e. the meter can transmit information to the utility and the utility can also send information to the meter. This all occurs without any personnel having to actually visit the meter.

The information sent to the utility may include

- detailed usage information
- voltage monitoring data
- various alarms

The information sent to the meter may include

- pricing information
- pre-pay information
- disconnect/reconnect instruction
- alarm/load-shed instruction
- programming of meter
- upgrade of meter software
- date and time

Some smart meters may not be used fully yet. They may be installed gradually in an area or the utility is currently using some of the features only to get experience with the technology. In practice, there is a lot of overlap with the more plain models and the same meter may suddenly do more in the future.

A smart meter may be able to communicate with appliances in the home, using a Home Area Network. It may communicate with:

- a display screen
- a gas or water meter
- various appliances (room thermostat, water heater, etc.)

It will communicate with the utility and the home's appliances using one or more of these methods:

- Telephone landline
- Cellular modem
- Fiber optic cable
- Wireless network (Wi-Fi, etc.)
- Power line network (PLC, HomePlug)

The smart meters are likely to transmit data more frequently than the simpler meters. Some models can transmit as frequently as every few seconds. Sending that frequently can help the utility discover problems (such as low voltage) fast enough to do something about them.

A central controller is also likely to do more frequent broadcasts of date/time, to keep the meters synchronized for accurate time stamps.

3.6 Pre-pay meters

With this type of meter, the electricity is paid for in advance. There is no monthly bill. When the meter runs low on money, it typically warns the customer. When the money runs out, it disconnects the power. A pre-paid meter may only offer a flat rate for electricity, not any discounts for off-hour use.

Some call these "pay-as-you-go" meters.

An early version of a pre-paid meter was common in some parts of Europe, where people put coins in them. Today's meters are much more sophisticated.

An example of a modern pre-paid meter is the emPOWER meter. The customer buys a plastic card at a kiosk or convenience store, which is used to add money to the emPOWER meter.

The meter has a control box, which can be placed anywhere in the house where there is a 110 volt outlet to power it. The control box communicates wirelessly with the electrical meter outside.

The control box has a little display which shows how much money is left in the meter. This information is constantly beamed to it from the meter (perhaps every 5-15 seconds).

When money is added to the control box by inserting the plastic card, it wirelessly transmits the information to the meter.

The transmitters in each device are much weaker than those used by most other meters, as they are only communicating short distances. But, the electrical meter is transmitting nearly continuously (the control box probably very rarely). This system may be more tolerable than the other meters that transmit frequently, but it is unlikely to be acceptable to a highly sensitive person.

The location of the control box, and whether it is turned on or off is unlikely to affect the emissions from the electrical meter.

Another pre-pay system is the M-Power meter, where the communication between the meter and the display is via the household wires instead (which also may be problematic, see later). This system is manufactured by Landis+Gyr, which calls it AMPY.

Neither the emPOWER nor the M-Power pre-pay meters communicate directly with the utility, so they may be more tolerable, though they do radiate more than a mechanical meter.

Some smart meters can be configured for pre-paid service, with the amount of money "in the meter" added remotely from the utility. These meters may not communicate any less with the utility than when in regular billing mode.

All pre-paid meters will probably include a status screen to be put inside the house, which communicates with the meter.

Landis+Gyr offers a model that has a display connected to the electrical meter through a cable.

3.7 Gas and water meters

The new digital gas and water meters currently see much slower growth than meters for electricity. The issues with these meters are much the same. However, gas and water meters are often placed where there is no electricity, so they have to be battery powered. Some models work together with a smart electrical meter. In this case, the gas or water meter uses a very low-powered transmitter to reach the electrical smart meter on the same building, and hands over the data, which the electrical meter then transmits on.

Gas and water meters may transmit once a month or as frequently as every few seconds.

4. The communication technologies

The previous section described the types of meters and what sort of information they may transmit, using what type of transmitter. This section describes the various technologies used to transmit.

There are four general types of communication used, some of which may be problematic to sensitive people:

- telephone line
- fiber optic cable
- wireless communication
- power line communication

There is sometimes a bit of confusion on the correct terminology for the different technologies. Various vendors use different names for the same technology, and there is a lot of overlap.

