TWACS smart meters problematic to public health and safety

The TWACS smart meters communicate with the utility by adding low frequency signals to the electrical lines. Some utilities promote such power line carrier (PLC) systems as a positive alternative to wireless smart meters. The reality is that all PLC technologies are problematic, including the "pulsing" TWACS systems.

The basic facts are that the TWACS system

- creates powerful dirty electricity
- the dirty electricity is a constant presence, possibly 24/7
- the dirty electricity turns all wires throughout the house into antennas
- keeping an analog meter will not help much
- the signals cannot be blocked or filtered
- scientific studies link dirty electricity with various health effects
- some people are sensitive to dirty electricity
- TWACS lacks basic security features

This article covers all these issues in detail.

Keywords: TWACS, DCSI, power line communication, power line carrier, PLC, dirty electricity, health, smart meter, security

The TWACS system

TWACS stands for Two-Way Automatic Communication System. It allows the utility company to communicate with smart meters placed on buildings throughout their service area. Some TWACS equipment is marketed under the DCSI name.

The communication system is two-way, which means the utility can both send instructions to the meter and receive data coming back.

The system can be used to read the electrical usage for a building, instead of sending out a meter reader once a month. The information is typically transmitted a few times a day, but could be only once a month. The transmission may contain information on how much power is used each hour of the day, or even every 15 minutes.

Other uses of the TWACS system are to detect power outages, faulty meters, voltage problems, etc. These functionalities will require transmissions throughout the day.

The TWACS system can also be used to remotely control utility equipment such as capacitor banks (Volt and Var Control).

Another possible use is to disconnect the electricity to a household remotely, instead of a service technician having to manually do that on site (using the Disconnect Switch Interbase).

The TWACS system may also be used for more advanced smart grid functions, such as turning off appliances in people's homes during energy shortages or when the cost of electricity is high. This requires the installation of the Aclara Demand Response Unit or Aclara Load Control Transponder.

The TWACS system transmits using the existing power lines in an area. It usually does not use wireless transmissions to communicate, though it always radiates unintentionally (see later).

The power lines are used to transmit locally between each household and the TWACS receiver at the substation. From the substation, the system communicates with the utility's central computer using other methods, such as fixed landlines, cell phone modems, microwave links, etc.

TWACS can communicate over dozens of miles. It is mostly used in rural areas and small towns where houses are further apart than in a city. Rural areas are more difficult to serve with wireless meters due to the limited range of some models.

For detailed technical information on TWACS, see the U.S. Patent Office web site(1) and other technical publications.(2, 3)

Identifying a TWACS smart meter

The TWACS system is marketed by Aclara in the United States, which produces modules that are installed inside meters from other vendors. The TWACS module is available for the FOCUS meter from Landis+Gyr, the I-210+ meter from General Electric, and other models as well. Some older mechanical ("analog") meters have a TWACS transmitter installed. These are probably not used for new installations.

Smart meters with a TWACS transmitter *may* have a special label with the Aclara logo on it. It is usually placed on the front, but could be elsewhere. The Aclara logo is a red square with rounded corners and two crossed white lines.

TWACS-compatible equipment is also marketed by Itron/Schlumberger and Landis+Gyr under the DCSI name. These may be identified by a label with the equipment model, such as “DCSI-EMT-3F” or similar.

Other power line communication

There are other systems that communicate via the power lines. These are also problematic, but are not covered in this article.

Any type of system that communicates by transmitting signals via power lines is called a Power Line Carrier or Power Line Communication (PLC) system.

TWACS meters may also be wireless

Some TWACS meters also have built-in wireless transmitters. These are mostly used to get meter readings from gas and water meters on the house. The electrical meter then passes that information on, using the TWACS system. The Aclara Badger ORION product is such a system.

On more advanced systems, the TWACS meter may use wireless to transmit signals to a display screen or “smart” appliances inside the house.

The line pulses

A TWACS meter sends out a brief pulse about 60 times a second when it transmits. This pulse travels along the power line to the substation, where it is received. The voltage fluctuations from the pulse may also go in other directions on the local grid, including into other houses in the area, even houses several miles away.

