The Discovery and Science of Smart Meter Fires

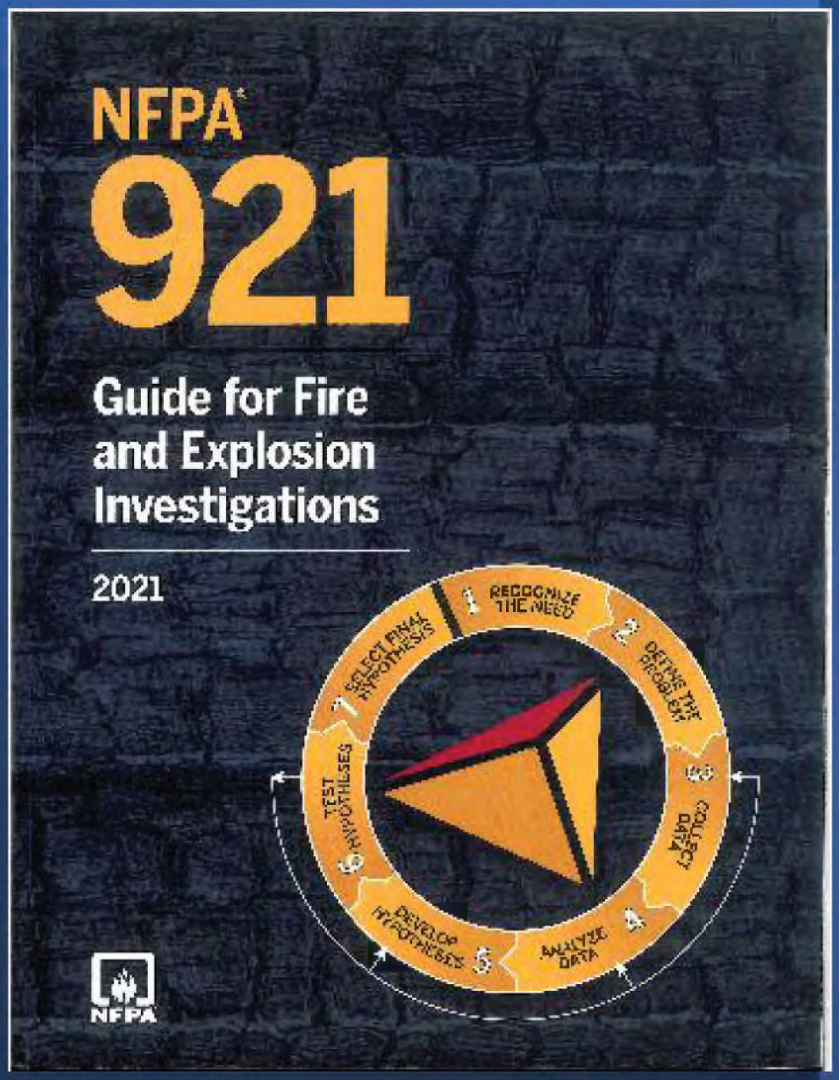
Introduction to the discovery of Radio Frequency Radiation (RF Rad) and the related breakdown of electrical wiring insulation leading to fire causation

Presented by

Jim Brown, CCAI-CFI
Fire Forensics & Technology

Dr. Robert Armstrong, PhD P.E.
Armstrong Engineering

Dr. Vytenis Babrauskas, PhD
Fire Science and Technology Inc.


NFPA
921
Guide for Fire and Explosion Investigations
2021
1 RECOGNIZE THE NEED
2 DEFINE THE PROBLEM
3 COLLECT DATA
4 ANALYZE DATA
5 DEVELOP HYPOTHESES
6 TEST HYPOTHESES
7 SELECT FINAL HYPOTHESIS
NFPA

Scientific Methodology

- Fire investigation requires the "global" responsibility to determine the origin of the fire and the fire cause. Utilization of this methodology is the age-old inductive and deductive reasoning process. This process is only as good as the thoroughness of the individual to examine possibilities and scientifically determine their probability in causation.
- Thus, the more information the investigator knows, the more hypotheses they can introduce into the inductive/deductive reasoning process, the better the result.
- The length and breadth of scientific knowledge and principles needed by the fire investigator is large in scope. Subject matter experts are generally required. These experts include crime scene examiners and evidence collection personnel, laboratory analysts, electrical/mechanical engineers and others.

Scientific Methodology…

- The pursuit of scientific analysis and discovery is a non-advocacy endeavor of the investigator. This applies to both criminal and civil fire investigation. The collection of data/evidence leading to the scientific conclusions are adjudicated/advocated in the legal system.

- As with the following investigation into the increase in and causation of, fixed wiring electrical fires, no blame is targeted to any specific agency or group. As you will see in this presentation, the investigation into the fire cause of the proliferation of fixed wiring fires followed scientific methodology to arrive at a probable causation theory.

“The Eyes will never see what the Mind does not know”

- This is the key to all scientific journeys and discovery. The more you know, the more you “see”.
- Therefore, your ability to hypothesize and test those hypotheses is only as good as your thorough knowledge of the subject at hand.
- Your “angle of perception” is as valuable as what you know. There are 360 different views of your evidence that makes up your final conclusion.

What the eyes saw that the mind did not know

- Every scientific discovery begins as a journey to find the truth of a confusing matter. This journey began to answer the question of electrically-caused fixed wiring fires that were beginning to exhibit a repeated modality not seen prior.

- Here is an example of the fire problem:

Resistive heating of Romex electrical conductors in mid span run

- Fixed electrical wiring fires are often caused by connection point failures over time at junction boxes or wire- nut connections. These failures result in arc faulting and resistive heating.
- Mid-span electrical fires may be attributable to a hard-driven staple that over time causes the insulation to be compressed. These failures result in resistive heating fires.
- Resistive heating from an electrical conductor does not cause the circuit breaker protection to trip, resulting in localized electrical heat energy to the wood structural member nearby. This heating causes slow pyrolytic damage to the wood that can eventually result in flaming combustion.

Smart Meters and the "Smart Grid Initiative"

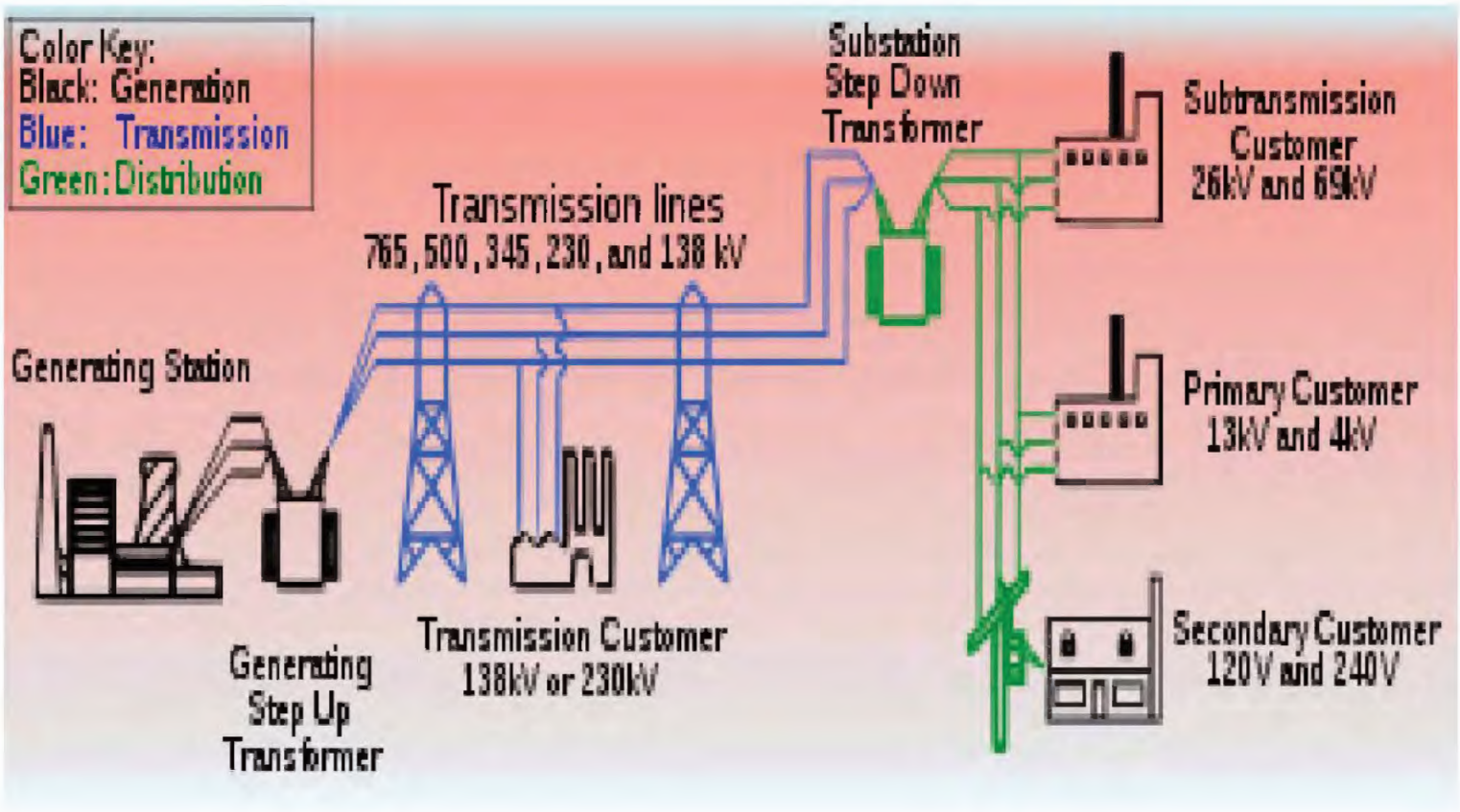
- Allows two-way real time communication between utility company and end user ("customer") using radio frequency (RF).