4.1 Telephone dialup

Once a day, typically late at night, the meter uses a built-in dialup modem to connect to the utility's computer. It can use the same telephone line that serves the household, or a separate phone line. This is similar to some pay-per-view television systems.

If the meter uses a separate phone line, the utility computer can connect to the meter multiple times a day by dialup.

This method is the safest of all the automated communication systems, but it is not suitable where the utility wants information from each meter many times a day.

4.2 Fiber optic cable

The smart meter communicates by sending brief light pulses along a glass fiber cable. The benefit of this technology is the high speed, secure and reliable communication and that the fiber cable does not radiate.

The drawback is the cost of installation.

This method is also one of the safest methods, though it does require a digital meter, which has other issues (see later).

Smart meters with fiber optic cables are presently rarely used. They are probably only feasible in densely populated areas.

4.3 Cellular communication (GPRS)

This is the simplest setup. The meter has a built-in cell phone type modem, so it dials the utility company's computer and downloads the information, or the utility computer can dial into the meter. It may not be practical to transmit more than a few times a day.

4.4 Radio communication

These are the simplest of the wireless systems. They essentially use one-way communication only. The utility cannot remotely program the meters or otherwise really communicate with them. These meters can typically just transmit their readings.

There are two versions:

- wake-up
- bubble-up

The wake-up meters listen for a signal prompting them to start transmitting their data. Otherwise, they do not transmit.

The bubble-up meters simply transmit every so often, typically every 15 or 30 seconds. It can also be just once a day, or every five seconds.

These meters can be read from a utility truck, which once a month drives through the neighborhood with an on-board receiver. It simply picks up the signals sent out from the bubble-up meters within range, as it passes through without stopping. The meters just transmit all the time (at least every 30 seconds), whether the utility vehicle is there or not.

If wake-up meters are used, the truck sends out a signal prompting all meters within range to transmit.

The wake-up and bubble-up meters can also be picked up by a fixed receiver *(collector)* in the neighborhood. It is typically mounted on a utility pole or lamp post. This collector then passes the information on to a central computer.

These radio systems typically transmit at 450 MHz or 900 MHz and may reach up to about two miles (3 km).

4.5 Fixed wireless network

In a wireless network, each meter does two-way communication with a central station in the neighborhood, which then communicates directly with the utility. This control station is sometimes called a “collector”, “access point” or “gatekeeper” and is usually mounted on a utility pole or a light pole. In rare cases, the collector is built into a smart meter mounted on a building.

In simple networks, each meter may just turn on its transmitter once a day, listen for a pause in the other meters’ transmissions, and then transmit its information to the collector. The collector may then transmit back new rate information, the current time, etc. Then the meter’s transmitter is turned off again.

A central collector may communicate with 500-5000 smart meters in an area. It may have a more powerful transmitter than the smart meters.

In a more sophisticated network (sometimes referred to as a LAN), the meters communicate throughout the day with the collector.

The meters may send a lot more frequently than needed for just billing readings, generating much wireless traffic. The extra information may be what the current voltage of the line is, and that each meter is okay, to quickly detect line failures. These networks may use Wi-Fi (2.4 GHz) or a proprietary system (900 MHz) to communicate.

The collector communicates with a central computer, using either dialup telephone, dialup cell phone (GPRS), DSL/ADSL, satellite link or other link.

A wireless network will likely require the installation of a whole separate set of transmitters mounted on lamp posts or utility poles throughout the area. These may be transmitting continuously.

Some vendors refer to this type of network as a "mesh network", even though it strictly isn't.

4.5.1 SUNDS

A special version of the fixed wireless network is SUNDS (Subterranean Urban Networks Deployment System). SUNDS has the wireless collector units located under manhole covers in the sidewalks. This system is presently only used in downtown San Francisco, where most electrical meters are located in the basements of the skyscrapers and there are no utility poles to mount the collectors on.

4.6 Mesh network

A mesh network is a fixed wireless network, with the addition that some of the household meters also act as relay stations. In an area where some meters are too far away from the collector to communicate wirelessly, a few household meters may act as a relay station (sometimes called a "router" or a "repeater"). Such a meter will receive messages from the more remote meters, and re-transmit the messages onwards to the collector. These relay meters will also forward messages back from the collector.