The utility equipment at the substation also transmits by sending pulses on the grid, which it uses to send instructions to the smart meters. These pulses travel on all the local power lines and into all houses. The system would not work if the pulses did not travel to all houses. The pulse does not “know” which meter it is going to, just as the signal from a radio station does not know in advance where the radio receivers are.

For a detailed discussion of how the TWACS signals travel on the local grid, see appendix D.

A constant stream of pulses

A TWACS meter will take about eight seconds[4] to transmit its reading and status, which it may do once a day, every hour, or once a month. In between, it may transmit briefer "all is well" messages or other information. Most of the time, each individual meter does not transmit.

The TWACS controller at the local substation transmits much more frequently, usually several times a minute. It needs to transmit a signal every time a meter is to be read or checked up on, by prompting the specific meter to respond (master-slave polling). Some TWACS systems also allow the central controller to download information or programming to the meters.

Together, there is a fairly constant stream of signals on the wires. The signals will be coming from either the smart meter on the building, other smart meters in the area or the controller at the local substation. With future smart grid technologies, the traffic may increase dramatically.

The substation controller is likely to be the main source of pulses entering the household.

See Appendix B for more detailed discussion of how often the TWACS system transmits.

Powerful pulses

The TWACS pulses need to travel for many miles, sometimes dozens of miles. At the other end, the pulse signals must be clearly detectable above the regular line noise, so the pulses must be fairly powerful. The strength of the TWACS transmitters are not disclosed by the vendor, however.

Dirty electricity from TWACS

The pulses are more than just a simple pulse. They contain and cause a broad range of frequencies, which are all sent along the wires. The basic TWACS frequencies are in the 400 to 600 hertz[11] range and are jagged and irregular, unlike the smooth sinusoidal curve of regular power (50 or 60 hertz). These are called transients.

Depending on the physical layout of the local electrical grid, there will also be a wide range of harmonics generated from the basic pulse/transients, as they resonate across the wiring system. The upper harmonic frequencies may reach into the lower kilohertz range.

This is all referred to as transients and harmonics. A more descriptive term is dirty electricity.

Dirty electricity from other sources

Dirty electricity is created by other sources than the TWACS signals. Many types of household electronics can create them as well, though they tend not to be as powerful. The TWACS signals must be stronger than most other kinds of dirty electricity, to be "heard" above the other noisemakers on the line.

The power supply inside digital utility meters is a common source of dirty electricity. There are utility meters available with quality components that do not create much dirty electricity, but many meters use components that produce much unnecessary dirty electricity.

Avoiding the high frequency dirty electricity from the internal electronics in a TWACS meter is a reason to opt-out and use a mechanical meter instead, even though it may not help much with the dirty electricity from the low frequency TWACS signals.

The wires become antennas

When the broad spectrum of frequencies of the dirty electricity travels along the electrical wires, they are turned into antennas that radiate these frequencies. More precisely, it causes the electrical and magnetic fields around the wires to fluctuate (see Appendix C for details).

The wiring in buildings and along the roads will act like giant antennas, similar to what is used for some types of radio transmitters. Decades ago, this principle was used in the Soviet Union to bring AM radio to remote villages. The villagers used ordinary AM radio receivers to play the signals radiated from the power lines going through the area. The TWACS signals cannot be picked up by AM radios, as different frequencies are used.

Almost all wireless communication uses frequencies much higher than that emitted from the TWACS system. But some communication systems use frequencies in the same area.

Navigation systems use frequencies down to about 9 kilohertz. The U.S. Navy uses communication systems for submerged submarines in both the 13 kilohertz range and even at 76 hertz — below the TWACS system frequency band.

For detailed coverage of this antenna effect with references to several government studies from Europe, Japan and the United States, see the section "For More Information" at the end of this article.

Ground currents

Another way dirty electricity can reach humans is via ground currents. Ground currents are electricity unintentionally running in the soil below a house. Like currents running in wires, ground currents will also radiate dirty electricity. Ground currents are a very common phenomenon.

Canadian researcher Magda Havas has shown[5] how dirty electricity, riding on ground currents, can be directly measured on the legs of a person.