- Transmits usage data based upon the settings selected by utility company. Numerous variables include:

  - Modulation — Signal strength
  - Frequency — Similar to Wi-Fi and cellphone but with greater power
  - Daisy chains — Data from meter to meter covering up to 750 locations

Electric Utility Power Distribution Systems

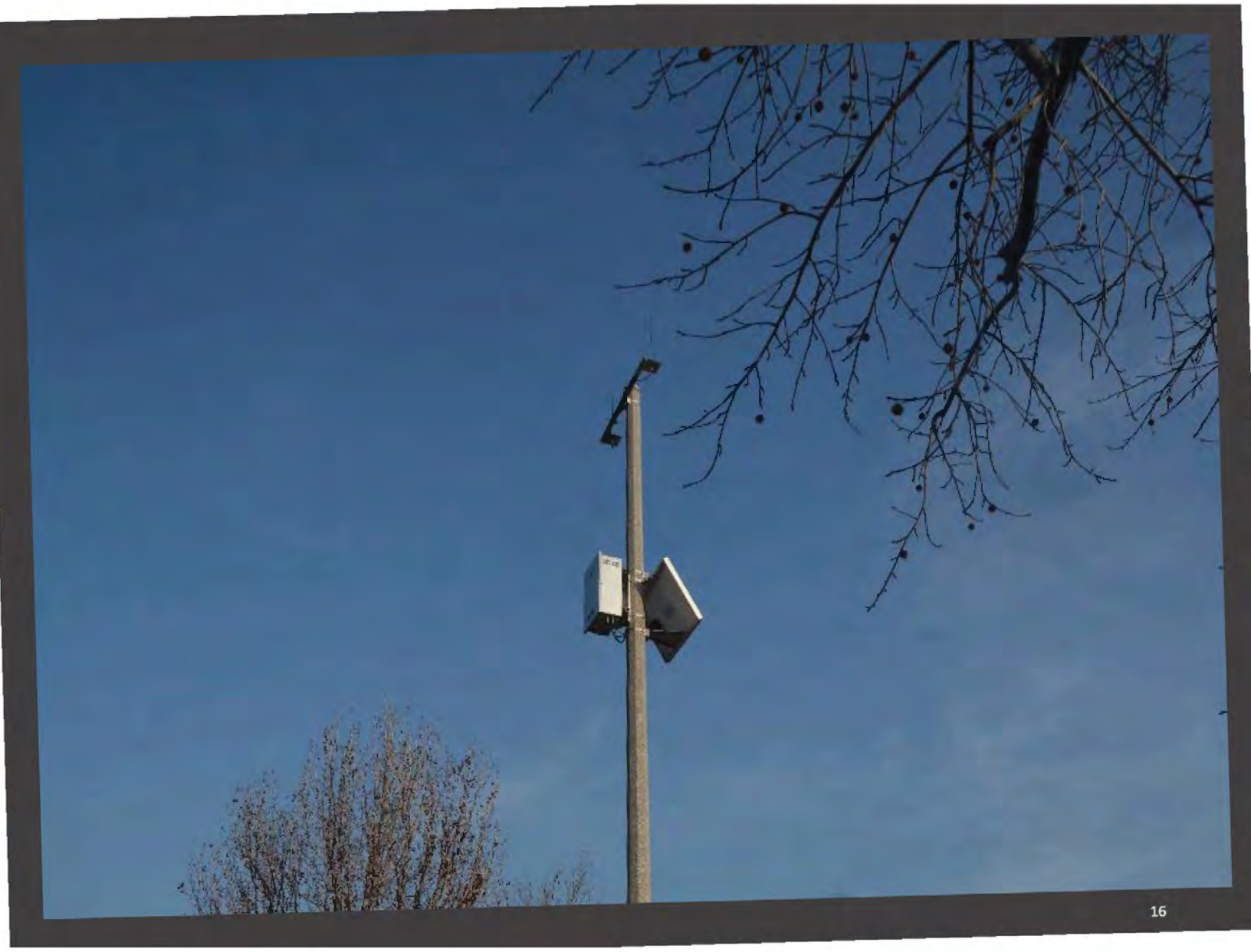
New Definition of Grid Now Includes "Customer Equipment"



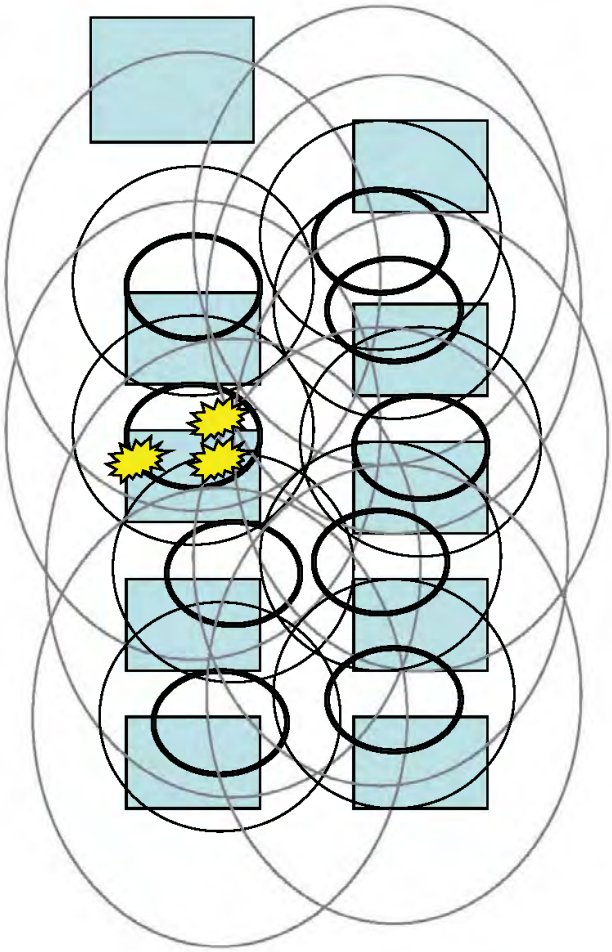
Digital Smart Meter

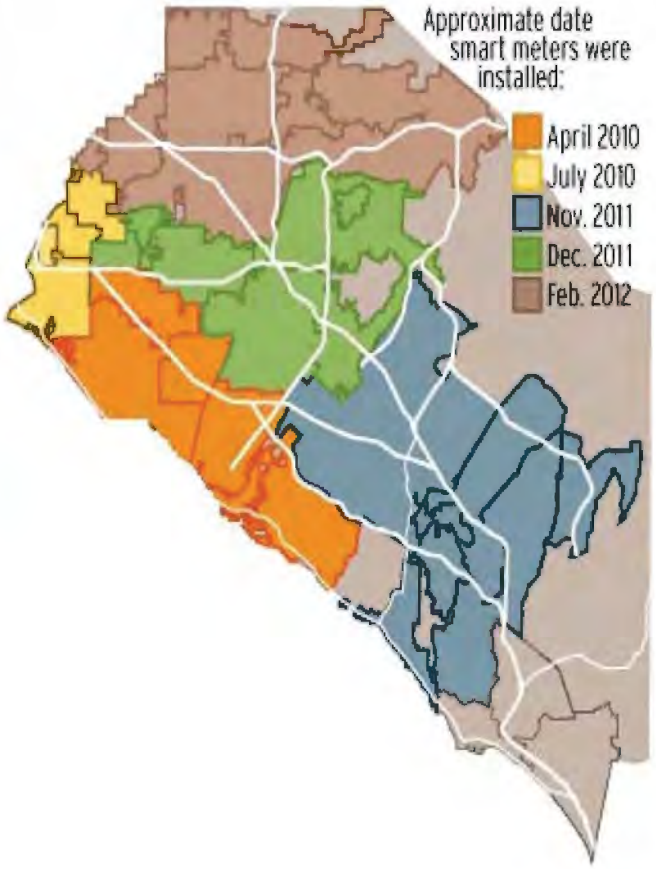
Collector or “Super Meter”