It is possible that a message may pass through more than one relay meter before it reaches the collector.

Relay meters are usually identical to non-relay meters. If a relay meter breaks down, another meter nearby will become the new relay meter. This happens automatically.

It is presently not possible to see or know whether a meter is a relay or not.

In a sophisticated network with synchronization and other frequent transmissions, a relay meter could be transmitting continuously. The positive news is that the transmitters may not need to reach so far, so their radiation level may be lower than on non-mesh models.

An example of a mesh network is the Elster REX2 meters, running the EA_LAN using the ZigBee protocol. Another is the iCon A meter, using FlexNet, also based on ZigBee.

Some vendors call their wireless networks "mesh network", even though they do not use relay stations.

4.7 Power line communication (PLC)

This technology uses existing electrical wires to communicate. It can be over the wiring inside the house or it can be over the utility wire coming to the house from the outside. This technology is also referred to as Power Line Carrier and Power line Telecommunication (PLT).

It appears that the electrical companies mostly use this type of communication to get billing information in rural areas. It may not be able to handle the traffic in more densely populated areas.

For in-house communication, it uses the household wiring to communicate between the smart meter and various "smart" appliances and display screens. This is done in both rural and urban areas.

There are three general technologies:

- low-frequency (TWACS/Turtle)
- medium-frequency
- broadband (BPL)

4.7.1 Low-frequency power line communication (TWACS/Turtle)

This method works by modifying the normal 60-cycle sinewave of the alternating current on the electrical wires. One system is called TWACS, another is the Turtle system from Hunt Technologies.

TWACS communicates by adding a brief pulse about 60 times a second (50 times for 50-cycle systems). The pulse is added when the voltage passes zero on the alternating current. The pulse itself is in the 400 to 650 Hz range, but the way the meter generates the pulses will also create broad spectrum harmonic waves as well (i.e. higher frequency signals).

The Turtle system has a specific frequency assigned to each meter. All meters communicate continuously by adding their individual frequency to the electrical lines.

Transmitting with these methods is very slow, compared to all other methods available. The benefit of this technology is that the signals can travel for many miles on the wires (sometimes 40 miles/60 km) and pass unhindered through transformers. The utility will need only one controller for a large area, typically placed at the substation. These methods are suitable only for thinly populated rural areas and small towns.

It has been argued that this type of system is safe because of the low frequencies. However, there are reports of sensitive people having much trouble with this type of system even a dozen feet away from any electrical line or household wire. This is probably because of the "dirty power" which turns the wires into unintentional antennas (see 5.5).

4.7.2 Medium-frequency power line communications

This technology adds to the electrical lines a signal that is similar to the "dirty power" created on the wires by electronic equipment (computers, televisions, etc.). It is just a much more powerful signal, so it will not drown in the static.

The method has been used in the past to bring AM radio to remote areas of Germany, Switzerland and the Soviet Union. Listeners could simply pick up the signals radiating off high-tension power lines in the area, using an ordinary AM radio. Switzerland transmitted several stations on the same power line, using frequencies from 175 kHz to 340 kHz.

Some electrical power companies use this method to control and monitor remote switching stations and transformers on their high-tension transmission lines. Frequencies from 15 kHz to 500 kHz have been used.

Some meters also use this method to transmit data to the utility. They tend to use frequencies in the 50 kHz to 100 kHz range. These signals do not travel far and can be blocked by transformers, so this method is mostly used in areas where several homes share a transformer. The method is popular in Sweden.

There has to be a receiving device not far from each house, often mounted on the same pole as the transformer. This device then retransmits the data it has received, perhaps using a telephone modem or some sort of wireless technology (cellular, Wi-Fi, WiMax).

4.7.3 Broadband over power lines

This method is used in some areas to provide fast internet (broadband) services to households, and can also be used to network smart meters though it presently does not seem to be used. It transmits high-frequency waves over the power line, usually in the 1 to 30 megahertz range. This gives a much higher transmission capacity than the low- and medium-frequency methods.

The system has been contested by amateur radio groups and short-wave radio broadcasters as the power lines act as giant antennas and interfere with their radios. The British industry group Electromagnetic Compatibility Industry Association (EMCIA) has also protested, contending the radiation from the power lines interferes with telephone systems, especially DSL/ADSL internet services.