See Appendix A for a more detailed description of ground currents.

Coming from "everywhere"

There are three ways the TWACS signals can reach into homes:

- from building wiring (electric/magnetic)
- from nearby power lines (electric/magnetic)
- from ground currents (magnetic only)

The importance of these three sources varies with the house. Some houses are set well back from the power line along the street, so it is not an issue, for instance.

Some locations have high levels of ground currents, where that may be the dominant issue.

The effects also differ some, depending on where each TWACS signal is sent from (see appendix D).

Cannot be blocked

The signals will enter any building connected to the grid, it is not really possible to block them.

Since almost all the signals travelling on the wires are generated elsewhere, it is not enough to put a non-transmitting meter on a building. The signals generated at the substation and some of the other smart meters in the area will continue coming in (see Appendix D).

There are no filters available to block these low frequency signals. The TWACS system is specifically designed to go right through obstacles, including isolation transformers. Filters designed to block high-frequency dirty electricity have no effect on the lower TWACS-frequencies. This includes the simple Stetzer filters, as well as more sophisticated filters.

Filters that would block the pulse frequencies would also interfere with the normal transfer of electricity. The only place the TWACS signals are stopped is at the substation.(2)

It may not help to turn off the breakers in a home. The breakers disconnect only one wire. It would be necessary to physically disconnect all wires in a circuit (phase, neutral and possibly also ground).

It may be possible to dampen the radiated signals by replacing all household wiring and all cords with shielded cables. Household appliances may also need modifications. This has not been attempted to mitigate TWACS to the knowledge of this author. Also, it will be very expensive, difficult to do correctly, and may not provide a livable solution anyway.

The radiation from the ground currents may be possible to stop in a rural area. It is probably not possible with nearby neighbors.

The only viable remedies may be to take all or part of the house off the grid, or sell it and relocate to another area. All impose a substantial hardship and are not acceptable solutions.

Typical wireless devices, such as cell phones and Wi-Fi networks transmit from only one point. To limit the radiation exposure, one can go to another part of a house. The transmitters can be placed away from the bedroom to limit radiation exposure during sleep.

The homeowner has the choice to turn off wireless devices in the home. There are no such choices with TWACS.

The health effects of TWACS

Most people do not seem to be affected by TWACS at all. It is only a small subset of the population who have problems with TWACS. Some people may have minor problems with insomnia, tinnitus and headaches. Children may become more restless.

Very few people have major problems, but to people who are hypersensitive to the TWACS signals, it can be devastating. Some have had to sell their homes and move to a TWACS-free area.(6,7)

Whether there are any long-term health effects is not known, as there are no studies. A few studies on the health effects from dirty electricity in general suggest that some diabetics have more problems managing their disease and school children are less attentive and more disruptive in school.(5) Other effects have also been suggested.(8)

In 2006, 31 scientists from 23 countries issued a statement cautioning against PLC systems, such as TWACS.(9)

For further discussion of health effects from TWACS and other PLC systems, see the links in the "For More Information" section of this article.

Measuring the radiation

There are many aspects to electromagnetic radiation, such as the average strength, the peak strength, the frequency, whether it is continuous or pulsed, the modulation, etc. A central issue is whether the radiation is ongoing or only brief and occasional.

The most common method is to simply measure the average magnetic field strength. For power frequencies (60 Hz in the USA) that is done using a gaussmeter. The TWACS frequencies are higher than the power frequency, and are not measured correctly by a gaussmeter.

A gaussmeter is designed to measure continuous and smooth sine waves, but the pulsed and broadband waves produced by the TWACS systems are neither continuous nor smooth. In this case, it is the equivalent of measuring the average sound level over time of a babbling brook and a gunshot. Over time, these two will produce the same average, but their effects on humans and wildlife are very different.

The dirty electricity creates fluctuations of the regular electrical waves, which makes them more bothersome. As an analogy, one could consider various types of sound. Some people use pleasing sounds to sleep at night. Perhaps sounds of nature, such as waves on a beach. Then imagine replacing this with screeching, disharmonic noise. To a simple sound meter, there is no difference. But to a human, it is very different. A gaussmeter is the same way; it cannot distinguish between clean power and dirty power.