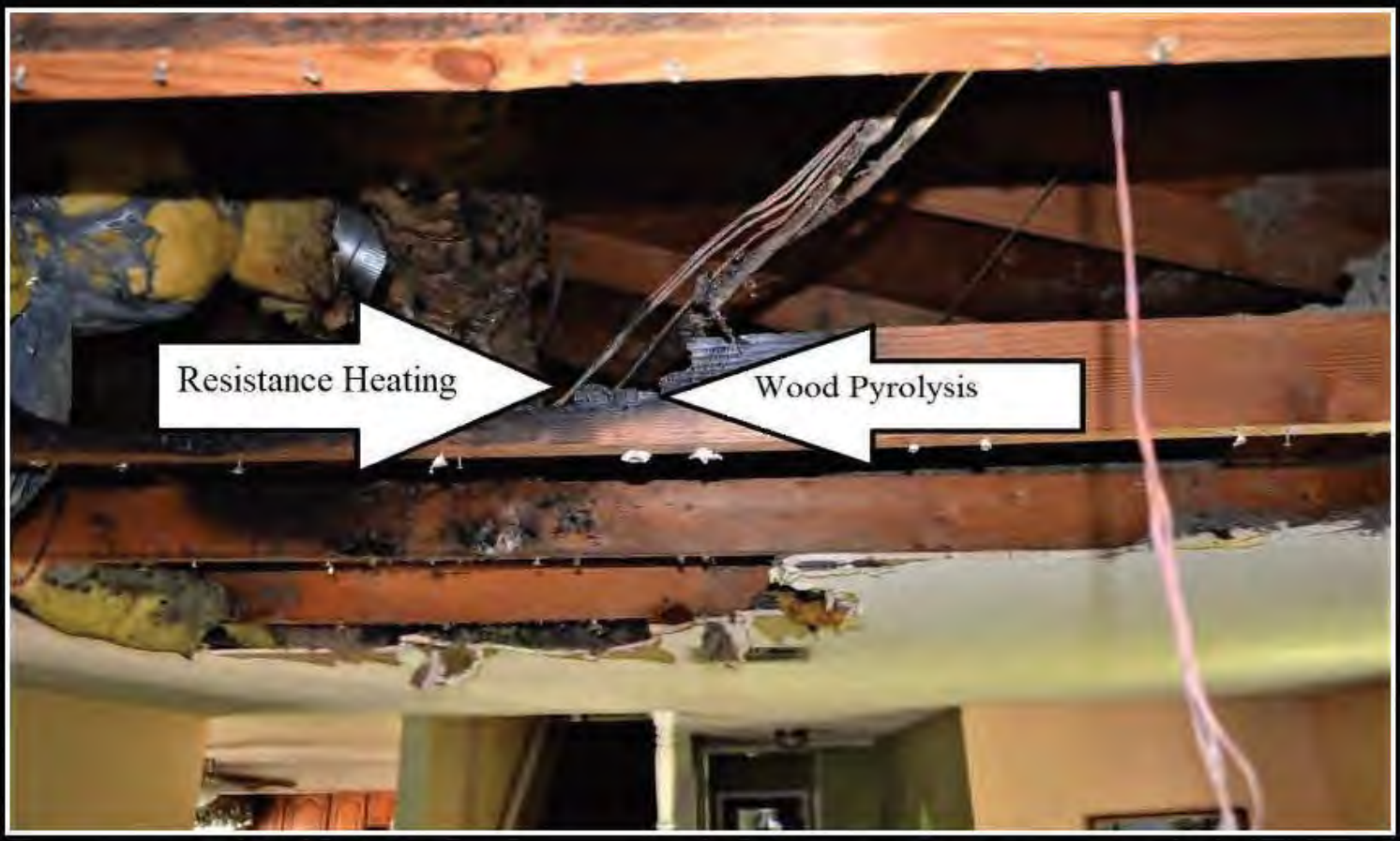
Sends Signals to WAN Antenna



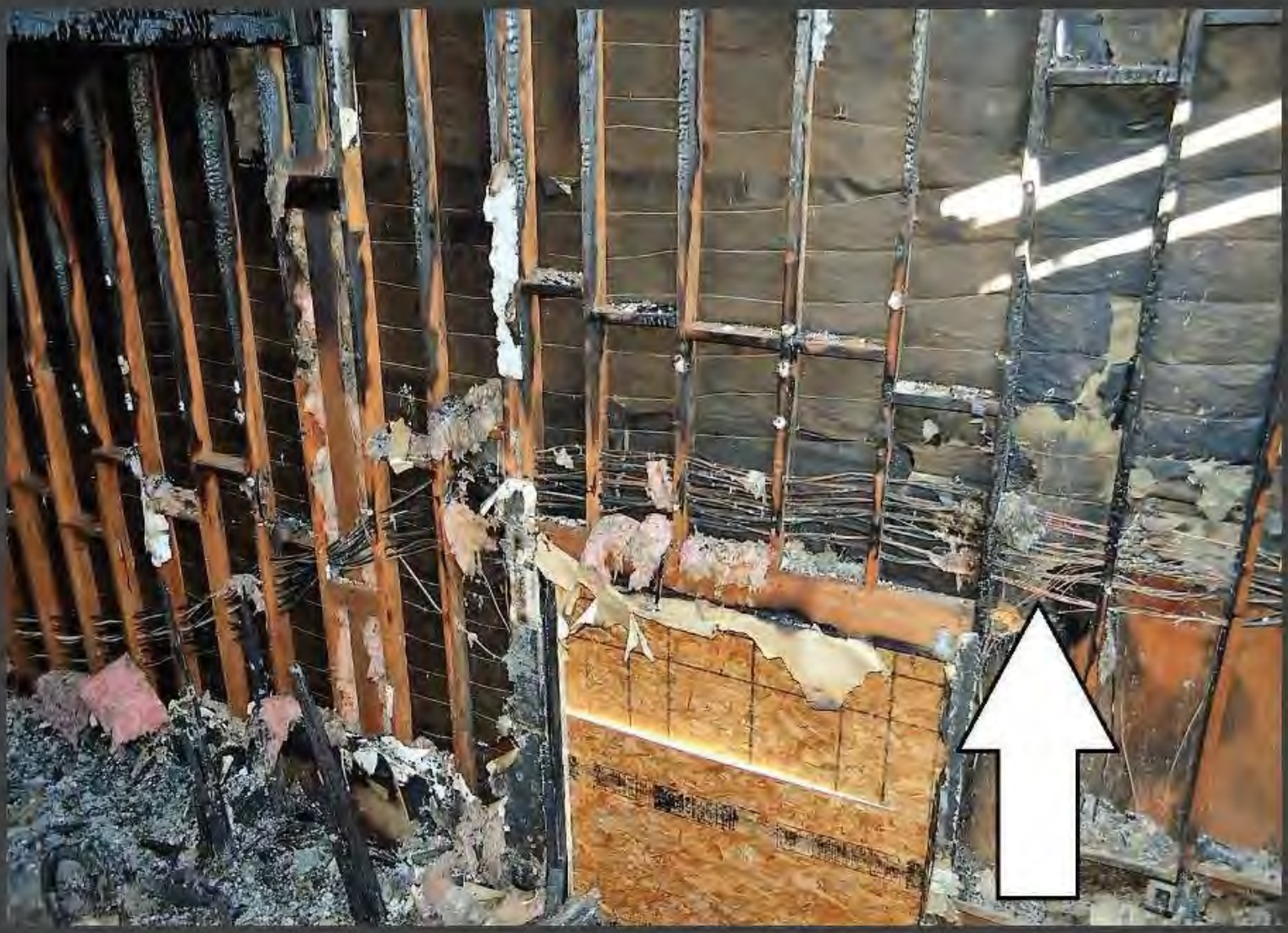
Mesh network communications







Typical Fires Resulting From Wiring Breakdown



Characteristics of smart meter fires from field observation

- Occur within 1 month to two years following initial replacement of analog meter with smart meter
- Within 15 – 25 feet of smart meter
- Occur in continuous sections of branch circuit wiring, not at points of connection or splices, not near staples, not in junction boxes
- No evidence of insect or rodent infestation
- Occur in void spaces (walls, ceilings) and in attics with no human activity
- Often small fires (5 – 10’ diameter)
- No correlation to service size or circuit loading
- No correlation to premises wiring age or material (Al or Cu)
- No correlation to significant weather events (lightning)
- No evidence of utility supply (distribution) system anomalies (voltage spikes)
- Fires cause typically listed as UNDETERMINED

5 Stages Leading to Fire…

- **1st Stage**: RF pulses (beams) away from meter in a specific pattern to send signals (data) to nearby meters in the "Daisy Chain".

- **2nd Stage**: RF from meter bounces off "reflected" surfaces causing RF to "double/quadruple" in intensity (in terms of energy density measured as microwatts per square meter; $\mu W/m^2$). The pulse bounces back and onto the oncoming pulse and intersects at a specific geometric focal point. If PVC insulation is present at that focal point, the RF energy can get converted to heat energy in the dielectric, causing micro fractures or bubbles in the polymer. The main effect is likely thermal, but the existing electric field may accelerate the degradation of the polymer (PVC).

5 Stages (cont.)

- **3rd Stage**: Sufficient heating can either ignite the polymer directly, or, more likely, first carbonize it. If PVC gets carbonized, then this can be the initiation of arc tracking, and arc tracking can end up in ignition.

- **4th Stage**: If wood structural members are near/touching, this resistive heating can initiate and sustain pyrolysis of wood.

- **5th Stage**: Flaming combustion begins.

New Scientific Discovery?

- Breakdown/destruction of wiring insulation due to RF radiation was first encountered by the DoD (Navy/Air Force) when radar was utilized. They encountered numerous fires to the electrical wiring onboard ships and airplanes. Steps were taken to produce an “RF resistant” insulation material to prevent the breakdown.
- Ignitions from military radar equipment were first observed in the early 1940s. But it is surprising how little literature can be found on the phenomenon.
- Below are some of the very few citations found in the published literature.

US Navy report, 1957

ELECTRONIC POTENTIAL — Lockheed Aircraft Corporation, having conducted actual tests with the AN/APS20 E Radar, has come up with the following findings:

- It ignited dry steel wool at a distance of 45 feet.
- It caused sparking among a mixture of aluminum chips which exploded a gasoline vaporair mixture at a distance of 251 feet.
- It set off photo flash bulbs at a distance of 850 feet.
- It caused audible and visible sparking among metallic chips shaken in a paper bag at a distance of 275 feet.
- Pronounced humming was produced by medium aluminum wool at 300 feet.