4.8 Home Area Network

Some of the most sophisticated smart meters can also serve as a hub for an in-home network, also called a Home Area Network. This would allow the meter to communicate with the gas and water meters, and send their readings on to the utility. A Home Area Network can also be used to adjust the room thermostat and temporarily turn off the water heater during periods of energy shortage or high energy prices.

A common use is a display that receives data from the meter to display how much electricity has been used today, etc.

A Home Area Network usually uses wireless (Wi-Fi) to communicate, though it could also use high-speed (high-frequency) power line communication over the household electrical wiring. One version of this technology is called HomePlug.

5. The radiation from the meters

All the modern digital meters radiate at various frequencies and various strengths. Some of the radiation is not intentional.

The possible sources of radiation fall into these categories:

- the switched-mode power supply
- the internal computer circuits
- the wireless receiver
- the wireless transmitter
- the household wires
- ground currents

5.1 The switched-mode power supply

The electronic circuits inside any digital meter (including the simpler models) cannot run directly on the household current. They need a much lower voltage. This lower voltage is usually generated by an electronic circuit called a switching power supply. A switching power supply generates the lower voltage by turning the power on and off about fifty thousand times a second, or even faster. That means it generates pulses (transients) in the kilohertz range, which radiate from the meter and also the connected wires. This is called *dirty electricity*. See section 5.5 for more on dirty electricity.

There are various types of switched power supplies, some of which generate much less dirty electricity than others.

Mechanical meters, without any upgrades, do not produce dirty electricity.

5.2 The internal computer circuits

There is a simple computer inside every digital meter, which controls all parts of it. The computer circuitry radiates all the time, typically in the frequency range of 25 megahertz (MHz) to 1 gigahertz (GHz). The radiation does not reach far and is very weak, probably less than the power supply described above. This should only be a concern to the highly electrically sensitive.

The computer circuits may generate high frequency dirty electricity, though probably less powerfully than the power supply.

5.3 The wireless receiver

If the meter can receive wireless signals, it will have to have a receiver which will be on all the time. The meters transmitting over the utility line usually do not have a receiver.

Even though a receiver is not intended to transmit anything, it does, however, weakly. That is the case with all sorts of wireless receivers, such as televisions and radios. They all radiate, this is unavoidable. The signal strength is very low, and thus a concern only for people with EHS. It is like having a small FM transistor radio on all the time, with the speaker turned off.

The wireless receiver may create dirty electricity, though it should be much less than that produced by the switching power supply and any form of PLC signals.

5.4 The wireless transmitter

The wireless transmitter intentionally radiates radio waves meant to be received somewhere else, and is a concern for everyone. The signal strength is typically in the 0.1 to 1 watt range (cell phones typically radiate from 0.1 to 2 watts, depending on the distance to the cell tower). The frequency it transmits on is typically around 450 MHz, 900 MHz, 1800 MHz (Canada) or 2400 MHz.

The transmitter is usually on only when there is something to transmit, to save electricity. This could be once a month, or basically all the time.

The radiation levels vary. Some are as strong as cell phones, and can reach miles, while others are only intended to reach 250 ft/75 m and put out as little as 1 milliwatt.

The antennas on the meters transmit somewhat equally in all directions.

The transmitter will also create some dirty electricity of various frequencies. They will come from the oscillator tuned to the transmission frequency. The transmitter may also backfeed various pulses, etc. into the electrical system as it modulates the transmitted signal.

5.5 Dirty electricity on the household wires

When electrical signals travel on an electrical wire, it will radiate as an antenna. Wires that are intended to carry communication signals are usually twisted or shielded, as is done with telephone cables, computer networks and cable TV. This greatly limits the radiation from the wires.

Household electrical wiring was never intended to be used for communication signals, so it is not twisted or shielded and therefore radiates more readily than telephone lines carrying DSL, computer network lines and cable TV connections.