A more appropriate instrument would seem to be the Stetzer meter, which measures the voltage fluctuations (dV/dt) and produces a proprietary number, the Graham-Stetzer (GS) unit. However, the Stetzer meter is calibrated for the range of 4 kilohertz to 150 kilohertz, whereas most of the TWACS output is well below 4 kilohertz. This means that the Stetzer meter will significantly underreport the TWACS output.

AM radios are sometimes a useful tool in EMF investigations, but the TWACS frequencies are too low to show up as static on an AM radio.

The best tool for inspecting the TWACS signals is the oscilloscope with a suitable filter to remove the 60 hertz frequency. However, an oscilloscope does not readily produce a comparable number. Such an instrument and associated filters also require technical expertise to use correctly. Even better would be a spectrum analyzer, but they are expensive.

TWACS lacks basic security

A search of the websites of the vendor (Aclara) in February 2013 did not find any claims that TWACS uses encryption. Searches of web sites for utilities using TWACS only found a vague claim of "natural encryption," which is deceptive and misleading.

It is possible to monitor the TWACS signals from an ordinary wall socket, as well as by other methods. With no encryption, it is possible for hackers, snoopers and spy agencies to monitor the use of electricity in a household or business. As some TWACS smart meters are capable of reporting electrical usage every 15 minutes,(10) they can provide a lot of detailed information. The Congressional Research Service cites two studies concluding that such 15-minute intervals are sufficient to identify specific appliances in a home.(11)

Terrorists and malicious hackers may use TWACS to create real disruptions. Some TWACS meters are equipped with a switch, so power can be disconnected to a household by remote control. This product is called Aclara Disconnect Switch Interbase and can be installed on existing TWACS meters. A terrorist could transmit signals to thousands of such TWACS meters, ordering them to disconnect power, and then to lock up the meter's processor, so the utility no longer has control. It will be a long, time-consuming process for the utility to replace, reprogram and restore each meter. Meanwhile, the customers would be without power.

The utility industry is far behind the rest of the world with regards to computer and network security. This is one example.

See the links in the "For more information" section for further details.

Discussion

Much evidence is available that low levels of magnetic and electromagnetic fields do have biological effects. There is also some evidence that the relative strength of the fields is not the sole standard to gauge by; frequency, waveform and modulation are also important.

There have been no health studies specifically on TWACS, but a few have been done on dirty electricity. The results of these studies merit caution.

A small subset of the population, the electro hypersensitives, are particularly vulnerable to dirty electricity, sometimes to the point of having to leave their homes.

There is no realistic opt-out method; retaining an analog electrical meter is not a solution. There is also no realistic method to block the signals from coming into a home, other than disconnecting the power. Once the signals are in the house, they will be on every electrical wire, which will radiate out the cocktail of frequencies they carry. The signals are much weaker than a cell phone, but they are present for a large part of the day, perhaps all day and night. The use of the system may be less frequent initially, but is very likely to grow further with time, just as is seen with all other types of networks.

There are better alternatives available for metering technologies today, such as meters communicating through telephone landlines. Most other technologies allow for a meaningful opt-out, while TWACS does not.

The trend is for smart meters to transmit more and more frequently, so the utility can get a real-time picture of people's use of electricity. The customer may also be able to see this information themselves. Some wireless smart meters transmit data every two seconds. Is this really necessary?

The more frequent the transmissions, the greater the human impact. It thus makes sense to reduce the transmissions. The TWACS meters are capable of recording power usage for every hour of a whole month, and then just transmitting it once a month. Why is that no longer acceptable?

It is customary for industry to demand absolute proof of any harm when faced with the threat of regulation. Such a demand may seem reasonable, but absolute proof is a steep requirement. It would require many scientific studies over decades, all financed without a conflict of interest (i.e. without any industry ties). To date, there have been no scientific health studies of these types of systems, and it is unlikely there will be any soon.

Where the public health is concerned, a lower standard is reasonable. It is not reasonable that the cost of any doubt is to be born by the health of the public, especially when the issue involves involuntary exposures, potential long-term health effects and imposing possible major expense. This burden is to disproportionately fall upon a subset of the population which is already disabled and often of limited means.