Fueling and defueling operations should not be conducted wtihin 275 feet of the radar beam,

US Navy report, 1958

RADAR RADIATION CAUSES FIRE—Returning from a routine flight, a ZPG-2 experienced what seemed to be an electrical fire. In-flight investigation indicated that the fire came from below the deck adjacent to the main inverter.

The deck plates were removed and CO_2 was discharged into the radome. Shortly thereafter the fire subsided. The airship returned to base and made a normal landing.

Later, removal of the radome fairing showed that oil from the bilge had seeped between the radome and the fairing and had accumulated in the low spot between them. A pair of pliers, a 1.5-volt battery, and several small pieces of wire were also found in this area. Charred portions of the radome and fairing described the path of the fire.

Investigation indicated that the fire was located in the dead space bounded by the car bilge bottom, the radome, and the after radome fairing. It was determined that the fire exhausted itself of oil and/or air and the discharged CO_2 did not reach the area.

Such objects as steel wool and aluminum chips can be set afire by the radiation pattern of this

Hypothesis or Fact?

- This hypothesis has been tested with a post-fire NM cable ("Romex") submitted for analysis to a well-respected materials laboratory. The conclusions yielded positive results of bond dissociation causing the breakdown of the PVC insulation material near the point of the resistive-heating-caused fire event.

- The analysis found molecular breakdown in PVC insulation that could have only been caused by RF radiation. The resulting breakdown compromises or destroys the insulating properties of PVC.

National Fire Statistics on Fixed Wiring Fires

- The following graphs were taken from an NFPA study dated September 2017. Please note the spike nationally on electrical fires to fixed wiring during 2012-2015, the time when most of the Smart Meters were initially installed and put into operation.

Electrical fires in the US for 2002 – 2016 (Source: NFPA)

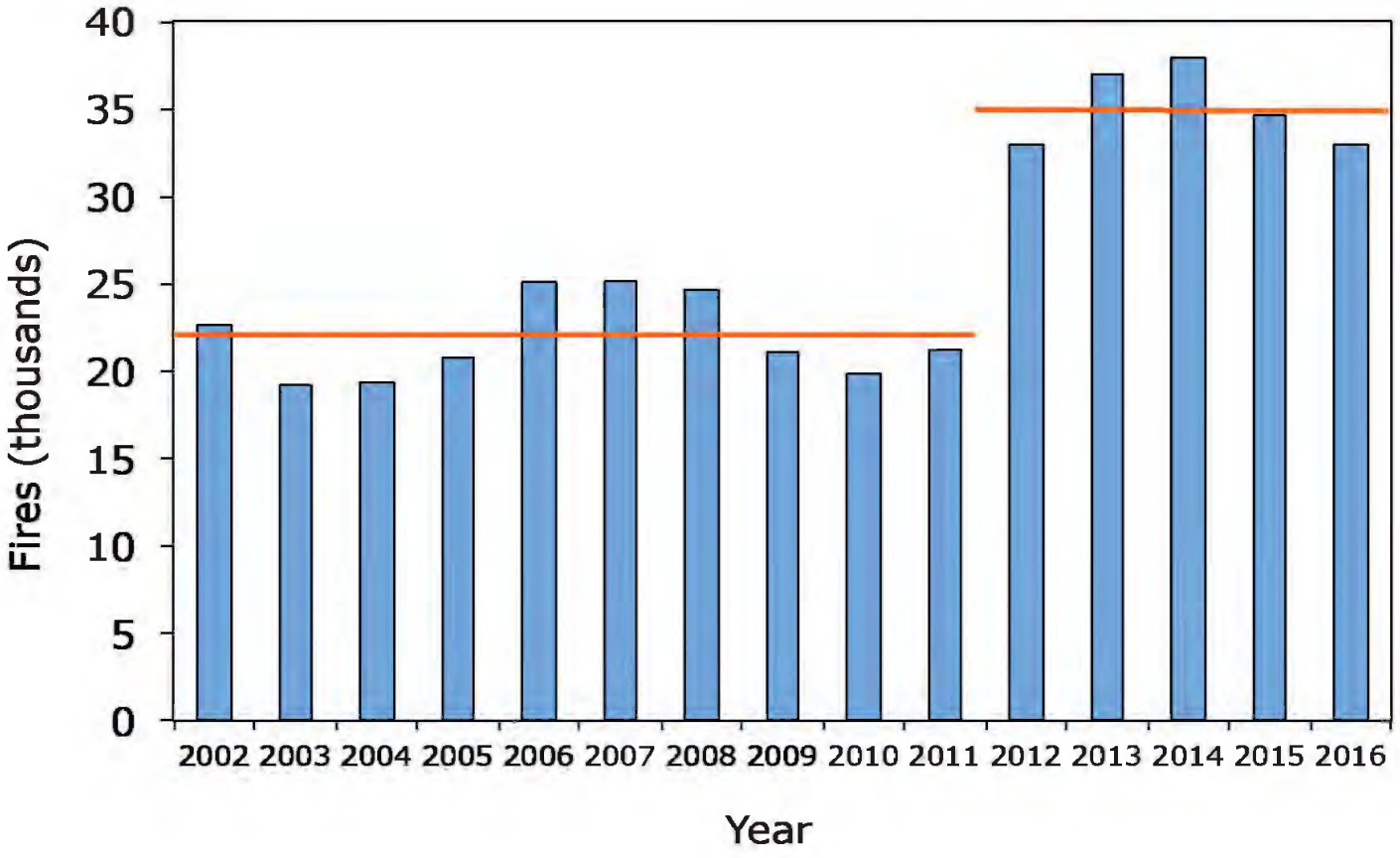


Figure 15. Home Electrical Distribution or Lighting Fires and Deaths, by Year

Figure 15A. Fires

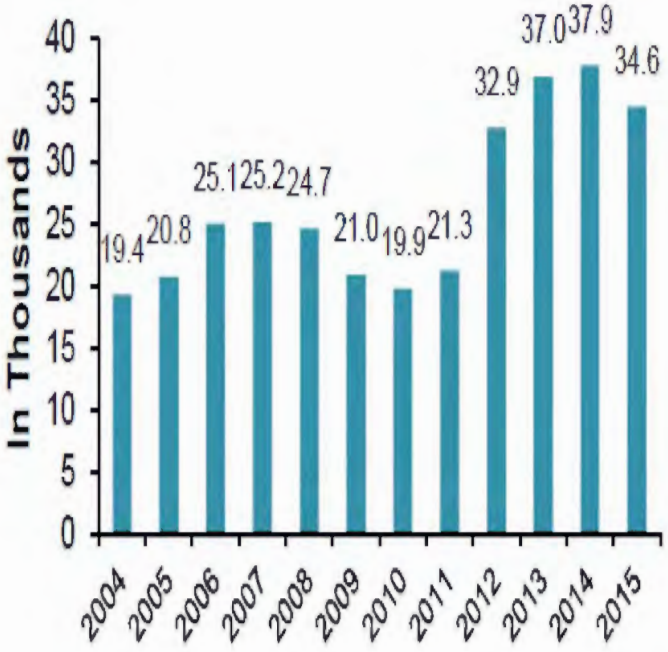
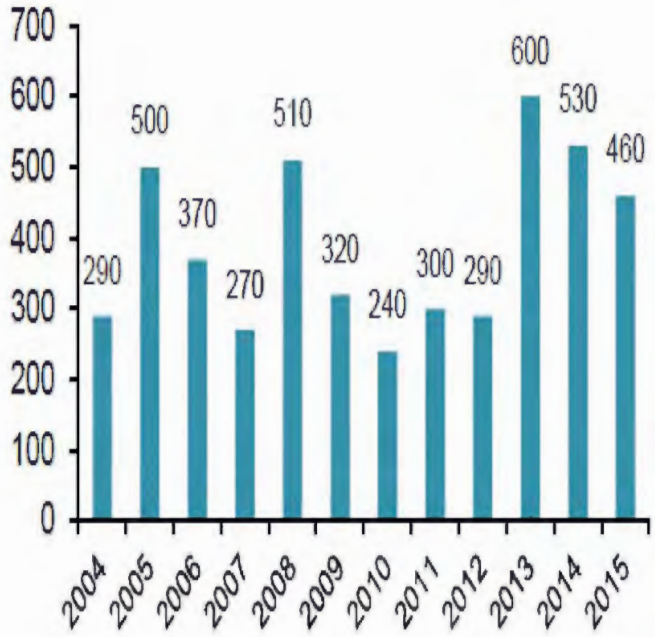


Figure 15B. Civilian Deaths



What the statistics indicate

- The number of fixed wiring fires in the U.S. during 2002 – 2011 was approximately 22,000. For the next 5 years, the number rose to 35,000 or a 59% increase.

- The figures tend to suggest the presence of some specific change in conditions that would cause such a jump. For fixed wiring that is hidden in walls and ceilings, the possibility of accidental damage of the PVC insulation is remote. For any given case, this can be ruled out by examining for staple damage or mechanical damage.

- Utilizing the Scientific Method, the question to all who examine fires is simple: What is the cause of this deadly spike?

If not this, then what?

- This investigation has taken several years to discover, theorize, analyze, test and conclude without prejudice or agenda. The scientific team assembled to exam these large number of fires has explored every known scientific possibility and reason. Leaving only one question: If not this, then what…
- The fire investigator has one primary mission, to DETERMINE the origin and cause of fires. As you have seen, the number of a specific electrical fire classification has spiked greatly. Therefore, staying "on mission" requires an answer to this proliferation.
- The team continually invites any new possibilities…

Video compilation of arcing sound prior to flaming combustion

- Sound emission captured on radio band as “static” for hours preceding a fire caused by arc tracking prior to eruption of flaming combustion.