The telecommunications industry is well aware of this phenomenon, and is making sure that the frequencies used to transmit on the electrical wiring are chosen so they do not interfere with broadcast transmitters. The British Broadcasting Corporation has early on studied the issue:

> . . . there is the difficulty for radio-system users that the signals PLT [Power Line Telecommunication] injects do not simply travel from point to point along the wiring, they also escape as *radiated emissions* (emphasis in original)
>
> BBC White Paper 099 by Jonathan Stott, November 2004

Smart meters may generate two sources of dirty electricity, which cause the wires to radiate:

- power line communication signals (PLC)
- transients from switched power supplies, transmitters, etc.

Both are problematic, both can enter the house from the neighbor's meter as well.

There are many other sources of dirty electricity, such as computers, battery chargers and other electronics, but these are not as powerful as the power line communication (PLC) signals, which are intentionally strong. Most of them are also not turned on 24/7.

There are several types of signals, some which may be dampened, some which by intent cannot be blocked. The higher frequency signals can sometimes be blocked by filters and transformers.

The problem with all these technologies is that they follow the electrical wires wherever they go. It is not just a question of staying away from the electrical meter, as it is with the wireless technologies. One may have to stay away from all wires in the entire house, or disconnect them totally.

5.6 Dirty electricity in the ground

Ground currents are electricity unintentionally running in the soil. This is a common phenomenon and is not predictable, but tends to be the strongest in areas with many separate buildings close together.

A ground current can carry the same dirty electricity as in the household wiring and may radiate it up into a house through the floor.

There have been cases where a household retained a mechanical meter, but the neighbor's smart meter dramatically increased the ground currents under the house, and also made them much "dirtier".

6. Health issues

Almost all the metering systems described here radiate, which is a health concern for the general population and may cause acute symptoms in people with severe electrical hypersensitivity (EHS).

Millions of people already live with these systems and do not have acute symptoms. The concern for the general population is more any long-term health effects, which will be difficult to identify the cause of and even more difficult to prove. The effect may be an increase in those diseases that have been linked to low levels of magnetic fields, microwave radiation and "dirty electricity", such as headaches, ADD/ADHD, anxieties, childhood leukemia, various cancers and electro hypersensitivity. Some people may feel more restless, have problems sleeping and be more irritable.

As the exposures from these technologies are often not voluntary, the standard for safety must be higher than for consumer products where people do have a choice (such as cell phones).

The amount of energy radiated from a wireless smart meter is similar to that of a cell phone, sometimes much less. Unlike a cell phone, they may transmit constantly, but are usually also some distance away from people.

The wireless meters that transmit frequently can be compared to a household wireless computer network (typically Wi-Fi) in a number of ways:

- they transmit most of the time
- the transmitters are several feet (meters) away from people, at least most of the day
- radiation also comes from the neighbors, especially in apartments and dense neighborhoods

The energy radiating from household wiring carrying PLC-signals and dirty electricity is much less than that from a wireless meter. However, all the wires in

the house are acting as antennas, so it is everywhere and often very close to a person.

Some people are more bothered by certain frequencies than others. A person who can use a cell phone may be bothered by the lower frequencies from PLC-signals, or it may be the other way.

The long-term health effects from smart meters will be nearly impossible to distinguish from the effects from cell phones, cell towers, neighbors' wireless networks, and the myriad of other wireless devices that are yet to come.

7. The most problematic technologies

For people who are particularly sensitive to electromagnetic fields (EMF), the effect of smart meter technologies can be devastating. But it may not. There are many people with EHS who have not noticed any difference after their meter was upgraded. However, there have also been several cases where they got severe symptoms and sometimes could no longer live in their home.

In the opinion of this author, the better technologies are, in order of safety:

- mechanical, non-communicating meters (analog meters)
- pre-paid meters using a cable to communicate with the in-house display
- meters using dialup telephone lines
- meters read through a communication port, by a person
- wake-up meters that are only transmitting when prompted by a passing utility vehicle
- meters that only transmit once a day, using cellular or wireless

The above list assumes the use of quality products that do not generate unnecessary dirty electricity.

The worst technologies are:

- any form of frequently communicating network
- all types of wireless networks
- all types of power line communication (PLC)
- bubble-up meters, which transmit 24/7

8. For more information

For more information on smart meter technologies, and how to possibly mitigate their impact, see the smart meter section of www.eiwellspring.org.

For more information about the health effects from low frequency and radio frequency radiation, see the BioInitiative report on www.bioinitiative.org.

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