It is thus not reasonable to wait for absolute proof, especially since such proof will likely take decades to arrive.

Also, the additional cost to the utility of using better technology for new installations, or at least reducing the use of the chosen technology, is relatively modest, possibly zero.

The prudent use of the *precautionary principle* and simple human compassion should be used to arrive at a reasonable resolution of this matter.

For more information

This article briefly covers a number of issues. Much more in-depth information about the TWACS/PLC antenna effect, health issues and security is available in articles on www.eiwellspring.org/smartmeter.html and www.eiwellspring.org/PLC.html.

These articles provide comprehensive references, including to various studies by government agencies.

The Aclara web sites are www.aclara.com and www.aclaratech.com.

December 2011 (last updated June 2013)

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Appendix A: Ground Currents

The building code in the United States and many other countries requires that the neutral wire of a household electrical system is grounded. This is typically done with a ground rod connected to the main breaker panel for the building.

Nearby buildings will have their own ground rods for their own household wiring.

The transformer will typically also have its own ground rod.

These ground rods are all connected to the same current-carrying electrical system.

Such multiple ground rods may provide an alternative path for the electricity to run down into and through the soil. This is called ground currents or stray currents.

In rural areas, it is common to connect the well casing to the neutral wire as an additional ground rod. This can produce substantial ground currents as well.

In a few rural areas of the United States, the electrical distribution system does not carry a neutral wire. This is called Delta distribution. There are no ground currents in these areas.

In normal household wiring, the phase and neutral wires run alongside each other. Since the currents in the two wires run in opposite directions and they are in such close proximity, their magnetic fields largely cancel each other out.

With ground currents, there is only current in one direction. There is no current running in the opposite direction in the soil. This means that a small current will produce a much larger magnetic field.

When a part of the current runs in the soil, that also means that the wires in the house may be unbalanced, which creates additional radiation from the wires.

Ground currents can be measured by a sensitive gaussmeter. Ambient levels are measured in locations well away from any building and electrical installation, such as in empty lots and parking lots.

Ambient levels in suburbia are typically around 0.1 milligauss, while in rural areas they are around 0.01 milligauss. In open land, they are zero.

Nearer to the source, i.e. inside a house, the ground current radiation can reach a few milligauss.

If the mains are carrying dirty electricity, they will be added to the magnetic field generated by the ground current. The magnetic field will then radiate the frequencies of the dirty electricity. This will not show up on a gauss meter.

Most people would not directly notice these low levels of radiation, but people particularly sensitive can get various symptoms, such as headaches, restlessness and insomnia. Extremely sensitive people may, in a few cases, get more severe neurological symptoms, possibly even seizures.

Dairy cows are well-known to be sensitive to ground currents, which can greatly reduce their milk production.

See [12.13] for additional details and references.

Appendix B: TWACS transmission time and duty cycle

The basic TWACS transmission speed is 15 bits per second, as it takes four of the 60 Hertz power cycles to transmit one bit.[3] With encoding, an actual throughput of 100 bps is achieved.[2] It takes about 8 seconds to read one meter.[4] Up to six meters can transmit simultaneously.[2]

The controller at each substation prompts each meter in turn.[4] Presumably, each of the three phases operate independently, so three meters can transmit in parallel.

The amount of time to read 2000 meters connected to one substation is then:

2000 meters x 8 seconds / 3 phases / 6 parallel = 888 seconds . . . or 15 minutes.

This is under optimal conditions. Optimal conditions are rare. Transients on the lines will interfere with the communication, requiring re-transmissions. How frequently this is needed is highly variable.

At a public meeting [4] a utility representative stated that they expected to read their meters in about 30 minutes, once their system was installed. They have 15,000 customers on 8 substations.

Another feature that can generate much network traffic is pinging each meter to check that it is alive and well. This will detect and locate power outages as well as equipment failures.

The equipment at the substation must send a signal (a "ping") to each meter in turn, and wait for each meter to respond with a brief reply.