Dr. Babrauskas Discussion and Final Notes

Types of smart meter fires

Smart-meter-caused fires can be grouped into three broad categories:

1) Inadequate mechanical or electronic design of the meter.
   - Example: Overheating component(s) inside meter; water ingress into electronics due to poor sealing; inadequately-sized shut-off relays causing fire upon remote re-energization; faulty Li-ion batteries (note that mechanical meters do not need one).
2) Problems at the meter/base stab connections.
   - This has nothing to do with the "smart" aspects. Usually due to an untrained gorilla force-fitting the new meter onto the base.
3) Ignitions of wiring at some distance from the meter.
   - This is the sole topic of our presentation today. #1 and #2 are fairly well understood and not particularly controversial.

Research is needed…

- On PVC failure mechanisms due to RF heating
- On RF fields created due to smart meters
- However, we can start by considering what we do know now:

Some important regions of the EM spectrum

Spectral region	Wavelength (m)	Frequency (Hz)	Energy (eV)
RF	$> 10^{-3}$	< 300 GHz	$< 1.24\times10^{-3}$
microwave	10^{-3} – 0.3	1 GHz – 300 GHz	4.1×10^{-6} – 1.24×10^{-3}
IR	7.6×10^{-7} – 10^{-3}	300 GHz – 30 THz	1.24×10^{-3} – 0.124
visible	3.8×10^{-7} – 7.5×10^{-7}	$4.0\text{x}10^{14}$ – $7.9\text{x}10^{14}$	1.61 – 3.26
UV	10×10^{-9} – 3.8×10^{-7}	7.9×10^{14} Hz – 3.4×10^{16} Hz	3.26 – 141
ionizing radiation	$< 1.24\times10^{-7}$	$> 2.42\times10^{15}$ Hz	> 10

RF heating

- Also called dielectric heating
- Old medical example: diathermy machines
- If it is in the microwave region, then it is called microwave heating

…Research…

- It is sometimes thought that, when RF fields are involved, one needs **ionizing radiation** in order to ignite or destroy a plastic.
- This is a fallacy. Ionizing radiation is of such huge frequencies (small wavelengths) that it only is found near nuclear reactions or in high-energy physics labs.
- Instead, normal microwaves (such as emitted by smart meters) can damage or destroy plastics due to **dielectric heating**.

…Research…

- An electric convection oven works in the visible/IR spectrum, yet try sticking in a piece of PVC wiring in there and turn it up to 550ºF!
- The microwave portion of the spectrum shows only slightly lower eV values, which are also way below the 10-eV minimum to constitute ionizing radiation.
- Destruction is not due to ionizing, but simply due to thermal heating.

Bond breakage…

- Ionizing radiation will normally not be encountered in practical conditions.
- But there is an intermediate mechanism between ionizing radiation and dielectric heating: **bond dissociation**.
- To break a C-Cl bond requires about 350 kJ/mol, which is equal to 3.5 eV.
- Whereas to *ionize* a molecule, the energy required is often in the range 8 – 12 eV.

…Bond breakage

- Microwave heating regime is below the 3.5 eV (and is, in fact, below 1.24×10^{-3} eV)
- But this just means that a single photon is not energetic enough to destroy a single chemical bond.
- It does not say that cumulative input energy from the microwave spectrum will not overheat the plastic, degrade it, char it, and then maybe ignite it.

…Research…

- Dielectric heating, if sufficient in magnitude, can damage polymers
- The polymer (PVC here) gets damaged by an excessive temperature rise.
- The excessive temperature rise breaks some chemical bonds and creates others (cross-linking)
- The net result manifests as charring.
- You don’t need ionizing radiation for this, you just need to put in enough heat.

Microwave heating

- Cellphones and microwave ovens are both very convenient modern electronic devices.
- But you should not put your cellphone in your microwave oven. If you do, get this:

Photo:
Nam-Kyu Park

Heating in microwave oven

- Note where the damage occurred to the flip-phone: near the hinge.
- The hinge is the single biggest metal object inside this particular model of flip-phone.

Fundamental dielectric heating equation

$$P = 2\pi\nu\varepsilon\varepsilon_o\mathcal{E}^2 \tan\delta$$

where

$\mathcal{E}$ = electric field (V m^{-1})

P = power absorbed per unit volume of dielectric (W m^{-3})

ε = relative permittivity (--),

ε_o = permittivity of free space (8.845×10^{-12} F m^{-1})

$\tan\delta$ = loss angle (--).

Sometimes also define for convenience a dielectric heating coefficient, J (--):

$$J = \frac{1}{\varepsilon \tan\delta}$$

Dielectric heating coefficient

Material	J (--)	
phenol formaldehyde	1.0 – 1.9	worse
melamine formaldehyde	2.4	
urea formaldehyde	3.8	
PVC	20	
ABS	40	
polyethylene	1100	
polystyrene	1330	better

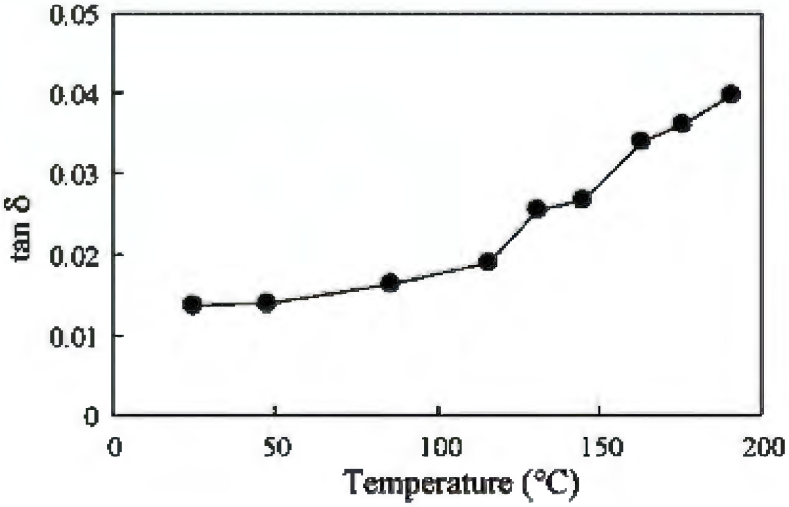
- So, PVC is not the worst…but it's bad enough

Dielectric heating equation

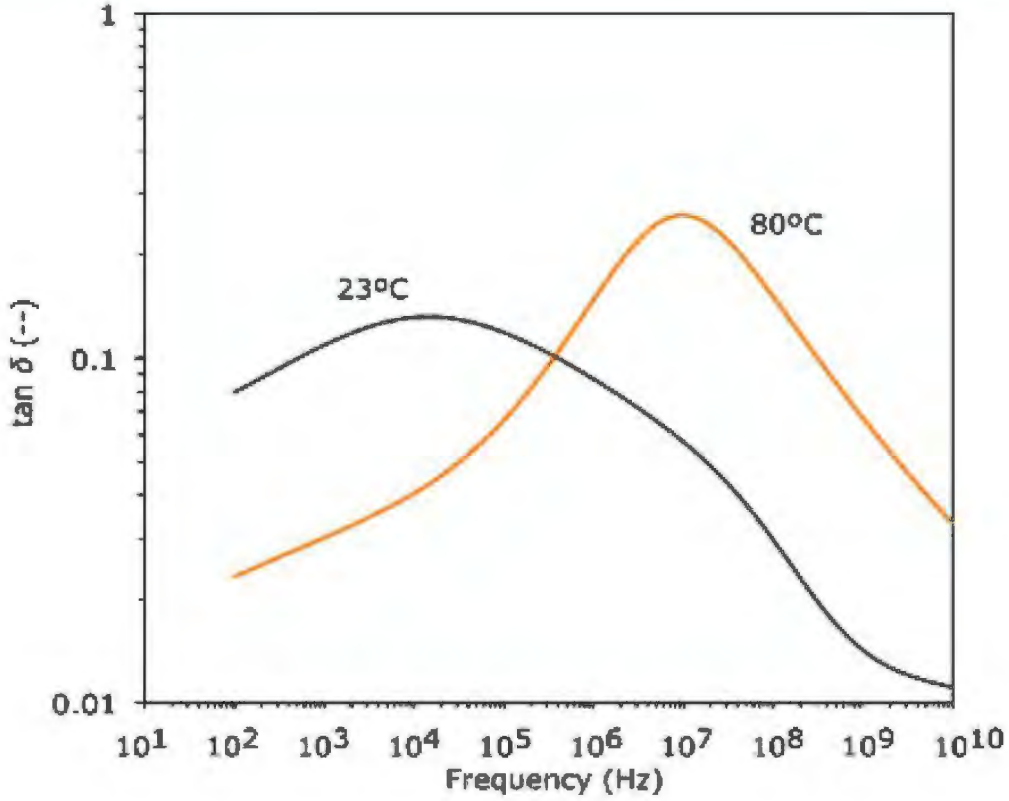
- The equation is fairly simple, but *using* it may not be simple.
- Primarily since ε and tan δ, vary with both frequency and temperature.

PVC temperature dependence of tan δ

- This is only applicable to 2.4 GHz; data for other frequencies are hard to find.
- Smart meters radiate in the 2.45 GHz band, but also 900 MHz and CDMA bands (850, 1900 MHz).