The amount of data and time needed for such a transaction is not disclosed, but is here estimated to take 2 seconds.

To ping 2000 meters served by one substation would thus take about

2000 x 2/3 / 6 = 222 seconds = 4 minutes

It costs nothing to do these pings. The more frequently the pings are done, the faster failures are discovered. There is thus much incentive to simply fill unused network capacity with pings. Or at least to do it regularly.

Some meters have the ability to have their software upgraded using the TWACS system. This may happen a few times a year. During such upgrades or programming, the network may be fully loaded for an extended period of time, depending on the size of the upgrade data and whether each meter must be transmitted to individually or the data can be broadcast to all meters of the same model.

With the TWACS basic transfer rate of only 100 bits per second, it will take 10 seconds to transfer 1 kilobyte under optimum conditions. The size of the download will depend on the system.

There are many other features which will add to the overall load of the TWACS system, such as on-demand meter readings, remote disconnect of service, control of capacitor banks, etc. Future technologies, such as smart appliances, can add much additional traffic. The TWACS system is versatile and new technologies are likely to be developed, meaning the traffic can be expected to increase over time.

The TWACS system costs the same to operate whether it is used a lot or very little. This creates an incentive to use the system more than strictly necessary. Essential services, such as a weekly meter read and investigation of reported outages, could be accomplished with little traffic, but a utility is unlikely to agree to that.

The substation controller

It appears that the transmissions from the substation controller are likely to be the main source of dirty electricity in a typical household.

This is based on the location of the controller in the electrical system and the fact that it is by far the most frequent transmitter. In this master-slave (or polling) topography, the controller sends a request for each TWACS meter to respond to. The TWACS meters do not initiate communication on their own. The controller is thus responsible for 50% of all transmissions.

The substation controller also provides data downloads to the meters, requests for status, on-demand meter reads, remote connect/disconnect commands, etc. which all adds to the overall traffic.

Simple duty cycle estimate

A utility with 2000 meters on a substation chooses to read each meter three times a day. It also chooses to check up on each meter once each hour. A meter reading is considered a check up. The amount of active transmission time is then:

3 meter readings	3 x 15 minutes
21 pings of all meters	21 x 4 minutes
Total network active	129 minutes = 2.2 hrs a day

This is for a perfect world, with no transients on the lines causing retransmissions and six meters can always transmit in parallel. Also, no downloads or any other traffic is included. In a realistic world, there will be many retransmissions and various overhead, making this a network, which is essentially transmitting much of the time.

If the same utility decided to read each meter every hour, the amount of active transmission time then becomes:

24 x 15 minutes = 360 minutes = 6 hours a day

With retransmissions, etc., that would produce a fully loaded network, essentially transmitting nonstop.

Appendix C: Magnetic and electric fields

At the low frequencies of the TWACS system, there are two types of possible effects on humans and animals:

- the magnetic field
- the electrical field

The magnetic field is generated when a current passes through a wire. Whenever electricity is used, there will be a current in the wires feeding the equipment using the electricity. The current goes all the way from the power plant, through the substation, along the distribution lines in the streets and then the wires in the house.

The strength of the magnetic field is proportional to the current. The magnetic field from a cord to a 1000 watt space heater is ten times as strong as the field from a cord to a 100 watt light bulb.

If a wire serves multiple electrical users, their currents add together. A cord serving two 60 watt light bulbs will have twice the current, and twice the magnetic field, of a cord serving only one 60 watt light bulb.

The average magnetic field radiated from electrical wires is measured in milligauss in the United States and microtesla in Europe.

When the current fluctuates, the magnetic field fluctuates as well.

In North America, the AC current always changes 60 times a second. The electricity is delivered with a smooth sine wave form, which generates an equally smoothly changing magnetic field.

When the current also fluctuates with many higher frequencies (transients), the magnetic field is no longer smooth, but appears “ragged” on oscilloscopes. The term is “dirty electricity”.

Dirty electricity is believed by some researchers to be unhealthy. Some people are particularly sensitive to dirty electricity and do not feel well when exposed to it.