Combined temperature and frequency effect



Microwave-metal interaction pyrolysis…

- This is a relatively new area of scientific study.
- While PVC has not yet been studied, work with some other polymers shows that the presence of metal in/at/near the polymer which is in a microwave field can greatly enhance the heating process.

…Microwave-metal interaction pyrolysis

- Gasner, L. L. Denloye, A. O., and Regan, T. M., Microwave and Conventional Pyrolysis of a Bituminous Coal, *Chem. Eng. Commun.* **48**, 349-354 (1986).
- "*The presence of the two parallel copper wires led to a concentration of microwave energy within the coal mass and the wires in effect acted as antennae for microwaves*."

Reflection loss in thin layers…

- Some studies exist on microwave losses due to reflections within thin layers, notably at ¼ λ and ¾ λ.
- This effect shows sharp peaks localized at a specific frequency.
- Some experimental data from Duan.
  - Duan, Y., Wu, G., Gu, S., Li, S., and Ma, G., Study on Microwave Absorbing Properties of Carbonyl-Iron Composite Coating Based on PVC and Al Sheet, *Applied Surface Science* **258**, 5746-5752 (2012).

Reflection loss in thin PVC layers

Layer thick. (mm)	Absorption peak (GHz)
1	5
2	4
3	2.6

“Non-thermal” microwave effects…

- For quite a long time, various studies have noted that microwave heating can—under some circumstances—provide more apparent heating, and greater rate of chemical reactions, than seems explainable by simply viewing the microwaves as a thermal energy source.

…"Non-thermal" microwave effects…

- This has proven perplexing to chemists, not just engineers. See for example, R. Dagani (1997).
- The simplest cause is the propensity for MW-heating to cause hot spots. This is very well known (why do you think the tray rotates in your MW oven?), but not always fully understood. Hot spots due to nonuniform external fields are well-understood, but hot spots due to the material's own response, less so.
- Hot spots are a "thermal" cause; other causes are termed "non-thermal."

…"Non-thermal" microwave effects…

- A more "chemical" explanation is MW-induced alignment of dipolar reacting molecules or groupings, also called *MW-forced tightening* of opposite polar heads of co-reacting groups. (Parodi, 1999). Or, storage of MW energy in the vibration-energy modes of the molecule (Peng, 2015).
- Other causes can include dielectric and crystal lattice polarization, electronic and ionic conduction, eddy current circulation, and interfacial polarization at grain boundaries (Parodi, 1999).

…"Non-thermal" microwave effects

- Possibly also, non-thermal MW effects are due to direct lowering of activation energy of some reactions (Xu, 2015; Ahirwar, 2016). This is an active debate area in chemistry, and the issue is unsettled.

The role of standards

- With most electrical devices, the public expects that there will be engineering standards which prevent fires and electric shock injuries.
  - But with smart meters, the situation is unusual.
- IEEE Std 1377, IEEE Std 1701, IEEE Std 1702, IEEE Std 1703, and IEC 62056 standards exist. But they only deal with data-interchange issues, not device safety.
- Way after the initial wave of smart meter rollouts, in 2014, UL first issued UL 2735, which is the first standard to contain some safety provisions.
  - BUT, compliance is not required. And there is no indication at this point if this standard is preventing fires.

Current status

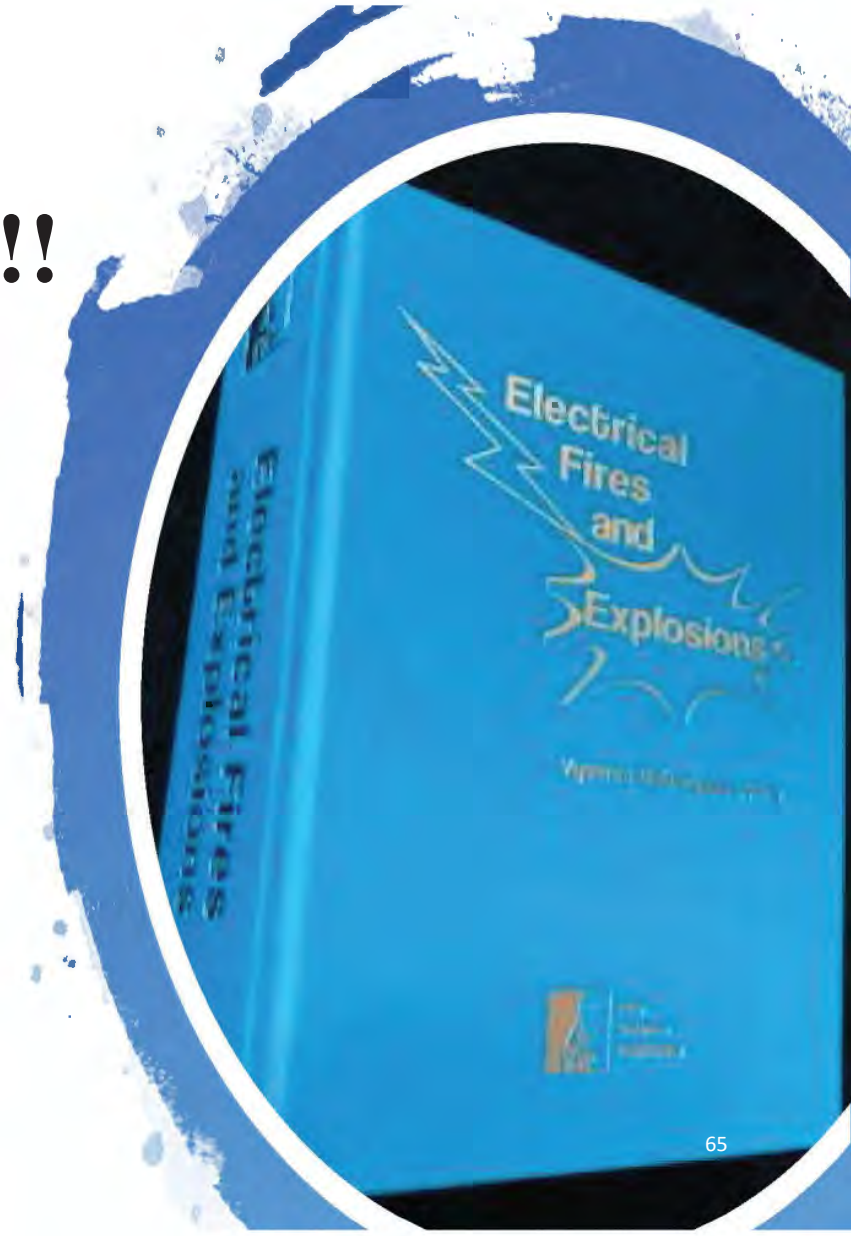
- The above has been a “brainstorming” output on the problem.
- Hypotheses have been considered, but need experimental examination (or, in some cases, checking against existing research work).
- The problem is very real, so now must come some concerted study to unravel the details.

How could things be fixed?

- It appears that the bulk of the problem may be due to the fact that RF (MW) power is directly coupled into wiring.
- An external antenna, used instead, would alleviate much of this.
- Models of smart meters are available with external antennas.
- Some countries (Italy, Portugal) require external antennas, with the antennas to be mounted above roof-level.

Breaking news !!!

- Brand new book, **Electrical Fires and Explosions**, will be released in about 2 weeks.
- 1300 pages
- Bigger than the **Ignition Handbook**
- Only sold in hardback; only on www.doctorfire.com web store.
- More information there on smart meter fires, plus all things electrical.




The end

ENGINEER REPORT

IN THE SUPREME COURT OF PENNSYLVANIA
MIDDLE DISTRICT

RE: No. 34 MAP 2021, *Povacz, M, et al. v. PUC*
Associated Case(s):
35 MAP 2021 Consolidated
36 MAP 2021 Consolidated
37 MAP 2021 Consolidated
38 MAP 2021 Consolidated
39 MAP 2021 Consolidated
40 MAP 2021 Consolidated
41 MAP 2021 Consolidated
42 MAP 2021 Consolidated
43 MAP 2021 Consolidated
44 MAP 2021 Consolidated
45 MAP 2021 Consolidated

Engineer Report – Smart Meters Operation & RF Emissions

Purpose of Statement

1. My name is Erik S. Anderson, P.E. I am a forensic electrical engineer working on root cause failure analysis of matters that cause loss of property, personal injury, and loss of life.

2. I am submitting my expert opinion regarding the operation of smart meters and digital meters and in support of the *amici*.

Credentials

3. I am the president of an engineering firm that offers professional engineering and investigation services across the United States and manufactures current transformers.[1]

4. It is my expert opinion that these smart and digital meters cause a significant amount of radio-frequency (RF) "noise" on homes' electric wiring system, thereby transforming them into a whole house antenna.

5. I have a Bachelor's of Science degree from North Dakota State University, Fargo, North Dakota, in Electrical and Electronic Engineering. I am a licensed Professional Engineer in the states of Minnesota, Illinois, Arizona, Wisconsin, Indiana, Iowa, New Mexico, Texas, Louisiana, California, Kentucky, Michigan, and Nevada. I am a licensed Class A Master Electrician in the state of Minnesota. I also hold a Private Investigator License in Arizona and I am a Certified Fire and Explosion Investigator.