Magnetic field disturbance by TWACS meters

A household TWACS meter transmits by adding a pulse of current to the line,[2] which travels to the substation along the distribution system. This current pulse contains higher frequency signals, in the 400 to 600 Hertz range,[1] plus all the higher harmonics which may reach up into the kilohertz range.

Where there are ground currents (see appendix A), the TWACS current can also travel in the soil and reach under the house and sometimes even the neighboring houses.

The electrical field

When the substation controller transmits, it sends out voltage pulses, i.e., a spike in the line voltage.[(2)] This voltage spike is designed to reach all TWACS meters in the entire area served by the substation. The TWACS meters all listen for these transmissions, which may prompt them to respond (master-slave).

This means that the voltage spikes, and their higher harmonic frequencies, will travel into all households in the area.

There is an electrical field around every wire connected to the electrical system. This is regardless of whether the wire carries any current or not. An extension cord that is plugged into a wall outlet and nothing else will have an electrical field around it. All the wires inside the walls of a house will have an electrical field around them, even if no electricity is used in the house. The field disappears only if the wires are not connected to the breaker panel.

The electrical field is directly related to the voltage of the wire (relative to the ground). It also depends on how far the wire is above the ground. This is why high-voltage transmission lines are on tall towers compared to the lower poles used for power lines in residential areas.

As the voltage fluctuates, so will the electrical field fluctuate. In North America, the electrical field will fluctuate in lockstep with the 60 cycle (60 Hertz) sine wave AC electricity.

Like the magnetic field, the electrical field will also fluctuate with transients (dirty electricity).

The important difference is that the transients in the voltage will travel on all wires in an area, even those NOT carrying a current. This means that the TWACS voltage transients will reach every wire in every building in the area.

Appendix D: Sources of fluctuating fields in a home or business

The fluctuation of the electrical and magnetic fields of the grid can reach people inside homes and businesses in three ways:

- building wiring
- outside power line
- ground currents (magnetic only)

Which are the most important depends on the local situation.

Some buildings have a power line right outside, while others are set back from the road or sit at the end of the line. Or the line is buried.

Some buildings have poorly constructed wiring, which by themselves create higher fields, making the modulation of greater concern as well. Wiring errors causing elevated fields are common, and most people are not aware of it.

Ground currents exist most places and can be elevated as well, without people knowing it.

The magnetic field from pulse currents

The location of each TWACS transmitter is of some importance. The TWACS meter adds its pulse to the current going back to the substation.(2) The current pulse does not continue further down the line. This means that the current pulses from the TWACS meters on buildings will not travel inside a building in most cases.

The current pulses from the TWACS meter (or meters) on the building, and possibly also from a neighboring house, are likely found in the ground currents below or around the house, as the pulse apparently is added to the neutral wire which is connected to the ground rods.

The current pulses from meters located further downstream on the power line will pass the house as it rides on the power line back to the substation.

The electrical field from pulse voltage fluctuations

The TWACS pulse effects the voltage of the electrical system. The voltage fluctuates just as the current does, but it travels much wider than the current.

These voltage pulses will essentially travel to a home from any TWACS meter and device in the neighborhood, as long as it is connected to the same substation phase line (there are three).

Voltage pulses from the substation controller(2) will reach into every house in the area. This is by intent, so each TWACS meter can listen for instructions.

These voltage fluctuations are an important part of dirty electricity. They make the electrical field inside a house or building fluctuate as well. These fields come from the building wiring and any nearby electrical line along the street.

The following table shows which TWACS transmitter can have which effect on the magnetic and electric fields in a home or building.

Table D.1: Sources and possible effects from TWACS system at a residence or business

Transmitter	**Magnetic field from household wiring**	**Magnetic field from ground currents**	**Magnetic field from nearby power line**	**Electric field from household wiring**	**Electric field from power line**
TWACS controller at substation	Possibly	Possibly	Yes	Yes	Yes
TWACS meter on building		Possibly	Yes	Yes	Yes
TWACS meter next door		Possibly	Possibly	Yes	Yes
TWACS meter further down the same power line			Yes	Yes	Yes
Other TWACS meter served by same phase				Yes	Yes

This represents our current best estimate, based on the incomplete technical details available on the TWACS system.