6. I have 30 years of experience as a forensic engineer. I have over 20 years of experience of design and manufacture of current transformers. I have been involved in many thousands of matters concerned with determining the root cause of failures of electrical devices that may have caused a loss of property, personal injury, or loss of life. I have given expert witness testimony in approximately 113

[1] https://www.aenpi.com/

separate matters. I personally have tested smart meters and given expert testimony regarding their operation and emissions. My *curriculum vitae* is attached (Exhibit 1).

7. As a designer and manufacturer of transformers, their operation is one of my main areas of expertise. Switch Mode Power Supply modules used by smart and digital meters are merely another type of transformers. I have investigated the involvement of the operation of the Switch Mode Power Supply in these meters and their involvement in the creation of radio frequency (RF) emissions.[2]

8. My expert determination principally relies on my own smart meter testing. I do also rely on reviews by other experts, their' testing reports and my professional education and vast experience.

Smart Meter Operation

9. Smart meters create intense exposure to pulsed radio frequencies (RF) in a few ways. RF antennas are embedded within the smart meter to transmit data usage to utility companies and/or to communicate with other smart meters or with other "smart" devices like home thermostats. These antennas emit pulsed RF radiation. The various radiofrequencies emitted by these antennas also conduct through the home electric wiring. RF "wire conducted" frequencies come also

[2] An explanation of what are radio frequencies and about the electromagnetic spectrum can be found in the scientists' statements which is also attached to the *amicus* brief as well as in the *amicus* brief itself.

from the conversion process from alternating current (AC) to direct current (DC) handled by the Switch Mode Power Supply (SMPS).[3] Non-transmitting digital meters also use SMPS, and therefore they too create RF, even though they do not contain a transmitting RF antenna for communications. These radio frequencies are transmitted on the residence's electrical distribution system and conduct over the internal wiring, thereby turning the home into a whole-house antenna.

RF Emissions from the Transmitting Antennas

10. The RF antennas that wirelessly transmit the consumer's electrical power usage data to the utility company use frequencies in the 900 MHz & 2,400 MHz range. These emissions are intense and can occur often, up to 190,000 times a day.[4] From my experience and testing done by others, these meters transmit more times than the electric companies report. This can easily be shown by measuring the emissions with a simple RF meter.

11. "Isotrope Wireless,"[5] which provides industry and municipalities with design, specification, evaluation, and construction support for wireless facilities, tested smart meters in three houses.[6] This testing showed that RF emission from the smart meters' transmitting antennas could be detected throughout the house and

---

[3] In some meters the conversion is done using capacitators instead of SMPS.

[4] https://childrenshealthdefense.org/pa-amicus-sage-smart-meters/.

[5] https://www.isotrope.im/about-2/.

[6] https://childrenshealthdefense.org/pa-amicus-isotrope/.

were "well above" the ambient RF radiation levels.[7] These pulsed RF emissions exceed the absolute energy output limits[8] stated in Federal Communications Commission (FCC) guidelines (if the emissions are not averaged over a 30-minute exposure as prescribed by those guidelines).[9]

RF from Wireless Antennas Enter the House's Electrical System

12. The Isotrope testing also showed that the house's electrical wiring conducted substantial levels of the RF emissions at 915 MHz – the communications-related frequency for that meter[10] – and this frequency was then radiated from outlets (electrical power delivery points) and along the house wiring (branch circuitry).

---

[7] https://childrenshealthdefense.org/pa-amicus-isotrope/#page=12.

[8] https://childrenshealthdefense.org/pa-amicus-sage-smart-meters/#page=3.

[9] On August 13, 2021, the Court of Appeals for the DC Circuit ruled that the FCC's 2019 decision that its guidelines adequately protect the public's health are arbitrary, capricious and not evidence-based. The Children's Health Defense is a Petitioner in this case. *Envtl. Health Tr., et al v. FCC*, Nos. 20-1025, 20-1138, 2021 U.S. App. LEXIS 24138 (D.C. Cir. Aug. 13, 2021). The opinion specifically questioned whether the FCC's testing procedures adequately captured the effect of pulsation or modulation. 2021 U.S. App. LEXIS 24138, *12, *29.

[10] Smart meters use a variety of frequencies for communications depending on the manufacturer's choice. PECO's meters operate at around 901 MHz. They also contain a "Zigbee" antenna that can be turned on and then communicate with nearby wireless smart devices. Zigbee uses 2400 MHz band.

13. Thus, the pulsed RF emissions from the smart meter's transmitting antenna not only enter the house wirelessly but also enter into and are conducted along the house's electrical wiring

RF "Noise" From the Switch Mode Power Supply

14. Other RF frequencies besides the RFs from the transmitting antennas, also enter the house electric system. In my testing I have witnessed and analyzed smart meters' effects on the incoming electrical power voltage waveform. These frequencies are a byproduct of the AC/DC conversion process which is done by the Switch Mode Power Supply (SMPS). The conversion process is necessary because utility service employs alternating current whereas the electrical components in smart meters use direct current.[11]

15. SMPS converts the 240 Volt AC power coming into the meter from the main power transformer, into the much lower DC voltage that the electronic devices require to function. The rapid back-and-forth conversion process used to remove the "alternating" aspect creates *unintended* RF frequencies. The on/off, back-and-forth, pulses can occur up to 150,000 times per second, which means frequencies of up to 150,000 Hz (150 KHz[12]), are created. These kilohertz

[11] Smart meters also rely on AC for some of the non-electronic functions they perform.

[12] 1,000 Hz is a kilohertz ("KHz"). 1,000,000 Hz is a megahertz ("MHz"). 1,000,000,000 Hz is a gigahertz ("GHz").

frequencies are within the RF band of frequencies.[13] Most of the observed "noise" spikes are in the range of 2 to 50 kHz (2,000 to 50,000 Hz).[14] The switching RF "spikes" are variable, and they are being imposed on the 60 Hz house electricity wave,[15] creating significant unintended RF "noise."

16. These frequencies are present all the time but are worse when less electricity is being used (e.g., at night) and when the smart meter's electronics need more power, for example, when transmitting RF bursts to the utility. These RF transmission bursts cause spikes over the electric wiring, and they are created because the SMPS has to suddenly supply more DC power.

Digital Meters Use SMPS and Therefore Also Created Unintended RF

17. Digital meters also use SMPS. Therefore, even though they do not contain an RF communications antenna, the AC/DC conversion process creates significant and variable RF spikes over the electrical wiring, which is then radiated into the house.

---

[13] FCC defines RF as frequencies between 3 KHz – 300 GHz.

[14] Finding of Fact 87 in *McKnight v. PECO* (once of the cases on hold below) states that "PECO's AMI meters do not produce 5 Hz, 3 kilohertz, or 5 megahertz fields. (April 13, Tr. 75-76)." While I have some doubt this is actually so, this finding does not rule out emissions in the other frequencies I list.

[15] Electricity comes to the house at a frequency of 60 Hz.

Analog Meters Do Not Have SMPS and Do Not Create RF Spikes

18. In contrast, unlike wireless smart meters and digital meters, analog meters do not contain an SMPS or other electronic components that create unintended RF frequencies. No AC/DC conversion is necessary, and unlike smart and digital meters, analog meters have a separate wired grounding rod that eliminates much of the "noise" that may come from the energy feed.

19. The images below compare a smart meter like that used by PECO[16] with an analog meter. The red waveform is the 60 Hz house electricity frequency. The yellow waveform indicates the RF frequencies imposed over the 60 Hz. **Image 1**shows that an analog meter does not create RF spikes. **Image 2** shows the smart meter causing significant RF spikes "noise" over the 60 Hz frequency house electric wiring system. [17]

[16] https://childrenshealthdefense.org/wp-content/uploads/pa-amicus-bathgate-pa-smart-meters.pdf. Pages 17-18.

[17] https://childrenshealthdefense.org/wp-content/uploads/pa-amicus-bathgate-pa-smart-meters.pdf#page=14.

Image 1: Analog Meter – No RF Spikes

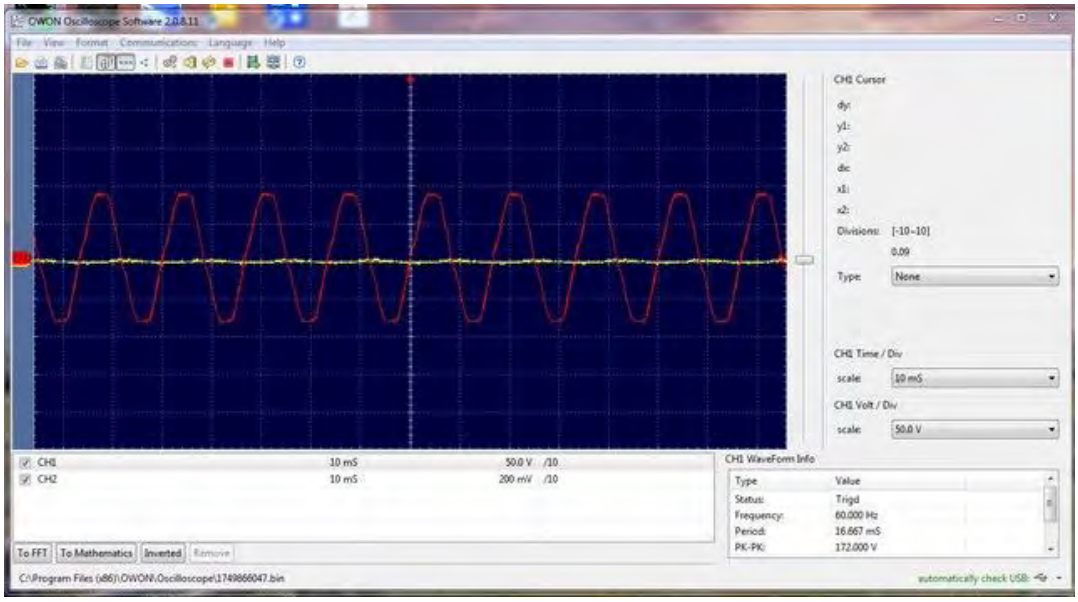
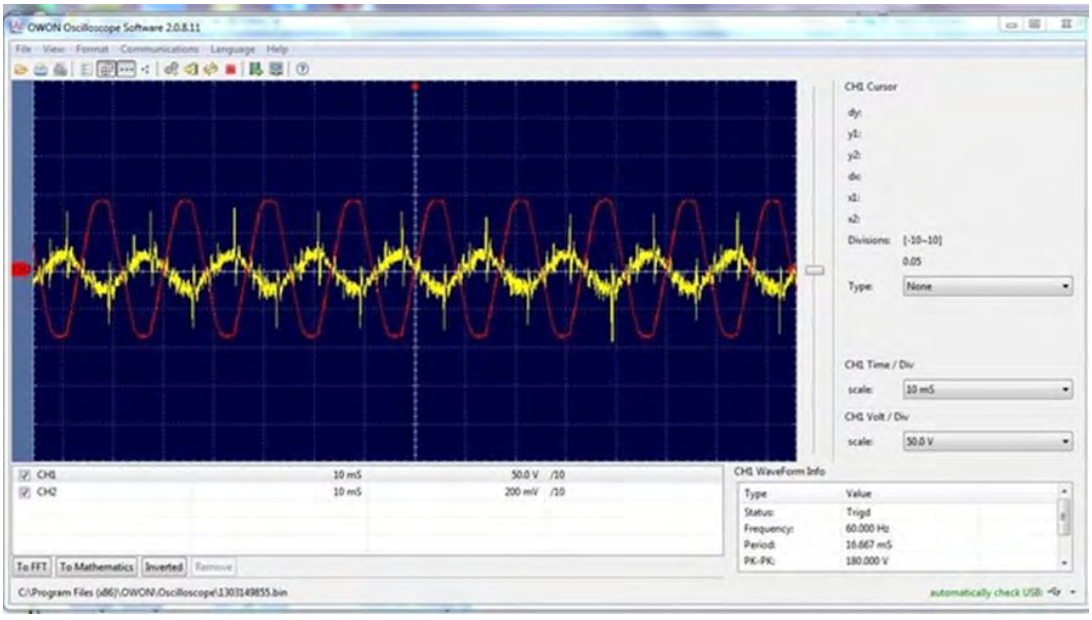


Image 2: Smart Meter – Intense RF spikes.



My Smart Meter Testing:

20. My test setup consisted of a meter socket enclosure suitable for 120/240 Volt, single-phase, three-wire connection. A smart meter, Landis & Gyr,

Gridstream RF, Focus AXR-SD, Form 2S, CL200, 240 V, 3 W, 60 Hz, power meter was used.[18] The voltage waveform was captured with a Fluke 215C Scopemeter. One input to the Scopemeter was connected to the incoming voltage, 120 Volts-to-Ground, unfiltered. The other input to the Scopemeter was connected to the incoming voltage with the 60 Hz waveform filtered out. A radiofrequency emissions meter was also used to indicate when an RF signal increase was detected.

21. When the test equipment was connected to the incoming power, the waveform of the incoming electrical power was observed. The 60 Hz signal was recognized as the dominant frequency with some noise observed on the waveform. The 60 Hz was filtered out to analyze the noise on the signal.

22. When the smart meter was not connected, the noise level was approximately 45 milliVolts at its peak. When the smart meter was added to the circuit, the noise on the 60 Hz sine wave was noticeably larger, approximately 85 milliVolts. This is nearly double the amount of noise than without the smart meter.

23. The dominant frequencies are in the range of 2 to 50 kHz. These are the frequencies that the "smart meter" generates when it is transmitting.

[18] PECO uses this meter, or one quite like it. R995a, 1046a.

Conclusion and Opinion

24. There is no doubt that smart and digital meters create pulsed RF emissions and these emissions, from the smart meters' antennas and the RF created by the SMPS, both enter the house's electric system. The result is that the entire house is transformed into a radiating RF antenna.

25. Any meter with a switch mode power supply will create RF frequencies in the Kilohertz range that enter the electrical wiring system of the house. Smart meters and digital meters inject significant levels of RF onto the home's electrical distribution system.

26. This report is based on information learned to date. I reserve the right to amend, clarify, or change my opinions based on more work or information learned.

Respectfully Submitted:

Erik S. Anderson, P.E.

ENGINEER REPORT – Exhibit 1

ANDERSON ENGINEERING OF NEW PRAGUE, INC.
9007 S. Third Street
Phoenix, Arizona 85042
Office: (602) 437-5455
Mobile: (952) 292-6416
Email: eanderson@aenpi.com

ERIK S. ANDERSON

Registered Professional Engineer

REGISTRATION:

Licensed Professional Engineer

State of Minnesota	1991	21471
State of Illinois	1999	062052733
State of Arizona	2003	39627
State of Wisconsin	2008	39418-006
State of Indiana	2008	PE.10809314
State of Iowa	2008	18758
State of New Mexico	2008	19001
State of Texas	2009	102714
State of Louisiana	2009	PE.0034787
State of California	2010	105359
State of Kentucky	2012	28492
State of Michigan	2013	6201060247
State of Nevada	2013	022690

Other Licenses:

Licensed Class A Master Electrician – State of Minnesota	1995	AM005344
Private Investigator – Arizona	2011	1615601
Private Detective – Illinois	2017	115.002549
Private Investigator – Minnesota	2019	PDC 2098
Certified Fire and Explosion Investigator (NAFI -CFEI)	2012, 2017	17853-9760

EDUCATION:

B.S. in Electrical and Electronic Engineering
North Dakota State University, Fargo, North Dakota, 1987.

Chemical Engineering Course Work
University of Minnesota, Minneapolis, Minnesota, 1981-1983.

CONTINUING EDUCATION:

Hazardous Materials: HAZWOPER: 40-hour worker 2008
Annual 8-Hr. HAZWOPER Refresher Course: 2009, 2010, 2011, 2012, 2013, 2014, 2015

Asbestos Awareness: 05/09, 3/14, 09/16, 01/2020

Annual Fire Investigation Seminar Instructor
Maricopa AZ: 04/08, 03/09, 03/12, 03/13

Minnesota Chapter IAAI Fire & Arson Conference
3/88, 3/89, 3/90, 3/01, 3/05, 3/06.

Instructor: Fire/Arson Level 3
Mesa, Arizona, 10/03.

Illinois Chapter IAAI Northern Zone Winter Seminar
Instructor: Electrical Appliance Fires, 2/03.

Completed Code & Code Change Class
Minnesota Electrical Association – National Electrical Code
1/99, 2/01, 1/03, 1/05, 1/07, 1/09, 1/11, 2/13, 5/15, 2/17, 3/19, 2/21

Illinois Chapter IAAI Fire Investigation Conference
Instructor: Forensic Electrical Engineering Principles & Practices, 9/99.

Graduate Course Work, University of Minnesota
Minneapolis, Minnesota, 1995-1997.

Master Electrician Course, Hennepin County Technical College, Eden Prairie, Minnesota 3/95.

Completed Designing Electrical Systems for Hazardous Locations University of Wisconsin-Madison, 4/92.

Completed Electrical Fires Accidental and Deliberate
Sponsored by Georgia Chapter of IAAI, 12/91.

Completed Fire and Arson Investigation Course,
Nebraska State Fire & Arson Investigators Conference, 10/87

EXPERIENCE:

01/05 - Present Anderson Engineering of New Prague, Inc., Phoenix, AZ
President & Forensic Electrical Engineer. Responsible for all aspects of business operations including engineering services to clients, product testing, fire investigation, and failure analysis.

Our case load also includes construction defect cases involving the evaluation of the workmanship of the electrical subcontractor and personal injury cases involving electric shock and/or electrocutions.

4/87 – 1/05 Anderson Engineering of New Prague, Inc., New Prague, MN
Electrical Engineer. Responsible to client for engineering services including product testing, fire investigation, and failure analysis.

Midwest Current Transformer, Division of Anderson Engineering of New Prague, Inc., New Prague, MN.
Designer, manufacturer, and quality control engineer of current transformers.

1/84 - 11/84 O.S. Anderson Engineering, Inc., New Prague, MN.
Research and Design Coordinator. Duties included work on transponder design for communications system through earth.

6/83 - 9/83 Koch Refinery, Southeast St. Paul, MN. Conducted ultrasound testing on oil refinery systems.

1981 & 1982 (Summers) O.S. Anderson Engineering, Inc., New Prague, MN.
Assistant Engineer. Designed software for and compiled data of E-fields generated by high voltage transmission lines, assisted in investigations of various cases involving questions of product liability.

PROFESSIONAL AFFILIATIONS:
Member Institute of Electrical and Electronic Engineers.
Member National Society of Professional Engineers.
Member Minnesota Society of Professional Engineers.
Member International Association of Arson Investigators.
Member National Fire Protection Association.
Member National Association of Fire Investigators.
Member American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

EXPERT TESTIFYING WITNESS:

Arbitrations:	02
Depositions:	91
Trials:	27
Arizona Corporation Commission	01